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Wafer-scale integration of InP DFB lasers

News from IMS, APEC and OFC 2021

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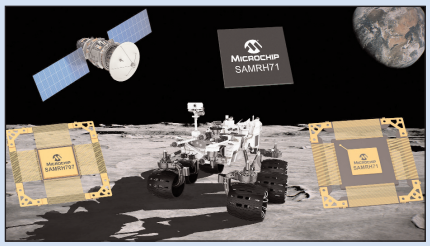
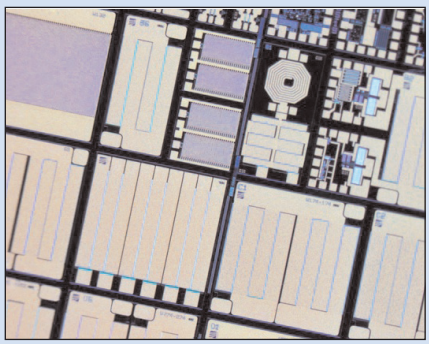
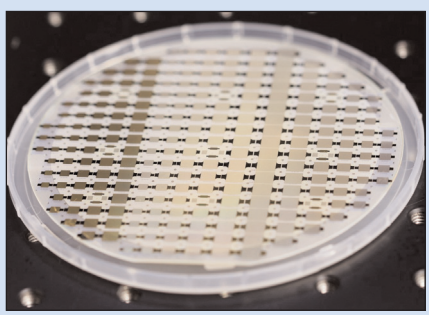


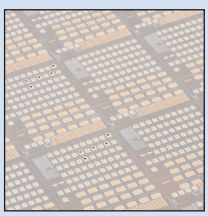
p29 Microchip has launched its first GaN MMICs, designed for use in commercial and defense satellite communications, 5G networks and other aerospace & defense systems.



p30 Fraunhofer IAF has presented GaN-on-silicon chip designs for future low-voltage battery-powered applications up to 48V.



p50 Porotech has raises £3m to fund development of its micro-LED production technique.



Cover: Together with die attach equipment supplier partner ASM AMICRA, Sivers Photonics has achieved wafer-scale integration of indium phosphide DFB lasers from its InP100 platform onto imec's silicon photonics platform (iSiPP). **p60**

editorial

Refocusing priorities

Due to focusing on increasing computer speed and memory capacity, the silicon industry has long been driven by shrinking feature sizes to maintain Moore's Law. But, given the increasing obstacles from silicon's inherent materials properties (limiting device performance), coupled with growing demand for other applications such as 5G wireless, semiconductor device makers that were previously focused on mainstream silicon are increasingly looking to either 'specialty' silicon technology or compound semiconductors. In addition, the pandemic-driven IC shortages have spotlighted not just leading-edge silicon but also the demand for trailing-edge and specialty technology. Also, trade tensions have driven governments to incentivize on-shore production to secure supplies of increasingly critical components.

For the higher millimeter-wave frequencies required by the transition to 5G wireless, fabless firm MixComm for example has designed front-end ICs based on the 45RF-SOI radio-frequency silicon-on-insulator process of US-based GlobalFoundries. To meet such demand, GlobalFoundries has agreed an $800m deal for GlobalWafers (GWC) to add 300mm SOI wafer manufacturing and expand existing 200mm SOI production at GWC's MEMC facility in Missouri, for 'feature-rich' RF applications such as 5G smartphones, wireless connectivity, automotive radar and aerospace (see pages 12–13).

In Europe, to accelerate the ramp-up of its R3 300mm-wafer fab being built in Agrate, STMicroelectronics is to share its cleanroom with specialty analog foundry Tower Semiconductor, targeting 130nm, 90nm and 65nm processes for smart power, analog, mixed-signal and RF ICs (page 14).

ST has also announced a strategic cooperation to design, develop, make and supply silicon carbide (SiC) and gallium nitride (GaN) transistors, packages and modules for the power electronics systems of battery-operated and hybrid vehicles to French auto maker Renault (page 22).

Also targeting power electronics applications such as automotive, following a joint development program with US-based equipment maker Applied Materials initiated in November 2019, France-based Soitec has adapted its Smart Cut SOI technology to the manufacture of SmartCut SiC engineered substrates, and has now recruited the CEO of Grenoble-based R&D center CEA-Leti to commercialize its Silicon Carbide Program (page 18). Meanwhile, in the USA, SiC substrate maker II-VI Inc has introduced heated ion implantation foundry services for 150mm SiC wafers.

New SiC and GaN devices were on show virtually at June's Applied Power Electronics Conference (APEC), such as ON Semiconductor's new 1200V full-SiC MOSFET modules for electric vehicle charging (page 20).

Also in June, for the International Microwave Symposium, GaN-on-SiC device technology for RF applications was presented by MACOM (page 17). Meanwhile, Microchip has added the first MMIC to its GaN RF product range.

Such developments are being driven by a GaN RF device market growing at a CAGR of 18% from $891m in 2020 to more than $2.4bn by 2026, reckons Yole Développement (see article on pages 82–83).

Showing how the interests of silicon and compound semi manufacturing are increasingly merging, on 5 July Netherlands-based Nexperia — a subsidiary of China's Wingtech that makes silicon bipolar transistors, MOSFETs and analog & logic ICs as well as GaN FETs — acquired Newport Wafer Fab, the UK's 200mm compound semiconductor wafer foundry. Nexperia Newport will focus on MOSFETs, IGBT, analog and compound semiconductor automotive-grade products (see next issue).

Mark Telford

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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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Transition from mini-LED to micro-LED displays to be a game-changer

Take-off of backlit mini-LED displays paves way for micro-LEDs

During 2020 and 2021 display manufacturers from Samsung to LG, from TCL to BOE, and from Konka to Hisense all launched their product lines based on mini-LEDs. Also, Apple is putting the technology into its future product lines. The take-off of backlit mini-LED displays has also paved the way for micro-LED displays, with large signage displays and TVs seeing initial adoption, notes the report 'Micro-LED Displays 2021–2031: Technology, Commercialization, Opportunity, Market and Players' of market research firm IDTechEx.

Mini-LEDs and micro-LEDs

Mini-LEDs are considered to be LEDs in the millimeter range, whereas micro-LEDs are in the micron range. However, in reality, the distinction is not so strict, and the definition may vary. But it is commonly accepted that micro-LEDs are under 100μm in size, and even under 50μm, while mini-LEDs are much larger.

When applied in the display industry, size is just one factor. Another feature is the LED thickness and the substrate. Mini-LEDs usually have a large thickness of over 100μm, largely due to the existence of LED substrates, whereas micro-LEDs are usually substrateless and therefore the finished LEDs are extremely thin.

A third feature distinguishing the two is the mass transfer techniques that are utilized to handle the LEDs. Mini-LEDs usually adopt conventional pick & place techniques, including surface-mounting technology. The number of LEDs that can be transferred each time is limited. For micro-LEDs, when a heterogenous target substrate is used, usually millions of LEDs need to be transferred, so the number of LEDs to be transferred at a time is significantly larger, and thus the disruptive mass transfer technique should be considered.

The differences between mini-LEDs and micro-LEDs determine their ease of realization and technology maturity, notes the market research report.

Two forms of mini-LED displays

Mini-LEDs can be used as the backlight source for a conventional LCD display, or as self-emissive pixel emitters.

In terms of backlight application, mini-LEDs can improve existing LCD technology, with enhanced colors and contrast. Essentially, mini-LEDs replace the edge-type backlight's dozens of high-luminance LEDs with tens of thousands of direct-type mini-LED units. Their level of high dynamic range (HDR) fineness sets a new record. Even though the mini-LED unit is not yet able to dim locally (pixel by pixel) like organic light-emitting diodes (OLEDs) can, at least it can meet the extreme requirements to process local dimming signals for HDR imaging. In addition, LCD panels with mini-LED backlights tend to provide better color rendering index (CRI) and can be manufactured to be as thin as an OLED panel.

In contrast to backlit mini-LED displays, which are essentially still LCDs, using mini-LEDs as the pixels creates direct emissive LED displays. This kind of display precedes micro-LED displays.

From mini-LED to micro-LED displays

Facing the difficulties in chip manufacturing and mass transfer, emissive mini-LED displays are a compromised solution regarding future micro-LEDs. From mini-LED to micro-LED displays, not only the LED size and thickness are further reduced but the manufacturing techniques involved and the supply chain will also be different. The rapid penetration of mini-LED displays, whether backlight-based or emissive, is aiding the establishment of the supply chain and assisting the accumulation of know-how and experience.

Micro-LED displays have value propositions, including wide color gamut, high luminance, low power consumption, excellent stability and long lifetime, wide viewing angle, high dynamic range, high contrast, fast refresh rate, transparency, seamless connection, and sensor integration capability. Some features are unique to micro-LEDs, so the technology is considered to be a potential game-changer in the display industry, concludes the report.

www.IDTechEx.com/MicroLED

LED video wall revenue to rebound by 13.5% from $5.53bn in 2020 to $6.27bn in 2021

China-focused manufacturers benefitted from recovering demand in Q3–Q4/2020

Affected by the emergence of the COVID-19 pandemic, global LED video wall revenue fell by 12.8% year-on-year in 2020 to $5.53bn, with the European and US markets suffering the most significant declines, according to market research firm TrendForce. However, in 2021, as overall market demand recovers and certain components in the upstream supply chain undergo price hikes due to shortages, LED video wall manufacturers have raised their product prices in response, so revenue is expected to grow by 13.5% to $6.27bn.

Overall demand for LED video walls has been gradually recovering due to increased vaccinations worldwide, which have enabled a gradual easing of border restrictions as well as the resumption of major commercial and sporting activities, including the delayed UEFA Euro 2020 soccer tournament and Tokyo 2020 Olympics, notes TrendForce. In addition, due to the rising prices of materials in the upstream LED video wall supply chain (such as driver ICs, PCBs and LED components), LED video wall manufacturers such as Leyard, Unilumin and Absen are gradually raising their product prices in order to maintain product profit.

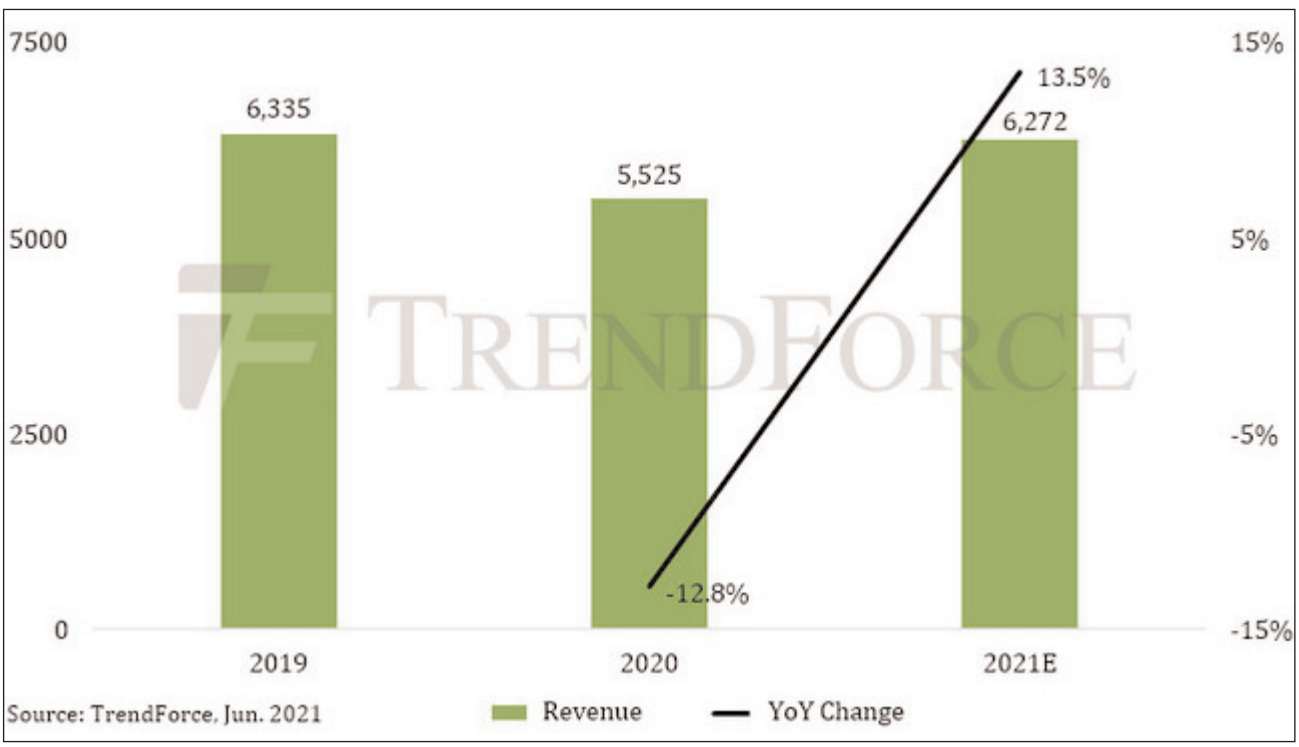
Demand in China was first to recover, but top eight suppliers comprised 60% market share

Regarding the ranking of LED video wall suppliers in 2020, Leyard took the leadership position with a market share of 11.3% even though its overall revenue fell due to the pandemic's impact on Leyard's overseas businesses. Likewise, Unilumin saw declines in its overseas businesses, which caused only a slight drop in its revenue because it had placed a greater focus on sales in the Chinese market. Unilumin took second place with 10.8% market share. Qiangli Jucai, on the other hand, primarily conducted business in domestic China. By aggressively strengthening its distribution channels, Qiangli Jucai was able to increase its revenue, contrary to the overall downtrend, and take third place. Daktronics, Hikvision, Samsung Electronics, Absen, and Shanxi High-tech Huaye took fourth to eighth places, respectively.

Demand for LED video walls has been gradually recovering due to increased vaccinations

On the whole, most LED video wall manufacturers, especially companies (including Leyard, Unilumin and Absen) whose primary markets were Europe and the USA, saw declines in their revenues for 2020 due to the pandemic last year. Conversely, companies with a primary focus on the Chinese market, such as Qiangli Jucai and Shanxi High-tech Huaye, benefitted from the recovering demand that began ramping up in third-quarter 2020 and peaked in fourth-quarter 2020. These companies were able to propel the combined market share of the top eight LED video wall manufacturers to 58% in 2020, which was four percentage points higher compared with 54% in 2019.

www.trendforce.com



Global LED video wall market, 2019–2021 (in US$m).

RF GaN device market surpasses $1bn in 2020

Base-station & defense applications to push revenue near $2bn in 2025

Revenue from RF gallium nitride (GaN)-enabled devices experienced another year of fast growth, increasing by almost 30% in 2020 to cross the $1bn barrier for the first time, according to the Strategy Analytics Advanced Semiconductor Applications (ASA) and Advanced Defense Systems (ADS) report 'RF GaN Device Market Forecast 2020–2025', which identifies base-station and defense applications as the prime drivers of growth.

The report forecasts that the long-term prospects for RF GaN revenue growth look good, with 5G base-station and defense applications pushing revenue to almost $2bn in 2025.

"Base stations continue to be the largest and fastest-growing opportunity for RF GaN revenue," notes Eric Higham, director of the Advanced Semiconductor Applications (ASA) and Advanced Defense Systems (ADS) services.

"Last year saw Huawei continue their aggressive buying patterns for base-station deployments in China as a buffer to US trade sanctions," he adds. "We may see some short-term volatility depending on China's 5G deployment plans, but the fundamentals for RF GaN devices in commercial and defense applications remain strong, and I expect revenue to approach $2bn by 2025."

www.strategyanalytics.com

Cellular radio component market growing 8% annually through 2025

Rapid growth in filters, power amps, millimetre-wave for 5G devices, despite component shortages

Despite the COVID-19 pandemic, the market for radio-frequency components used in cellular user equipment grew to an all-time high in 2020 and will continue to grow through 2025, according to the report 'Cellular UE Radio Component Forecast 2021-2025: A Robust Future Post-COVID with 5G' from the Strategy Analytics RF & Wireless Components service. The report details historical and expected sales in dollars and units by air interface and type of radio component, including baseband processors, RF transceivers, power amplifiers, RF filters, switches, antenna tuners, drain modulators, tuners and other radio-frequency front-end (RFFE) components.

"We predict that the cellular radio component market will grow 8% per year through 2025," says report author Christopher Taylor, director of RF & Wireless Components. "In the wake of stagnating device shipment growth and to help counter increasing radio complexity with 5G, suppliers of RFFE component have continued to develop system-in-package modules with more capabilities, allowing companies to capture more RFFE content per design-win while making design and assembly of mobile phones easier for OEMs," he adds.

"The on-going semiconductor shortages are likely to persist through 2022, validating strong underlying demand," notes Sravan Kundojjala, associate director, Handset Component Technologies. "However, mobile phone OEMs face supply constraints that could keep them from reaching full upside device sales potential this year. Semiconductor foundries including TSMC, UMC, GlobalFoundries, SMIC, Samsung Foundry and compound semiconductor foundries have responded with efforts to increase capacity as quickly as possible," he adds. "Strategy Analytics predicts that robust demand for both sub-6GHz and mmWave 5G RF components along with new 5G opportunities beyond smartphones will drive significant cellular radio component growth over the next few years."

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Skyworks and Xilinx enable 5G across newly available C-band spectrum

Companies demo 280MHz C-band solution for 5G infrastructure

Together with Xilinx Inc of San Jose, CA, analog semiconductor manufacturer Skyworks Solutions Inc of Irvine, CA, USA has demonstrated compliance with 3GPP linearity and bandwidth requirements for C-band signals that are critical for enabling next-generation 5G infrastructure. The 280MHz instantaneous bandwidth (IBW) solution uses a Xilinx Zynq RFSoC Gen 3 and a Skyworks SKY66523-11 high-efficiency power amplifier (PA).

The SKY66523-11 wide instantaneous-bandwidth high-efficiency PA has an operational frequency range of 3550–4200MHz and is suitable for use as both a C-band 5G NR small-cell PA and as a driver amplifier for massive MIMO and macro base stations. US C-band spectrum refers to mid-band frequencies in the range 3.7–3.98GHz, which are optimal for 5G because they provide the right balance of geographic coverage, capacity and speed. At nearly $81bn, the recent US Federal Communication Commission (FCC) auction of 280MHz C-band spectrum was the highest-value spectrum sale in history.

The first portion of the C-band spectrum ('A-block') is expected to be available by the end of this year. In anticipation of deploying as soon as the A-block spectrum becomes available, OEMs are already in the process of designing C-band systems. B-block and C-block spectrums are expected to be available by the end of 2023.

The demo incorporating the SKY66523-11 PA and the Xilinx adaptable SoC shows multiple scenarios covering the full 280MHz C-band spectrum with an occupied bandwidth (OBW) of up to 200MHz, which is the maximum bandwidth won by any operator during the recent auction. In all scenarios, the combined Skyworks/Xilinx solution achieved adjacent-channel leakage ratio (ACLR) compliance, a critical requirement of the 5G specification, making this combination ready for immediate A-block deployment and future B-block and C-block deployments.

"The majority of early 5G deployments are leveraging Xilinx technology for the radio. Along with our silicon platforms, Xilinx is providing industry-leading signal processing IP that is enabling both wider bandwidths required by C-band while also maintaining energy efficiency in the radio," comments Brendan Farley, VP of wireless engineering at Xilinx. "This demonstration, together with Skyworks PA technology, shows how our adaptable digital RF IP can quickly scale to address new and emerging radio requirements," he adds.

The first portion of C-band spectrum (A-block) is expected to be available by the end of this year. OEMs are already in the process of designing C-band systems. B-block and C-block spectrums are expected to be available by the end of 2023

"Our demo with Xilinx highlights the readiness and maturity of this 5G solution and, with the C-band auction concluded and winners announced, the next phase is for deployments as rapidly as possible," says Yusuf Jamal, senior VP & general manager of diversified analog and AI solutions at Skyworks. "The C-band is a unique and important piece of the 5G landscape, and Skyworks has long been investing in and preparing to deliver innovative technologies that address this new spectrum."

The Xilinx Zynq RFSoC Gen 3 is in full production and contains the direct RF transceivers along with the adaptable CFR (crest factor reduction) and DPD (digital predistortion) IP. The SKY66523-11 is part of a 5mm x 5mm pin-to-pin compatible family of PAs supporting major 3GPP bands and is sampling now.

www.skyworksinc.com/en/Products/Amplifiers/SKY66523-11

Skyworks launches front-end module for Wi-SUN, Internet of Things and industrial applications

SKY66122-11 provides over twice the range of standalone SoCs

Skyworks Solutions Inc of Woburn, MA, USA has launched the SKY66122-11, an RF front-end module (FEM) for Wi-SUN and other proprietary technologies operating in unlicensed bands.

Designed to enable greater range extension, the SKY66122-11 provides more than twice the range of standalone SoCs, greater power delivery to antenna and low power consumption for optimal battery operation.

The new solution is uniquely designed for IoT applications including end points and access points for smart grid and smart metering, smart city, industrial IoT sensors, and surveillance.

www.skyworksinc.com/en/Products/Front-end-Modules/SKY66122-11

Qorvo ships first commercially available reconfigurable dual-band GaN power amplifiers

PAs enable dual-use S- and X-band radar systems

Qorvo Inc of Greensboro, NC, USA is now shipping what it claims is the first commercially available family of electronically reconfigurable dual-band (S- and X-band) gallium nitride power amplifiers (PAs). The patented PAs support what is said to be a revolutionary shift in radar architecture for defense, weather and commercial avionics.

As the first commercially available GaN PAs that can be rapidly reconfigured for operation between the S-band (3.1–3.5GHz) and the X-band (9–11GHz), the QPA0007 and QPA0004 enable a single radar platform to be used across multiple applications, offering precise long-range and short-range capabilities. This eliminates the need for independent systems, saving size, weight, power and cost (SWaP-C). Now designers can dramatically reduce the bill of materials (BOM) and footprint by as much as 50% while improving overall performance, it is reckoned. The QPA0007 and QPA0004 are available in small QFN surface-mount technology (SMT) packages measuring 7mm x 6mm and 7mm x 4mm, respectively. Compared with traditional switched dual-band solutions, offer higher saturated power (P_{SAT} = 32W S-band and 28W X-band for the QPA0007 and 9W S-band and 8W X-band for the QPA0004) and power-added efficiency (PAE = 47% S-band and 32% X-band for the QPA0007 and 51% S-band and 34% X-band for the QPA0004). Power gain is 21dB (S-band) and 18.5dB (X-band) for the QPA0007 and 21dB (S-band) and 19dB (X-band) for the QPA0004.

"This new family of products streamlines next-generation radar designs," says Roger Hall, general manager of Qorvo's High Performance Systems (HPS).

"The defense industry is evolving toward a 'more with less' strategy, and this places a premium on system performance and flexibility," notes Eric Higham, Advanced Semiconductor Applications/ Advanced Defense Systems service director at market research firm Strategy Analytics. "The capabilities and performance advantages of GaN technology make it attractive in all defense applications, particularly radar. Qorvo's long heritage and leadership in GaN technology and defense applications allow them to develop innovative products like these that will support and enable emerging dual-band radar solutions," he comments.

The QPA0007 and QPA0004 are now sampling to qualified customers.

www.qorvo.com

Qorvo appoints Judy Bruner to board

Financial management expert joins Audit & Governance and Nominating Committees

Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defense applications) has announced the election of Judy Bruner to its board of directors. She will also join the board's Audit & Governance and Nominating Committees.

"She brings semiconductor industry leadership and significant experience in financial management with a range of technology companies, and we look forward to her insights and contributions to our board," comments president & CEO Bob Bruggeworth.

Bruner was most recently executive VP, administration & chief financial officer of flash storage product supplier SanDisk Corp from June 2004 until its acquisition by Western Digital in May 2016. Previously, she was senior VP & chief financial officer of handheld computing and communications solutions provider Palm Inc from September 1999 until June 2004. Prior to Palm, Bruner held financial management positions at 3Com Corp, Ridge Computers and Hewlett-Packard Company. She is currently a member of the boards of directors of Applied Materials Inc, Rapid7 Inc and Seagate Technology plc.

GlobalFoundries and GlobalWafers partner to expand silicon-on-insulator wafer supply

Long-term $800m deal includes $210m capital expansion, creation of over 75 jobs in Missouri and will provide SOI wafers for GF's fabs in New York and Vermont

GlobalFoundries (GF) of Santa Clara, CA, USA (which has operations in Singapore, Germany and the USA) and Taiwan-based silicon wafer manufacturer GlobalWafers Co Ltd (GWC) have announced an $800m agreement to add 300mm silicon-on-insulator (SOI) wafer manufacturing and expand existing 200mm SOI wafer production at GWC's MEMC facility in O'Fallon, Missouri.

The announcement expands GF's domestic silicon wafer supply from the USA. In particular, the 300mm wafers made at GWC's MEMC site in Missouri will be used at GF's most advanced manufacturing facility, Fab 8 in Malta, New York, and the 200mm wafers made at the Missouri site will be used at GF's Fab 9 in Essex Junction, Vermont. These wafers will be used to create feature-rich semiconductor solutions to meet the sharply growing demand for GF's RF technologies across a range of applications including 5G smartphones, wireless connectivity, automotive radar, and aerospace.

The long-term agreement includes nearly $210m in capital expenditure to expand GWC's MEMC facility in Missouri and will create more than 75 new jobs. The 300mm pilot line is on track to be completed in fourth-quarter 2021. The agreement is strengthened by $9.4m in investments and support from the State of Missouri, as well as support from the City of O'Fallon, Ameren Missouri, Spire, and Greater St. Louis Inc.

GF is investing $1.4bn in 2021 alone to expand its manufacturing capacity, to meet the needs of customers and address the growing global demand for computer chips. As part of this growth, GF will require an increased supply of wafers like those made by GWC. GWC has a long and ongoing relationship for supplying 200mm SOI wafers to GF. In February 2020, GWC and GF announced the intention to collaborate closely to significantly expand GWC's existing 300mm SOI wafer manufacturing capacity. The latest announcement signals a significant step forward in that collaboration.

The announcement comes at a time when the USA is seeking to fortify and expand its semiconductor supply chain. Only 12% of the world's semiconductor manufacturing capacity is in the USA. Critical to increasing the number of chips manufactured in the USA, and making US chip manufacturing more globally competitive, are federal investments like those enabled by the bipartisan-supported US Innovation and Competition Act and the already passed CHIPS for America Act.

"Semiconductors are critical to our national security and economic competitiveness," comments US Senator Roy Blunt of Missouri, an instrumental supporter of the US Innovation and Competition Act. "The supply chain of these computer chips is highly complex and largely dominated by other countries. We need to begin making more chips at home to protect US industries from chip shortages like we have seen in recent months. Today's announcement is good news for semiconductor manufacturing and will create steady, good-paying, high-tech jobs for Missourians," he adds.

The announcement expands GF's domestic silicon wafer supply from the USA... 300mm wafers made at GWC's MEMC site in Missouri will be used at GF's most advanced manufacturing facility, Fab 8 in Malta, New York, and the 200mm wafers made at the Missouri site will be used at GF's Fab 9 in Essex Junction, Vermont

"As a trusted semiconductor manufacturer and supplier to the US government, and the world leader in RF semiconductor technology, GF has been leading the charge to accelerate US semiconductor manufacturing and boost our capacity to meet the growing global demand for chips," says GF's CEO Tom Caulfield. "The kind of partnership we are announcing today with GWC is only possible thanks to Congressional leadership and the renewed national interest in growing US semiconductor manufacturing capacity," he adds.

"We are proud to deepen our strategic partnership with GF, and to expand our important role in the US semiconductor supply chain," says GWC's chairman & CEO Doris Hsu.

"For more than six decades, we have been the home of MEMC and its manufacturing of world-class silicon wafers," notes O'Fallon mayor Bill Hennessy.

GF employs more than 7000 people across the USA. Over the past 12 years, the firm has invested $15bn in US semiconductor development, and it is doubling its planned investment in 2021 to expand global capacity and support growing demand from the USA government and industry customers for secure processing and connectivity applications.

www.sas-globalwafers.com
www.globalfoundries.com

MixComm launches 37–41GHz 5G front-end IC

GlobalFoundries' 45RFSOI process combines output power, energy efficiency and integration

Fabless semiconductor company MixComm Inc of Chatham, NJ, USA has added to its portfolio of front-end ICs for 5G millimeter-wave (mmWave) with the SUMMIT 3741, which operates at frequencies of 37–41GHz and integrates novel power amplifiers (PAs), low-noise amplifiers (LNAs), T/R switching, beam-formers, calibration, gain control, beam table memory, temperature and power telemetry, and high-speed SPI control for a front-end module with optimal partitioning for 5G infrastructure. The device is suitable for Antenna-in-Package (AiP) implementations, as well as conventional chip-on-board integration through the use of interposers.

The SUMMIT 3741 also features enhanced digital integration, uniquely enabled by the 45RFSOI (radio-frequency silicon-on-insulator) process of GlobalFoundries (GF), which is said to have inherent advantages over other semiconductor technologies for mmWave applications.

SUMMIT 3741 product highlights are cited as:

- four-element dual-polarization TX/RX;
- independent dual-polarization beam directions;
- ultra-low TX- and RX-mode power consumption;
- high-power, high-efficiency stacked SOI CMOS PAs;
- low-loss T/R switch for TDD support;
- 6-bit full-360° phase shifting and 0.5dB-step 16dB-range variable gain in each path;
- fully calibrated for gain/phase matching across ICs;
- on-chip temperature sensor;
- gain control for temperature compensation;
- on-chip power sensor for each TX;
- operates from 1V, 1.8V and 4V power supplies;
- 100MHz SPI with 2048-entry on-chip beam table storage;
- 6-/8-bit chip ID with multiple modes of programming; and
- flip-chip die with 75μm bump size and 200μm bump pitch.

"5G will continue to push towards the higher mmWave frequency bands, bringing new challenges to conventional approaches," says co-founder & chief technology officer Dr Harish Krishnaswamy. "With SUMMIT 3741, we are introducing several 'firsts' to the market and look forward to working with our customers to push the envelope for 5G mmWave."

Like the SUMMIT 2629, which has been shipping to customers since fourth-quarter 2020, the SUMMIT 3741 has been designed to address the critical challenges that currently constrain 5G mmWave success, by:

- extending range to decrease carrier cost and improve customer satisfaction;
- reducing thermal and electrical power consumption budgets, and
- optimizing antenna arrays to reduce module cost.

5G will continue to push towards the higher mmWave frequency bands, bringing new challenges to conventional approaches. When we announced our first product in 2020, we highlighted that no other company has as much mmWave and RFSOI design and product experience. This deep experience has resulted in many design wins for the SUMMIT 2629 and now the latest breakthrough product in our portfolio, the SUMMIT 3741

MixComm says that these benefits make its solutions suitable for 5G infrastructure ranging from gNodeB base stations and repeaters to customer premises equipment. The flexible architecture and ultra-low-power operation can also enable 5G hotspots and other user equipment demanding long battery life and sleek form factors.

The SUMMIT 3741 debut follows MixComm's recent announcements including being the first mmWave company selected to join the 5G Open Innovation Lab and being named the Broadband Innovation of the Year by the 2020 Mobile Breakthrough Awards. MixComm also recently co-hosted the in augural mmWave Summit with Microwave Journal and was selected by the US Defense Advanced Research Projects Agency (DARPA) to develop next-generation mmWave innovations for 5G and satellite communications.

"When we announced our first product in 2020, we highlighted that no other company has as much mmWave and RFSOI design and product experience," says MixComm's CEO Mike Noonen. "This deep experience has resulted in many design wins for the SUMMIT 2629 and now the latest breakthrough product in our portfolio, the SUMMIT 3741."

The SUMMIT 3741 will be available for sampling in early third-quarter 2021. MixComm showcased the SUMMIT 3741 and its other products and technology at the 2021 IEEE MTT-S International Microwave Symposium (IMS) in Atlanta, GA, USA on 8–9 June.

www.globalfoundries.com
www.mixcomm.com/mixcomm-products

ST brings Tower into 300mm analog and power fab under construction in Italy

Partners to accelerate Agrate R3 300mm fab ramp-up to large volumes

Independent device manufacturer STMicroelectronics of Geneva, Switzerland and specialty analog foundry Tower Semiconductor Ltd (which has fabrication plants in Migdal Haemek, Israel, and at its US subsidiaries in Newport Beach, CA and San Antonio, TX, and at TowerJazz Japan Ltd) have agreed that ST will welcome Tower to its Agrate R3 300mm fab under construction on its Agrate Brianza site in Italy.

ST and Tower will join forces for an accelerated fab ramp-up, a key factor to reach a high utilization level and therefore a competitive wafer cost. ST will share the clean-room in R3, with Tower installing its own equipment in one third of the total space. The fab is expected to be ready for equipment installation later this year and to start production in second-half 2022.

STMicroelectronics and Tower will share the facility infrastructure. Both firms will invest in their respective process equipment and work together on the acceleration of the fab qualification and subsequent ramp-up. Operations will continue to be managed by ST, with select Tower personnel seconded to ST in specific roles to support fab qualification and volume ramp-up, as well as other engineering and process roles. In the early stage, 130nm, 90nm and 65nm processes for smart power, analog mixed-signal and RF applications will be qualified in R3.

"The key parameter for industrial and economic performance of a fab is its utilization. With Tower we have a great partner for analog, power and mixed-signal volume manufacturing that will enable us to qualify and ramp up the Agrate R3 300mm fab significantly faster. This will enable an optimal utilization of the fab almost right from the early stage of production. The capacity of the full build-out state of the fab could even be increased compared to the original capacity estimate of 2018, when we started the project," says STMicroelectronics' president & CEO Jean-Marc Chéry.

"The products manufactured in Agrate R3 will support the automotive, industrial and personal electronics markets. They will contribute to ease the supply tensions in a wide range of applications in the mid to longer term," he adds.

"ST is well known for its leading technology, operational excellence and corporate integrity," comments Tower's CEO Russell Ellwanger. "Tower's strong execution in advanced 65nm, 300mm-based analog RF, power platforms, displays and other technologies will be significantly enhanced by this activity in Agrate; more than tripling Tower's 300mm foundry capacity to well service our customers' increasing demand within these fast-growing markets."

To implement the project, Tower will establish an Italian subsidiary. The firm will provide details of its cap-ex investment schedule and amounts invested as the project progresses.

www.st.com
www.towersemi.com

Guerrilla RF surpasses 100 million RFIC/MMIC deployments after less than six years

Guerrilla RF Inc of Greensboro, NC, USA — a provider of radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless applications — has surpassed the 100 million milestone for RFIC/MMIC deployments in less than six years after releasing its first product.

Guerrilla RF says that, since being established in 2013, it has experienced incredible growth in the wireless infrastructure market. In 2020, the firm was recognized by Inc. magazine as being one of top 500 fastest-growing companies in the USA.

"When we shipped our first device in 2015, we set out with a singular, strategic philosophy where we aimed to create cutting-edge RF semiconductor technology for markets that were becoming underserved within the wireless space," says founder & CEO Ryan Pratt. "Many of the larger incumbents in this industry had become enamored with higher-volume wireless sockets, thus creating a golden opportunity for Guerrilla to stealthily disrupt the underserved wireless infrastructure market by combining the very best in RF innovation and performance with unparalleled customer support," he adds.

"Over the past three years, we've seen our business grow over 1000% as we established leadership positions within high-end wireless infrastructure markets like 5G/4G cellular base stations, cellular repeaters/boosters, automotive communications, military comms, navigation and wireless audio," notes Pratt.

www.guerrilla-rf.com/100M

InGaP HBT power amplifiers with 23dBm output

¼W PAs target 5G/4G wireless infrastructure applications requiring high native linearity over temperature extremes

As part of its expansion into the cellular market, Guerrilla RF has launched three new ¼W linear power amplifiers designed specifically for 5G/4G wireless infrastructure applications requiring exceptional native linearity over temperature extremes of –40°C to 85°C.

Spanning frequency ranges of 1.7–1.8GHz, 1.8–1.91GHz and 1.92–2.0GHz respectively, the GRF5517, GRF5518 and GRF5519 indium gallium phosphide (InGaP) heterojunction bipolar transistor (HBT) amplifiers are tuned to operate within the n1, n2, n3, n25, n39, n65, n66 and n70 5G new radio (NR) bands.

The devices typically deliver 23dBm of linear power over the entire –40°C to 85°C temperature range while maintaining ACLR (adjacent-channel leakage ratio) levels of better than –45dBc, IMD3 (third-order intermodulation distortion) levels <–20dBm, EVM (error vector magnitude) levels <1.5% and power-added efficiency (PAE) >14% — all without the aid of supplemental linearization schemes like digital pre-distortion (DPD).

The ability to beat the –45dBc ACLR performance metric without DPD is critical for cellular applications like home and commercial repeaters/boosters, femtocells, picocells and cable loss compensators associated with automotive 'shark fin' antennas, says the firm. In each of these use cases, the sensitivity to cost, power and size constraints prohibits the use of elaborate linearization techniques like DPD. Instead, designers must rely on the power amplifier's native linearity to meet the stringent emissions mask requirements imposed by the latest 5G and 4G standards.

During the development of the GRF55xx series, Guerrilla RF consulted directly with its base of customers to ensure the devices delivered the best blend of power and linearity, thus maximizing the effective range and throughput for their cellular systems. The firm also designed the entire family of devices to be fully footprint compatible, enabling its customer base to rapidly customize their designs for a myriad of cellular frequencies.

"The GRF55xx family builds upon the groundbreaking work which we started over a year ago with the release of the GRF5504/9 series of 5W InGaP HBT power amplifiers," says CEO & founder Ryan Pratt. "These new ¼W PAs were created specifically to meet the needs of our strategic customers in the cellular and automotive industries," he adds. "Together with the original GRF5504/9 series, the GRF55xx family will serve as the beachhead for Guerrilla RF's expansion into the growing power amplifier market."

The GRF55xx family comes in pin-compatible 3mm x 3mm, 16-pin QFN packages. The common footprint enables a single design to address multiple bands via simple component swaps.

Samples and evaluation boards are available now for the GRF5517, GRF5518 and GRF5519. Prices start at $1.55 (10,000-up, EXW USA).

www.guerrilla-rf.com/5517-19

pSemi kicks off portfolio expansion in Wi-Fi 6E and ultra-wideband

8.5GHz RF switch delivers range, speed and accuracy in 1.5mm x 1.5mm form factor

Murata company pSemi Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) — says that its top-selling UltraCMOS PE42424, a single-pole, double-throw (SPDT) radio-frequency switch, supports the latest Wi-Fi 6E and ultra-wideband (UWB) standards and technology.

Designed to enhance next-generation carrier and enterprise connectivity products, the PE42424 offers high linearity, fast switching and optimal isolation up to 8.5GHz. In a compact 1.5mm x 1.5mm form factor, it exceeds the power and performance requirements of 802.11ax Wi-Fi and ultra-wideband technologies.

Unlike Wi-Fi 6, which only supported devices that operated up to 6GHz, Wi-Fi 6E is extended up to 7.125GHz, providing more seamless connections, faster data rates and transmission accuracy to the wireless ecosystem. The PE42424 delivers a frequency range up to 8.5GHz to accommodate the increasing demand for reliable ultra-wideband technology, while remaining fully compliant for use in

Wi-Fi 6 applications at 2.4GHz and 5GHz bands for maximum application flexibility.

"The semiconductor industry has seen a marked increase in device designers taking advantage of ultra-wideband technology, from location detection and radar to proximity sensing, and the extended frequency range of Wi-Fi 6E," says Vikas Choudhary, VP of sales & marketing. "pSemi has sold over 25 million units of the PE42424, and this high-performance switch will continue being an ideal solution for existing and emerging connectivity technologies, such as Wi-Fi 7," he adds.

The PE42424 delivers high linearity levels of 61dBm IIP3 and 125dBm IIP2 and fast switching of 145ns at up to a 125kHz switching rate to ensure the highest levels of signal routing performance and transmit signal integrity in Wi-Fi 6E and ultra-wideband applications. Additionally, the switch provides what is claimed to be exceptional off-port isolation levels of 48dB at 2.4GHz and 35dB at 5.8GHz and exceeds 31dB at 7.125GHz, enabling more reliable connections and additional spectrum capacity up to 8.5GHz.

