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COMPOUNDS & ADVANCED SILICON

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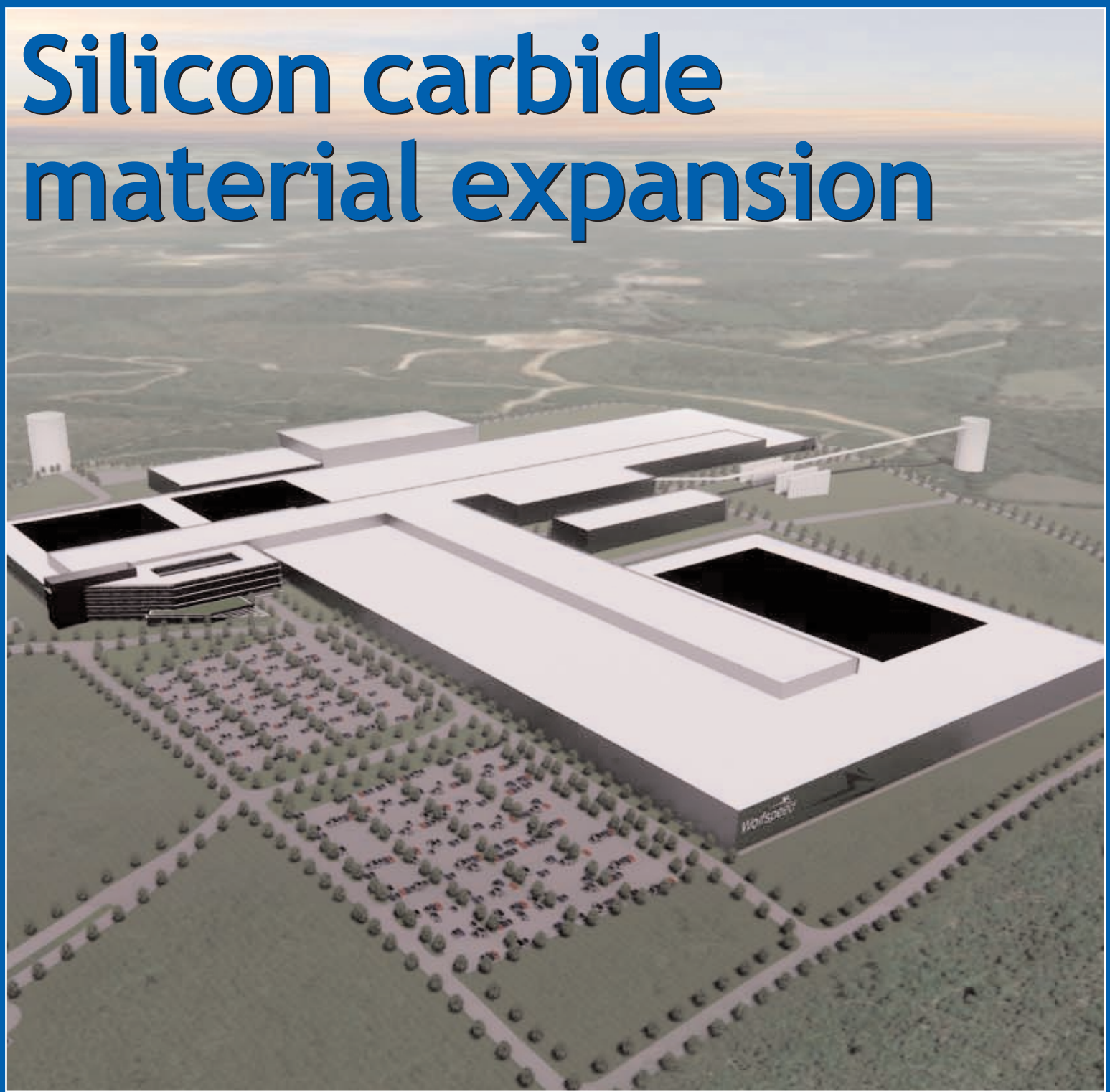
Silicon carbide material expansion



Aixtron launches 200mm SiC CVD system • News from ECOC
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p13 US-based power semiconductor IC supplier onsemi has inaugurated its expanded SiC fab in the Czech Republic.

p39 Australia's BluGlass says that its new Silicon Valley GaN laser fab is now contributing to its technical roadmaps.

Cover: Wolfspeed is to build a new multi-billion-dollar materials manufacturing facility in Chatham County, North Carolina, near its existing Durham factory that should boost its silicon carbide production capacity in Durham more than tenfold. **p12**

editorial

Expanding SiC substrate & epi growth

Amidst COVID-19 and trade and geopolitical disruption to supply chains and production throughput, silicon chip makers have been scrambling to develop alternative sources of supply and to expand or establish onshore manufacturing. Much of this has been for ICs going into communications networking equipment, consumer electronics or automotive electronics.

However, longer term, silicon carbide (SiC) is one of the fastest-growing sectors that may present a more vital demand, for the increasingly urgent need for energy conservation, specifically for use in more efficient power conversion electronics in electric vehicles, for example. Strategy Analytics forecasts the market for SiC power semiconductors will continue to rise at a compound annual average growth rate (CAAGR) of 39% until 2026, and reach $8.3bn in 2029, overtaking revenue for silicon power semiconductors.

