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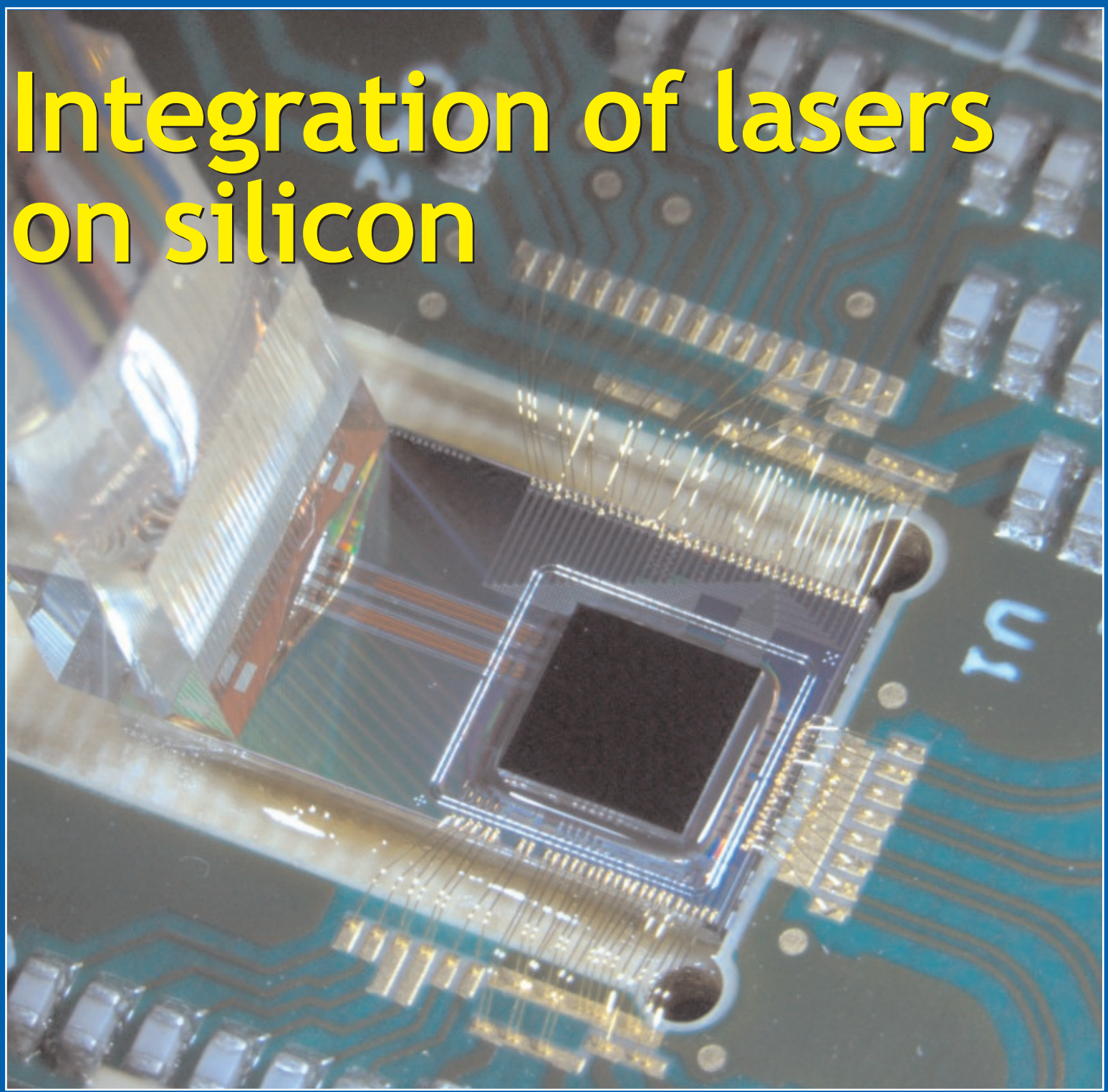
www.semiconductor-today.com



Integration of lasers on silicon

II-VI licenses GE's SiC power electronics technology • UV-C LED disinfection proliferating • Epistar & Lextar partner

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contents

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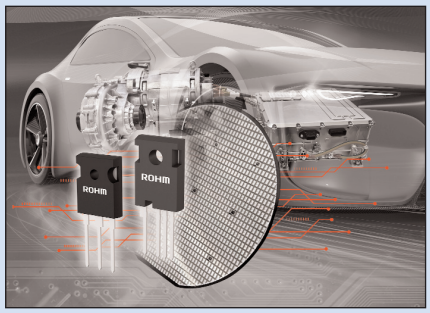
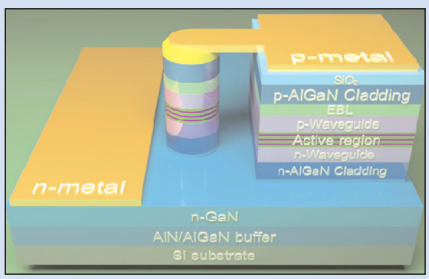
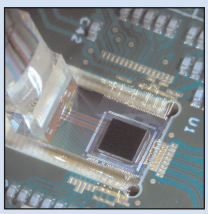


p14 Power semiconductor maker ROHM has announced its 4th Generation 1200V SiC MOSFETs optimized for automotive powertrain systems.

p26 EasyGaN, Riber and CRHEA have fabricated the first 200mm AlN-on-Si template using ammonia-based MBE.



p54 Researchers based in China have fabricated the first room-temperature CW electrically pumped InGaN microdisk laser grown on silicon.



Cover: As part of the EU project COSMICC, CEA-Leti has demonstrated a fully packaged CWDM silicon-photonics-based optical transceiver module with data transfer of 100Gb/s per fiber with a low-power-consumption electronic chip co-integrated on the photonic chip. **p40**

editorial

Compounds to aid economic recovery

In the last month, the COVID-19 pandemic has continued its spread to most remaining regions of the world, and a second wave has arisen in many countries through the economy-driven lifting of work and leisure restrictions.

While a return to work re-starts economies, for many there may not be a full return to prior lifestyles after switching work and leisure from in-person to online, with fewer people commuting into central offices, greater online commerce (home deliveries) etc.

A major hindrance to the recovery of sectors involving public contact (mass transport, hospitality, in-store retail etc) is the public's lack of confidence in safety, especially as the unknowns grow (e.g. the possibility of airborne transmission of the virus on particles in suspension).

This is one area where compound semiconductor technology can step up, in the form of UV-C LED light sources such as those from AquiSense and Signify, which have been shown (by the universities of Miyaki in Japan and Boston in the USA, respectively) to inactivate the SARS-COV-2 virus (see pages 31–32). Applications focusing on indoor environments include disinfecting the interiors of vehicles (such as trains, buses and taxis). Correspondingly, Signify is increasing its UV-C lighting production capacity and expanding its UV-C product portfolio. Meanwhile, Seoul Viosys' Violeds UV LED technology has been adopted by China's largest air-conditioner manufacturer (page 31). Meanwhile, US-based UV-C LED maker Crystal IS and Japanese parent firm Asahi Kasei have launched the UV Accelerator initiative, which aims to fund firms developing new disinfection products (page 30).

Although mass transport has been much diminished by coronavirus, home deliveries have multiplied and personal transport is rebounding. Technology development into things like driverless taxis and electric vehicles in general is still ongoing. Specifically, regarding 1200V silicon carbide (SiC) MOSFETs for inverters (page 14–16), Japan's Mitsubishi Electric has launched its new N-series, while ROHM has launched its fourth-generation product (as well as opening a joint development lab in Shanghai with China-based automotive power-train manufacturer Leadrive). US-based Cree's 1200V SiC MOSFETs are being used in China-based StarPower's power modules for electric-bus maker Yutong. Also, to open up new medium-power applications (like EV charging), Germany's Infineon has added a 62mm-package module to its CoolSiC range.

In addition, joining vertically integrated SiC substrate & device makers like Cree (Wolfspeed) and ROHM (SiCrystal), US-based SiC substrate maker II-VI Inc is moving down the supply chain to higher-value products by licensing General Electric's SiC power electronics device and module technology. "SiC-based power electronics materials and components will become increasingly deployed in electrification systems including, for example, in electric vehicles, industrial infrastructure, and large datacenters, and so we continue to invest to position II–VI in strategic points of the evolving supply chains to enable key customers," says II–VI's CEO Dr Vincent D. Mattera Jr. The agreement will "broaden GE's commercial reach beyond the industry sectors we already serve with SiC technology," adds GE Aviation Electrical Power Systems.

However, a possible constraint, due to the potential customers/development partners in China, is the ongoing US-China trade war, which also affects other COVID-19-driven growth sectors such as optical communications.

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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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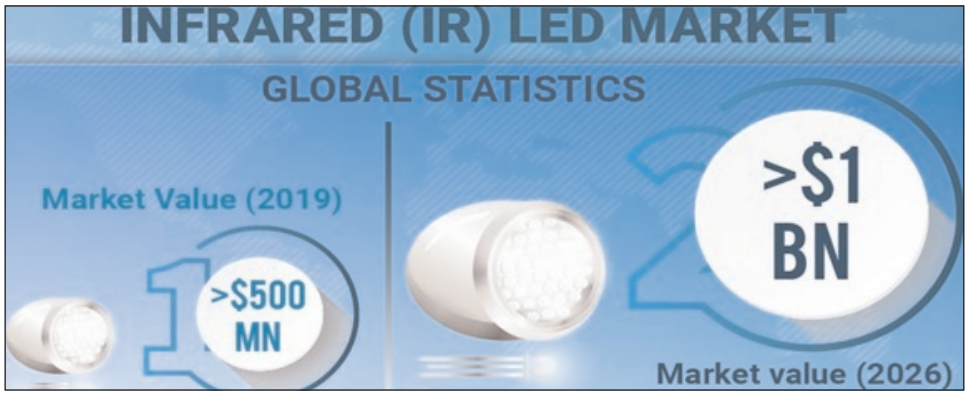
IR LED market to double from $500m to $1bn by 2026

The infrared LED market will grow from more than $500m currently to over $1bn by 2026, driven by ongoing technological advances, high demand from automotive sector, and rising adoption of CCTV and surveillance cameras across the industrial sector, forecasts a report from Global Market Insights Inc.

Infrared LEDs are used in cameras, remote controls for televisions, as well as in several types of electronic devices. Since infrared LEDs are used in combination with different types of sensors, these are now becoming common to IoT (Internet of Things) applications as well as M2M (machine-to-machine) environments as well. Other applications include smoke detectors, transmission systems, infrared applied systems, optoelectronic switches, industrial equipment and infrared remote-control devices.

Based on spectral range, the IR LED market is classified into 1020–1720nm, 950–1020nm, 850–950nm and 700–850nm.



Among these, the market share for the 1020–1720nm spectral range was over 5% in 2019 due to growing adoption in high-power applications such as surveillance, security and biomedical.

In terms of application, the market is categorized into lighting, surveillance, biometrics, remote sensing, and imaging. Among these, remote sensing held a market share of about 10% in 2019 due to the growing adoption of IR LED lightning systems in automotive applications.

With respect to end-use, the IR LED market is bifurcated into consumer electronics, retail, aerospace & defense, healthcare, automotive, industrial, BFSI (banking, financial services and insurance) and education. The industrial end-use segment held a market share of over 15% in 2019 due to the growing adoption of CCTV and surveillance cameras in manufacturing process.

From a regional frame of reference, the Middle East & Africa market saw a growth rate of nearly 10% in 2019 due to high investment in infrastructure and the commercial sector, the report concludes.

www.gminsights.com

Huawei sanctions bad for US economy and semiconductor competiveness, says Strategy Analytics

Damage could start at $7bn in lost sales, plus reduced R&D spending

The new US Government policy announced on 15 May against Huawei (to restrict its ability to use US technology and software to design and manufacture its semiconductors abroad) threatens US semiconductor industry exports, innovation and global leadership, reckons market research firm Strategy Analytics in its report 'Huawei Sanctions: Bad for Telecoms, Global Semiconductors and the US Economy', which details the short-term and longer-term effects of the new policy on US-based semiconductor companies, global wireless and international trade overall.

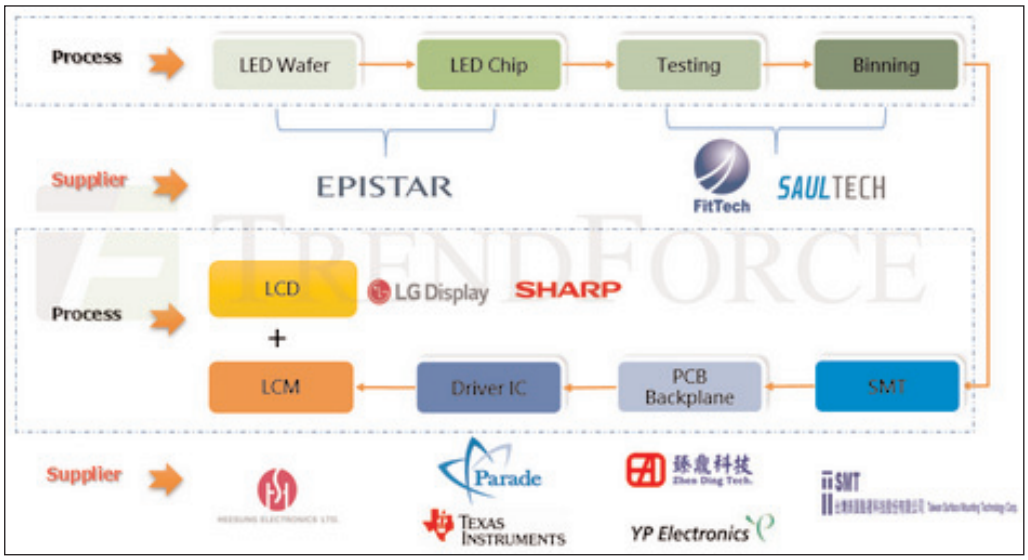
"The new trade policy aimed against Huawei seems to be motivated by US domestic politics rather than a clear understanding of international trade in the technology sector," says report author Christopher Taylor, director of RF & Wireless Components. "The US has legitimate differences with China, but the damage to the US semiconductors industry from this new policy would start at $7bn in lost sales, and put the industry's future competitiveness at risk through reduced R&D spending, far outweighing any benefits to the US," he adds.

"Semiconductor suppliers Broadcom, Intel, Micron, Skyworks, and Qualcomm and many others will be affected," believes Stephen Entwistle, VP of strategic technologies at Strategy Analytics. "The US semiconductor industry employs about 250,000, and a loss of US semiconductor leadership would put these jobs at risk, with a multiplier effect extending to three or four times as many US jobs. Foreign semiconductor firms in the supply chain using US technology including MediaTek and the foundry TSMC are also barred from selling to Huawei under the policy, which will affect the entire electronics industry," he concludes.

www.strategyanalytics.com

Mini-LED supply chain to benefit from Q1/21 release of Apple's 12.9-inch iPad Pro

Taiwanese suppliers chosen to avoid impacts of China–US trade war



As Apple's upcoming release of products featuring mini-LED backlighting is generating growth in mini-LED demand, the firm has also stimulated players in the mini-LED supply chain to increase their production capacities. According to the LEDinside research division of TrendForce, in first-quarter 2021 Apple is expected to not only release its 12.9-inch, mini-LED backlight-equipped iPad Pro but also open contract bids for its 14-inch and 16-inch MacBooks.

Apple has currently chosen Taiwanese manufacturers of display-related components to supply its mini-LED backlights, since Taiwanese suppliers are said to have an advantage in new product development, given their product stability and technological maturity. Both upstream and downstream suppliers are expected to participate in the mini-LED supply chain, including LED chip maker Epistar, testing & sorting OEM FitTech, pick & place and die attach solutions provider Saultech, SMT supplier TSMT, and PCB backplane manufacturer Zhen Ding Tech — all of which serve important roles in the development of new mini-LED backlight displays.

Mini-LED backlight displays have high brightness and high contrast ratios, which can exceed 1,000,000:1, compared with the 10,000:1 of existing mainstream displays. Furthermore, mini-LED displays are also highly reliable, as they can maintain proper functioning and deliver consistent brightness in harsh environments with temperatures ranging between +60°C to −10°C.

All of these strengths make mini-LED technology especially attractive to branded manufacturers. As such, Apple has incorporated mini-LED backlights as one of its core areas of focus in its future planning of new display products.

Although Chinese manufacturers currently possess enormous production capacity and cost advantages in the upstream and downstream LED supply chain, Apple has instead chosen to collaborate with Taiwanese manufacturers (which form a more stable supply chain) in an effort to avoid the impacts from the China–US trade war. In addition, Taiwan invested in LED R&D significantly earlier than China did, meaning it leads the latter in terms of both technological maturity and patents. These advantages, combined with the ease of procuring raw materials and components, make Taiwanese suppliers more efficient in the development of new technologies, says TrendForce.

Apple's 12.9-inch iPad Pro to spur wave of demand in LED supply chain

Apple's 12.9-inch iPad Pro is expected to feature 10,384 mini-LED chips and achieve high contrast ratio and high color saturation through local dimming; as such, the biggest challenge facing manufacturers in the supply chain remains the demand for low cost and high yield rate, according to TrendForce. From the perspective of LED chips, Epistar remains Apple's first choice because of its products' consistency and cost-performance ratio, as well as its protection of patents. Also, mini-LED backlight technology requires an extremely stringent testing and sorting process for LED chips based on wavelength and specifications; FitTech and Saultech are thus able to become key partners for Epistar due to their cost-to-performance advantage as well.

On the other hand, SMT supplier TSMT is in partnership with Kulicke and Soffa Industries Inc (K&S), as specified by Apple, to attempt to overcome mass-production bottlenecks through their specific high-speed SMT process. For PCB backplanes, Apple has chosen to collaborate with Korean manufacturer YP Electronics and Taiwan-based Zhen Ding Tech, a subsidiary of longtime Apple ODM Hon Hai Precision Industry (better known as Foxconn). Finally, Apple has partnered with Heesung Electronics and LG Display, both Korean manufacturers, to supply its backlight modules and panels. With the release of Apple's new models, more suppliers, such as GIS, Radiant, Sharp and BOE, are expected to become part of Apple's supply chain, says TrendForce.

www.ledinside.com

Western Europe smartphone revenue dips by 10% to $10bn in Q1/2020

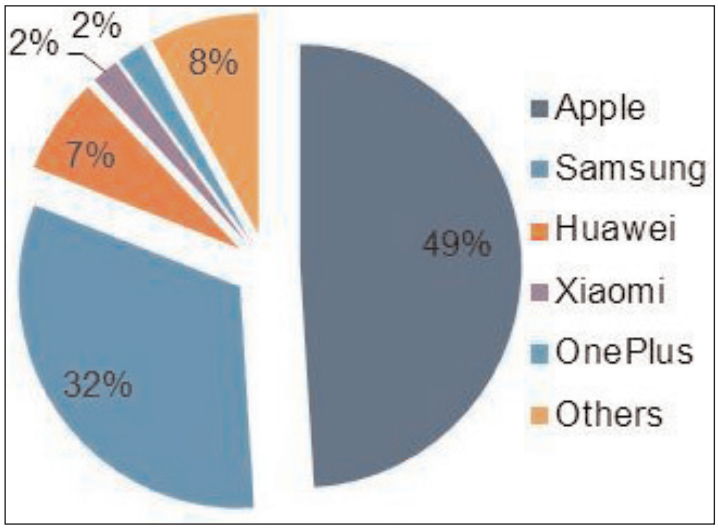
Apple and Samsung capture 80% value share, but Xiaomi, OnePlus, Oppo gaining

Despite the average selling price (ASP) nudging upwards, wholesale revenue for smartphones in the Western European region in first-quarter 2020 fell by 10% year-on-year due to COVID-19-limited demand, according to Strategy Analytics' Wireless Smartphone Strategies (WSS) service report 'Smartphone Vendor ASP and Revenue Share by Region: Q1 2020'.

Western Europe is the third largest region by value globally. Apple and Samsung continue to have a duopoly, as the two collectively account for more than 80% of overall revenue in the region. Huawei was ranked third with 7% of the wholesale revenue share.

In Western Europe, the most hotly contested battle is just behind third-place Huawei, which continued to see its share decline due to the ban on Google mobile services globally. Xiaomi and OnePlus are close behind in the chasing pack and positioning for both volume and value share gains with ramped-up marketing and promotion and expanded portfolios.

"Xiaomi has had success in several Western European markets and notably is seeing strong demand for its Redmi Note 8 and Redmi 8 models," says associate director Boris Metodiev. "OnePlus — with recent growth in Norway, Switzerland and Netherlands — is a rising star. Oppo is currently at modest volume and value share, but its recent ranging success with Vodafone will make a huge difference moving forward," he adds.



Western Europe smartphone revenue share percentage Q1/2020.

"As Europe begins to emerge from the COVID-19 ground stop and with 5G volumes waiting in the wings for 2021, the market will become much more competitive," believes Neil Mawston, executive director of Strategy Analytics' the Wireless Smartphone Strategies (WSS) service. "Legacy brands Motorola, LG and even Sony from the 2010s will continue to struggle as they try to balance a desire for premium-tier presence with the reality that their brands have questionable ability to support this aspiration anymore," he adds.

"In a commodity market the two key battlegrounds will be marketing and price," continues Mawston. "These brands lack the scale globally to compete on price (for long) and their marketing cost per unit needed to even make a ripple in the smartphone pond will be huge. Creative marketing to segments of the market that are open to the brand and willing to switch from the big two is needed."

www.strategyanalytics.com

GaN substrates market growing at 10.9% CAGR to $7.72bn in 2026

The global gallium nitride (GaN) substrate market is expected increasing at a compound annual growth rate (CAGR) of 10.9% from 2018 to $7.72bn in 2026.

Factors such as increasing adoption of GaN devices in many applications and rising popularity of GaN power electronic devices are driving market growth. However, usage of SiC in high-voltage semiconductor applications is hampering market growth.

Based on size, the 4-inch substrate segment is going to have lucrative growth during the forecast period as they are used in devices such as optoelectronics devices, high power devices, high-temperature devices, and high-frequency power devices and also rising because of its applications in power device, LEDs, and radio frequency.

Key vendors include Toshiba Corp, Sumitomo Electric Industries, Sumitomo Chemical group, Soitec, Seoul Semiconductor Co Ltd, Mitsubishi Chemical Holdings, Kyocera Corp, Hitachi Cable and GaN Systems Inc.

www.researchandmarkets.com/reports/5024785/global-gallium-nitride-gan-substrates-market

Silicon photonics market to grow at 23.4% CAGR from $1bn to $3bn in 2025

Transceivers to lead market, while laser components to see highest growth rate

The silicon photonics market is projected to grow at a compound annual growth rate (CAGR) of 23.4% from $1bn in 2020 to $3bn by 2025, forecasts the report 'Silicon Photonics Market with COVID-19 Impact, by Product, Application, Component And Geography — Global Forecast to 2025'.

Factors accelerating growth are the rising demand for CMOS-integrated silicon photonics technology in data centers, the growing focus on reducing power consumption using silicon photonic transceivers, the increasing requirement for high bandwidth and high data transfer capabilities, and the surging demand for high-speed broadband services. Increasing government and stakeholder funding, growing deployment of 5G networks, emerging applications of silicon photonics, and surging utilization of silicon photonics technology in short-reach communication provide lucrative opportunities to the silicon photonics market, the report notes.

Silicon photonic transceivers to lead market

Transceivers are expected to lead the silicon photonics market during 2020–2025, primarily due to their reduced power consumption and high integration density, enabling high-speed data transmission. Further, these transceivers can be upgraded to handle higher-capacity bandwidth, enabling optical modules to handle data-center network speeds of 100Gbps, 400Gbps, and beyond.

Additionally, the growing adoption of silicon photonic transceivers in data centers is another primary factor for the leading position of these transceivers in the silicon photonics market during the forecast period. For instance, Alibaba Cloud will be using 400G DR4 optical transceivers to support its next-generation data-center network.

Laser components to see highest growth rate

Hybrid silicon lasers (silicon and III–V semiconductors) are used to overcome mass-production issues in silicon lasers. The hybrid approach takes advantage of the light-emitting properties of III–V semiconductor materials combined with the process maturity of silicon to fabricate electrically driven lasers on a silicon wafer that can be integrated into other silicon photonic devices.

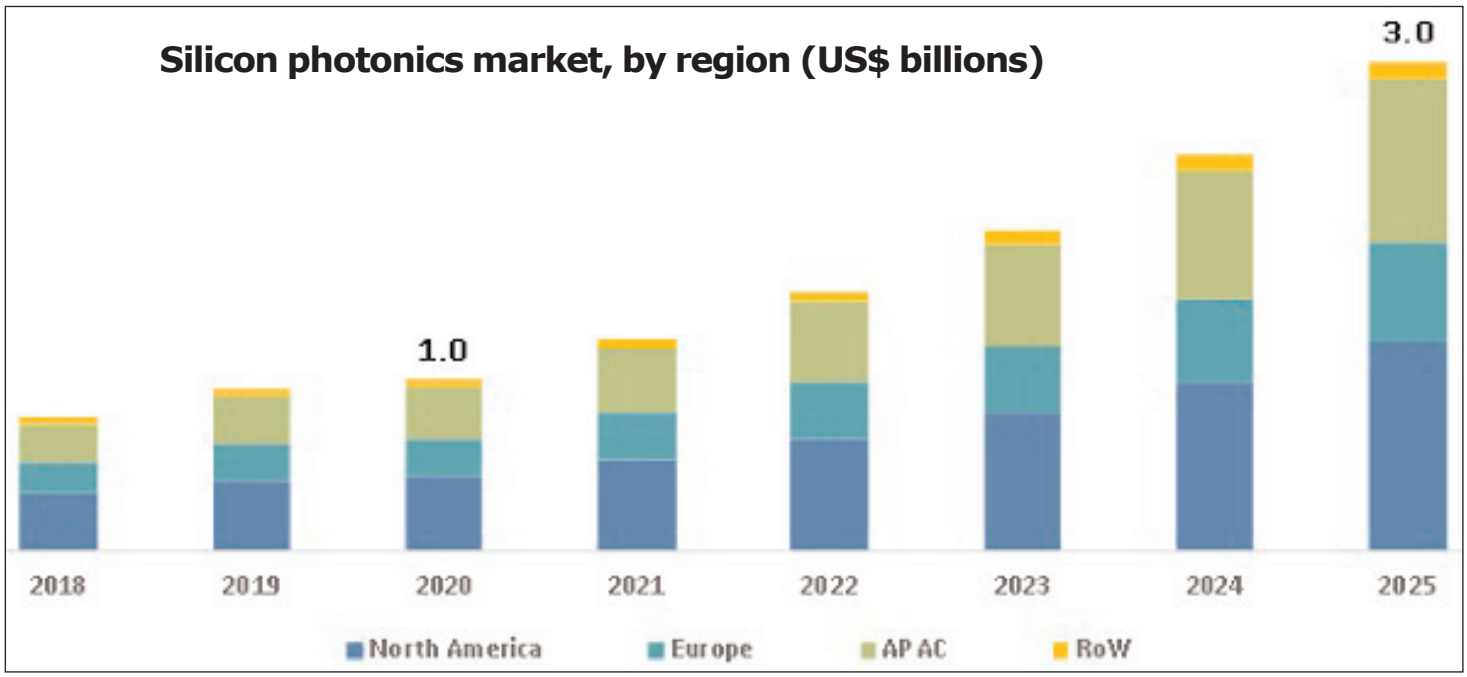
Intel is working on hybrid silicon lasers with indium phosphide (InP)-based materials and other compound semiconductor materials.

APAC to be fastest-growing market for silicon photonics

China, Japan and South Korea are the major contributors to the market. Growing population, increasing investments toward the development of silicon photonic products, the rising focus of international and domestic players on the development of modern silicon photonic products, and increasing R&D activities to increase the data transmission rate in the region are also fueling market growth.

The report cited the key market players as Cisco, Intel, MACOM, GlobalFoundries, NeoPhotonics, InPhi, Mellanox, II–VI Inc and Rockley Photonics (all US-based).

www.marketsandmarkets.com/



Qorvo completes offering of additional $300m of 2029 senior notes

Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defense applications) has completed its offering of an extra $300m worth of its senior notes (maturing in 2029). The offering had been upsized from the $250m initially announced on 28 May. Paying interest semi-annually at a rate of 4.375% per annum, the additional notes will mature on 15 October 2029, unless earlier redeemed in accordance with their terms.

The additional notes were issued to qualified institutional buyers (pursuant to Rule 144A under the Securities Act of 1933, as amended) and to certain non-US persons (in accordance with Regulation S under the Securities Act).

Qorvo expects to use the net proceeds of the offering of additional notes for general corporate purposes.

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

The additional notes have not been registered under the Securities Act or any state securities laws and may not be offered or sold in the USA absent registration or an applicable exemption from such registration requirements.

Custom MMIC receives BAE Systems' Gold Tier Supplier Excellence Award for second consecutive year

Qorvo says that Custom MMIC, which it acquired in February, has been awarded BAE Systems' Gold Tier Supplier Excellence Award for 2019.

The award, which recognizes outstanding supplier quality, service and performance, is part of BAE Systems' 'Partner 2 Win' program, which is designed to achieve operational excellence and eliminate defects in its supply chain by raising the bar of performance expectations to meet the demand of current and future customers. This is the second consecutive year that Custom MMIC has been awarded the honor.

"Custom MMIC has an outstanding reputation among leading defense customers," comments James Klein, president of Qorvo's Infrastructure & Defense Products (IDP) group. The award from BAE Systems "recognizes the top-tier, highest-quality performers selected among many suppliers," he adds.

Custom MMIC's gallium arsenide (GaAs) and gallium nitride (GaN) monolithic microwave integrated circuits (MMICs) have been proven in mission-critical defense, aerospace and space applications. Now part of IDP, it is contributing to Qorvo's expanding RF and millimetre-wave product portfolio, enabling further integration for defense phased-array radars, electronic warfare (EW), land/space-based satellite communications, wireless backhaul and microwave test equipment.

Custom MMIC awarded legacy Raytheon business Supplier Excellence Distinction for fourth consecutive year

Qorvo says that Custom MMIC, which it acquired in February, has been awarded a 4-Star Supplier Excellence Award by Raytheon Technologies' legacy Integrated Defense Systems business (now Raytheon Missiles and Defense) for its 2019 performance.

The supplier excellence program was instituted to recognize quality, on-time delivery and commitment to continuous improvement. This is the fourth consecutive year that Custom MMIC has received the honor.

"The 4-Star award is presented by Raytheon's legacy Integrated Defense Systems business to suppliers that achieve excellence in quality and performance," says James Klein, president of Qorvo's Infrastructure and Defense Products (IDP) group. "We are proud of Custom MMIC's history and pleased that its technology and strong customer service will significantly benefit Qorvo customers."

Custom MMIC's gallium arsenide (GaAs) and gallium nitride (GaN) monolithic microwave integrated circuits (MMICs) have been proven in mission-critical defense, aerospace and space applications. Now part of IDP, it is contributing to Qorvo's expanding RF and millimetre-wave product portfolio, enabling further integration for defense phased-array radars, electronic warfare (EW), land/space-based satellite communications, wireless backhaul and microwave test equipment.

www.raytheon.com
www.custommmic.com
www.qorvo.com

Skyworks achieves AS9100D certification for defense & space programs

Skyworks Solutions Inc of Woburn, MA, USA (which makes analog and mixed-signal semiconductors) says that its facility in Milpitas, CA has achieved AS9100D certification. Through its defense & space business (formerly Isolink), Skyworks is a global supplier of high-performance, high-quality radiation-tolerant components for aerospace, defense, medical, extreme industrial and high-reliability markets and applications.

AS9100D certification is an industry-recognized, international aerospace quality management system standard that provides manufacturing suppliers such as Skyworks with a comprehensive quality system for providing safe and reliable products.

Skyworks says that this certification allows global manufacturers in the aerospace and defense industries to partner with it with full confidence in its ability to meet and exceed the increasingly stringent industry requirements for aerospace, defense and military medical applications. The scope of Skyworks' registration spans the design, manufacture and testing of its high-reliability optoelectronic and RF components.