The PE42424 is manufactured on pSemi's patented UltraCMOS process and offered in 6-lead, 1.5mm x 1.5mm DFN packaging. At nearly half the size of competing products, it is reckoned, the switch's compact form factor returns valuable board real estate back to the designers and system architects of next-generation connectivity products.

www.psemi.com

Altum RF announces Digi-Key marketplace storefront

Evaluation boards for selected products available for purchase on Digi-Key website

Altum RF of Eindhoven, The Netherlands (a designer of high-performance RF to millimeter-wave solutions for next-generation markets and applications) says that the Altum RF marketplace storefront is now live on the website of distributor Digi-Key Corp, featuring a selection of its evaluation boards.

Evaluation boards available include the ARF1306C5, a 2–18GHz gallium nitride (GaN) distributed amplifier delivering greater than 2W of output power, and the ARF1010Q4, a 22–30GHz linear power amplifier achieving 28dB gain and 36dBm OIP3. Several low-noise amplifier (LNA) evaluation boards are also available.

"A key milestone in our product development strategy is to make our evaluation boards more widely available to customers to enable full and complete evaluations of our versatile catalog products," says Altum RF's CEO Greg Baker. "Digi-Key's industry-leading website makes it easy for customers to purchase our evaluation boards on a popular, trusted platform."

www.digikey.com/en/supplier-centers/altum-rf
www.altumrf.com

MACOM gives live demonstrations and technical talks at International Microwave Symposium

At the IEEE's International Microwave Symposium (IMS 2021) in Atlanta, Georgia (7–10 June), MACOM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for analog RF, microwave, millimeter-wave and photonic applications) hosted eight virtual live demonstrations (scheduled with customers) and four virtual technical talks, hosted by MACOM's high-performance RF design, product management and applications engineering teams.

High-performance discretes:

DEMO #1: *'MACOM KV CAPS: Industry's Highest Voltage Semiconductor-Based Capacitor'* — showcased MACOM's KV CAPS product line being used in a simulated medical application.

DEMO #2: *'Industry Highest Power Switch and Driver in a Plastic Surface Mount Package for Military Applications'* — showcased the innovative design and performance of a surface-mount PIN Diode SP4T switch and a PIN Diode Driver for military applications.

RF Power Offerings — MACOM PURE CARBIDE:

DEMO #3: *'Demonstrating 3kW Power from a Single Device GaN-on-SiC Amplifier'* — showcased what is claimed to be the highest power in the industry from a single device at 1GHz. The demonstration highlighted amplifier performance of 3kW of pulsed power at 1030MHz with efficiency >67%.

DEMO #4: *'Demonstrating High Efficiency at 3.1GHz to 3.5GHz with a 100W Power Amplifier'* — showed the high-efficiency performance of GaN-on-SiC for S-band applications over the 3.1–3.5GHz frequency band.

DEMO #5: *'Demonstrating Ultra-Wideband 25W Matched Performance'* — highlighted a 25W power amplifier over the 30MHz to 2.7GHz frequency range. Showcasing wideband performance, the amplifier features a 50Ω input match and is housed in a standard QFN package.

DEMO #6: *'Demonstrating Industry Leading DPD Performance at 400MHz for 5G mMIMO applications'* — showed the capability of correcting a 110 W Doherty power amplifier designed for Massive MIMO applications for band 78, using digital pre-distortion over a wide instantaneous bandwidth of 400MHz.

Millimeter Wave Portfolio:

DEMO #7: *'Demonstrating 5G 28GHz Tx/Rx Front-End Module Capabilities'* — showcased MACOM's capability in mmWave front-end modules (FEMs) using mixed technologies to deliver optimum performance for 5G applications.

DEMO #8: *'Demonstrating High Performance MMIC Power Amplifiers for Ka-Band'* — combined two 6W DIE power amplifiers on an evaluation board for a total output power of 12W for Ka-Band applications.

IMS 2021 live technical talks included:

TECH TALK #1: *'PCB Design for MMIC Amplifiers'* — In this presentation, MACOM covered three fundamental PCB design considerations critical for achieving optimal performance — device grounding, thermal considerations and arrangement of bias feeds for amplifiers.

TECH TALK #2: *'Demonstration and Application of MACOM PURE CABRIDE Products'* — In this presentation, MACOM highlighted the high power, efficiency and broadband operation of MACOM's GaN-on-SiC power amplifiers along with the companion power management integrated circuit (PMIC).

TECH TALK #3: *'Hybrid and MMIC-Based Limiters'* — In this presentation, MACOM showed the technical merits of its broad portfolio of limiter diodes, limiter modules and proprietary AlGaAs PIN diode limiter technology.

TECH TALK #4: *'AlGaAs W-Band, High Frequency packaging, High Power Switches'* — In this presentation, MACOM highlighted the technical merits of MACOM's patented AlGaAs technology while highlighting the performance of AlGaAs-based product lines covering 2-40GHz limiter, mmW power, mmW SMT and W-Band components.

www.ims-ieee.org
www.macom.com

Altum RF showcases new products at IMS 2021

27–31.5GHz GaN power amplifier MMICs provide 6W & 12W output

At the IEEE's International Microwave Symposium (IMS 2021) in Atlanta, Georgia (8–9 June), Altum RF of Eindhoven, The Netherlands (a designer of high-performance RF to millimeter-wave solutions for commercial and industrial applications) showcased its featured products and technical expertise at the Georgia World Conference Center.

New products featured included two 27–31.5GHz gallium nitride (GaN) power amplifier monolithic microwave integrated circuits (MMICs), with the ARF1013 delivering 6W output power and the ARF1014 achieving 12W output power. Both devices have output return loss of typically 12dB.

www.ims-ieee.org

II-VI introduces heated ion implantation foundry for 150mm SiC wafers

Engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA — which manufactures silicon carbide (SiC) substrates and also provides foundry ion implantation services and support to the microelectronics industry — has introduced heated ion implantation foundry services for 150mm SiC wafers.

The growing interest in clean energy is accelerating the electrification of the global energy and transport infrastructure and driving the demand for power electronics with high reliability that can be produced at scale, notes II-VI. The firm is therefore now offering ion implantation foundry services and support for 150mm-diameter SiC wafers. II-VI says that its ion implantation process enables highly reliable power electronics by running at temperatures of up to 650ºC to anneal the crystal structure dynamically and eliminate defects. The process provides a very high level of doping precision, both in terms of depth and concentration, the firm adds.

"To our knowledge, II-VI is the first foundry in the world to provide such advanced ion implantation services commercially for 150mm SiC wafers and we plan to scale to 200mm in the future," says Sohail Khan, executive VP, New Ventures & Wide-Bandgap Electronics Technologies business unit. "II-VI's new ion implantation process is extremely versatile: It delivers a broad energy range from 10keV to 1MeV and can be heated or unheated for a wide range of compound semiconductor wafer materials and devices," he adds. "This process is compatible with a vast array of materials, including silicon and diamond for special-purpose applications, as well as those that can be integrated into wafer-scale optics platforms."

II-VI says that it implants tens of thousands of wafers per week and adds tools and capacity as required to support customers' changing needs, provides capacity for urgent spikes in demand, and offers same-day turnaround. It adds that its technical expertise, quality program and broad range of tooling offer a flexible outsourcing option for ion implantation, serving production manufacturing and R&D environments.

II-VI maintains a large complement of high- and medium-current and high-energy production implanters handling 2" to 12" substrates. The firm's wafer foundry services include silicon carbide, gallium arsenide, and indium phosphide epitaxial growth. It also provides ion implantation disk refurbishing and reconditioning services to maximize quality, uptime and utilization.

www.ii-vi.com/product/ion-implantation

Soitec creates VP role for Silicon Carbide Program

Former CEA-Leti CEO to bring SmartCut SiC technology to market

Engineered substrate manufacturer Soitec of Bernin, near Grenoble, France has appointed Emmanuel Sabonnadière as new vice president of its Silicon Carbide (SiC) Program. The newly created position reports to Bernard Aspar, chief operating officer and head of global business units at Soitec.

Soitec reckons its SmartCut SiC substrates will enable new levels of device performance and accelerate the adoption of SiC in automotive and other markets.

Before joining Soitec, Sabonnadière was CEO of Grenoble-based micro/nanotechnology R&D center CEA-Leti, a technology research institute of the French Alternative Energies and Atomic Energy Commission (CEA). Before that, he served in executive positions at Philips Lighting (now Signify), European investment firm Gimv, and General Cable Europe. He started his career at Schneider Electric, Alstom/ Areva, and the manufacturing group NKM/Noell.

"With his profound experience in industry, business and technology, with his impressive global profile and his leadership skills, Emmanuel is a perfect fit for Soitec to drive our promising SmartCut SiC technology and conquer new markets," reckons Aspar. "Emmanuel has the intimacy with our local ecosystem and our customers worldwide to lead this development, launch manufacturing and drive the industrialization of our SiC program," he adds.

"Soitec's technology is a powerful motor to fuel new businesses and launch innovative and disruptive applications in the automotive and industrial markets," believes Sabonnadière. "Soitec is well placed to capture the growing demand for smart semiconductor substrate solutions," he adds. "I am looking forward to bringing Soitec's SiC solutions to market fruition quickly and thank CEA-Leti for its reliable and long-standing support."

In November 2019, Soitec announced a SiC substrate joint development program leveraging its proprietary Smart Cut technology — used in the manufacture of silicon-on-insulator (SOI) products — with the process technology expertise of Applied Materials Inc of Santa Clara, CA, USA. The firms were due to install a SiC engineered substrate pilot line at the Substrate Innovation Center at CEA-Leti, entering operation in first-half 2020 and producing wafer samples using Smart Cut in second-half 2020.

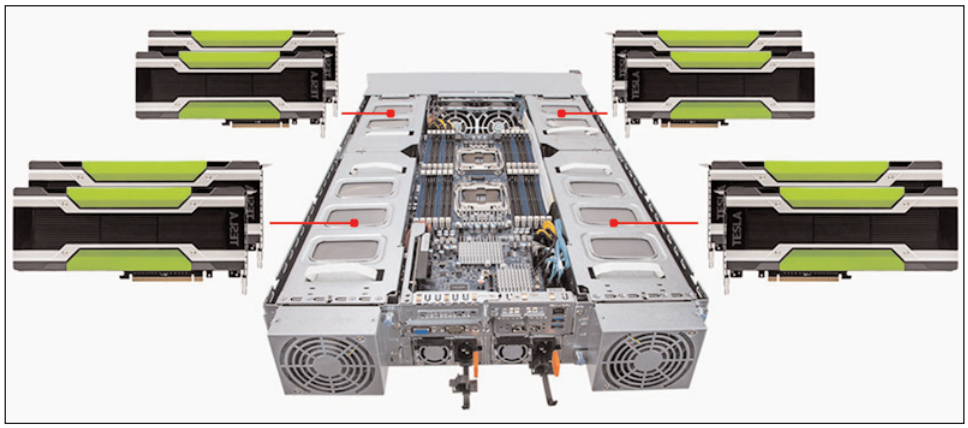
www.soitec.com

Gospower uses Cree's Wolfspeed 650V SiC MOSFETs for common redundant power supply

Data-center power servers supporting China's digital storage demands

Cree Inc of Durham, NC, USA says that China-based power electronics converter maker Shenzhen Gospower Digital Technology Co Ltd will utilize its Wolfspeed 650V silicon carbide MOSFETs for next-generation common redundant power supply (CRPS) solutions. As the demand for cloud-based storage continues to expand rapidly, Gospower will leverage Wolfspeed's SiC technology to deliver power efficiencies that will boost China's power server market and better support the country's digital storage demands.

Server and computing power supply demands are increasing significantly due to rapid developments in the cloud, artificial intelligence, distributed storage and 5G industries. Cree says that its Wolfspeed 650V silicon carbide MOSFETs offer high efficiency through low switching and conduction losses, as well as high-power-density features including smaller footprints, lighter weight and fewer components. Customers benefit from lower total cost of ownership through the more efficient use of power, reduced cooling requirements and what is claimed to be industry-leading reliability, enabling faster rollout of server power supply solutions.



Gospower will leverage Wolfspeed's SiC technology to deliver power efficiencies that will boost China's power server market and better support the country's digital storage demands

"To meet the growing need for a power supply solution that has higher efficiency, smaller size and high power density, we partnered with Cree to utilize its Wolfspeed 650V silicon carbide MOSFETs to create an application that will help transform the Chinese server market," says Gospower's CEO Ruan Shiliang.

Gospower developed a 2400W/2600W 185mm CRPS solution that utilizes Wolfspeed silicon carbide MOSFETs in the totem-pole bridgeless power factor correction (PFC) design. This device creates a highly efficient, reliable and cost-effective solution that operates under higher temperatures and features lower switching losses, zero reverse recovery and high power density, all in a smaller size.

"This solution will help advance the power supply sector and is a testament to the innovations that are made possible by silicon carbide when we collaborate with industry leaders such as Gospower," says Cree's CEO Gregg Lowe.

www.wolfspeed.com/power/products

GeneSiC launches Gen5 650V SiC Schottky MPS rectifiers

Merged-PiN-Schottky diode rectifiers offer low knee-voltage

Silicon carbide (SiC) power semiconductor supplier GeneSiC Semiconductor Inc of Dulles, VA, USA has announced the availability of its 5th generation (GE*** series) SiC MPS merged-PiN-Schottky diode rectifiers.

Claiming superior price-performance index and industry-leading surge current and avalanche robustness, the new devices are targeted at meeting the high efficiency and power density goals in applications such as: boost diodes in power factor correction (PFC); server and telecom power supplies; solar inverters; uninterruptible power supplies (UPS); battery chargers; and freewheeling/anti-parallel diodes in inverters.

"GeneSiC was one of the first SiC manufacturers to commercially supply SiC Schottky rectifiers in 2011," says Dr Siddarth Sundaresan, VP of technology. The low built-in voltage (knee-voltage) of the new devices enables low diode conduction losses under all load conditions — crucial for applications demanding high-efficiency energy usage. "In contrast to other competitor SiC diodes also designed to offer low-knee characteristics, an additional feature of our Gen5 diode designs is that they still maintain that high level of avalanche (UIL) ruggedness that our customers have come to expect from GeneSiC's Gen3 (GC*** series) and Gen4 (GD*** series) SiC Schottky MPS," he adds.

www.genesicsemi.com/

ON Semiconductor launches 1200V full-SiC MOSFET modules for electric vehicle charging

Planar-technology-based 2-pack modules suited to 18–20V drive voltage

Power semiconductor IC supplier ON Semiconductor of Phoenix, AZ, USA has announced a pair of 1200V full silicon carbide (SiC) MOSFET 2-pack modules, enhancing its range of products suitable for the electric vehicle (EV) market.

As sales of EVs continue to grow, infrastructure must be rolled out to meet the needs of drivers, providing a network of rapid charging stations that will allow them to complete their journeys quickly and without 'range anxiety'. Requirements in this sector are rapidly evolving, requiring power levels in excess of 350kW and efficiencies of 95% becoming the norm. Given the diverse environments and locations in which these chargers are deployed, compactness, robustness and enhanced reliability are all challenges that designers face.

ON Semiconductor says that its new 1200V M1 full-SiC MOSFET 2-pack modules, based on planar technology and suited to a drive voltage in the range 18-20V, are simple to drive with negative gate voltages. The larger die reduces thermal resistance compared with trench MOSFETs, reducing die temperature at the same operating temperature.

Configured as a 2-pack half-bridge, the NXH010P120MNF1 is a 10mΩ device housed in an F1 package while the NXH006P120MNF2 is a 6mΩ device in an F2 package. The packages feature press-fit pins, making them suitable for industrial applications, and an embedded negative temperature coefficient (NTC) thermistor facilitates temperature monitoring.

As part of the ON Semiconductor EV charging ecosystem, the new SiC MOSFET modules have been designed to work alongside driver solutions such as the NCD5700x devices. The recently introduced NCD57252 dual-channel isolated IGBT/MOSFET gate driver offers 5kV of galvanic isolation and can be configured for dual low-side, dual high-side or half-bridge operation.

The NCD57252 is housed in a small SOIC-16 wide body package and accepts logic level inputs (3.3V, 5V and 15V). The high-current device (source 4.0A/sink 6.0A at Miller plateau voltage) is suitable for high-speed operation, as typical propagation delays are 60ns.

Complementing the new modules and gate driver are the ON Semiconductor SiC MOSFETs that, it is claimed, provide superior switching performance and enhanced thermals compared with similar silicon devices. This results in improved efficiency, greater power density, improved electromagnetic interference (EMI) and reduced system size and weight, the firm adds.

The recently announced 650V SiC MOSFETs (launched in February) employ a novel active cell design combined with advanced thin wafer technology enabling a best-in-class figure of merit (FoM) for ($R_{DS(on)}$*area). Devices in the series such as the NVBG015N065SC1, NTBG015N065SC1, NVH4L015N065SC1 and NTH4L015N065SC offer what is claimed to be the lowest $R_{DS(on)}$ on the market for D2PAK7L/TO247 packaged MOSFETs.

Also, the firm's 1200V and 900V N-channel SiC MOSFETs feature a small chip size that reduces device capacitance and gate charge (Q_g — as low as 220nC), reducing switching losses when operating at the high frequencies demanded by EV chargers.

During the Applied Power Electronics Conference (APEC 2021) Virtual Conference + Exposition held online on 14–17 June, ON Semiconductor showcased SiC solution for industrial applications as well as presenting exhibitor seminars about its solutions for off-board EV charging.

www.apec-conf.org
www.onsemi.com/products/power-modules/sic-modules

ROHM launches first surface-mount AC/DC converter ICs with built-in 1700V SiC MOSFET

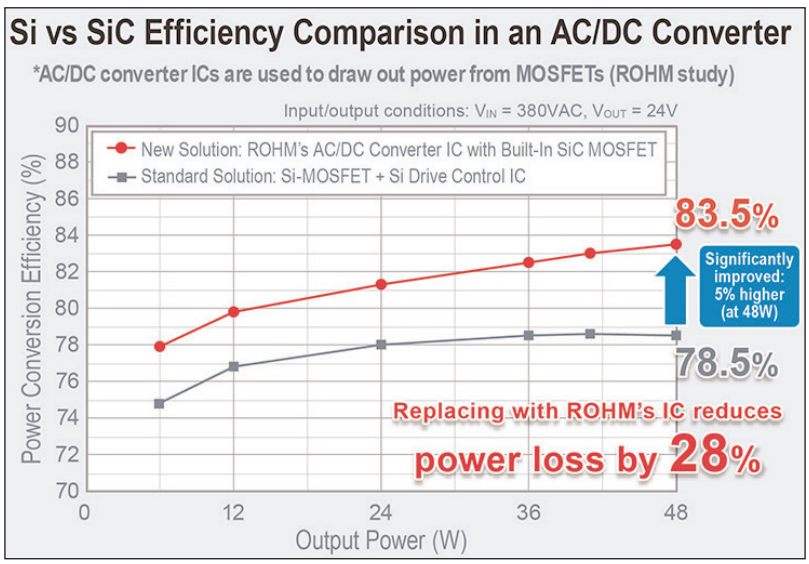
Improving reliability & energy savings; reducing mounting area & costs

Power semiconductor maker ROHM Semiconductor of Kyoto, Japan has launched AC/DC converter ICs with a built-in 1700V silicon carbide (SiC) metal-oxide-semiconductor field-effect transistor (MOSFET) along with control circuitry, optimized for industrial applications focusing on auxiliary power supplies for street lamps, commercial air-conditioning systems, general-purpose inverters and for AC servos drives.

An auxiliary power supply is an essential part of industrial applications for delivering different levels of DC voltages for gate drivers and control units but, using existing silicon MOSFET devices, designers cannot achieve higher efficiency and increased output power because of the higher losses of silicon devices. Existing solutions require a heat-sink and additional components that increase both the losses of the devices and also the size of the system through additional space. Designing an auxiliary power supply using existing silicon devices would also be expensive due to a larger bill of materials (BOM).

ROHM's BM2SC12xFP2-LBZ power ICs are quasi-resonant (QR) AC/DC converters with an integrated 1700V SiC MOSFET in a single compact surface-mount package (TO263-7L, developed specifically for embedded SiC MOSFETs). The ICs are said to be the right fit for industrial auxiliary power supply solutions in terms of efficiency, shortening design time, simplifying the circuitry and reducing additional components through offering integrated solutions. The ICs also increase product reliability by minimizing the risk of component failure, the firm says.

When used in 400V_{AC} 48W output auxiliary power supplies, besides enabling automatic board mounting that was not previously possible, the number of external parts can be significantly reduced compared with standard configurations — from 12 parts (AC/DC converter IC, 800V SiC MOSFET x2, Zener diode x3, resistor x6) plus a heat-sink to just one part.

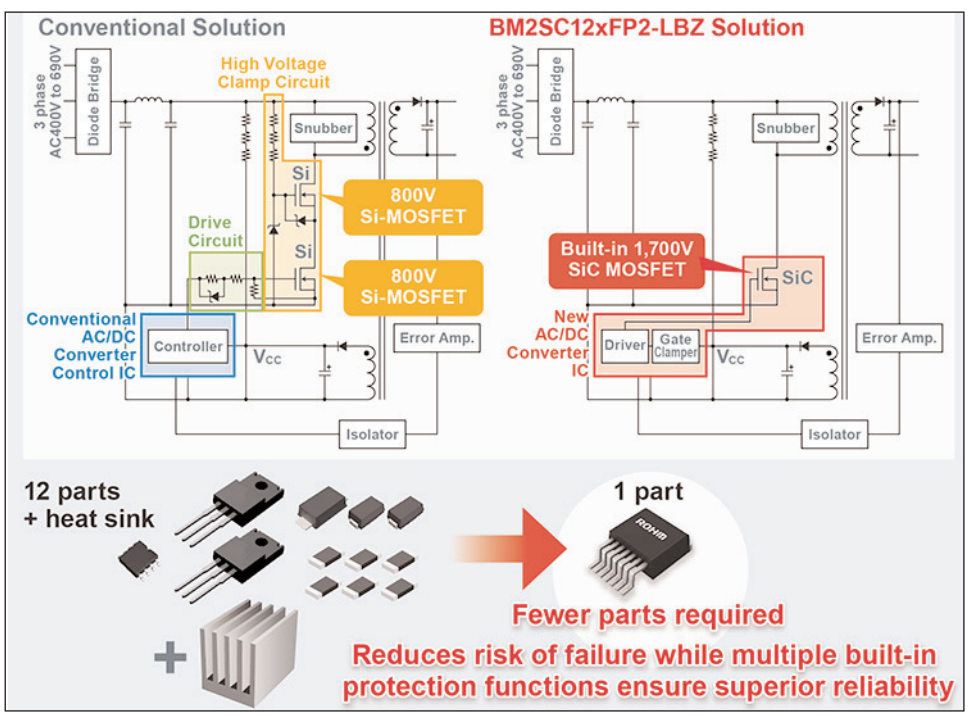


At the same time, adopting a SiC MOSFET improves power efficiency by up to 5% and minimizes the risk of component failure. This makes it possible to dramatically increase reliability and energy savings in industrial equipment while significantly reducing the mounting area and costs, says ROHM.

Also, to support designers, ROHM has made available the BM2SC123FP2-EVK-001 evaluation board using the AC/DC BM2SC123FP2-LBZ IC, which delivers power up to 48W at 400V_{AC} without any heat-sink. Test results for the evaluation board show that the output voltage (24V) is constant and independent from the input voltage.

Pricing is $7.20/unit for the BM2SC12xFP2-LBZ ICs (samples, excluding tax) and $238.80/unit for the BM2SC123FP2-EVK-001 evaluation board, via online distributors Digi-Key, Mouser, and Farnell. Samples are available now, with mass production scheduled for October.

www.rohm.com



ST to design, develop and make SiC- and GaN-based transistors, packages and modules for Renault

Cooperation targets electric and hybrid vehicles produced from 2026

A strategic cooperation has been announced for independent device manufacturer STMicroelectronics of Geneva, Switzerland to design, develop, manufacture and supply products and related packaging solutions for the power electronics systems of battery-operated and hybrid vehicles to France-based automotive manufacturer Renault Group. It is expected that these technologies will have significant impacts on the driving range and charging of electric vehicles (EVs) by reducing power losses and improving efficiency, resulting in lower battery costs, more kilometres per charge, shorter charging time and reduced user-cost.

The aim of the collaboration is to improve the power performance of Renault's applications for electric and hybrid vehicles, based on ST's wide-bandgap semiconductor technologies and products. The firms will collaborate on the development of efficient, right-sized and modular components based on the understanding of Renault's technology needs for silicon carbide (SiC) devices, gallium nitride (GaN) transistors, along with related packages and modules. As Renault's key innovation partner, ST will benefit from significant volumes guaranteed for the annual usage of these power modules and transistors during 2026–2030.

"We are delighted to work with market leader STMicroelectronics to integrate their advanced power electronics and to co-develop technologies to further improve the energy capacity of our electric and hybrid vehicle batteries and their performance on the road and when charging," says Renault Group's CEO Luca de Meo. "This partnership secures future supplies of key components which will significantly contribute to reducing wasted energy by 45% and decreasing the cost of the e-powertrain by 30%, helping us fulfil our ambition of making electric vehicles affordable, profitable and popular," he adds.

"With higher-efficiency products and solutions based on advanced materials such as silicon carbide and gallium nitride, we will support Renault Group's strategy for its next generation of electric and hybrid platforms," says STMicroelectronics' president & CEO Jean-Marc Chery. "This partnership will be another step forward in the progressive decarbonization process initiated by the mobility industry and its supply chain."

It is reckoned that the transition to more energy-efficient technologies and improved power performance for the operation of full-electric and hybrid vehicles will enable Renault to continue making improvements to carbon emissions reduction, in line with its objective of achieving carbon neutrality in Europe by 2040 and worldwide by 2050.

www.st.com

UnitedSiC launches new 650V/1200V D2PAK-7L SiC FETs

Silicon carbide (SiC) power semiconductor maker United Silicon Carbide Inc (UnitedSiC) of Princeton, NJ, USA has further expanded its field-effect transistor (FET) portfolio with the introduction of six new 650V and 1200V options, all housed in the industry-standard D2PAK-7L surface-mount package. Available in 30, 40, 80 and 150m_ versions, these latest SiC FETs represent another step in accelerating migration to SiC across applications such as telecom/server power supplies, industrial battery chargers and power supplies, electric vehicle (EV) on-board chargers and DC-DC converters, says the firm.

The D2PAK-7L SiC FETs support significantly heightened switching speeds, with a Kelvin source connection improving gate drive return performance, as well as offering industry-leading thermal capabilities. Through the use of Ag sintering, die attachment can be done on conventional PCBs as well as complex insulated metal substrate (IMS) arrangements. In addition, they exhibit what is claimed to be excellent creepage and clearance figures of 6.7mm and 6.1mm, respectively, so the highest degrees of operational safety can be assured even at elevated voltages.

"Through the fast switching capabilities of these latest FETs, alongside the superior thermal performance resulting from Ag sintering, we continue to bring performance, reliability, size and layout benefits to the power designer," says Anup Bhalla, VP engineering.

The new D2PAK-7L devices are fully supported by UnitedSiC's FET-Jet Calculator. Utilizing this free online resource, engineers can assess the different operational parameters needed for their application, carry out detailed performance comparisons and then identify which is the best SiC solution for their design requirements quickly and with confidence, says the firm.

Pricing for the new 650V D2PAK-7L SiC FETs (in 1000-unit quantities, FOB USA) range from $3.27 for the UF3C065080B7S to $7.54 for the UF3SC065030B7S. For the 1200V D2PAK-7L devices, prices range from $3.10 for the UF3C120150B7S to $10.91 for the UF3SC120040B7S. All devices are available from UnitedSiC authorized distributors.

www.unitedsic.com

MaxLinear linearization and Cree GaN-on-SiC PAs combine to efficiently power new ultra-wideband 5G

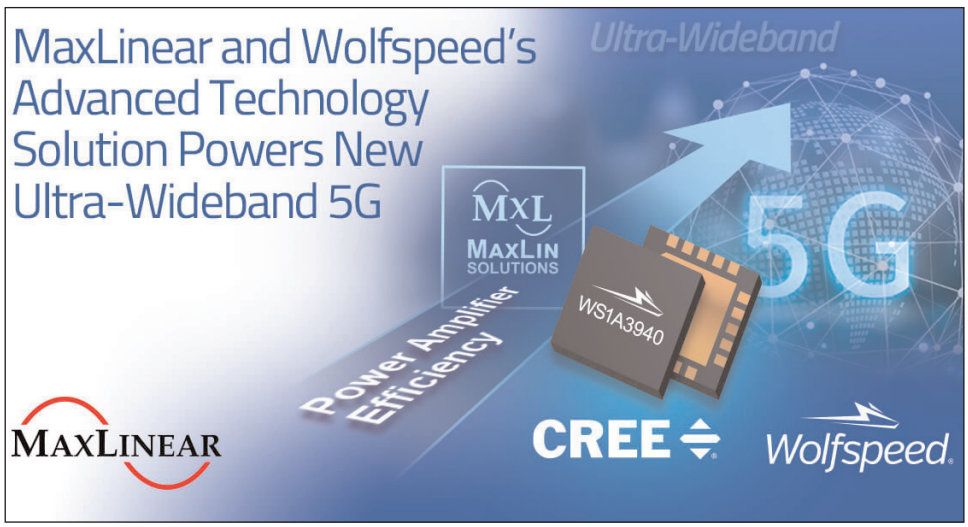
GaN-on-SiC linearization enables 5G base stations to support more high-speed data for mobile users

Radio-frequency (RF), analog, digital and mixed-signal integrated circuit provider MaxLinear Inc of Carlsbad, CA, USA and Cree Inc of Durham, NC, USA say that combining MaxLinear's ultra-wideband linearization solution (MaxLin) and Cree's Wolfspeed gallium nitride (GaN) on silicon carbide (SiC) mid-band power amplifiers can increase wireless capacity of a 5G base station, supporting more simultaneous users and increasing the speed of data transmissions.

The use of GaN-on-SiC with effective linearization accelerates the rollout of 5G by enabling significant power, thermal and cost savings through more efficient wireless transmission, say the firms. The power savings from combining Cree's highly efficient GaN-on-SiC power amplifiers with a highly effective linearization solution implemented by MaxLinear can be hundreds of watts for the massive MIMO radios that 5G demands, it is reckoned.

"Our GaN-on-SiC power amplifiers are designed to achieve high efficiency with extremely wide instantaneous bandwidth in a very small form factor at the newly released 5G spectrum," says Gerhard Wolf, senior VP & general manager of RF at Cree | Wolfspeed. "Working with MaxLinear's solution, this technology demonstrates a significant step forward in achieving outstanding linearity performance and will help wireless providers deliver a superior level of performance and service to mobile customers."

The new solution tackles a substantial industry challenge: implementing radio units with 5G massive MIMO arrays such as 64x64 or 32x32, while maintaining a reasonable size, weight and power. The newer 5G spectrum is at a higher carrier frequency and has wider bandwidths, making it more challenging to achieve high power efficiency for radio units.



"We are solving a substantial challenge of 5G radios," says Helen Kim, VP of MaxLinear's Wireless Technologies & IP. "Customers need to find a way to deliver mid-band 5G capacity without a commensurate increase in cost and power. Our wideband, power-efficient linearization solution and our low-power 400MHz transceivers significantly reduce the heat dissipated by massive MIMO arrays, resulting in a substantially slimmer, lower-cost radio solution," he adds.

The use of GaN-on-SiC with effective linearization accelerates the rollout of 5G by enabling significant power, thermal and cost savings through more efficient wireless transmission, say the firms. The power savings can be hundreds of watts for the massive MIMO radios that 5G demands, it is reckoned

Using GaN-on-SiC, MaxLinear's solution delivers the linearization performance for a 280MHz channel to support US 5G spectrum (3.7–3.98GHz) and a 400MHz channel to support Asian and European 5G mid-band spectrum (3.4–3.8GHz). At 280MHz of instantaneous bandwidth, Cree's WS1A3940 power amplifier achieves ~50% efficiency for the average output power of 39.5dBm, MaxLinear's MxL1600 transceiver provides a sampling rate of 983MSPS, and MaxLin improves linearity by >20dB to exceed 3GPP (3rd Generation Partnership Project) and Federal Communications Commission (FCC) requirements with margin. Using the Wolfspeed WS1A3640 power amplifier, MaxLin also demonstrates a >20dB linearization improvement at 400MHz of instantaneous bandwidth.

Cree's WS1A3940 and WS1A3640 GaN-on-SiC power amplifier modules, MaxLinear's MxL15xx and MxL16xx 400MHz transceivers and MaxLinear's MaxLin linearization technology are solutions that enable both traditional and Open RAN innovations.

www.cree.com
www.maxlinear.com

ROHM develops 150V GaN HEMT with 8V breakdown

Design margin and reliability increased for power supplies in base stations and data centers

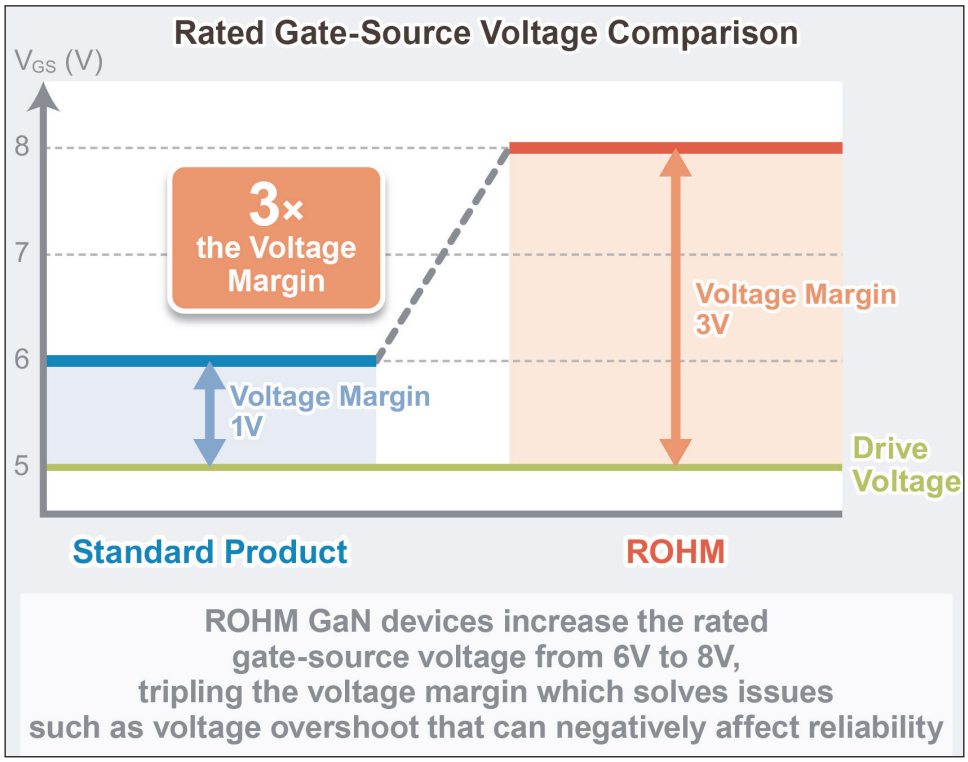
Power semiconductor maker ROHM says that it has developed the industry's highest (8V) gate breakdown voltage (rated gate-source voltage) technology for 150V gallium nitride (GaN) high-electron-mobility transistor (HEMT) devices – optimized for power supply circuits in industrial and communication equipment.

Along with mass-producing silicon carbide (SiC) devices and a variety of feature-rich silicon devices, ROHM has developed GaN devices for high-frequency operation in the medium-voltage range. Cultivating technology that increases the rated gate-source voltage has allowed ROHM to propose a wider range of power solutions for a variety of applications.

As GaN devices provide improved switching characteristics and lower ON-resistance than silicon devices, they are expected to contribute to lower power consumption and greater miniaturization of switching power supplies used in base stations and data centers. However, drawbacks that include low rated gate–source voltage and overshoot voltage exceeding the maximum rating during switching pose major challenges to device reliability.

In response, ROHM has succeeded in raising the rated gate–source voltage from the typical 6V to 8V by using an original structure. This makes it possible to both improve the design margin and increase the reliability of power supply circuits using GaN devices that require high efficiency.

ROHM says that, in addition to maximizing device performance with low parasitic inductance, it is also developing a dedicated package that facilitates mounting and delivers excellent heat dissipation, enabling easy replacement of existing silicon devices while simplifying handling during the mounting process.

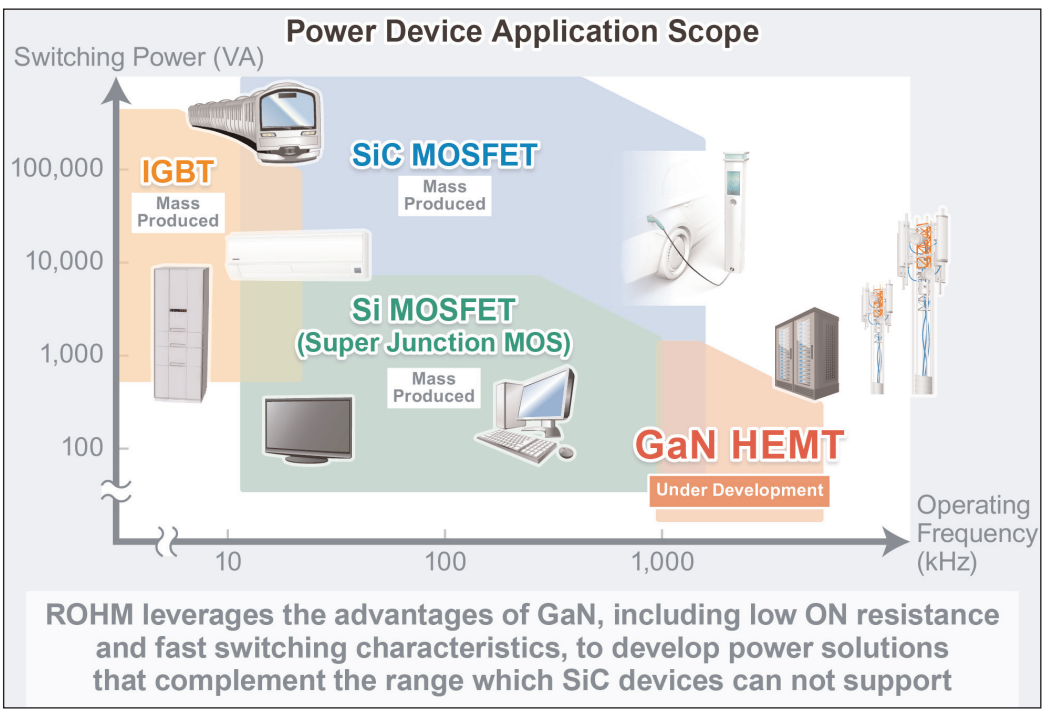


ROHM GaN devices increase the rated gate-source voltage from 6V to 8V, tripling the voltage margin which solves issues such as voltage overshoot that can negatively affect reliability

Application examples are cited as: 48V input buck converter circuits for data centers and base stations; boost converter circuits for the power amplifier block of base stations; Class D audio amplifiers; and light detection & ranging (LiDAR) drive circuits and wireless charging circuits for portable devices.

Going forward, ROHM aims to accelerate the development of GaN devices based on this technology, for sample shipment s in September.

www.rohm.com



ROHM leverages the advantages of GaN, including low ON resistance and fast switching characteristics, to develop power solutions that complement the range which SiC devices can not support

Microchip adds first MMIC to GaN RF portfolio

High linearity in Ka-band allows SatCom Earth stations to transmit at high RF levels without sacrificing signal quality

Satellite communication systems use complex modulation schemes to achieve the fast data rates required to deliver video and broadband data. To attain this, they must deliver high RF output power while simultaneously ensuring the signals retain their desired characteristics. Microchip Technology Inc of Chandler, AZ, USA says that its new GMICP2731-10 gallium nitride (GaN) monolithic microwave integrated circuit (MMIC) power amplifier (available now in volume production) can help to meet both of these requirements.

The new device, Microchip's first GaN MMIC, is designed for use in commercial and defense satellite communications, 5G networks and other aerospace & defense systems.