SiC device makers have hence been expanding their capacities. For example, in April, Wolfspeed of Durham, NC, USA opened the world's first 200mm-wafer SiC device fab (Mohawk Valley Fab) in Marcy, NY.

But critical to the supply chain are SiC substrates and epitaxial wafers, of which there are few suppliers in the formerly niche semiconductor industry sector of silicon carbide, concentrated in specific geographical areas.

Wolfspeed (formerly Cree, stemming from North Carolina State University) has the security of vertical integration, as a pioneering supplier of SiC wafers. In early September, it said it will boost its SiC materials capacity in Durham more than 10-fold by building a multi-billion-dollar new factory in nearby Chatham County, NC (page 12), producing mainly 200mm wafers. The $1.3bn Phase 1 construction should be completed in 2024. This adds to a 30-fold SiC materials expansion in Durham being completed this year.

Seeking similar vertical integration and security of supply, Japan-based epiwafer maker Showa Denko in March started in-house mass production of its own 150mm substrates (stemming from its takeover in 2018 of the SiC-related assets of Nippon Steel), supplementing its merchant suppliers.

Also in March, as part of its $1bn investment in SiC over 10 years, vertically integrated II-VI Inc (now Coherent Inc) said it was accelerating its investment in 150–200mm SiC substrate and epi manufacturing via expansions in Easton, PA, USA, and Kista, Sweden (formerly Ascatron AB until 2020), supplying both merchant markets and its own SiC power device & module manufacturing (based on technology licensed from GE in mid-2020).

Likewise, after inaugurating its new SiC facility in Hudson, NH in mid-August (boosting the firm's SiC boule production capacity by five-fold year-on-year), in late September power semiconductor IC maker onsemi of Phoenix, AZ, USA opened a new, larger building at its site in Roznov, Czech Republic that will enable (by the end of 2024) a 16-fold expansion of its SiC wafer and epi production there (see page 13), which was originally added to the site's existing silicon polished wafer and epiwafer and die manufacturing there in 2019.

Most recently, on 5 October, STMicroelectronics said it is investing €730m over five years to build a SiC substrate & epiwafer plant in Catania, Italy (starting with 150mm wafers in 2023, while it develops 200mm) — see next issue for details. Establishing its own manufacturing will "enable a balanced supply of SiC substrate between internal and merchant supply" as it supports the "increasing demand from customers for SiC devices across automotive and industrial applications as they transition to electrification and seek higher efficiency".

With such booming demand driving a transition from 150mm to 200mm SiC, it is no surprise that Aixtron has just launched its new CVD system for high-volume manufacturing of power devices on 150/200mm SiC (see page 26).

Mark Telford, Editor

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

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- feature articles (technology, markets, regional profiles);
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- event calendar and event previews;
- suppliers' directory.

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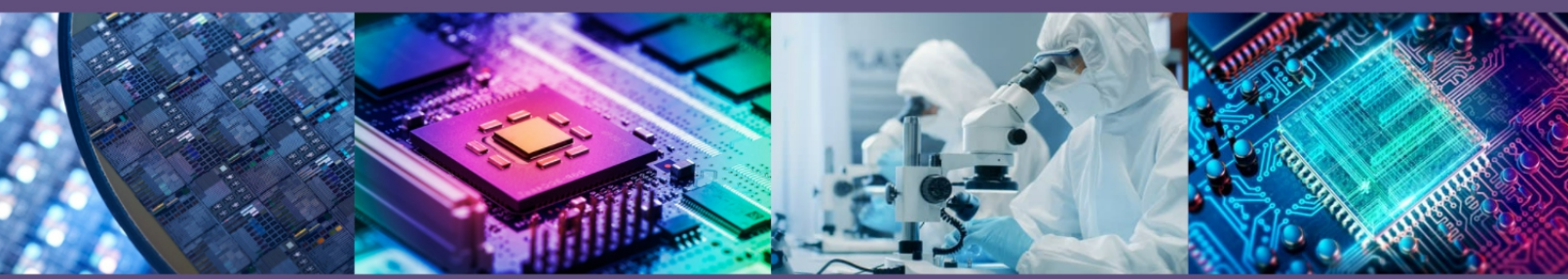

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news

RF GaAs device revenue declining in 2022 with softening of handset demand due to inflation, trade sanctions, supply chain issues and global economic uncertainty

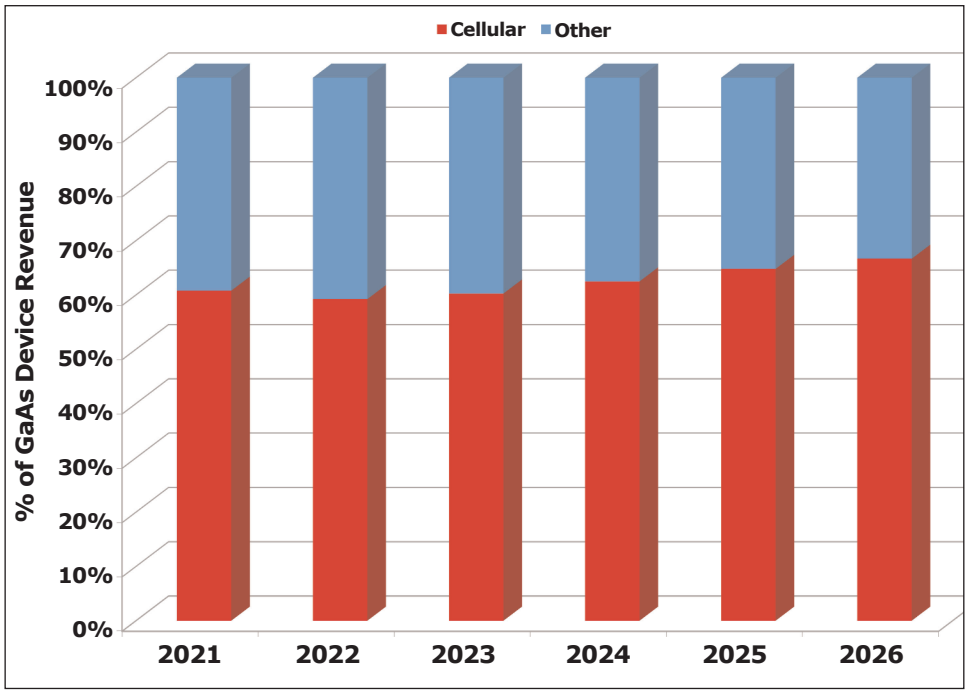
Rebound expected beyond 2022 as inflation subsides and global economies get back to growth