"Achieving AS9100D certification is a competitive advantage, as well as a significant milestone that validates our commitment to delivering high-performance, high-reliability precision-engineered solutions for the aerospace & defense industry," says Dave Stasey, VP & general manager of diversified analog solutions. "With this certification, Skyworks once again demonstrates our dedication to exceeding our customers' compliance requirements regarding performance, quality and reliability following a rigorous audit process."

www.skyworksinc.com/EN/MARKETS/AEROSPACE-AND-DEFENSE

Skyworks launches front-end modules for Wi-Fi 6 applications

Skyworks has launched the SKY85334-11 and SKY85750-11, 2.4GHz and 5GHz front-end modules (FEMs) respectively, as the latest additions to its portfolio of FEMs designed for growing retail, carrier and enterprise Wi-Fi 6 (802.11ax) applications.

The modules offer what is claimed to be best-in-class linearity, power dissipation and efficiency for access points, routers and gateways where regulatory, thermals or Power-over-Ethernet limitations demand low current consumption.

Packaged in a compact, 16-pin 3mm x 3mm land grid array (LGA), the highly integrated FEMs incorporate switching, low-noise amplifier (LNA) with bypass and power amplifier (PA).

www.skyworksinc.com/en/System-Solutions/WiFi6

MixComm names vice president of business development

Wireless semiconductor veteran to lead mm-wave go-to-market strategy

Fabless semiconductor company MixComm Inc of Chatham, NJ, USA has appointed James 'Jay' Martin as VP of business development, driving growth in 5G and related markets for the millimetre-wave startup.

Martin has a background in wireless business development, design and engineering management with a history of building deep technical relationships with customers in the RF and millimetre-wave industries. With 25 years of experience, he has led significant value creation through new opportunity identification and customer engagement, says the firm.

Most recently, Martin was the senior marketing and business development manager at IDT (now Renesas), where he led wireless infrastructure marketing and business development. Previously, he was senior business development director at Anadigics (now Skyworks) and has held senior engineering roles at RF Micro Devices, Paratek Microwave and Anadigics.

MixComm was co-founded in 2017 by Dr Harish Krishnaswamy (of Columbia University's Engineering School) and Frank Lane (formerly senior director at Flarion Technologies and VP of technology for Qualcomm). Its technology is based on breakthroughs from Krishnaswamy's CoSMIC lab at Columbia University and is funded by Kairos Ventures.

As VP of business development, Martin joins the leadership team that includes MixComm's chief technology officer Krishnaswamy, VP of engineering Lane, VP of RF technology Dr Arun Natarajan, and CEO Mike Noonen. MixComm introduced its first production device, the SUMMIT 2629, earlier this year.

"Millimeter-wave 5G technology is at a crucial juncture and will require a combination of both technological advancement and sound business strategy to be successful," notes Krishnaswamy. "Jay is unparalleled in his expertise and understanding that ranges from dBs to dollars," he adds.

"Jay's deep technical experience, customer relations expertise and unique insight into millimetre-wave opportunities makes him a vital addition to the MixComm team," believes Noonen.

www.mixcomm.com

Leti demos seven-level stacked gate-all-around nanosheet transistor architecture for HPC

Three-fold improvement in drain current over two-level stacked nanosheet GAA transistors

Micro/nanotechnology R&D center CEA-Leti of Grenoble, France has demonstrated fabrication of a new gate-all-around (GAA) nanosheet device as an alternative to FinFET technology targeting high-performance (HPC) applications such as smartphones, laptops and mobile systems with data collection and processing involving low-power and high-speed operation.

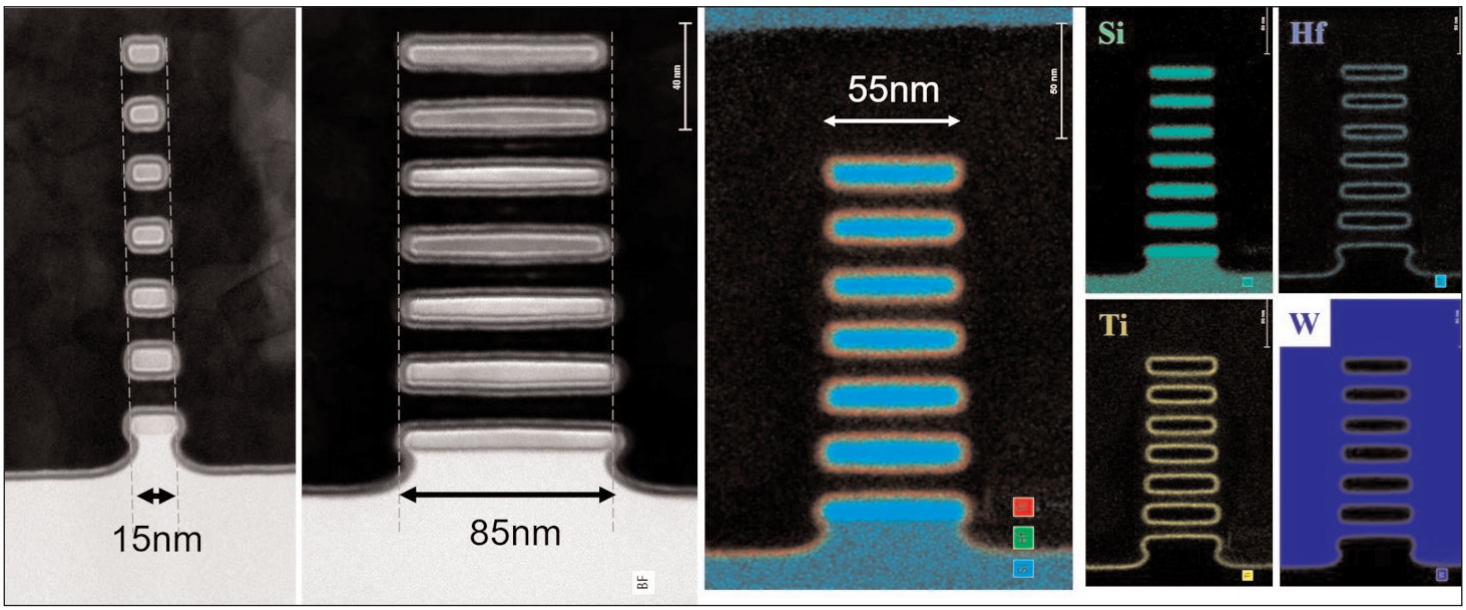
Researchers fabricated GAA nanosheet transistors with seven levels of stacked silicon channels (more than twice as many as the existing state-of-the-art) with widths ranging from 15nm to 85nm. The results were summarized in the paper '7-Levels-Stacked Nanosheet GAA Transistors for High Performance Computing', presented virtually during the 2020 Symposia on VLSI Technology & Circuits (14–19 June).

Sylvain Barraud, one of the authors, said that the seven levels of stacked nanosheet GAA transistors fabricated using a replacement metal gate process, inner spacer and self-aligned contacts show excellent gate controllability with extremely high current drivability (3mA/μm at V_{DD}=1V) and a 3x improvement in drain current over the usual two-level stacked nanosheet GAA transistors.

"By increasing the number of stacked channels, we increase the effective width of the device for a given layout footprint," Barraud says. "Increasing the effective width induces higher drive current. This is why the DC performance of our devices is better than leading-edge devices."

Barraud commented that Leti's demonstration was based on a 'replacement metal-gate' process developed for FinFETs. "We added specific modules for GAA structures on this FinFET route and we showed that, for the same surface occupation, we can propose an alternative to FinFET technology due to a gate-all-around configuration," he adds. "In fact, GAA structures offer many advantages over FinFET, such as better gate control and higher DC performance, thanks to higher effective channel width. In addition, the wide range of variable nanosheet widths allows more design flexibility, which is not possible for FinFET because of its discrete number of fins."

www.leti.fr



First demonstration of GAA nanosheet transistors with seven stacked channels from tall and straight (SiGe/Si) fins (15nm≤W≤85nm).

Anokiwave board gains ex-Broadcom& MACOM execs

As one of several strategic investments to achieve its growth objectives, Anokiwave Inc of San Diego, CA, USA — which provides highly integrated silicon core chips and III–V front-end integrated circuits for millimeter-wave (mmW) and active antenna-based 5G communications, mobile satellite communications, and aerospace & defense markets — has expanded its board to nine directors by appointing two wireless industry executives (effective 7 May): Bryan Ingram, formerly senior VP & general manager of Broadcom's Wireless Semiconductor Division (WSD), and Michael T. Murphy, formerly senior VP & general manager of MACOM's RF and Microwave Business. The additions bring more than 50 years of combined operational expertise, a track record of success with development and production of high-growth, high-volume RF and handset products, and industry relationships that are both broad and deep, says Anokiwave.

"Given how 5G mmW infrastructure buildout will have a high-volume aspect similar to that of Wi-Fi access points and handset modules, their industry expertise is highly valued," says CEO Robert S Donahue. "The knowledge and experience Bryan and Mike bring, along with the expertise of our other board members and employees, will accelerate Anokiwave's transformation into the industry's most successful commercial-volume supplier of highly integrated mmW silicon core ICs for some of the fastest-growing markets in the entire electronics industry."

Ingram has a background in RF/MW engineering management, semiconductor operations, and new product development. At Broadcom, he oversaw development, production and marketing of RF components for handsets and other devices. Earlier, he was chief operating officer of Avago, where he led the legacy Avago business units and operations. Prior to Avago's founding from the Agilent Semiconductor Products Group in 2005, he was VP & general manager of the SPG Wireless Semiconductor Division. Before that, he had management roles at Hewlett Packard and Westinghouse. Ingram has a B.S. in Electrical Engineering from the University of Illinois and an M.S. in Electrical Engineering from Johns Hopkins University.

Prior to being senior VP & general manager of MACOM's RF & Microwave business, Murphy was its senior VP of engineering. He led all worldwide engineering sites and was responsible for new technology development, product development and product engineering. Prior to joining MACOM, he was VP of engineering, Networks, and Standard Products at TriQuint, where he led all new product development teams and activities across the business unit's six design centers. Previously, he was director of TriQuint's New England Design Center following its acquisition of Infineon's GaAs business unit. In 1999, Murphy proposed and founded a US-based GaAs IC design center in Nashua, NH for Infineon Technologies GmbH of Munich, Germany. Before that he served in MACOM's GaAs MMIC business in design engineering, engineering management and product line management for multi-function ICs for mobile phone and Wi-Fi applications. He began his career as a microwave design engineer at Raytheon Company. Murphy has a B.S. and M.S. in Electrical Engineering from University of Massachusetts, Amherst and an M.B.A. from Boston University. He was previously a member of Anokiwave's board of advisors.

www.anokiwave.com

Teledyne e2v HiRel launches 10GHz InGaP gain blocks

Teledyne e2v HiRel of Milpitas, CA, USA has launched a family of 10GHz RF gain blocks using space-qualified indium gallium phosphide (InGaP) amplifier technology.

Spearheaded by an 18.4dB gain model, the TDGB010 series of gain blocks is based on InGaP technology suitable for both space and, optionally, defense flight applications. It achieves this through its ceramic packaging and space qualification.

Customers now access a standard amplifier solution that spans from L-band through X-band. Since a standardized amplifier solution reduces the number of new qualified components that flight programs typically require, it greatly simplifies the procurement process for components, notes the firm. The X-band gain blocks are available in configurations of 13.6dB, 16.5dB and 18.4dB, enabling RF design engineers to more precisely configure the signal gain.

The TDGB010 50Ω gain block incorporates proprietary monolithic microwave integrated circuit (MMIC) design techniques and also utilizes a mature and reliable heterojunction bipolar transistor (HBT) InGaP process. With space-flight heritage, the process has shown to be radiation tolerant to 100krad, making it an viable choice for satellites and other high-altitude applications.

"Our ongoing expansion of RF offerings is designed to help our customers produce high-reliability signal chains for the most demanding defense and space environments," says Mont Taylor, VP of business development. "Our new gain blocks offer excellent gain flatness and high P1dB [output power at 1dB gain compression point]," he adds.

Teledyne e2v's Hi-Rel X-band gain block family is available now, packaged in a 2-lead, ultra-small, hermetic gullwing package. Both the wafer process technology and the package have space-flight heritage.

www.e2v.com/products/semiconductors/power-solutions

ROHM unveils 4th-generation 1200V SiC MOSFETs featuring lowest ON-resistance

Low ON-resistance with high-speed switching performance targets adoption in main drive inverters of electric vehicles

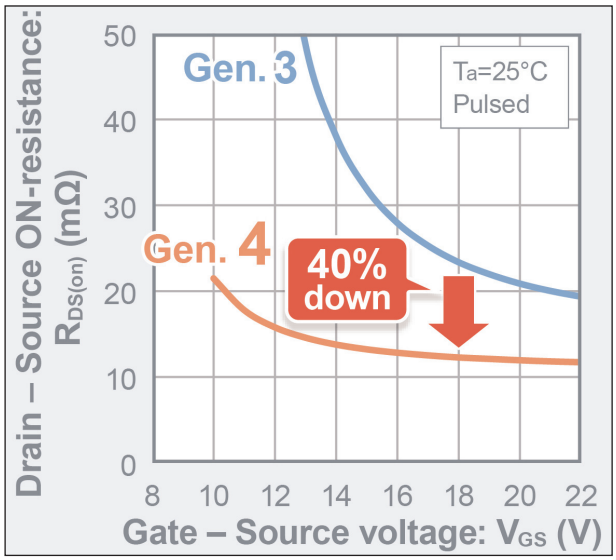
Power semiconductor maker ROHM Semiconductor of Kyoto, Japan has announced its 4th Generation 1200V silicon carbide (SiC) metal-oxide-semiconductor field-effect transistors (MOSFETs) optimized for automotive powertrain systems, including the main drive inverter, as well as power supplies for industrial equipment.

In recent years, the proliferation of next-generation electric vehicles (xEVs) has been accelerating the development of smaller, lighter and more efficient electrical systems. In particular, improving efficiency while decreasing the size of the main inverter that plays a central role in the drive system remains among the most important challenges, requiring further advances in power devices.

To improve the cruising range of EVs, the capacity of the onboard battery is increasing. In conjunction with this, the use of higher-voltage batteries (800V) is progressing to meet the demand for shorter charging times.

To solve these various challenges, designers urgently need SiC power devices capable of providing high breakdown voltage with low losses. ROHM says that it began mass producing SiC MOSFETs ahead of the industry in 2010. ROHM has since strengthened its lineup to include AEC-Q101-qualified products, allowing it to hold a large market share for automotive onboard chargers (OBC).

For power semiconductors there is often a trade-off relationship between lower ON-resistance and short-circuit withstand time (the time it takes for a MOSFET to fail due to a short-circuit). Normally, when a short-circuit occurs, a large current exceeding the maximum rating flows, which can lead to abnormal heat generation, thermal runaway and ultimately destruction. Longer short-circuit withstand time is in a trade-off relationship with higher-performance characteristics, such as ON-resistance. So, there is a need to strike a balance to achieve lower power losses in SiC MOSFETs.

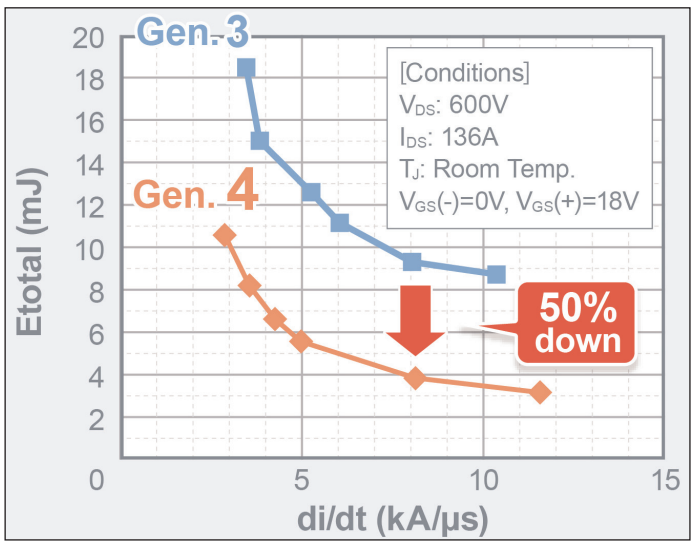


Although the adoption of a trench structure to SiC MOSFETs was shown to be effective in reducing ON-resistance, it was necessary to mitigate the electric field generated in the trench gate section to ensure long-term reliability of the device. In response, ROHM adopted a unique double-trench structure that minimizes electric field concentration, allowing it in 2015 to be first to mass produce trench-type SiC MOSFETs. By further improving its original double-trench structure, the firm has now been able to improve the trade-off relationship and reduce ON-resistance per unit area by 40% compared with the firm's previous generation of SiC MOSFETs without sacrificing short-circuit withstand time (see Figure 1).

Also, in general, lower ON-resistances and larger currents tend to increase the various parasitic capacitances in MOSFETs, which can inhibit the inherent high-speed switching characteristics of SiC. However, by significantly reducing the gate–drain capacitance (C_{gd}), ROHM was able to achieve 50% lower switching loss over the firm's previous generation of SiC MOSFETs (see Figure 2).

As a result, ROHM's new 4th Generation SiC MOSFETs are capable of delivering low ON-resistance with high-speed switching performance, contributing to greater miniaturization and lower power consumption in a variety of applications, including automotive traction inverters and switching power supplies. Bare chip samples have been made available from June, with discrete packages to be offered in the future.

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



Mitsubishi Electric launching 1200V SiC MOSFET

Tokyo-based Mitsubishi Electric Corp is launching its N-series of 1200V silicon carbide (SiC) metal-oxide-semiconductor field-effect transistor (MOSFET), featuring low power loss and high tolerance (input capacitance/mirror capacitance or C_{iss}/C_{rss}) to self-turn-on.

Specifically, junction field-effect transistor (JFET) doping technology reduces both switching loss and on-resistance, achieving what is claimed to be an industry-leading figure of merit (FOM) for a power MOSFET of 1450mΩ.nC (on-resistance multiplied by the gate-drain charge, at 100°C junction temperature). Power consumption in power-supply systems is reduced by about 85% compared with using conventional Si-IGBTs.

By reducing the mirror capacitance (the stray capacitance C_{rss} between the gate and drain in a MOSFET structure), the self-turn-on tolerance improves 14-fold compared with competitor's products, it is claimed. Fast switching operation can thus be realized, helping to reduce switching loss.

Reduced switching-power loss enables the downsizing and simplification of cooling systems as well as the downsizing of peripheral components, such as reactor by driving power semiconductors with a higher carrier frequency, helping to reduce the cost and size of overall power supply systems.

The new series can therefore help to reduce the power consumption in miniaturize power supply systems requiring high-voltage conversion, such as electric vehicle (EV) on-board chargers, photovoltaic power systems etc, says the firm.

Sample shipments will start in July. Also, Mitsubishi Electric is exhibiting its new N-series 1200V SiC-MOSFET at trade shows including PCIM Asia 2020 in Shanghai, China (16–18 November).

www.MitsubishiElectric.com/semiconductors

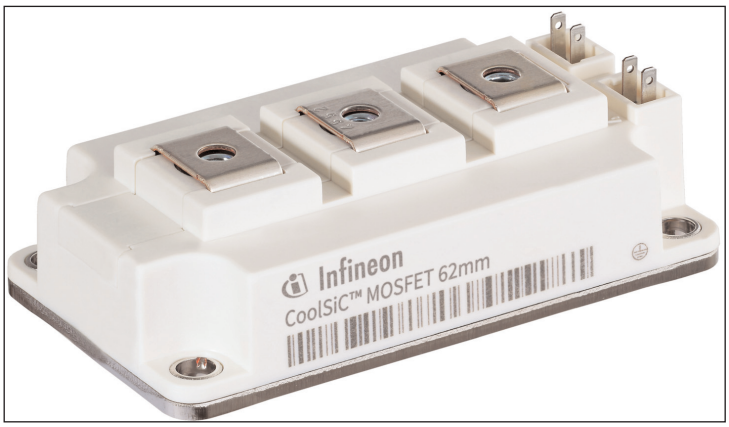
Infineon adds 62mm package to CoolSiC MOSFET 1200V module family

New medium-power applications opened up for silicon carbide

Infineon Technologies AG of Munich, Germany has added another industry-standard package to its family of CoolSiC MOSFET 1200V modules.

Designed in half-bridge topology and based on trench chip technology, the proven 62mm device opens up silicon carbide for applications in the medium power range, starting at 250kW — where silicon reaches the limits of power density with insulated-gate bipolar transistor (IGBT) technology. Compared with a 62mm IGBT module, the list of applications now additionally includes solar, server, energy storage, electric vehicle (EV) charger, traction, commercial induction cooking and power conversion systems.

The 62mm module features Infineon's CoolSiC MOSFETs, which enable high current density. Very low switching and conducting losses minimize cooling efforts, whereas operating the device at high switching frequency allows for using smaller magnetic components. By implementing CoolSiC chip technology, it is possible to design smaller inverter designs for the application in terms of size, so overall system costs can be reduced.



The 62mm module (which comes in variants of 6mΩ/250A, 3mΩ/357A and 2mΩ/500A respectively) features Infineon's CoolSiC MOSFET 1200V chip set, which enables high current density.

With a base plate and screw connections, the housing is characterized by a very robust mechanical design, which is optimized for the highest system availability, a minimum of service cost and off-time losses. The reliability is made possible by high thermal cycling capability and a continuous operating temperature (T_{vjop}) of 150°C. The symmetrical internal design of the housing allows identical switching conditions for the upper and lower switch. As an option, the thermal performance of the module can be improved even further with pre-applied thermal interface material (TIM).

CoolSiC MOSFETs 1200V in the 62mm package come in variants of 6mΩ/250A, 3mΩ/357A and 2mΩ/500A, respectively. Designed for fast characterization (double pulse/continuous operation), an evaluation board is available for the devices. For ease of use, it offers flexible adjustment of the gate voltage and gate resistors. At the same time, it can serve as a reference design for driver boards for series production.

www.infineon.com/sic-mosfet-modules

II-VI licenses GE's SiC power electronics technology

SiC substrate maker extends scope to devices and modules

Engineered materials and optoelectronic component maker II–VI Inc of Saxonburg, PA, USA — which manufactures silicon carbide (SiC) substrates — has signed an agreement to license from General Electric technology for manufacturing silicon carbide (SiC) devices and modules for power electronics.

Rapid growth in electric vehicles (EVs), renewable energy, microgrids and power supplies for data storage and communications is driving the strong demand for SiC-based power electronics, notes II–VI. Compared with state-of-the-art silicon-based devices, silicon carbide achieves superior efficiency, higher energy density and lower system-level cost per watt. Power electronics based on SiC have demonstrated their potential to have a highly beneficial impact on the environment via significant reductions in carbon dioxide emissions and energy consumption, adds the firm.

"We believe that SiC-based power electronics materials and components will become increasingly deployed in electrification systems including, for example, in electric vehicles, industrial infrastructure, and large datacenters, and so we continue to invest to position II–VI in strategic points of the evolving supply chains to enable key customers," says II–VI's CEO Dr Vincent D. Mattera Jr. "As such, we intend to remain focused on executing our recently announced plan to scale our capacity of 150mm SiC materials by 5–10x while scaling volume production of a differentiated 200mm materials technology to meet the anticipated growing demand over the next five years," he adds.

The agreement "positions II–VI well to capitalize on the growing market demand for SiC-based electronics," says Joe Krisciunas, president of GE Aviation Electrical Power Systems. "At the same time, it will broaden GE's commercial reach beyond the industry sectors we already serve with SiC technology."

GE and its industrial businesses, led by Aviation, continue to develop next-generation silicon carbide for new applications. The business offers electrical power products with power levels from kilowatts to megawatts for harsh environments in aerospace, industrial, and military applications.

www.ii-vi.com

Yutong to deliver its first electric bus in China to use silicon carbide in the powertrain

E-bus manufacturer partners with Cree and module maker StarPower

Chinese commercial vehicle manufacturer Zhengzhou Yutong Group Co Ltd (which specializing in electric buses) is using 1200V silicon carbide devices from Cree Inc of Durham, NC, USA in a power module made by StarPower Semiconductor for its new high-efficiency electric bus powertrain system. Use of SiC-based power solutions enables faster, smaller, lighter and more powerful electronic systems for commercial electric vehicles (EVs).

As a power module supplier in the China market, StarPower provides a range of power modules. In 2017, it established its automotive module production headquarters in Shanghai.

The parties are working together to accelerate the commercial adoption of SiC-based inverters in electric bus applications. Upon rollout, Yutong will deliver its first electric bus in China to use silicon carbide in its powertrain.

"Cree and StarPower's collective effort in driving the innovation of silicon carbide technology perfectly fits with Yutong's high-end roadmap of powertrain products," says Wei Wei, general manager of Yutong's Electronic Devices business unit. "This collaboration ensures we are able to provide an even more efficient electric bus through the benefits of silicon carbide."

Coupled with StarPower's power module technology, the use of Cree's SiC-based MOSFET in the powertrain will help to extend driving range while lowering weight and conserving space.

Cree is currently expanding its manufacturing capacity to support the expected growth of the EV market. In 2022 it plans to open the world's largest silicon carbide fabrication facility in New York while at the same time significantly expanding silicon carbide crystal growth capacity at its operations in North Carolina. The firm offers a portfolio of silicon carbide and gallium nitride power and RF devices through its Wolfspeed business unit.

"Cree's technology is at the heart of the dramatic change underway in electric vehicles for the commercial and consumer markets, and we are committed to supporting the industry as it transitions to more efficient, higher-performing silicon carbide solutions," says Cree's CEO Gregg Lowe. "The work with StarPower and Yutong Group is a great example of how strong partnerships can deliver innovative solutions to the marketplace," he adds. "Cree is continuing to expand capacity to meet market demands with our industry-leading power MOSFETs."

www.cree.com

https://en.yutong.com

Atom Power raises $17.75m in Series B round

Funds to help develop next-generation SiC-based digital circuit breaker, scale digital power management platform and address power distribution challenges

Atom Power of Charlotte, NC, USA, which invented what is claimed to be the first commercial digital solid-state circuit breaker, has raised $17.75m in Series B funding from investors including Valor Equity Partners, Rockwell Automation Inc, ABB Technology Ventures, and Atreides Management. Atom Power has now raised $23m in total funding, including a previous $3m Series A in 2017.

Atom Power says that last June its silicon carbide (SiC)-based digital circuit breaker was the first of its kind to be listed by UL. Unlike traditional circuit breakers, the device intelligently manages the flow of power with software and semiconductors, connects unlimited power sources into one point, and dynamically switches between them based on need.

The latest funding should equip Atom Power to develop the next-generation digital circuit breaker, scale its intelligent power management platform, and address the most pressing power distribution challenges, like integrating renewables into the grid, building more efficient data centers, and supporting other sustainable energy initiatives.

Looking ahead, Atom Power aims to apply its technology via advanced e-mobility to dramatically shift how electric vehicle (EV) charging infrastructure is deployed through inherent demand management that saves energy and costs.

"Modern life is increasingly digital, yet the electrical infrastructure powering our buildings has remained decidedly analog. This poses huge challenges for supporting a smooth transition to electrification, renewable energy, and electric vehicles," notes CEO Ryan Kennedy. "We need technology that gives us digital control over when and how we use power. Last year, we made huge strides when we introduced the first solid-state circuit breaker to market."

Atom Power's overall intelligent product suite includes its digital circuit breakers (Atom Switch), distribution panels (Atom Panel) and software (Atom OS), which together form what is claimed to be the fastest power distribution system in existence. With circuit interruption capabilities up to 150,000A, a single Atom Switch can replace the need for more than 100 products used in commercial power today and mitigates explosions from electrical faults, the firm adds.

www.atompower.com

GTAT adds ST veteran to board to accelerate growth in SiC

GT Advanced Technologies (GTAT) of Hudson, NH, USA — which produces silicon carbide (SiC) and sapphire material and crystal growth equipment for the solar, power electronics and optoelectronics industries) — has appointed Bob Krysiak to its board of directors.

Krysiak has over 30 years of experience at semiconductor maker STMicroelectronics, a supplier of SiC devices. Most recently he was executive VP & general manager of ST's Americas Region, a multi-billion-dollar business. He was also a member of the company's strategic committee and managed the worldwide digital marketing effort. He retired from ST at the end of 2018. While at ST, Krysiak was a key player in driving its SiC-based semiconductor business into the market. GTAT reckons that this experience will further strengthen its strategy as a player in the SiC space.

"GTAT has made a remarkable pivot over the last few years, becoming a world-class supplier of crystal materials," says GTAT's chairman Gene Davis. "The appointment of Bob to the board of directors strengthens the relevant experience and talent on the board in order to continue to effectively govern and support the company as it takes a leading position in the silicon carbide market… Leveraging Bob's expertise in this area will further accelerate its growth going forward," he adds.

"His outstanding accomplishments in the SiC semiconductor space will prove invaluable to us as we accelerate our leadership in high-quality, attractively priced SiC crystal for substrate manufacturers," reckons president & CEO Greg Knight.

Highlights of Krysiak's career at ST include numerous roles held between 1983 and 2019 where he contributed to the position that the firm now holds. "During my time at ST, we recognized very early that silicon carbide devices would be a game-changer for high-growth markets such as electric vehicles (EVs)," says Krysiak. "GTAT's top-tier quality combined with a business model focused on high-volume crystal production and cost leadership will enable a broader supply of silicon carbide wafers and accelerate the use of silicon carbide in power electronics."

Krysiak graduated from the UK's Cardiff University with a degree in Electronics and holds an MBA from the University of Bath. He replaces Matthew Aronsky, who resigned after being on GTAT's board since 2016.

www.gtat.com

Cambridge GaN Devices leading €10.3m European-funded GaNext project

Cambridge spin-off sole supplier of transistors for GaN power modules

Cambridge GaN Devices Ltd (CGD) is leading the €10.3m European project Next Generation GaN Power Module (GaNext) under the PENTA program (funded through the EUREKA network of countries), targeting the design and development of highly efficient, highly compact prototypes of next-generation gallium nitride power modules for low- and high-power applications.

Running from February 2020 to end-December 2022, the GaNext project is being undertaken by a consortium of 13 partners based in Germany, The Netherlands and the UK from industry and academia (with complementary expertise in GaN technology, high-frequency drivers, magnetics, smart controllers and end-user dedicated applications in the diverse field of power electronics), namely: advICo microelectronics GmbH, Besi Netherlands B.V., Cambridge GaN Devices Ltd, CSA Catapult, Eindhoven University of Technology, Fraunhofer IMS, Infineon Technologies AG, Lyra Electronics Ltd, MACCON Elektroniksysteme GmbH, Neways Technologies B.V., SUMIDA Components & Modules GmbH, Signify B.V., and Technische Universität Dortmund. CGD is the sole supplier of the GaN power devices at the heart of the power modules.

Supported by the University of Cambridge tech transfer office, Parkwalk advisors, Cambridge Capital Group, Martlet and other angel private investors, CGD was spun off from the University of Cambridge Department of Engineering's Electrical Power and Energy Conversion group in 2016 by CEO Dr Giorgia Longobardi (research fellow in Electronic Engineering at Gonville & Caius College) and chief technology officer Florin Udrea (professor in semiconductor engineering and head of the High Voltage Microelectronics and Sensors group) in order to develop power semiconductors using GaN-on-silicon substrates.

CGD has since assembled a team of professionals with combined experience of over 100 years in the semiconductor industry and over 50 years in GaN design, technology, operations and business development. The firm's engineering, management and executive team has "unique experience in the start-up eco-system in Cambridge and Silicon Valley and in commercializing power devices and power ICs in high volume," says Longobardi.

CGD says that it offers GaN transistors that can operate at significantly higher switching frequency with lower losses and lower on-resistance compared with state-of-the-art silicon devices. The firm is developing a range of GaN transistors, customized for different applications, which would enable it to push the boundaries of conversion systems in terms of efficiency and power density, it is reckoned.

Numerous companies, large and small, now offer GaN transistors, some using GaN-on-Si to benefit from larger and lower-cost wafers. While the efforts to date have focused on making GaN transistors work reliably and proving them in the market, existing GaN devices are still difficult to use, which impedes broad market adoption. CGD says it is focused on eliminating this obstacle by developing GaN devices that can be driven in a similar way to silicon transistors and are easy to use. The firm adds that its technology allows easy control using standard MOSFET drivers as well as micro-controllers, and complements this with additional smart features and protection functions, fully embedded into its product solutions.