Fabricated using GaN-on-silicon carbide (SiC) technology, the GMICP2731-10 delivers up to 10W of saturated RF output power across the 3.5GHz of bandwidth between 27.5GHz and 31GHz. Its power-added efficiency (PAE) is 20%, with 22dB of small-signal gain and 15dB of return loss. A balanced architecture allows the GMICP2731-10 to be well matched to 50Ω and includes integrated DC blocking capacitors at the output to simplify design integration.

"As communication systems employ complex modulation schemes such as 128-QAM and as the power of solid-state power amplifiers (SSPAs) trends ever upwards, RF power amplifier designers have the difficult challenge of finding higher-power solutions while at the same time reducing weight and power consumption," notes Leon Gross, VP of Microchip's Discrete Products Group business unit. "GaN MMICs used in high-power SSPAs can achieve greater than 30% lower power and weight as compared to their GaAs [gallium arsenide] counterparts, which is a huge gain for satellite OEMs," he adds. "This product delivers on the promise of GaN and enables the size, weight, power and cost OEMs are searching for."

The GMICP2731-10 complements Microchip's existing portfolio of GaAs MMIC RF power amplifiers, switches, low-noise amplifiers, and Wi-Fi front-end modules, as well as GaN-on-SiC high-electron-mobility transistor (HEMT) driver and final amplifier transistors for radar systems.

To help with design-ins, Microchip provides board design support, as do the firm's distribution partners. The company also provides compact models for the GMICP2731-10, which allow customers to model the performance and expedite the design of the power amplifier in their systems more easily.

www.microchip.com/wwwproducts/en/GMICP2731-10-POWER-AMPLIFIER

Fairview launches GaN-based input-protected LNAs

Input power protection for receive chains sensitive to higher RF input signal conditions

Fairview Microwave Inc of Lewisville, TX, USA (an Infinite Electronics brand that provides on-demand RF, microwave and millimeter-wave components) has unveiled a new series of low-noise amplifiers (LNAs) suitable for use in electronic warfare (EW), radar, space systems, R&D, prototype/proof-of-concept, electronic countermeasures (ECM), microwave radio, VSAT, SATCOM, and test & measurement applications.

The new series of input-protected LNAs feature gallium nitride (GaN) technology, which provides robust input power protection. GaN ensures what is claimed to be an excellent power-to volume ratio that is suitable for broadband high-power applications.

The amplifiers also feature significantly higher breakdown voltage that allows for higher toleration of RF input power signal levels while maintaining excellent low noise figure performance. This is possible without the need for an input protective limiter circuit that is required for other semiconductor technologies and could contribute to higher noise figure levels.

The new input-protected LNAs cover desirable microwave and mm-wave frequency bands. Additional features include high gain up to 46dB typical, high RF input power handling up to 10W CW, broadband frequencies of 1–23GHz and noise figures as low as 1.5dB typical. The LNAs also have rugged, mil-grade compact coaxial designs, what is claimed to be excellent thermal properties, and SMA connectors.

"RF designers will find these industry-leading, state-of-the-art, GaN LNAs extremely useful in receive chains that may be sensitive to higher RF input signal conditions," says senior product line manager Tim Galla.

Fairview Microwave's new input-protected LNAs are in-stock and available for immediate shipping with no minimum order quantity (MOQ) required.

www.fairviewmicrowave.com/rf-products/gan-input-protected-low-noise-amplifiers.html

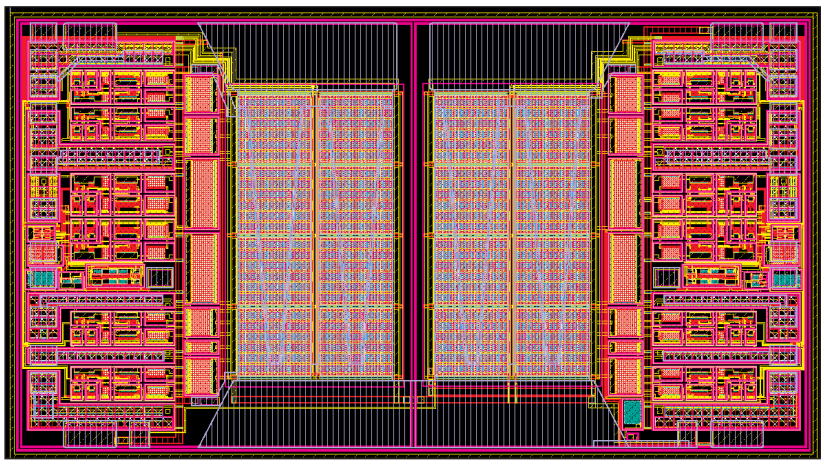
Imec.IC-link and EUROPRACTICE launch design contest for first-time users of GaN-IC 650V technology

Winner gets prototype fabrication on imec's 650V GaN-IC MPW run

Imec.IC-link and the EUROPRACTICE consortium (which provides academic institutions and medium-sized companies with access to IC prototyping services, system integration solutions, training activities and small volume production) are launching a design contest for first-time users of the GaN-IC 650V technology of nanoelectronics research centre imec of Leuven, Belgium.

The use of gallium nitride for power electronics is becoming more important as applications in automotive, consumer electronics and data centers demand ever higher switching speeds, lower losses and smaller form factors, notes imec. The research centre has responded to these challenges through the development of its GaN-IC technology, which permits the integration of power and control devices on a single GaN-on-SOI (silicon-on-insulator) die.

By providing free, open access to this technology for universities worldwide, imec's goal is to stimulate novel designs and applications that will take full advantage of the capabilities of this unique technology.



The winner will get a free prototype fabrication (excluding packaging) of one standard (5mm x 5mm) block size design on imec's 650V GaN-IC MPW (multi-project wafer) shuttle in October (worth €30,000). The design has to be taped out on the October GaN-IC MPW run.

Those eligible to apply span researchers from academic institutions and research institutes worldwide that have never prototyped in imec's GaN-IC technology before.

A two-page application template can be downloaded from www.imeciclink.com/en/design-contest-first-time-users-gan-ic-650v-technology and submitted to Maritza.TangarifeOrtiz@imec.be.

Imec.IC-link says that multiple applications can be submitted, but a maximum of one design per university can be approved.

Submission of proposals is open until 18 August.

The evaluation criteria comprise the following:

- application novelty of the GaN-IC design;
- proposed design methodology;
- clarity of application and credibility of case;
- how this will lead to further research using design and fabrication by your institute.

Proposals will be evaluated by an independent committee and the winner will be informed before 8 September.

www.europractice-ic.com
www.imeciclink.com

MACOM releases GaN Product Model Library to speed customer design cycle time

MACOM joins Modelithics Vendor Partner program

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes semiconductors, components and subassemblies for analog RF, microwave, millimeter-wave and photonic applications) has released its new GaN Product Model Library with the support of Modelithics Inc of Tampa, FL, USA, which provides RF and microwave active and passive simulation models for electronic design automation (EDA). The initial release of the GaN Library includes highly accurate non-linear models for MACOM PURE CARBIDE devices for the MAPC-A1500 (2.6kW, 960–1215MHz), the MAPC-A1501 (1.3kW, 960–1215MHz), and the MAPC-A1101 (85W, DC–3.5GHz).

Product models will be provided to qualified customers at no cost. Each model is developed and validated by Modelithics using extensive linear and non-linear data sets and intended for high power microwave applications. Additional models will be added to the Modelithics MACOM GaN Library on an ongoing basis.

MACOM has joined the Modelithics Vendor Partner (MVP) program. In addition to the latest GaN models, MACOM is sponsoring free extended 90-day trials of all Modelithics models available in the Modelithics COMPLETE Library for MACOM components.

www.Modelithics.com/MVP/Macom

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Fraunhofer IAF presents GaN low-voltage designs enabling compact 3-phase motor inverter IC

GaN-based circuits for battery-powered power electronics at 48V

In battery-powered applications, in the automotive sector and in IT infrastructures, 48V technology is on the rise. In this voltage class, gallium nitride (GaN) power transistors offer the best compromise between safety, compactness and efficiency. Now, Fraunhofer Institute for Applied Solid State Physics (IAF) of Freiburg, Germany has presented integration concepts with GaN-based integrated circuits (ICs) for low-voltage applications.

Whether battery-powered applications such as e-bikes, robotics or drones, drive and board systems in mobility, or IT infrastructures — all these sectors rely on cost-effective, efficient and compact electronics. To meet this demand, Fraunhofer IAF is researching GaN-based circuits for power electronics applications, even at low voltages of up to 48V.

The 48V class has recently been on the rise and finds application in a wide variety of industries. This is due to the more efficient power transmission it offers compared to lower supply voltages. A change to 48V is thus a resource-saving alternative for applications that previously used even lower voltages. In contrast to high-voltage power electronics, 48V offers an ideal compromise between efficiency and safety, says Fraunhofer IAF. There is no need for elaborate safety measures, which renders the voltage class suitable for everyday applications.

Highly integrated GaN components and systems are the ideal solution for 48V technology, says Fraunhofer IAF. Compared with silicon, GaN has significantly better physical properties for power electronics. In addition, GaN technology allows entire circuit components to be integrated on a chip. Researchers at Fraunhofer IAF have developed various highly integrated GaN circuits and pioneering integration concepts for low-voltage applications. They presented their research at the conference PCIM 2021 (Power Conversion and Intelligent Motion): Here, the scientists showed how they merged the two transistors of an integrated half-bridge into a highly compact interleaved design, instead of the usual side-by-side integration, which increases its area-efficiency. They furthermore integrated three such half-bridges into a motor inverter GaN IC for low-voltage applications, and realized an advanced packaging technique for GaN ICs.

Compact and efficient chip layout for low-voltage applications

For several years, GaN-on-Si high-electron-mobility transistors (HEMTs) have been an integral component in various power electronics applications, mostly in high-voltage systems. At Fraunhofer IAF, it was possible to show how advanced layouts and new analytical design concepts will make GaN devices even more compact and efficient in the future. "In research and development, the focus has so far been mainly on 600V GaN devices. Concepts for designing highly compact low-voltage GaN power ICs have hardly been explored," says Richard Reiner, who presented his paper on area-efficient designs for GaN HEMTs at PCIM 2021.

Advanced packaging technology for half-bridge ICs

"GaN technology allows the integration of a half-bridge consisting of two power transistors in one chip, which significantly increases the compactness of a system. To take advantage of this, however, it is extremely important to optimize the integration at the packaging and chip level," explains Michael Basler, a PhD student at Fraunhofer IAF. The packaging of half-bridge ICs is a challenge due to the high requirements regarding electrical and thermal performance as well as reliability. In his talk at the PCIM, he presented a combination of GaN ICs with PCB embedding technology as an advanced packaging solution that can be extended to a system-in-package and enables extremely high power densities for low-voltage DC/DC converters.

Integrated chip design for motor inverter

In addition to single transistors, commercial GaN low-voltage half-bridge ICs are already available. These half-bridge ICs integrate two power transistors in one chip, but only side-by-side, which does not yet capitalize on the full potential. Fraunhofer IAF has now managed to interleave both half-bridge transistors at the smallest structural level, which further improves efficiency and integrated three of these half-bridge structures into a 3-phase motor inverter GaN IC. The developer of the motor inverter GaN IC, Stefan Mönch of Fraunhofer IAF, explains the advantages that result from this interleaved structure: "The intrinsic half-bridge improves the electrical switching properties, and all three phases in the same IC reduce the temperature swing during motor operation. Only one IC is also more cost-efficient and easier to build than six transistors or three half-bridges previously needed for a GaN-based motor inverter."

Fraunhofer IAF says that the integration concepts for low-voltage GaN ICs that it has presented show pioneering approaches to material development, packaging designs as well as user-friendly circuits. Such concepts for efficient and compact GaN technologies form a key component for future applications in the 48V class.

The presented technologies have been developed within the research projects 'GaNTraction' (supported by the Vector Stiftung) and 'GaNonCMOS' (funded by Horizon 2020 of the European Union).

www.iaf.fraunhofer.de

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Live Oak II files SEC registration statement for business combination with Navitas in Q3/2021

Live Oak Acquisition Corp II has filed with the US Securities and Exchange Commission (SEC) a registration statement on Form S-4 that contains a preliminary proxy statement/prospectus for the proposed business combination (announced on 7 May) with Navitas Semiconductor Inc of El Segundo, CA, USA and Dublin, Ireland.

The transaction, which values the combined entity at a pro forma equity value of $1.4bn, will result in Navitas becoming a publicly traded company on a national exchange under a new ticker symbol.

Since gallium nitride (GaN) is reckoned to run up to 20x faster than silicon, Navitas' proprietary GaNFast power ICs are said to deliver up to 3x faster charging in half the size and weight, and with up to 40% energy savings compared with silicon chips. Founded in 2014, Navitas introduced what it claimed to be the first commercial GaN power ICs, which monolithically integrate GaN power field-effect transistors (FETs) and drive plus control and protection circuits, enabling faster charging, higher power density and greater energy savings for mobile, consumer, enterprise (data center, 5G), renewables (solar, energy storage) and electric vehicles (EVs)/eMobility markets.

Navitas is in mass production and ramping shipments to many major OEMs and after-market suppliers, including Dell, Lenovo, LG, Xiaomi, OPPO, Amazon, Belkin and dozens of others. Over 20 million GaNFast power ICs have been shipped, with zero reported field failures.

As a publicly traded special-purpose acquisition company (SPAC), Live Oak II is a blank check company whose business purpose is to effect a merger, capital stock exchange, asset acquisition, stock purchase, reorganization or similar business combination with one or more businesses. Live Oak II is led by a team of managers, operators and investors who have played key roles in helping to build and grow profitable public and private businesses, both organically and through acquisitions, to create value for stockholders. The team has experience operating and investing in a wide range of industries, bringing a diversity of experiences as well as expertise and perspective.

Live Oak II raised $253m in December 2020, and its units, Class A common stock and warrants are listed on the NYSE under the tickers 'LOKB.U', 'LOKB' and 'LOKB WS', respectively.

In connection with the closing of the transaction, Live Oak's Class A common stock will be listed under the new ticker symbol 'NVTS'.

Navitas was originally funded by the company's management team, along with venture capitalists with long-term track records, focused on disruptive businesses in the clean-tech and electronics industries. Capricorn Investment Group, Atlantic Bridge and seed investor Malibu IQ, along with all current investors, are rolling 100% of their equity into the combined company.

Completion of the transaction, which is expected in third-quarter 2021, is subject to approval by Navitas' and Live Oak's respective stockholders, the registration statement being declared effective by the SEC, and other customary closing conditions.

Proceeds of the transaction will be used to fund Navitas' future growth initiatives.

www.navitassemi.com/sec-filings

Navitas showcases GaN power ICs at APEC 2021

GaNFast power ICs for mobile fast charging, data-center, electric vehicle and solar applications

At the virtual Applied Power Electronics Conference (APEC 2021) on 14–17 June, Navitas Semiconductor Inc of El Segundo, CA, USA and Dublin, Ireland showcased its GaN power ICs, and highlighted its partnerships with firms including Dell, Lenovo, OPPO, Xiaomi and LG, all of whom have developed high-efficiency, high-power-density fast chargers for smartphones or laptops using Navitas technology. The 'virtual' booth contained links to deeper technical information on all of these applications, including the very latest 100W Baseus phone/laptop charger that can charge smartphones from zero to 50% in just five minutes.

Among the devices showcased at APEC was the NV6128, the firm's most recent high-power GaNFast IC, which offers 650V/800V nominal/peak operation in a compact 6mm x 8mm PQFN package.

"Engineers trying to design next-generation, energy-saving and high-density power systems are finding that legacy silicon and early 'discrete' GaN can't help them," says Stephen Oliver, VP of corporate marketing & investor relations. "GaNFast power ICs, with fully integrated power, drive, control & protection, unlock the full promise of wide bandgap technology," he adds. "Taking part in APEC allows us to show visitors state-of-the-art GaN power IC design and applications, and give them access to experts with experience in how to best deploy these technologies across a variety of applications."

At APEC 2021, Navitas presented next-generation power solutions in the following presentations:

- IS02 'Gallium Nitride's Penetration into the Power Silicon Market', by David Carroll, senior VP worldwide sales;
- IS06 'Pulsed ACF for Low-Profile GaN Fast Chargers' by Xiucheng Huang, senior director, applications engineering and Stephen Oliver, VP corporate marketing & IR;
- IS13 '300W Multi-Mode Totem-pole PFC Using GaN Power ICs', by Tom Ribarich, senior director strategic marketing and Liming Ye, principal applications engineer;
- ES41 – Gallium Nitride (GaN): 'Electrify Our World', by Stephen Oliver, VP corporate marketing & investor relations.

www.apec-conf.org
www.navitassemi.com

Navitas powers Baseus GaN2 100W charger

First GaN fast charger with Qualcomm QC 5 technology

The first charger with Qualcomm Quick Charge 5 technology fast-charging protocol has been launched by Chinese consumer electronic brand Baseus, featuring Navitas' GaNFast power ICs. With 100W of power, and Quick Charge 5 plus USB-PD and USB-PPS control protocols, the new charger can power any phone or laptop including Samsung's 45W S21 Ultra and Apple's 96W MacBook Pro 16".

The Baseus GaN2 100W charger has a single USB-C output and is 67mm x 30mm x 55mm (111cc), weighs just 178g, and retails for only $34. These specifications make it 40% smaller, 40% lighter and 50% lower retail price than premium silicon-based chargers, it is reckoned.

"With 100W of charging power, users can charge a 4500mAh battery phone from 0% to 50% in just five minutes," says Long Kou Chen, Baseus' vice general manager, Tech Charger Products. "Moreover, Quick Charge 5 enables 100W of charging power to provide better performance in areas like fast-charging laptops. With thanks to the Navitas team for their help bringing the GaN2 100W to market so quickly, users can replace the original large laptop charger — plus phone and tablet chargers — with one, small, light device," he adds.

"Baseus are a future-facing company, with a laser-focus on user experience, which means that they are at the leading edge of not only power semiconductor technology with Navitas, but also in terms of control and fast-charging with Qualcomm Technologies Inc," comments Stephen Oliver, Navitas' VP of corporate marketing & investor relations. "The mobile fast-charger market is only the start for GaN, as we expand into higher-power markets like TVs, home connectivity, data centers, electric vehicles (EVs)/eMobility and solar, attacking an estimated $13bn power semiconductor market by 2026."

The GaN2 100W (model #CCGAN100CS) uses the NV6125 650V GaNFast power IC, running in a high-speed, soft-switching circuit. Alternative discrete GaN solutions require increased component count, larger PCB footprints and higher system cost without integrated protection circuits, creating inherent reliability risks, says Navitas. In contrast, GaNFast power ICs have integrated drive, control and protection circuits that enable unparalleled energy efficiency, robustness & reliability, operating frequencies, design simplicity, system cost and PCB footprint reduction, says the firm.

BrightLoop leverages EPC's eGaN transistors to develop affordable DC/DC converters for off-highway and commercial vehicles

VALUE product line follows PERFORMANCE product line

BrightLoop Converters of Paris, France (which develops and makes high-efficiency, high-reliability power converters) is aiming to democratize access to performance and offer a range of converters dedicated to off-highway and commercial vehicles. The firm is teaming up with Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA — which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) and integrated circuits for power management applications — to deliver the upcoming VALUE DC–DC product line.

BrightLoop says that it has gained experience from many years of development for motorsport applications and learned to make the most out of GaN technology to deliver highly reliable, extremely light and compact converters. In 2020, the firm released a PERFORMANCE DC–DC product line offering what is claimed to be the highest power density on the market (~3kW/kg) and great versatility to extreme vehicle applications and motorsports.

After demonstrating that GaN technology can significantly improve performance, BrightLoop now wants to prove that using this technology does not necessarily lead to higher costs. With the launch of the new VALUE product line later this year, the strategy is to make performance accessible to these markets, which are now also looking for lightweight, space-saving and high-performance converters in the most cost-effective way.

The VALUE product line consists of two converters (M and L) respectively delivering 6kW/300A and 12kW/600A. While being competitively priced, they have a significantly smaller footprint and weight (<5kg) than the equivalent power converters currently available on the market, it is claimed. The VALUE range also features rugged and durable design, as per commercial and off-highway market expectations, and compliance with market standards such as ECE R 10, ECE R 100 and LV 124.

Moreover, BrightLoop's VALUE M and L DC–DC converters can be used in 12V, 24V, 48V architectures and with 400V, 800V or more exotic battery ranges: the same platform addresses all these needs. Like the other BrightLoop converters, this range is based on a foolproof versatility and is available in single- or dual-output version (plus optional) with the possibility to set the output voltage by CAN between 10V and 54V. This feature allows the removal of some components — thus saving space — from the vehicle such as the battery equalizer (present when there are several batteries in the system). In addition, VALUE converters offer a reversibility function that allows, for example, to precharge the HV bus without the need for bulky resistors.

These features are made possible by the use of EPC's EPC2029 80V,48A eGaN FETs, which feature a 1mm ball pitch. The wider pitch allows for placement of additional and larger vias under the device to enable high current-carrying capability despite the extremely small 2.6mm x 4.6mm footprint. Compared with a state-of-the-art silicon power MOSFET with similar on-resistance, the EPC2029 is much smaller and has many times superior switching performance, making it suitable for applications such as BrightLoop's VALUE DC–DC converters.

"We are delighted to continue our collaboration with BrighLoop Converters to demonstrate the capability of our eGaN FETs and ICs to deliver the superior performance and the extreme reliability needed in these commercial and off-highway vehicles," says EPC's CEO & co-founder Alex Lidow. "We look forward to working together on future applications," he adds.

"Our focus has always been to push the limits of performance further and, with this new VALUE product line, our goal is clearly to bring our know-how to markets which have historically worked with heavy and bulky power electronics, making it possible for them to have a taste of outstanding performance, versatility and power density while remaining in their price range," says BrightLoop's CEO Florent Liffran.

www.brightloop.fr/en/value-dc-dc-product-line
www.epc-co.com/epc/Products/eGaNFETsandICs/EPC2029.aspx

EPC participates at APEC 2021

High-power-density solutions using eGaN FETs and ICs showcased in volume applications

At the Applied Power Electronics Conference (APEC) held online on 14–17 June, 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 — delivered multiple technical presentations, an educational tutorial, and an exhibitor webinar on GaN technology and applications

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

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

Technical presentations and seminars featuring eGaN FETs and ICs by EPC included:

- 'Examples of Applications Benefitting from the Monolithic GaN Power Stage and Redefining the State of the Art' (Industry Session IS04.3);
- 'A 1 kW eGaN FET-Based LLC Resonant Converter in the 1/8th Power Brick Size for 48 V Server Applications' (Industry Session IS07.1);
- 'How the Monolithic Integration of Power, Analog, and Digital Components in GaN-on-Si Technology Is Changing Power Conversion' (Industry Session IS08.3);
- 'eGaN FETs and ICs enable next-generation motor drives, robot, drones, eBikes and eScooters' (Industry Session IS15.2);
- 'Physics-Based Models of eGaN Device Failure Mechanisms' (Industry Session IS6.3);
- 'EPC eGaN FETs Enables MPS High Power Density, Fixed-Ratio Intermediate Bus Converters' (Industry Session IS20.1);
- 'Professional Education Seminar: Maximizing GaN FET and IC Performance' (Session S16);
- Exhibitor Seminar: 'How GaN is Driving Changes in Autonomy, Automotive, and eMobility'.

www.apec-conf.org

EPC launches family of rad-hard eGaN FETs and ICs

Mission-critical components target power conversion in spaceborne and high-reliability applications

EPC has launched a new family of radiation-hardened enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) and integrated circuits.

With higher breakdown strength, faster switching speed, higher thermal conductivity and lower on-resistance, power devices based on GaN significantly outperform silicon-based devices, notes EPC. The lower resistance and gate charge enable faster power supply switching frequencies, resulting in higher power densities, higher efficiencies, and more compact and lighter-weight circuitry for critical spaceborne missions. GaN is also inherently radiation tolerant, making GaN-based devices a reliable, higher-performing power transistor option for space applications.

Applications benefiting from the performance and fast deployment of these products include power supplies for satellites and mission equipment, light detection & ranging (LiDAR) for robotics and autonomous navigation and rendezvous docking, motor drives for robotics and instrumentation, and ion thrusters for satellite orientation and positioning, as well as interplanetary propulsion of low-mass robotic vehicles.

The EPC7014, a 60V, 340mΩ, 4APulsed, rad-hard eGaN FET in a tiny 0.81mm^2 footprint, is the first in what will be a wide-range family of rad-hard transistors and ICs. The EPC7014 has a total dose rating greater than 1Mrad and SEE (single event effects) immunity for linear energy transfer (LET) of 85MeV/(mg/cm^2). These devices are offered in a chip-scale package, the same as the commercial eGaN FET and IC family. Packaged versions will be available from EPC Space LLC of Haverhill, MA, USA, a joint venture formed in June 2020 between EPC and VPT Inc of Blacksburg, VA, USA (part of HEICO Electronic Technologies Group).

"EPC's GaN technology enables a new generation of power conversion and motor drives in space operating at higher frequencies, higher efficiencies and greater power densities than ever achievable before," says EPC's CEO & co-founder Alex Lidow. "We are excited about this technologies ability to provide mission-critical components to the space and high-reliability markets."

The EPC7014 is available for engineering sampling and will be fully qualified for volume shipments in October.

www.epc-co.com/epc/Products/eGaNFETsandICs/EPC7014.aspx

GaN Systems presents power electronics solutions at APEC

Firm demonstrating new solutions in fast chargers, audio, EVs

At the virtual Applied Power Electronics Conference (APEC 2021) on 14–17 June, GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) showcased its most recent GaN-based solutions.

In particular, the firm demonstrated new solutions in mobile phone and laptop PC chargers, audio, electric vehicles (EVs) and more, highlighting the technology's ability to meet the rapid growth in data and energy demands across key industries.

Experts from GaN Systems participated in several industry presentations:

- 'WBG High Performance Switches: Transforming the World: The 7 Habits of Highly Effective GaN Designs';
- 'The Effect of Dynamic On-State Resistance to System Losses in GaN-Based Hard-Switching Half-Bridge Applications';
- 'Wide Bandgap Semiconductors in Production: GaN Systems Performance and Reliability in Customer Applications'.

GaN Systems says that it continues to experience accelerated growth with mainstream adoption of GaN technology to meet energy and data demands as well as size and weight reductions required in the consumer electronics, data-center, renewable energy, industrial and automotive industries.

Also at APEC 2021, GaN Systems is exhibiting the following solutions:

- Consumer audio: GaN technology is increasingly being used in the audio market as it supports extreme performance levels, while allowing significant weight reductions and generating minimal heat. GaN Systems says that its transistors, which offer high switching performance in a small package, can be found in Syng's Cell Alpha wireless speaker.
- Consumer power chargers: GaN Systems' innovations include what it claims is the industry's smallest 100W dual USB-C intelligent PD GaN charger, which delivers high efficiency, power density and circuit intelligence. In addition, the firm showcased examples of high-efficiency GaN-based 65W QR and 65W active-clamp flyback (ACF) chargers. Visitors to the GaN Systems' virtual booth could also learn about the firm's EZDrive circuit, which eliminates the cost of double-driver solutions.
- Data center: GaN Systems reckons that its power transistors can reduce energy costs by more than $100m annually and reduce CO_2 emissions by nearly 1 million metric tons for large data-center operators. The firm's high-density, high-efficiency GaN-based 3kW LLC resonant converter reference design can reduce design cycles, costs and time-to-market for companies developing data-center, telecom and industrial switching-mode power supply (SMPS) applications. Paired with the 3kW bridgeless totem-pole power factor correction (PFC) reference design, it enables what is reckoned to be the industry's highest-performing, lowest-cost design for power supply units.
- Automotive: GaN Systems offers solutions for onboard battery chargers (OBC), DC/DC converters and traction inverters. The firm is showcasing its new automotive-grade 650V, 60A transistors, which meet the requirements for high-power, low-loss and high-reliability performance in today's automotive applications, meeting AEC-Q101 and AutoQual+ testing and qualification.

www.apec-conf.org
www.gansystems.com

Odyssey's advisory board gains Cornell professor Khurram Afridi

Odyssey Semiconductor Technologies Inc of Ithaca, NY, USA, which is developing high-voltage power switching components based on proprietary gallium nitride processing technology, has added Khurram Afridi to its board of advisors.

Afridi is an associate professor of electrical and computer engineering at Cornell University, where he conducts research in power electronics and energy systems incorporating power electronic controls. Afridi's team of engineers at Cornell has been studying many applications of GaN devices, including the concept of On-the-Go Charging for electric transportation.

"Afridi is one of the country's top experts on power electronics," says chairman & CEO Alex Behfar. "Customers of our GaN-based vertical-conduction devices are focused on enabling higher-efficiency, lower-weight and smaller-size power electronic systems," he adds. "As a member of our advisory board, professor Afridi will help our team focus on specific device configurations for customers in power system applications such as electric vehicles (EVs) and solar energy."

Afridi's degrees include a PhD in Electrical Engineering and Computer Science from MIT. He was previously chief operating officer and chief technology officer of Techlogix and has worked for JPL, Lutron, Philips, and Schlumberger. He is an associate editor of the IEEE Journal of Emerging and Selected Topics in Power Electronics. Awards for his work include, most recently, the 2016 National Science Foundation CAREER Award from NSF.

Odyssey has also reported a strong first half of the year. The firm announced in April it had raised $5m (1.25 million shares at $4 per share) in a common stock private placement to further fund the development and production of high-voltage vertically conducting GaN power-switching devices. Odyssey has developed new GaN processing technology to produce high-voltage power switching devices that, it claims, can break down long-standing performance barriers for high-power and high-voltage applications such as EVs, solar energy, power grids and industrial motors.

In 2020, Odyssey began trading on the OTCQB Venture Market under ticker ODII and is focused on the premium power switching device market (applications where silicon-based systems perform insufficiently), which is projected to exceed $3.5bn by 2025.

www.odysseysemi.com

Silanna and Transphorm develop 65W USB-C PD GaN adapter reference design

Transphorm GaN-based solution delivers 30W/in^3 power density and 94.5% efficiency

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and manufactures JEDEC- and AEC-Q101-qualified 650V and 900V gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion applications — and Silanna Semiconductor of San Diego, CA, USA, which makes AC/DC and DC/DC power converter ICs, have announced a GaN power adapter reference design.

The solution is an open-frame 65W USB-C power delivery (PD) charger that combines Transphorm's SuperGaN Gen IV platform with Silanna's proprietary Active Clamp Flyback (ACF) PWM controller. Together, the technologies yield peak efficiency of 94.5% with an uncased power density of 30W/in^3. These performance levels are said to outpace currently available competing solutions using silicon superjunction MOSFETs or e-mode GaN transistors, and furthermore utilize a smaller GaN FET from Transphorm. Silanna and Transphorm's universal GaN adapter design is suitable for powering laptops, tablets, smartphones and other Internet of Things (IoT) devices.

The SuperGaN FET in the new reference design is Transphorm's TP65H300G4LSG, a 650V 240mΩ device in an industry-standard PQFN88 package. It leverages the SuperGaN Gen IV platform, which uses advanced epi and patented design technologies to improve performance. The robust GaN FET also offers high reliability, including what is claimed to be the industry's best gate robustness. Also, unlike enhancement-mode (E-mode) devices, protective external circuitry such as additional bias rails or level shifters are not needed — an advantage that produces higher efficiency. Collectively, these and other features further increase the adapter system's overall power density and reduce bill-of-materials (BoM) costs.

Silanna's SZ1130 is claimed to be the first fully integrated ACF PWM controller that integrates an adaptive digital PWM controller, an active-clamp FET, an active-clamp gate driver, and a UHV startup regulator. As an ACF solution, it is claimed to deliver higher performance than competing quasi-resonant (QR) controllers and offer the simplest design in the smallest PCB area among all ACF controllers on the market. Silanna's technology-agnostic design focuses on the ultimate power management challenges with what is claimed to be best-in-class power density and efficiency, yielding unprecedented BoM savings, it is reckoned.

"Transphorm and Silanna Semiconductor offer best-in-class performance in a complete GaN-based reference solution for USB-C PD adapter customers by pairing our SuperGaN devices with Silanna Semiconductor's novel and highly integrated active-clamp flyback controller," says Tushar Dhayagude, VP field applications & technical sales, Transphorm. "Our GaN FETs are known to improve efficiency, power dissipation and size of AC/DC chargers, particularly when compared to competitive E-mode GaN and integrated GaN IC solutions. Our partnership is a powerful combination of two innovators that will positively impact the adoption of GaN in power adapters worldwide," he adds.

"Our ACF controllers are versatile and provide the design flexibility for the charger manufacturers to select their preferred FET technology," says Ahsan Zaman, Silanna's director of marketing. "The ACF controller is delivering 94.5% efficiency with the combination of our SZ1130 and Transphorm's TP65H300G4LSG, achieving industry-leading performance," he claims. "At Silanna Semiconductor, we are extremely excited to further advance the best-in-class efficiency and power density results by combining our knowledge and expertise with technology ecosystem partners."

The 65W USB-C PD GaN power adapter reference design's schematic, design files, and bill of materials are available from the website's of both manufacturers.

www.powerdensity.com/sz1110-sz1130-new
www.transphormusa.com/en/product/tp65h300g4lsg

Transphorm's revenue grows 20% in March quarter

Fiscal year-end changed ahead of applying for Nasdaq Capital Market listing in second-half 2021

Reflecting the firm's new fiscal year-end period (as part of its preparations for a planned application to uplist to the Nasdaq Capital Market in second-half calendar 2021), for fiscal fourth-quarter 2021 (ended 31 March) Transphorm Inc of Goleta, near Santa Barbara, CA, USA has reported revenue of $2.42m, up 20% on the prior quarter's $2m and almost doubling from $1.1m a year previously, due to record product sales driven by expanding adoption of its gallium nitride (GaN) devices for power conversion applications. Full-year revenue was $12.7m for fiscal 2021, up slightly on $12.5m in fiscal 2020.

On a non-GAAP basis, operating expenses were $4.5m, up from $3.7m last quarter but cut from $4.7m a year previously. Full-year OpEx has been cut from $16.5m in fiscal 2010 to $15.6m for fiscal 2021.

Net loss was $5.2m ($0.13 per share), up from $4.7m ($0.13 per share) last quarter but cut from $6.1m ($0.19 per share) a year previously. Full-year net loss was $15.5m ($0.42 per share) for fiscal 2021, up from $13.6m ($0.47 per share) for fiscal 2020.

During the quarter, cash and equivalents have hence fallen from $14.7m to $9.5m.

"Following our strong results and record product revenue in the March quarter, we have continued to secure new design wins and experience growing customer demand for Transphorm's GaN power devices," says president & co-founder Primit Parikh. "Throughout the current quarter our team has been focused on ramping both volume production shipments and future capacity, and we remain on track toward our goal of having the capacity to ship more than 1 million GaN devices for adapters per month by the end of calendar 2021," he adds. "We are also continuing to leverage the field-proven reliability, quality and performance of Transphorm's devices to extend our market-leading position in GaN products for high-power applications, including gaming, crypto-mining and data centers — for which Transphorm's latest Gen 5 product will also be commercially released in the coming quarter."

www.transphormusa.com

Aehr receives $2.3m follow-on order for FOX-XP

System to be used for high-volume wafer-level production test & burn-in of silicon carbide devices

Aehr Test Systems of Fremont, CA, USA says that, in its fiscal fourth-quarter (ended 31 May 2021), it shipped a follow-on order worth more than $2.3m from its lead silicon carbide (SiC) customer for a FOX-XP wafer-level test and burn-in system for high-volume production.

The customer is a Fortune 500 supplier of semiconductor devices with a significant customer base in the automotive semiconductor market, and is using the FOX-XP system for high-volume production burn-in and infant mortality screening of SiC devices at wafer level for electric vehicle (EV) power modules. The FOX-XP system is configured to test 18 SiC wafers in parallel while contacting and testing 100% of the devices on each wafer.

"This follow-on order for an additional FOX-XP system is the result of our working closely with this lead customer to achieve their test requirements and validation of our FOX-P platform and WaferPak full-wafer contactors as their production qualified solution," notes president & CEO Gayn Erickson. "We expect this customer will order a full set of WaferPaks for this system in our new fiscal year that just began, and a significant number of FOX systems, WaferPaks and related consumables that they have forecasted to purchase from Aehr over the next several years," he adds.

"In addition, we remain engaged in promising discussions with multiple key companies in the silicon carbide space, some of which have also publicly indicated plans for significant capacity increases," Erickson continues.

"Silicon carbide continues to be promising as a key growth driver for Aehr, and we anticipate that silicon carbide wafer-level burn-in will become the industry standard for low cost and 100% traceability for burn-in and reliability screening."

The power semiconductor market for electric vehicles is expected to triple between 2020 and 2026, growing at a 25.7% compound annual growth rate (CAGR) to $5.6bn, according to a March report from market research firm Yole Développement. In addition, a July 2020 report from Deloitte forecasts that total EV sales will grow at a CAGR of 29% from 2.5 million in 2020 to 11.2 million in 2025, before reaching 31.1 million by 2030 and securing about 32% of the total market share for new car sales.

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

www.aehr.com

Cadence launches AWR Design Environment Version 16

Custom RF to mmWave IP developed with AWR software now accessible across Cadence design platforms

Electronic design automation (EDA) software provider Cadence Design Systems Inc of San Jose, CA, USA has announced AWR Design Environment Version 16 (V16) with cross-platform interoperability to support RF to millimetre-wave (mmWave) intellectual property (RF IP) integration for heterogeneous technology development across the Cadence Virtuoso design platform as well as the Allegro PCB and IC package design platforms.

The V16 release also introduces seamless integration with the Clarity 3D Solver and Celsius Thermal Solver, delivering unconstrained capacity for electrothermal performance analysis of large-scale and complex RF systems.

The new AWR Design Environment, including Microwave Office circuit design software, enables customers to efficiently design 5G wireless and connected systems for automotive, radar systems and semiconductor technologies and to get to market faster, Cadence says. Platform and solver integration in the V16 release provides up to a 50% reduction in turnaround time (TAT) versus competing workflows, it is claimed.

"To win today in the highly competitive 5G/wireless markets, customers are demanding solutions that enable complete and comprehensive RF workflows that don't just start and stop at the chip but extend to the entire system," notes Vinod Kariat, corporate VP of research & development at Cadence. "The RF workflow innovations enabled by the AWR Design Environment V16 release start with a foundational advance in the way design data and software IP are now shared and seamlessly transferred across products," he adds. "Under the overarching Cadence umbrella, the level of RF integration being introduced with this release is truly an advancement for engineering team productivity."

Platform interoperability is crucial to expediting RF integration and promoting engineering productivity. Seamlessly sharing design data among the AWR Design Environment, Virtuoso and Allegro platforms eliminates any disconnect between RF design and manufacturing layout teams, saves engineering resources and positively impacts development schedules, says Cadence. With the V16 release and its deep electromagnetic (EM) and thermal embedded analyses, customers are seeing more than a 3x reduction in TAT, the firm adds.

Key features in the V16 release include:

- Allegro integration: ensures manufacturing compatibility and RF integration with PCB and IC package design flows
- Virtuoso integration: leverages Microwave Office for RF front-end design IP and combines it with the Virtuoso Layout Suite for IC and module integration;
- Clarity integration: enables EM analysis for design verification of large RF structures such as module packaging and phased-array feed networks;
- Celsius integration: provides thermal analysis for monolithic microwave IC (MMIC) and PCB high-power RF applications;
- AWR enhancements: accelerates RF IP creation with advances in design automation and finite-element analysis (FEA) solver performance.

"Cadence platforms such as the AWR Design Environment, Allegro PCB/SiP and Virtuoso RF with integrated EM solver technologies are critical to the development of our RF/mmWave MMIC, RFIC and multi-chip 2.5/3D packaging technology," comments Florian Herrault, group leader, Advanced Packaging Solutions at HRL Laboratories. "Our design team is very excited by the performance and productivity gains to be had through Cadence's RF solutions. Having the ability to share RF IP created in Microwave Office with our IC, package and board teams is driving a significant reduction in our overall design time so we can deliver the highest-quality products to market faster."