After turning the tide in 2020 from the first decline in over a decade, revenue for RF gallium arsenide (GaAs) devices continued its upward trajectory in 2021, summarizes the 'RF GaAs Device Technology and Market Forecast: 2021 – 2026' from Strategy Analytics Advanced Semiconductor Applications (ASA).

The report identifies 5G devices and networks as the primary reason for this growth, but it also points out some trouble on the horizon, forecasting that revenue will decline in 2022 as inflation, trade sanctions, supply chain issues and global economic uncertainty prove too much to overcome.

Beyond 2022 however, growth will resume, with RF GaAs device revenue approaching $9.3bn by 2026. Wider deployment of 5G handsets and networks will be the growth engine for future RF GaAs device revenue growth.

"The RF GaAs device market has been pretty impervious to the forces affecting global economies the past few years," notes Eric Higham, director of the Advanced Semiconductor Applications (ASA) and Advanced Defense System (ADS) service. "GaAs device revenue ties so strongly to the cellular market, and the uptake of 5G with more RF content has powered revenue growth these past two years," he adds. "However, we now see substantial softening of handset demand in 2022 that will cause RF GaAs device revenue to drop in 2022. Fortunately, the underlying growth trends remain strong and, as inflation subsides and global economies get back to growth, RF GaAs device revenue will turn upward."



The importance of cellular applications to RF GaAs device revenue (source: Strategy Analytics, Advanced Semiconductor Applications).

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Smartphone production falls 6% in Q2 to 292 million

Distribution channel inventory adjustment plus China's pandemic controls to suppress growth in Q3

According to market research firm TrendForce, second-half 2022 smartphone production planning was quite conservative as brands gave priority to adjusting distribution channel inventory. At the same time, weak market demand worsened on the back of China's pandemic controls and brands were forced to lower their production targets. As a whole, production volume dropped by 6% in second-quarter 2022, even though volume had always grown in previous second quarters. Global output was only about 292 million units, down 5% on the same period in 2021 when a second wave of pandemic outbreaks occurred in South Asia and Southeast Asia.

As the primary vendor in Europe, Samsung was forced to carry out a series of inventory adjustments for finished products and components including large-scale promotions and suspension of component procurement due to the impact of the Russian–Ukrainian war. Thus, production volume in Q2/2022 was significantly reduced by 16.3% quarter-to-quarter to 61.8 million units. Looking to Q3, Samsung is still focusing on the adjustment of distribution channel inventory and, as the outlook remains conservative, total production in Q3 is forecasted to remain flat or trend upward marginally compared with Q2. It is worth noting that, in recent years, due to its aggressive investment in R&D and marketing of folding devices, Samsung has successfully maintained the popularity of these devices, and has also become the market leader in this segment. Samsung will account for nearly 90% of the 1.1% global smartphone market share held by folding devices in 2022.

For Apple, Q2 is a transition period as it hands off old models for new and is nominally the quarter with the lowest production performance during the year. Initial operational performance was affected in Q2 by the implementation of lockdowns in Shanghai and Kunshan which hobbled supply chain supply. The output shortfall created during the lockdown period was made up with production capacity adjustment after the lockdowns were lifted. Apple still produced 48.2 million units in Q2, ranking second in the world. Looking to Q3, the iPhone 14 Pro and Pro Max are among four new models to be upgraded to the A16 (TSMC 4nm) processor. Upgrades such as initial starting memory capacity increasing to LPDDR5 6GB and 256GB, primary camera moving up to 48 million, Face ID Design changes etc., are expected to raise starting prices. However, under pressure from rising global inflation and foreign exchange rates, Apple is expected to adopt a more cautious pricing strategy so as not to affect its sales performance.

Company	2Q22		3Q22E	
	Ranking	Market Share	Ranking	Market Share
Samsung	1	21.2%	1	21.3%
Apple	2	16.5%	2	16.8%
Oppo	3	13.3%	3	13.1%
Xiaomi	4	13.0%	3	13.1%
Vivo	5	8.8%	5	8.6%

OPPO (including Realme, OnePlus) produced 38.8 million units in Q2, down 4.2% quarter-on-quarter. Xiaomi (including Redmi, POCO, Black Shark) produced 38 million units, down 14.6%. Since Vivo (including iQoo) began to adjust its pace of production significantly in Q1/2022, it rebounded by 12.7% to 25.7 million units in Q2. Ranked third to fifth respectively, these three brands overlap significantly in sales market and product planning. In Q2/2022, China's lockdowns plus extreme weather in the Indian market affected economic performance, resulting in sluggish sales in these two major markets, which in turn affected production performance. Furthermore, the rapid rise of Honor in the Chinese market poses a considerable threat to the market share of brands such as OPPO, Xiaomi and Vivo. Honor's market share in China is estimated to surpass Xiaomi and approach OPPO and Vivo in 2022.