"The Penta project creates a tremendous opportunity for CGD to engage with leading-edge companies in the area of power electronics," says Longobardi. "Not only will the project advance the knowledge in GaN technology and provide insights into its complex facets, but will aim at delivering fully working prototypes in lighting, motor drives, converter blocks for renewable energies and on-board chargers for automotive with record specifications and outstanding performance."

www.camgandevices.com

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Fuji Electric Lambda Series
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The New Generation of Low Voltage Earth Leakage Circuit Breakers

- Compact! Ground Fault Protection Built in One Unit for Space Saving Designs
- Same Footprint! MCCBs & ELCBs Interchangeable without Panel Modifications
- 18mm Per Pole Width(2P & 3P), IEC 35mm DIN Rail Mounting
- Higher Capacity SCCR ⇒ 18kA@ 240VAC UL489
- Lock Out Tag Out (LOTO) safety devices (fixed and removal types) are available as option.

Fuji Electric Corp. of America Distribution & Control Department

For sales, product & distributor information, please visit https://americas.fujielectric.com/products/distribution-control/

or contact us: x-fea-fuji-dc@fujielectric.com

EPC and VPT form joint venture targeting radiation-hard power electronics

EPC Space to provide GaN power conversion for critical satellite and high-reliability environments

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA — which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) for power management applications — and VPT Inc of Blacksburg, VA, USA (part of the HEICO Corp subsidiary HEICO Electronic Technologies Group of Miami, FL) — which provides DC–DC power converters, EMI filters and custom engineering services for avionics, military, space, and industrial applications — have established EPC Space LLC, a joint venture focused on designing and manufacturing radiation-hardened GaN-on-silicon transistors and ICs packaged, tested and qualified for satellite and high-reliability applications.

EPC Space will provide high-reliability power conversion solutions for critical spaceborne environments in applications including power supplies, light detection & ranging (LiDAR), motor drive, and ion thrusters. The GaN-based components offer superior performance advantages over traditional silicon-based solutions, EPC claims.

"VPT's global leadership in power conversion solutions for avionics, military and space applications is the perfect complement to EPC's leadership in GaN-based power conversion devices," says EPC's CEO & co-founder Dr Alex Lidow. "The joint venture — EPC Space — is taking the superior performance of gallium nitride to the high-reliability community, offering electrical and radiation performance beyond the capabilities of the aging rad-hard silicon MOSFET," he adds.

"EPC's GaN technology enables a new generation of power converters in space operating at higher frequencies, higher efficiencies and greater power densities than ever achievable before," comments VPT's founder & CEO Dan Sable.

www.epc.space
www.vptpower.com

EPC presents at 'virtual' PCIM Europe 2020

New high-power-density eGaN FETs and ePower stage ICs showcased in customer applications

At the 'virtual' PCIM Europe 2020 Digital Days (7–8 July), EPC delivered three technical presentations and participated in two panel discussions on gallium nitride technology and applications.

In addition, the firm participated in the event's virtual exhibit, showing its latest eGaN FETs and ICs in customers' end products that are rapidly adopting eGaN technology.

In the virtual exhibit, EPC experts were available to discuss eGaN devices in several applications including: high-performance 48V DC–DC power conversion for advanced computing and automotive applications; high-power nanosecond pulsed laser drivers for light detection and ranging (LiDAR) used in autonomous vehicles; and precision motor drives for robotics and drones.

Technical presentations and panels featuring eGaN FETs and ICs by EPC included the following:

- Stream 1: Si and GaN Integration, 'A Low Voltage BLDC Motor Drive Inverter Using a Monolithic GaN ePower Stage', by Michael de Rooij Ph.D., Brandon Perez, Yuanzhe Zhang, Henry Qiu.
- Poster/Dialogue Sessions (PP140), 'GaN FET-Based Ultra-Thin DC–DC Step-Down Converter', by Jianjing Wang, Yuanzhe Zhang, Michael de Rooij.
- Poster/Dialogue Sessions (PP144), '300 W 48V–12V Digitally Controlled 1/16 Brick DC–DC Converter Using GaN FETs', Yuanzhe Zhang, Michael de Rooij.
- Panel Session 'Power GaN: Past — Present — Future', speaker: Alex Lidow.
- Panel Session 'GaN Devices — the Game Changer', speaker: Alex Lidow.

www.mesago.de/en/PCIM/main.htm
www.epc-co.com

GaN Systems sponsoring sixth annual China Power Supply Society 'GaN Systems Cup' design competition

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) is sponsoring the China Power Supply Society (CPSS) design competition, which focuses on innovation in energy conservation, emission reduction, and new energy utilization. In its 6th year, the GaN Systems Cup challenges engineering teams from China's universities to design new or improved power electronics systems using GaN power transistors.

"Innovation continues to take place in power electronics and flourishes with competitions like the GaN Systems Cup that challenge young engineers to create solutions from design to build that address growing global power consumption and delivery needs," says GaN Systems' CEO Jim Witham. "GaN is part of that transformation in solving critical power systems challenges."

This year, teams are tasked to design a high-efficiency and high-power-density bidirectional AC/DC converter with a 400W-rated output power, 220V_{AC} input voltage and 300–400V_{DC} output voltage while achieving 94% efficiency in both directions at full load, and no greater than 30W/cm3 power density. Additional factors such as total cost is evaluated as part of overall performance. Participating teams will be using GaN Systems 650V GS66502B transistor.

The competition is underway, with submissions coming from universities all over China. In the coming months, the next stages will proceed, including the selection of teams entering the preliminary round at the end of June, the list of finalists to be announced in September, and a live finals and awards ceremony near the end of 2020.

The contest is organized in partnership with CPSS, the China Power Society Science Popularization Committee, and Huazhong University of Science and Technology, with participation from Ningbo Xici Electronic Technology Co Ltd and Itech Electronics Co Ltd.

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

GaN Systems participates in online PCIM Europe 2020

GaN Systems says that, at the 'virtual' PCIM (Power Conversion and Intelligent Motion) Europe 2020 'Digital Days' online event (7–8 July), its CEO Jim Witham participated in two panel sessions, 'GaN Devices – The Game-Changers' and 'Power GaN: Past-Present-Future', illustrating how GaN power semiconductors are becoming the fundamental building block in power electronics. Furthermore, technical experts from the company presented papers at the event.

Additionally, at its Virtual Experience site, GaN Systems showcased its latest solutions and design tools as well as featuring products by companies that have used GaN Systems' devices in consumer, industrial, automotive and data-center applications.

"While it will be a different PCIM Europe this year, the global power electronics community will once again converge to exchange knowledge and ideas on trends and technologies shaping our industry," says Witham. "We look forward to participating in the discussions and highlight how GaN is establishing itself as a preferred solution."

New solutions

- 650V/60A Gen2 automotive transistors that meet enhanced AEC-Q101 performance requirements and have lifetime results of failure-in-time (FIT)<<1;
- 650V/150A Full-Bridge Module & Driver;
- 650V/150A Half-Bridge IPM (intelligent power module); and 650V/300A 3-phase Module & Driver;
- 100V integrated DrGaN device and 650V integrated Half-Bridge DrGaN power stage.

New design tools

- 100V DrGaN module that features the highest power density and efficiency for board and brick power delivery;
- 65W QR charger reference design that is easy to implement and meets size (18.5W/in^3 cased), thermals, EMI, cost and efficiency requirements;
- Class-D amplifier evaluation kit that includes a 2-channel, 200W-per-channel (8Ω) Class-D audio amplifier and companion 400W, continuous-power audio-grade switched-mode power supply (SMPS).

Applications

- Consumer: Includes the industry's smallest 65W mobile device charger.
- Industrial: High-efficiency motor drive and power supplies from industry leaders.
- Automotive: Leading EV powertrain performance with GaN including the 'All GaN Vehicle' and the latest EV power electric designs from Canoo's onboard charger and BrightLoop's DC–DC converter. Most recently, BrightLoop was chosen as the sole supplier of DC–DC converters for ETCR (Electric Touring Car Racing).
- Data Center and 5G: Delivering 5G mmWave data indoors has been unsolved, until now. This GaN-based high-power, through-wall wireless power solution solves this 5G challenge.

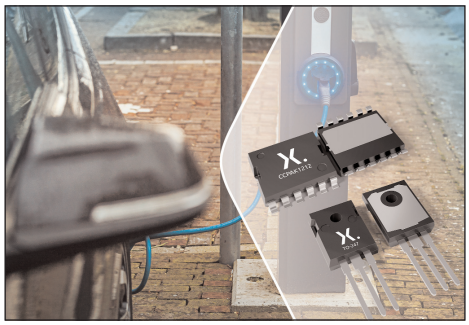
www.mesago.de/en/PCIM/main.htm
www.gansystems.com

Nexperia launches 650V GaN FETs in TO-247 and copper-clip SMD packaging

Nexperia BV of Nijmegen, Netherlands (which manufactures discrete and MOSFET components and analog & logic ICs) has launched a new range of gallium nitride (GaN) field-effect transistor devices featuring next-generation high-voltage GaN high-electron-mobility transistor (HEMT) H2 technology in both TO-247 and the company's proprietary CCPAK surface-mount packaging.

Devices are said to achieve superior switching figures of merit (FOMs) and on-state performance with improved stability, and simplify application designs due to their cascode configuration, which eliminates the need for complicated drivers and controls.

The new GaN technology employs through-epi vias, reducing defects and shrinking die size by about 24%. The on-resistance ($R_{DS(on)}$) is also reduced to just 41mΩ (maximum 35mΩ typical at 25°C) with the initial release in traditional TO-247 packaging, with high threshold voltage and low diode forward voltage. The



reduction will further rise to 39mΩ (maximum 33mΩ typical at 25°C) with CCPAK surface-mount versions.

Because the parts are configured as cascode devices, they are also simple to drive using standard silicon MOSFET drivers. Both versions meet the demands of AEC-Q101 for automotive applications.

"Customers need a highly efficient, cost-effective solution for high-power conversion at 650V and around the 30–40mΩ $R_{DS(on)}$, where applications include on-board chargers, DC/DC converters and traction inverters in electric vehicles, and industrial power supplies in the 1.5–5kW range for titanium-grade rack mounted telecoms, 5G and data centers," says GaN strategic marketing director Dilder Chowdhury. "Nexperia continues to invest in the development and expansion of its range of products using next-generation GaN processes, initially releasing traditional TO-247 versions and bare-die format for power module makers, followed by our high-performance surface-mount CCPAK packages."

CCPAK surface-mount packaging adopts Nexperia's proven copper-clip package technology to replace internal bond wires. This is said to reduce parasitic losses, optimize electrical and thermal performance, and improve reliability. CCPAK GaN FETs are available in top- or bottom-cooled configurations, making them versatile and helping to further improving heat dissipation.

The 650V GAN041-650WSB in TO-247 packaging and the GAN039-650NBB in CCPAK packaging are sampling now.

www.nexperia.com/gan-fets

Navitas presents GaNFast technology at 'virtual' PCIM Europe

At a 'virtual' PCIM (Power Conversion and Intelligent Motion) Europe 2020 (7–8 July), Navitas Semiconductor Inc of El Segundo, CA, USA showed how its GaNFast power ICs have penetrated the fast charger and power conversion market, taking share from legacy silicon chips.

Forty years ago, the power electronics industry saw a disruptive change with the advent of silicon MOSFET technology. In the next decade, the power supply industry saw a 5x increase in power density, a 5x improvement in energy savings and a 3x reduction in costs. The next 30 years saw heavy investment but this yielded smaller and smaller improvements.

Founded in 2014, Navitas launched what it said was the first commercial gallium nitride (GaN) power ICs. The firm says that its proprietary 'AllGaN' process design kit (PDK) monolithically integrates GaN power field-effect transistors (FETs) with GaN analog and logic circuits, enabling faster charging, higher power density and greater energy savings for mobile, consumer, enterprise, eMobility and new energy markets.

Now, GaN power ICs with monolithic integration of GaN FET, GaN digital and GaN analog circuits have driven a new generation of high-frequency, high-efficiency and very high-density power converters. Lenovo, Xiaomi and Asus/NVIDIA are amongst the tier-1 OEMs that have adopted GaNFast technology.

"2020 is the game-changer year for power electronics, with high-speed GaN taking market share from old, slow silicon chips — and demand is high for more GaN knowledge," says Stephen Oliver, VP corporate marketing & investor relations. "This year's virtual conference format prompted us to reconsider how we can help more customers discover and utilize GaNFast power ICs — and do it in a safe, yet extremely productive way. The in-depth video presentations can be viewed by designers at their convenient time, place and pace."

GaNFast power ICs are said to enable next-generational upgrades across diverse markets from 25–100W consumer and mobile USB-C fast chargers and adapters for smartphones and laptops, to 200–800W TV and all-in-one computers and on up to multi-kW electric vehicles (EV), industrial and data-center power supplies.

www.navitassemi.com
www.mesago.de/en/PCIM/main.htm

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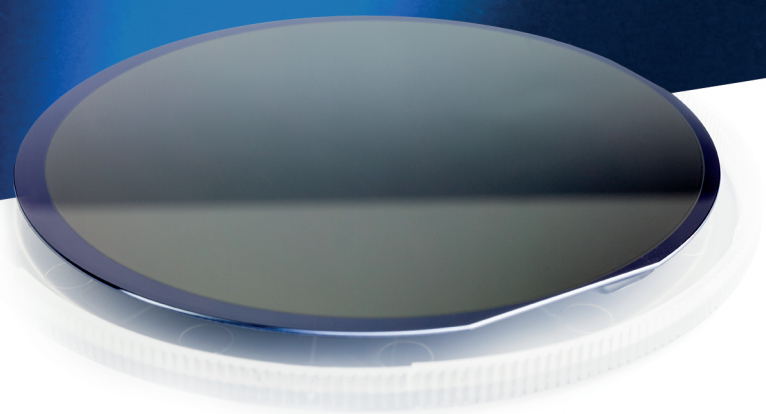

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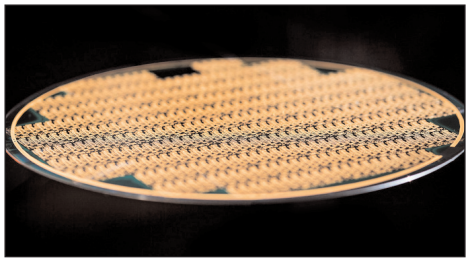
BAE collaboration with AFRL speeds development of next-gen radar, EW and communications technology

Phase 3 extending technology and providing access to larger community

BAE Systems' FAST Labs R&D organization says it continues to advance millimeter-wave gallium nitride (GaN) technology to support critical next-generation radar, electronic warfare (EW) and communications. Currently in Phase 3 of a multi-year, cooperative agreement with the US Air Force Research Laboratory (AFRL), it continues to develop defense-critical GaN technologies and is providing Department of Defense (DoD) suppliers with access to support its warfighters.

GaN technology provides broad frequency bandwidth, high efficiency and high transmit power in a small footprint, enabling greater system capabilities for critical DoD applications. The technology fills a unique DoD need for low-cost, high-performance amplifier technology.

In the multi-phase program, Phase 1 focused on transitioning the technology to BAE Systems' foundry from AFRL. Phase 2 is about maturing the technology and scaling to 6-inch wafers to slash per-chip costs. Phase 3, which runs concurrently with Phase 2, extends this technology and, for the first time, provides technology access to a larger community to develop high-



performance integrated circuits for next-generation applications. Developing this expertise and capability onshore is part of the DoD's ongoing effort to build a trusted, US-based supply of key advanced electronics capabilities.

Phase 3 includes a government-sponsored challenge — utilizing BAE Systems' foundry and leveraging the firm's expertise — that will open access to non-traditional teams from industry and universities to gain design diversity and experience in GaN across the broader community. Expanding the universe of organizations that can access GaN and develop applications utilizing the technology could exponentially speed adoption of this key technology, it is reckoned.

"This GaN program with AFRL is establishing the foundation for advanced technology development that could lead to new mission-critical technologies for a generation of warfighters," says Chris Rappa, product line director for Radio Frequency, Electronic Warfare and Advanced Electronics at BAE Systems FAST Labs. "As a result of this multi-year, multi-phase program and our own internal investment, we have seen more than $15m worth of updates to technology and facilities that will allow additional growth, and increased capacity to help fulfil the DoD's goal of creating additional trusted, US-based centers of excellence for next-generation technology."

The GaN program is part of BAE Systems' defense electronics R&D portfolio, its open foundry service, and builds on its recent T-MUSIC award, and its MATRICs technology. The firm is researching and developing microelectronic technologies, including GaN, in its 70,000ft^2 Microelectronics Center (MEC) in Nashua, NH. The MEC has been an accredited DoD Category 1A Trusted Supplier since 2008, and fabricates integrated circuits in production quantities for critical DoD programs.

www.baesystems.com/en-us/product/defense-electronics-r-d

Raytheon awarded $2.3bn US MDA contract

GaN-based AN/TPY-2 missile defense radars for THAAD system

Raytheon Missiles & Defense, a business of aerospace & defense firm Raytheon Technologies Corp of Waltham, MA, USA, has received a $2.3bn US Missile Defense Agency (MDA) production contract for seven gallium nitride (GaN)-based AN/TPY-2 (Army Navy/Transportable Radar Surveillance) units as part of the Terminal High Altitude Area Defense (THAAD) system, which is designed to protect against incoming ballistic missile threats. The contract is part of a foreign military sale to the Kingdom of Saudi Arabia.

"These highly capable X-band radars are the sharpest eyes in the global missile defense system," says Bryan Rosselli, VP of Strategic Missile Defense at Raytheon Missiles & Defense. "The addition of GaN technology delivers capability for threats to be detected, tracked and discriminated with improved radar reliability."

The mobile AN/TPY-2 missile defense radar uses X-band to clearly see ballistic missile threats. The radar system operates in two modes: forward-based mode — which detects ballistic missiles and identifies any lethal objects as they rise after launch — and terminal mode as part of the THAAD system, which guides interceptors toward a descending missile's warhead.

Of the 14 AN/TPY-2 radars produced, seven are fielded as a part of US-operated THAAD systems, five operate in forward-based mode for the USA, and two are part of foreign military sales.

www.raytheonmissilesanddefense.com/capabilities/products/antpy-2

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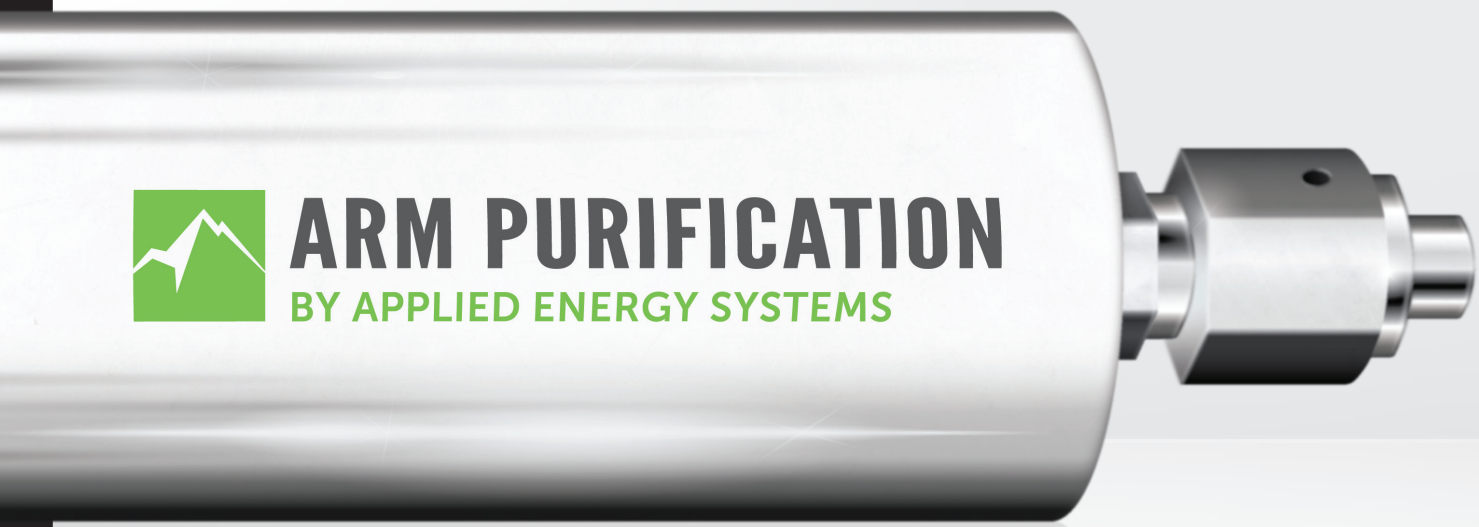

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Siltronic acquiring further GaN-on-Si epi reactor

Investment follows good performance of epiwafers in customers' pilot lines

Silicon wafer manufacturer Siltronic AG of Munich, Germany says that, since its gallium nitride-on-silicon (GaN-on-Si) wafers have exhibited very good performance in the pilot lines of its customers, it has decided to invest further in an epitaxial reactor.

Fast-growing new applications such as data centers, renewables and the next generation of wireless networks (5G) need high switching frequencies and efficient energy management while simultaneously working under high power density. GaN technology enables all three requirements, says Siltronic. By doing so, GaN can not only support future growth markets but also help to contribute in parallel to decarbonize digitalization, energy distribution and mobility, it adds. GaN-on-Si wafers are hence expected to be increasingly used as the material of choice for such applications.

Siltronic's GaN-on-Si activities commenced as early as 2011 by joining the respective Imec Industry Affiliation Program (IIAP). A comprehensive and high-performing GaN-on-Si technology platform was developed including GaN wafers intended for use in efficient power electronics as well as GaN-on-Si wafers for high-frequency applications (such as 5G) based on 6" and 8" wafer diameters.

Siltronic is also investing in research on this future technology at the European Union (EU) level. Together with 25 other partners, the firm says that it is driving GaN technology closer to the limits of its physical properties as part of the European 'Ultimate GaN' research project, strengthening Europe's competence in power products and sustainable energy management.

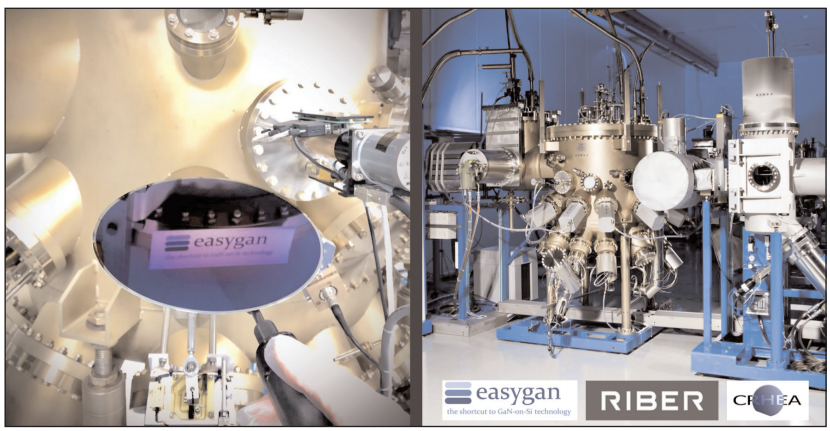
www.siltronic.com

EasyGaN, Riber and CRHEA grow first 200mm AlN-on-Si template using ammonia-based MBE

EasyGaN advances development of GaN-on-Si epiwafers

GaN-on-silicon technology start-up EasyGaN SAS of Sophia Antipolis, France, molecular beam epitaxy (MBE) system maker Riber S.A. of Bezons, France and CRHEA (a CNRS research laboratory specialized in epitaxial growth of wide-bandgap semiconductor materials) — from which EasyGaN was spun off in 2017 — have fabricated what it says is the first 200mm aluminium nitride on silicon (AlN-on-Si) template using ammonia (NH_3)-based MBE.

Using a Riber MBE 49 reactor at CRHEA, the team grew the template on an 8-inch silicon wafer with what is claimed to be unprecedented quality in terms of roughness, pit density and structural quality. EasyGaN says that it will hence be able to provide high-quality AlN templates to the electronic market enabling the fabrication of gallium nitride on silicon (GaN-on-Si) devices with improved breakdown voltages, significantly lower RF losses, and allowing for higher manufacturing throughput with the required diameters. The advance is also a step forward in the development of EasyGaN's own GaN-on-Si epiwafer solutions.



"This achievement was crucial for the adoption of our template technology by the GaN-on-Si manufacturers," reckons EasyGaN's CEO André Bonnardot. "We are looking forward to showing what our NH_3-MBE AlN template solution can bring to the market," he adds.

"Despite the impact of the Covid-19 pandemic on working conditions, the epi team remained fully mobilized to complete quickly this proof of concept, which qualifies the Riber MBE 49 GaN as the perfect 200mm MBE production tool for growing high-quality GaN epilayers on silicon for power electronics," says Riber's CEO Philippe Ley.

"The growth of III-nitrides on silicon by MBE has been a major research area at CRHEA for the last two decades," says CRHEA's director Philippe Boucaud. "Growing AlN-on-Si templates on an industrial 200mm MBE reactor represents a major achievement, a perfect example of successful transfer from original academic ideas to industrial partners."

www.riber.com
www.easy-gan.com
www.crhea.cnrs.fr

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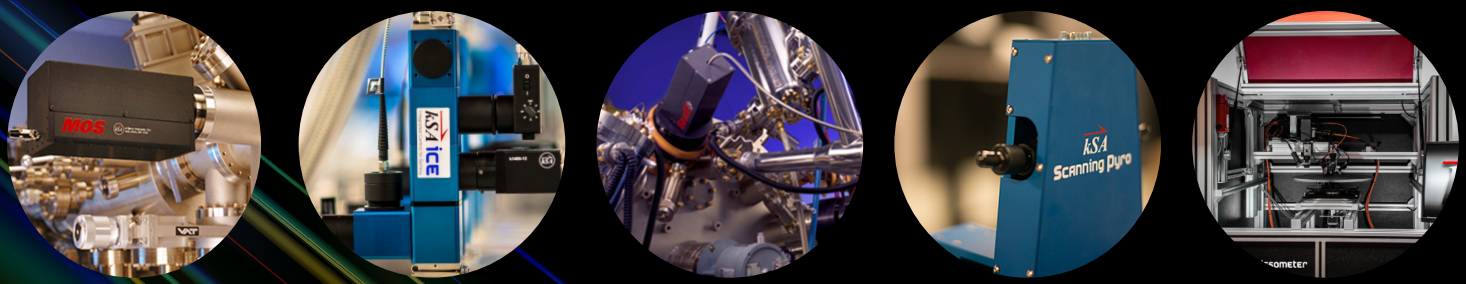

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CSconnected funded through UK Research and Innovation's Strength in Places Fund

First wave of £25.44m to support £43.74m project

The UK Government has announced the first wave of funding through UK Research and Innovation's flagship Strength in Places Fund (SIPF), in which a major £43.74m project with South Wales' compound semiconductor cluster has been approved and will be supported by £25.44m funding.

Comprising a cluster of academic institutions, innovation organizations and industrial partners, the CSconnected project is based on integrating research excellence with the unique regional supply chains in advanced semiconductor manufacturing. Its primary aim is to develop a competitive advantage in key enabling technologies which will allow the UK to increase trade globally in critical sectors such as communications, 5G, autonomous and electric vehicles, medical devices.

Project partners include: Cardiff University (lead partner); Cardiff Capital Region City Deal; Compound Semiconductor Applications Catapult; Compound Semiconductor Centre (CSC); IQE plc; MicroLink Devices UK Ltd; Newport Wafer Fab (NWF); Rockley Photonics; Swansea University; SPTS Technologies; and Welsh Government. Activities are to be coordinated by CSconnected Ltd.

"Today's announcement is excellent news for Wales and the UK, providing a unique opportunity to harness the excellent research and innovation capabilities in a way that translates into world-class UK-based manufacturing for new and emerging global technology markets," says CSC director Dr Wyn Meredith, lead author of the SIPF application.

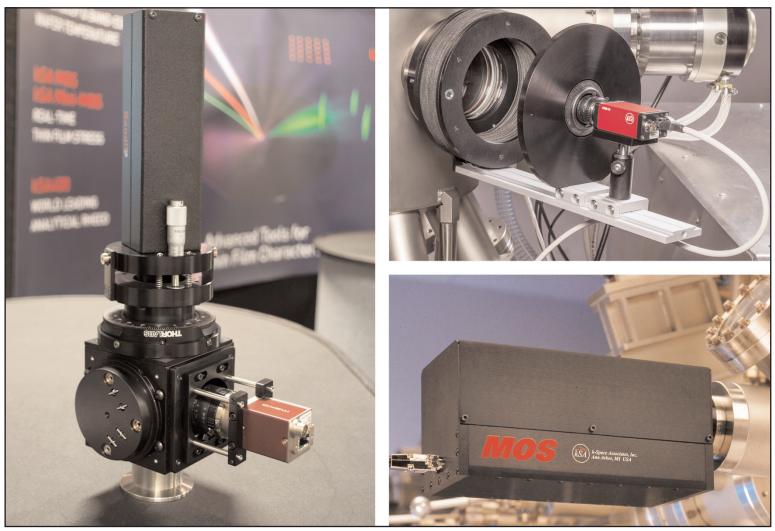
www.csconnected.com
www.csa.catapult.org.uk
www.ukri.org

k-Space receives multi-tool metrology order from Veeco

k-Space Associates Inc of Dexter, MI, USA — which makes in-situ, ex-situ and in-line thin-film metrology instrumentation for both research and manufacturing of microelectronic, optoelectronic and photovoltaic devices — has received a multi-system order from epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA consisting of multiple units each of kSA UV BandiT, kSA MOS with spectral reflectance and kSA 400 metrology systems.

Veeco will incorporate the kSA metrology tools onto a multi-deposition-chamber GEN200 MBE system configured for the growth of nitride materials. The GEN200 is a high-performance and cost-effective multi-4"-wafer production MBE system, used in leading production MBE facilities worldwide.

"k-Space and Veeco have a long and successful partnership working together in the molecular beam epitaxy (MBE) deposition market," says k-Space's CEO Darryl Barlett. "We have worked closely with Veeco to supply in-situ metrology that communicates directly with Veeco's control software, giving the end user complete monitoring and control over their deposition process.



The kSA UV BandiT is designed for in-situ temperature monitoring of wide-bandgap semiconductors in ranges that pyrometers cannot measure, including temperatures of substrates that are transparent in the infrared (IR) and visible wavelength ranges. The kSA UV BandiT monitors temperature via band-edge-based absorption spectra in the range 200–500nm.

The kSA MOS is a complete curvature, stress, reflectivity and growth rate in-situ metrology instrument. k-Space has created a custom configuration that includes capabilities for both standard kSA MOS measurements and spectral reflectance monitoring in the 380–1100nm range.

Both the kSA BandiT and kSA MOS use kSA patented technology.

The kSA 400 is a powerful analytical reflection high-energy electron diffraction (RHEED) system with state-of-the-art software. This system captures static and real-time data and uses the robust analysis tools in the software to analyze the RHEED data.

k-Space will ship the systems to Veeco this summer for eventual installation at the customer site.

www.k-space.com
www.veeco.com

EVG earns eighth consecutive triple win in VLSIresearch's annual Customer Satisfaction Survey

EV Group — a supplier of wafer bonding and lithography equipment for semiconductor, micro-electro-mechanical systems (MEMS) and nanotechnology applications — has again been voted by customers as one of the '10 BEST Focused Suppliers of Chip Making Equipment' and one of 'THE BEST Suppliers of Fab Equipment' in the VLSIresearch's annual Customer Satisfaction Survey, increasing its score and ranking in both award segments compared with last year's listings. EVG also received a 'RANKED 1st in Specialty Fab Equipment' award again, marking the eighth consecutive year that it has received all three customer satisfaction awards.

For the first time, EVG was also recognized this year as one of 'THE BEST Suppliers of Fab Equipment to Foundation Chip Makers' — a category defined as those firms whose spending provides the foundation of wafer fab equipment development and infrastructure in the global semiconductor industry, and which include several of the top semiconductor sales leaders including foundries.

In addition, for the fourth consecutive year, EVG was recognized as one of 'THE BEST Suppliers of Fab Equipment to Specialty Chip Makers', increasing its score in this award category as well.

As a result, 2020 marks the first time that EVG has won awards in five award categories.

According to VLSIresearch, EVG earned its highest 10 BEST rating ever this year, with customers rating the firm best at partnering and recommended supplier. Other categories where EVG earned its highest marks include technical leadership, trust in supplier, application support, support after-sales, and product uptime. 2020 marks the 18th consecutive year that EVG has been listed among THE BEST Suppliers of Fab Equipment, as well as the eighth year that EVG has achieved the number-one spot as the highest-ranked wafer bonder supplier.