AWR Design Environment V16 supports the Cadence Intelligent System Design strategy, enabling system-on-chip (SoC) design excellence and system innovation. The V16 platform has been released and is now available for download.

www.cadence.com/go/AWRV16

5N Plus invests $8.5m to support demand for II-VI materials

New process technologies and supply chain optimization to lower unit cost of production, reduce carbon footprint and improve access to essential materials

Engineered materials and specialty chemicals producer 5N Plus Inc of Montreal, Québec, Canada, is investing US$8.5m in its Montreal campus to expand the development and manufacturing of critical and strategic materials (including those containing tellurium) for II-VI semiconductor compounds and engineered powders.

The investment is supported by and has received funding from the Ministère de l'Économie et de l'Innovation (Ministry of Economy and Innovation) and the Ministère de l'Énergie et des Ressources Naturelles (Ministry of Energy and Natural Resources) within the province of Quebec, accounting for about a third of the investment.

Alignment between investment and strategy

For over 20 years, 5N Plus has developed ultra-high-purity compounds based on the family of II-VI specialty semiconductor materials at 5N Plus Montreal. With this investment, 5N Plus will expand the capacity of its Montreal campus to address the growing demand for II-VI semiconductor compounds and powders, including those essential for the renewable energy market. The investment in process technology and supply chain optimization will reduce unit cost of production and the overall carbon footprint of the activity. The investment package is expected to be completed by autumn 2022. The firm has indicated that it will be investing near the rate of depreciation over fiscal years 2021 and 2022. This investment package is included in this assumption.

"Following the project's completion, 5N Plus will have the capacity to competitively produce over half of the world's high-purity tellurium-bearing II-VI semiconductor compounds, which are essential elements for several critical industries including renewable energy," says president & CEO Arjang Roshan.

The firm says that, as a global supplier of critical materials for specialty semiconductor devices, it continues to accelerate its semiconductor activities across its sites in Montreal and St George, Utah, USA and recently expanded its II-VI value-chain to include engineered substrates that are essential for optoelectronic applications. This effort has subsequently yielded products that facilitate what is claimed to be unrivalled performance in customer devices used for imaging and sensing applications.

Strategic alignment with AZUR acquisition

While the firm has organically expanded its II-VI semiconductor value-chain, its III-V semiconductor value-chain has required a combination of organic growth initiatives and strategic investments. The announcement in March of 5N Plus' intent to acquire AZUR SPACE Solar Power GmbH supports its strategic transformation. Given AZUR's established business in III-V semiconductor materials, the acquisition, along with 5N Plus' complementary activities in this space, will expand the combined companies' value-chain and serve as a substantial catalyst for growth, it is reckoned. The synergies of AZUR and 5N Plus should further result in a higher total addressable market beyond the expanded space market, allowing the firm to enter markets such as energy efficiency, electrification, advanced communication, and wireless charging.

Following the project's completion, 5N Plus will have the capacity to competitively produce over half of the world's high-purity tellurium-bearing II-VI semiconductor compounds, which are essential elements for several critical industries including renewable energy

"The continued investment in our II-VI and III-V family of specialty semiconductor materials reflects 5N Plus' aim to be the leading global supplier of these critical materials to the growing markets of the future," says Roshan. "We are taking a transformational step in building a unique value-chain that will be a long-term, competitive advantage for our company."

Financial rationale behind investment in sustainability and reliability

The new process technologies facilitated by the $8.5m investment will enable 5N Plus to consolidate and onshore a sizeable portion of its supply chain related to its family of II-VI materials at 5N Plus Montreal, which is powered by hydroelectricity. The totality of this shift will decrease the firm's carbon footprint per unit of production for II-VI specialty semiconductor materials. Further, these new process technologies will reduce chemical reagent consumption along with processed water and solid by-product generation, contributing to the overall cost reduction per unit of production. With this investment, 5N Plus will also enhance its oversight of the tellurium supply chain and ensure competitive and reliable access to critical products for its customers.

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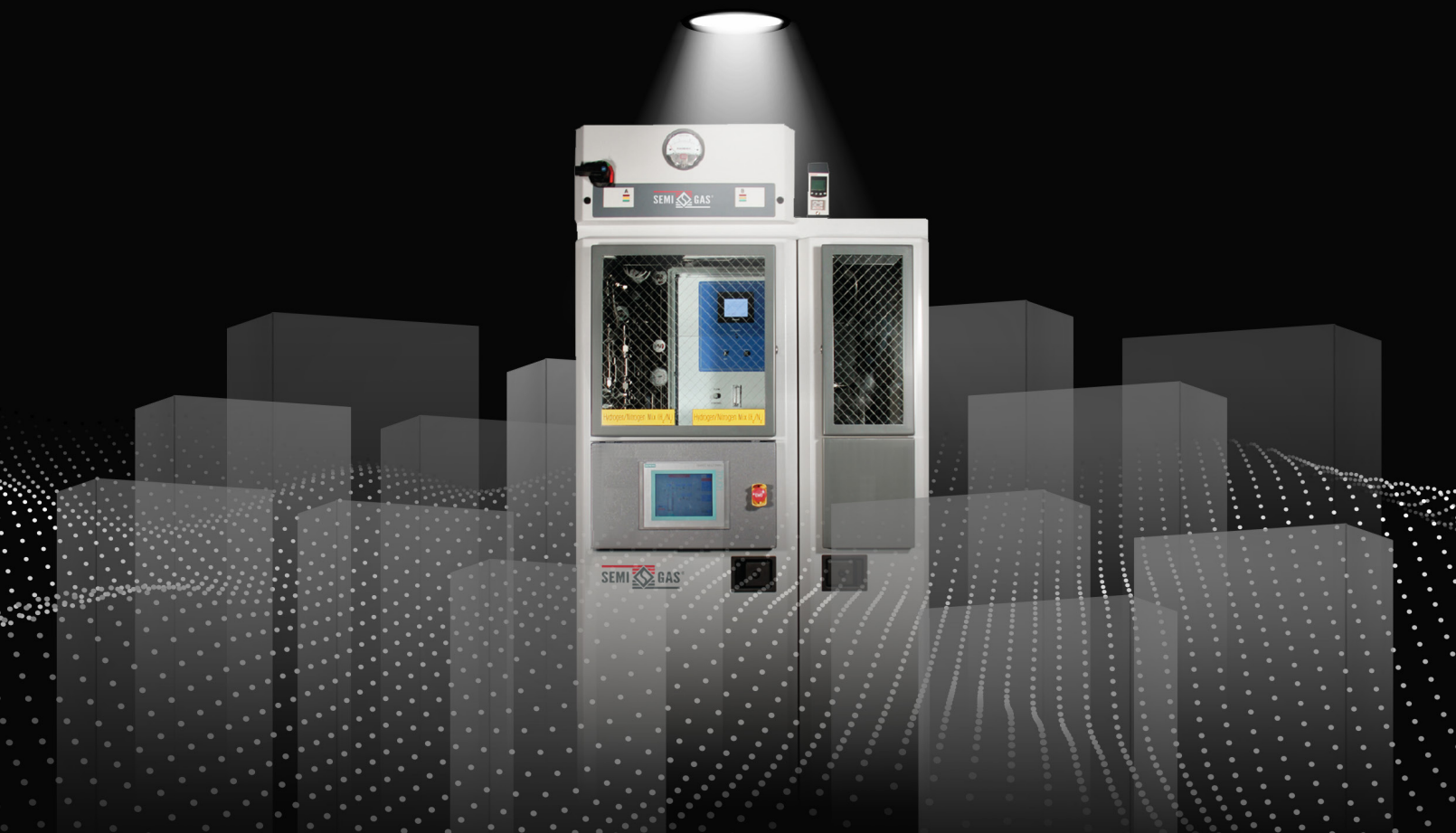

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Riber's Q1 revenue down 41% year-on-year due to deferrals

...but order book rises 20% despite Asia export license difficulties

For first-quarter 2021, Riber S.A. of Bezons, France — which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells — has reported revenue of €3.2m, down 41% on €5.3m a year ago (28% from Europe, 62% from Asia and 10% from the USA).

Revenue came entirely from Services & Accessories, up 4% on €3m a year ago.

There was no revenue from MBE Systems (compared with €2.3m a year ago) due to the deferral of orders from 2020 in the context of the COVID-19 pandemic.

Revenue from Evaporators remained zero.

Despite being down on €22.5m a year ago, the order book rose by 20% during Q1/2021 from €14.4m to €17.3m.

Specifically, while orders for Evaporators remain zero, Services & Accessories orders were €7.7m, up slightly on €7.6m a year ago. While still down on €14.9m a year ago, the Systems order book rose from €5.7m to €9.6m, comprising four machines to be delivered in 2021 (including one production unit). This included two orders for MBE systems recorded during the quarter, "confirming the gradual upturn in new orders despite the persistent difficulties with finalizing certain contracts in Asia, subject to the granting of export licenses," notes Riber.

In addition, this does not include an order for a production system announced on 13 April.

Also, during Q1/2021, the first MBE 8000 system was made available in March to one of the company's long-standing clients.

Riber says that, for 2021, it plans to consolidate its business compared with 2020.

www.riber.com

Istituto Nanoscienze CNR orders research MBE system

Compact 21 DZ system to grow terahertz quantum cascade lasers

Istituto Nanoscienze, a research institute of the Italian National Research Council (CNR), has ordered a Riber model Compact 21 DZ research MBE system, including the brand new Riber EZ-CURVE real-time curvature measurement system for in-situ monitoring of vacuum thin-film deposition. The order will be installed at the NEST laboratory of Scuola Nomale Superiore in Pisa, Italy.

Istituto Nanoscienze is focused on exploring nanostructures and nanodevices by applying fundamental research as well as emerging technologies. Its research impact encompass several fields, including energy, health, information and safety.

"Our MBE activity will take place in the framework of the infrastructure Pas(c)qua dedicated to the development of a novel quantum co-processor in Italy for the next generation of photonic devices," says professor Lucia Sorba, director of the Istituto Nanoscienze CNR. "Our new Riber's Compact 21 DZ system will be dedicated to the growth of terahertz quantum cascade laser (THz QCL) structures based on III-V semiconductor materials. Particularly noteworthy are the reliability and stability of the Compact 21 DZ, as well as the advanced real-time monitoring features embedded for the MBE growth control," he adds.

Riber's Compact 21 range includes flexible research MBE systems with designs configurable for traditional III-V compounds semiconductors, II-VI materials, nitrides, oxides and other new materials. The Compact 21 DZ system features MBE technologies allowing the production of highly complex epitaxial layers with high quality.

www.nano.cnr.it

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Aixtron raises guidance for full-year order intake, revenue and EBIT margin

Guidance raised for revenue from upper end of €320–360m range to €400–440m; and for EBIT margin from 18% to 20-22%

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has further raised its guidance for its full-year 2021 financial results.

The firm says that it was recently able to book a number of large orders and also expects strong customer demand for the remainder of the year. In particular, order intake in second-quarter 2021 is expected to be at a level similar to that seen in first-quarter 2021 (which was €124.4m, up 35% on the prior quarter's record €92.2m and up 81% on €68.8m a year previously). As a result, Aixtron's executive board has raised its guidance for full-year 2021 order intake further, from the upper end of the prior €340–380m range to now €420–460m.

This very positive order situation, which exceeds expectations, should lead to an increase in shipments and revenues in full-year 2021.

Aixtron has hence also further raised its guidance for full-year 2021 revenue from the upper end of €320–360m to now €400–440m.

While gross margin guidance remains about 40% of revenue, the guidance for full-year 2021 EBIT margin has also been raised further, from about 18% of revenue to now 20–22% of revenue (compared with the initial guidance of 16%).

www.aixtron.com

Sandia orders second Nippon Sanso SR4000HT

MOCVD system to be used for AlGaN and AlN power electronics and UV optoelectronics R&D

Taiyo Nippon Sanso Corp (TNSC) of Tokyo, Japan says that the USA's Sandia National Laboratories has ordered a second SR-4000HT metal-organic chemical vapor deposition (MOCVD) system, to be used for its expansion of aluminium gallium nitride (AlGaN) and aluminium nitride (AlN) power electronics and ultraviolet (UV) optoelectronics device development.

"The SR-4000HT's advanced and stable performance for high-temperature wide-bandgap materials processing met the need for Sandia's MOCVD capabilities," says TNSC's executive corporate officer Kunihiro Kobayashi. "Taiyo Nippon Sanso is looking forward to supporting Sandia's advanced technology development efforts for years to come," he adds.

TNSC expects the ultra-wide-bandgap power and optoelectronics sectors go grow substantially, and for the SR-4000HT MOCVD system to be the platform of choice for many AlGaN and AlN applications.

www.tn-sanso.co.jp/en

Advanced Energy acquires TEGAM for $18m

RF process power provider adds metrology and calibration instrumentation

Advanced Energy Inc of Denver, CO, USA (which designs and manufactures power conversion, measurement and control solutions) has acquired Tegam Inc of Geneva, OH, USA (a provider of metrology and calibration instrumentation used in semiconductor and advanced industrial markets) for $18m in cash (subject to customary adjustments for net working capital).

TEGAM generated about $10m in revenue for its fiscal year ending October 2020. Advanced Energy expects the acquisition to be accretive to 2021 earnings on a non-GAAP basis.

Advanced Energy says that TEGAM strengthens its process power business by adding complementary RF power instruments and calibration systems and further expanding its presence in several advanced industrial markets.

"We are committed to delivering complete solutions to our customers," states Advanced Energy's president & CEO Steve Kelley. "With this acquisition, we further extend our leadership in RF power by adding TEGAM's industry-leading metrology and calibration technologies that contribute to the precise control and repeatability of RF power delivery in plasma etch and deposition processes," he adds.

"Combined, we will enhance the power precision of our customers' equipment," says Andy Brush, former CEO of TEGAM.

www.advancedenergy.com
www.tegam.com

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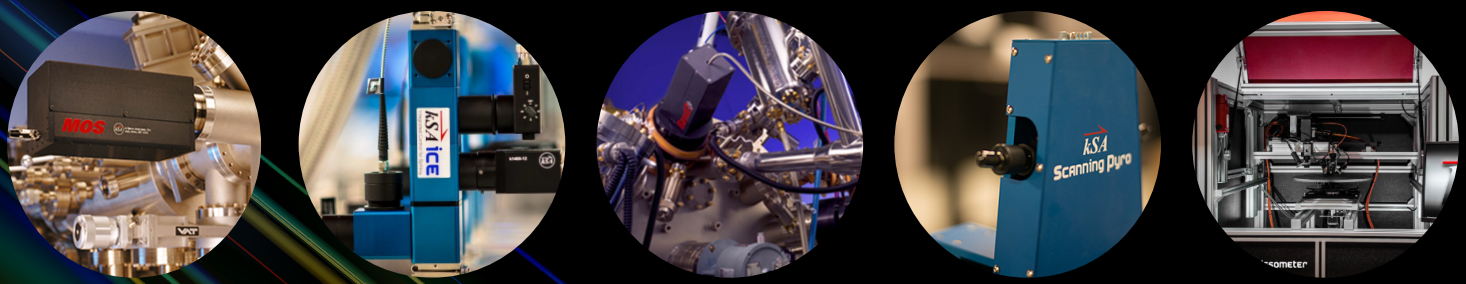

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Linton opens Wuxi research, design & manufacturing facility

Crystal growing equipment production capacity expanded to over 2000 units per year

Dalian Linton NC Machine Co Ltd has opened a research and design center and manufacturing base covering more than 70,000m^2 in Xishan, Wuxi, China.

This comes eight years after obtaining the exclusive license to use the Kayex brand name and becoming the sole owner of Kayex technology. Xishan is home to Linton Kayex Technology Co Ltd, the Chinese business partner of Linton Crystal Technologies (LCT) of Rochester, NY, USA, which designs and makes equipment for producing monocrystalline ingots of silicon as well as materials such as germanium and gallium arsenide (GaAs) for the semiconductor and solar industries.

The opening of the new facility brings Linton's annual production capacity for Czochralski (CZ) crystal growing equipment to more than 2000 units per year.

"Over the years, we've taken the proprietary Kayex technology we were entrusted with and added engineering and service expertise, supported by a strong manufacturing infrastructure and sales team," says Ron Kramer, Linton's director of business development. "Since taking over the Kayex brand, we have tripled in size as a company and introduced nine new models of grower, as well as several updates and retrofits. The completion of this new facility in Wuxi enables us to conduct research, design and manufacturing of our CZ process growers under one roof, expediting product delivery to customers."

Linton's R&D targets both the development of new machines and technologies and supporting the Kayex technology still used in the marketplace. Among the most recent releases are retrofits to support the older Kayex growers. As the sole owner of Kayex technology, Linton says that it is the only company able to develop retrofits, upgrades or replacement parts for these machines. In the past couple of years, the firm has developed a targeted retrofit image processing system, as well as a more comprehensive retrofit of the legacy consoles.

Linton says that the facility in Wuxi represents an investment of more than $432m. Saws and other wafer processing equipment continue to be manufactured in the company's facility in Dalian, China.

www.lintoncrystal.com

AMEC launches Prismo UniMax MOCVD system for mini-LED production

Orders received from leading China customers; more demos in progress

As the latest addition to its portfolio of Prismo metal-organic chemical vapor deposition (MOCVD) products, which are already in use by many gallium nitride (GaN)-based LED makers, Shanghai-based Advanced Micro-Fabrication Equipment Inc China (AMEC) has launched the Prismo UniMax, which is engineered for high-performance mini-LED production.

With increasing demand for applications in LED-based TVs, tablets, laptops, monitors, smartphones, automotive displays etc, mini-LEDs are gaining popularity as an emerging technology that can significantly enhance display quality by delivering superior brightness, precise dynamic response and excellent contrast. The UniMax system is hence engineered to help address the challenges in mini-LED production.

The new system can accommodate up to four reactors which can be controlled independently. With its local temperature-adjustable heating system, the UniMax can deliver what is claimed to be excellent wavelength uniformity, repeatability and reliability for mini-LED production. Other novel features include an optimized showerhead for better uniformity and production stability, and a large-sized susceptor that can improve production throughput and reduce cost of ownership (CoO). Built for high throughput, the system's high wafer capacity is extendable to 164 4-inch or 72 6-inch wafers via susceptor configuration change.

AMEC says that it has received orders for the system from leading customers in China, while more customer demonstrations are in progress.

"With core technology evolved from our proven Prismo platform, the UniMax system is the most innovative MOCVD tool that provides a cost-effective solution for high-performance mini-LED production," says chairman & CEO Dr Gerald Yin. "Prismo UniMax has been used by leading LED customers in China. The tools can not only meet the stringent technical requirements but also achieve higher productivity with lower cost of ownership," he adds. "A new uprising market for MOCVD is coming earlier than expected. We are looking forward to work together with our customers and partners to further accelerate the development of mini-LED technology and the MOCVD market."

www.amec-inc.com/products.html#MOCVD

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OEM Group and Rite Track unite as Shellback

Combined firm to provide new and remanufactured equipment & services for both emerging and legacy markets

OEM Group of Phoenix, AZ, USA (which supplies new and re-manufactured semiconductor capital equipment and upgrades focused on emerging markets) has acquired Rite Track Inc of West Chester, OH (which provides semiconductor equipment products and services for legacy markets), forming Shellback Semiconductor Technology of Coopersburg, PA. The new global entity is headed up by president & CEO Wayne Jeveli and the senior management teams from both OEM Group and Rite Track.

"Rite Track has flourished for nearly 30 years in a demanding global market. They've created a brand that's respected and loved across the industry and have become integral to our customers' operations. "Their expertise in coat & develop technologies is legendary, and their expansion into wafer carrier inspection with the EAGLEi system is a game changer for fab productivity," comments Jeveli. "Similarly, OEM has a 22-year track record of supplying iconic technologies from Semitool, Varian and Applied P5000. We serve the same customers, and this union is symbiotic. We've respected Rite Track from afar for a long time for their complete focus on customer satisfaction. Now, we've got a chance to work together every day on the same team. Our industry is at an incredible inflection point where the need for chips is greater than it's ever been. Shellback will enable our customers to meet this challenge," Jeveli adds.

"I'm so proud of the team we've built over the past 28 years and excited about the opportunities this union will create for our employees, our partners and, most importantly, our customers," says Rite Track's president & CEO Tim Hayden. "We have seen the strategic relationships that Wayne and the OEM Group have built over the years and very much look forward to working with his team to grow Shellback into a market-leading position within the semiconductor industry."

With about 150 staff, an installed base of equipment of over 600 customers and a wide range of proprietary technologies (including Semitool Spray Batch, STORM Wafer Carrier Cleaner, and EAGLEi Wafer Carrier Inspection), Shellback provides both new and remanufactured semiconductor capital equipment and services for both front-end of line (FEOL) and back-end of line (BEOL) processing to enable emerging and legacy markets, such as LEDs, MEMS, wireless, power, energy harvesting, wafer-level packaging (WLP), data storage, analog and logic.

www.oemgroupinc.com
www.shellbacksemi.com

Picosun's PicoArmour corrosion protection increases tool up-time

Etch-resistant Y_2O_3 process combined with more robust ALD processes

Atomic layer deposition (ALD) thin-film coating technology provider Picosun Group of Espoo, Finland says that it has pending patent rights for an ALD-enabled corrosion protection solution against plasma etch that can bring benefits in semiconductor fabrication processes in terms of throughput, film uniformity and conformality. With PicoArmour, corrosion protection can be achieved more efficiently than with the industry solutions commonly used today, it is claimed.

Wafer fabrication process flows include several steps where plasma etching is necessary. An inevitable consequence of using etching chemicals is that the tool itself is etched. A common industrial solution for reducing tool damage is applying a corrosion-resistant coating to the etch tool using, for example, physical vapor deposition (PVD) or spray coating with Y_2O_3. Compared with only using Y_2O_3, PicoArmour enables a method of producing the coating that is up to five times faster and more cost-effective, it is reckoned. Compared with Y_2O_3, the coating can be five times more durable (depending on the deposition and etch parameters). Also, the maintenance interval for etch tools can be increased, which also translates to significant reductions in manufacturing costs.

"Picosun's approach with PicoArmour is to combine the highly etch-resistant Y_2O_3 ALD process with more robust ALD processes," says Juhana Kostamo, vice president, Picosun's Industrial business area. "A high-performance ALD corrosion barrier combining the speed and convenience of the Y_2O_3 process with the durability of Y_2O_3 can be achieved by carefully controlling the film composition," he adds. "With ALD, the protective effect can be achieved with thinner films, which in turn leads to material savings and a more environmentally friendly process."

Picosun gave a presentation related to protective coatings against plasma damage at the virtual conference on Atomic Layer Deposition (ALD 2021) on 29 June.

www.picosun.com

Inova implements DR YIELD's YieldWatchDog

Yield management software to allow parallel production data processing

DR YIELD software & solutions GmbH of Graz, Austria, which provides the smart data analytics solution YieldWatchDog, has been selected by Inova Semiconductors GmbH of Munich, Germany to enable actionable insights into their chip test data. YieldWatchDog is said to transform production data collected during chip manufacturing and testing into valuable information, allowing yield improvements and cost optimization.

Founded in 1999, Inova is a fabless semiconductor company specializing in the development of products for automotive Gigabit/s serial data communication and interior lighting. Besides its APIX (Automotive Pixel Link) products (sold in high volume – with more than 150 million devices on the road – and now in their third generation), Inova developed ISELED (Intelligent Smart Embedded LED) technology in 2016, while offering its first products. With a strong focus on the automotive industry, the firm is committed to the highest manufacturing and product quality. To achieve this, continuous improvement and thus the use of the latest analysis tools and technologies in the semiconductor field is required, says DR YIELD.

"With the YieldWatchDog software, Inova now has a tool that is capable of parallel production data processing, enabling the rapid load and analysis of large amounts of information," says Dr Malte Leisner, head of Quality & Foundry Management at Inova. "A variety of integrated functions allow different methods for inspecting production data. Easy-to-use automated rules for applying quality screening techniques further improve device filtering. This ensures a continuous delivery of products with the highest quality," he adds.

"It is an honor for us at DR YIELD to work with Inova Semiconductors, as we are both innovation leaders in rapidly growing markets, and we are looking forward to exciting developments in the future," comments Dieter Rathei, CEO at DR YIELD software & solutions GmbH.

https://inovasemiconductors.de
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Porotech raises £3m to fund development of micro-LED production technique

Next step to integrate InGaN RGB μLEDs for full-color micro-displays

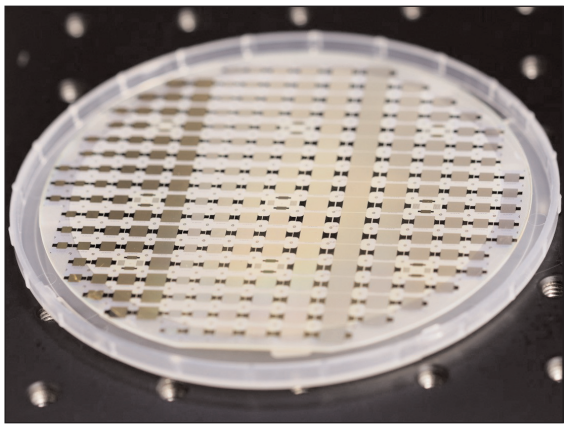
To fund the next stage of development of its unique micro-LED production technique, gallium nitride (GaN) material technology developer Porotech (a spin-out from the Cambridge Centre for Gallium Nitride at the UK's University of Cambridge) has raised £3m in a funding round led by European venture capital fund Speedinvest and joined by previous investors IQ Capital, Cambridge Enterprise, Martlet, and Cambridge Angels.

Micro-LEDs represent next-generation technology for displays in products such as smartphones, smartwatches and virtual reality/augmented reality (VR/AR) headsets. They are particularly useful in outdoor settings, where sunlight can often make existing displays difficult to see clearly. However, the performance of existing micro-LED technologies deteriorates as the device size decreases.

Porotech has created a new class of porous GaN semiconductor material that offers performance improvements suitable for mass production and can be customized for individual customers' needs.

"Porous GaN is basically GaN with tiny holes in it that are a few tens of nanometers across," says CEO & co-founder Dr Tongtong Zhu. "It's an entirely new engineered GaN material platform to build semiconductor devices on. It offers performance improvements that are suitable for mass production, scalable in wafer size — and crucial for the next generation of micro-display devices such as AR glasses," he adds.

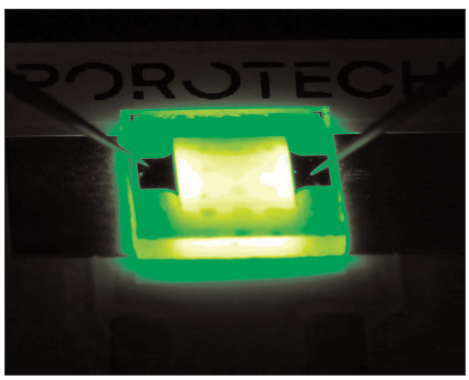
Despite only spinning out in January 2020, Porotech has been generating revenue for 10 months, and says that it is working with some of the biggest global names in display technology. In November, the firm launched the first commercial native red indium gallium nitride

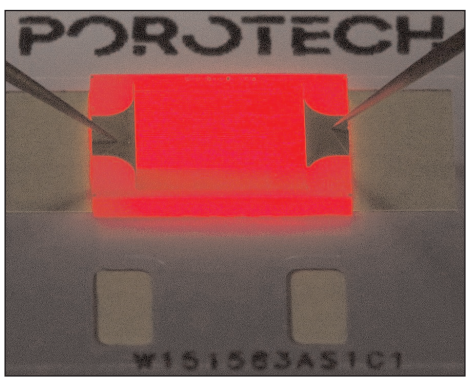


(InGaN) LED epiwafer for micro-LED applications.

Porotech's next step is to expand its novel approach to integrate InGaN-based red, green and blue (RGB) micro-LEDs for full-color micro-displays — and ultimately create smart pixels that can be controlled independently for unrivalled responsiveness and accuracy for things like AR gestures.

Currently, technologies being tested for smart pixels are largely based on aluminum indium gallium phosphide (AlInGaP) material and quantum dot color conversion (QDCC). But AlInGaP struggles at the small pixel sizes required by AR — and QDCC suffers from uniformity and stability issues. In addition, both approaches require a mixture of different material.





Porotech's novel approach enables all three primary colors to be made with the same GaN material and integrated on a single wafer, with no need for special structuring. The firm also plans to develop its own supply chain ecosystem to help it develop and produce products more quickly.

"We are already seeing high levels of demand for our standard and customized porous GaN substrates and micro-LED epiwafers, which we can provide on sapphire and silicon platforms ranging from 100mm (4") to 300mm (12")," says Zhu.

"Smart pixels will be our next development – monolithically generated and integrating native self-emissive RGB micro-LEDs on a single wafer to give smaller, lighter, thinner displays that use less energy and offer the greater accuracy required for things like AR gestures," he adds.

"The revolutionary technology developed by Porotech is set to transform the electronics industry as demand grows for smaller, lighter, sharper displays that are more accurate and environmentally friendly than ever before," comments Rick Hao, principal at Speedinvest. "This new type of porous GaN semiconductor material fits within existing industry processes and is robust and flexible enough to be tailored to different applications. Porotech has demonstrated that it has both the product and the commercial capability to become a key player in next-generation display technology."

www.porotech.co.uk

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Asahi Kasei and Nara Medical University confirm 226nm UVC LED efficacy against SARS-CoV-2

Reduced effect on animal skin cells verified

Tokyo-based Asahi Kasei has announced results of joint research with Nara Medical University regarding the efficacy of 226nm ultraviolet-C (UVC) LEDs in the inactivation of the coronavirus (SARS-CoV-2) that causes COVID-19, and its effects on animal skin cells.

This is reckoned to be the first study in the world conducted with LEDs of this wavelength, and the results confirm that the 226nm UVC LEDs are able to quickly in activate SARS-CoV-2 while having significantly less effect on animal skin cells than 270nm UVC LEDs.

Combating pathogens with UVC light

The inactivation (killing) of viruses and other pathogens using UV light rather than chemical disinfectants has drawn greater attention with the COVID-19 pandemic. Nevertheless, it has been necessary to prevent light from conventional mercury UV lamps (254nm) and UVC LEDs (260–280nm) from directly irradiating human skin due to the risk of harmful effects.

In contrast, UV excimer lamps with a wavelength of 222nm were introduced last year that show negligible effect on the human body. However, LEDs are more compact and allow greater flexibility in design, have less risk of breaking, and have a quicker startup time than traditional lamps, opening up new potential for smaller, safer and more responsive applications of UVC light.

Asahi Kasei company Crystal IS Inc of Green Island, NY, USA, which makes proprietary ultraviolet light-emitting diodes, has commercialized Klaran UVC LEDs in the 260–270nm wavelength range, and is now supporting research by Asahi Kasei to reach shorter wavelengths. Recently, Asahi Kasei's corporate R&D was able to create 226nm UVC LED prototypes, and tests were conducted for these LEDs regarding their efficacy for inactivating SARS-CoV-2 (strain 2019-nCoV JPN/TY/WK-521) as well as their effects on animal skin cells.

All the biological experiments were conducted on the campus of Nara Medical University in Bio Safety Level 3 (BSL3) testing facilities under appropriate means to safely contain the active virus. Furthermore, airborne viruses or their effects on humans were not tested.

One hundred of the 226nm UVC LEDs were placed on a panel in a 10x10 array, as shown in Figure 1. For comparison, a similar array of 270nm UVC LEDs was also prepared. All of the UVC LEDs used in this study were created from the proprietary aluminium nitride (AlN) substrate and pseudomorphic aluminium gallium nitride (AlGaN) technology of Crystal IS.

Asahi Kasei + Nara Medical University
226 nm UVC LED Research Study

AsahiKASEI

Figure 1: UVC LED Array Panel

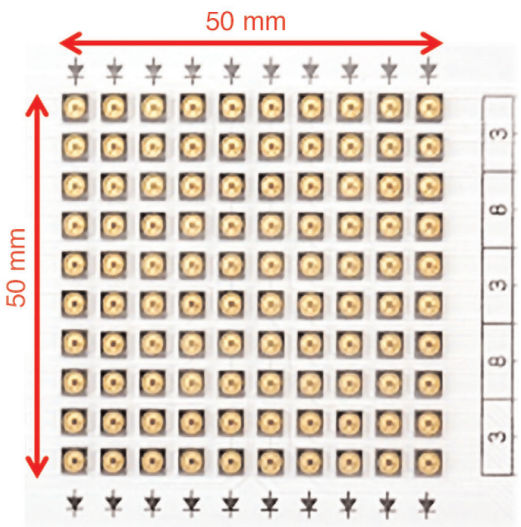


Figure 2: UVC light exposure vs contagion amount over time

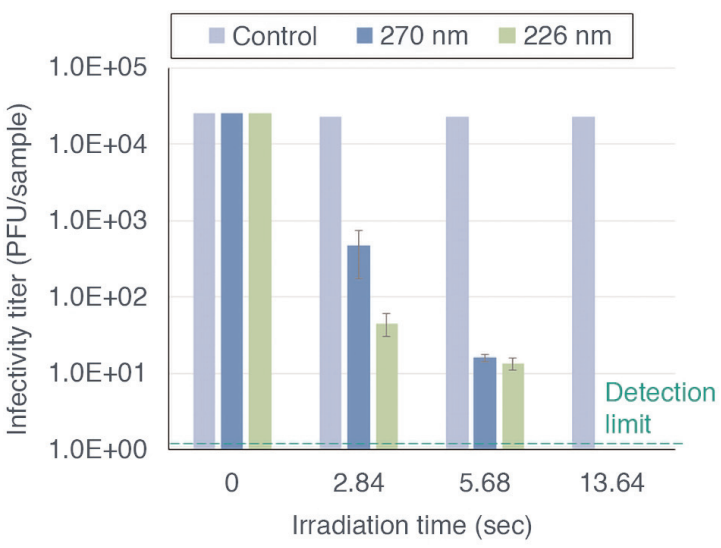


Figure 1 and Figure 2, indicating the efficacy of 226nm UVC LEDs against SARS-CoV-2, the virus that causes COVID-19.

Figure 3: Flow of the experiment on both layers of mouse skin cells

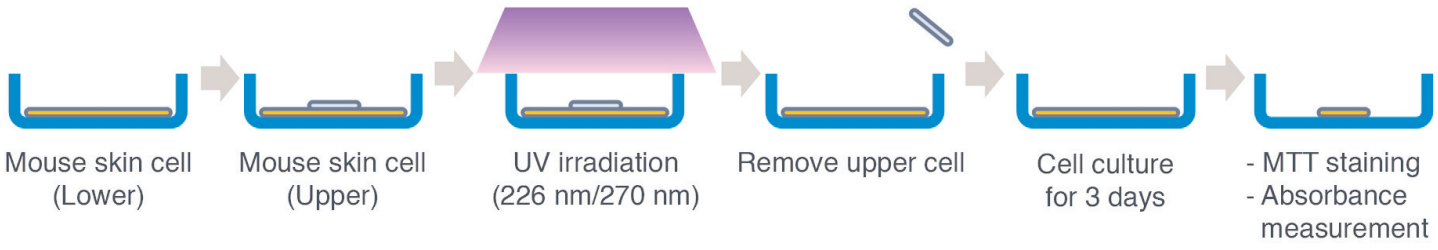


Figure 4: Evaluation results of the mouse skin cells

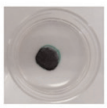
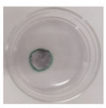
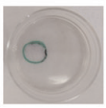
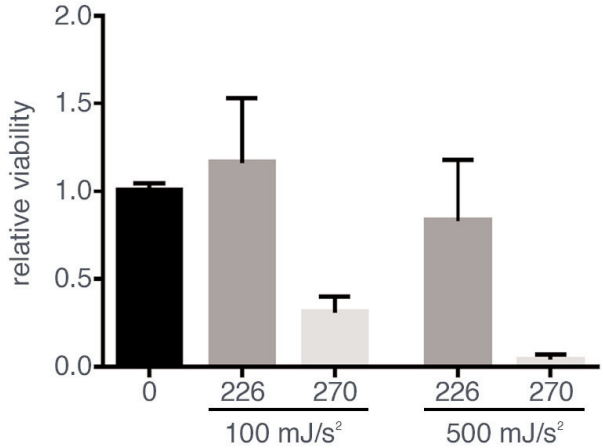
mJ/cm²	226 nm	270 nm	Comments
0			When there was no exposure to UV light, the entire surface is stained by MTT reagent, confirming survival of the cells.
100			The lower layer cells that were covered by the upper layer (inside the green line) show partial damage at 270 nm, but no damage at 226 nm.
500			All lower layer cells that were covered by the upper layer appear damaged at 270 nm, but show significantly less damage at 226 nm.

Figure 5: The rate of living cells after UVC light exposure



Figures 3, 4 and 5, which show the experimental flow and the evaluation of the results on animal skin cells.

226nm UVC LED efficacy for inactivating SARS-CoV-2

Liquid containing viable SARS-CoV-2 was injected into a Petri dish and then dried. Panel arrays of 226nm and 270nm UVC LEDs were activated at the same output (440μW/cm²). Afterwards, the virus was collected, and the amount of contagion was measured by the plaque technique (a method of measuring virus volumes after the degeneration of virus infected cells). The results, shown in Figure 2, indicate that, in about 6 seconds, 99.9% of the virus was inactivated by both 226nm and 270nm UVC LEDs.

Evaluating the effects on animal skin cells

An additional experiment was conducted on mouse skin cells to estimate the damage that 226nm UVC LED light has on animal skin compared with 270nm light. Figure 3 shows the flow of the experiment. The mouse skin cells were arranged in two layers which were then exposed to either 226nm or 270nm UVC LED light at a dosage of 100mJ/cm² and 500mJ/cm².

After the exposure, the upper layer of the cells was removed and the relative fraction of living cells in the bottom layer was evaluated by measuring the absorbance (optical density) after applying an MTT reagent dye (tetrazolium salt) to the cells on the bottom layer. The dark colored dye indicates the amount of living cells that remain.

It has been necessary to prevent light from conventional mercury UV lamps (254nm) and UVC LEDs (260–280nm) from directly irradiating human skin due to the risk of harmful effects. 226nm UVC LEDs can quickly inactivate SARS-CoV-2 while having significantly less effect on animal skin cells compared with the existing generation of 270nm UVC LEDs for disinfection

The results shown in Figure 4 and Figure 5 indicate that the 226nm UVC LED light had little to no effect at 100mJ/cm², and even at 500mJ/cm² there was significantly less effect on the cells of the bottom layer compared with that of the 270nm UVC LED light.

The above results indicate that 226nm-wavelength UVC LEDs can quickly inactivate SARS-CoV-2 while having significantly less effect on animal skin cells compared with the existing generation of 270nm UVC LEDs for disinfection. This suggests the possibility that 226nm-wavelength UVC LEDs may be safely used to disinfect hands or objects where there are people nearby.

Moving forward, further advancements in technology will be necessary before the power of the light emitted from 226nm UVC LEDs can be improved enough for commercialization. Continued research and development by Asahi Kasei is progressing to make this possible.

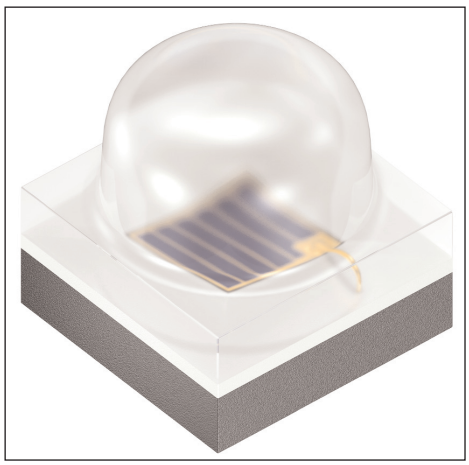
www.cisuvc.com/products/klaran
www.asahi-kasei.com

ams Osram adds space-saving IREDs with primary optics for facial recognition

Compact size enables biometric ID in laptops with slim displays

While facial recognition on smartphones and tablets is already widely used to protect sensitive data, portable computers are often still only password-protected. ams Osram of Premstaetten/Graz, Austria and Munich, Germany says its two new infrared LEDs (IREDs) not only enable user identification via facial recognition in laptops, but also allow particularly slim display designs due to their extremely compact dimensions. Similar to smartphones, laptop manufacturers are also working on displays with ever narrower bezzels. As a result, components such as webcam that include lighting, can take up less and less space — an advantage for miniaturized components such as the SFH 4171S and 4181S.