Looking to Q3/2022, China's economy (the primary market of OPPO, Xiaomi and Vivo) is expected to remain weak. Originally upbeat emerging markets such as India and Indonesia have also found it difficult to maintain growth due to global inflation, food crises and extreme weather. Considering the numerous negative market factors and the fact that distribution channel inventory is still to be digested, TrendForce believes that the production volume of the three aforementioned brands will be roughly in line with Q2/2022, while all showing a sharp decline of more than 10% compared with the same period last year, which is enough to herald worrying performance in peak season during second-half 2022. On the whole, the Chinese market (one of the world's three major markets) has reached a high degree of saturation and demand growth has slowed. In the future, the focus of China's three major smartphone brands will remain on expanding overseas markets, TrendForce concludes.

www.trendforce.com

Smartphone shipments to fall 6.5% in 2022, amidst global inflation and softer demand

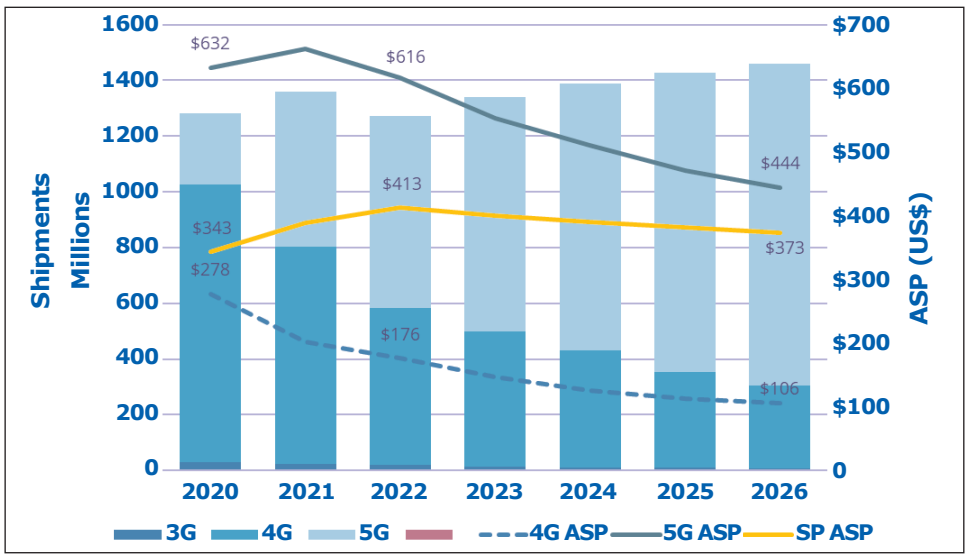
Market to rebound by 5.2% in 2023, with five-year CAGR of 1.4%

Due to record-breaking inflation, geopolitical tensions and other macroeconomic challenges that have significantly dampened consumer demand, shipments of smartphones will decline by 6.5% to 1.27 billion units in 2022, according to the latest International Data Corp (IDC) Worldwide Quarterly Mobile Phone Tracker forecast. As a result, the latest forecast figures represent a reduction of three percentage points from previous projections. However, IDC expects the setback to be short term and the market to rebound in 2023 with 5.2% growth year-over-year and, in the long term, a five-year compound annual growth rate (CAGR) of 1.4%.

"The supply constraints pulling down on the market since last year have eased and the industry has shifted to a demand-constrained market," says Nabila Popal, research director with IDC's Worldwide Mobility and Consumer Device Trackers. "High inventory in channels and low demand with no signs of immediate recovery has OEMs panicking and cutting their orders drastically for 2022. The events of the last 12 months have shaved 150 million units off the market for 2022 from our forecast in the second quarter of 2021,"she adds. "Despite the unit decline, average selling prices (ASPs) have grown 10% year-over-year in Q2 and are forecast to grow 6.3% for the full year. The premium segment ($800+) has proved resilient to the economic turmoil and has grown four percentage points in share to 16% of the total smartphone market and will continue to grow. This includes foldable devices, which is the fastest-growing segment today and expected to increase 70% year-over-year in 2022 to reach 13.5 million units shipped."

From a regional view, the economic crisis has hit emerging markets (where most of the shipment volume comes from sub-$400 devices) significantly harder. Central and Eastern Europe (CEE) is expected to be down 17.4% in 2022 and Asia/Pacific (excluding Japan and China) (APeJC, previously forecast to grow 3%) is now expected to drop by 4.5% in 2022. However, the most significant volume drop is by China, which is now forecast to decline by 12.5% or roughly 41 million units, contributing almost half of the overall reduction this year. In contrast, developed markets like North America (USA and Canada) and Western Europe are forecast to do much better in 2022. The USA will be relatively flat at 0.3% growth year-over-year, while the Canadian market will fare slightly better with 3.2% growth, and Western Europe will decline only slightly by 0.7%.