"EV Group's customer satisfaction has always excelled by bringing new technology solutions that are expandable into high-volume production," comments VLSIresearch's CEO & chairman G. Dan Hutcheson. "EVG continues to raise the bar in customer satisfaction by improving its rating in the VLSIresearch Customer Satisfaction Survey year after year, with increases across all 14 award categories this year. In particular, the company achieved the highest score of all 10 BEST Focused Chip Making Equipment Suppliers in technical leadership, partnering, and application support. EVG continues to outperform the largest equipment companies in its markets with a strong emphasis on partnering with customers," he adds.

"Helping our customers to speed development and achieve manufacturing success on their new products and applications is our number one priority," says Hermann Waltl, executive sales and customer support director at EVG. "EVG accomplishes this through a combination of innovative industry-leading process solutions, in-house expertise and close customer collaborations, which are all brought together through our centers of technology excellence — our Heterogeneous Integration Competence Center and our NILPhotonics Competence Center," he adds. "EVG has invested significant resources in enhancing this unique holistic approach to customer service and support, and we are pleased to see the fruits of these efforts recognized once again in the results of the VLSIresearch's Customer Satisfaction Survey."

www.EVGroup.com
www.vlsiresearch.com

Asahi Kasei and Crystal IS launch UV Accelerator funding initiative

$250,000 each to companies to support development of new disinfection products using UVC LEDs

Crystal IS Inc of Green Island, NY, USA, which makes proprietary ultraviolet light-emitting diodes (UVC LEDs), and its parent company Asahi Kasei have launched the UV Accelerator funding initiative, which aims to provide investment of up to $250,000 each to firm to support the development of new disinfection products using UVC LEDs.

Crystal IS' Klaran product family is found in many water disinfection systems, though the use of this technology in products that can disinfect surfaces or air is still in its infancy. Traditional UV lamps are bulky, fragile and contain mercury, making this an inconvenient and dangerous way for disinfection that will likely be retired soon (in line with the Minamata Convention on Mercury).

Crystal IS is confident that Klaran UVC LEDs, unlike older UV lamps, can be safely used in the fight against COVID-19. As an initial attempt to bolster the study of UVC products against the virus, Crystal IS has been providing free LED samples to universities and, with this latest UV Accelerator initiative, Asahi Kasei is joining forces to provide funding.

UV Accelerator: the opportunity

Led by Dr Steven Berger, managing director at Asahi Kasei America and former CEO of Crystal IS, the UV Accelerator has been established as a proactive measure of developing technology that can be used to stop the spread of deadly viruses and bacteria, contributing to the ongoing fight against COVID-19.

Asahi Kasei, at its sole discretion, will fund successful applicants up to $250,000 per company to support and accelerate product development. Crystal IS will also provide engineering expertise for the design and control of the UVC LED light source, as necessary. Applications are currently being accepted and screened for organizations with ideas for UVC LED-based disinfection products, and discussions are expected to begin this July. The UV Accelerator is an ongoing project that strives to attract new partnerships from countries around the globe to help create a safer world.

www.cisuvc.com/products/klaran
www.akm.com/akm/en
www.uvaccelerator.com

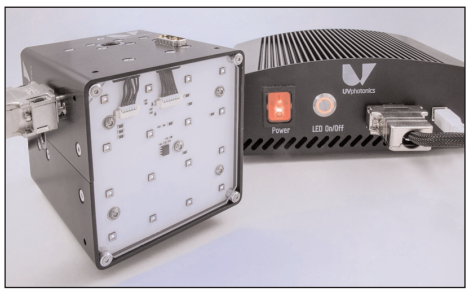
FBH and UVphotonics develop LED irradiation system

Applications span disinfection to medical surface treatments

Berlin-based Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH) and its spin-off UVphotonics NT GmbH have designed and developed a versatile turnkey irradiation system for surface treatment.

Since the compact, modular system can be equipped with both in-house-developed UV LEDs as well as commercially available UV, visible and infrared LEDs, it can be flexibly adjusted to the targeted emission spectrum.

For disinfection purposes the system can be equipped with in-house-developed LEDs emitting at 265nm to eliminate germs on critical surfaces, including personal items such as mobile phones and reusable masks as well as menu cards in restaurants. It can also be used in the professional sector, for example in healthcare clinics and laboratories.



Modular LED irradiation system with UVC LEDs for disinfection.

The system is equipped with an illumination module comprising 16 UV LEDs distributed over an area of 80mm x 80mm. The LEDs provide an illumination intensity of >5mW/cm^2. So, the irradiation system achieves the minimum UV dose of 500mJ/cm^2 recommended by the Centers for Disease Control and Prevention (US Department of Health) in less than two minutes. An integrated timer ensures the correct dosage.

Flexible und expandable plug & play solution

The module can control up to four different wavelengths separately, which can be an advantage in applications such as medical treatments and curing.

To cover larger areas, the modular segments can be mechanically interconnected wire-free and therefore the system is flexibly expandable into one-dimensional as well as two-dimensional arrays. Also, individually shaped arrays are possible, which can be integrated into a large number of disinfection systems.

The overall system is a plug & play solution that can be computer-controlled or operated as stand-alone with constant power. Even programming a timing pattern is possible.

www.uvphotonics.de
www.fbh-berlin.de

Seoul Viosys' Violeds UV LED technology adopted by Chinese air-conditioner manufacturer Gree

Ultraviolet LED product maker Seoul Viosys Co Ltd (a subsidiary of LED firm Seoul Semiconductor) says its Violeds technology (said to be the first UV LED technology proven to sterilize new coronaviruses) has been adopted for the new Fresh Air brand produced by China's largest air-conditioner manufacturer Gree Electric Appliances Inc.

The Violeds UV LED technology adopted for Fresh Air is said to provide robust disinfection on the surface of the evaporator, as well as sterilization of any indoor airborne contaminants drawn into the air conditioner (including various harmful viruses and bacteria), ensuring that fresh air is continuously discharged. Conventional household air conditioners typically draw outside air into the AC unit, and discharge that air into the interior after cooling and filtering, where it is continuously recirculated. This recirculation of indoor air may cause a higher risk of infection through aerosol transmission when viruses are present.

In testing by Guangzhou Institute of Microbiology in China (CGMT), Gree has demonstrated that Fresh Air with Violeds UV LED technology has the performance to sterilize 99.15% of viruses and bacteria, 98% of enteroviruses such as EV71 and H1N1, and 99% of staphylococcus albus bacteria. In addition, according to the results of testing conducted in April and May by a research group at Korea University, Violeds UV LED technology has been proven to sterilize 99.9% of the new coronavirus in 30 seconds. Seoul Viosys provides major customers with optimized UV LED solutions based on these test results.

"Since air-conditioning systems operate by circulating indoor air drawn in and discharged again, aerosol transmission is a concern when using these systems. In South Korea, health authorities rolled out a new guideline for citizens to prevent aerosol transmission, which included advising people to open windows every two hours when using their air conditioners," notes Seoul Viosys' executive VP Chae Hon Kim. "We offer an optimized solution to simultaneously enable disinfection of viruses in air, as well as air purification by disinfecting the air drawn into air conditioner and eliminating viruses in air using Violeds technology. As more applications adopt the Violeds technology to support healthy life, the cost of UV LEDs is anticipated to be reduced to a level closer to visible white LEDs," he adds.

"Seoul Viosys' Violeds technology has been adopted not only by the Chinese AC manufacturer Gree, but also by RGF Environmental Group, the leading in-duct air treatment supplier in the USA," continues Kim. "As a result of receiving production approval to supply Violeds products to these two leading global companies, Violeds UV LEDs have clearly been recognized as essential technology for air purifiers and air conditioning systems."

www.seoulviosys.com

AquiSense's UV-C LED lamps used by University of Miyazaki to determine UV dose response for SARS-CoV-2

Nikkiso Group company AquiSense Technologies LLC of Erlanger, KY, USA says that its UV-C LEDs (with a peak wavelength of 280nm) have been used by Japan's University of Miyazaki to irradiate SARS-CoV-2 virus (which causes COVID-19) isolated from the Diamond Princess cruise ship (which saw many cases early in the pandemic) to determine a UV dose response curve.

"This work certainly bolsters the case for the use of UV-C LEDs for societal benefit against SARS-CoV-2," says chief technology officer Jennifer Pagan Ph.D. "Considering the large number of research projects underway exploring the efficacy of UV-C on the virus, we can expect the supporting body of evidence to only increase," she adds.

The study used an infectivity assay on Vero cells to measure the inactivation of SARS-CoV-2 under UV-C LED irradiation. By varying the exposure time for each sample, the researchers were able to generate a series of datapoints (a dose response curve). Data such as these are used throughout the UV industry, allowing system designers to match a target UV exposure to a desired degree of inactivation. This study is the first demonstration of a UV dose response curve for SARS-CoV-2.

Analysis of these data gives a D90 value (the UV dose required to achieve a 90% reduction) in the 4.2–5.3mJ cm^{-2} range, indicating that SARS-CoV-2 may be more susceptible to UV exposure than other common viruses such as norovirus. However, a low starting concentration of the virus limited the maximum inactivation that could be measured to 3.3-log (99.95%) and may have resulted in an effect known as 'tailing'. Both features limit conclusions that can be drawn from the data.

"The more we learn about the way this virus behaves, the better we can design systems to combat it effectively," says Rich Simons Ph.D, head of Application Science at AquiSense. "This study is certainly not the end of discussion on UV as a tool for SARS-CoV-2 inactivation but adds a useful datapoint to our ongoing analysis and gives us confidence that we're on the right track."

www.aquisense.com

Signify increasing UV-C light source production

Leveraging over 35 years of expertise in UV-C lighting to address the growing global need for the disinfection of air, surfaces and objects, Signify of Eindhoven, The Netherlands is increasing its UV-C lighting production capacity and expanding its UV-C product portfolio.

The firm says that its UV-C lighting is well proven and trusted as an effective disinfectant, as was recently validated in a laboratory test by Boston University that showed that Signify's UV-C light sources inactivate the virus that causes COVID-19 in just seconds. This comes when organizations are seeking ways to continue operations and provide service in a safe environment.

Signify's new UV-C product range includes luminaires and chambers for various professional applications. "We have introduced 12 families of UV-C lighting fixtures specifically designed to disinfect air, surfaces and objects," says Digital Solutions Division leader Harsh Chitale. "These products target different customer segments, ranging from offices, schools, gyms, retail stores, warehouses, and on public transport."

Part of the range comprises UV-C fixtures that are suitable for the deep disinfection of surfaces in offices, schools and restrooms. They are equipped with sensors and controls to ensure that they only operate when people and animals are not present. Other products include mobile, freestanding UV-C luminaires that can be wheeled into a hotel room or used to disinfect surfaces on public transport such as buses and trains.

For the disinfection of objects, Signify is launching a range of safe and quick-to-use UV-C disinfection chambers, which are used in offices and municipal buildings to disinfect visitor tags, phones, bags, laptops and wallets in a matter of seconds. In stores they are suitable for disinfecting returned items, glasses or clothes tried on in a changing room.

UV-C fixtures can also be used inside surface disinfection tunnels. In North America a large retailer is piloting a UV-C tunnel for disinfecting shopping trolleys. In India, a hotel plans to use a Signify UV-C tunnel for disinfecting guests' bags at check-in.

To complement its portfolio, Signify recently acquired the assets of small, Netherlands-based UV-C disinfection firm Germicidal Lamps & Applications (GLA), including GLA's upper-room UV-C air disinfection portfolio as well as application knowledge. "The assets and know-how acquired from GLA will help us to accelerate the development of our roadmap of UV-C based upper-room air disinfection systems," says Paul Peeters, leader of Signify's Digital Solutions Europe. "We plan to make these products available across the world soon."

The upper-room air disinfection luminaires can be used with people in the room, as they are installed at a height which, in combination with shielding and optics, prevents exposure to the UV-C light source. Air in the upper part of the room is constantly disinfected using UV-C irradiation and natural convection of airflow in the room, making them suitable for use in schools, offices, gyms, retail outlets and other high-contact areas

www.signify.com/global/innovation/uv-c

Boston University validates effectiveness of Signify's UV-C light sources in inactivating SARS-CoV-2 virus

Signify, together with the National Emerging Infectious Diseases Laboratories (NEIDL, which encompasses containment labs at Biosafety Level -2, -3, and -4) at Boston University in the USA, have conducted research that validates the effectiveness of Signify's UV-C light sources on the inactivation of SARS-CoV-2 (the cause of COVID-19).

Since the start of the SARS CoV-2 pandemic, the team of Dr Anthony Griffiths, associate professor of Microbiology at Boston University's School of Medicine, has been working on developing tools to support scientific advancement in this field (Griffiths' team develops vaccines and therapeutics for Risk Group 3 and 4 viruses, which include organisms that can cause serious or deadly diseases in humans). During the research they treated inoculated material with different doses of UV-C radiation from a Signify light source and assessed the inactivation capacity under various conditions. The team applied a dose of 5mJ/cm^2, resulting in a reduction in SARS-CoV-2 virus of 99% in 6 seconds. Based on the data, it was determined that a dose of 22mJ/cm^2 will result in a reduction of 99.9999% in 25 seconds.

"Our test results show that, above a specific dose of UV-C radiation, viruses were completely inactivated: in a matter of seconds we could no longer detect any virus," says Griffiths. "We hope that this will accelerate the development of products that can help limit the spread of COVID-19."

"Boston University has validated the effectiveness of our light sources as a preventive measure for companies and institutions as they seek ways to provide virus-free environments," says Signify's Eric Rondolat. "Given the potential of the technology to aid the fight against the coronavirus, Signify will not keep the technology for its exclusive use but make it available to other lighting companies," he adds. "To service the growing need for disinfection we will increase our production capacity multifold in the coming months."

www.bu.edu/nitrides

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Giving our customers the lead through mass production of high performance TCOs, metals and DBRs with the best cost of ownership is our daily business. However, leveraging our know how to help customers develop new more demanding processes or ramp up production of next generation Optoelectronic devices like Micro LED or OLED on CMOS is where we add value too, and in this edition of LAYERS you can also read about solutions we can offer for exactly that.

Stefan Seifried, Head of BU Optoelectronics

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Epistar and Lextar jointly establish new holding company

Taiwan-based LED epitaxial wafer and chip maker Epistar Corp and vertically integrated LED firm Lextar Electronics Corp (a subsidiary of AU Optronics) of Hsinchu Science Park, Taiwan are to jointly establish a 'holding company A' via share conversion, as approved in meetings of the boards of both firms.

The share conversion ratios are tentatively set at one Epistar share for 0.5 ordinary shares of Company A, and one Lextar share for 0.275 ordinary shares of Company A.

Acting as a III–V investment platform, Company A aims to explore technologies for applications including mini/micro-LED displays, intelligent sensing and III–V microelectronics. While Company A should strengthen the global competitiveness of both firms, Epistar and Lextar will operate independently with no impact on their respective customers and staff.

The intended synergies of the collaboration include the following: (1) to integrate the resources and refocus expertise of the two firms — Epistar will focus on LED upstream and midstream technology (with Lextar becoming a customer) and Lextar will concentrate in-depth on downstream technologies (with Epistar one of its strategic suppliers); (2) to reinforce the connection between resources and product/technology development for faster commercialization, and to maximize the benefit with efficient investment and cost management, and (3) to urge the application of mini/micro-LED technology to benefit customers, partners and consumers.

The daily operation of Company A will be coordinated and decided by the Steering Committee set up jointly by both parties (comprising two representatives from each).

Epistar's chairman Dr B.J. Lee says that, in displays, LED technology has to not only beat the competition but also widen the gap to be ahead of competing technologies. At this critical moment, the LED industry needs more collaboration than ever, he adds. Company A will plan overall operations to leverage resources effectively and develop a collaboration strategy for the industry in a macro view so that all its subsidiaries can evolve on this platform.

Epistar's president Patrick Fan said that it will continue to concentrate on upstream and midstream LED technology to provide better products and services while Lextar will focus on downstream products and be one of Epistar's key customers. This will not only contribute to the overall supply chain but also accelerate application development, so consumers can enjoy the advantage of LED miniaturization, improving the visual quality of displays.

Lextar's products span the upstream, midstream and downstream of the industry, notes chairman & CEO Dr David Su. The firm has expertise in each process platform plus the capability for T.E.M.P. (thermal, electrical, mechanical, photo-electrical) integration. Also, Lextar has the advantage of retaining downstream customers and being close to the market.

As the collaboration deepens, Epistar will be a strategic partner of Lextar's for LED dies and Lextar will develop packaging and modular technologies to provide prompt service to customers worldwide.

www.lextar.com
www.epistar.com

Firms to comprise 12.43% of global LED chip production capacity

TrendForce's LEDinside division comments that the partnership of Epistar and Lextar should enable them to seize commercial opportunities in micro- and mini-LEDs.

Sharing production capacities

With the rise of micro- and mini-LED commercial opportunities, leading manufacturers such as Apple and Samsung are placing high hopes in the future of these two emerging display technologies and forecasting high demand for micro/mini-LED suppliers' production capacities. However, as Taiwanese LED makers have suffered continuous financial losses over the past few years, most of them can no longer afford to expand their production capacity on a large scale to meet demands from end-product brands.

Furthermore, the recent surge in capital expenditure by Chinese LED chip makers and packaging companies, as well as their partnership with domestic panel manufacturers, has alarmed Taiwanese LED companies to the hypercompetitive state of the LED industry.

By forming a holding company, Epistar and Lextar are now able to jointly bear the enormous burden of investing in new equipment, in turn lowering their operational risk and helping them gain a foothold in the market for new types of displays, reckons TrendForce.

TrendForce estimates that, after formation of the holding company, Epistar and Lextar will collectively account for 12.43% of global LED chip production capacity.

Supply-chain integration allows firms to collectively pursue orders

Epistar's production capacity is primarily focused on LED epitaxy and LED chip fabrication, whereas Lextar specializes in LED packaging and modules. The partnership between the two firms will result in vertical integration throughout the entire LED industrial supply chain. Given that both companies have been actively involved in mini-LED backlight R&D, the collaboration between Epistar and Lextar should serve to reduce their competition with each other over client orders as mini-LED backlight demand from panel manufacturers and branded end-product OEMs skyrockets, it is reckoned.

www.ledinside.com

CEA-Leti breaks throughput record for LiFi using single GaN blue micro-LED

Transmission rate of 7.7Gbps positions LiFi as replacement for WiFi

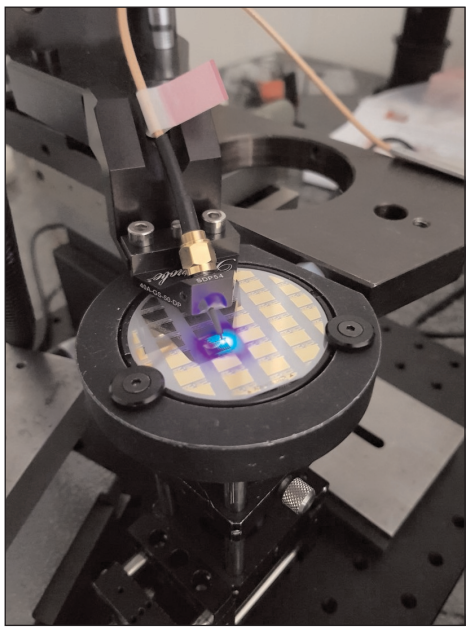
Micro/nanotechnology R&D center CEA-Leti of Grenoble, France has set a throughput record of 5.1Gbps in visible light communications (VLC) using a single gallium nitride (GaN) blue micro-LED. The data transmission rate of 7.7Gbps achieved with a 10µm micro-LED marks another step toward commercialization and widespread use of LiFi communication.

VLC, or LiFi (light fidelity), is an emerging wireless communication system that offers an alternative or a complementary technology to radio frequency (RF) systems such as WiFi and 5G. It is considered to be promising for security-related applications because light propagation can be confined to a room with no information leakage, in contrast to WiFi communication, which penetrates walls. LiFi also holds promise for ultra-high-speed data transmission in environments where RF emissions are controlled, like hospitals, schools and airplanes.

Single micro-LED communication offers an ultra-high data transmission rate for a variety of opportunities for new applications. These include industrial wireless high-speed links in demanding environments such as assembly lines and data centers, and contact-less connectors, or chip-to-chip communication. But their weak optical power limits their applications to short-range communications. In contrast, matrices of thousands of micro-LEDs contain higher optical powers than open mid- and long-range applications. However, preserving the bandwidth of each micro-LED within a matrix requires that each signal has to be brought as close as possible to the micro-optical source.

Potential for mass-market applications

CEA-Leti says that its expertise in micro-LED epitaxial processing produces micro-LEDs as small as 10µm (among the smallest in the world). The smaller the emissive area of the LED, the higher the communication bandwidth — 1.8GHz in CEA-Leti's single-blue micro-LED project. The team also produced multi-carrier modulation combined with digital signal processing. This high-spectrum-efficiency waveform was transmitted by the single LED and was received on a high-speed photodetector and demodulated using a direct sampling oscilloscope.



CEA-Leti testbed for single GaN blue micro-LED that achieved 7.7Gbps throughput.

"This technology has exciting potential for mass-market applications," believes research scientist Benoit Miscopein. "Multi-LED systems could replace WiFi, but wide-scale adoption will require a standardization process to ensure the systems' interoperability between different manufacturers," he adds. "The Light Communications Alliance was created in 2019 to encourage the industry to implement this standardization."

In addition to a stand-alone WiFi-like standard, the possibility of including this new technology as a component carrier in the downlink of 5G new radio (NR) — a radio-access technology for 5G mobile considerations — is also under investigation to bring a large additional license-free bandwidth.

"This may be feasible because CEA-Leti's LiFi physical layer relies on the same concepts as WiFi and 5G technologies," says Miscopein. "Matrices of thousands of micro-LEDs could also open the way to mid- to long-range applications, such as indoor wireless multiple access."

Preserving the bandwidth of each micro-LED within a matrix requires that each signal is generated as close as possible to the micro-optical source.

"To meet this challenge, we expect to hybridize the micro-LED matrix onto another matrix of CMOS drivers: one simple CMOS driver will pilot one micro-LED," Miscopein says. "This will also enable the additional feature of piloting each micro-LED pixel independently, and that allows new types of digital-to-optical waveforms that could eliminate the need for digital-to-analog converters commonly used in the conventional 'analog' implementations of LiFi," he adds.

While the Light Communications Alliance will promote interoperability between different manufacturers' LiFi systems, CEA-Leti will continue its research in two areas:

- a better understanding of the electrical behavior of single LEDs in high-frequency regimes and the link between bandwidth and electro-migration patterns, and
- techniques to improve the range and/or increase the data rate using multi-LED emissive devices; this requires adapting the waveform generation as well as a CMOS interposer to drive the matrix on a pixel basis.

www.leti.fr
www.LightCommunications.org

Verticle develops chemical dicing for mini-LEDs

LED and display technology specialist Verticle Inc of San Francisco, CA, USA notes that, to improve the picture quality of mini-LED displays by increasing local dimming zones, significantly more LEDs are required than in a conventional LED backlight. For example, 10,000 LEDs are used in a 12.9-inch iPad Pro screen. Consequently, lowering LED cost is the primary issue for the commercialization of mini-LED displays.

One of the most effective ways to reduce the manufacturing cost would be to shrink die size. However, this is limited by current die singulation technologies (e.g. the industry-standard stealth laser dicing process) due to chip damage and extremely long processing time. This is particularly true for LED die of less than 100mm.

Verticle has developed innovative die singulation technology called 'Chemical Dicing', which enables a reduction in mini-LED die size without chip damage. Using the chemical dicing process, dramatic cost reduction can be achieved through a substantial increase in die count per wafer. Furthermore, as shown in Table 1, it can also result in narrower scribe street width.

This is attributed to a damage-free nature of the chemical dicing as it separates die by wet chemical etching the street line instead of thermal or mechanical methods that generate heat or acoustic shock waves. As a result, there is no damage around the chip edge, which means that distance between active areas and chip cutting edges can be less than 2mm. Therefore, active area can be enlarged, which results in more light output from the same size LED die.

As shown in Table 1, die size shrinking and street narrowing yield a dramatic increase in DPW (die per wafer), by up to 8x, compared with conventional flip-chip-based mini-LEDs, which have a larger die size and wider street widths.

Mini-LED die size	Street width	No. of die per 4" wafer	No. die change b ystreet width	Total DPW change
200x200 μm	10 μm 20 μm	167,436 153,462	9.0 % up	
150x150 μm	10 μm 20 μm	283,555 254,198	11.5 % up	1.8X
100x100 μm	10 μm 20 μm	614,834 526,932	16.7 % up	2.4X 4.0X
75x75 μm	5 μm 10 μm	1,239,243 1,054,398	17.5 % up	8.0X

Table1. Increasing die per wafer by shrinking die size and street width (including 3mm edge exclusion).

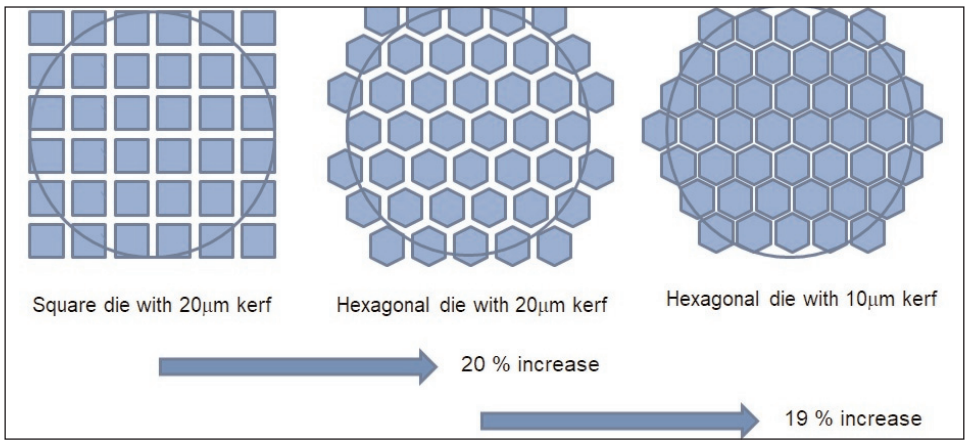


Figure 1. Increased die per wafer by chip shaping and narrowing street width.

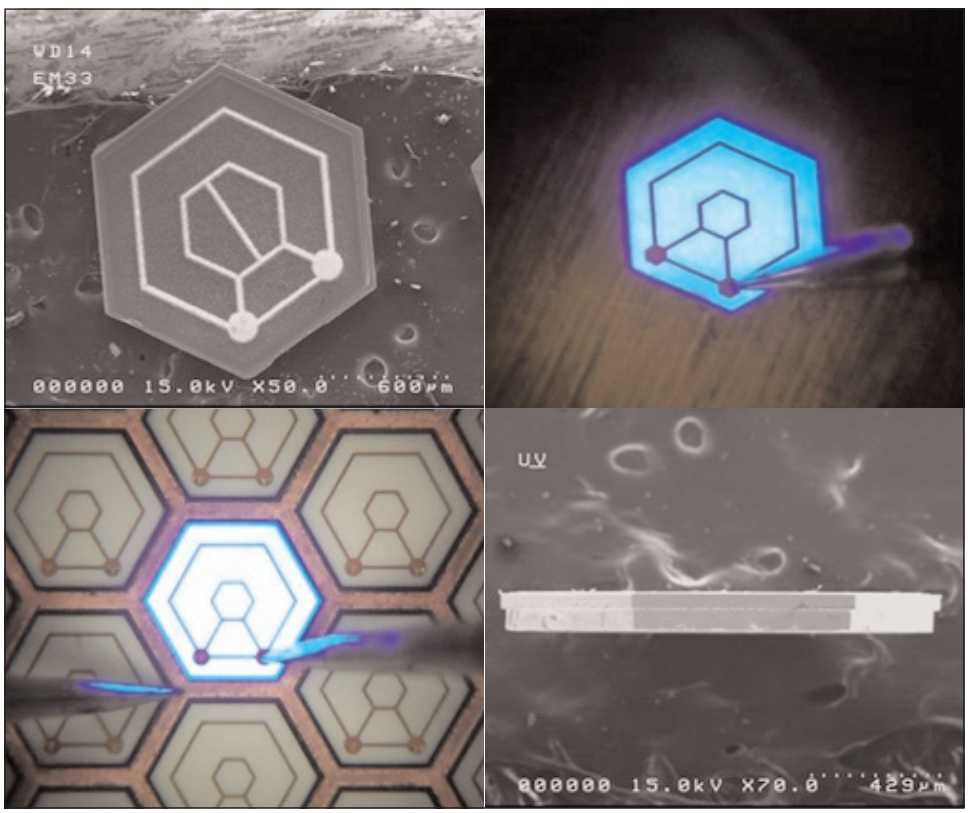


Figure 2. First hexagonal LED die separated by chemical dicing.

Additional DPW increase can be obtained by chip shaping. Unlike conventional die singulation methods that can only separate die in a linear direction (i.e. only able to separate either square or rectangu-

lar die), chemical dicing enables free-shape die (e.g. hexagonal) formation and singulation. Hexagonal die can increase DPW by more than 20% due to enhanced tiling efficiency and increased usable wafer area (Figure 1).

Using this unique chemical dicing, Verticle was able to fabricate the first hexagonal die (Figure 2). The hexagonal shape symmetry can help to achieve better current spreading, which results in higher light output than square or rectangular die. Additionally, hexagonal die light output is enhanced after packaging too. A hexagonal die produces a beam profile that is much closer to the circular shape of a circular lens used in optics design. In contrast, the beam profile of the typical square or rectangular die, when combined with a circular lens, is typically distorted.

	Stealth Laser Dicing	Chemical Dicing
Separation time	**248 min/wafer** Including back grinding/polishing, laser scribing, and breaking	**3 min/wafer*** Including patterning and chemical etch, no back grinding & polishing
Die shape and size	Square or rectangular die only, >100 μm	Any die shape, < 40 μm
Min. kerf width	20~30 μm	< 2 μm
Chip damage & performance	Brightness reduction and leakage current	No chip degradation, no leakage current
CAPEX	12X higher than Chemical Dicing	-

Table 2.Benefits of chemical dicing (based on 100μm x 100μm die, 2-inch wafer,100 wafers x 2"-wafer/lot, 10min/lot = 6 sec/wafer) compared with stealth laser dicing. Chemical dicing is 83x faster than stealth laser dicing for 100μm x 100μm die. Benefits include faster dicing speed and throughputs with increasing number of loading wafers per batch and shrinking die size. Also, chemical dicing speed is independent of die size.

Moreover, multiple wafers in one batch can be etched simultaneously, resulting in die singulation throughputs 500x greater than stealth laser dicing, says Vertical (Table 2).

www.verticleinc.com

BluGlass commissions US laser diode test facility

Aixtron 2800G4 system retrofit assembly completed; final commissioning for RPCVD underway

BluGlass Ltd of Silverwater, Australia (which was spun off from the III-nitride department of Macquarie University in 2005) has given an update on its direct-to-market laser diode business unit, laser diode product development, and the retrofit of its Aixtron 2800G4 metal-organic chemical vapor deposition (MOCVD) system.

Laser diode test facility

BluGlass has commissioned its laser diode test facility in New Hampshire, USA on time. As a key component of its product quality assurance activities, it will assess the quality, performance and characteristics of the firm's laser diode products. The installed reliability ovens, burn-in rack and electro-optical, spectral and spatial characterization capabilities will enable the accurate measurement of laser diode output power and lifetime performance.

The new facility is already being used for R&D testing during product development and will ultimately enable fully automated testing of commercial volumes of laser diode products.

BluGlass has hired an experienced laser diode characterization and testing expert, based at the new facility, as it continues to enhance its people capabilities.