"With the help of our two new infrared LEDs, we are simplifying the integration of security applications in laptops and giving manufacturers new design options for future models," says product manager Bianka Schnabel. Unlocking laptops via biometric identification eliminates the need to enter passwords and ensures that users can quickly and easily access their laptops after a break. The two IREDs were developed specifically for 2D facial recognition systems. Here, the user's face is illuminated with an infrared light source, an infrared camera records the image and, if the captured image matches the one stored in the system, the device is unlocked. In this case, the security system pays attention to two-dimensional features of the user, such as the distance between the eyes and the length of the bridge of the nose.



Primary optics focus infrared light into a very narrow beam, enabling high-quality images for the IR camera.

ams Osram offers the IREDs in two wavelengths — 850nm (SFH 4171S) and a 940nm version (SFH 4181S). With the SFH 4171S, customers benefit from the high sensitivity of the infrared cameras in this range. The SFH 4181S avoids the 'red glow', which the human eye perceives as red flickering. Both products are installed in the extremely compact Oslon P1616 package. Even with a lens, the product requires very little installation space, measuring only 1.6mm x 1.6mm x 1.71mm, says the firm. Despite their small size, the two IREDs deliver optical power of 1150mW at 1A and beam intensity of 680mW/sr. The special primary optics bundle the light at a beam angle of 35°, improving performance values and making it easier for the infrared camera to take high-quality images, concludes ams Osram.

www.osram.com/os/applications/biometric-identification/index.jsp

LEEDARSON & Bridgelux to co-develop lighting products

F90 LEDs to be incorporated in luminaires for CRI90 conversion

LEEDARSON of Xiamen, China, an ODM partner for developing Internet of Things (IoT) products and the manufacturer behind many tech brands, and Bridgelux Inc of Fremont, CA, USA (a vertically integrated developer and manufacturer of solid-state light sources for lighting applications) have jointly announced a technology partnership on F90 LED lighting products.

As an ODM, LEEDARSON partners with businesses to help them design, manufacture, test, certify, kit and deliver IoT devices and end-to-end IoT services, leveraging multi-protocol standards, platforms and ecosystems to ensure IoT device interoperability.

Bridgelux's new F90 Series LED uses potassium fluorosilicate (PFS) phosphor technology licensed from Current Lighting Solutions LLC for use in commercial lighting applications. By replacing broadband red nitride phosphor with narrowband red PFS phosphor, the F90 LED products can achieve today's CRI80 LED efficacy with a CRI (color rendering index) of 90. Due to the partnership, LEEDARSON can work with Bridgelux to incorporate the new F90 LEDs for CRI90 conversion in luminaires (such as linear lamps, downlights, spotlights and high-bay) to provide lighting products with what is claimed to be industry-leading efficacy and high CRI.

"With LEEDARSON's track record of bringing innovative lighting technology to market, this is an exciting opportunity for Bridgelux," reckons Bridgelux's CEO Tim Lester. "We anticipate the industry-leading efficacy, combined with high CRI, will be compelling in the commercial applications that Leedarson's products serve."

www.bridgrelux.com
www.leedarson.com

Vector appoints principal device engineer

Jon Orchard to fast-track PCSEL technology roll-out into datacoms, additive manufacturing and 3D printing markets

Vector Photonics Ltd (which was spun off from Scotland's University of Glasgow in March 2020, based on research led by professor Richard Hogg) has appointed Dr Jon Orchard as principal device engineer. Orchard will help to fast-track the firm's photonic-crystal surface-emitting laser (PCSEL) technology into next-generation datacoms, additive manufacturing and 3D printing markets.

"Dr Jon Orchard is a well-known and well-respected engineer in the photonics industry and a great asset to our business," believes chief technology officer Dr Richard Taylor. "He will play a critical part in expediting our PCSEL device development, optimizing it for a fabless environment," he adds.

"Jon brings extensive experience of compound semiconductor EEL [edge-emitting laser] and VCSEL [vertical-cavity surface-emitting laser] development and has worked on both active and passive photonic device fabrication," Taylor continues.

Vector's principal device engineer Dr Jon Orchard.

"He also has unique expertise in MOCVD [metal-organic chemical vapor deposition] and MBE [molecular beam epitaxy] products, machines and characterization equipment. This was gained whilst he was a KTP (Knowledge Transfer Partnership) candidate at the University of Glasgow, collaborating with CST Global (now Sivers Photonics) on their MOCVD development, where he later became a development engineer."

Orchard has a degree in Solid State Devices and a PhD ('Development of Electrically Pumped VECSELs') from the University of Sheffield. His post-doctoral research on 'Silicon based quantum dot (QD) lasers and light sources' was an UK Engineering and Physical Sciences Research Council (EPSRC)-funded, collaborative project with University College London (UCL), Cardiff University and the University of Warwick. Orchard also has 18 published, peer-reviewed articles and many national and international conference credits to his name where he was the invited or guest-speaker.

www.vectorphotonics.co.uk

PhotonDelta, TNO, Eindhoven and Twente collaborating on Photonic Integration Technology Center

Netherlands-based PITC to accelerate commercialization of integrated photonics

Integrated photonics industry accelerator PhotonDelta, research institute TNO (the Netherlands Organization for Applied Scientific Research in Delft), Eindhoven University of Technology and University of Twente have signed a cooperation agreement for the new Photonic Integration Technology Center (PITC) in the Netherlands, which aims to accelerate the commercialization of integrated photonics for applications such as autonomous mobility, healthcare, data and communications.

Sited on the premises of Eindhoven University of Technology and University of Twente, PITC is enabled by Brainport Development, the Ministry of Economic Affairs & Climate, regional growth accelerators BOM and OostNL and the provinces of Noord-Brabant, Overijssel and Gelderland.

Bridging the gap between research and application

The new PITC is an independent R&D and innovation center that aims to bring photonic technologies to industrial maturity, build partnerships, strengthen the photonics ecosystem, and link it to a global customer base.

Customers get access to technology and know-how at an early stage while sharing the costs and risk of new technology development. The jointly developed innovations will be extensively tested for reliability and stability, facilitating the route to production.

With a wide spectrum of applications, integrated photonics is a key enabling technology enabling a prompt and efficient response to societal challenges. "The Photonic Integration Technology Center brings integrated photonics to a level that it can be easily adopted by industry," says Carlos Lee, general director of the European Photonics Industry Consortium (EPIC). "This great ambition makes the PITC a perfect fit to the EPIC ecosystem," he adds.

Specific PITC tasks will be:

- developing technology in shared innovation programs;
- ensuring a smooth path to manufacturing and commercialization;
- providing access to high-tech infrastructure and facilities; and
- supporting talent development for skilled professionals building a high-tech ecosystem in the Netherlands.

www.pitc.nl

BluGlass' prototype lasers meet commercial power and wavelength specifications

but reliability testing shows weaknesses with post-epi production steps

BluGlass Ltd of Silverwater, Australia — which develops low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology for manufacturing devices such as laser diodes, next-generation LEDs and micro-LEDs — has provided an update on the status of its laser diode development, executive changes and rights issue.

Progress developing laser diode products

BluGlass says that, in the latest results of testing of early samples for its laser diode development, the prototype laser diodes are showing results consistent with commercial specifications for output power and wavelength, demonstrating the soundness of the firm's wafer epitaxial process.

However, reliability testing has demonstrated weaknesses with the post-epitaxy production steps, with gradual loss of light output due to degradation of the optical facet of the BluGlass laser chip when operated to high power in continuous-wave conditions.

BluGlass says that, while disappointing, the results confirm that its core laser diode design is working to specification, and the challenges that the firm is facing are in production steps involving third-party providers. As an historically R&D business, these steps are new to BluGlass, but are also well understood in the industry generally, and hence the firm is confident that they can be solved expeditiously.

BluGlass intends to place all of its short-term focus on resolving the reliability issue, and over the coming year on all aspects of the production supply chain to scale commercial-grade products needed by the market – to be demonstrated by customer orders of the firm's product. Given the nature of the challenge, BluGlass intends to seek additional experienced assistance in the post-epitaxial phase of development, from those with established production capabilities from the industry.

To ensure the success of this phase of work, BluGlass proposes to undertake a non-renounceable rights issue to current shareholders to raise up to $8m. The firm is finalizing the terms of the offer and it is expected that the terms and accompanying offer booklet will be released to the market prior to the commencement of trading on 9 June.

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Proceeds from this offer should ensure sufficient financial runway to secure the necessary resources, and to allow the required development time to apply those resources, and secure initial customer orders.

Executive changes

Giles Bourne has advised the firm of his intention to step down as managing director & CEO, effective immediately. After 13 years at BluGlass, both Bourne and the board believe that it is time for the firm to recruit a new CEO for its next stage of development.

"During his time at the helm, Giles has built a globally focused semiconductor research business, which is poised to move into its next stage of its growth," comments BluGlass' chair James Walker.

Walker will take on the role of executive chair as the company undertakes a search for a new CEO.

Laser industry appointments

Reflecting its intended approach to ensuring it can deliver on the production aspects of its laser diode development, BluGlass says that it is pleased with the contributions already made by recently appointed laser diode experts JeanMichel Pelaprat as non-executive director and Dr Arkadi Goulakov as a senior scientist (announced on 3 May and 30 April, respectively).

Goulakov has already applied his deep fabrication and product integration expertise to the Development and Operations team in the USA and identified key areas of improvement.

BluGlass says that it intends to build on these appointments, to ensure it has the right skills in place to complement the technical successes of the core BluGlass team and application of its IP to create fully production-ready laser diodes.

Rights issue

The company is finalising the terms of its proposed offer and expects to release the terms and accompanying offer booklet to the market prior to the commencement of trading on 9 June.

In conjunction with the offer, to both preserve cash and increase alignment with shareholders, BluGlass' non-executive directors have agreed to take 50% of their professional fees over the coming three months in equity, at the same price as the rights offering (subject to shareholder approval). Each of the directors intends to take up their full entitlement under the rights offer.

www.bluglass.com.au

BluGlass private placement raising A$2m and rights issue raising A$6m

Funds to speed laser diode product delivery and enable execution of business strategy

BluGlass Ltd of Silverwater, Australia — which develops low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology for manufacturing devices such as laser diodes, next-generation LEDs and micro-LEDs — has announced a non-renounceable entitlement offer on a 1-for-4 basis to holders of ordinary shares in the company held on 15 June (the record date).

BluGlass has also undertaken a private placement of 66,666,667 new fully paid ordinary shares to raise $2m at an issue price of $0.03 per new share. The new shares were issued to a "leading technology-focused fund" on 11 June and were eligible to participate in the entitlement offer.

The entitlement offer was offered to those shareholders who are registered as a holder of ordinary shares in the company as at the record date with a registered address in Australia, New Zealand and certain other jurisdictions in which the firm has decided to extend the entitlement offer and are not in the USA. E

Details of entitlement offer

Pursuant to the entitlement offer, the firm will issue up to 197,333,333 new shares to raise about A$6m (before costs). The new shares will rank equally with existing ordinary shares in the company.

Eligible shareholders are invited to subscribe for 1 new share for every 4 ordinary shares held by them at the record date. Fractional entitlements will be rounded up to the next whole new share. BluGlass directors and key executives intend to take up their full entitlement. The issue price per new share of $0.03 represents a 46.4% discount to the firm's closing share price of $0.056 on 4 June, and a 47.5% discount to the firm's 15 day VWAP to 7 June of $0.0571. The firm will make an application to the ASX for official quotation of the new shares.

Entitlements are non-renounceable and will not be tradeable on ASX or otherwise transferable. The entitlement offer is not underwritten. Eligible shareholders who do not take up their entitlements will not receive any value in respect of those entitlements that they do not take up (and their shareholding in the company will be diluted). No shareholder approval is required for the entitlement offer.

Purpose of the placement and entitlement offer; use of funds

BluGlass intends to invest the proceeds of the placement and entitlement offer as follows:

- R&D of the laser diode product;
- continuing product development and testing to expedite delivery of laser diode products in selected markets;
- investment in sales & marketing channels for future laser diode product launch;
- continue investment in specialist laser diode epitaxy and commercialization expertise;
- advance development with existing and potential new industry strategic partners, including LED, micro-LED and RPCVD market participants;
- reduce operating expenses by developing in-house fabrication processes; and
- general working capital to enable ongoing execution of business strategy.

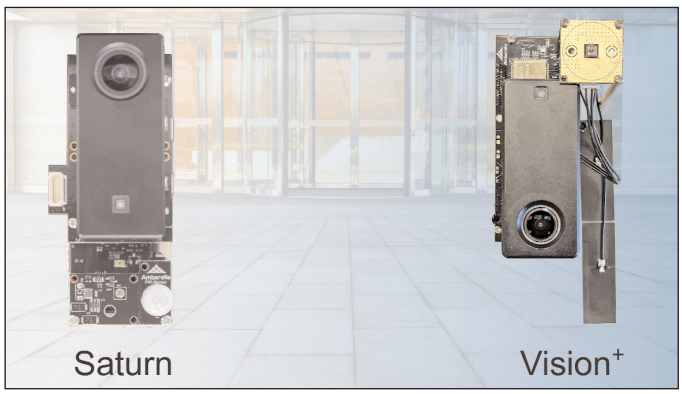
Ambarella, Lumentum and ON Semi collaborate on AI processing-based 3D sensing for AIoT devices

Joint reference designs offer approaches for biometric access control, 3D electronic locks and intelligent sensing

Artificial intelligence (AI) vision silicon company Ambarella Inc of Santa Clara, CA, Lumentum Holdings Inc of San Jose, CA (which makes lasers for industrial and consumer markets) and ON Semiconductor of Phoenix, AZ (which supplies CMOS image sensors) have announced two new joint reference designs that accelerate AIoT device deployment across verticals, building on the companies' prior joint solution for contactless access systems. By combining data from Lumentum's high-performance vertical-cavity surface-emitting laser (VCSEL) array illuminators and an ON Semiconductor image sensor using Ambarella's AI system-on-chip (SoC), higher levels of accuracy and more intelligent decision-making can be achieved in next-generation AIoT devices for biometric access control, 3D electronic locks and other intelligent sensing applications, it is reckoned.

Originally intended for biometric access control and electronic locks, the new reference designs can also address the needs of smart cities, smart buildings, smart homes and intelligent healthcare. Additionally, the high level of integration provided by these joint solutions significantly lowers system power consumption and thermal design requirements while enabling much smaller product form factors.

"Ambarella's vision is to combine AI processing with 3D and vision sensing to create an ambient intelligent future," says president & CEO Fermi Wang. "This collaboration with Lumentum and ON Semiconductor will further advance the convergence of AI and IoT to enable a new generation of access control systems, while inspiring novel categories of ambient sensing products — all powered by the fusion of sensors using AI vision processors that interact intelligently and unobtrusively with people to address their ever-evolving needs," he adds.



"Our new joint solutions will greatly increase the accuracy of AIoT devices across application verticals — starting with biometric access control and electronic locks — enabling them to recognize people and predict their needs, rather than requiring a direct human interface," says Téa Williams senior VP & general manager, 3D Sensing, at Lumentum. "Many of these applications will take advantage of 3D sensing to inject a new dimension of data input for improved decision making. As an example, using higher-resolution VCSEL-based spot illumination enables longer sensing ranges and higher-accuracy facial recognition. Lumentum's industry-leading and high-performance VCSEL arrays with zero field failures, used across these joint solutions, are driving new applications and helping realize the dream of AIoT devices with 3D sensing capabilities," he adds.

"Image sensors are the eyes for intelligent sensing devices. Their ability to see farther with more detail provides significantly more information for the AI processor's decision-making in AIoT devices," comments Gianluca Colli, VP & general manager of ON Semiconductor's Industrial and Consumer Sensor Division (ICSD) group. "Our industry-leading RGB-IR sensor technology, combined with the advanced ISP capabilities of Ambarella's AI vision SoCs, can bring both visible and IR images into devices simultaneously," he adds. "For this second generation of our joint solutions, we leveraged customer feedback to quadruple the resolution of our RGB-IR image sensors to 4K (8MP)."

The three companies' new joint AIoT solutions consist of two reference designs and additional 3D sensing development kits, each uniquely configured to address application-specific demands for the combination of AI processing, 3D depth sensing and vision sensing:

- Targeted at next-generation biometric access control readers, the Vision+ reference design is the AIoT industry's first 4K solution to perform single-camera 940nm structured-light sensing based on RGB-IR technology. It is also the first to leverage a single-chip solution for depth processing, AI processing and video processing. Based on the Ambarella CV22 CVflow AI vision processor, it includes single-camera structured-light sensing powered by Lumentum's VCSEL technology, featuring a range of 2m, and a 4K (8MP) RGB-IR CMOS image sensor from ON Semiconductor.
- Targeted at next-generation smart electronic door locks (eLocks) for both commercial and residential applications, the Saturn reference design is said to be the AIoT industry's first to integrate AI processing for both ►

single-camera structured-light sensing and fast-boot video processing. It is based on the Ambarella CV25 CVflow AI vision processor and includes a structured-light camera powered by Lumentum's VCSEL technology and the AR0237CS 2MP RGB-IR image sensor from ON Semiconductor.

- Targeted at intelligent sensing applications and with opportunities across verticals, Ambarella's CV2 series CVflow AI vision processor-based development kits can now be outfitted with time-of-flight (ToF) sensor adapters that are powered by Lumentum's VCSEL arrays. An optional 4K RGB-IR image sensor adapter is also available for these kits.

The open software development kit (SDK) for Ambarella's CVflow AI vision processors allows the easy integration of third-party applications while enabling OEMs to address differing regional requirements with a single platform (for example, using different AI algorithms in different regions). Additionally, this robust, Linux-based SDK expands the capabilities of edge sensing devices, simplifies product development and speeds time-to-market through:

- Custom application development capabilities.
- Support for different 3D modalities, including structured light and ToF. Uniquely, a single Ambarella SoC provides 3D sensing processing without the need for a dedicated depth processor or a separate host processor.
- High AI inference capabilities on the camera device to enable multiple neural networks (NNs) running simultaneously.
- Robust AI tools to support deep neural network (DNN) development and migration.
- Integrated ISP to handle challenging scenes, including high dynamic range (HDR) and low light scenarios.
- Built-in Arm processors to run customer applications.
- Integrated security hardware, including secure boot, OTP to store encryption keys and Arm TrustZone technology for secure encryption key comparisons.
- Rich peripheral interface support to simplify system designs.

The joint reference designs and development kits were expected to be available in June. Additionally, the three companies presented the new joint solutions on 2 June in a live webinar hosted by Laser Focus World magazine.

www.lumentum.com
www.onsemi.com
www.ambarella.com

IEEE Best Paper Award recognizes Rockley's work on co-packaged optics

Technical feasibility demonstrated of integrating CMOS switching functionality with single-mode optical interfaces in same package

The IEEE Communications Society says that the 2021 Charles Kao Award for Best Optical Communications & Networking Paper has been awarded to a team from Rockley Photonics Ltd of Oxford, UK and Pasadena, CA, USA (which develops integrated silicon photonic chipsets and supplies modules for high-volume sensor and communication products) for their paper 'Reimagining datacenter topologies with integrated silicon photonics', published in the July 2018 edition of the IEEE/OSA Journal of Optical Communications and Networking (JOCN).

The paper presents Rockley's pioneering work in co-packaged optics (CPO), demonstrating the technical feasibility of integrating CMOS switching functionality with single-mode optical interfaces within the same package.

"IEEE awards represent the pinnacle of technological achievement and we're extremely proud of our team's success," says chief executive Dr Andrew Rickman. "Co-packaging optics with electronics enables us to rearchitect the data-center network to achieve significant efficiency gains in terms of data processing and power usage."

Rockley is leveraging CPO to design high-density pluggable optical modules with at least 800Gb/s of capacity.

The IEEE Communications Society Awards Committee evaluates nominated papers based on the extent to which the works open new lines of research, envision bold approaches to optical communication and networking, formulate new problems to solve, and essentially enlarge the field of optical communications and networking. Papers published in the prior three calendar years of JOCN are eligible for the award. The key selection criteria are quality, exposition, novelty, and impact.

This work establishes the capability of Rockley's unique silicon photonics platform to address next-generation data communications. Rockley is in the process of leveraging its versatile platform in the consumer healthcare space, which it believes will drive wafer volumes and economies of scale that will ultimately benefit a variety of market verticals.

In March, Rockley entered into a definitive agreement to combine with SC Health Corp, a publicly traded special purpose acquisition company, that will result in Rockley becoming a publicly traded company on the New York Stock Exchange (NYSE) under the symbol RKLY.

www.rockleyphotonics.com

Sivers Photonics, Imec and ASM AMICRA achieve wafer-scale integration of InP DFB lasers

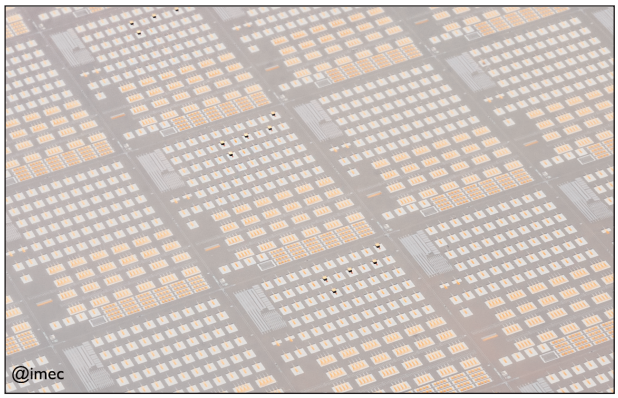
Hybrid integration to accelerate adoption of silicon photonics

Sivers Semiconductors AB of Kista, Sweden says that its subsidiary Sivers Photonics (formerly CST Global of Glasgow, Scotland, UK, a high-volume manufacturer of III-V compound semiconductors for photonics products) has reached a significant milestone, together with its partners nanoelectronics research centre imec of Leuven, Belgium and die attach equipment supplier ASM AMICRA Microtechnologies GmbH of Regensburg, Germany. In their joint silicon photonics project, they have achieved the wafer-scale integration of indium phosphide distributed feedback (DFB) lasers from Sivers' InP100 platform onto imec's silicon photonics platform (iSiPP). It is reckoned that this will be able to boost the adoption of silicon photonics in a range of applications from optical interconnects, through light detection & ranging (LiDAR), to biomedical sensing.

Silicon itself does not emit light efficiently, due to the lack of efficient on-chip light sources many silicon photonic systems currently still rely on external light sources made of III-V semiconductors such as indium phosphide (InP) or gallium arsenide (GaAs) typically implemented as separately packaged components. These off-chip lasers often suffer from higher coupling losses, a large physical footprint and high packaging cost.

Using ASM AMICRA's latest NANO flip-chip bonder tool, the InP DFB laser diodes were bonded onto a 300mm silicon photonics wafer with an alignment precision within 500nm, enabling reproducible coupling of more than 10mW of laser power into the silicon nitride waveguides on the silicon photonics wafer.

Supported by its partners, imec will offer this technology later in 2021 as a prototyping service, thereby accelerating the adoption of silicon photonics in a wide range of applications from optical interconnects, over LiDAR, to biomedical sensing.



Indium phosphide DFB laser dies bonded onto a 300mm silicon photonics wafer.

Together with partners Sivers and ASM AMICRA, imec is extending its silicon photonics prototyping services to include high-precision flip-chip integration capability of InP lasers and amplifiers. In the recently completed development phase, C-band InP DFB lasers have been passively aligned and flip-chip bonded onto 300mm silicon photonics wafers with ultra-high alignment precision within 500nm (three-sigma value), resulting in reproducible on-chip waveguide-coupled laser power beyond 10mW.

Throughout second-half 2021, the hybrid integration portfolio will be extended with reflective semiconductor optical amplifiers (RSOA), leveraging the etched-facet capability of Sivers' InP100 technology, and ASM AMICRA NANO's superior bonding alignment precision. This capability will enable advanced, external cavity laser source types, as required for emerging optical interconnect and sensing applications, and will become available in early 2022.

"We are very pleased to be working with Sivers Photonics and ASM AMICRA to extend our silicon photonics platform with hybrid integrated laser sources and amplifiers," says Joris van Campenhout, Optical I/O program director at imec. "This additional functionality will enable our joint customers to develop and prototype advanced photonic integrated circuits (PICs) with capabilities well beyond what we can offer today, in key areas such as datacom, telecom and sensing," he adds.

"The availability of tailored InP laser sources, designed and fabricated on our InP100 manufacturing platform, will boost the adoption of silicon photonic circuits for a wide variety of commercial applications," reckons Sivers Photonics' managing director Billy McLaughlin.

"Our strength in high-precision placement seamlessly complements the expertise of all partners," reckons ASM AMICRA's managing director Dr Johann Weinhändler. "With automated and ultra-precise flip-chip bonding, the way to high-volume manufacturing of these hybrid assemblies is open."

Sivers, imec and ASM AMICRA can now extend silicon photonic prototyping with additional functionality, allowing their joint customers to develop photonic integrated circuits (PICs) with capabilities beyond what is possible today, it is reckoned. Silicon photonic products will account for about half of all integrated optical devices by 2026, at $30bn over this period, forecasts market research firm LightCounting in May in its 'Integrated Optical Devices Report'. This widespread adoption of silicon photonic products will impact across several key application areas, such as datacom, telecom and optical sensing, it is reckoned.

www.sivers-semiconductors.com
www.imec.be
www.amicra.com

Sivers approved for listing on Nasdaq Stockholm

Transfer from Nasdaq First North Growth Market

Sivers Semiconductors AB of Kista, Sweden (which supplies chips and integrated modules) says that Nasdaq Stockholm's listing committee has approved its application for its shares to be admitted for trading on Nasdaq Stockholm main market, subject to the fulfilment of certain customary conditions.

In light of the list change, Sivers Semiconductors has published a prospectus, which has been approved and registered by Swedish Financial Supervisory Authority (SFSA).

After initially being listed on Spotlight Stock Market, Sivers Semiconductor's shares have been listed on the Nasdaq First North Growth Market since end-November 2017. Following the firm's last day of trading on that market on 9 June, its first day of trading on the Nasdaq Stockholm main market is scheduled for 10 June, with shares traded in the Mid Cap segment under the same ticker (SIVE) and ISIN code (SE0003917798). There will not be any offer or issue of new shares in connection with the list change. Shareholders will not need to take any action in connection with the list change.

"The listing on Nasdaq Stockholm main market is a quality stamp and an important milestone for us. It is another important piece of the puzzle in our continued expansion and development of the company as it contributes to an increased awareness of our business," says group CEO Anders Storm.

Sivers Semiconductors has two business areas:

- Wireless develops RF chips and antennas for 5G systems for datacoms and telecoms networks.
- Photonics develops and manufactures semiconductor-based optical products for optical fiber networks, sensors and optical fiber communications (Li-Fi).

"The listing strengthens our profile and our brand both with our customers and with investors, which means that we have increased access to the Swedish and international capital markets. In addition, our ability to attract and retain qualified employees increases.," says Storm. "All in all, the listing is an important part of creating increased long-term shareholder value," he concludes.

www.fi.se
www.sivers-semiconductors.com

Sivers Photonics receives SEK14m follow-up order from Fortune 100 customer

Total orders for optical sensing laser project now SEK50m

Sivers Semiconductors says that its subsidiary Sivers Photonics (formerly CST Global of Glasgow, Scotland, UK) has received a new optical sensing order worth about SEK14m from one of its established Fortune 100 customers, to be delivered and billed during 2021.

The order covers one of several parallel projects for design, development and supply of semiconductor laser devices for use in advanced optical sensing applications. Sivers Photonics has been working with this key customer on projects for about 2.5 years.

"This is the second order from this customer in 2021, at total value of some SEK25m, which is already on the same level as during the full-year 2020," says Sivers Semiconductors' group CEO Anders Storm. "Over the last 12 months the total order value now stands at some SEK50m," he adds. "I am very pleased to see that we are accelerating the number of orders and, for each order, the chance increases that we will be part of the future volume production for the sensors."

www.sivers-semiconductors.com/sivers-photonics

POET cuts loss during Q1/2021

Cash reserves boosted by private placement and exercise of stock options and warrants

For first-quarter 2021, POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center and telecom markets — has reported a net loss of US$4.1m (US$0.01 per share), an increase from US$3.5m (US$0.01 per share) a year ago but cut from US$5m (US$0.02 per share) last quarter.

During the quarter, POET completed a private placement of 17,647,200 units of the firm at a price of CAD$0.85 per 2021 unit for gross proceeds of about CAD$15m, including the full exercise of an agents' option.

The firm also raised US$8.5m from the exercise of stock options and warrants, and further improved liquidity by US$2.3m through the conversion of convertible debentures;

POET ended the quarter with cash and cash equivalents of US$23.5m, up from US$6.9m at end-December 2020 and US$12.3m at end-March 2020.

The firm says that it continued to execute on its strategic plan and achieved the following milestones:

- Completed the design of a 100G LR4 (4-channel long-reach) optical engine with a reach of 10km for client-side interconnects to data centers, enterprises and edge computing networks;
- Made significant progress with Super Photonics Xiamen Co Ltd (SPX), its joint venture with Sanan Integrated Circuit Co Ltd of Xiamen City, Fujian province (a subsidiary of Sanan Opto-electronics Co Ltd, China's first 6-inch pure-play compound semiconductor wafer foundry), including the appointment of the board of directors and key personnel, completion of 5000ft^2 of operating facilities, ordering of key capital equipment for installation and qualification in April–May, and receipt by SPX of about US$5m from Sanan IC to cover initial operating and capital expenditures;
- Entered into development and supply agreements with a technology leader in photonic neural network systems for artificial intelligence (AI), which represents an entry point into the new large and extremely high-growth chipset market for AI applications.

"We have continued to make solid progress on our strategic and commercialization initiatives over the past few months," says chairman & CEO Dr Suresh Venkatesan. "Following the achievement of key technology milestones, including the successful testing of designs for multiple products, we are experiencing strong pull from customers that recognize the disruptive value proposition of POET's unique approach to integrated solutions. We are now working closely with customers on further product customization for their specific end-market applications and with others on project proposals to leverage the benefits our Optical Interposer platform for specific end-market applications," he adds.

"As part of the continued build-out of our robust product development pipeline, we recently announced the completion of our design for a 100G LR4 optical engine targeted for client-side interconnects for data centers, enterprises and edge computing networks. As the industry standard for interconnects in long-haul networks, we believe 100G LR4 transceivers represent a rapid go-to-market opportunity to address a high-volume market leveraging the significant cost and performance advantages our transmit (Tx) design," Venkatesan continues.

"Additionally, we continue to advance our joint venture with Super Photonics Xiamen to support the anticipated increase in customer demand and associated commercial production. SPX has begun the installation and qualification of the equipment that will provide the ability to scale and ramp volume manufacturing in 5000ft^2 of SPX's temporary operating facilities."

"With our planned participation in the upcoming OFC Conference & Exhibition in June, the POET team is working closely with a number of customers and ecosystem partners for hosting technology demonstrations and virtual meetings," says Venkatesan. "We plan to provide updates on the expected near-term availability of product prototypes in conjunction with the OFC conference."

www.poet-technologies.com

POET sampling 100G and 200G CWDM4 Optical Interposer-based engines from early July

400G DR4 and FR4 transmit and receive optical engines offered soon

POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of integrated optical engines, based on the POET Optical Interposer, for the optical communications, computing and sensing markets — says that samples of its 100G and 200G CWDM4 Optical Engines will be available from early July.

Powered by four flip-chipped 28G and 28G PAM4 CWDM (course wavelength division multiplexed) distributed feedback (DFB) lasers, the optical engines include an integrated athermal multiplexer and demultiplexer, 28G detectors, monitor photodiodes and bonding pads. Operating to MSA (multi-source agreement) standards for the QSFP28 module, the POET Optical Engines will be available in chip-sets for transmit only, receive only or in a combination transmit and receive single multi-chip engine less than 60mm square.

Fabricated on a high-resistivity 8" silicon wafer with low-loss, athermal waveguides, POET's Optical Engines include passively aligned active devices and superior thermal management, it is claimed. These engines offer what is said to be best-in-class coupling efficiencies, including to fiber attach units, and operate over a range of 500m to 10km under ambient operating temperatures of 0°C to 70°C.

Powered by four flip-chipped 28G and 28G PAM4 CWDM DFB lasers, the optical engines include an integrated athermal multiplexer and demultiplexer, 28G detectors, monitor photodiodes and bonding pads

Based on the POET Optical Interposer platform, the 100G and 200G Optical Engines are fabricated entirely at wafer scale, offering cost and size advantages. All engines are fully tested and burned-in prior to shipment. Super Photonics Xiamen Co Ltd, POET's joint venture with Sanan Integrated Circuit Co Ltd of Xiamen City, Fujian province, China, will be manufacturing the optical engines, with the capability to rapidly scale for customers with high-volume requirements.

POET Technologies will also soon be offering 400G DR4 and FR4 transmit and receive optical engines. Samples of the receive optical engine will be available in September. Samples of the transmit engine, based on high-power CW (continuous wave) lasers and silicon photonic modulators, will be available beginning in fourth-quarter 2021.

www.poet-technologies.com

POET sampling O-band LightBar product in September

Live demonstrations conducted at OFC 2021

POET says that samples of its O-band LightBar product will be available beginning in September.

POET LightBar products address the need for remote, aligned light sources to power datacom transceivers, co-packaging of electronics and photonics in applications such as data-center switch architectures, optical computing and various sensing devices. In data processing, a remote light source offers the benefit of more effective control of heat generated from lasers. Remote light sources also facilitate the field replacement of lasers that are more susceptible to failure than other components. In sensing and computing, remote light sources function as a key element, in which the close interaction of photonic and electronic components operate together in a miniaturized, self-contained system.

A family of fully customizable LightBar products in the O-band (1270–1330nm) includes a base platform of 4–12 channels, with high-power continuous-wave (CW) distributed feedback (DFB) lasers passively aligned to the waveguides on the Optical Interposer platform. Each lane will provide up to 17dBm of optical output power, equivalent to 50mW per channel, over an operating temperature range of 0–70ºC. Channel spacing and output pitch are customizable according to customer requirements. A variety of wavelength multiplexing options can also be specified by the customer based on their requirements.

Each lane will provide up to 17dBm of optical output power, equivalent to 50mW per channel, over 0–70ºC

LightBar products incorporate all of the intrinsic features of the POET Optical Interposer, including integrated spot-size converters that minimize coupling losses and increase the power efficiency of lasers.

Live demonstrations of POET's products were conducted during the virtual Exhibition at the Optical Networking and Communication event (OFC 2021) on 7–11 June.

www.ofcconference.org

II-VI Inc participation at OFC 2021

At the Optical Networking and Communication Conference & Exhibition (OFC 2021) held virtually on 6–11 June, engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA participated via presentations by the following speakers:

Dr Sanjai Parthasarathi, chief marketing officer:
- Panel: '3D Sensing Uses in Consumer and Automotive Markets'.

Dr Martin Zirngibl, chief technologist, Optoelectronics:
- Short Course: 'SC486 Optoelectronic Devices for LiDAR and High-BW or 3D Sensing';
- Market Watch Panel: 'Terabit WDM Channels – Beyond 100GBaud Operation';
- Tech Talk: 'LiDAR, Boom or Bust?'.

Dr Tsurugi Sudo, senior director of Design Engineering:
- Invited Speaker: 'Challenges and Opportunities of Directly Modulated Lasers in Future Datacom, Datacenter, and 5G Networks'.

Vipul Bhatt, senior director of Datacom Marketing:
- Workshop: 'Are We on the Right Track to Bring Co-Packaged Optics to Its Prime Time?';
- Panel: 'Next-Generation Optical Interfaces'.

Dr Yasuhiro Matsui, technical staff engineer:
- Workshop: 'Which Device Technologies Will Get Us Beyond 400G?';
- Panel: 'Advanced Laser Technologies in Post-100GBaud Era'.

Dr Argishti Melikyan, senior principal Silicon Photonics engineer:
- Symposium Organizer: 'Emerging Photonic Technologies and Architectures for Femtojoule per Bit Optical Networks'.

Ken Cockerham, product marketing manager:
- Panel: '5G Optics – Mobile Optical Solutions and Standards'.

Dr Chris Cole, II-VI advisor and OFC Technical Program chair:
- Symposium Organizer: 'Vision Talks: Beyond 2021 and Towards 2030';
- Rump Session Organizer and WDM Team Captain: 'Did the Optics Industry Blunder by Switching Intra-Datacenter Links From NRZ to PAM-4?';
- Symposium Panel: 'The Role of Machine Learning in Optical Systems and the Role of Optics in Machine Learning Systems'.

OIDA Executive Forum

Separately, chief strategy officer & president of Compound Semiconductors Dr Giovanni Barbarossa participated in the Business Fireside Chat at the Optical Society of America Industry Development Associates (OIDA) Executive Forum 2021 on 3 June. The virtual chat featured leaders from the optical networking market providing their unique perspectives on a broad range of industry issues.

www.ofcconference.org

II-VI demonstrates 400/800G transceivers at OFC

Support for 100Gbps PAM4 electrical interface compatible with 25.6T and 51.2T switch ASICs

At the OFC 2021 virtual exhibition, II-VI Inc gave a demonstration of 400/800G transceivers that the company says can enable next-generation 25.6T and 51.2T data-center switches.

Shown in a video at II-VI's digital booth, the demonstration showcased a broad range of transceiver configurations, reaches and form factors, each supporting the new breakthrough 100Gbps PAM4 electrical interface compatible with next-generation 25.6T and 51.2T switch application-specific integrated circuits (ASICs). The density of these 400/800G transceivers can enable 25.6T in a compact 1RU height.

At the II-VI digital booth, OFC visitors were able to view the following three Finisar transceiver demonstrations:
- 800G-DR8 OSFP and 400G-DR4 QSFP-DD — II-VI showed an 800G-DR8 OSFP module operating on a link with two 400G-DR4 QSFP-DD modules over parallel single-mode fiber. 800G-DR8 transceivers are also capable of interconnecting with eight 100G transceivers or point-to-point with another 800G transceiver.
- 400G-FR4 QSFP112 and 2x400G-FR4 QSFP-DD800 — II-VI showed a 2x400G-FR4 QSFP-DD800 module operating on a link with two 400G-FR4 QSFP112 modules.
- 400G-SR4 QSFP112 — II-VI showed a pair of 400G-SR4 QSFP112 modules operating on a link. Multimode transceivers and active optical circuits (AOCs) that employ vertical-cavity surface-emitting laser (VCSEL) technology offer the lowest cost for short-reach optical interconnect applications, a trend that is expected to continue with 800G products. In addition, 400G-SR4 transceivers are also capable of interconnecting with four 100G transceivers.

All the demonstrations manifested state-of-the-art optical transmission performance with pre-forward error correction (FEC) bit-error rate (BER) margin against the IEEE specification and post-FEC error-rate performance.

www.ii-vi.com

II-VI receives extra $350m equity commitment from Bain

Engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA says that Bain Capital is making an additional equity investment of $350m in II-VI, increasing its total equity commitment to the firm to $2.15bn.

As disclosed on 31 March, II-VI sold 75,000 shares of a new Series B-1 Convertible Preferred Stock to Bain Capital at $10,000 per share, for a total $750m.

Bain also committed to purchase, immediately prior to the closing of II-VI's pending business combination with Coherent Inc of Santa Clara, CA, USA (which provides lasers and laser-based technology for scientific, commercial and industrial applications), 105,000 shares of a new Series B-2 Convertible Preferred Stock at $10,000 per share (for $1.05bn), for a total commitment of $1.8bn, including the $750m received by II-VI on 31 March.

II-VI also had the right to request that Bain purchase an additional 35,000 shares of Series B-2 Convertible Preferred Stock at $10,000 per share (for $350m), which would also occur immediately prior to the closing of the pending business combination with Coherent.

With this additional $350m commitment, Bain will purchase a total of 140,000 shares of Series B-2 Convertible Preferred Stock for a total $1.4bn immediately prior to, and conditioned on, the closing of the Coherent transaction. As a result, Bain will have purchased a total of $2.15bn of II-VI's Series B Convertible Preferred Stock.