Global shipments of 5G devices should grow 23.6% year-over-year in 2022 and account for over half (54%) of all shipments with 688 million devices and an ASP of $616. In the long term, 5G is projected to reach a volume share of 79% in 2026 with an ASP of $444. In contrast, the 4G ASP will hit $176 in 2022, dropping to $106 by the end of the forecast period. As a result, the overall smartphone ASP will decline from $413 in 2022 to $373 in 2026.



IDC's 2020-2026 worldwide smartphone forecast, including shipments by air-interface generation (3G, 4G, 5G) and ASP for 4G and 5G phones.

"The resilience of the market's upper echelon has been a testament to the success of iOS, which has not witnessed a full-year shipment decline since 2019," notes Anthony Scarsella, research director with IDC's Worldwide Mobility and Consumer Device Trackers. "Despite the overall market decline, iOS shipments will remain positive in 2022 with 0.5% growth. Additionally, the operating system will display minimal growth throughout the forecast period, with ASPs hovering well above $950," he adds. "As for the world's most popular operating system, Android, 2022 will bring a near 8% decline but will rebound nicely in 2023 with 6.2% growth. Unfortunately, the low-end of the market has not fared well in 2022, as shipments of Android-based devices under $200 declined 22.4% in Q1 and 16.5% in Q2. On a positive note, devices above $1000 have displayed 35.2% growth, thanks to premium flagships and the recent success of foldable devices in the market."

www.idc.com/solutions/data-analytics/tracker/mobile

Guerrilla RF moves first SOI product into production

SOI allows expansion to switches, step attenuators, variable-gain amplifiers, cores with complex bias control

Guerrilla RF Inc (GRF) of Greensboro, NC, USA — a provider of radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless applications — has started the production phase for its new GRF6402 digital step attenuator (DSA). After sampling and receiving positive validation from its strategic customer base, the firm is now ready to move forward with mass producing its first silicon-on-insulator (SOI) product, as it marks the expansion of its existing portfolio to now include state-of-the-art silicon from one of the industry's premier semiconductor foundries.

"This marks an important milestone for Guerrilla RF as we launch an entirely new product line and technology platform," says founder & CEO Ryan Pratt. "This industry-leading SOI technology enables us to expand Guerrilla RF's catalog to include switches, step attenuators, variable-gain amplifiers, cores with complex bias control, and other similar products. We believe these new products will be key to driving accelerated growth in strategic markets like automotive telematics and 5G communications," he adds.

"The GRF6402 is a prime example of how GRF utilized SOI to address the special needs of its customer base," says Jim Ahne, VP of Automotive and 5G Products. "Our marketing, sales and engineering teams collaborated directly with select customers to define and design a drop-in-compatible DSA with a novel twist on the device's serial controller," he adds. "Our new Rapid Fire control scheme will lead to significant cost and performance enhancements for many TDD and fast-attack applications that require quick state toggling," he believes.

By employing the Rapid Fire feature, the GRF6402 will reduce overall component count, directly leading to savings in footprint and ultimately cost, says Guerrilla RF.

Samples and evaluation boards for the GRF6402 are available now.

http://guerrilla-rf.com

Guerrilla RF appoints Susan Barkal to board

RFIC & MMIC firm gains quality, operational and technical expertise

Guerrilla RF has appointed Susan Barkal to its board, which now consists of seven directors.

"Susan brings with her extensive quality, operational and technical expertise," comments CEO & founder Ryan Pratt. "Her incredible depth of experience and insight will be very beneficial to us as we continue to grow as a public company."

Barkal is currently senior VP of quality, supply chain executive, chief compliance officer, and CFIUS security officer at Yageo Corp, overseeing global quality and compliance functions for over 30,000 staff in 40 manufacturing sites as well as 20 R&D centers spanning 16 countries.

Of note, she has served as an inside board director for the KEMET/TOKIN Electronics joint venture, a $200m acquisition where she provided input and oversight of the acquisition financing strategy. Following Yageo's acquisition of KEMET Corp in 2020, Barkal was promoted to her current role.

Guerrilla RF says that, throughout her career, she has gained extensive experience in global quality and compliance as well as technology and chemical manufacturing. Barkal is an experienced executive in the technology sector with a proven track record of driving global technology roadmaps, portfolio management strategies, and new product development.

Barkal also holds a Master of Science degree in Chemical Engineering from California Polytechnic State University.

Qorvo appoints Grant Brown as chief financial officer

Former vice president of treasury transitions from interim CFO

Qorvo Inc of Greensboro, NC, USA (which provides core technologies and RF solutions for mobile, infrastructure and defense applications) has appointed Grant Brown as chief financial officer. Brown was named interim chief financial officer on 18 April, and previously served as vice president of treasury.

Grant Brown.

"Grant has broad experience and expertise leading finance teams, and he deeply understands our company and strategic vision," comments president & CEO Bob Bruggeworth. "He has been a significant contributor to Qorvo over many years, and I look forward to continuing to work with him as we drive Qorvo's growth and profitability."

www.qorvo.com

X-FAB expands IHP collaboration by licensing 130nm SiGe BiCMOS

Early-access PDK available for prototyping, prior to volume manufacturing at X-FAB France

Analog/mixed-signal, micro-electro-mechanical system (MEMS) and specialty semiconductor foundry X-FAB Silicon Foundries SE of Tessenderlo, Belgium has announced a further expansion of its long-standing partnership with German government-funded IHP — Leibniz Institute for High Performance Microelectronics of Frankfurt (Oder). As part of a new agreement, X-FAB will now license IHP's silicon germanium (SiGe) technology, so the performance benefits of this technology can be brought to high-volume customers.