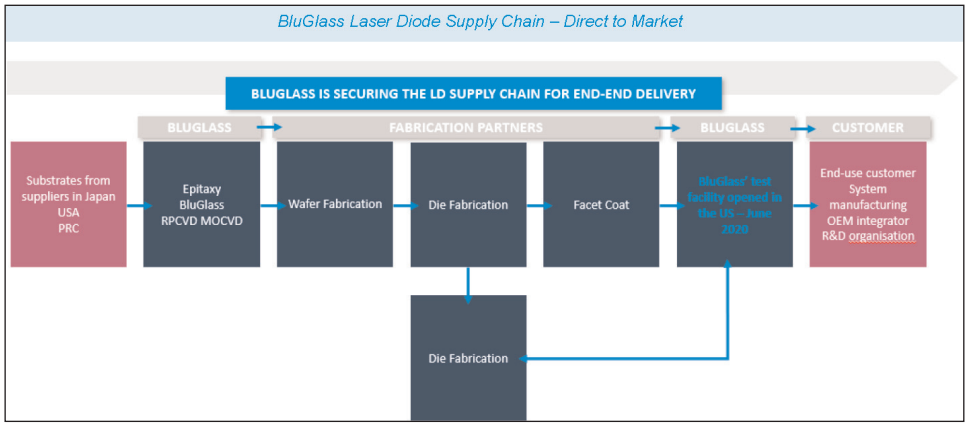
Product development

BluGlass says that it continues to develop and strengthen its global supply chain by working with and qualifying multiple partners on the fabrication of laser diode devices. Its laser diode product development remains on track to deliver test products by the end of 2020, with customer revenues anticipated to commence in early 2021 (as per the firm's published roadmap).

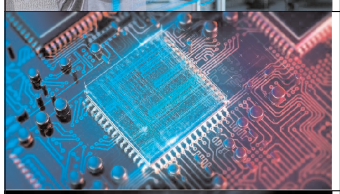
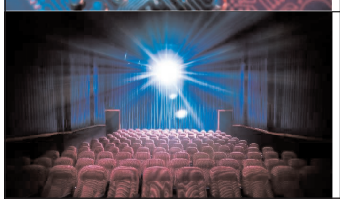
Laser diode product suite

BluGlass is developing bespoke laser diodes across multiple market segments, including industrial, display and biotech applications, which is being driven by specific customer needs within these industries.

The firm says that the advantages of its unique technology have the potential to offer high-power, differentiated laser diode products by using novel designs that leverage low-temperature remote plasma chemical vapor deposition (RPCVD) and active as-grown (AAG) p-GaN technologies. Existing product development spans a range of wavelengths from violet (395nm) through blue to green (525nm) wavelengths for various customer applications (pictured on left).



Discrete LD chips and Chip-on-Submount (C-o-S) from 395nm-525nm in both single-mode (SM) and multi-mode (MM)

Markets		Applications
	Industrial Markets (405nm, 450nm, 525nm)	• Welding Cutting • Machine Vision & Sensing • 3D Printing • Printing
	Display Markets (450nm, 525nm)	• Pico Projector • Business/Cinema Projector • Heads-up-Display • AR/VR
	Biotech/Life Sciences Markets (405nm, 420nm, 450nm, 490nm, 525nm)	• Flow Cytometry • Medical Diagnostics • DNA Sequencing • Endoscopy • Bio-Fluorescence
	Scientific Markets (405,420,450, 490,525)	• Raman Spectroscopy • Confocal Fluorescence Microscopy • Quantum Computing • Optical Clocks • Forensics • Machine Vision
	Lighting Markets (450)	• Automotive Headlamps • Spot-Light / Torch • General Lighting

Aixtron 2800G4 Retrofit

The Aixtron 2800G4 MOCVD system retrofit has now completed hardware assembly and is undergoing final commissioning, testing and software optimization for RPCVD mode in collaboration with equipment partner Aixtron SE of Herzogenrath, Germany.

www.bluglass.com.au

VIGO develops its first VCSEL epiwafers

Poland-based VIGO System S.A. (which makes photodetector, edge-emitting laser and transistor epitaxial wafers) has expanded its product portfolio to new epi-structures for vertical-cavity surface-emitting lasers (VCSELs). The firm says that it has developed its first VCSEL (the first to be manufactured in Poland) in order to demonstrate its capability for meeting increasing customer demands for disruptive epiwafer technology.

With optical power >4mW, low threshold current of 0.6mA and appropriate spectra characteristics, the 850nm VCSEL epi-structure is suitable for telecom and datacom optical applications.

Compared with other infrared technologies, VCSELs offer a highly efficient optical beam, excellent focusing and a very small footprint. Since they emit light perpendicular to the top surface, a VCSEL chip can be integrated into a single, two-dimensional array, consisting of several hundred individual apertures.

So, as well as communication systems, applications for VCSEL products include light detection & ranging (LiDAR), printers, time-of-flight (ToF) sensors, autonomous vehicles (AVs), robots and drones.

The laser was fabricated within the project 'The technology of the production of innovative epitaxial structures and VCSELs' as part of the national program 'Pathway for Mazowsze'. The project consortium includes project coordinator VIGO, Lodz University of Technology, and Warsaw University of Technology.

Wlodek Strupinski, head of VIGO's Epitaxy Division, was responsible for development of the epitaxial technology, VIGO's Marcin Gebski for device processing, and professor Tomasz Czyszanowski of Lodz University of Technology for the laser design. Elements of the processing technology were verified at Poland's Institute of Electron Technology (ITE).

"We have been able to launch the production of this complicated structure in just less than six months after starting up the newly purchased [Aixtron] AIX 2800G4 [metal-organic chemical vapor deposition] system," says Strupinski. "One of the greatest challenges was to achieve extremely high precision — with a single-nanometer accuracy — in layer thickness control (cavity, DBRs, MQWs) in order to rightly position the resonance dip, as required by demanding telecom applications," he adds. "The whole epi-structure is about 7μm thick (which is regarded quite thick) and it consists of more than 200 layers."

Following the launch of its first VCSEL epiwafer, VIGO intends to increase the production of VCSEL epiwafers as well as other innovative epi-structures.

"This is another future technology that VIGO System is adding to its product line," notes CEO Adam Piotrowski. "The production of III–V compound semiconductor epitaxial structures for VCSELs and other photonic and microelectronic devices will enable us to further drive long-term profitable growth."

www.ent-epitaxy.com
www.ite.waw.pl/en

II–VI prices offerings, upscaled from $750m to $800m

Engineered materials and optoelectronic component maker II–VI Inc of Saxonburg, PA, USA has priced its concurrent underwritten public offerings of (i) 9,302,235 shares of its common stock at $43 per share, to yield gross proceeds of about $400m (upscaled from the $350m announced on 30 June); and (ii) 2,000,000 shares of its Series A mandatory convertible preferred stock at a price of $200 per share, to yield gross proceeds of $400m (before deducting the underwriting discounts and commissions and estimated offering expenses).

In addition, II-VI has granted the underwriters a 30-day option to purchase (at the applicable public offering price) up to an additional (i) 1,395,335 shares of its common stock; and (ii) 300,000 shares of Series A mandatory convertible preferred stock (solely to cover over-allotments), minus underwriting discounts and commissions. Each offering closed on 7 July.

Unless earlier converted, each share of Series A mandatory convertible preferred stock will automatically convert on 1 July 2023 (subject to postponement for certain market disruption or other events) into between 3.8760 and 4.6512 shares of II-VI's common stock, subject to customary anti-dilution adjustments.

Dividends on the Series A mandatory convertible preferred stock will be payable on a cumulative basis when, as and if declared by II–VI's board of directors, at an annual rate of 6% on the liquidation preference of $200 per share. If declared, these dividends will be payable in cash, by delivery of shares of II–VI's stock or through any combination of cash and shares, as determined by II–VI in its sole discretion, on 1 January, 1 April, 1 July and 1 October of each year, commencing on 1 October 2020 and ending on, and including, 1 July 2023.

II–VI expects to use up to $714.6m of the net proceeds from these offerings and/or cash on hand to repay borrowings (including accrued interest) under its existing credit agreement, and to use the remainder of net proceeds (if any) to develop, enhance, invest in or acquire related, emerging or complementary technologies, products or businesses and for other general corporate purposes.

BofA Securities, J.P. Morgan and Citigroup acted as joint book-running managers for each offering.

www.ii-vi.com

EU's COSMICC project demos full-data-transfer silicon photonics module delivering 100Gb/s

Building blocks developed for terabits per second

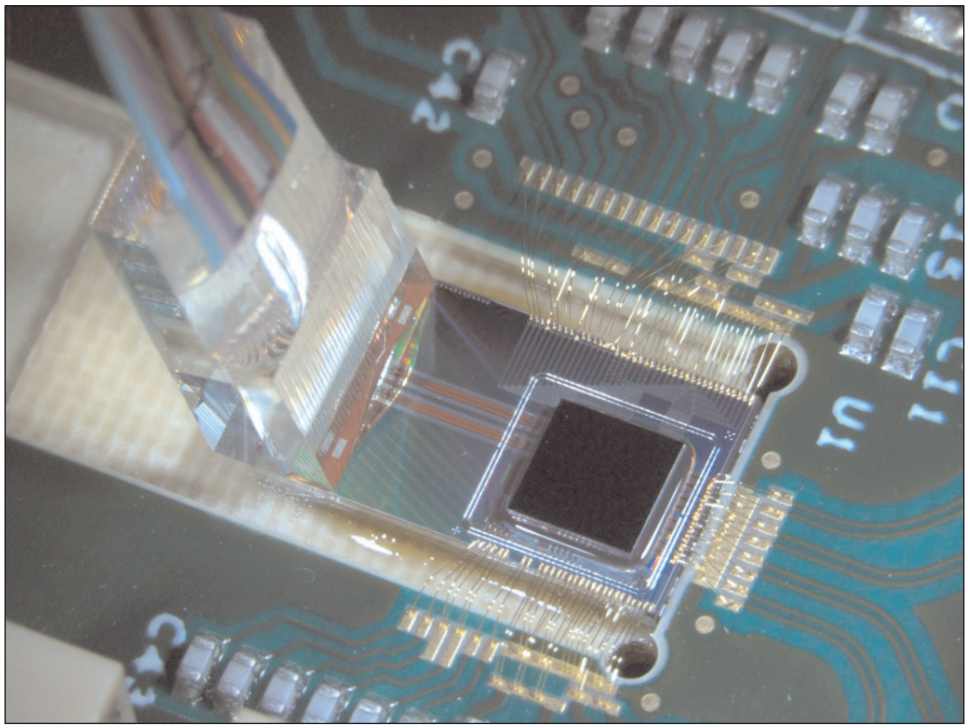
Micro/nanotechnology R&D center CEA-Leti of Grenoble, France has demonstrated a fully packaged coarse wavelength division multiplexing (CWDM) optical transceiver module with data transfer of 100Gb/s per fiber with a low-power-consumption electronic chip co-integrated on the photonic chip. The silicon-photonics-based transceiver multiplexes two wavelengths at 50Gb/s and is designed to meet the ever-increasing datacommunication demands and energy use of data centers and supercomputers.

The European Union (EU) Horizon 2020 project COSMICC (CmOs Solutions for Mid-board Integrated transceivers with breakthrough Connectivity at ultra-low Cost) further developed all the required building blocks for a transmission rate of 200Gb/s and beyond without temperature control with four 50Gb/s wavelengths and by aggregating a large number of fibers.

The key breakthroughs are the development of broadband and temperature-insensitive silicon nitride (SiN) multiplexing components on silicon (Si), the integration of hybrid III–V/Si lasers on the Si/SiN chips, and a new high-count adiabatic fiber-coupling technique via SiN and polymer waveguides.

The demonstration opens the way to technology that allows a reduction in the cost, the power consumption and the packaging complexity and opens the way to reaching a very high aggregated data rate beyond terabits per second (Tb/s).

Starting with STMicroelectronics' silicon photonics integration platform, the COSMICC project developed a CWDM silicon photonics transceiver in a packaged module at 100Gb/s per fiber. It is scalable to 400Gb/s and includes 3D assembly of a silicon photonic chip and its electronic control chip. The silicon photonic chip integrated high-performance 50Gb/s NRZ optical modulators and photodetectors, and a two-channel CWDM multiplexer and demultiplexer. The control electronics was optimized to minimize energy consumption down to 5.7pJ/bit per channel at 50Gb/s data rate.



The COSMICC project's 100G CWDM transceiver, demonstrated by CEA-Leti.

Separately, a library of enabling building blocks for higher-data-rate data-center interconnects was built on a SiN-enhanced silicon photonics platform, including new broadband and athermal SiN components and hybrid III–V/Si lasers. SiN, which is 10 times less sensitive to temperature than silicon, will dramatically reduce the transceiver cost and power consumption by eliminating the need for temperature control and will thus contribute to a reduction in the heat output and cooling costs of mega datacenters.

CEA-Leti's Ségolène Olivier, who coordinated the EU project, says that the development of modulators and photodetectors at 50Gb/s and their co-integration with their control electronics was a breakthrough that led to the low-power-consumption 100Gb/s transceiver module. "In addition, the new building blocks are essential for addressing the need for terabit-per-second transceivers at low cost and low energy consumption to sustain the exponential growth of data traffic in datacenters and in high-performance computing systems," she adds. "COSMICC's technology will answer tremendous market needs with a target cost per bit that traditional WDM transceivers cannot meet."

In addition to CEA-Leti, COSMICC consortium members include:

- Industry: STMicroelectronics Italy & France, Vario-Optics, Seagate, Finisar.
- Academic & institutional: Université Paris Sud, Universita di Pavia, University of Southampton Optical Research Center, University of Saint Andrews, and Cork Institute of Technology.
- Consultants: Ayming.

www.leti.fr
www.h2020-cosmicc.com

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POET and Sanan IC to form $50m joint venture

100–400G optical engines to be based on Optical Interposer platform

POET Technologies Inc of Toronto, Ontario, Canada has signed a non-binding letter of intent (LoI) to establish a joint venture in Xiamen, China with Sanan Integrated Circuit Co Ltd of Xiamen City, Fujian province (China's first 6-inch pure-play compound semiconductor wafer foundry) to manufacture cost-effective, high-performance optical engines based on POET's proprietary CMOS-compatible Optical Interposer platform technology.

The non-binding letter of intent outlines the basic terms and conditions related to the business model and contributions of each of the parties, and is subject to execution of definitive agreements.

The combined commitment of cash and intellectual property from Sanan IC and intellectual property plus expertise from POET will comprise US$50m (once volume production begins, when the JV will then be 53% owned by Sanan IC and 47% owned by POET).

As a subsidiary of ultra-high-brightness LED epiwafer and chip maker Sanan Optoelectronics Co Ltd, Sanan IC's compound semiconductor wafer foundry technology platform serves optical, RF microelectronics and power electronics markets. The JV is expected to design, develop, manufacture, test and sell 100G, 200G and 400G optical engines with customized lasers and photodiodes from Sanan IC combined with optical interposer platform technology from POET. Based on know-how from both companies, such optical engines are engineered for high yield and large-scale to meet the burgeoning market for high-speed datacoms applications, including Internet data centers and 5G carrier networks.

The proposed joint venture aims to offer a new generation of cost-effective, high-performance optical engines based on POET's Optical Interposer to module manufacturers, systems suppliers, data-center operators and network providers globally.

We will be able to offer transceiver manufacturers the ability to span several generations of devices and unlimited scale for high-volume applications

"Combining the advanced wafer foundry manufacturing platform capabilities of Sanan IC with the true wafer-scale and hybrid integration approach of the POET Optical Interposer platform, we will be able to offer transceiver manufacturers the ability to span several generations of devices and unlimited scale for high-volume applications at a highly economical price," believes POET's chairman & CEO Dr Suresh Venkatesan.

"We will employ Sanan IC's flexibility and experience in customized lasers and photodiodes with our advanced foundry manufacturing platform capability and extensive capacity with POET's Optical Interposer platform to enable our joint venture company to offer the market the highest-performance optical engines at a competitive price," says Sanan IC's CEO Raymond Cai.

The global market for optical transceivers will increase at a compound annual growth rate (CAGR) of 10% from US$5.7bn in 2020 to US$9.2bn by 2025, according to MarketsandMarkets Research Private Ltd.

www.sanan-ic.com/tech/3
www.poet-technologies.com

POET extends exercise period for warrants from 2018 public offering

COVID-19 restrictions prompt more time for warrant conversion and stock issuance

In connection with its public offering managed by Toronto-based Cormark Securities Inc (which was completed on 21 March 2018), POET has extended the original two-year exercise period again, to 30 September, for a total of 12,545,350 common share purchase warrants granted to investors, all of which are exercisable at C$0.75 per share. The expiry of the warrants was previously extended from 23 March to 23 July.

All other terms and conditions of the warrants remain unchanged. The warrant extension, approved by the board of directors, has been accepted by the firm's warrant agent TSX Trust and the TSX Venture Exchange.

"We have been alerted by investment banks and others in the financial community that the processing of transactions such as warrant conversions and stock issuances are taking longer with the COVID-19 restrictions, as many of the employees of these companies and agencies continue to work from home," notes executive VP & chief financial officer Thomas Mika. "The purpose of this extension is to ensure that the warrant holders have enough time to complete the exercise process, should they decide to do so."

CW-WDM Multi-Source Agreement Group forms to drive industry standard for laser sources

Spec sets stage for artificial intelligence, data-center efficiency and advanced optical interconnects

The CW-WDM MSA (Continuous-Wave Wavelength Division Multiplexing Multi-Source Agreement) Group has been formed as an industry consortium dedicated to defining and promoting specifications for multi-wavelength advanced integrated optics.

IEEE and MSA standards specify four WDM interfaces for existing high-volume datacom optics. Emerging advanced integrated optics applications, such as silicon photonics (SiPh)-based high-density co-packaged optics, optical computing and artificial intelligence (AI), are expected to move to 8, 16 and 32 wavelengths. Standardizing higher wavelength counts is a crucial part of an emerging ecosystem that is enabling a leap in efficiency, cost and bandwidth scaling compared with current technology. Increasing the number of wavelengths, while staying in the O-band and aligning with ITU and IEEE standards, allows developers and suppliers to leverage their strategic investments in the current generation of optical products to accelerate time to market of next-generation products.

"We support and encourage consortiums like the CW-WDM MSA Group in order to accelerate important technical innovations," says Christopher Berner, head of Compute at OpenAI. "OpenAI must be on the cutting edge of AI capabilities, and low-latency, high-bandwidth optical interconnect is a central piece of our compute strategy to achieve our mission of delivering artificial intelligence technology."

The CW-WDM MSA is different from optical communication standards groups in that it focuses solely on specifying the laser source instead of the full communications link, and is not targeted at any specific application. Such an approach allows developers to fully optimize optics to their customers' requirements without interoperability constraints while simultaneously creating a large business opportunity for laser source suppliers.

"Laser sources have been the critical building block of fiber-optic communications, and standardizing their specifications has been key to the success of telecom and datacom optics," says CW-WDM MSA chair Chris Cole. "ITU-T established complete baselines for DWDM and CWDM grids. The IEEE then specified subsets of these grids for high-volume data-center applications, starting with 40G and 100G Ethernet optics," he adds. "The CW-WDM MSA will similarly leverage ITU-T and IEEE standards to specify 8-, 16- and 32-wavelength grids in O-band for emerging advanced datacom and computing optics. With the definition of multiple grid sets, the MSA will enable developers to choose what is optimum for their application while allowing laser suppliers to only have to invest in one technology platform."

Promoter Members of the CW-WDM MSA are Arista Networks, Ayar Labs, CST Global, imec, Intel, Lumentum, Luminous Computing, MACOM, Quintessent, Sumitomo Electric, and II–VI.

In addition, several Observer Members have signed on to be briefed on the development of the standard to enable early technology development based on the new specifications. Observer Members are AMF, Axalume, Broadcom, Coherent Solutions, Furukawa Electric, GlobalFoundries, Keysight Technologies, NeoPhotonics, NVIDIA, Samtec, Scintil Photonics, and Tektronix.

www.cw-wdm.org

NeoPhotonics demos 90km 400ZR transmission in 75GHz DWDM channels, enabling 25.6Tbps-per-fiber

End-to-end ZR link test completed by using 400ZR interoperable pluggable modules and 75GHz MUX and DEMUX

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 completed experimental verification of the transmission of 400Gbps data over data-center interconnect (DCI) ZR distances in a 75GHz-spaced dense wavelength division multiplexing (DWDM) channel.

NeoPhotonics achieved two milestones using its interoperable pluggable 400ZR coherent modules and its specially designed athermal arrayed waveguide grating (AWG) multiplexers (MUX) and de-multiplexers (DMUX). First, data rate per channel increases from today's non-interoperable 100Gbps direct-detect transceivers to 400Gbps interoperable coherent 400ZR modules. Second, the existing DWDM infrastructure can be increased from 32 channels of 100GHz-spaced DWDM signals to 64 channels of 75GHz-spaced DWDM signals. The total DCI fiber capacity can thus be increased from 3.2Tb/s (100Gb/s/channel x 40 channels) to 25.6Tb/s (400Gb/s/channel x 64 channels), which is a total capacity increase of 800%.

NeoPhotonics says that its technology overcomes multiple challenges to transporting 400ZR signals in 75GHz-spaced DWDM channels. The 400ZR signal utilizes an approximately 60Gbaud symbol rate and 16 QAM modulation, resulting in a broader transmitting signal spectrum compared to that of a standard 100Gb/s coherent or PAM4 signals. Furthermore, it is recognized that the center frequencies of the lasers, MUX and DMUX will all drift due to temperature changes and aging. Consequently, as the channel spacing is reduced from 100GHz to 75GHz, adjacent channel interference (ACI) becomes more critical, and can potentially degrade the optical signal-to-noise ratio of 400ZR signals.

The filters used in the MUX and DMUX units are designed to limit ACI while at the same time having a stable center frequency against extreme temperatures and aging. The optical signal spectrum of the pluggable 400ZR transmitter is very important for two reasons. First, the spectrum should not be too wide, as that would result in 'spillover energy' impacting its neighboring DWDM channels. Second, it also cannot be too narrow, as that would degrade the signal quality or even recoverability, especially after the MUX and DMUX filtering.

NeoPhotonics has demonstrated end-to-end 90km DCI links using three in-house 400ZR pluggable transceivers with their tunable laser frequencies tuned to 75GHz spaced channels, and a pair of passive 75GHz-spaced DWDM MUX and DMUX modules designed specifically for this application. The optical signal-to-noise ratio (OSNR) penalty due to the presence of the MUX and DMUX and the worst-case frequency drifts of the lasers, as well as the MUX and DMUX filters, is less than 1dB. The worst-case component frequency drifts were applied to emulate the operating conditions for aging and extreme temperatures.

"The combination of compact 400ZR silicon photonics-based pluggable coherent transceiver modules with specially designed 75GHz-channel-spaced multiplexers and de-multiplexers can greatly increase the bandwidth capacity of optical fibers in a DCI application and consequently greatly decrease the cost per bit," says chairman & CEO Tim Jenks. "These 400ZR coherent techniques pack 400Gbps of data into a 75GHz-wide spectral channel, placing stringent requirements on the multiplexers and de-multiplexers," he adds. "We are uniquely able to meet these requirements because we do both design and fabrication of planar lightwave circuits and we have 20 years of experience addressing the most challenging MUX/DMUX applications."

www.neophotonics.com

Infinera appoints two directors, raising board size to 11

Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide (InP)-based photonic integrated circuits (PICs), has appointed George Riedel and Christine Bucklin to its board of directors. Riedel has executive leadership experience in the global networking and cybersecurity industries and track record in strategy and mergers and acquisitions (M&A). Bucklin has experience in operations, strategic planning and management consulting.

"George's deep knowledge of the networking industry and his breadth of strategic experience as a senior technology executive will be invaluable to Infinera as we focus on building shareholder value," comments chairman Kambiz Hooshmand. "Christine's diversity of thinking, together with her strong operational experience and strategic discipline, will continue to strengthen the skills and perspectives of our board as Infinera continues to drive our innovative solutions into the world's leading network operators and the entire optical ecosystem."

Riedel has been a senior lecturer in the General Management Unit at Harvard Business School since 2017. From 2014 to 2017, he was chairman & CEO of cybersecurity company CloudMark Inc, overseeing its sale to Proofpoint Inc in 2017. From 2006 to 2011, he served in executive leadership roles at Canadian telecoms and data networking equipment manufacturing company Nortel Networks Corp, including as chief strategy officer and vice president of Business Units. From 2003 to 2006, Riedel was VP of strategy and M&A at networking and cybersecurity company Juniper Networks. From 1987 to 2003, he worked at McKinsey & Company, including as a senior partner. Riedel has served as an independent director at technology company Xperi Corp since 2013 and at health information technology company Cerner Corp since April 2019. Between 2010 and 2017, he also served on various boards, including as chairman of Canadian network communications software firm Accedian Networks Inc and as a director for caching solution provider PeerApp Ltd and compliance innovation company NextDocs Corp (acquired by Aurea Software, Inc). Riedel has a BS with distinction in Mechanical Engineering from the University of Virginia and an MBA from Harvard Business School.

Bucklin was managing director Operations Group at private equity firm Gryphon Investors Inc from 2015 to 2018. From 2008 to 2010, she was senior VP, Corporate Strategic Planning at technology company Sun Microsystems Inc, prior to its acquisition by Oracle Corp in 2010. From 1999 to 2007, Bucklin was chief operating officer of internet media company Internet Brands Inc. From 1988 to 1999, she worked at consulting company McKinsey & Company, including as a partner. From 2011 to 2019, she was a director for radio station and event firm Local Media San Diego LLC. From 2015 to 2018, she served as a director for Leadership Platform Acquisition Corp, a portfolio company of Gryphon Investors related to educational services. Bucklin has an AB in Mathematics from Dartmouth College and an MBA from Stanford Business School.

In connection with the appointments, Infinera's board of directors increased from nine to 11 members. Riedel will serve as a Class I director with a term expiring at the 2023 Annual Meeting of Stockholders and Bucklin will serve as a Class III director with a term expiring at the 2022 Annual Meeting of Stockholders. Bucklin is the independent designee as defined in the letter agreement between Infinera and Oaktree Optical Holdings L.P. dated 13 April.

www.infinera.com

AOI elects new director and Audit Committee member

Applied Optoelectronics Inc (AOI) of Sugar Land, TX, USA — which designs and makes optical components, modules and equipment for fiber access networks in the Internet data-center, cable TV broadband, fiber-to-the-home (FTTH) and telecom markets — says that, at its annual meeting of shareholders, Elizabeth G. Loboa Ph.D. was elected to its board and has been appointed to the Audit Committee.

Loboa succeeds Alan Moore, who had served on the board since 2013. "I would like to thank Alan for his many contributions during his seven-year tenure and as a member of our Audit Committee," says CEO & chairman Dr Thompson Lin.

"Elizabeth brings valuable and complementary skills and expertise to our board," he adds. Loboa is vice chancellor for strategic partnerships at the University of Missouri and is on the board of directors for the Missouri Innovation Center. Previously, she was a professor and associate chair of the Joint Department of Biomedical Engineering at University of North Carolina-Chapel Hill and North Carolina State University and a director of the Cell Mechanics Laboratory at the Joint Department of Biomedical Engineering at University of North Carolina-Chapel Hill and North Carolina State University.

Loboa has a B.S. in Mechanical Engineering from the University of California, Davis, an M.S.E in Biomechanical Engineering from Stanford University, and a Ph.D. in Mechanical Engineering from Stanford University. She is a Fellow in the Biomedical Engineering Society, American Institute for Medical and Biological Engineering, and the National Academy of Inventors. From 6 July, Loboa is provost and vice president for Academic Affairs at Southern Methodist University.

www.ao-inc.com

Phosphorus-free S-band InAs quantum dot lasers on SOI

Growing InGaAs buffer layers over a trench grating in silicon-on-insulator can improve material quality, yielding the first 1.5μm InAs QD laser on SOI substrate.

Researchers based in China claim the first 1.5μm-wavelength indium arsenide (InAs) quantum dot (QD) laser on silicon-on-insulator (SOI) substrate without phosphorus-based intermediate layers [Wen-Qi Wei et al, Optics Letters, vol45, p2042, 2020].

The team from Wuhan University, Beijing National Laboratory for Condensed Matter Physics and Institute of Physics, and Songshan Lake Materials Laboratory, hope for deployment in photonic integrated circuits (PICs) on silicon. The 1.5μm infrared wavelength falls in one of the major optical communications bands — for S-band optical fibers, covering 1460–1530nm. The team sees their work as potentially providing "a cost-effective and compact platform to realize the on-chip light source of PICs for long-haul telecommunications".

The SOI layers were produced in a dual-chamber III-V/IV semiconductor solid-source molecular beam epitaxy (MBE) system: 3μm buried silicon dioxide (BOX), and 340nm silicon top layer. The substrate was then patterned and dry etched with 280nm deep U-shaped trenches with 360nm period and 220nm spacing. The trenches were oriented along the [110] direction of the silicon crystal lattice.

The team then grew further silicon and gallium arsenide (GaAs) layers over the trenches, which left hollow gaps with (111) facets in the region of the trenches (Figure 1). The technique was based on previous work that was shown to result in ultralow-defect-density material.

Further epitaxial layers included a dislocation filter with InGaAs/GaAs and indium aluminium arsenide

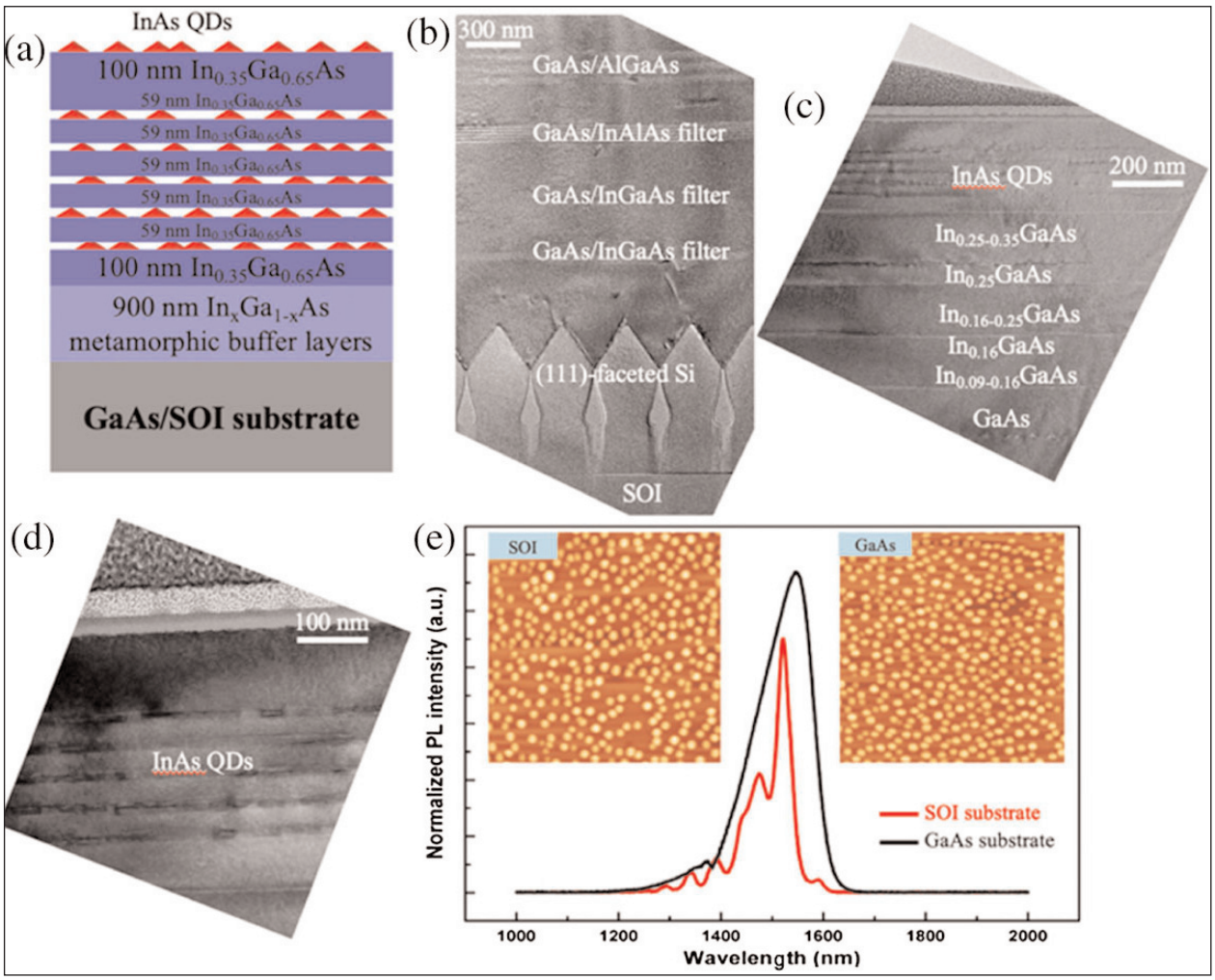

Figure 1. (a) Schematic diagram of five-layer QDs grown on GaAs/SOI platform with InGaAs metamorphic buffer layer. (b)–(d) Cross-sectional transmission electron microscope images of GaAs-on-SOI template, InAs/InGaAs metamorphic structure, and InAs QDs, respectively. (e) Room-temperature PL spectra of five-layer QD structure on SOI (red curve) and GaAs (black curve) substrates. Inset: 1μmx1μm atomic force microscope images of surface QDs.