All of the shares of Series B Convertible Preferred Stock will be convertible into shares of II-VI common stock at a conversion price of $85 per share, and the shares of Series B-1 Convertible Preferred Stock issued in March became voting shares upon expiration of the Hart–Scott–Rodino Act waiting period on 3 June.

www.ii-vi.com

Merger of II-VI and Coherent approved by stockholders

Special meetings of II-VI's shareholders and Coherent's stockholders have each yielded overwhelming votes to adopt and approve (as applicable) all proposals relating to the agreement (announced in late March) for II-VI to acquire Coherent.

About 99% of the votes cast at II-VI's special meeting voted to approve the proposal to issue shares of II-VI common stock, and about 99% of the shares of Coherent common stock voting at Coherent's special meeting voted to approve the proposal to adopt the merger agreement.

The merger creates a "diversified global leader in engineered materials, photonics and electronics, gaining greater exposure to irreversible market megatrends," says II-VI's CEO Dr Vincent D. Mattera Jr. "Together, we will be able to leverage our disruptive technology platforms and complementary scale to address a broader customer base around the globe and drive continued growth and innovation, while gaining deeper market insights from our combined businesses to better inform our strategic investments and decisions," he adds.

"The combination of II-VI and Coherent will provide compelling benefits to our customers, create more opportunities for our team members to continue to develop innovative new products and solutions, and deliver significant value for our stockholders," reckons Coherent's president & CEO Andy Mattes.

The firms believe that (subject to the completion of customary closing conditions, including the receipt of required regulatory approvals) the merger is on track to close by year-end 2021 or at the start of first-quarter 2022.

II-VI Inc unveils 100Gbps InP directly modulated lasers

II-VI Inc has introduced 100Gbps indium phosphide (InP) directly modulated lasers (DMLs) for high-speed transceivers deployed in data centers.

Growing demand for 400 and 800 Gigabit Ethernet (GbE) transceivers is driving substantial investments in DML technology advances due to their lower cost and lower power consumption compared with electro-absorption modulated lasers (EMLs) currently used in these high-speed transceivers. II-VI says that its 100Gbps DMLs can achieve state-of-the-art modulation speed and signal quality at high output power and low power consumption, making them preferable to EMLs in 400GbE and 800GbE transceivers that use 100Gbps optical lanes.

"Our early results were published in the journal Nature Photonics in January," says Dr Charlie Roxlo, VP, Indium Phosphide Devices business unit. "This breakthrough performance was achieved thanks to multi-year R&D investments and deep expertise across a broad internal multi-disciplinary team of semiconductor laser physicists, high-speed RF analog integrated circuit designers, and transceiver experts."

II-VI's new DMLs are built on its InP technology platform — one of the very few in the industry that has been proven with more than 100 million lasers in the field deployed over the last decades. The low power consumption of the DMLs and their design for non-hermetic packaging suit both existing pluggable form factors and future co-packaged solutions, the firm adds.

www.ofcconference.org

Telcordia qualification for Skorpios' Heterogeneous Photonic Integrated Circuit platform

100G CWDM4 chipset & transceiver both shipping in limited quantities

Skorpios Technologies Inc of Albuquerque, NM, USA (which provides integrated silicon photonics products based on proprietary, wafer-scale heterogeneous integration process) has completed formal Telcordia qualification on its 100G CWDM4 chipset, as well as its 100G CWDM4 optical transceiver, both of which are shipping in limited quantities. The chipset is based on Skorpios' Heterogeneous Photonic Integrated Circuit (HPIC) technology platform, which integrates III-V material into a standard CMOS process flow.

At the device level, extensive testing demonstrated full compliance to GR-468. Testing beyond Telcordia requirements resulted in demonstrating >10,000 hours high-temperature operating life (HTOL) against a requirement of 2000 hours, and extensive accelerated aging testing demonstrated a 50+ year lifetime for the four-channel devices.

At the optical transceiver level, full compliance was demonstrated to GR-468, GR-326 and GR-1217 standards. Testing beyond Telcordia requirements resulted in demonstration of 2000 hours of unbiased damp heat against a 1000-hour requirement.

Skorpios says that this qualification, especially the extended HPIC HTOL and accelerated aging results, demonstrates best-in-class reliability for its HPIC technology platform. Qualification of the HPIC platform enables Skorpios to offer products with the performance of traditional III-V optoelectronic devices, the cost advantages of traditional silicon photonics and the scalability for next-generation products that neither traditional III-V nor traditional silicon photonics can achieve, the firm adds.

"With a technology platform passed full Telcordia qualification with no issues and demonstrated industry-leading lifetimes, Skorpios secures a commanding position in current and future applications requiring high levels of photonic integration with many lasers and modulators on a single die," reckons chief technology officer Glenn Li.

www.skorpiosinc.com

CW-WDM MSA releases first specification for multi-wavelength optical laser sources

The CW-WDM MSA (Continuous-Wave Wavelength Division Multiplexing Multi-Source Agreement) Group, which is dedicated to defining and promoting specifications for multi-wavelength advanced integrated optics, has released its first official specification for 8-, 16- and 32-wavelength optical sources.

The CW-WDM MSA was formed in mid-2020 to standardize WDM CW sources in the O-band for emerging advanced integrated optics applications that are expected to move to 8, 16 and 32 wavelengths.

The MSA defines laser sources covering three spans in the O-band wavelength grids. Higher wavelength counts are needed for emerging applications such as silicon photonics (SiPh)-based high-density co-packaged optics, optical computing, and machine learning/artificial intelligence (AI), and enable a leap in performance, efficiency, cost and bandwidth scaling compared with previous technology generations. Each wavelength grid is defined with enough technical detail to ensure interoperability across the range of applications. The MSA also outlines measurement methods required for standards compliance.

"The CW-WDM MSA just published an 8-, 16- and 32-wavelength O-band laser source standard for use in optical transceivers for emerging advanced datacom applications," says MSA chair Chris Cole. "Laser sources are the critical component in optical communications and having an agreed set of grids creates great opportunities for transceiver and laser suppliers to develop innovative products."

Key features of the MSA specifications are as follows:

- frequency assignments for 8-, 16- and 32-wavelength grid configurations with multiple grid spacings;
- two physical configurations, including a modular optical source with each output port carrying a single wavelength, and an integrated optical source with each output port carrying all the wavelengths;
- a range of output power classes targeting applications requiring very low and very high output levels;
- definitions of optical parameters and measurement methods, including relative intensity noise, side-mode suppression ratio (SMSR), and linewidth; and
- fixed and flexible wavelength grid configurations to support deployment in a variety of environmental conditions.

Promoter members of the CW-WDM MSA are Arista Networks, Ayar Labs, II-VI, imec, Intel Corp, Lumentum, Luminous Computing, MACOM, Quintessent, Sivers Photonics, and Sumitomo Electric.

www.cw-wdm.org

OIF unveils three new projects at Q2/21 Virtual Meeting

External Laser Small Form Factor Pluggable Module for Co-Packaged Optics, AI for Enhanced Network Operations and CEI-112G-Linear

At the second-quarter 2021 Technical and MA&E Committees Meeting of the Optical Internetworking Forum (OIF), held virtually on 10–14 May, members initiated three new projects, including a Co-Packaged Optics external laser module, Artificial Intelligence (AI) for Enhanced Network Operations and CEI-112G-Linear.

External Laser Small Form Factor Pluggable (ELSFP) Module Project — companion project to support co-packaged optics applications

This project for a blind-mate pluggable external light source module will define a new form factor optimized to package lasers to support co-packaged optical modules. It also includes provisions for the longevity of this form factor beyond the initial scope of the Co-Packaged Optics Module project (i.e. more fibers, thermal, and optical power classes).

"The ELSFP project is an important step for enabling co-packaged optics deployments," says OIF board member Gary Nicholl of Cisco. "The project objectives include the necessary technical considerations to ensure this project will be relevant for multiple generations," he adds.

Application of AI to Enhanced Network Operations Project

A healthy and high-performance network serves as the foundation for all 5G application scenarios, notes OIF. Traditional approaches face significant difficulties in automatically and efficiently analyzing network data, solving network faults, and optimizing network performance. This new project will result in a white paper identifying a collection of use cases for applying AI to construct intelligent, resilient and high-performance optical and packet networks.

CEI-112G-Linear Project

A linear chip-to-optical engine interface is needed to enable low-power, low-cost, small-form-factor 112G serial optical modules in co-packaged optics, near package optics (NPO) and server/GPU applications. This new project will facilitate increased bandwidth and reduced power of switch ports using co-packaged and closely packaged optical modules.

www.oiforum.com

Source Photonics launches suite of 800G transceivers

During the Optical Networking and Communication Conference & Exhibition (OFC 2021) held virtually on 6–11 June, Source Photonics Inc of West Hills, CA, USA (which provides optical connectivity products for data centers, metro and access networks) has launched a range of 800G optical transceivers for data-center and telecom applications.

As the initial wave of widescale deployment of 400G is taking place in data centers, hyperscale data-center customers are already looking into 800G and beyond, together with the release of 25.6T switching application-specific integrated circuits (ASICs), to further support the increasing demand for bandwidth-intensive applications. The 800G client interfaces will not only double port density over currently available 400G transceivers but also should further reduce per gigabit power and cost over equivalent 400G client interfaces.

Source Photonics says that it is deeply engaged with key customers to ensure that these solutions meet market requirements for these critical applications. The firm leverages vertical integration for optical chips and assembly, enabling what is claimed to be industry-leading performance and power consumption. The portfolio of 800G transceivers for switching and routing applications includes:

800G DR8 OSFP & QSFP-DD800

- support 500m, 2km and 10km reaches for 800G-DR8, 800G-DR8+ and 800G-DR8++, respectively;
- support 8x100GbE and 2x400GbE breakout modes;
- compliant to IEEE P802.3ck and IEEE 802.3cu-2021 standards;
- complaint to OSFP multi-source agreement (MSA) and QSFP-DD800 MSA;
- 800G DR8 OSFP supports (i) MPO-16 and (ii) Dual MPO-12 for backward compatible to 2x400GbE DR4 breakout;
- 800G DR8 QSFP-DD800 supports MPO-16.

2x400G FR4 OSFP & QSFP-DD800

- support 2km, 6km, 10km reaches for 2x400G-FR4, 2x400G-LR4-6 and 2x400G-LR4-10, respectively;
- compliant to IEEE P802.3ck, IEEE 802.3cu-2021 and 100G Lambda MSA standards;
- complaint to OSFP MSA and QSFP-DD800 MSA;
- 2x400G FR4 OSFP supports (i) Dual CS and (ii) Dual LC for legacy fiber plants;
- 2x400G FR4 QSFP-DD800 supports Dual CS.

"Multiple 800G transceiver offerings in different form factors and optical interfaces will be available to support optical connectivity between transport, routing and switching equipment," says chief technology officer Sheng Zhang. "These transceivers will be available for customer samples starting third-quarter 2021 to address the demand that has been accelerated by the COVID-19 pandemic."

www.ofcconference.org
www.sourcephotonics.com

MACOM releases new 25G & 50G DFB laser portfolio

New single-ridge design boosts performance for global 5G infrastructure and data-center applications

MACOM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for analog RF, microwave, millimeter-wave and photonic applications) has announced the production release of its new high-speed laser portfolio, after the successful completion of Telcordia GR-468 qualification testing. All products in the portfolio incorporate a new single-ridge design for enhanced optical performance and utilize MACOM's patented Etched Facet Technology (EFT) and wafer-scale indium phosphide (InP) manufacturing capabilities which can support high-volume applications, including 5G wireless infrastructure and Cloud data center.

"Customer feedback on our new 25 and 50 Gigabit laser performance has been positive and our focus will now turn to gaining market share," says president & CEO Stephen G. Daly.

MACOM is branding the new 25Gbps and 50Gbps distributed feedback (DFB) single-ridge laser portfolio as CLEAR DIAMOND LASERS. The portfolio includes over 50 laser products with wavelengths between 1260nm and 1380nm to support multiple global 5G infrastructure applications, including 1310 BiDi, CWDM6, MWDM12, LWDM12, DWDM16 and 50Gbps PAM4. The portfolio also supports 200G FR4, 100G CWDM4 and LR4 applications for data-center networks.

All products incorporate a new single-ridge design for enhanced optical performance and utilize MACOM's patented Etched Facet Technology and wafer-scale InP manufacturing which can support high-volume applications, including 5G wireless infrastructure and Cloud data center

MACOM says its CLEAR DIAMOND LASERS product portfolio offers customers high performance, high reliability and supply chain security. The lasers' standardized form factor supports ease of use and design flexibility, enabling shorter optical transceiver design cycle time and faster time to market. The CLEAR DIAMOND LASERS product portfolio can be paired with MACOM's high-speed analog and mixed-signal chipsets to achieve what is claimed to be leading optical transceiver performance.

All CLEAR DIAMOND LASERS products are available as bare die or in TO-Can packages and are available to support G-Temp, I-Temp and E-Temp requirements.

www.macom.com

MACOM launches two-chip analog solution for 200G and 400G short-reach modules and AOC applications

Alternative to traditional DSP-based technology for data-center multimode connectivity

MACOM has announced the availability of its two-chip analog solution for 200G and 400G short-reach modules (QSFP, OSFP, QSFP-DD) and active optical cable (AOC) applications in the data center. The chipset is said to deliver better than IEEE standard specified bit-error rate (BER) performance and is compliant with Open Eye multi-source agreement (MSA) eye mask specifications.

The chipset consists of two integrated combo devices:

- MATA-38044, a 4x56Gbps PAM-4 CDR (clock & data recovery) and TIA (transimpedance amplifier);
- MALD-38045, a 4x56Gbps PAM-4 CDR and vertical-cavity surface-emitting laser (VCSEL) driver.

The MATA-38044 is a four-channel 28GBaud linear PAM-4/NRZ TIA with automatic gain control and integrated CDRs. The MALD-38045 is a four-channel 28GBaud PAM-4/NRZ VCSEL driver with an integrated CDR designed to directly modulate VCSELs in the transmit path of optical modules. Each of the four channels can operate independently. Both devices consume what is claimed to be industry-leading low power and can operate at Ethernet, Fibre Channel and InfiniBand PAM-4 and NRZ data rates up to 56Gbps.

The two-chip analog solution provides an alternative to traditional digital signal processing (DSP)-based technology. It has lower power consumption, lower latency, lower cost and requires a smaller footprint compared with a DSP-based solution, MACOM says.

At the Optical Networking and Communications Conference (OFC 2021) held virtually on 7–10 June, MACOM hosted virtual demonstrations highlighting the chipset's standard compliance and interoperability with Ethernet switches.

www.ofcconference.org

MACOM and MaxLinear collaborate on 100G, 400G and 800G solutions for data-center applications

Interoperability demonstrated between MaxLinear's DSPs and MACOM's TIAs

MACOM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for analog RF, microwave, millimeter-wave and photonic applications) and MaxLinear Inc of Carlsbad, CA, USA, a provider of radio-frequency (RF), analog, digital and mixed-signal integrated circuits, have announced a collaboration to assure interoperability of MaxLinear's PAM4 (4-level pulse amplitude modulation) digital signal processors (DSPs) and MACOM's 100G/lane transimpedance amplifiers (TIAs) for 100G/lambda applications. Customers can now select a proven design solution with what is claimed to be an exceptionally low bit-error rate (BER) for their optical module designs.

The collaboration includes pairing MaxLinear's second-generation 100G Snowmass DSP (the MxL93516), with MACOM's low-power MATA-05817 100G TIA to achieve exceptional sensitivity and a low-BER floor. This configuration is suitable for 100G-DR1/FR1/LR1 QSFP28 applications for data-center and front-haul applications.

"Our customers are requesting proven high-performance solutions," says Marek Tlalka, senior director, High-Performance Analog, at MACOM. "This collaboration offers the industry a compelling performance proof point and a potential path to shorter design cycle times for 100G, 400G and 800G module manufacturers," he adds.

"The market for 100G/lambda transceivers continues to grow, and performance and time to market are critical for our customers," says Drew Guckenberger, VP of MaxLinear's High-Speed Interconnect Group. "The pairing of our second-generation power-optimized Snowmass 100G DSP with integrated driver with MACOM's high-performance TIAs is an ideal solution for customers, providing tight integration, proven high performance and low-power capabilities."

The companies plan to continue collaborating on 400Gbps and 800Gbps applications utilizing the recently announced MaxLinear 5nm Keystone DSPs and MACOM's portfolio of four-channel 400Gbps TIAs.

www.macom.com/products/product-detail/MATA-05817
www.maxlinear.com/MxL93516

Lumentum presents lasers capable of transmitting at 224Gbps for 800 Gigabit Ethernet

Lumped-element EA-DFB laser capable of 2km reach for data-centers

With the massive proliferation of data-heavy services, including high-resolution video streaming and conferencing, cloud services infrastructure growth in 2021 is expected to reach a compound annual growth rate (CAGR) of 27%. So, while 400 Gigabit Ethernet (GbE) is currently enjoying widespread deployment, 800GbE is poised to rapidly follow to address these bandwidth demands.

One approach to 800GbE is to install eight 100Gbps optical interfaces or lanes. As an alternative to reduce the hardware count, increase reliability and lower cost, a team of researchers at Lumentum has developed an optical solution that uses four 200Gbps wavelength lanes to reach 800GbE.

During the Optical Networking and Communication Conference (OFC) on 6–11 June, Lumentum principal optical engineer Syunya Yamauchi presented the optimized design in the paper '224-Gb/s PAM4 Uncooled Operation of Lumped-electrode EA-DFB Lasers with 2-km Transmission for 800GbE Application'.

"Active optical devices are the most important components of optical communications systems," says Mike Staskus, VP of Datacom product line management.

To achieve high-speed, high-bandwidth operations, Yamauchi's team developed a lumped-element (LE) electroabsorption modulator-integrated distributed feedback (EA-DFB) laser capable of 2km transmission — a requirement for many modern large data centers — of 224Gbps signals operating over a wide temperature range.

"There are tradeoffs between high bandwidth and modulation characteristics, such as extinction ratio," Staskus says. "We overcame the tradeoff by optimizing the design of EA-DFB using a simplified packaging method."

Compared with a conventional EA-DFB, the LE EA-DFB's reduced capacitance and inductance resulting from design and assembly optimizations in the EA modulator improves its power and bandwidth.

"It can enable the development of optical transceivers with twice the data rate of current 400GbE modules, without dramatic increases in the cost and power consumption, by using higher-speed laser transmitter chips that do not require power-hungry thermoelectric coolers," says Staskus.

These results suggest that the LE EA-DFB could enable 800GbE applications, making this device a promising light source for future data-center applications.

"Next-generation lasers using this same 'toolbox' of advanced semiconductor and packaging processes may enable higher speeds, longer reaches and lower costs with the competitive levels of performance, reliability and power consumption," says Staskus. "With the increase of various data streaming and other internet services, intra-data-center links will require higher speeds, including 1.6Tb/s and beyond."

Lumentum's board gains operational expert

Lumentum Holdings Inc of San Jose, CA (which designs and makes photonic products for optical networks and lasers in industrial and consumer markets) has appointed Isaac ('Ike') Harris, corporate VP, global supply chain operations for ZT Systems, to its board of directors as an independent member. The election of Harris expands the board to eight members, seven of whom are independent.

"Ike brings a track record of successfully expanding global operations and creating a positive impact on business performance and operational excellence for industry-leading organizations," says board chair Penny Herscher.

At ZT Systems, a provider of compute and storage solutions for hyperscale data centers, Harris is a global business leader with broad experience in leading customer and global manufacturing operations, platform and commodity procurement, logistics and compliance, and corporate, social and environmental responsibility.

"Lumentum's growing global reach, continued innovation and its commitment to improving their operations for its business, people and the environment has been truly inspiring to watch," says Harris.

Previously, Harris held several senior leadership roles in supply chain operations where he optimized global business performance and customer satisfaction through fulfillment excellence at Cisco Systems and at HP.

"Our focus is on exceeding customer expectations through exceptional quality while upholding our commitment to reducing our environmental impact and operating in a sustainable and socially responsible manner," notes Lumentum's president & CEO Alan Lowe. "Ike's influence as a pioneer and trailblazer in his field will bring a unique and valuable perspective to Lumentum."

Harris is an active member of the Executive Leadership Council and has served on Howard University's Business School Advisory Board. Additionally, he was recognized by Savoy Magazine as one of the Most Influential Black Executives in Corporate America in 2020.

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NeoPhotonics announces general availability of QSFP-DD and OSFP 400ZR coherent modules

Pluggable high-speed coherent modules enable IP over DWDM in DCI and metro-regional networks, reducing cost-per-bit

NeoPhotonics Corp of San Jose, CA, USA – a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications – says that its QSFP-DD and OSFP 400ZR pluggable modules are in general availability and shipping to customers.

The products utilize NeoPhotonics' silicon photonics coherent optical subassembly (COSA) and low-power-consumption, ultra-narrow-linewidth Nano-ITLA tunable laser, combined with the latest generation of 7nm-node DSP (digital signal processing) technology, to provide full 400ZR transmission in a standard data-center QSFP-DD or OSFP form factor that can be plugged directly into switches and routers. This greatly simplifies and cost reduces data-center interconnect (DCI) networks by enabling the elimination of a layer of network equipment and a set of short-reach client-side transceivers, and paves the way for similar benefits in metro networks.

The 400G modules are compliant with the OIF 400ZR Implementation Agreement and are interoperable with other manufacturers' 400ZR modules that utilize a standard forward error correction (FEC) encoder and decoder. The modules are capable of tuning to and transmitting within 75GHz- or 100GHz-spaced wavelength channels, as specified in the OIF agreement, and operate in 400ZR mode for Cloud DCI applications. For longer metro reaches, the modules are designed to support 400ZR+ modes.

NeoPhotonics' QSFP-DD and OSFP modules have completed reliability qualification and have passed 2000 hours of high-temperature operating life (HTOL) as well as other critical tests per Telcordia requirements.

NeoPhotonics recently announced that it had used its QSFP-DD coherent pluggable transceiver to transmit at a 400Gbps data rate over a distance of 800km in a 75GHz-spaced DWDM system with more than 3.5dB of optical signal-to-noise ratio (OSNR) margin in the optical signal while remaining within the power consumption envelope of the QSFP-DD module's power specification.

"This demonstration of high data rates over longer distances shows the potential of these game-changing products, and we expect to see increasing deployment of coherent pluggable modules with different use cases, from data-center interconnect to metro and regional applications as well as 5G wireless backhaul," says chairman & CEO Tim Jenks. "Since the beginning of coherent transmission, NeoPhotonics has been at the forefront in meeting the volume needs of our customers, as is indicated by our recent announcement that we had shipped a cumulative total of more than 2 million ultra-narrow-linewidth tunable lasers."

www.neophotonics.com

NeoPhotonics announces CFP2-DCO module transmission of 400Gbps over 1500km in 75GHz-spaced EDFA-only DWDM system

NeoPhotonics Corp of San Jose, CA, USA – a vertically integrated designer and manufacturer of silicon photonics and hybrid photonic integrated circuit (PIC)-based lasers, modules and subsystems for high-speed communications – says that it has used its multi-rate CFP2-DCO coherent pluggable transceivers to effectively transmit at a 400Gbps data rate over a distance of 1500km in a 75GHz-spaced DWDM network.

This 1500km transmission demonstration was carried out on NeoPhotonics' Transmission System Testbed using production modules with enhanced firmware and utilized 75GHz-spaced channels taking the adjacent-channel crosstalk-induced penalty into account. The transmission system contains 19 in-line erbium-doped fiber amplifiers (EDFAs).

To achieve 1500km reach and a 400G data rate, the modules were operated at 69Gbaud using 16 QAM modulation. Probabilistic constellation shaping and a soft-decision forward error correction (FEC) codec were used to achieve a required optical signal-to-noise ratio (OSNR) of about 20dB, which is comparable to coherent line-card port performance from leading chassis-based coherent systems. The modules each consumed considerably less electrical power than line-card solutions operating at comparable data rates and distances, it is reckoned.

The 400G CFP2-DCO coherent pluggable transceiver modules use NeoPhotonics' high-performance indium phosphide (InP)-based coherent components, along with its ultra-narrow-linewidth tunable laser. These components are all shipping in high volume into multiple coherent system applications, and include:

- *Class 40 CDM:* NeoPhotonics' Class 40, polarization-multiplexed, quadrature coherent driver modulator (CDM) features a co-packaged InP modulator with a linear, high-bandwidth differential driver, and is designed for low V-Pi, low insertion loss and a high extinction ratio. The compact package is designed to be compliant with the form factor of the OIF Implementation Agreement #OIF-HB-CDM-01.0.
- *Class 40 Micro-ICR*: NeoPhotonics' Class 40 high-bandwidth micro-intradyne coherent receiver (Micro-ICR) is designed for >60GBaud symbol rates. The compact package is designed to be compliant with the OIF Implementation Agreement OIF-DPC-MRX-02.0.
- *Nano-ITLA*: NeoPhotonics' Nano-ITLA is based on the same proven and reliable high-performance external-cavity architecture as the firm's Micro-ITLA and maintains comparable ultra-narrow linewidth, low-frequency phase noise and low power consumption in a compact package approximately half the size.

NeoPhotonics' multi-rate CFP2-DCO modules are fully qualified. Telcordia testing has been successfully extended to 2000 hours of high-temperature operating life (HTOL) testing, showing the high reliability and performance of NeoPhotonics' CFP2-DCO platform.

Multi-rate CFP2-DCO modules supporting metro (64Gbaud/DP-16 QAM) and long haul (64Gbaud/DP-QPSK) applications are shipping in general availability.

"Coupled with our recent demonstration of 800km 400Gbps transmission using our 400ZR+ QSFP-DD, our CFP2-DCO 400G 1500km transmission brings the use of pluggable modules in regional and long-haul networks closer to reality," says chairman & CEO Tim Jenks. "The ability to implement a long-haul coherent transponder in the size and power envelope of a pluggable module is a testament to the progress that has been made in photonic integration and DSP [digital signal processor] development, and has the potential to be a game changer for telecom as well as DCI networks," he concludes.

www.neophotonics.com

Emcore added to Russell 2000 Index

Emcore has been included in the Russell 2000 Index and the broad-market Russell 3000 Index as part of the annual reconstitution of the Russell stock indexes.

Leveraging quartz MEMS, indium phosphide and lithium niobate chip-level technology, Emcore's component and system-level products support applications including navigation and inertial sensing, defense optoelectronics, broadband transport, 5G wireless infrastructure, optical sensing, and cloud data centers. The firm has vertically integrated manufacturing capability at its wafer fabrication facility in Alhambra, CA, and quartz MEMS manufacturing facility in Concord, CA. Manufacturing facilities maintain ISO 9001 quality management certification, and the firm is AS9100 aerospace quality certified at its facility in Concord.

"Russell 2000 index inclusion is an important milestone for our company as we continue our momentum and growth trajectory," says CEO Jeff Rittichier. "Our hope is this increased visibility will lead to more awareness of Emcore and greater shareholder value," he adds.

www.emcore.com

First Solar to invest $680m in expanding US PV manufacturing capacity by 3.3GW to 6GW

New factory in Ohio to be firm's third in USA

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA says that it is investing $680m to expand US domestic photovoltaic (PV) solar manufacturing capacity by 3.3GW$_{DC}$ annually, representing an implied capital expenditure of about $0.20 per watt. The firm intends to fund construction of its third US manufacturing facility (in Lake Township, Ohio) with existing cash resources.

Contingent upon permitting and pending approval of various state, regional and local incentives, the new facility is expected to commence operations in first-half 2023. It is projected to achieve its throughput entitlement (modules produced per day) by the end of the same year with over 3GW$_{DC}$ of nameplate capacity, and is expected to attain full nameplate capacity, based on the firm's module efficiency roadmap, in 2025. When fully operational, the facility will scale the company's Northwest Ohio footprint to a total annual capacity of 6GW$_{DC}$, which is believed to make it the largest fully vertically integrated solar manufacturing complex outside of China. (In addition to its Ohio manufacturing facilities, First Solar also operates factories in Vietnam and Malaysia.)

"These investments in American-made solar technologies are the perfect embodiment of President Biden's strategy to build out domestic manufacturing and supply chains for critical industries," says US Energy Secretary Jennifer M. Granholm. "As a partner to our solar program since 2003 and a DOE [Department of Energy] loan guarantee recipient in 2012, this company is a great example of how investment and innovation can build the clean energy future right here at home — shoring up American competitiveness," she adds.

Unique among the world's ten largest solar manufacturers for being the only US-headquartered company and for not using crystalline silicon (c-Si), First Solar produces its ultra-low-carbon thin-film PV modules using a fully integrated, continuous process under one roof.

The 1.8 million square foot facility is projected to directly create about 500 jobs and is expected to produce an enhanced thin-film PV module for the utility-scale solar market in the USA, which is anticipated to have a higher efficiency and wattage in a larger form factor. The additional production capacity from this new facility, when available, is also expected to help mitigate the challenges currently being experienced in the global ocean freight market, by reducing the transoceanic gap between international supply and domestic demand.

Strong demand for Series 6, a compelling technology roadmap, a strong balance sheet, and a largely fixed operating expense cost structure, are each catalysts as we evaluate the potential for future capacity expansion. We are continuing to evaluate the potential for further domestic and international expansion

"We stand ready to support President Biden's goal to transition America to a clean, energy-secure future, and our decision to more than double our US manufacturing capacity with this new facility is First Solar making good on that commitment," says CEO Mark Widmar. "This facility will represent a significant leap forward in photovoltaics manufacturing... It will leverage our advantaged position at the intersection of efficiency, energy yield, optimized form factor, and cost competitiveness, while leading our manufacturing fleet in delivering the highest efficiency and wattage, and the lowest cost per watt."

The facility will allow First Solar to produce an anticipated average of one module every 2.75 seconds across its three-factory Ohio footprint once it achieves its full production capacity. The facility will combine highly skilled workers with Industry 4.0 architecture, machine-to-machine communication, artificial intelligence and Internet of Things connectivity to produce a higher degree of automation, precision and continuous improvement.

"While designing and building this factory of the future we're challenging ourselves to focus on the continuous improvement of our throughput, quality and safety through automation," says chief manufacturing operations officer Mike Koralewski. "We see this as an opportunity for our associates to upskill, learn new technologies, continue to grow and develop themselves as our factories and products continually evolve."

First Solar continues to evaluate opportunities to further expand its global manufacturing footprint. "Looking forward, strong demand for Series 6, a compelling technology roadmap, a strong balance sheet, and a largely fixed operating expense cost structure, are each catalysts as we evaluate the potential for future capacity expansion," Widmar notes. "While we have made no such decisions at this time, we are continuing to evaluate the potential for further domestic and international expansion."

www.firstsolar.com

Ascent Solar delivers contract to supply new HyperLight PV modules for high-altitude airships

Third and largest order from customer since March 2018

Ascent Solar Technologies Inc of Thornton, CO, USA — which makes lightweight, flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic (PV) modules that can be integrated into consumer products, off-grid applications and aerospace applications — has completed the delivery of a major order for its HyperLight thin-film modules for high-altitude airship applications.

The HyperLight family of modules further reduces packaging and PV module mass, achieving what is claimed to be best-in-class power-to-weight ratio (specific power) of over 350W/kg for a fully laminated product on an airship, while streamlining customer operations to integrate the modules to their application.

The shipment represents the third and the largest order from the customer since March 2018. The customer is the developer of an unmanned, helium-filled airship operating in the stratosphere at an altitude greater than 60,000ft above sea level. The robust, versatile and solar-powered high-altitude platform aims to provide several services, including delivering high-speed Internet directly-to-device, enabling high-resolution real-time Earth imagery, and facilitating other humanitarian endeavors.

Ascent says that its PV modules will benefit various future missions, ranging from CubeSats, solar sails, and potentially missions to the moon and Mars. To obtain the necessary data to determine how flexible CIGS performs in the space environment, Ascent's PV modules have been undergoing extensive evaluation for years, including protracted and demanding ground simulation test and, as part of the 10th Materials International Space Station Experiment (MISSE-X) flight experiment aboard the International Space Station that was launched on 17 November 2018 for a duration of over one year. The upcoming LISA-T demonstration, part of NASA's Pathfinder Technology Demonstrator 4 CubeSat slated for launch in 2022, will also include Ascent's flexible CIGS as part of its further photovoltaic experiment.

"We have noted previously that Ascent's thin-film CIGS PV technology produces modules with the highest power-to-weight ratio, and this characteristic is incredibly important for aerospace, near-space and space applications," says Dr Joseph Armstrong, founding team member, chief technology & chief operating officer of Ascent. "We were able to provide our customer with a unique modular product that is designed to reduce part count significantly over our competition, while providing the ability and flexibility to integrate the modules into different form factors for different applications as their product evolves. Based upon results from the first two orders supplied to them, we worked with the customer to significantly reduce the mass of the PV module while including in-laminate circuit protection to enable them to streamline their integration process as well… we were able to complete this order that dramatically improved upon performance from earlier designs while overcoming significant challenges of the past 15 months."

"This contract is by far the single largest PV sales contract in the corporate history of Ascent Solar, which follows the success of multiple large shipments of such customized high-voltage superlight thin-film for high-altitude applications," says CEO & president Victor Lee. "The contract is not only significant in value but also underscores the power of Ascent's proprietary technology to address these rapidly emerging and growing premium PV markets," he adds. "We hope that this contract is only the 'tip of the iceberg' as the project, if successfully launched, is expected to be rolled out on a much larger scale in the future."

www.AscentSolar.com

Quantum dot powering up p-AlGaN

Researchers claim an order-of-magnitude reduction in activation energy in 60%-Al-content material.

Researchers in China have improved the p-doping capability of magnesium in ultra-wide-bandgap (UWBG) aluminium gallium nitride (AlGaN) by incorporating quantum dot (QD) structures [Ke Jiang et al, Light: Science & Applications, vol10, p69, 2021]. The team from Changchun Institute of Optics, Fine Mechanics and Physics, together with University of Chinese Academy of Sciences, believes that the GaN QDs help to shift the valence-band maximum (VBM) closer to the Mg interband level (Figure 1), reducing the activation energy (E_a) by an order of magnitude and hence increasing the hole density.

The researchers comment: "The quantum engineering doping method may also work in other UWBG semiconductors such as II–VI alloys, conductive oxides, or diamond because there are abundant heterostructures among their own congeners." They see the technique as having implications for microelectronic and optoelectronic applications of AlGaN. As part of the work, they implemented the p-AlGaN:GaN QD structure in deep-ultraviolet light-emitting diodes (DUV-LEDs). On the pure electronic side, the availability of more effective p-doping could benefit efforts to produce high-voltage, high-frequency and high-power devices.

A test structure was grown by metal-organic chemical vapor deposition (MOCVD) on sapphire, using a non-equilibrium growth method. The buffer layers consisted of an AlN template and AlN/AlGaN superlattices to block dislocations.

The p-doped AlGaN:GaN QD system was realized using a non-equilibrium interrupt process. The AlGaN matrix resulted from simultaneous injection of trimethyl-Al and trimethyl-Ga, along with ammonia (NH_3) and bis(cyclopentadienyl)-magnesium (Cp_2Mg) for 10 seconds. The TMAl flow was then stopped for 10 seconds to grow the GaN QDs. The TMGa flow was then also stopped for 25 seconds to allow the QD structure to settle and encourage enriched Mg incorporation at the matrix-QD interface. The process was repeated about 40 times to give a 370nm p-AlGaN:GaN QD layer.

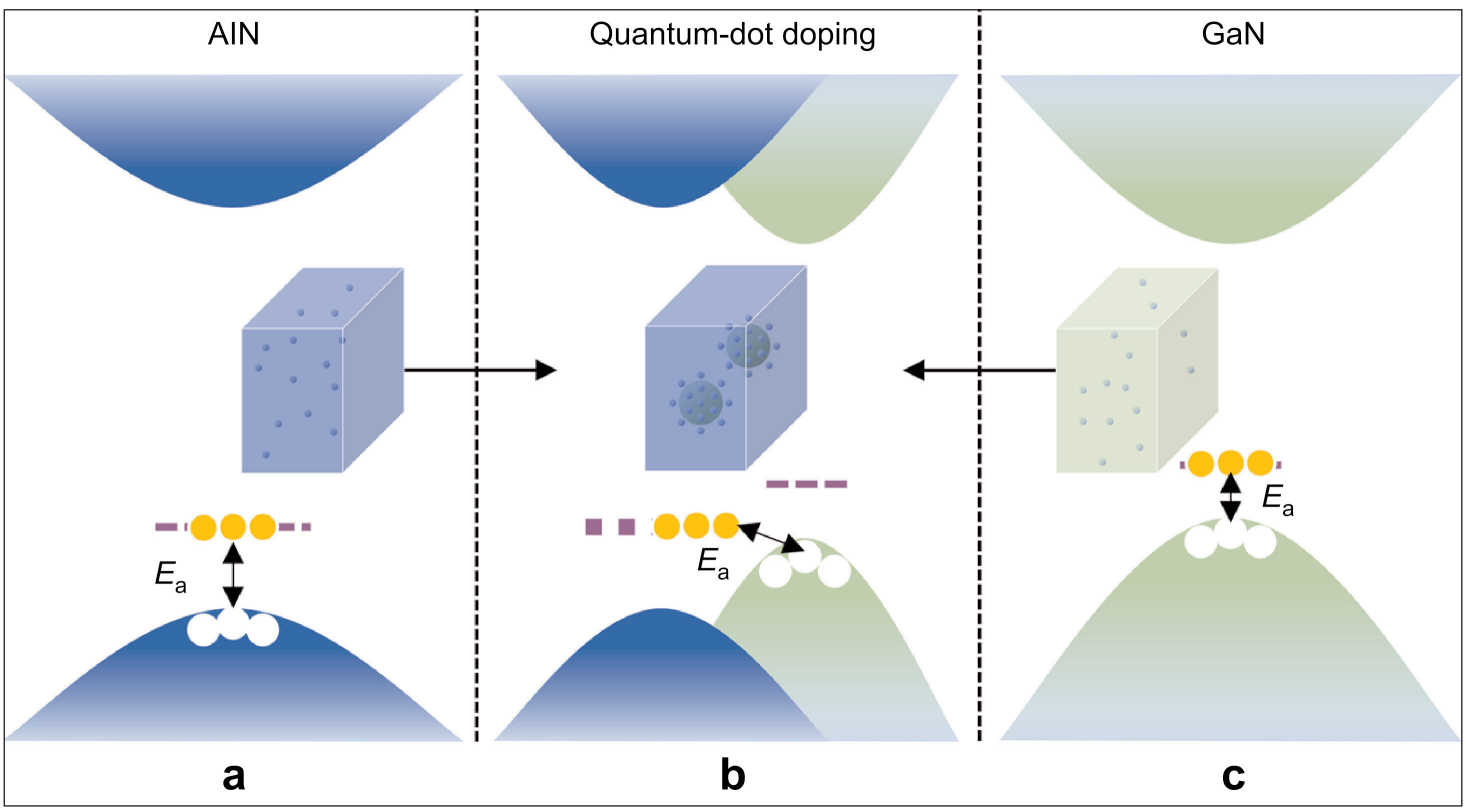

Figure 1. VB modulation to lower the acceptor Ea in UWBG nitrides. Acceptors randomly doped in (a) AlN and (c) GaN. (b) GaN QDs embedded in AlN matrix–acceptors in matrix concentrate near QD interface.