Significantly strengthening the X-FAB technology portfolio, the newly created 130nm platform provides what is said to be a unique solution attaining the elevated performance parameters needed to address next-generation communication requirements. Examples of areas benefiting from the technology include Wi-Fi 6 (and future Wi-Fi 7) access points, plus next-generation cellular infrastructure (in particular 5G mmW and emerging 6G standards) and vehicle-to-vehicle (V2V) communication. This technology will also be pivotal in the development of +100GHz radar systems, it is reckoned, for use in both automotive and consumer applications.

The license agreement follows on from the collaborative work that began in 2021, where X-FAB's copper back-end was added to IHP's SG13S and SG13G2 front-end technologies to boost the bandwidth figures that could be supported. In relation to this SiGe platform, X-FAB is set to start engaging with selected early adopters on prototyping projects during fourth-quarter 2022.

An early-access process design kit (PDK) is available, enabling prototyping, while volume manufacturing will occur at X-FAB France, the company's facility near Paris.

"The incorporation of IHP's HBTs [heterojunction bipolar transistors] into X-FAB's RF platform will provide customers with a truly differentiated SiGe BiCMOS [bipolar complementary metal–oxide–semiconductor] technology that is certain to bring tangible performance benefits," believes IHP's scientific director professor Gerhard Kahmen. "The technology transfer between our two organizations is a perfect example of how industry and research institutions can work together to achieve outstanding results," he adds.

"X-FAB and IHP have a successful track record of combining our respective resources to develop advanced semiconductor solutions, and this latest SiGe announcement takes that on to a whole new exciting phase," says X-FAB's RF technology director Dr Greg U'Ren. "This is the starting point for us to make further SiGe BiCMOS-related innovations that will contribute to defining the communications sector in the years ahead, covering industrial automation, consumer and automotive use cases."

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US DoE grants $10.3m to establish first Energy Frontier Research Center in Arkansas

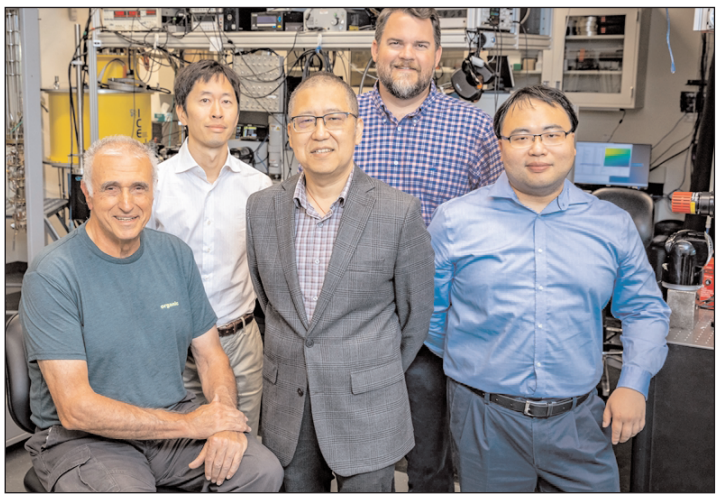
Center for Manipulation of Atomic Ordering for Manufacturing Semiconductors to investigate short-range order in alloys

A team of researchers led by Shui-Qing 'Fisher' Yu, electrical engineering professor at the University of Arkansas (U of A), is to receive a $10.35m grant from the US Department of Energy (DoE) to establish the first Energy Frontier Research Center in Arkansas.

The Center for Manipulation of Atomic Ordering for Manufacturing Semiconductors will be dedicated to investigating the formation of atomic orders in semiconductor alloys and their effects on various physical properties. The research program aims to enable reliable, cost-effective and transformative manufacturing of semiconductors.

The four-year grant is part of the DoE's $540m in research funding to universities and national laboratories focused on clean energy technologies. The ultimate goal is to create and develop low-carbon manufacturing processes that will reduce greenhouse-gas emissions.

The award is based on the multi-institutional team's recent discovery that atoms in the semiconducting alloy silicon germanium tin (SiGeSn) demonstrate a short-range order in a periodic lattice (i.e. a regular and predictable arrangement of atoms over a short distance, usually only one or two atom spacings). This discovery had a significant effect on the energy bandgap and led to the hypothesis that material properties in semiconductor alloys could be designed and fabricated by manipulating the order of atoms.



From left: Greg Salamo, Hiro Nakamura, Shui-Qing 'Fisher' Yu, Hugh Churchill and Jin Hu, of the University of Arkansas.

"We particularly thank the institutional support from U of A, which played a critical role in proposal completion and will assist center operation," Yu says.

In addition to Yu, the team comprises four colleagues in the Department of Physics — distinguished professor Greg Salamo, assistant professor Jin Hu, associate professor Hugh Churchill and assistant professor Hiro Nakamura — and several researchers at other institutions.