(InAlAs)/GaAs quantum well structures designed to block threading dislocations from reaching the active photonic region. A further GaAs/AlGaAs superlattice was aimed at giving a smooth surface for subsequent growth.

In between the filter layers/superlattice the indium content of the InGaAs buffer material was increased in steps from 9% to 35%. The growth temperature was relatively low, at 380°C. Thermal cycle annealing at 510°C was carried out to further smooth the layer surfaces.

The QD layers consisted of 3.1 monolayer InAs, followed by $In_{0.35}Ga_{0.65}As$ layers: a 14nm 425°C cap and a 45nm 500°C spacer.

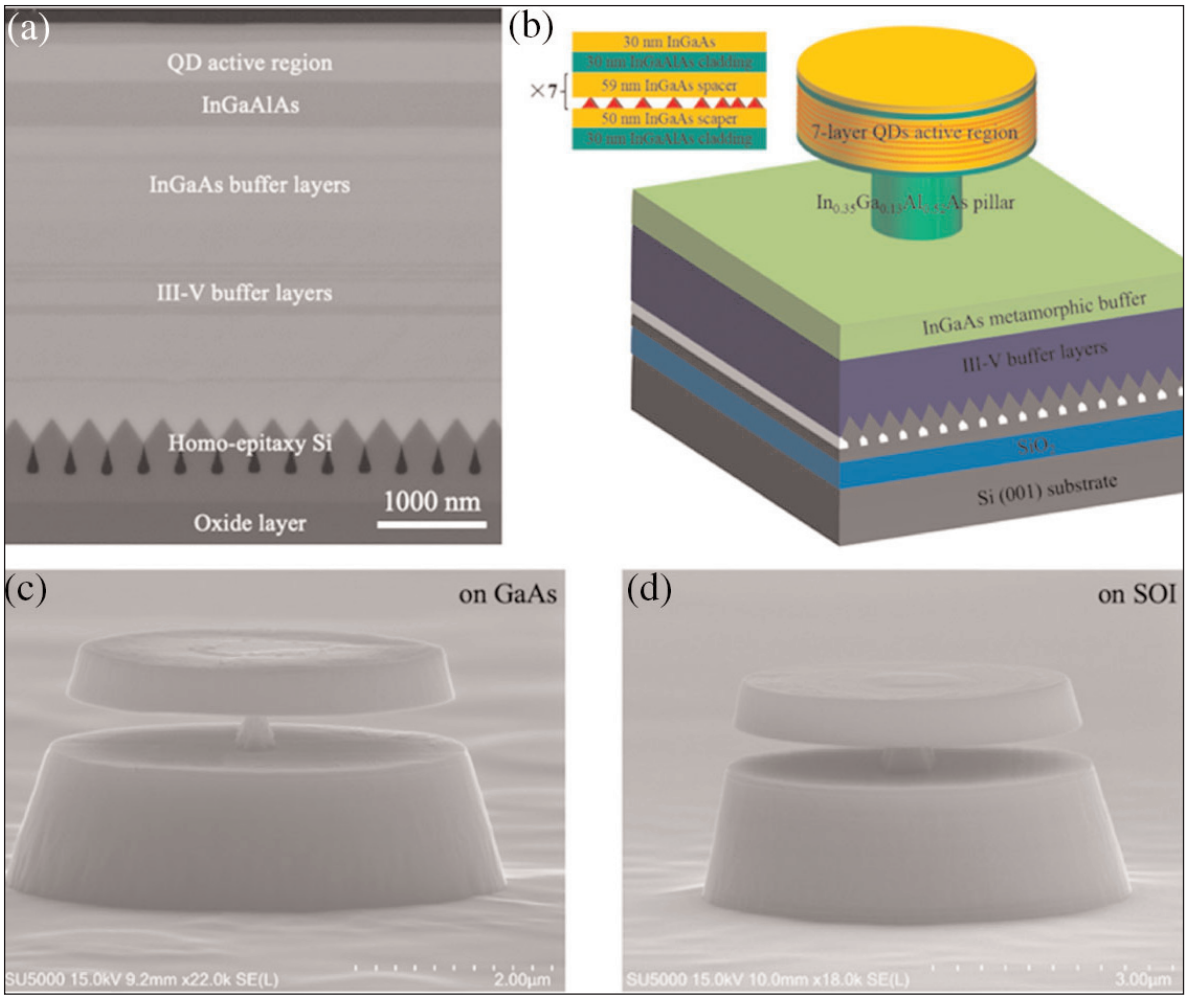

Figure 2. (a) Cross-sectional scanning electron microscope (SEM) image of microdisk sample on SOI substrate. (b) Schematic of microdisk laser. Inset: schematic of active region. (c), (d) Tilted SEM images of microdisk lasers on GaAs and SOI platforms.

Photoluminescence (PL) spectra showed that material with five layers of QDs on SOI produced a peak that was 80% that of a similar structure grown on pure GaAs substrate. The corresponding dot densities were $3.56x10^{10}/cm^2$ and $4.24x10^{10}/cm^2$, according to atomic force microscopy. The PL spectra on SOI had multiple peaks, which the team suggests could be due to varying Fabry–Perot cavity interference effects from reflections at the underlying grating in the hollow SOI and the top surface of the sample.

Samples with seven QD layers were processed for microdisk fabrication. The epitaxial material also included 600nm $In_{0.35}Ga_{0.13}Al_{0.52}As$ as a sacrificial layer for the etch process used in fabrication. This layer was also used to create a supporting pillar for the microdisk (Figure 2). InGaAlAs layers were also used as 30nm cladding layers around the QD active region.

The microdisks were fabricated by using silica beads as hard masks for a two-step etch process: mesa etching, using a dry plasma process, followed by a dip in hydrochloric acid, under-cutting the disks, removing InGaAlAs material and creating the support pillars.

The lasing experiments were carried out on 4μm-diameter microdisks at 200K. The optical pumping power for threshold was found to be 234μW for devices on SOI substrate, compared with 43μW for microdisks on pure GaAs substrates. The researchers suggest that the much increased threshold on SOI was due to lower optical gain of the QDs and a lower rate of heat dissipation in the silicon dioxide layer relative to GaAs.

The laser spectrum consisted of two main peaks at 1468nm and 1428nm on GaAs, and at 1512nm and 1467nm on SOI. The SOI microdisk spectra also experienced some red shift as the pump power increased, further indicating thermal effects.

Along with improving the thermal management for room-temperature operation, the team hopes to reduce the buffer thickness to enable laser-waveguide coupling for PIC applications. The researchers write: "To solve this issue, we intend to grow an embedded III–V laser structure on the bottom silicon of the SOI substrate (beneath the BOX layer) to allow butt coupling, by pre-patterning the laser epi-area on the SOI substrate." ■

https://doi.org/10.1364/OL.389191

Author: Mike Cooke

Lower thresholds for InAs quantum dash laser on silicon

HKUST has used a range of defect reduction strategies to improve the potential for 1.3μm- and 1.5μm-wavelength optoelectronics platforms.

Hong Kong University of Science and Technology (HKUST) has reduced the threshold current for indium arsenide (InAs) quantum dash (QDash) laser diodes on an indium phosphide (InP) on on-axis (001) silicon (Si) template [Wei Luo et al, Appl. Phys. Lett., vol116, p142106, 2020].

The devices emitted at 1.3μm wavelength, but the researchers believe that tuning the metal-organic chemical vapor deposition (MOCVD) growth process could enable ~1.5μm emissions as well. These wavelengths fall in the key optical communication O- and C-bands of 1260–1360nm and 1530–1565nm.

The team comments: "This platform offers a feasible path toward achieving O-band and C-band lasers using the same InP-based material system by the manufacturing-friendly MOCVD process, benefiting silicon-based on-chip optical interconnects."

Confined QDash regions enable lower threshold, less temperature sensitivity, and larger modulation bandwidths, compared with quantum well light-emitting structures. Further, the confinement of QDashes results in them being less subject to defects such as threading dislocations.

The use of on-axis (001) Si opens the way to integration with efficient complementary metal-oxide-semiconductor (CMOS) mainstream electronics, lower material costs, and economies of scale from larger-diameter substrates.

The team used low-pressure MOCVD to build the epitaxial material on gallium arsenide (GaAs) on V-grooved (GoVS) and unpatterned (GoPS) on silicon.

One defect reduction technique involved 5x thermal cyclic annealing (TCA) at 800°C after a high-temperature 600°C step of GaAs growth on GoVS. The GoPS template used a 4-cycle TCA. Further measures included two superlattice layers of InGaAs/GaAs in the GaAs buffer. The total thickness of the GaAs part of the template structure on GoVS was 2μm, while the GoPS structure was only 1.1μm.

The 3.1μm InP template section also included superlattices to deflect and filter out threading dislocations. The researchers estimated that the defect density of InP/GoVS and InP/GoPS templates were $2.75 \times 10^8/cm^2$ and $3.54 \times 10^8/cm^2$, respectively, according to transmission electron microscope analysis. The researchers point out that recent advances in GaAs-on-Si templates have resulted in defect densities of order $10^6/cm^2$.

Growth continued to the laser layers with n-InP, InAs/InAlGaAs QDashes, and p-InGaAs/InP. Zinc was

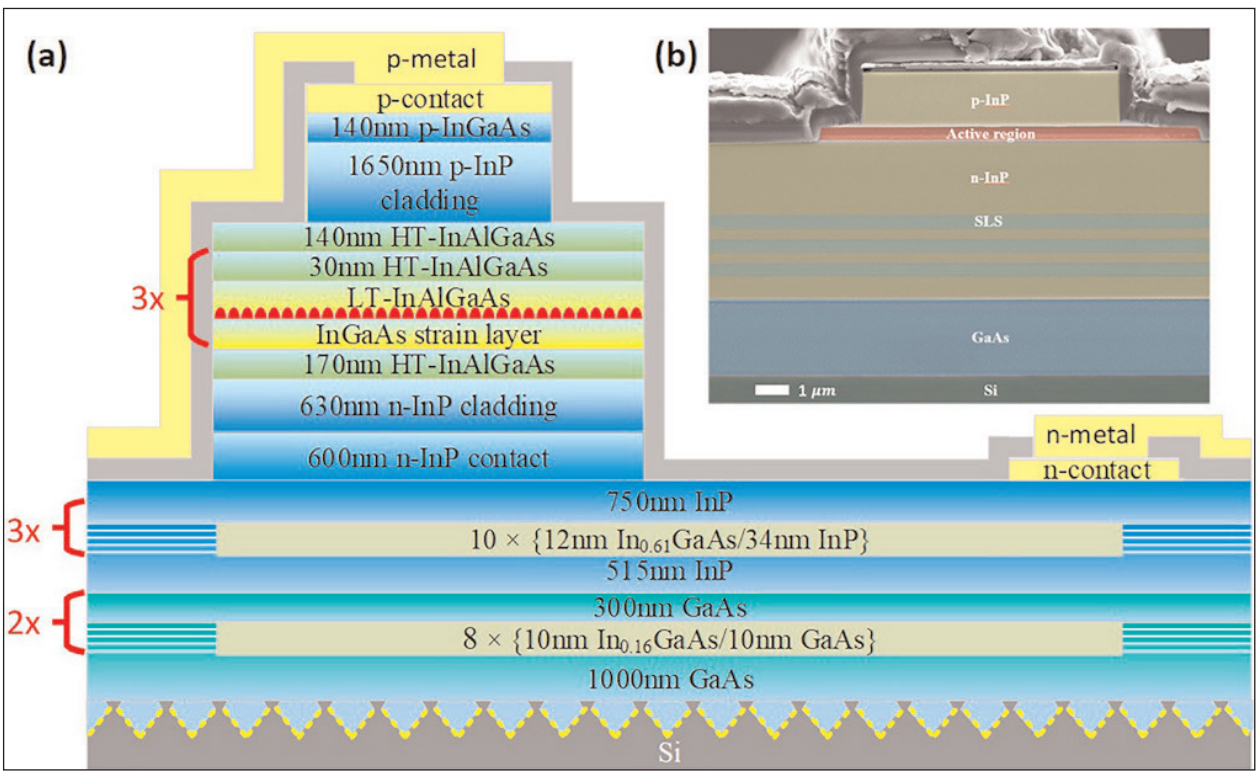

Figure 1. (a) InAs/InAlGaAs QDash laser device on V-grooved Si; (b) color-enhanced scanning electron microscope image of Fabry–Pérot laser device with mirror-like facet.

used as the p-dopant. The QDashes were self-assembled with a 5-second growth interruption, allowing the 510°C InAs to separate into dashes. The indium aluminium gallium arsenide (InAlGaAs) matrix for the dashes was grown in two steps: first at low temperature to avoid desorption of the dashes, and then at 630°C as a spacer from the next QDash layer.

The density of QDashes was estimated to be 2.5x10^{10}/cm^2, according to atomic force microscopy. The accumulated strain in the structure resulted in some vertical alignment between the dashes in the different layers.

Photoluminescence measurements showed a 45nm difference in emission wavelengths for the GoVS and GoPS templates: ~1300nm for GoPS and ~1350nm for GoVS. "The wavelength discrepancy is speculated to be related to the different residual strain and surface temperature of the two templates," the team writes.

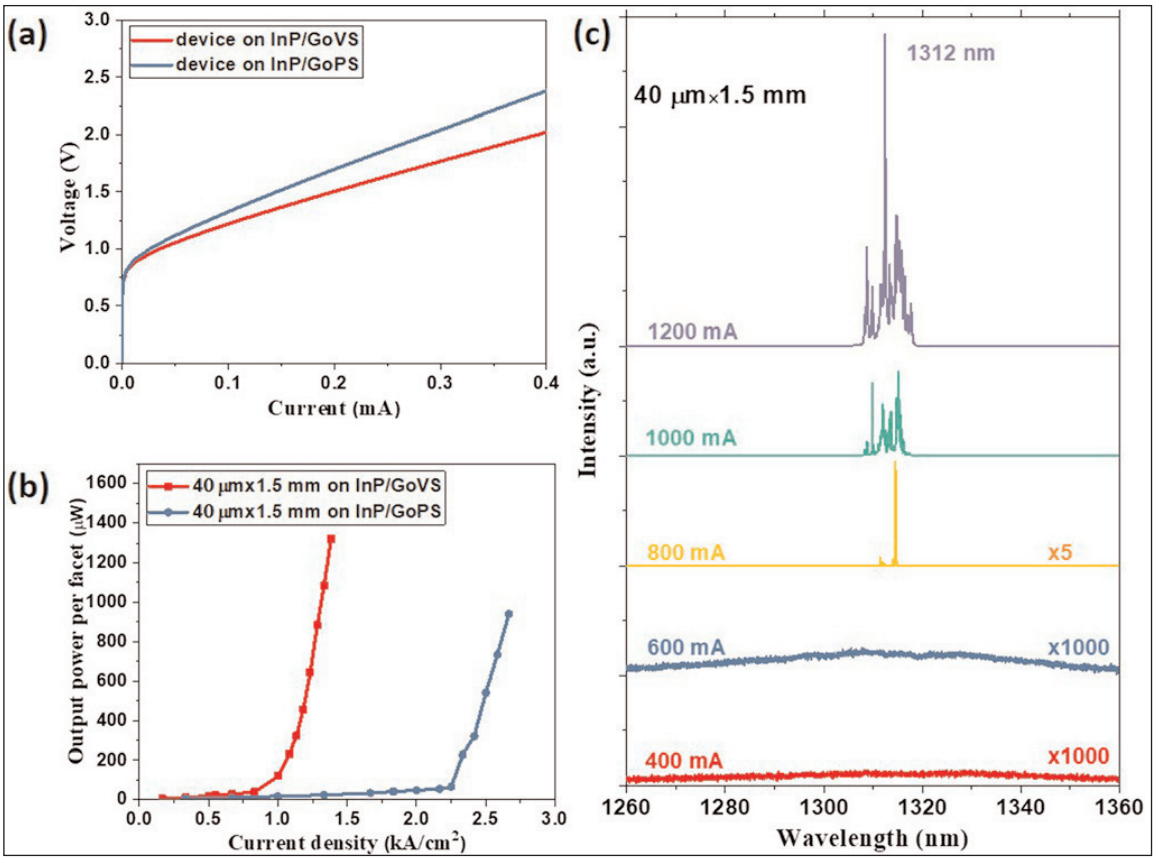

Figure 2. (a) Current–voltage curves of different size InAs QDash lasers grown on InP/GoVS and InP/GoPS; (b) current light output power curves of 40μmx1.5mm InAs QDash lasers on InP/GoVS and InP/GoPS; (c) emission spectrum of 40μmx1.5mm InAs QDash lasers.

The photoluminescence on the GoVS template was about half the intensity of that of the GoPS structure. Even so, the laser diodes on GoVS had a lower threshold, compared with the GoPS sample (Figure 2).

The researchers explain: "This is primarily because the QDash growth condition was initially optimized on InP/GoPS instead of on InP/GoVS, resulting in a weaker PL intensity for QDashes on InP/GoVS. However, the material quality, regarding defect density and surface roughness, of the InP/GoVS accounts for the more appealing device result."

The team, therefore, expects that further optimization will improve the photoluminescence on GoVS and enable continuous-wave operation. The present devices were only tested under 400ns, 0.5% duty cycle pulsed operation at room temperature.

The lowest threshold current density for the laser diodes on GoVS came in at 1.05kA/cm^2 for a 40μmx1.5mm cavity. The single-facet light output power reached 22mW without roll-over in a 20μmx1mm device.

A 40μmx1.5mm laser cavity on GoPS managed a 2.24kA/cm^2 threshold current density. A 20μmx1mm device on GoPS continued lasing up to 70°C. Devices on GoVS are said to have a "similar" temperature performance.

As the current increased above threshold, multi-mode spectra were produced in these devices. The emissions were around 1.3μm wavelength. The researchers say that tuning the QDash growth could produce 1.5μm emission.

The active QDash region was sandwiched in a separate-confinement heterostructure with InAlGaAs spacers and InP cladding.

The materials were processed into ridge-waveguide lasers through photolithography, dry etching, and metallization. The metal contacts were placed laterally on the top-side of the epitaxial layers. This avoided current flow through the highly defective buffer layers.

On InP substrate, vertical top-to-bottom current flow is possible, which has advantages in terms of avoiding current crowding and so on. The device wafers were finally thinned to about 100μm thick, and cleaved into wafer bars. The cleaved mirror facets were not coated to enhance reflectivity. ■

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Author: Mike Cooke

Room-temperature continuous-wave 1.55µm quantum dash laser diodes on silicon

HKUST has claimed the first electrically pumped room-temperature CW lasing of 1.55µm QDash lasers grown on patterned on-axis (001) silicon by MOCVD.

Hong Kong University of Science and Technology (HKUST) in China has claimed "the first electrically pumped room-temperature (RT) CW [continuous wave] lasing results of 1.55µm quantum dash (QDash) lasers directly grown on patterned on-axis (001) Si [silicon] using metal-organic chemical vapor deposition (MOCVD)" [Ying Xue et al, Optics Express, vol28, p18172, 2020].

Previously, 1.55µm QDash laser diodes had achieved pulsed operation at RT in work by members of the HKUST team. The researchers have also recently reported on reducing threshold currents of 1.3µm-wavelength QDash pulsed laser diodes [www.semiconductor-today.com/news_items/2020/may/hkust-210520.shtml].

Such devices are desired to enable monolithic opto-electronics capabilities on silicon for communications through the optimum wavelength for 1.55µm optical fibers. MOCVD is the preferred material growth technology in III-V manufacturing, compared with much slower molecular beam epitaxy (MBE). A CW 1.55µm laser diode is the vital link to plugging the gap between

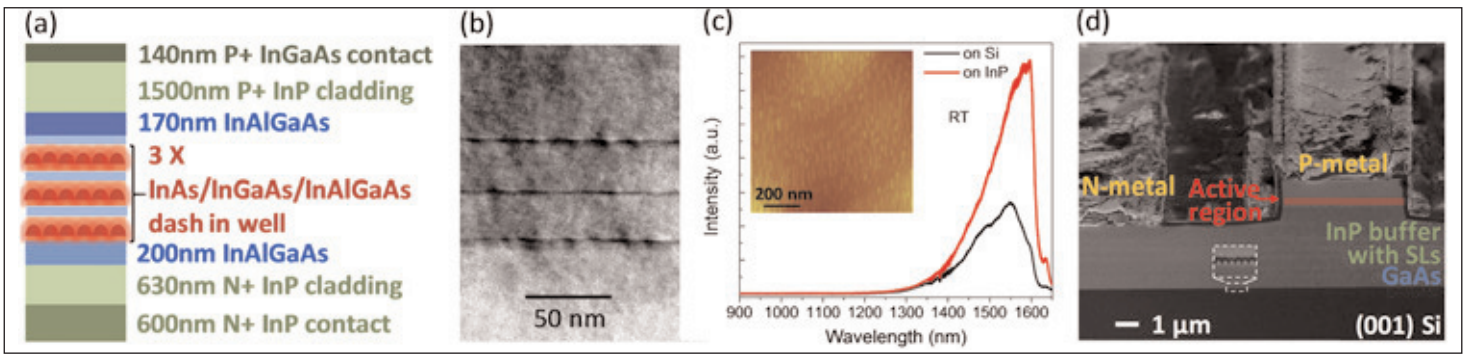

Figure 1. (a) Laser structure schematic; (b) TEM image of three layers of QDashes; (c) room-temperature PL of three-layer QDashes grown on Si and InP substrates (inset: AFM of QDashes); (d) tilted-scanning electron microscope view of fabricated device 6µm-wide waveguide with zoomed-in patterned V-groove silicon.

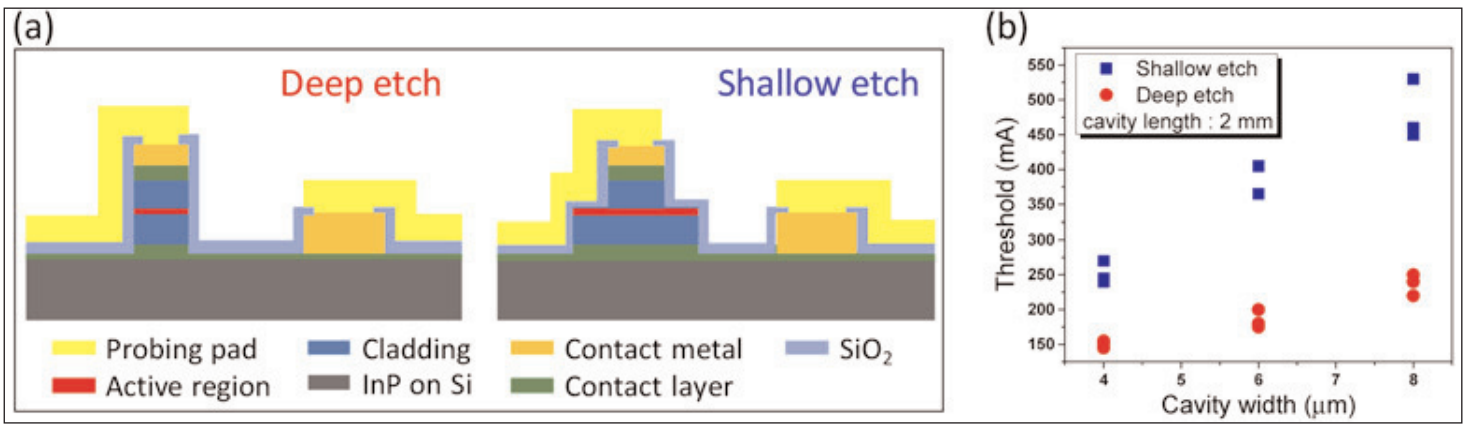

Figure 2. (a) Schematic of finalized devices with deep- and shallow-etched structures; (b) threshold currents plotted as a function of various cavity widths with 2mm cavity length.

silicon complementary metal-oxide-semiconductor (CMOS) electronics and photonics via silicon waveguides and out-coupling to fibers.

Direct growth of III–V laser materials is preferred over the presently successful wafer bonding techniques, which are limited in the longer term regarding scalability, cost and fabrication compatibility.

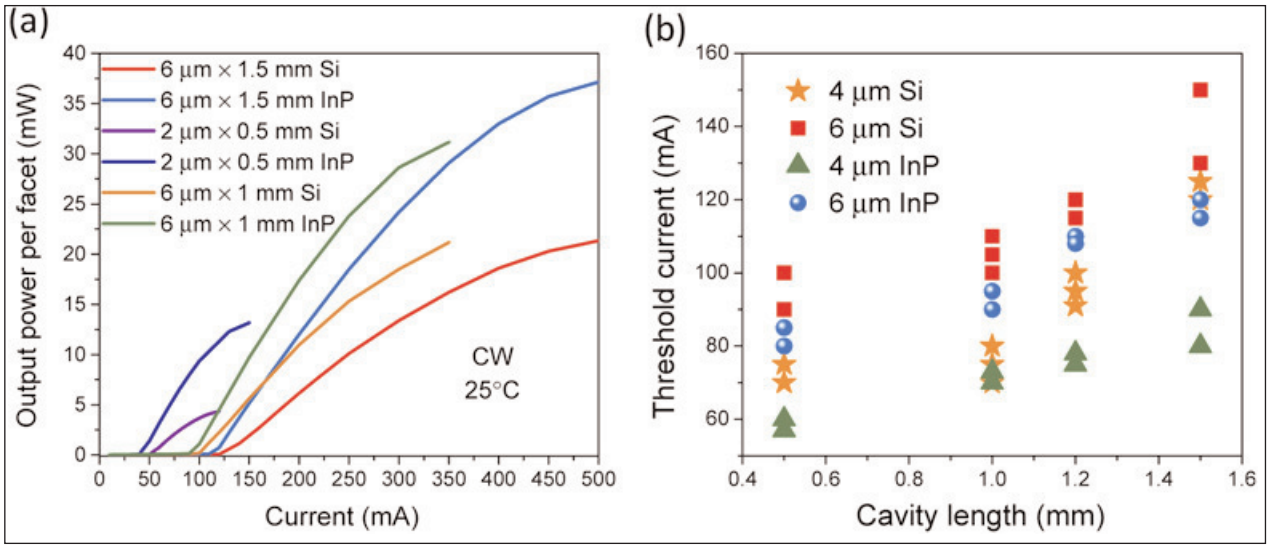

Figure 3. (a) Light output power versus current curves of lasers on silicon and native InP substrate; (b) threshold current distribution of QDash lasers on silicon compared with lasers on InP at various cavity lengths and widths.

The researchers used substrates with V-groove patterns etched into the surface, enabling all epitaxial layers to be grown by MOCVD, including the initial 1.1μm gallium arsenide (GaAs) buffer. The actual laser layers were grown on a 3.1μm indium phosphide (InP) template layer.

The InP buffer included three sets of strained-layer superlattices, which each consisted of 10 periods of 12nm/34nm $In_{0.63}Ga_{0.37}As$/InP pairs. The surface roughness of the InP layer was 2nm, root mean square, according to atomic force microscopy (AFM). The threading dislocation density was estimated to be $3.6x10^8/cm^2$, obtained through plan-view transmission electron microscopy (TEM).

The active region of the laser (Figure 1) consisted of three QDash-in-well structures. The InAlGaAs step contained 24% aluminium in the III–metal mix. The InGaAs cap was grown at low temperature. The structure was optimized with AFM measurements and photoluminescence (PL) experiments, which aimed at increasing emission intensity and shrinking linewidth. The final QDash density was $3.2x10^{10}/cm^2$. The p-InP cladding layer was doped with zinc.

The material was fabricated into deep-etched narrow ridge-waveguide laser diodes with titanium/platinum/gold and germanium/gold/nickel/gold p- and n-electrodes, respectively. Silicon dioxide in a 550nm layer was used as passivation. Cleaved laser bars were characterized without facet coating.

Laser diodes based on traditional quantum-well structures typically use shallow-etching techniques to reduce optical losses at sidewalls (Figure 2). These considerations are not so critical for QDash emission due to reduced carrier diffusion lengths in such structures. The deep-etched structure also avoids electrical losses from current spreading in the n-contact region.

A 6μmx1.5mm laser bar achieved a CW threshold current density of $1.3kA/cm^2$ and more than 44mW light output power. The device was placed on a heatsink with a temperature controller.

Spectral analysis showed the peak wavelength blue-shifted as the threshold was approached, before settling into single-mode operation at 1580nm above threshold. The laser diode emission was red-shifted relative to the PL study, due to thermally induced refraction index changes.

The researchers compared their devices on silicon with the same structures produced on InP substrates (Figure 3). In fact, the InP-based devices were found to have "somewhat lower" thresholds compared with QDot laser diodes reported in the scientific literature in work by University of Kassel, Germany.

In real systems, laser diodes need to operate at above room temperature due to electrically induced heating. The reduced threshold performance at increased temperature had a T0 characteristic of 44.8K between 25°C and 50°C on silicon. The T_0 value reduced above that to 27.11K up to 59°C. The T_0 for the device on InP was 41K between 25°C and 60°C. A higher T_0 indicates a slower degradation in threshold performance.

Both silicon- and InP-based devices were able to sustain pulsed lasing performance up to 100°C. The silicon-substrate threshold current density was $555A/cm^2$ at room temperature with 400ns pulses at a 0.5% duty cycle. Output power reached more than 360mW. The T_0 values for silicon- and InP-substrate laser diodes were around 60K in pulsed mode. ■

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Author: Mike Cooke

Optical transceiver market to more than double to $17.7bn by 2025

The COVID-19 pandemic is affecting telecoms globally, negatively impacting transceiver module sales in 2020, says Yole Développement.

Optical transceiver revenue is increasing at a compound annual growth rate (CAGR) of 15% from $7.7bn in 2019 to more than double, to about $17.7bn, in 2025, reckons Yole Développement in its report 'Optical Transceivers for Datacom & Telecom 2020'

"This growth will be driven by high-volume adoption of expensive high data rates including 400G and 800G modules by big cloud service operators," says Martin Vallo PhD, technology & market analyst Solid-State Lighting technologies, in Yole's Photonics, Sensing & Display division. "Therefore, such players invest more and more in new data centers and, on top of that, telecom operators have also increased their investments into the 5G networks that use wireless optical transceivers," he adds.

High demand from data-center and telecom operators has been confirmed as follows:

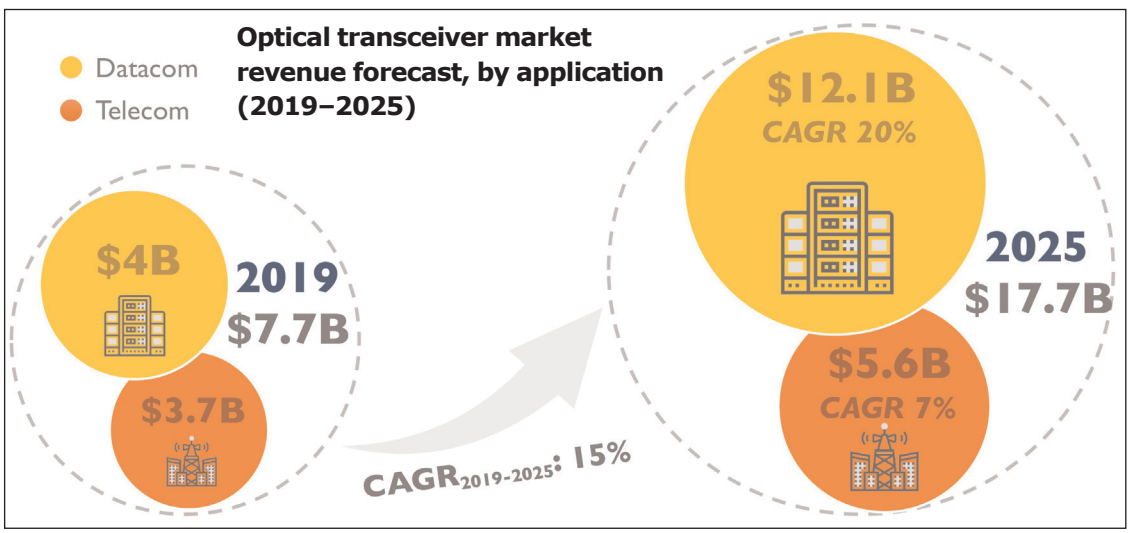
- Datacom transceiver module revenue growth at about 20% CAGR will be driven by the adoption of expensive higher-data-rate optical modules, migrating from core/spine networks down to inter-rack connections.
- Telecom transceiver module revenue growth at a 5% CAGR will be driven by coherent technologies for data-center interconnect (DCI) optical transport solutions and 5G optical transceivers deployment in Asia.