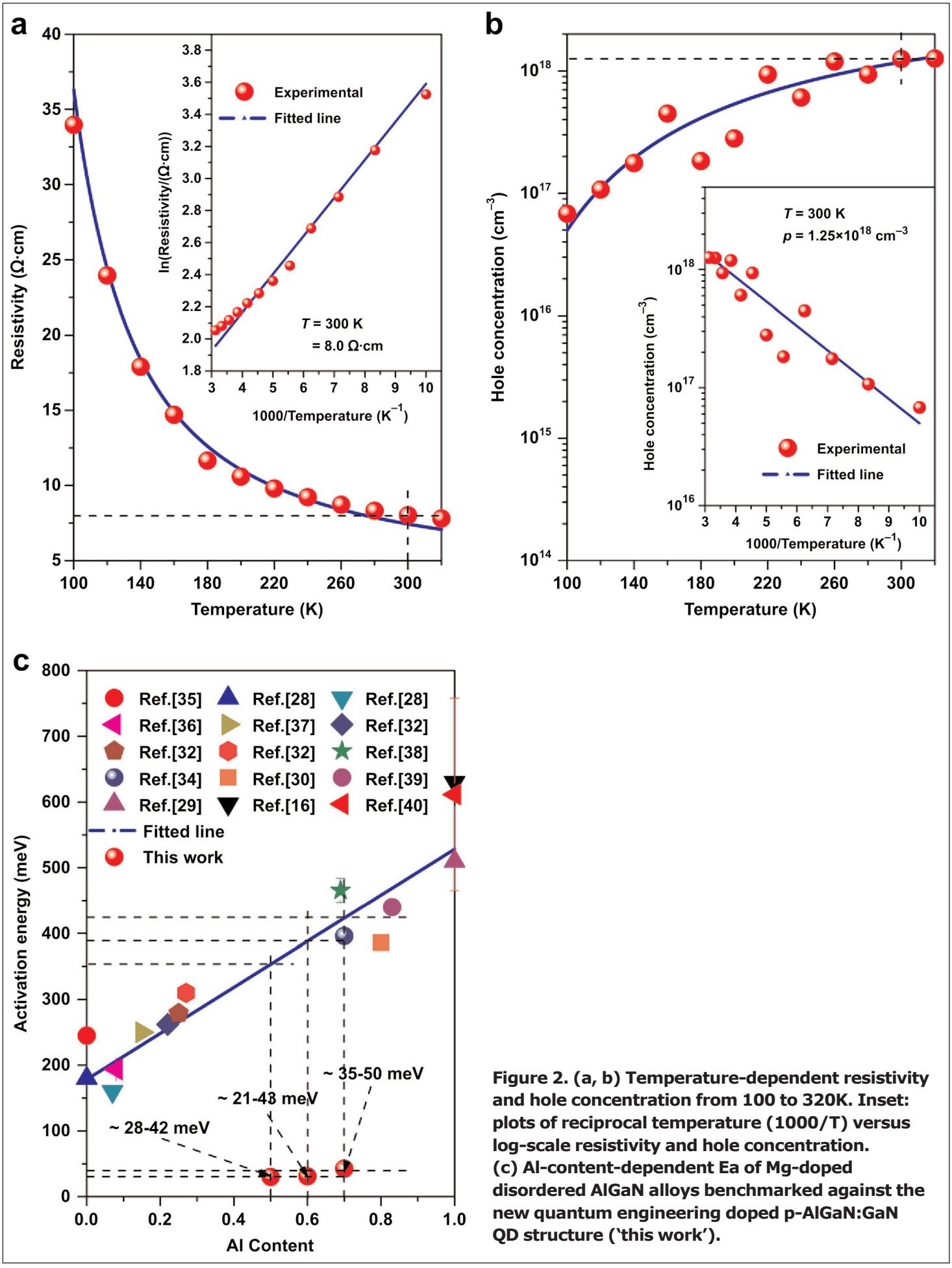

Figure 2. (a, b) Temperature-dependent resistivity and hole concentration from 100 to 320K. Inset: plots of reciprocal temperature (1000/T) versus log-scale resistivity and hole concentration. (c) Al-content-dependent Ea of Mg-doped disordered AlGaN alloys benchmarked against the new quantum engineering doped p-AlGaN:GaN QD structure ('this work').

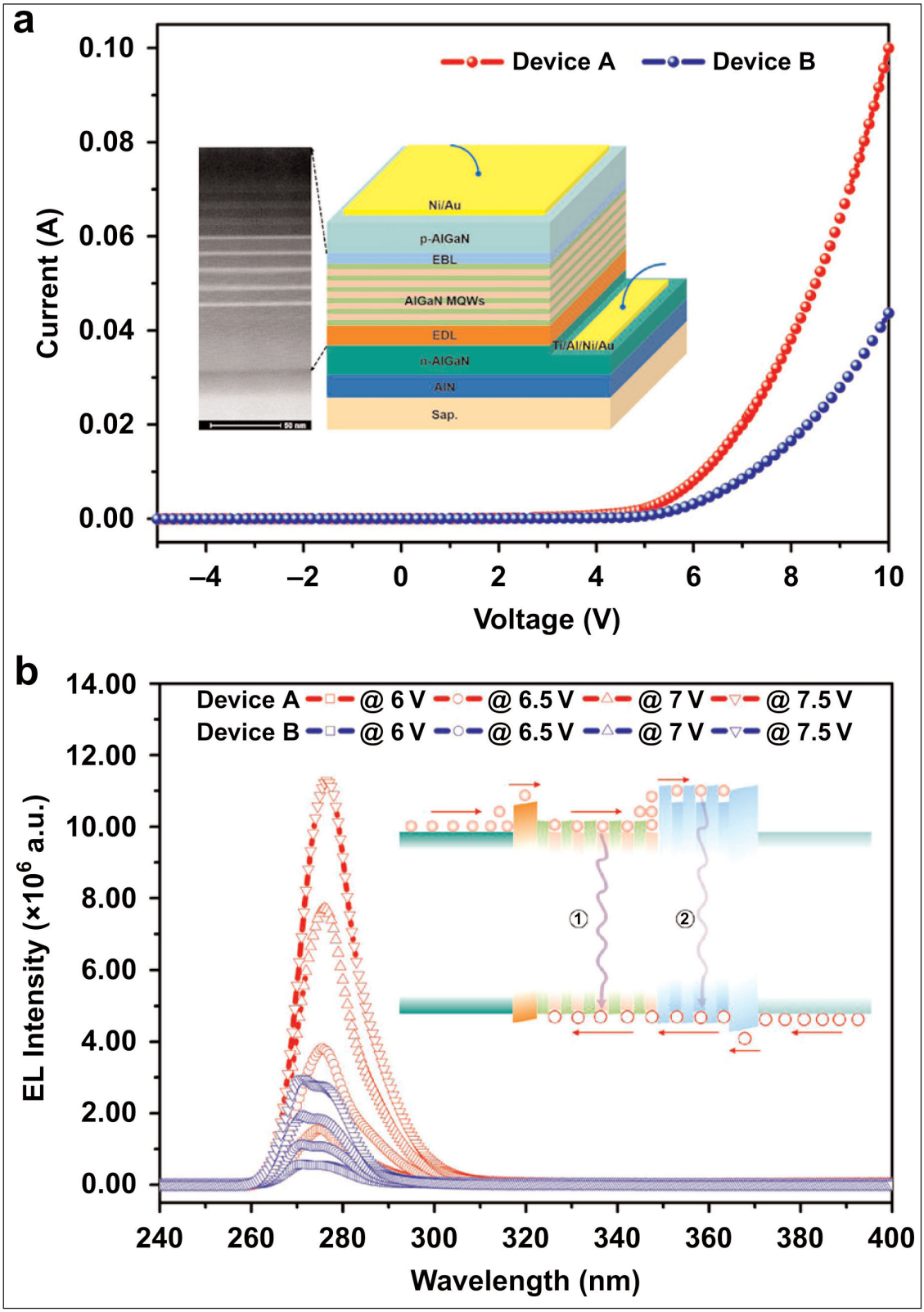

Figure 3. (a) Current–voltage behavior of DUV-LEDs with p-AlGaN:GaN QD (A) and uniform p-AlGaN (B). Inset: device structure and STEM image of active region. (b) EL spectra at different voltages. Inset: energy-band diagram of devices under bias.

A post-deposition thermal anneal was used to activate the doping by driving out the hydrogen that tends to passivate the p-doping effect of Mg.

A high-angle annular dark-field scanning transmission electron microscope (HAADF-STEM) study found that the QDs were 2–3nm high and 6–8nm high. The Al content of the matrix was around 60%, according to secondary-ion mass spectroscopy (SIMS).

The resistivity of the material (Figure 2) was found to be 8.0Ω-cm at room temperature (300K). The activation energy for hole formation (derived from the temperature dependence of the resistivity) was 21meV, compared with ~400meV for p-AlGaN at 60% Al content. The hole concentration was put at $1.25 \times 10^{18}/cm^3$. The temperature dependence of this factor gave an activation energy estimate of 43meV.

Deep-ultraviolet light-emitting diodes were fabricated using the AlGaN:GaN QD p-doping. The current–voltage behavior showed improved current for a given voltage and higher light output, compared with a device using a standard p-AlGaN layer (Figure 3).

The electroluminescence from the AlGaN:GaN QD LED red-shifted to longer wavelength under higher bias. The researchers attribute this to the quantum-confined Stark effect (QCSE) due to the higher electric field in the active region. By contrast, the uniformly doped p-AlGaN device saw little red-shift, which the team explains as being due to the lower potential drop across the active region. In the latter case, there is a larger potential drop across the more resistive p-AlGaN layer, compared with the p-AlGaN/GaN QD system. ■

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Fujitsu demonstrates X-band GaN HEMT on AlN

A thin channel reduces leakage current at pinch-off and gives high current while maintaining high breakdown.

Japan's Fujitsu Ltd has claimed the first demonstration of output power characteristics for X-band (8–12GHz) gallium nitride (GaN)-channel high-electron-mobility transistors (HEMTs) produced on aluminium nitride (AlN) substrate [Shiro Ozaki et al Appl. Phys. Express, vol14, p041004, 2021].

GaN-based HEMTs have a wide range of potential applications for high-frequency and high-power applications such as radio frequency (RF) power amplifiers in wireless base-stations and radar systems. The technology is particularly attractive in enabling higher output power density, extending communication distances.

The use of an AlN substrate enabled a higher-Al-content AlGaN buffer to be used in conjunction with a thin GaN two-dimensional electron gas (2DEG) channel, compared with structures grown on more conventional silicon carbide (SiC). The 200nm-thick channel was designed to reduce leakage current and improve pinch-off. This high-Al-content AlGaN buffer created an effective back-barrier through charge polarization effects of the different ionicity of the chemical bonds, and large conduction-band offsets, relative to GaN.

The advantage of AlN over SiC in growing AlGaN with higher Al contents and lower dislocation density is due to the closer lattice match with AlN. The effect of lattice mismatch limits AlGaN on SiC to less than 15% Al content before a substantial density of dislocations is generated.

Some research has explored the use of GaN substrates to reduce dislocations, but there would be potential thermal management issues due to a lower thermal conductivity (230W/mK). By contrast, AlN and SiC are much better in this respect, with conductivities of 341W/mK and 420W/mK respectively. Previous reports of HEMT on AlN have focused on high-temperature operation with AlGaN channels, which suffer reduced mobility from alloy scattering.

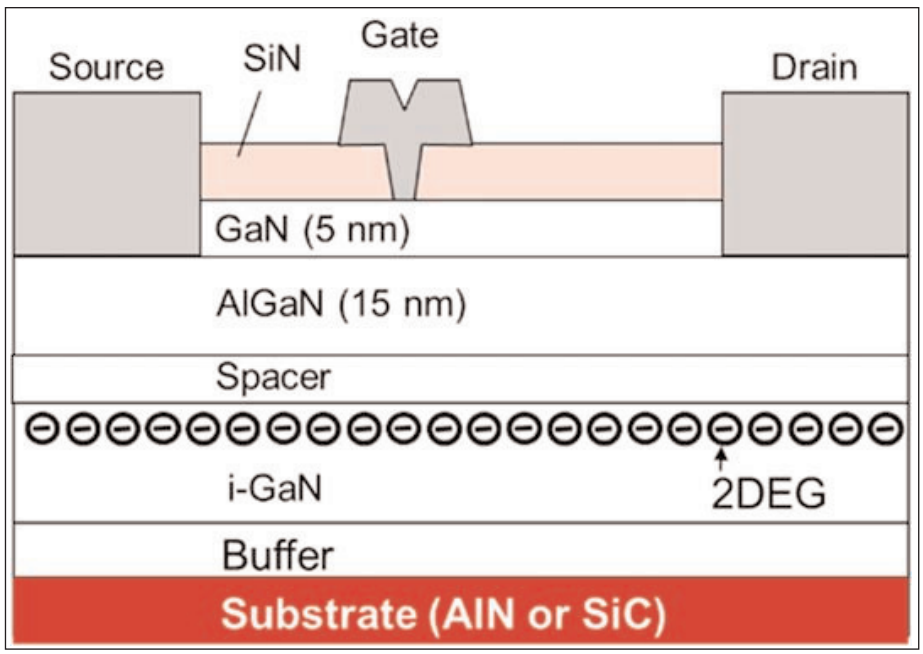

Figure 1. AlGaN/GaN HEMT structure.

The team fabricated HEMTs (Figure 1) with gate length, gate width and gate-to-drain length of 0.25μm, 50μm and 3μm, respectively. A range of comparison devices was produced on SiC substrates (Table 1). The materials were produced using metal-organic vapor phase epitaxy (MOVPE) on AlN or SiC. The 1-inch (0001) AlN substrate was created using physical vapor transport (PVT), resulting in less than $10^3/cm^2$ dislocation density and

Table 1. Epitaxial structures. Carrier densities determined by Hall measurements. Substrate for A was AlN, the remainder were on SiC. The AlGaN buffer for A had 30% Al, while the remainder on SiC had 5%. A and F included a 2nm AlN spacer.

Sample	A	B	C	D	E	F
GaN channel	200nm	200nm	1000nm	1000nm	1000nm	1000nm
AlGaN barrier composition	31% Al	31% Al	31% Al	17% Al	17% Al	17% Al
Carrier density (x10^{13}/cm^2)	1.13	0.83	0.82	0.66	0.74	1.15

~1nm root-mean-square surface roughness.

The ohmic source–drain electrodes of the HEMTs were titanium/aluminium, and the gate was nickel/aluminium. The devices were passivated with silicon nitride.

While the maximum drain current for the HEMT on AlN reached more than 1A/mm, the devices on SiC had current all below 1A/mm, and device D had a maximum current as low as 0.7A/mm. Also, the higher-drain-current devices on SiC paid a penalty in terms of breakdown voltage, which was reduced from ~270V for D down to ~160V for F. By contrast, device A on AlN had a breakdown ~250V, close to that of D. The leakage current for HEMT A was of order 1μA/mm at 20V drain bias, compared with almost 10μA/mm for B and 0.1mA/mm for C.

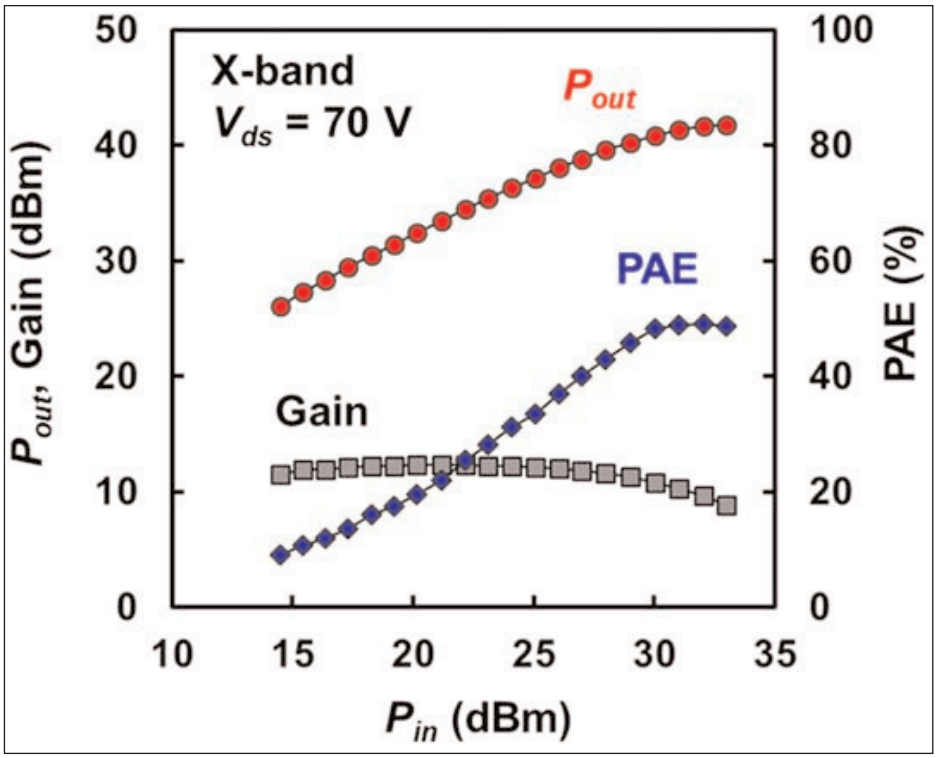

Figure 2. Output (P_{out}) versus (P_{in}) characteristics of AlGaN/GaN HEMT on free-standing AlN from X-band load-pull measurements.

Load-pull measurements (Figure 2) for X-band frequencies at 70V drain bias (V_{ds}) achieved peak power-added efficiency (PAE) of 49.1% with associated output power (P_{out}) of 41.7dBm. The team reports that these values are equivalent to a power output of 14.7W/mm and 9.6dB gain.

Saturated output power density reached 15.7W/mm. Reducing the drain bias reduced the power linearly. The team comments: "We believe that the influence of the current collapse because of electron capture was reduced by high 2DEG density of the HEMT on AlN substrate, especially at high V_{ds}."

Since these results were obtained without source-field plate and optimized dimension enhancements, the researchers believe that even better output power characteristics could be achieved for next-generation high-power RF devices. ■

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Author: Mike Cooke

GaN RF device market growing at 18% CAGR from $891m in 2020 to $2.4bn in 2026

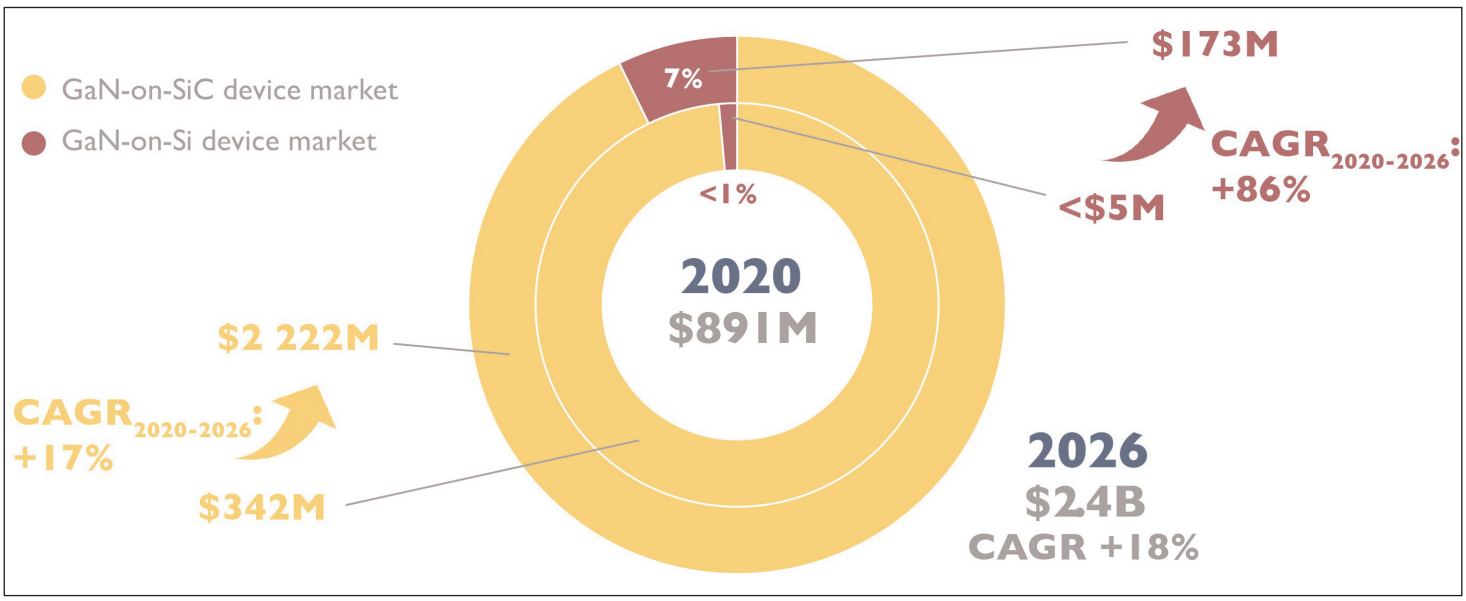
The GaN-on-SiC is growing at a CAGR of 17% from $342m to $2 222m, but GaN-on-Si is growing at 86% from $5m to $173m over 2020–2026, says Yole.

The gallium nitride (GaN) radio-frequency (RF) device market is rising at a compound annual growth rate (CAGR) 18% from $891m in 2020 to more than $2.4bn by 2026, forecasts market analyst firm Yole Développement in its report 'GaN RF Market: Applications, Players, Technology, and Substrates 2021'. The market will be dominated by defense and 5G telecom infrastructure applications, representing 49% and 41% of the entire market by 2026, respectively, it is forecasted. In particular, the GaN-based macro/micro-cell sector will represent more than 95% of the GaN telecom infrastructure market in 2026.

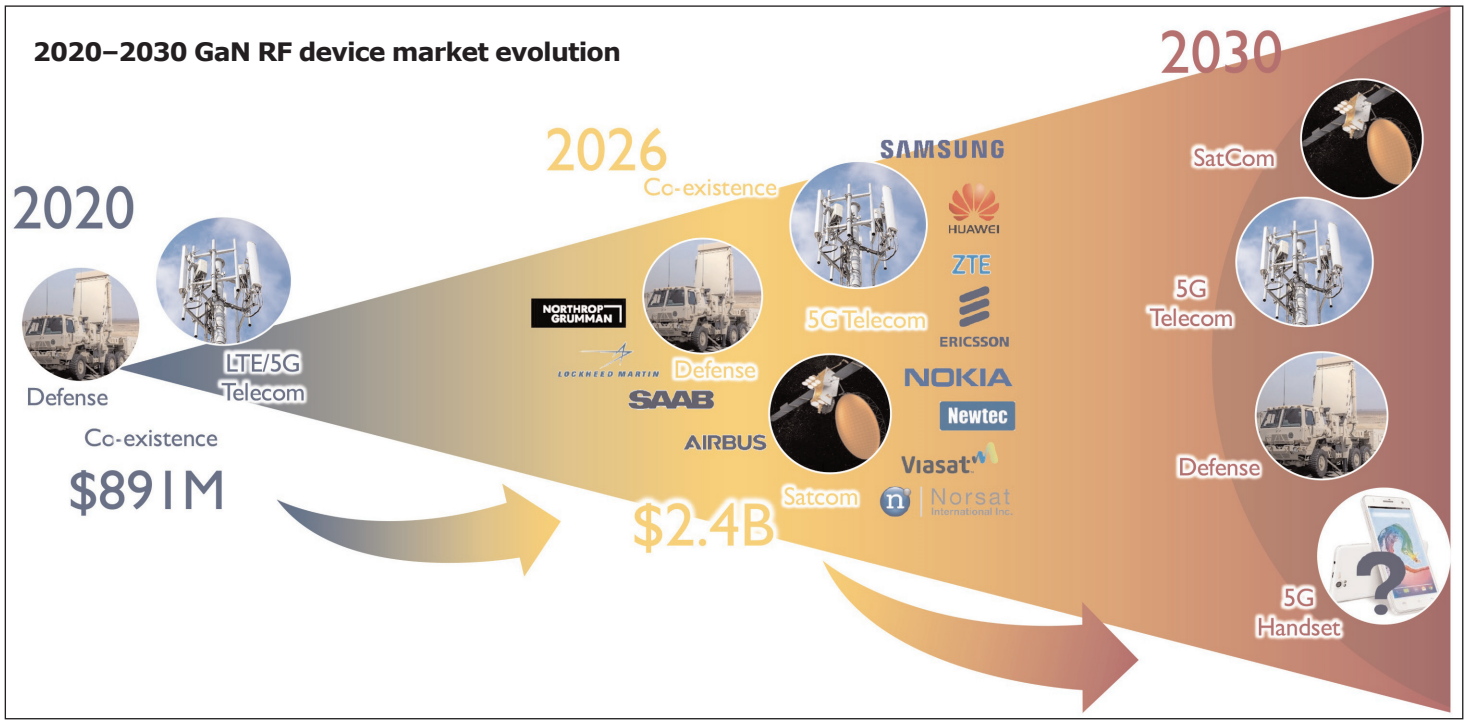
In the RF GaN industry, everything started with GaN-on-SiC (gallium nitride on silicon carbide) technology. Launched more 20 years ago, GaN-on-SiC is now a serious rival to silicon LDMOS and gallium arsenide (GaAs) in RF power applications. Dominated by GaN-on-SiC technology, vertical integration of the supply chain has been preferred in both defense and 5G telecom applications. "In view of the emerging GaN RF market, notable investments in recent years have been shaping the future relationship between demand and supply, which is important to watch closely," says Ezgi Dogmus PhD, team lead analyst in Compound Semiconductor & Emerging Substrates activity within the Power & Wireless Division. In particular, competition between GaN-on-SiC and GaN-on-Si technology has emerged. "GaN-on-SiC is the main technology platform. The market leader at the device level, SEDI [Sumitomo Electric Device Innovations], has partnered with the leading SiC wafer supplier, II–VI, for vertical integration," she adds.

Driven by the 5G telecom and defense segments, GaN-on-SiC technology is still preferred in terms of high power density and thermal conductivity. In addition to its deep penetration in military radar, GaN-on-SiC has also been the choice of telecom OEMs such as Huawei, Nokia, Samsung for 5G massive MIMO infrastructures. Due to their high bandwidth and efficiency, GaN-on-SiC devices keep taking share from LDMOS in the 5G market and are starting to benefit from the 6" wafer platform transition. In this context, the GaN-on-SiC device market is growing at 17% CAGR from $342m in 2020 to $2.222bn in 2026, it is reckoned.

In 2020, NXP opened the world's first 6"-wafer GaN-on-SiC fab, in Arizona, USA. The transition from 4" to 6" substrates for GaN-on-SiC is ongoing and expected to accelerate in the coming years. At the



2020–2026 packaged GaN device market forecast (in $m) — split by technology platform.



foundry level, major actors like Taiwan's WIN Semiconductor are expanding their capacity to fulfill growing market demand. In addition, there is strong motivation for technology independence in the Chinese ecosystem, for example at SICC, CETC, HiWafer and Sanan IC. In particular, China's SICC has invested in a new 6" plant in Shanghai.

"However, as a key challenger, GaN-on-Si is still in the game, promising cost-efficient and scalable solutions," notes Poshun Chiu, technology & market analyst specializing in Compound Semiconductor and Emerging Substrates. "Despite the tiny market volume as of second-quarter 2021, GaN-on-Si PAs attract smartphone OEMs owing to their large bandwidth and small form factor," adds Chiu. "Its adoption in some sub-6GHz 5G handset models is likely soon, following the significant technology progress of innovative players. This would certainly mark a milestone for the GaN-on-Si RF industry."

GaN-on-Si keeps attracting newcomers. "As MACOM–STMicroelectronics' development on 6" platform is ongoing, GlobalFoundries and Raytheon recently announced a partnership to target 5G wireless applications, defense and beyond," notes Selsabil Sejil PhD, technology & market analyst, specialized in Compound Semiconductors and Emerging Substrates. "To serve increasing demand, newcomers have been joining with newly built capability."

The recent entry of foundries and synergy with the emerging power electronics GaN-on-Si industry can also help GaN-on-Si RF to gain momentum in the longer term, says Yole. Driven by handsets but also defense and 5G telecom infrastructure applications, the GaN-on-Si device market is growing at a CAGR of 86% from less than $5m in 2020 to $173m in 2026, reckons Yole. ■

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www.yole.fr/GaN_RF_Market_Update_2021.aspx

Diamond for Ga_2O_3 thermal management

A silicon dioxide interlayer enables polycrystalline layers with high ~110W/m-K thermal conductivity.

Researchers based in the USA claim "the first significant step towards device-level thermal management of β-Ga_2O_3 electronic devices" with the development of a polycrystalline diamond deposition process [Mohamadali Malakoutian et al, Appl. Phys. Express, vol14, p055502, 2021].

Gallium oxide (Ga_2O_3) is a promising material for high-voltage and high-power-density applications due to its wide bandgap of 4.8eV and resultant resistance to breakdown under large electric fields up to 8MV/cm. Further, high-quality low-cost melt-grown Ga_2O_3 wafers are commercially available.

However, thermal management is a critical consideration for high-power devices, and unfortunately Ga_2O_3 has a relatively low and anisotropic thermal conductivity in the 11–27W/m-K range. In recent years, thermally conductive diamond layers have been proposed for thermal management across a wide range of electronics applications.

The team from Stanford University, Pennsylvania State University, Georgia Institute of Technology, and University of California Davis, used (-201) β-Ga_2O_3 substrates from Sojitz Machinery Corp in Japan. The substrates were tin-doped.

The 5–10nm-diameter diamond nanoparticles were supplied by Adamas Nanotechnologies in the USA, suspended in deionized water and dimethyl sulfoxide (DMSO). The colloidal dispersions had various zeta potentials, both positive and negative. Three seeding processes were tried: ultrasonication, drop, and polymer-assisted.

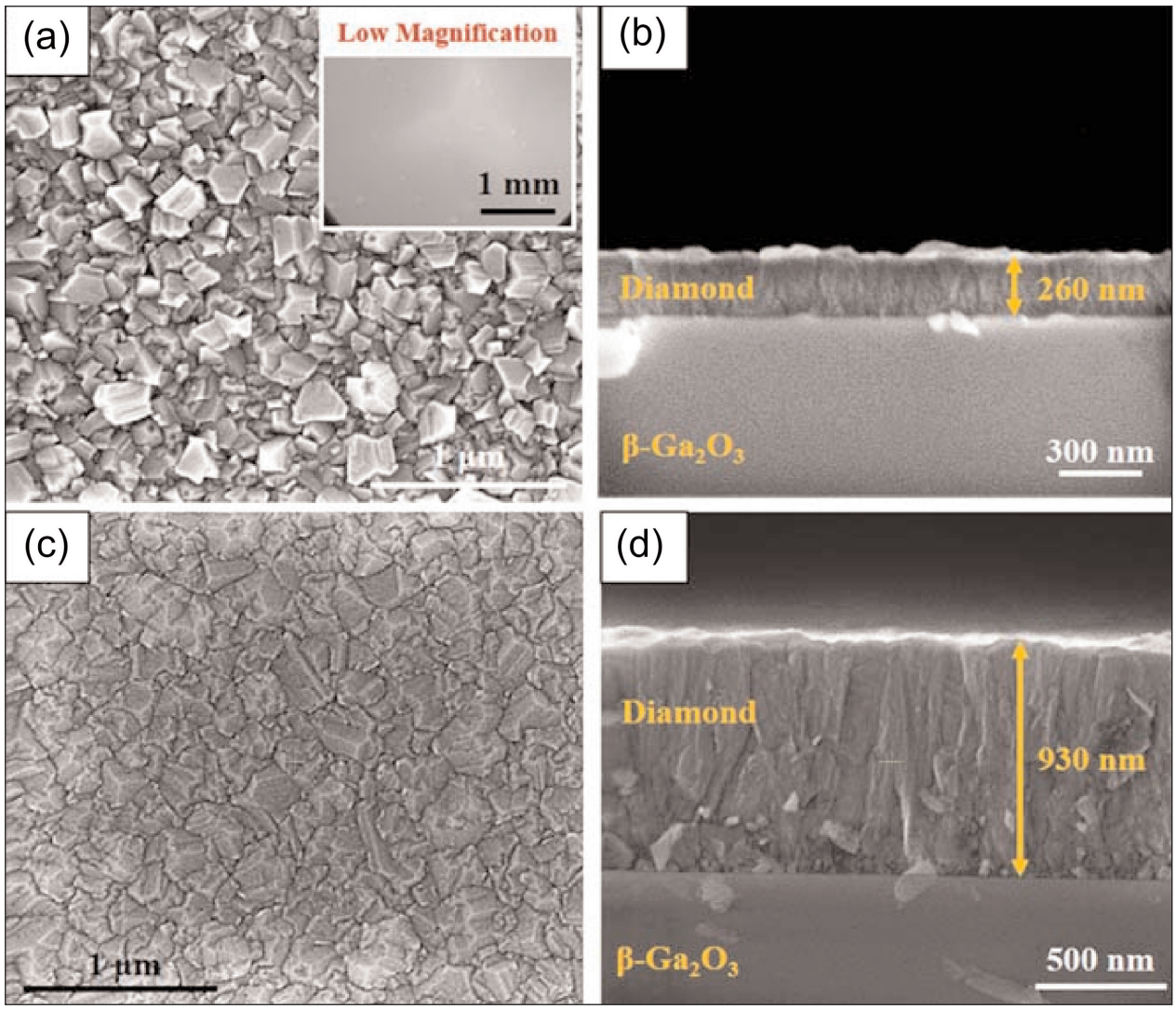

Figure 1. Scanning electron micrographs of polycrystalline diamond films grown on SiO_2/Ga_2O_3: (a) and (b) ~260nm diamond on 19nm SiO_2. Inset shows uniform growth on larger area of surface; (c) and (d) ~930nm diamond on 100nm SiO_2.

The main diamond growth was by microwave plasma chemical vapor deposition (CVD). The carbon source was methane (CH_4). The growth temperature was between 500°C and 700°C.

The researchers found that ultrasonication seeding was not viable for the subsequent CVD process because the seed deposition resulted in bare Ga_2O_3 patches, which were decomposed by the hydrogen plasma in the CVD reaction chamber. This resulted in non-contiguous diamond layers.

Drop-seeding used a nanoparticle suspension diluted with DMSO. This enabled a contiguous diamond layer to be grown by CVD. However, the seeding layer was very thick, giving a non-uniform CVD diamond layer. Further, the diamond tended to delaminate if thicker than 200nm. This was attributed to a larger coefficient of thermal expansion (CTE) mismatch between Ga_2O_3 and diamond.

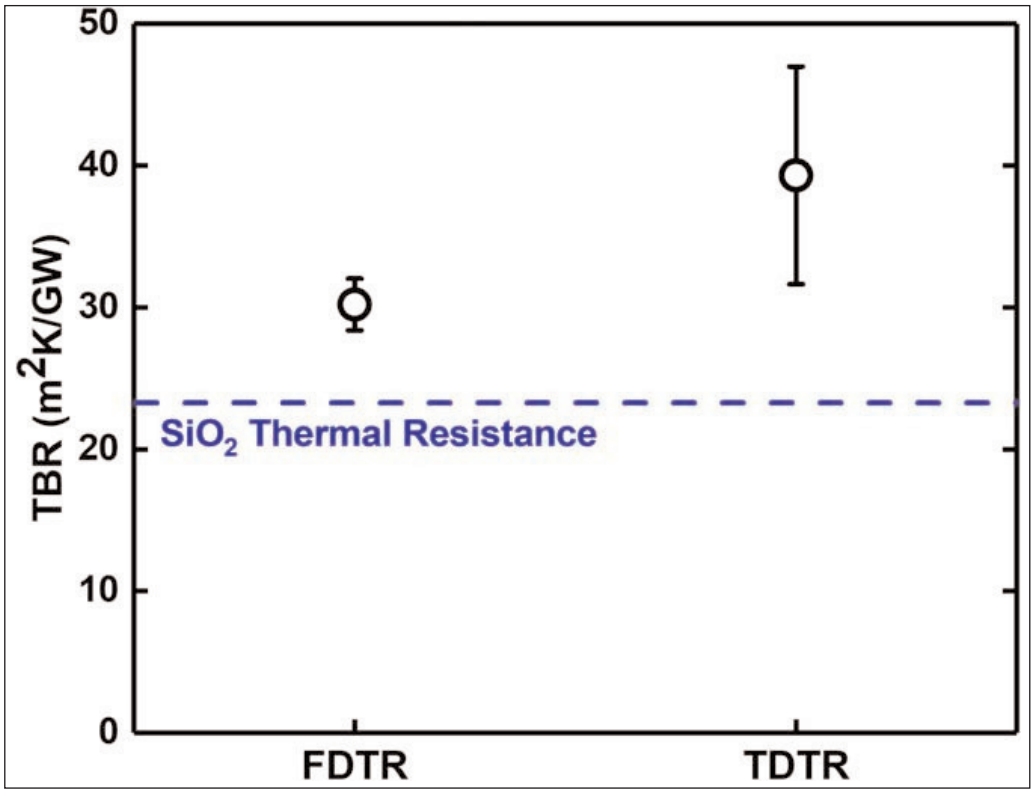

Figure 2. Effective diamond/β-Ga_2O_3 TBR measured by TDTR and FDTR methods. Dashed line shows estimated contribution from 19nm SiO_2 interlayer.

Polymer-assisted seeding consisted in coating the Ga_2O_3 surface with poly-diallyldimethylammonium chloride (PDDAC) beforehand. This created a negative potential surface, which attracted diamond nanoparticles with positive zeta potential. The resulting seed layer consisted of a nanoparticle monolayer with a density of more than $10^{12}/cm^2$.

CVD growth with a single polymer-assisted seed layer was found to have insufficient coverage to protect the Ga_2O_3 from hydrogen-plasma attack, as before. Therefore, the researchers modified the method to give three nanoparticle monolayers. Even so, the CVD diamond was non-uniform.

Finally, the researchers applied a thin silicon dioxide (SiO_2) layer to the Ga_2O_3 through plasma-enhanced CVD. SiO_2 is less subject to decomposition under hydrogen plasma than Ga_2O_3. This allowed the use of a single monolayer of polymer-assisted nanoparticles to be used as seed.

The team describes the resultant uniformity of the diamond film as "excellent" (Figure 1). The layer thicknesses were 19nm SiO_2 and 260nm diamond. A diamond layer grown on 100nm SiO_2 reached 930nm thickness — the average grain size was ~400nm. The grain size for the thinner film was ~130nm.

The team comments: "Adding a dielectric layer prevents substrate etching and improves diamond adhesion onto the surface. Also, thicker diamond growth becomes possible due to reduction in the diamond film residual stress by lowering the CTE mismatch between the diamond and the dielectric layers. "

Time- and frequency-domain thermoreflectance (TDTR and FDTR) were used to characterize the thermal conductivity and boundary resistance. Thermoreflectance involves detection of acoustic waves generated by pulsed laser radiation. The resulting response is analyzed to extract the thermal properties of material structures. For example, TDTR studies with an 82nm gold layer as transducer between 1.2MHz laser pulses and the acoustic waves were used to extract thermal conductivities. FDTR across the range 10kHz–20MHz enabled the boundary resistance to be derived, using the TDTR thermal conductivities as part of the input. These FDTR resistances were found to be more precise than estimates derived using just TDTR.

The direction-averaged thermal conductivity of the ~260nm diamond film was estimated at ~110W/m-K. The thermal boundary resistance (TBR) was derived using both TDTR and FDTR (Figure 2). The SiO_2 layer accounted for about three-quarters of the thermal boundary resistance of ~30m^2K/GW. The researchers add: "The rest of the TBR is thought to mainly originate from the diamond nucleation region defects and the interface roughness." ■

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Author: Mike Cooke

Routes to stacked III–V RF on silicon logic

Researchers claim highest frequency performance so far for devices aimed at three-dimensional integration on silicon with gate lengths above 100nm.

Researchers based in Korea claim the highest cut-off and maximum oscillation frequencies reported for RF transistors with gate lengths longer than 100nm aimed at monolithic 3D (M3D) integration with silicon circuitry [Jaeyong Jeong et al, IEEE Transactions on Electron Devices, vol 68 , issue 5, (May 2021) p2205].

The team from KAIST (formerly the Korea Advanced Institute of Science and Technology), Korea Advanced Nano Fab Center (KANC) and Gwangju Institute of Science and Technology ensured that the fabrication processing temperature was below 250°C with a view "to minimize the thermal budget for the bottom interconnects and bottom silicon devices".

The researchers see the combination of high-speed III–V materials with silicon circuitry as providing a route to mixed-signal radio-frequency analog and digital logic capabilities in the millimeter-wavelength range.