The U of A will lead researchers from Arizona State University, George Washington University, Stanford University, University of California Berkeley, Dartmouth College, Rensselaer Polytechnic Institute, University of Arkansas Pine Bluff, University of Delaware, and Sandia National Laboratory.

https://research.uark.edu

Altum RF showcases new products at EuMW

GaN power amplifiers and GaAs pHEMT low-noise amplifiers, linear amplifier and distributed amplifier on show

Altum RF of Eindhoven, The Netherlands (which designs high-performance RF to millimeter-wave solutions for commercial and industrial applications) showcased its technical expertise and featured products at European Microwave Week (EuMW 2022) in Milan, Italy (27–29 September).

The new gallium nitride (GaN)-based power amplifiers (PAs) and gallium arsenide (GaAs)-based pseudomorphic high-electron-mobility transistor (pHEMT) low-noise amplifiers (LNAs), linear amplifier and distributed amplifier include the following:

- ARF1009Q5: 9–11GHz GaN PA, 10W, >30dB power gain (three stages);
- ARF1020Q5: 9–11GHz GaN PA, 10W, >20dB power gain (two stages);
- ARF1208: 37–59GHz GaAs pHEMT LNA/driver, 2.5dB noise figure, 26.5dB gain, 19dBm saturated output power (P_{sat});
- ARF1207: 57–71GHz GaAs pHEMT linear amplifier, >20dB gain, 22dBm P_{sat};
- ARF1206: 71–86GHz GaAs pHEMT LNA, 22dB gain, 3.2dB noise figure at 77GHz;
- ARF1303: DC–50GHz GaAs pHEMT distributed amplifier, 22dBm P1dB.

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Wolfspeed to build largest SiC materials plant in Chatham County, North Carolina

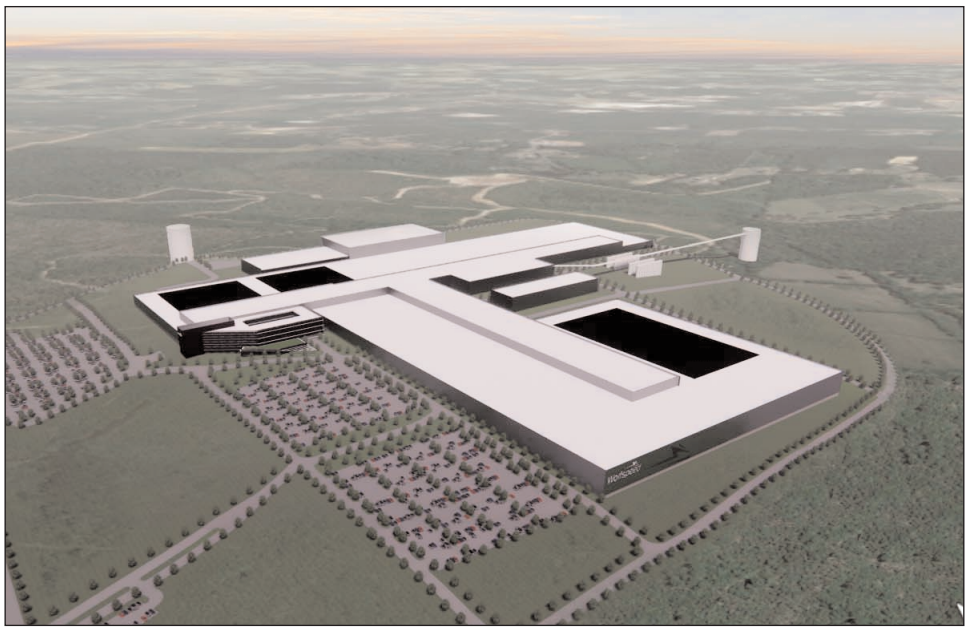
Silicon carbide manufacturing capacity to be boosted more than 10x

Wolfspeed Inc (formerly Cree Inc) of Durham, NC, USA is to build a new multi-billion-dollar materials manufacturing facility in Chatham County, North Carolina (strategically near its existing Durham materials factory). The investment should generate a more than tenfold increase from Wolfspeed's existing silicon carbide (SiC) production capacity in Durham, supporting its long-term growth strategy, accelerating the adoption of silicon carbide across a wide array of end-markets.

"Wolfspeed is the industry leader in supplying the materials required to meet the accelerating demand for next-generation semiconductors and creating a more sustainable future for all," claims Wolfspeed's president & CEO Gregg Lowe. "Demand for our products continues to grow at a rapid pace, and the industry continues to be supply constrained. Expanding our materials production will further our market leadership and allow us to better serve the growing needs of our customers," he adds. "We are particularly excited and proud to not only expand Wolfspeed's footprint in our home state of North Carolina, but also further our relationship with North Carolina Agricultural and Technical State University to nurture our best-in-class talent pool."

The facility will primarily produce 200mm silicon carbide wafers, which are 1.7x larger than 150mm wafers, translating into more chips per wafer and, ultimately, lower device costs. These wafers will be used to supply Wolfspeed's Mohawk Valley Fab, which opened in April as the world's first, largest and only fully automated 200mm silicon carbide fabrication facility.

Phase one construction should be completed in 2024 and cost about $1.3bn. Between 2024 and the end of the decade, the firm will add extra capacity as needed, eventually occupying more than 1 million square feet on the 445-acre site.



State and local funding, including a Job Development Investment Grant from the North Carolina Department of Commerce, will support the development of the facility's first phase and represents an approximately $1bn incentive package from the State, County and local governments. In addition, the firm hopes to apply for and obtain federal funding from the CHIPS and Science Act to accelerate the construction and build-out of the facility. Over the next eight years, the company intends to continue to invest, looking to create about 1800 jobs.