The sharp difference in revenue growth is caused by lower sales expectation in 2020 due to the COVID-19 pandemic. In addition, total revenue is expected to rise only moderately in 2020 due to the effect of the pandemic. Indeed, COVID-19 is naturally affecting telecommunications globally and hence sales of optical transceiver modules. However, demand from data-center operators for optical modules is very strong in China, pushed by the local government. Its strategy is focused mainly on 5G deployment and the development of cloud data centers.

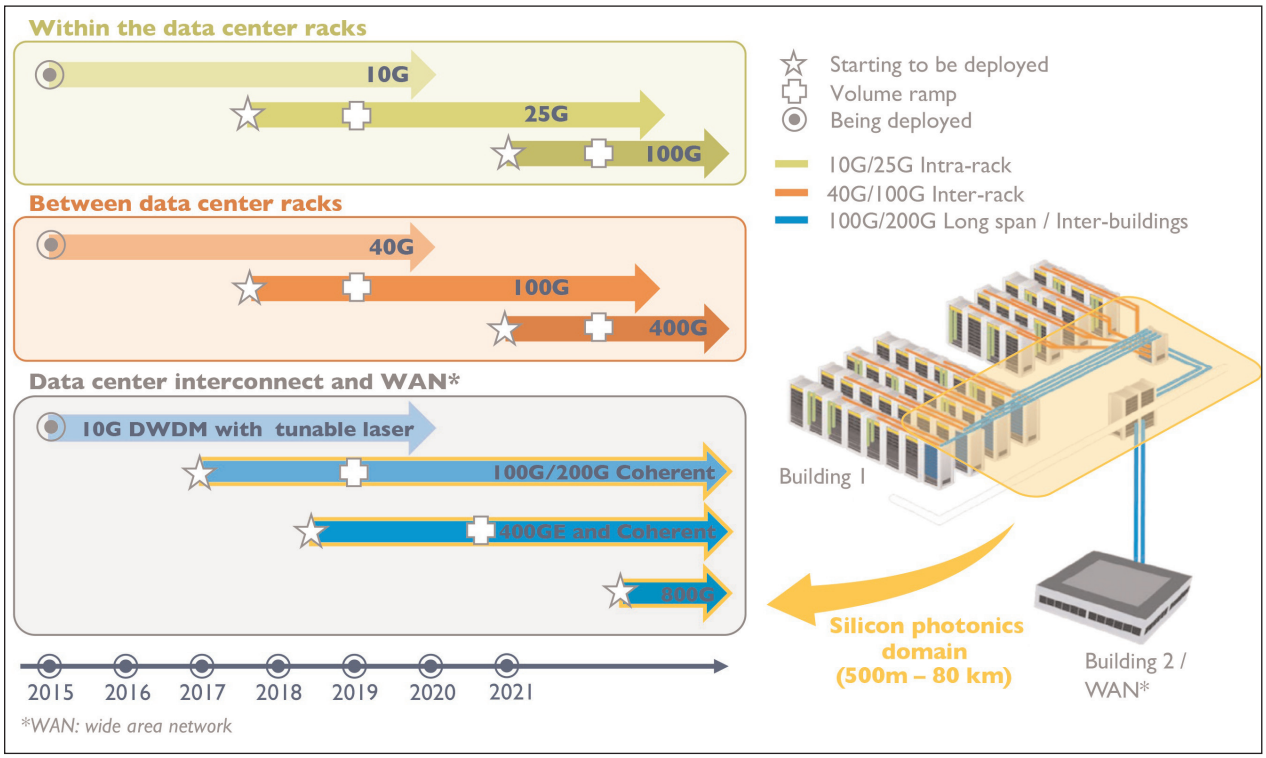
"The state of the art of fiber-optic communication technologies has advanced dramatically over the past 25 years," notes Pars Mukish, business unit manager, Solid-State Lighting (SSL) & Display at Yole. "The highest capacity of commercial fiber-optic links available in the 1990s was only 2.5–10Gb/s, while today they can carry up to 800Gb/s. The last decade of developments has enabled higher-efficiency digital communication systems and solved problems with degraded signals."

Network traffic growth has been increasing at an enormous pace over the decades and across all the network architectures from the long-haul, mobile access to intra-data-center networks. This growth has been driven by streaming ultra-high-definition (UHD) videos (which need ever higher data throughput) and now newly emerging digital applications and services requiring fast access to the digital networks. It appears that the success and demand for existing applications is continuously driving the scale and capacity of the underlying network infrastructure (including optical transceivers) to points where further applications are enabled, renewing the cycle.

Optical transceivers are widely used in server network cards, switches, routers and wireless base-station



Optical transceiver market revenue forecast, by application (2019–2025)



Optical transceiver migration to higher datacom speeds.

equipment in a variety of network architectures and applications. Distances covered start from less than 50m for server and storage interconnections in data centers and enterprise networks to more than 800km in telecom networks.

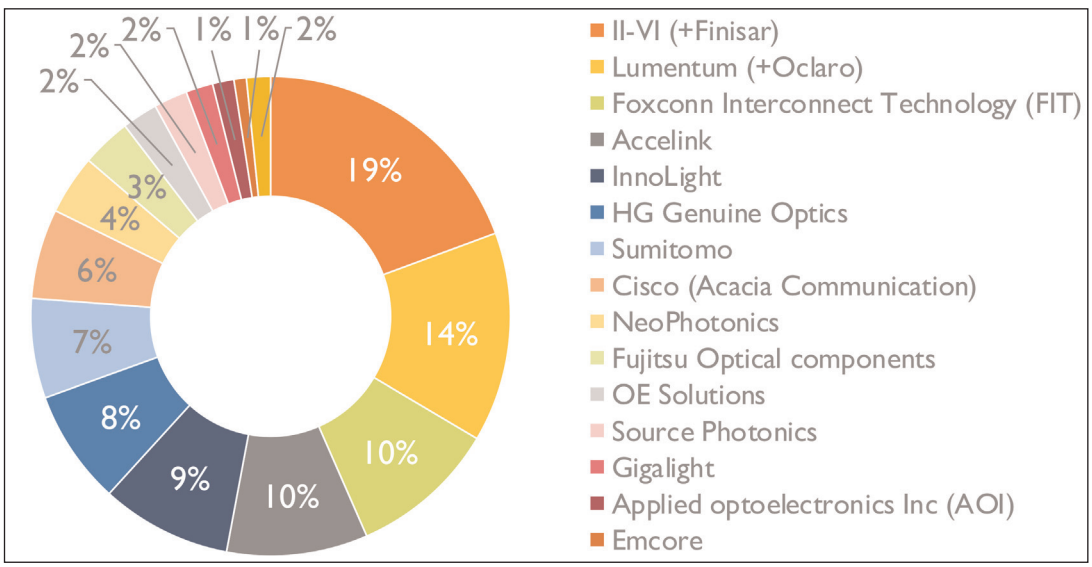
The evolution of multiple technologies has enabled transmission speed of 400G and beyond in long-haul and metro networks. Today's trend of migration to 400G speeds stem from cloud operators' demand to interconnect data centers. Furthermore, the exponential increase in digital communication network capacity and the growing number of optical ports is impacting optical module technology hugely. The new form factors are increasingly universal and designed to reduce their size and thus power consumption. Inside modules, the optics and integrated circuits are getting closer together.

Silicon photonics hence may represent a key enabling technology for the further development of optical interconnect solutions needed to address growing traffic. This technology will play an important role in 500m–80km distance applications, reckons Yole. The industry is working on the heterogeneous integration of indium phosphide (InP) lasers directly onto silicon chips. The advantage is scalable integration and the elimination of cost and complexity of the optical package. Reduced efficiency and lower optical power at high temperature are typical challenges for these lasers.

"Besides increasing speed by integrating amplifiers, the higher data throughput is also achieved by integrating state-of-the-art digital signal processing chips, providing different multi-level modulation techniques such as PAM4 or QAM," notes Eric Mounier PhD, Fellow Analyst at Yole. "Another technique to increase data rates is parallelization or multiplexing, which enables increasing capacity using parallel fibers or different wavelengths onto a single fiber," he adds.

Progress in the integration of optical component technologies has led to dramatic reductions in the complexity and cost of optical transceivers. The massive growth in bandwidth has yielded a 10–100-fold decrease in cost per transmitted bit, Yole concludes. ■

www.i-micronews.com/products/optical-transceivers-for-datacom-telecom-2020



Market shares of top 15 optical transceiver module suppliers (2019).

Continuous-wave lasing from InGaN microdisk laser diodes on silicon

Researchers in China have reduced the serial resistance and optical loss in a p-type cladding superlattice by lowering the carbon concentration.

Researchers based in China claim the first room-temperature continuous-wave electrically pumped indium gallium nitride (InGaN) microdisk laser diode (LD) grown on silicon (Si) substrate [Jin Wang et al, Optics Express, vol. 28, p12201, 2020].

The team from University of Science and Technology Beijing, Suzhou Institute of Nano-Tech and Nano-Bionics, University of Science and Technology of China, and Tsinghua University, hope that their work could benefit optical storage, and chemical and biological sensing applications, among others. The team further suggests that such laser diodes could be used to power optoelectronic integration with III–N waveguides and visible light communication (VLC) on a low-cost mass-production silicon platform.

The smaller sizes of microdisk laser diodes, compared with conventional ridge-waveguide Fabry–Perot structures, tend to favor low threshold currents and also give higher-quality factors.

Up to now, only pulsed operation has been achieved in InGaN microdisk laser diodes. In 2018, China-based researchers from Suzhou Institute of Nano-Tech and Nano-Bionics, University of Science and Technology of China, and Changchun Institute of Optics Fine Mechanics and Physics

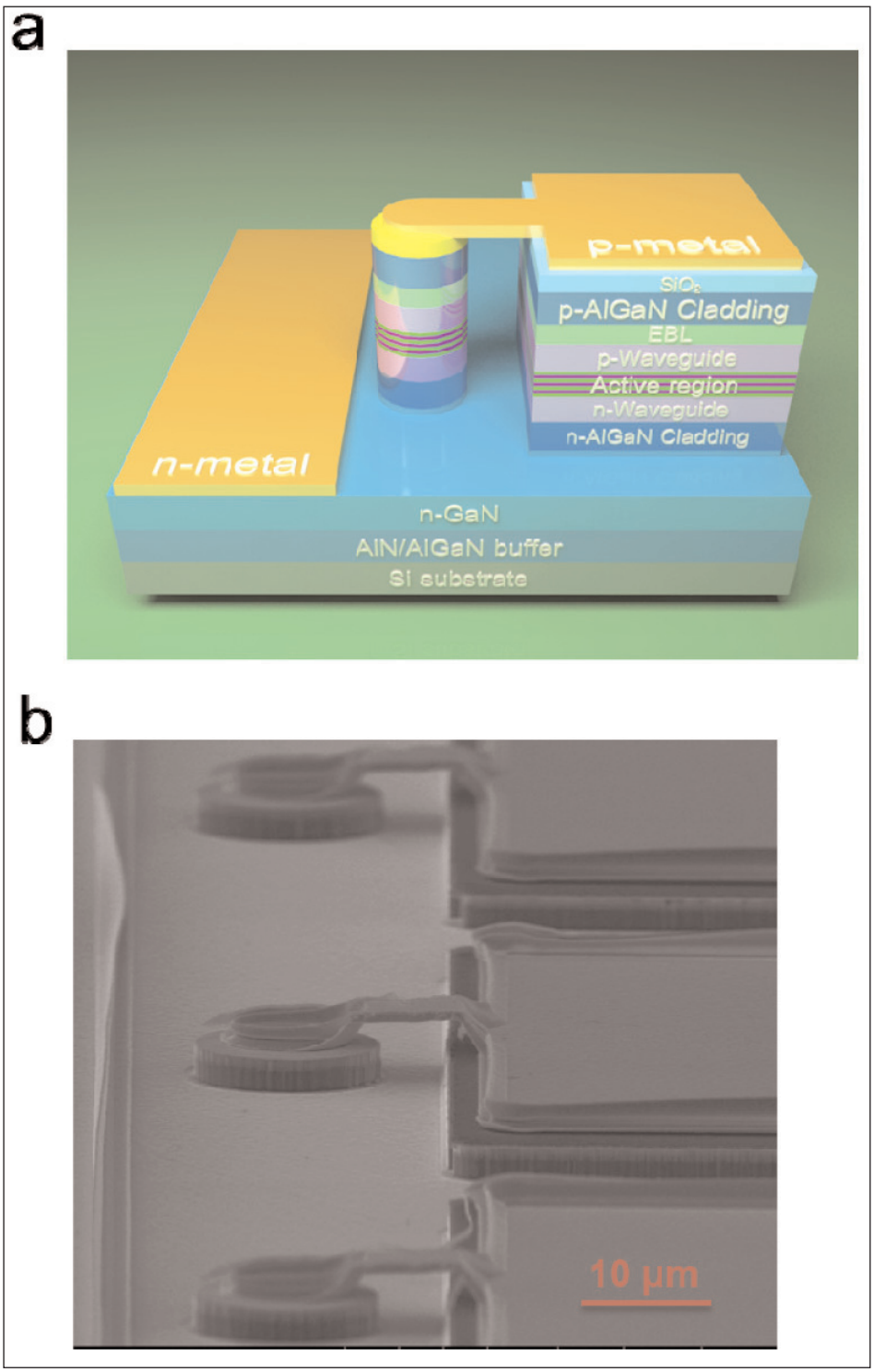


Figure 1. (a) Schematic of GaN-based microdisk laser on silicon with air-bridge electrode structure, (b) bird's-eye-view scanning electron microscope image of microdisk laser diode array.

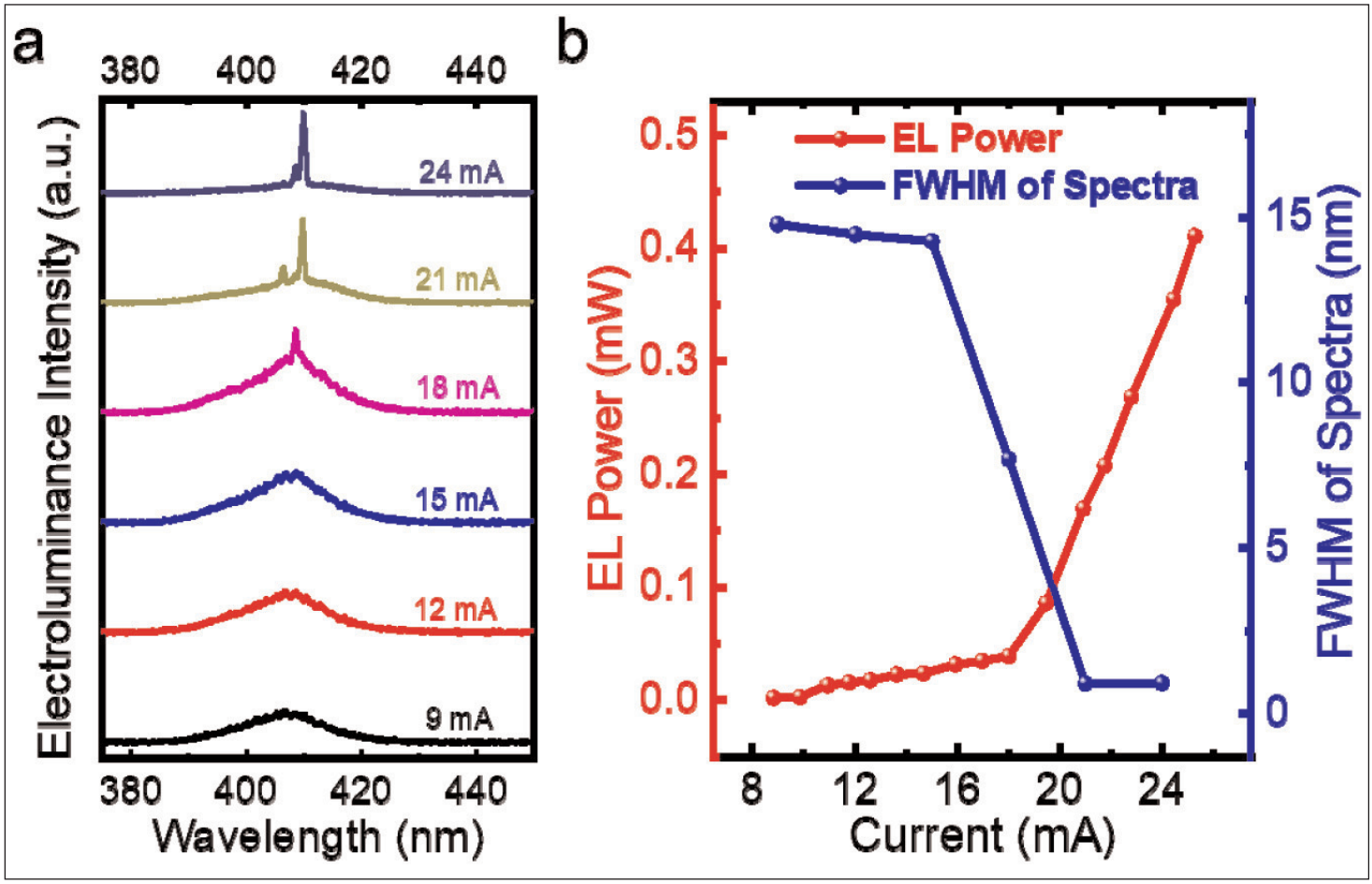


Figure 2. (a) Electroluminescence spectra of microdisk laser diode under continuous-wave current injection. (b) Full-width at half maxima of spectra and light output power as function of CW injection current.

reported pulsed operation of microdisk structures on silicon [www.semiconductor-today.com/news_items/2018/mar/sin_120318.shtml].

The latest research began their work by optimizing the p-type gallium nitride/aluminium gallium nitride (GaN/AlGaN) superlattice cladding layers to reduce series resistance and optical losses. In particular, the carbon contents of the layers were reduced from $2x10^{18}/cm^3$ to $2x10^{17}/cm^3$ by slowing the growth rate from 17.4nm/minute to 8.7nm/minute, respectively.

The growth rate was slowed down by reducing the flow rates of the Ga and Al metal-organic precursors. Another technique to reduce carbon content would have been to increase the deposition temperature, but this would damage the InGaN active light-emitting layers. The slower growth enabled a lower growth temperature, avoiding InGaN damage.

Up to now, only pulsed operation has been achieved in InGaN microdisk laser diodes. When the reduced-carbon p-clad material was fabricated into 8μm-radius microdisk laser diodes, using previously reported techniques, a CW lasing threshold current was achieved around 18mA. Under pulsed operation, a slightly lower threshold of 15mA was found

Top-ring contact 20μm-radius (10μm inner ring) micro-LDs with reduced-carbon p-cladding showed reduced series resistance and optical loss. In particular, the threshold current was reduced from 240mA to 60mA.

Unfortunately, the thermal management properties of the 20μm laser diode were not sufficient to achieve room-temperature continuous wave (CW) operation. By contrast, when the reduced-carbon p-clad material was fabricated into 8μm-radius microdisk laser diodes (Figure 1), using previously reported techniques, a CW lasing threshold current was achieved around 18mA (Figure 2). Under pulsed operation, a slightly lower threshold of 15mA was found.

The researchers see the relatively small difference in threshold as "indicating that the influence of self-heating on the device performance was greatly suppressed because of the improved epitaxial structure and reduced microdisk size".

The emission peak was around 407nm wavelength, and the full-width at half maximum (FWHM) linewidth reduced to around 0.5nm above threshold injection. ■

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Author: Mike Cooke

GaAs wafer market growing at 10% CAGR to more than $348m by 2025

VCSELs and micro-LEDs will drive the gallium arsenide wafer market for the next five years, forecasts Yole Développement.

The total gallium arsenide (GaAs) wafer market is rising at a compound annual growth rate (CAGR) of 10% from US$200m in 2019 to more than US$348m by 2025, estimates Yole Développement's new technology & market analysis report 'GaAs Wafer and Epiwafer Market: RF, Photonics, LED, Display and PV Applications 2020'.

"RF is the historical market driver for GaAs wafers. In 2019 it represented 33% of market volume and 37% of market value. RF represents 67% of the GaAs epiwafer open market," notes Ezgi Dogmus PhD, a member of the Power & Wireless division at Yole. "GaAs RF demand is mainly driven by handset evolution, with the transition to 5G resulting in greater penetration of GaAs power amplifiers (PAs) for the high-end sub-6GHz phones," he adds.

"In the past few years, the GaAs wafer market has been dominated by RF application," notes Ahmed Ben Slimane PhD., technology & market analyst specialized in Compound Semiconductors. "As of 2020, photonics and LEDs represent the main drivers for this markets," he adds.

Photonics has a 5% share of GaAs wafer volume, corresponding to a $24m market. However, the photonics market will grow at a double-digit CAGR over 2019–2025, dominated by GaAs vertical-cavity surface-emitting laser (VCSEL) technology. In this context, photonics applications represent 32% of the GaAs epiwafer open market.

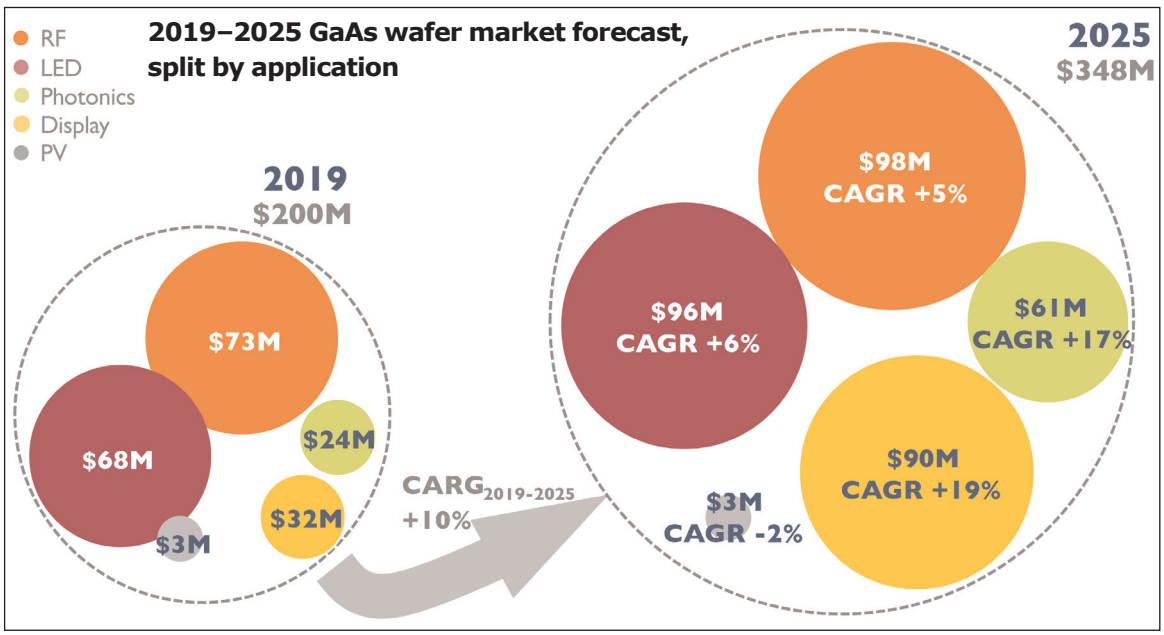
With the transition of LEDs from low-end applications to high-end applications (such as horticultural lighting or automotive), LEDs still represent the highest GaAs wafer market volume, with a 41% share. Automotive will be the main driver for visible LEDs and infrared (IR) LEDs, with a dynamic 6% CAGR estimated over 2019–2025.

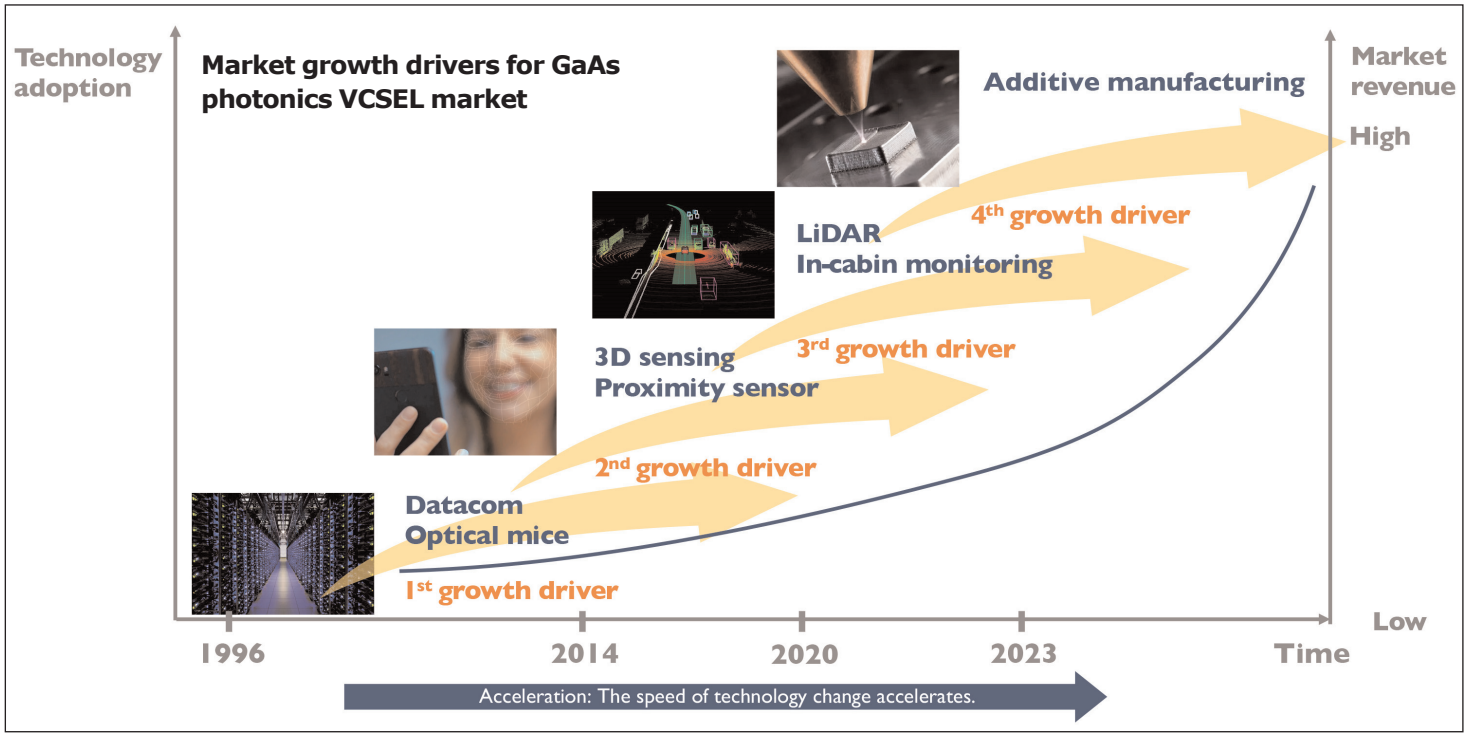
Driven by hot new applications such as micro-LEDs, GaAs will find another source of growth in the display market, which is growing at a CAGR of 19% over 2019–2025, reckons Yole.

The 2020 edition of the 'GaAs Wafer and Epiwafer Market' report also takes into account the COVID-19 outbreak and its impact on multiple industries directly linked to GaAs-based technologies.

Without doubt consumer and automotive market segments will be strongly modified by the crisis. Consequently, the compound semiconductor team at Yole has included three different scenarios in the report, focused especially on market evolution and production recovery.

In the mobile market segment, Yole forecasts that the most likely scenario is a drop in production of 20% in 2020 compared with 2019. Also, some major original equipment manufacturers (OEMs) such as Samsung and Apple have re-positioned their products. In fact, due to a reduction in household income, OEMs expect





a shift from high-end to mid-range and even entry-level smartphones. Regarding automotive applications, Yole forecasts a drop in production of about 30%.

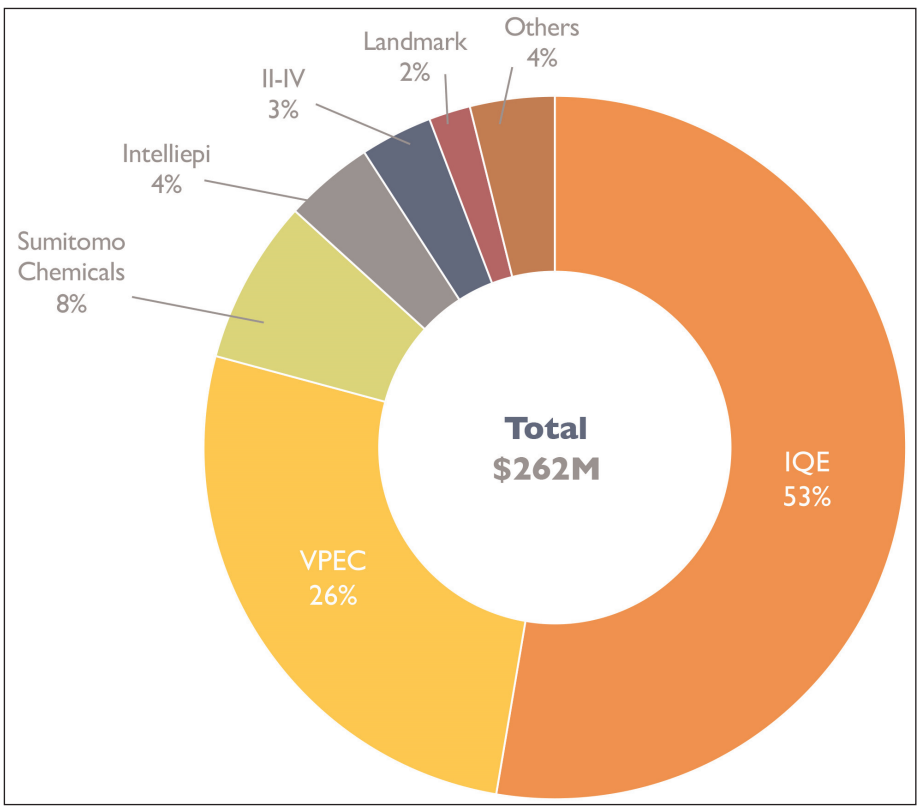
From a supply-chain perspective, the GaAs epiwafer supply chain is constantly changing, notes Yole.

"In the photonics market, the epiwafer business model is application dependent," notes Slimane. "In datacom, it is mostly integrated, dominated by Finisar, Avago and II-VI. However, for 3D sensing and other VCSELs for smartphones, manufacturers prefer to outsource the epitaxy, a less complicated strategy adopted by Apple, which is supplied by IQE," he adds. "IQE remains the biggest epiwafer supplier, with 61% photonic epiwafer market share in 2019. But, with increased adoption of 3D sensing, numerous players such as VPEC, II–VI, Sumitomo Chemicals and Landmark are ramping up their production."

The RF GaAs epitaxy market is about 90% outsourced. Previously it was largely dominated by IQE, but it has lost share to the Chinese–Taiwanese supply chain. As of 2019, IQE and VPEC represent more than 80% of the RF epi market. The LED epiwafer market remains almost entirely integrated within very well-established companies like Osram, San'an, Epistar and Changelight.

In terms of GaAs wafer supply, Freiberger, Sumitomo Electric, AXT and Vital Materials led the market in 2019. The top players have a bigger market share in high-end applications and, due to stringent laser-grade wafer specifications, they will maintain their advantage for the next 5–8 years, reckons Yole. Having only recently entered the market with low-end products for LEDs, the outlook for new Chinese GaAs suppliers is challenging, the firm adds. Also, their transition to high-end products and expansion out of China is risky due to potential IP infringement issues, Yole reckons. ■

www.i-micronews.com/products/gaas-wafer-and-epiwafer-market-rf-photonics-led-display-and-pv-applications-2020



Gallium arsenide open epiwafer market share.