The III–V material was grown on indium phosphide (InP) substrates by molecular beam epitaxy (MBE) — see Figure 1. The channel region was an indium arsenide

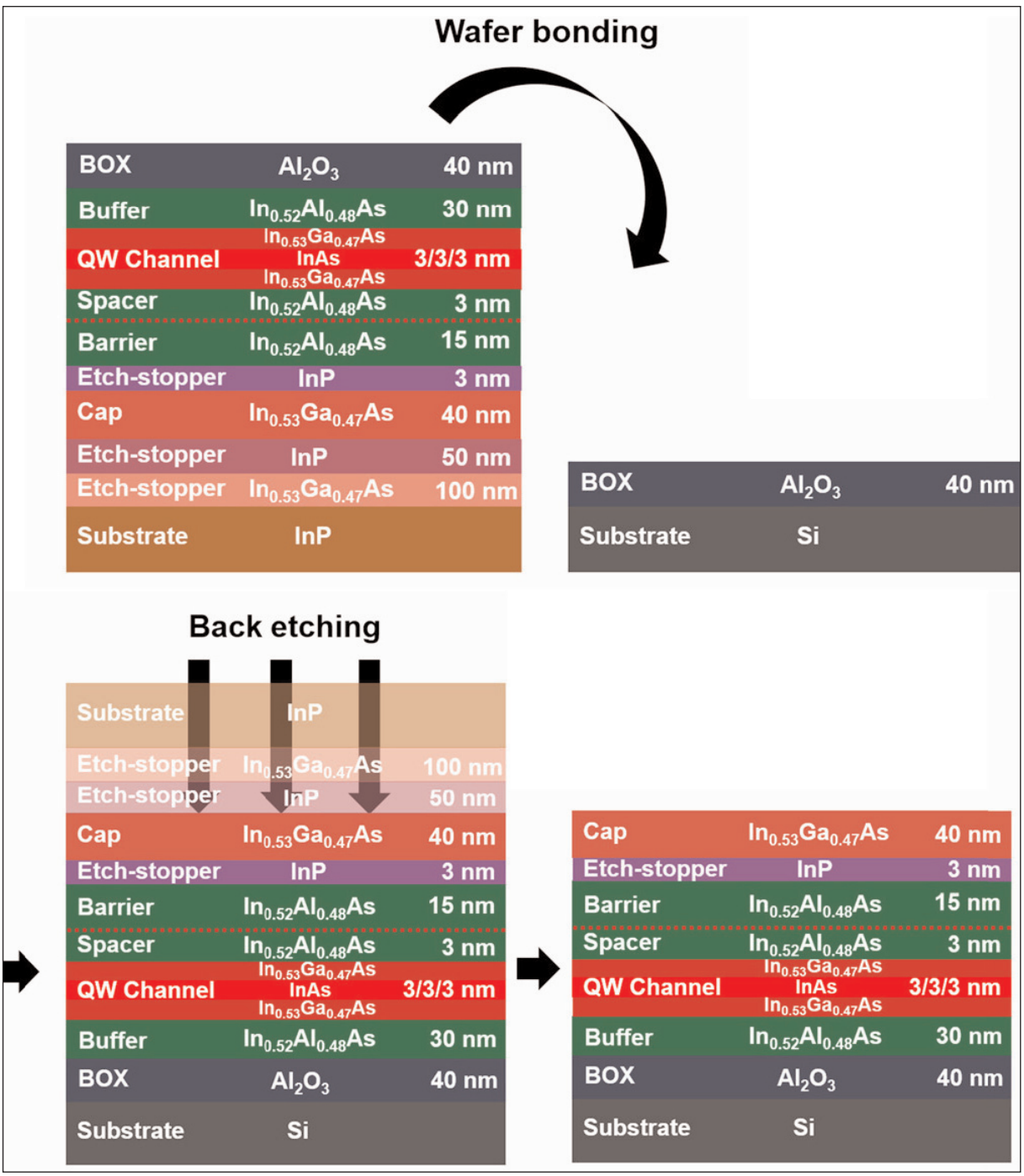

Figure 1. Fabrication process of InGaAs HEMT/Al_2O_3 BOX/Si structure.

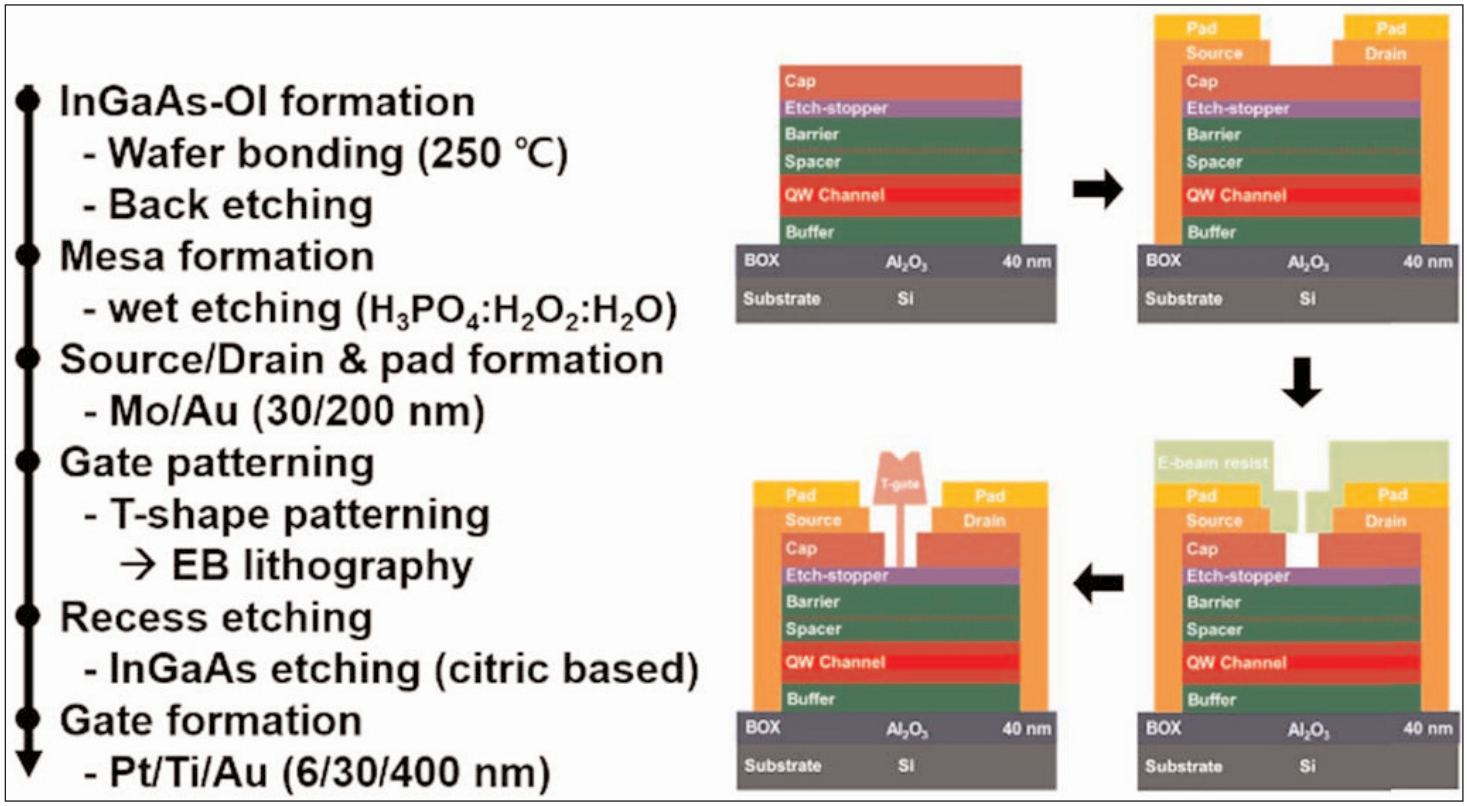

Figure 2. Process flow of InGaAs–OI HEMTs on silicon.

(InAs) quantum well in indium gallium arsenide (InGaAs) barriers. This resulted in 25μm gate-length (L_G) 'long-channel' transistors achieving an effective mobility of 7950cm^2/V-s, compared with 5550cm^2/V-s for similar transistors using an InGaAs channel.

The material was flipped and wafer-bonded to silicon, using 250°C atomic layer deposition (ALD) aluminium oxide (Al_2O_3) as the bonding layer and buried oxide (BOX). The bonding consisted of oxygen plasma activation and bonding at 200°C in vacuum. The InP growth substrate and etch stop layers were removed with various acidic mixtures, giving an InGaAs-on-insulator (InGaAs–OI) wafer.

Transistor fabrication (Figure 2) began with mesa etching with a

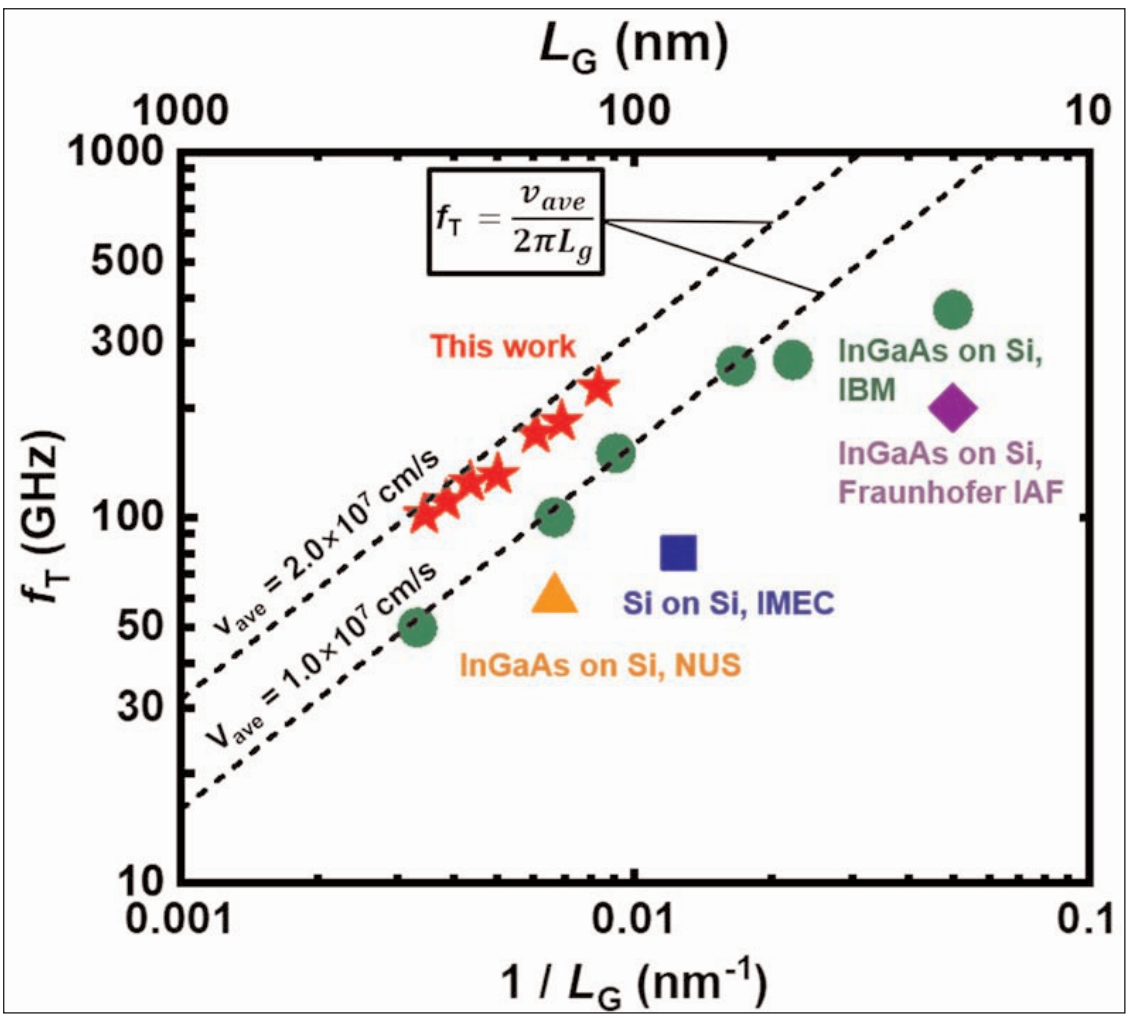

Figure 3. Benchmarks of III–V transistors on silicon, and silicon transistors on silicon, for M3D RF applications: f_T versus 1/LG.

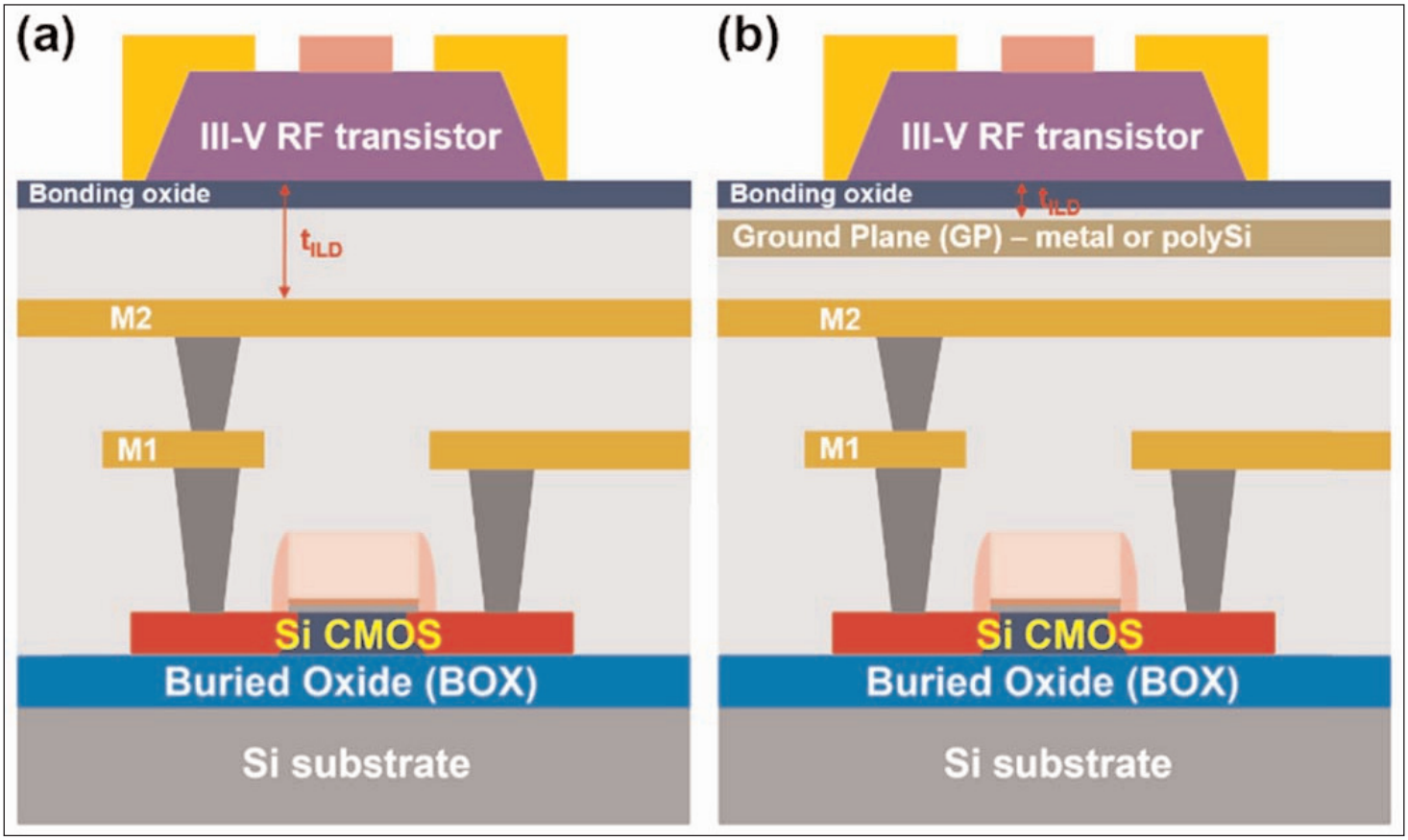

Figure 4. Schematic of simulated III–V transistor on silicon CMOS for M3D integrated RF applications (a) without ground plane and (b) with ground plane.

phosphoric acid, hydrogen peroxide and water mixture. Ohmic contacts of non-alloyed molybdenum/gold were used for the source/drain. T-shaped gates with a L_G of 125nm were formed through lithography, citric acid gate recess etch, and electron-beam evaporation of platinum/titanium/gold. The T-head was 400nm wide. The source–drain distance was 1.7μm. The process temperature was limited to less than 250°C.

The subthreshold swing of the 125nm L_G 'short-channel' device was 63.7mV/decade and 62.1mV/decade at drain biases of 0.05V and 0.5V, respectively. These values are close to the ~60mV/decade theoretical limit. The corresponding on/off current ratios were 10^5 and 10^6. The peak transconductance and maximum drain current were 0.5S/mm and 650mA/mm, respectively.

The gate leakage was less than 10nA/μm, due mainly to "the thick $In_{0.52}Al_{0.48}As$ barrier (15nm) and spacer (3nm)", according to the researchers. They add: "This low gate-leakage current is the essential figure-of-merit for developing analog applications such as low-noise amplifiers (LNAs) in terms of noise and power consumption."

The source resistance was estimated at a relatively high 475.5Ω-μm. The researchers believe that around 78% of this can be traced to the thick barrier layer, which they hope to reduce in future work.

The frequency performance was characterized using measurements in the 1–40GHz range. The effect of parasitic elements was estimated using suitable test structures, and corrected to give 'de-embedded' results of 227GHz for the cut-off (f_T) and 187GHz for the maximum oscillation (f_{MAX}).

The researchers comment: "To the best of our knowledge, these values are the highest ever reported in the M3D RF transistors at given LG above 100nm."

The relatively low f_{MAX} was attributed to a large parasitic gate resistance. The team comments: "The f_{MAX} of our InGaAs–OI HEMTs on Si can be further improved through tuning of the T-shape gate structure and optimized post-annealing process."

The researchers also looked at the performance of other groups reported in the scientific literature (Figure 3). The team expects to be able to improve on the present results through various techniques to boost RF performance.

The team also performed simulations on III–V devices stacked over silicon circuitry (Figure 4). The researchers were particularly concerned about back-gate effects from bottom device electrodes and metal lines, particularly when a ground plane is used to reduce crosstalk between the top tier and bottom tier. These back-gate effects were found to severely impact RF performance, but were ameliorated by using thicker interlayer dielectric (ILD) layers, reducing parasitic capacitance. ■

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III–V resonant tunneling for ULTRARAM

Researchers target high-speed, efficient, random-access, non-volatile 'universal memory'

UK-based researchers report the first tests of an 'ULTRARAM' III-V memory that incorporates quantum resonant tunneling as part of its operation "to achieve non-volatility at extremely low switching energy per unit area" [D. Lane et al, IEEE Transactions on Electron Devices, vol 68 (2021), issue 5 (25 March), p2271].

The team from Lancaster University, University of Liverpool and University of Warwick hopes that the technology could form the basis for a 'universal memory', combining the speed and random-access advantages of dynamic random access memory (DRAM) and the non-volatility of Flash. The universal-memory dream is discounted by most researchers as being "unfeasible or almost impossible".

The UK team believes that the "unusual band offsets" of the '6.1Å' lattice-spacing family of high-mobility III–V materials — indium arsenide (InAs), aluminium antimonide (AlSb) and gallium antimonide (GaSb) — offer hope in this regard. The researchers write: "In particular, the extraordinarily large conduction-band offset of InAs/AlSb (2.1eV) delivers electron barriers akin to those of dielectrics to achieve non-volatility."

The material structure for the ULTRARAM was grown on 2-inch heavily doped n-type GaAs substrates, using molecular beam epitaxy (MBE). The lattice mismatch between GaSb and GaAs is 7.8%. An interfacial misfit array between the GaAs and GaSb buffer was used to mitigate the problems that can arise from the relatively large difference in lattice parameter. The active part of the memory element was provided by GaSb/InAs/AlSb layers.

The triple-barrier resonant tunneling (TBRT) structure consisted of alternating InAs/AlSb layers. The InAs/AlSb provides a 2.1eV barrier to charge leakage from the InAs floating gate (FG) structure at low bias. However, the resonant tunneling allows electrons to enter and leave the FG easily with an applied bias of about 2.5V. This voltage is about a factor of ten lower than that needed in Flash memory program/erase operations.

The fabrication used a combination of alternative inductively coupled plasma (ICP) and selective wet etching. The plasma etch was controlled using in-situ reflectance measurements. The plasma source gases were boron trichloride, chlorine and argon. The wet etching variously used tetramethylammonium hydroxide (AlSb and GaSb) and a citric acid/hydrogen peroxide solution in water (InAs).

The drain/back gate/drain (D/BG/D) and source (S) contacts were sputtered titanium/gold. The control gate (CG) stack consisted of atomic layer deposition (ALD) aluminium oxide (Al_2O_3) and the CG metal. The Al_2O_3 was used to reduce current flow during operation, which adversely impacts device efficiency. The Al_2O_3 presents a 3.1eV barrier to charge leakage from the InAs floating gate. Passivation was provided by plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide (SiO_2).

Buffered oxide etching was used to reveal the various contacts and then titanium/gold pads were applied. The metallization also included the formation of word-lines connecting the CGs and bit-lines linking the S-terminals.

The gate length of the devices was 20μm. The devices were fabricated in 2x2 arrays. The program (P) and erase (E) cycles, at –2.5V and +2.5V, respectively, lasted 500μs. The team comments: "Such a P/E cycle corresponds to a 10^2 and 10^3 reduction in switching energy per unit area compared to DRAM and NAND flash, respectively."

The P/E cycle was 2000x faster than the group's pre-

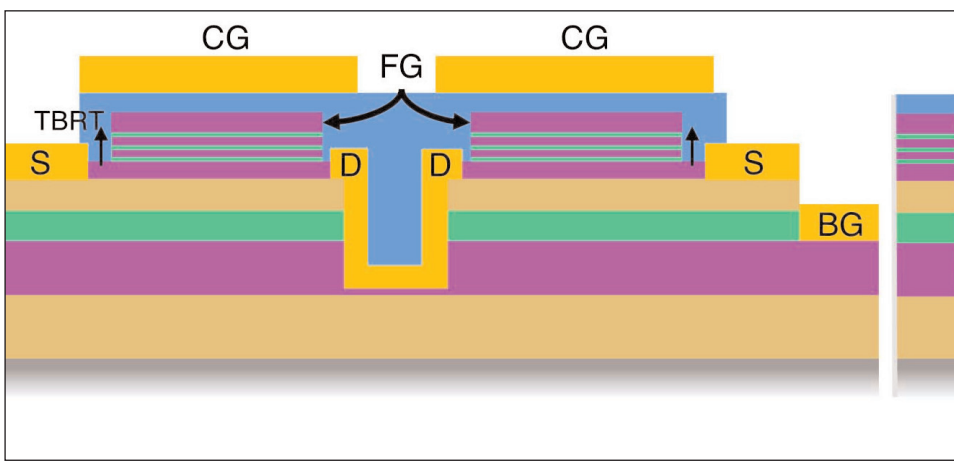


Figure 1. Left: cross-sectional schematic of ULTRARAM and material layers. Right: dark-field transmission electron microscope image of epitaxial structure.

vious devices. The researchers suggest that smaller devices with gate lengths of the order of 20nm could perform at sub-nanosecond rates: "significantly faster than DRAM and comparable to static RAM (SRAM)". However, this would need to be confirmed in actual devices, rather than through assuming ideal scaling.

It was found that the 2.5V P/E biasing could be applied in various ways, e.g. grounding the word-line while biasing the bit-line, or applying opposite 1.25V biases to the word- and bit-lines.

The current flow contrast between the 1 and 0 states is presently a concern if 1000s of cells were to be connected to the bit-line. The relatively small difference was attributed to the use of n-InAs as the channel, which tends to be 'normally-ON', and the 'OFF' state is achieved with partial depletion of the channel by charges in the floating gate structure. The team reports: "Work is ongoing to incorporate the normally-OFF InGaAs channel design described in our previous work to address this issue."

Reliability studies carried out on one memory element showed stable current contrast between the states over $8x10^5$ readout cycles, involving 0.5V SD bias. In a test with 10^6 5ms P/E switching cycles performed at a rate of 200/minute, the 0/1 contrast was successfully maintained (Figure 2).

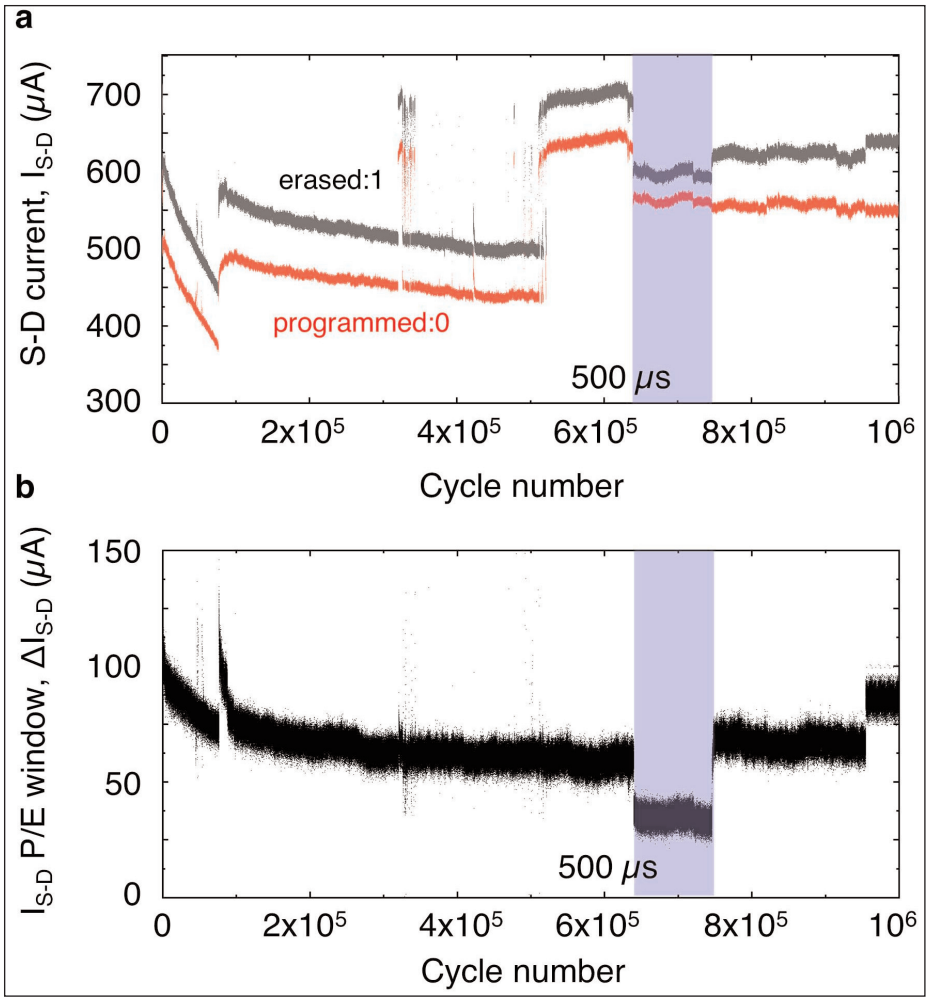
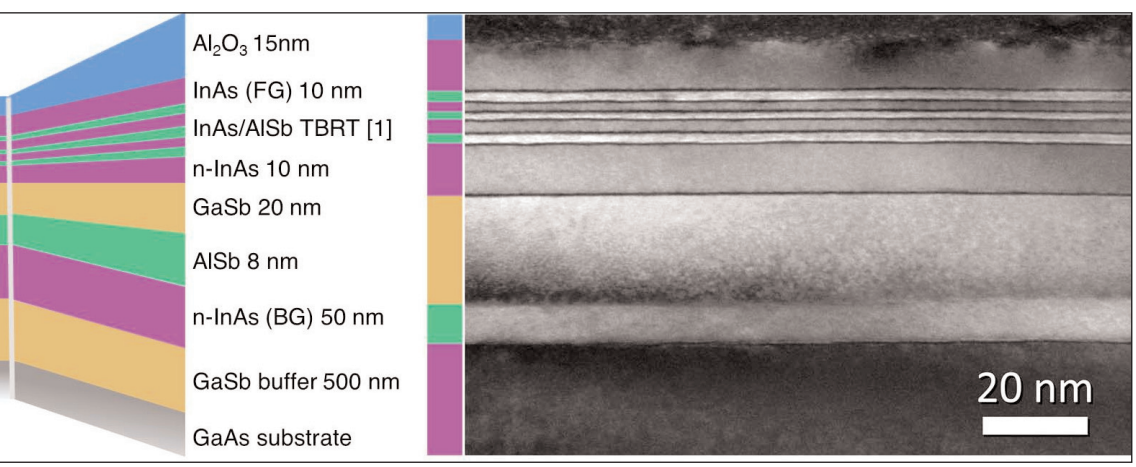


Figure 2. Memory cell endurance data: (a) S-D current after +2.5V erase cycle (gray), and −2.5V program cycle (red). Pulse duration 5ms, except for blue shaded region where 500µs pulse duration was used. (b) S-D current difference calculated by subtracting erase and program current from consecutive cycles.

Shorter P/E cycles (500µs) suffered from reduced contrast (blue-shaded region in Figure 2), the problem being resistance-capacitance (RC) delays rather than the extremely fast tunneling mechanism. The delay means that the bias does not reach the desired 2.5V within the shortened cycle. Presumably, reduced feature sizes would speed up the devices through reducing parasitic capacitance.

"In this first-ever test, endurance is at least an order of magnitude higher than flash memory," says the team.

The researchers are not sure of the cause of shifts of the 0/1 window within the time-span of the test. They suggest it could be due to "an inconsistent channel contact that is sensitive to temperature or vibrations". Visual evidence for this hypothesis came in the form of atomic force microscopy (AFM) scans showing etch pits in the channel surface, which could create inconsistent contacts. The team reports: "An ICP etch process to create a smooth surface for consistent contact to the thin (10nm) channel material is currently being developed in response." ■



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Germany
Tel: +49 3731 280 0
Fax: +49 3731 280 106
www.fcm-germany.com

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

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

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

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

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

III/V-Reclaim
Wald 10, 84568 Pleiskirchen,
Germany
Tel: +49 8728 911 093
Fax: +49 8728 911 156
www.35reclaim.de

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

Wafer Technology Ltd
34 Maryland Road, Tongwell,
Milton Keynes, Bucks, MK15 8HJ, UK
Tel: +44 (0)1908 210444
Fax: +44 (0)1908 210443
www.wafertech.co.uk

Wafer Technology Ltd is a UK based producer of III-V materials and epitaxy-ready substrates offering the widest product range in the business.

Wafer World Inc
1100 Technology Place, Suite 104,
West Palm Beach,
FL 33407,
USA
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Fax: +1-561-842-2677
www.waferworld.com

4 Epiwafer foundry

Albemarle Cambridge Chemical Ltd
Unit 5 Chesterton Mills,
French's Road, Cambridge CB4 3NP,
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.camchem.co.uk

Intelligent Epitaxy Technology Inc
1250 E Collins Blvd,
Richardson, TX 75081-2401,
USA
Tel: +1 972 234 0068
Fax: +1 972 234 0069
www.intelliepi.com

IQE
Cypress Drive,
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Cardiff
CF3 0EG, UK
Tel: +44 29 2083 9400
Fax: +44 29 2083 9401
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IQE is a leading global supplier of advanced epiwafers, with products covering a diverse range of applications within the wireless, optoelectronic, photovoltaic and electronic markets.

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France
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Fax: +33 1 45 10 69 53
www.ommic.fr

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Chemin des Franques, 38190
Bernin, France
Tel: +33 (0)4 76 92 75 000
www.soitec.com

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Quebec H9R 6A8, Canada
Tel: +1 925 980 5645
Fax: +1 514 630 0227
www.thefoxgroupinc.com

VIGO SYSTEM S.A.
ul. Poznanska 129 /133, 05-850
Ozarów Mazowiecki, Poland
Tel: +48 22 733 54 10
E-mail: ent@vigo.com.pl
ent-epitaxy.com

www.vigo.com.pl www.ent-epitaxy.com

VIGO System's Epitaxy Division produces high-grade III–V compound semiconductor epitaxial structures for photonic and microelectronic devices. With more than 35 years' experience, the division offers a broad range of epi-wafers, both in large volumes and small customised batches. It focuses on innovative products for wireless, TC, sensing or printing applications.

5 Deposition materials

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

Matheson Tri-Gas
6775 Central Avenue,
Newark, CA 94560,
USA
Tel: +1 510 793 2559
Fax: +1 510 790 6241
www.mathesontrigas.com

Nouryon Functional Chemicals B.V.
Zutphenseweg 10, 7418 AJ
Deventer,
The Netherlands
Tel. +31 652 478554
https://hpmo.nouryon.com

Praxair Electronics
542 Route 303,
Orangeburg,
NY 10962,
USA
Tel: +1 845 398 8242
Fax: +1 845 398 8304
www.praxair.com/electronics

Vital Thin Film Materials (Guangdong) Co Ltd (Vital Materials subsidiary)
18G, 18th Floor, Shenzhen Free Trade Centre, No.111 Taizi Road,
Nanshan District,
Shenzhen, Guangdong, China 518067
Tel: (+86) 0755-21651348
sales@vitaltfm.com
www.vitaltfm.com
Vital Materials is the world's leading producer of rare metals as well as the first Chinese manufacturer to deliver G11 rotary ITO target. Vital is also one of the world's three major supplier of infrared materials, a key supplier of compound semiconductor substrates, and a strategic partner of the world's largest thin film solar manufacturer.

6 Deposition equipment

AIXTRON SE
Dornkaulstr. 2,
52134 Herzogenrath,
Germany
Tel: +49 2407 9030 0
Fax: +49 2407 9030 40
www.aixtron.com

ETC (LPE subsidiary)
Via Falzarego, 820021 Baranzate (Mi),
Italy
Tel: +39 02 383 41 51
Fax: +39 02 383 06 118
www.lpe-epi.com

Evatec AG
Hauptstrasse 1a,
CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

FHR Anlagenbau Gmbh (Vital Materials subsidiary)
Am Hügel 2, D-01458
Ottendorf-Okrilla,
Germany
Tel: +49 35205 520-0
E-mail: sales@fhr.de
E-mail: sales@vitalchem.com
www.fhr.biz
Vital Materials is the world's leading producer of rare metals as well as the first Chinese manufacturer to deliver G11 rotary ITO target. Vital is also one of the world's three major supplier of infrared materials, a key supplier of compound semiconductor substrates, and a strategic partner of the world's largest thin film solar manufacturer.

LPE S.p.A.
Via Falzarego, 8
20021 Baranzate (Mi), Italy
Tel: +39 02 383 41 51
Fax: +39 02 383 06 118
www.lpe-epi.com

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

Plasma-Therm LLC
10050 16th Street North,
St. Petersburg, FL 33716,
USA
Tel: +1 727 577 4999
Fax: +1 727 577 7035
www.plasmatherm.com

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31 rue Casimir Périer, BP 70083,
95873 Bezons Cedex,
France
Tel: +33 (0) 1 39 96 65 00
Fax: +33 (0) 1 39 47 45 62
www.riber.com

SVT Associates Inc
7620 Executive Drive,
Eden Prairie, MN 55344, USA
Tel: +1 952 934 2100
Fax: +1 952 934 2737
www.svta.com

Temescal, a division of Ferrotec
4569-C Las Positas Rd,
Livermore, CA 94551, USA
Tel: +1 925 245 5817
Fax: +1 925 449-4096
www.temescal.net

Veeco Instruments Inc
100 Sunnyside Blvd.,
Woodbury, NY 11797, USA
Tel: +1 516 677 0200
Fax: +1 516 714 1231
www.veeco.com

7 Wafer processing materials

Kayaku Advanced Materials Inc
200 Flanders Road,
Westborough, MA 01581, USA
Tel: +1 617 965 5511
www.kayakuam.com

Praxair Electronics
(see section 5 for full contact details)

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

8 Wafer processing equipment

Evatec AG
Hauptstrasse 1a, CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

EV Group
DI Erich Thallner Strasse 1,
St. Florian/Inn, 4782,
Austria
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Fax: +43 7712 5311 4600
www.EVGroup.com

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

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

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

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

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

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

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

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

9 Materials & metals

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

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

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

10 Gas and liquid handling equipment

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

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Ismaning, 85737,
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Fax: +49 89 96 2400122
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Fax: +1 978 436 6735
www.entegris.com

IEM Technologies Ltd
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Bridgwater, Somerset TA6 5JJ, UK
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Fax: +44 (0)1278 420666
www.iemtec.com

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

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

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

11 Process monitoring and control

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

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

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

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

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

12 Inspection equipment

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

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

13 Characterization equipment

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

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

14 Chip test equipment

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

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

15 Assembly/packaging materials

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

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

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

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

16 Assembly/packaging equipment

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

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

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

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

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

17 Assembly/packaging foundry

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

18 Chip foundry

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

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

19 Facility equipment

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

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

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20 Facility consumables

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

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

21 Computer hardware & software

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

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

22 Used equipment

Brumley South Inc
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Fax: +1 770 808 8308
www.ClassOneEquipment.com

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1484 Highland Avenue,
Cheshire, CT 06410,
USA
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Fax: +1 203-250-7389
www.riff-co.com

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

24 Resources

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

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

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

event calendar

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

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

22–25 July 2021 (postponed from 22–25 July 2020 then 12–15 March 2021)
International Congress on Advanced Materials Sciences & Engineering (AMSE)
Vienna, Austria
E-mail: eve@istci.org
www.istci.org/amse2021

1–5 August 2021
SPIE Optics + Photonics 2021 — Conference and Exhibition
San Diego Convention Center, San Diego, CA, USA
E-mail: customerservice@spie.org
www.spie.org/opstm

24–26 August 2021 (postponed from 9–11 February 2021, then 22–24 June 2021)
Strategies in Light 2021
~~Santa Clara, CA, USA~~ — now a virtual, online event
E-mail: registration@endeavorb2b.com
www.strategiesinlight.com

1–3 September 2021
CIOE 2021:
23rd China International Optoelectronic Exposition
Shenzhen World Exhibition & Convention Centre, China
E-mail: cioe@cioe.cn
www.cioe.cn/en

~~**8–10 September 2021**~~
(postponed to December 2021 or January 2022)
SEMICON Taiwan
Taipei Nangang Exhibition Center, Taipei City, Taiwan
E-mail: semicontaiwan@semi.org
www.semicontaiwan.org/en

~~**12–17 September 2021**~~ **(postponed to 2022)**
19th International Conference on Silicon Carbide and Related Materials (ICSCRM 2021-2022)
Davos, Switzerland
E-mail: info@icscrm2021.org
www.icscrm2021.org

13–15 September 2021
ECOC 2021 (47th European Conference on Optical Communication)
Bordeaux Exhibition Centre, Bordeaux, France
E-mail: sales@ecocexhibition.com
www.ecocexhibition.com/ecoc-exhibition-2021

advertisers' index

22–24 September 2021
LASER World of PHOTONICS INDIA 2021
Bengaluru, India
E-mail: info@world-of-photonics-india.com
www.world-of-photonics-india.com

10–14 October 2021
27th International Semiconductor Laser Conference (ISLC 2021)
Potsdam, Germany
E-mail: islc@fbh-berlin.de
www.islc2021.org

~~**10–15 October 2021**~~
(postponed to 13–18 February 2022)
24th European Microwave Week (EuMW 2021)
ExCel, London, UK
E-mail: eumwreg@itnint.com
www.eumweek.com

17–21 October 2021 (postponed to Fall 2022)
4th International Workshop on Gallium Oxide and Related Materials (IWGO 2021)
Nagano, Japan
E-mail: secretary@iwgo2021.org
www.iwgo2021.org

24–28 October 2021
(postponed from 13–17 September 2020)
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

7–9 November 2021
8th IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA 2021)
Crowne Plaza Redondo Beach and Marina,
Redondo Beach, CA, USA
www.wipda.org

16–19 November 2021
SEMICON Europa 2021 (co-located with productronica)
Messe München, Munich, Germany
E-mail: semiconeuropa@semi.org
www.semiconeuropa.org

11–15 December 2021
67th IEEE International Electron Devices Meeting (IEDM 2021)
Hilton San Francisco Union Square Hotel, CA USA
Deadlines: paper submission, 23 July;
late news papers, 30 August
E-mail: info@ieee-iedm.org
www.ieee-iedm.org

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

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

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

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

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

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

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

17–22 September 2023
26th European Microwave Week (EuMW 2023)
Berlin Messe, Germany
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