Increasing wet etch rate in gallium nitride by thermal enhancement

Researchers have achieved 25nm/minute etching speed using contactless photo-electrochemical etch with sulfate radical oxidation and UV exposure.

Researchers based in Japan claim a ten-fold increase in gallium nitride (GaN) contactless photo-electrochemical (CL-PEC) etch based on sulfate radical (SO_4^-) oxidation from increasing the temperature of a persulfate ($S_2O_8^{2-}$) ion solution and 254nm-wavelength ultraviolet (UVC) exposure [Fumimasa Horikiri et al, Appl. Phys. Express, vol13, p046501, 2020]

The team from SCIOCS Co Ltd, Hosei University, Koganei, and Hokkaido University, believe that the 25nm/minute rate could lead to a rate sufficient for through-via fabrication processes. A narrow-bandgap indium gallium nitride (InGaN) layer would allow the design of CL-PEC lift-off etch processes, which are impossible where there is only a single bandgap to respond to incoming photons.

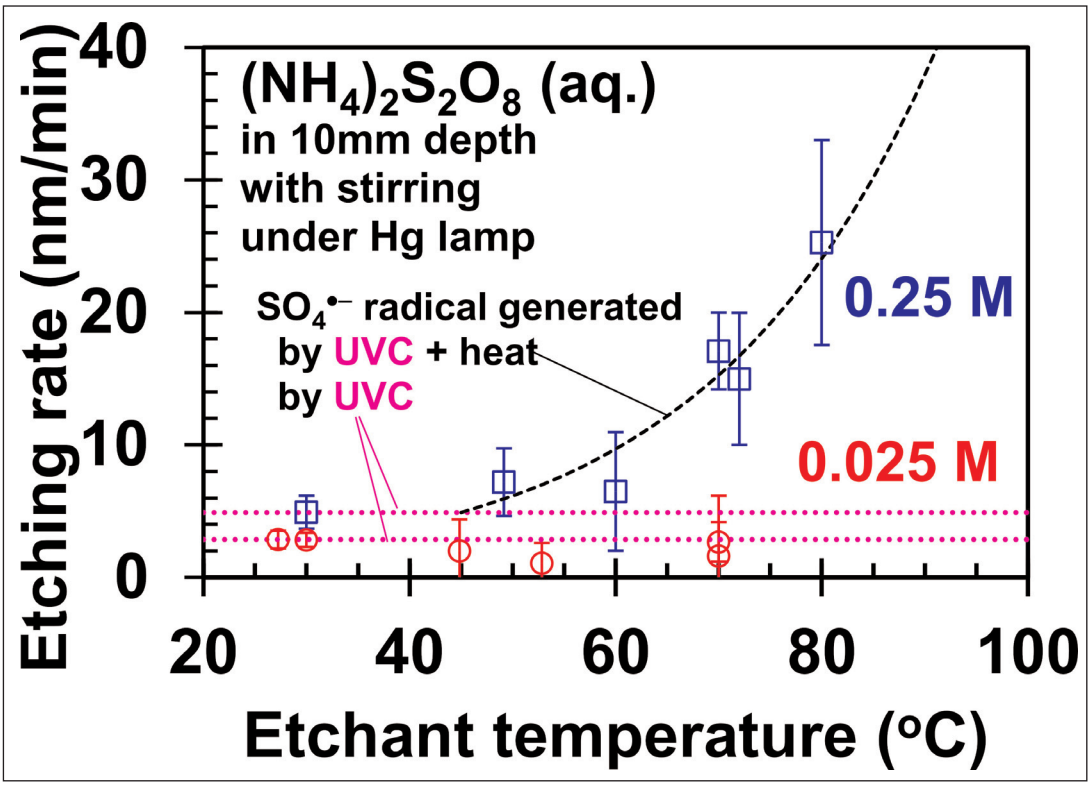


Figure 1. Etch rate versus electrolyte temperature. Broken lines: eye guides of trends for SO_4^- radicals produced from $S_2O_8^{2-}$ ions by heat or UVC.

GaN-based electronics is being developed for 5G wireless network mobile base-station and other high-power applications, based on low specific on-resistance and high breakdown voltages. Such devices need etching processes that result in low surface damage for electrical isolation, mesas, trenches and gate recessing. Surface damage results in paths for unwanted leakage currents. Fast plasma etch processes often need a second slow wet chemical etch to reduce surface roughness.

Even with the low rate of room-temperature CL-PEC (up to 1nm/minute) the team believes that the process could be the best solution for gate recessing in terms of smooth surface and low processing cost. A through-via process, however, need rates of more than 100nm/minute.

After a series of experiments on potassium ($K_2S_2O_8$) and sodium ($Na_2S_2O_8$) persulfates as sources for SO_4^- radical anions, the researchers chose a solution of ammonium persulfate, $(NH_4)_2S_2O_8$, since it had a higher water solubility of 1.95M (mole/liter) at room temperature, compared with 0.18M and 1.5M, respectively, for the other options. Apart from the resulting high concentration of $S_2O_8^{2-}$ ions, the solution is 'alkali-free', which is seen as minimizing contamination of downstream process steps.

The etch experiments were carried out in a 4-inch manual mask aligner system with UV radiation sourced from a high-pressure mercury lamp. Since the rear side of the GaN sample was used as cathode for the electrochemical process, it was placed on small

0.4mm-thick sapphire chips in the reaction beaker, allowing the electrolyte access.

The etching was carried out on 6mmx6mm pieces derived from a 2inch-diameter freestanding GaN sample with metal-organic vapor phase epitaxy (MOVPE) layers designed for Schottky barrier diodes. The freestanding GaN was produced by a void-assisted separation from sapphire, designed by the research team.

The mask for the etch was silicon dioxide produced using a spin-on process, patterned using photo-lithography and buffer hydrofluoric acid etch.

Experiments were carried out with 0.25M and 0.025M $(NH_4)_2S_2O_8$ concentration electrolytes. A hotplate was used to control the temperature. The UV lamp emitted 254nm-wavelength UVC with a power density at the chip of 2mW/cm^2.

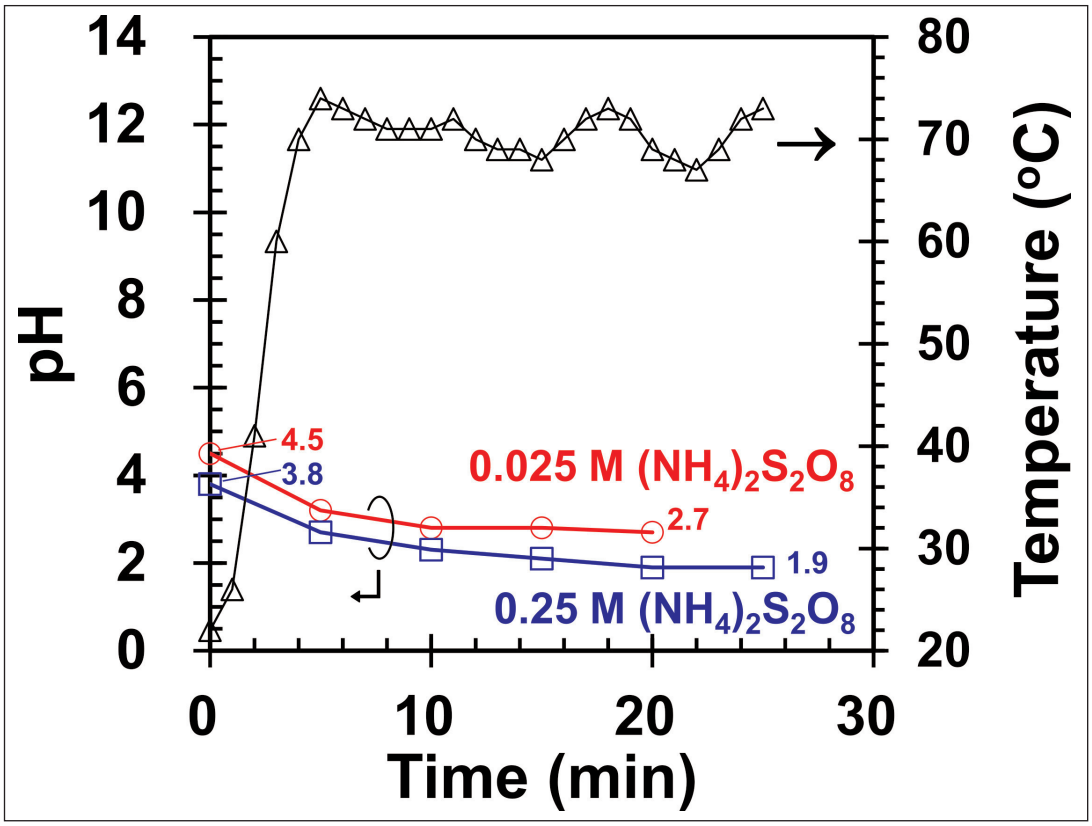


Figure 2. Temperature and pH against process time in thermal-assisted CL-PEC etch experiment.

The heating and high $(NH_4)_2S_2O_8$ concentration enabled higher etch rates of around 25nm/minute at 80°C, compared with around 5nm/minute at room temperature (Figure 1). The researchers claim the 25nm/minute value was "approximately 10 times higher than that reported by previous studies because of the high generation rate of SO_4^-." The low 0.025M-concentration electrolyte did not show a noticeable thermal effect.

The change seems to be related to the greater acidity of the 0.25M solution at high temperature, as indicated by lower pH (Figure 2). The applied heat split more of the $S_2O_8^{2-}$ into sulfate radical SO_4^- anions. The etch process in terms of redox electron and hole transfers is given as:

GaN + photocarriers $(3h^+ + 3e^-) + 3SO_4^-$
$\longrightarrow Ga^{3+} + 3SO_4^{2-} + \frac{1}{2}N_2(g)\uparrow$ ■

https://doi.org/10.35848/1882-0786/ab7e09

Author: Mike Cooke

GaN and SiC power semiconductor markets to surpass $1bn in 2021

The gallium nitride & silicon carbide power semiconductor market is being energized by demand from electric vehicles, power supplies and PV inverters, says Omdia.

Energized by demand from hybrid & electric vehicles (HEVs), power supplies and photovoltaic (PV) inverters, the global market for silicon carbide (SiC) and gallium nitride (GaN) power semiconductors is forecast to grow to $854m by the end of 2020 (up from just $571m in 2018) then surpass $1bn in 2021, according to Omdia's 'SiC & GaN Power Semiconductors Report — 2020'. Revenue is expected to increase at a double-digit annual rate for the next decade, surpassing $5bn by 2029.

These long-term market projection totals are about $1bn lower than those in last year's edition of the report because demand for almost all applications has slowed since 2018. Moreover, device average prices fell in 2019. Omdia adds a note a caution: the equipment forecasts used to create this year's forecast all date from 2019, and do not take account of the impact of the COVID-19 pandemic.

SiC Schottky diodes have been on the market for more than a decade, with SiC metal-oxide-semiconductor field-effect transistors (SiC MOSFETs) and junction-gate field-effect transistors (SiC JFETs) appearing in recent years. SiC power modules are also becoming increasingly available, including hybrid SiC modules, containing SiC diodes with silicon insulated-gate bipolar transistors (IGBTs), and full SiC modules containing SiC MOSFETs with or without SiC diodes.

SiC MOSFETs are proving popular among manufacturers, notes Omdia, with several companies already offering them. Several factors caused average pricing to fall in 2019, including the introduction of 650V, 700V and 900V SiC MOSFETs priced to compete with silicon superjunction MOSFETs, as well as increasing competition among suppliers.

"Declining prices will eventually spur faster adoption of SiC MOSFET technology," says Richard Eden, senior principal analyst for power semiconductors. "In contrast, GaN power transistors and GaN system ICs have only appeared on the market quite recently," he adds. "GaN is a wide-bandgap material offering similar performance benefits as SiC, but with a higher cost-reduction potential. These price and performance advantages are possible because GaN power devices can be grown on either silicon or sapphire substrates, which are less expensive than SiC. Although GaN transistors are now available, sales of GaN system integrated circuits, from companies such as Power Integrations, Texas Instruments and Navitas Semiconductor, are forecast to rise at a faster rate."

SiC and GaN power semiconductor market trends

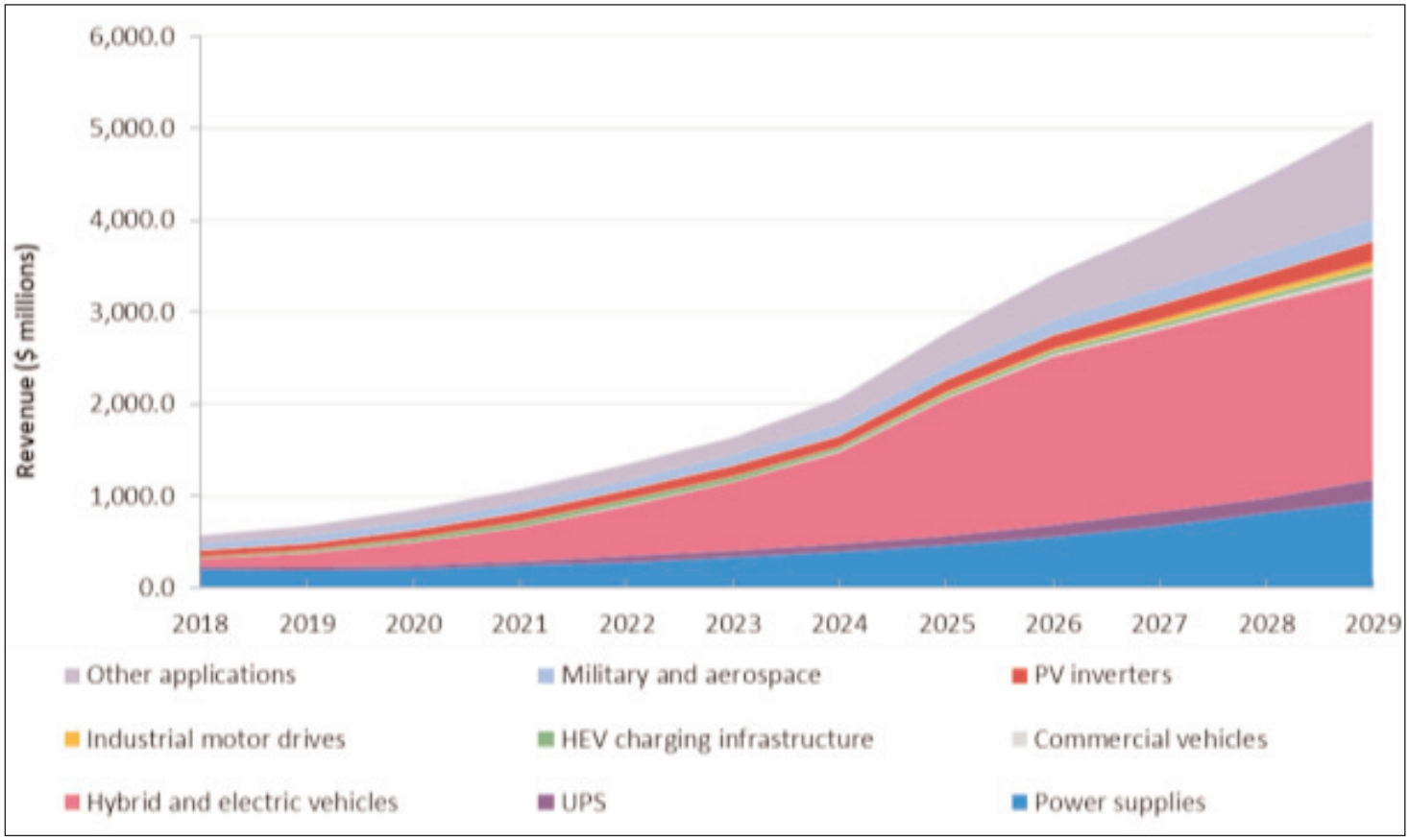
By the end of 2020, SiC MOSFETs are forecasted to generate revenue of about $320m, matching that of Schottky diodes. From 2021 onwards, SiC MOSFETs will grow at a slightly faster rate to become the best-selling discrete SiC power device, it is expected. Meanwhile, SiC JFETs are each forecasted to generate much smaller revenues than those of SiC MOSFETs, despite achieving good reliability, price and performance.

"End-users strongly prefer normally-off SiC MOSFETs, so SiC JFETs appear likely to remain specialized, niche products," Eden says. "However, sales of SiC JFETs are forecast to rise at an impressive rate, despite having very few active suppliers."

It is estimated that, in 2019, hybrid SiC power modules (combining Si IGBTs and SiC diodes) generated $72m in sales and full SiC power modules generated $50m. Full SiC power module revenue is forecasted to exceed $850m by 2029, as they will be preferred for use in HEV powertrain inverters. In contrast, hybrid SiC power modules will be used mainly in PV inverters, uninterruptible power supply (UPS) systems and other industrial applications, delivering a much slower growth rate.

What has changed since 2019?

There are now trillions of hours of device field experience available for both SiC and GaN power devices. Suppliers, even new market entrants, are demonstrating this by obtaining JEDEC and AEC-Q101 approvals. There do not appear to be any unexpected reliability problems with SiC and GaN devices; in fact, they usually appear better than silicon, notes Omdia.



Market forecast for GaN and SiC power semiconductors (millions of US dollars).

SiC MOSFETs and SiC JFETs are available at lower operating voltages, such as 650V, 800V and 900V, allowing SiC to compete with Si Superjunction MOSFETs on both performance and price.

End-products with GaN transistors and GaN system ICs inside are in mass production, particularly USB type-C power adaptors and chargers for fast charging of mobile phones and notebook PCs. Also, many GaN devices are being made by foundry service providers, offering in-house GaN epitaxial crystal growth on standard silicon wafers, and potentially unlimited production capacity expansion as volumes ramp, concludes the report. ■

https://technology.informa.com/624431/sic-gan-power-semiconductors-report-2020

II-VI relying on GE's IP to conquer power SiC markets

The patent deal should promote the adoption of planar SiC MOSFET technology, reckons patent and technology intelligence firm Knowmade.

As announced at the end of June, engineered materials and optoelectronic component maker II–VI Inc of Saxonburg, PA, USA — which manufactures silicon carbide (SiC) substrates — has licensed SiC technology from General Electric with a view to moving into power device and module manufacturing. Just like II–VI's main competitors in the SiC wafer market — US-based Cree/Wolfspeed and Japan-based Rohm Group Company (including SiCrystal) — the new licensee aims to capitalize on the growing market demand for SiC-based power electronics, driven by the fast development of electric vehicle and hybrid electric vehicle (EV/HEV) applications.

General Electric's SiC power device technology has been reviewed by Knowmade in its report 'Power SiC Patent Landscape 2019 (MOSFETs –SBDs – Modules)'. "GE's patenting activity took off in the late 2000s, focusing on the planar device architecture of SiC MOSFETs," notes Rémi Comyn PhD, technology & patent analyst Compound Semiconductors and Electronics at Knowmade. Indeed, as of 2020, GE's patent portfolio includes over 30 patent families (i.e. single inventions patented in multiple countries) related to SiC MOSFETs, grouping over 30 granted patents and 40 pending patent applications, which reflects GE's global IP strategy, extending over USA, China, Japan and Europe.

According to Knowmade's analysis, General Electric was the most active IP player on planar SiC MOSFET technology, but still a challenger for Cree/Wolfspeed and Mitsubishi Electric (as shown in Figure 1). Starting its patenting activity in the 1990s, Cree took the leadership on planar SiC MOSFETs and currently holds over 90 granted patents worldwide, including numerous key patents in the domain, while GE's patent portfolio was mainly composed of pending patent applications as of 2018. Yet, within the last couple of years, GE has managed to convert a promising IP potential into a strong patent portfolio with more and more enforceable patents (Figure 1).

Furthermore, GE's current patenting activity related to SiC MOSFET technology has now shifted towards power converters based on this technology. "We're observing a slowdown in GE's patenting activity in the SiC MOSFET patent landscape, with only a couple of new inventions published since 2018, indicating that GE's SiC MOSFET technology has reached a high level of maturity," says Comyn. "GE's patenting activity is now mainly related to the extension of US priority patents worldwide." Apart from SiC MOSFETs and SiC-based converters, GE also published several new inventions related to low-inductance SiC power modules, e.g. US patent 10,021,802 (2018) and US patent 9,893,646 (2017).

Interestingly, numerous patents filed by GE focus on issues related to the gate structure of planar SiC MOSFET, e.g. the mitigation of negative-bias temperature instability in the threshold voltage of SiC MOSFET devices. In US patent 10,367,089, GE's inventors insert a dielectric layer deposited on the gate electrode and a remedial layer deposited on, within or below the dielectric layer in order to limit the variation in threshold voltage below 1V.

Moreover, GE's patent portfolio addresses different building blocks of planar SiC technology, such as:

- systems and methods for ohmic contacts (based on an annealed nickel silicide layer) in SiC devices (US patent 9,230,807);
- electric field shielding in SiC MOSFET devices having an optimization layer (US patent 10,096,681);
- a planar SiC MOSFET device with reduced electric field at the sharp corners of a gate electrode, for enhanced device reliability (patent application EP 3,108,507); and
- a non-planar SiC n-channel DMOSFET device with increased channel periphery (US patent 9,024,328).

More recently, GE has disclosed an invention related to gate networks having positive temperature coefficients of resistance (PTC) for SiC power devices (2019) and a second invention focusing on SiC devices having improved electric field suppression over the termination regions (2020).

In 2013, GE qualified its technology for the automotive industry (AEC-Q101, 200°C). In late 2016, the company entered high-volume production of SiC power devices at the New York Power Electronics Manufacturing Consortium (NY-PEMC) facility (SUNY Poly's 150mm SiC fab in Albany, NY, USA), in addition to low-volume production at its existing 4-inch pilot SiC fab (GE Global Research Center in Niskayuna, NY, USA). In 2017, in the framework of NY-PEMC, GE announced a manufacturing partnership with Danfoss to produce SiC power modules in Utica (NY, USA). Interestingly, Danfoss is a new entrant in the 'Power SiC Patent

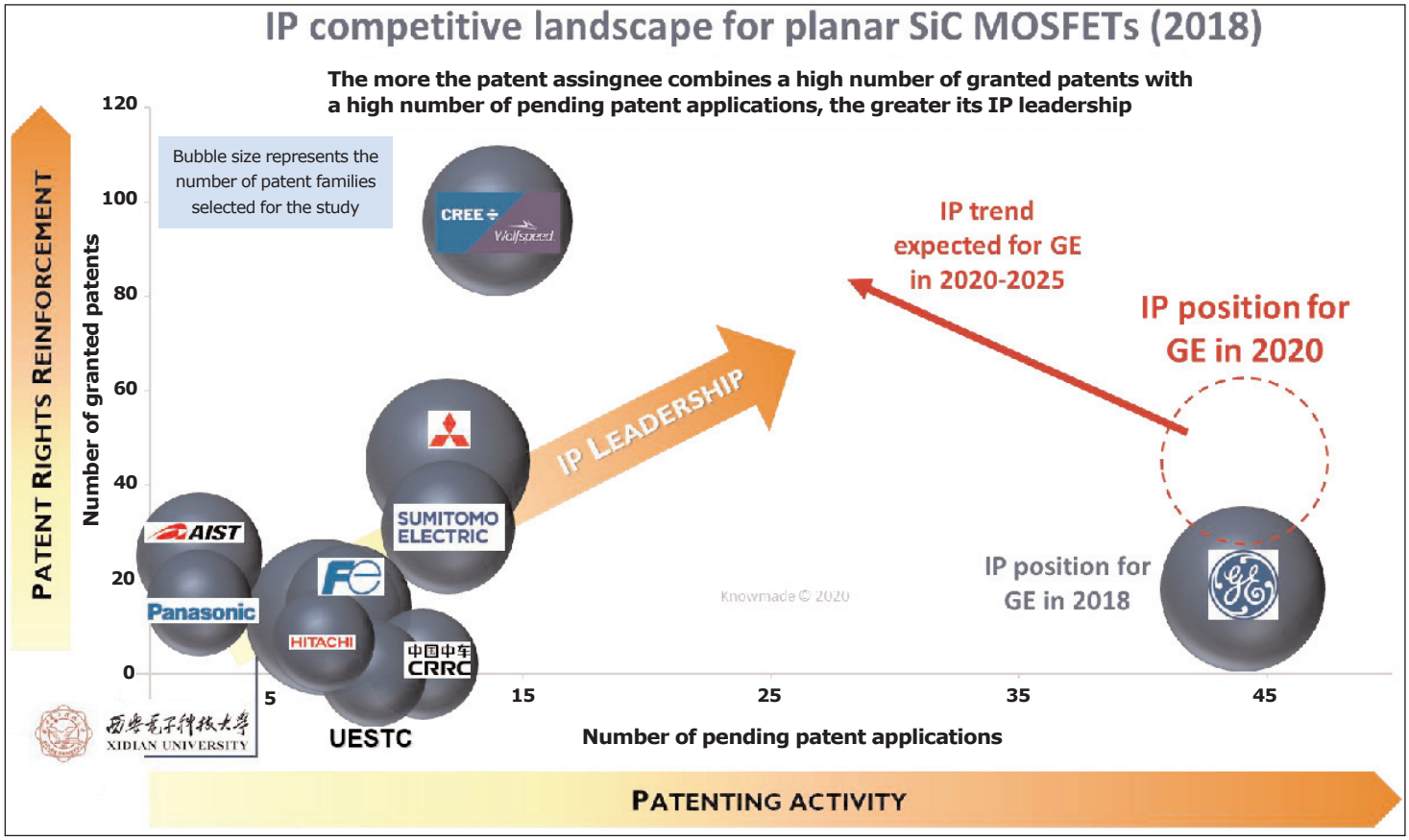


Figure 1: Evolution of GE's IP leadership in the planar SiC MOSFET patent landscape.

Landscape 2019' report and filed four pending applications in 2018 related to the optimization of high-power-conversion-efficiency and high-power-density modules based on SiC power devices.

The patent agreement between II–VI and General Electric will further promote the adoption of planar SiC MOSFET technology for the electrification of systems including, for example, industrial infrastructure, large data centers and vehicles (EV/HEV). "While most automotive-focused patent applicants such as Toyota Motor and Rohm seem to place the emphasis on trench SiC MOSFET technology for automotive applications, we're also observing partnerships involving planar SiC MOSFET suppliers such as Cree/Wolfspeed to develop SiC-based automotive applications," comments Comyn. By way of example, in November 2019, a strategic partnership was established between Cree/Wolfspeed and automotive supplier ZF to enhance the electric powertrain with SiC-based inverters. ■

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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

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

Henry Butcher International
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High Holborn, London WC1V 6EG,
UK
Tel: +44 (0)20 7405 8411
Fax: +44 (0)20 7405 9772
www.henrybutcher.com

M+W Zander Holding AG
Lotterbergstrasse 30,
Stuttgart,
Germany
Tel: +49 711 8804 1141
Fax: +49 711 8804 1950
www.mw-zander.com

24 Consulting

Fishbone Consulting SARL
8 Rue de la Grange aux Moines,
78460 Choisel,
France
Tel: + 33 (0)1 30 47 29 03
E-mail: jean-luc.ledys@neuf.fr

25 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

21–23 July 2020
SEMICON West 2020 — now a virtual event
~~Moscone Center, San Francisco, CA, USA~~
E-mail: semiconwest@semi.org
www.semiconwest.org

22–25 July 2020
International Congress on Advanced Materials Sciences & Engineering (AMSE-2020)
Vienna, Austria
E-mail: eve@istci.org
www.istci.org/amse2020

28–30 July 2020 (postponed from 5–7 May)
PCIM Europe 2020 (Power Conversion and Intelligent Motion)
Nuremberg Exhibition Centre (Messe Nürnberg), Germany
E-mail: pcim@mesago.com
https://pcim.mesago.com/nuernberg/en.html

4–6 August 2020 (live online event dates)
4 August – 30 September 2020 (on demand dates)
Microwave Week, including:
IEEE MTT-S International Microwave Symposium (IMS 2020)
Radio Frequency Integrated Circuits Symposium (RFIC 2020)
Automatic Radio-Frequency Techniques Group Conference (ARFTG)
E-mail: e.niehenke@ieee.org
www.ims-ieee.org

23–27 August 2020
SPIE Optics + Photonics 2020
San Diego Convention Center, San Diego, CA, USA
E-mail: customerservice@spie.org
https://spie.org/Optics_Photonics

23–28 August 2020
International Workshop on Nitride Semiconductors (IWN 2020)
Maritim Hotel Berlin, Germany
E-mail: iwn2020@conventus.de
www.iwn2020.org

23–28 August 2020
9th International Conference on Optical, Optoelectronic and Photonic Materials and Applications (ICOOPMA)
University of Pardubice, Czech Republic
E-mail: info@icoopma.com
www.icoopma.com

24–25 August 2020
TSMC North America Technology Symposium and Open Innovation Platform Forum
Santa Clara Convention Center, Santa Clara, CA, USA
E-mail: press@tsmc.com
www.tsmc.com/english/newsEvents/events.htm

3–6 September 2020 (postponed from 17–21 May)
32nd International Symposium on Power Semiconductor Devices and ICs (ISPSD 2020)
Hofburg Palace, Vienna, Austria
E-mail: ispsd2020@guarant.cz
www.ispsd2020.com

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7–11 September 2020
22nd European Conference on Power Electronics and Applications (EPE 2020 ECCE Europe)
Lyon, France
E-mail: info@epe2020.com
www.epe2020.com

9–11 September 2020
22nd China International Optoelectronic Exposition (CIOE 2020)
Shenzhen World Exhibition & Convention Center, China
E-mail: cioe@cioe.cn
www.cioe.cn/en

13–17 September 2020
(postponed to 24-28 October 2021)
13th European Conference on Silicon Carbide and Related Materials (ECSCRM 2020-2021)
Vinci International Convention Centre, Tours, France
E-mail: ecscrm-2020@univ-tours.fr
www.ecscrm-2020.com

13–18 September 2020
23rd European Microwave Week (EuMW 2020)
Utrecht, The Netherlands
E-mail: eumwreg@itnint.com
www.eumweek.com

10–13 November 2020
SEMICON Europa 2020
Munich, Germany
E-mail: SEMICONEuropa@semi.org
www.semiconeuropa.org

6–8 December 2020
2020 IEEE 51st Semiconductor Interface Specialists Conference (SISC)
San Diego, CA, USA
E-mail: mpasslack@ieeesisc.org
www.ieeesisc.org

6–10 December 2020
(postponed from 20–24 September)
46th European Conference on Optical Communication (ECOC 2020)
Brussels Expo, Brussels, Belgium
E-mail: info@ecoc2020.org
www.ecoco2020.org

12–16 December 2020
IEEE International Electron Devices Meeting (IEDM 2020) — now a virtual, online event
~~Hilton San Francisco and Towers, San Francisco, CA, USA~~
Paper submission deadline: 24 July
E-mail: info@ieee-iedm.org
www.ieee-iedm.org

17–19 December 2020
SEMICON Japan 2020
Tokyo Big Sight,
Tokyo, Japan
E-mail: semicon@sakurain.co.jp
www.semiconjapan.org/en

21–25 March 2021
IEEE Applied Power Electronics Conference and Exposition (APEC 2021)
Phoenix, AZ USA
E-mail: registration@apec-conf.org
www.apec-conf.org

28 March – 1 April 2021
Optical Networking and Communication Conference & Exhibition (OFC 2021)
Moscone Center, San Francisco,
CA, USA
E-mail: OFC@csreg.zohodesk.com
www.ofcconference.org

15–16 April 2021
EPIC Annual General Meeting 2021
Radisson Blu Hotel Lietuva,
Vilnius, Lithuania
E-mail: neringa.norbutaite@epic-assoc.com
www.epic-assoc.com/epic-annual-general-meeting-2020

20–22 April 2021
Components for Military & Space Electronics Conference & Exhibition (CMSE 2021)
Four Points by Sheraton (LAX) Los Angeles,
CA, USA
E-mail: info@tjgreenllc.com
www.tjgreenllc.com/cmse

9–14 May 2021
2021 Conference on Lasers & Electro-Optics (CLEO)
San Jose Convention Center, San Jose, CA, USA
E-mail: CLEO@compusystems.com
www.cleoconference.org

11–14 May 2021
10th World Congress of Nano S&T 2021
Venetian Macao Resort Hotel, Macao, China
E-mail: esther@bitcongress.com
www.bitcongress.com/nano2021-macao

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

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