"Wolfspeed's decision further validates North Carolina as the epicenter of clean energy," says North Carolina Governor Roy Cooper. "This is another milestone in our drive toward a clean energy economy as it will boost electric vehicle manufacturing and offshore wind while fighting climate change."

The company's talent development strategy is complemented by its continued partnership with North Carolina Agricultural and Technical State University (N.C. A&T). In 2020, Wolfspeed committed $4m over five years to the HBCU — at the time, the single largest donation in the university's history, to create the Wolfspeed Endowed Scholars Program. The two entities aim to establish comprehensive education and training curricula and cutting-edge research and innovation programs. This partnership will open up opportunities for undergraduate and graduate credentials in silicon carbide manufacturing, as well as training and career advancement programs for existing semiconductor manufacturing workers.

"North Carolina A&T is proud to partner with Wolfspeed to provide new opportunities to pursue the next generation of careers in the green economy, drive innovation and explore new possibilities," says N.C. A&T chancellor Harold L. Martin senior. "Throughout our rich history as a doctoral, land-grant university and the largest historically Black university in the country, we have believed in the power of our students to change the world," he adds. "Our expanded partnership with Wolfspeed will allow us to change the world together."

www.wolfspeed.com

onsemi expands Czech silicon carbide wafer and epi fab

Production capacity to rise 16-fold over next two years

Power semiconductor IC supplier onsemi of Phoenix, AZ, USA has inaugurated its expanded silicon carbide (SiC) fab in Roznov, Czech Republic with a ribbon-cutting ceremony led by Ministry of Industry and Trade section chief Zbynek Pokorny, Governor of the Zlín Region Radim Holis and City Mayor Jirí Pavlica as well as other local governmental dignitaries.

Starting in 2019, onsemi added SiC polished wafer and SiC epitaxy wafer production to its existing silicon polished and epitaxy wafer and die manufacturing in Roznov. Having outgrown the original site, construction of a new building began in 2021 to further expand wafer and SiC epi manufacturing. Over the next two years, this expansion will increase the site's SiC production capabilities by 16 times and create 200 jobs by the end of 2024. So far onsemi has invested more than $150m in the Roznov site and plans to spend an additional $300m through 2023.

Ribbon-cutting ceremony for the expansion of onsemi's Roznov SiC fab.

onsemi was recently awarded the Association for Foreign Investments (AFI) Prize for Significant Contribution in the Field of Investment for its SiC investments in the Czech Republic.

"Together with our SiC boule production expansion in Hudson, NH, these increased SiC manufacturing capabilities enable onsemi to provide customers the critical supply assurance to meet the rapidly growing demand for SiC-based solutions," says Simon Keeton, executive VP & general manager Power Solutions Group at onsemi. "Full control over our SiC manufacturing supply chain and the market-leading efficiency of our products underscore onsemi's progress."

www.onsemi.com

KISAB raises €7.5m to expand production of defect-free silicon carbide wafers

Silicon carbide (SiC) material development and production company Kiselkarbid i Stockholm AB (KISAB) of Kista, Sweden has raised €7.5m in an investment round led by Fairpoint Capital, with participation from existing investors including Industrifonden, Ingka GreenTech and LPE, as the firm enters its commercialization phase.

KISAB says that its growth technology, which emanates from Linköping Technical University, enables the growth of virtually defect-free SiC wafers, free of basal plane dislocations (BPDs).

"KISAB's ability to cost-effectively grow defect-free SiC wafers will be providing power component manufacturers with a drastically improved way to increase yield and build larger components at higher voltages," comments Fairpoint Capital's investment director Hadar Cars.

"We have recently started to sample our wafers to customers and will now be able to ramp up production to help our customers produce higher-quality products at higher yields," notes KISAB's CEO & founder Johan Ekman.

Driven by the electric vehicle (EV) market, the global SiC device market is reckoned to be rising at a compound annual growth rate of 34%, but SiC applications are still limited by poor quality of the underlying wafer materials. Market analysis firm Yole Développement forecasts that the SiC device market will grow to $6.3bn in 2027, and has identified KISAB as "innovative SiC growth technology".

"KISAB will also soon be able to ship defect-free 8" SiC wafers, which will further increase its competitiveness," says Cars.

"We invested in KISAB in 2018 because of the stellar research behind the technology," comments Industrifonden's senior investment director Per Anell. "We are looking forward to continuing supporting KISAB in the next phase and welcome Fairpoint on that journey," he adds.

KISAB presented its latest developments at the 19th International Conference on Silicon Carbide and Related Materials (ICSCRM 2022) in Davos, Switzerland (11–16 September).

www.icscrm2022.org
www.kisabsemi.com

Toray and A*STAR's IME co-developing high-heat-dissipating adhesive sheets for SiC power semiconductors

Toray Industries Inc and the Institute of Microelectronics (IME) at Singapore's Agency for Science, Technology and Research (A*STAR) have begun joint research to develop practical applications for high-heat-dissipating adhesive sheets for silicon carbide (SiC) power semiconductors.

Due to their significant energy-efficiency and carbon neutrality benefits, applications of SiC power semiconductors include automobiles, smart grids, and data centers. In particular, for further energy conservation, SiC is being applied more extensively for automotive use. Compared with conventional silicon, SiC has superior heat resistance, which leads to significantly improved performance by efficiently dissipating the heat generated.

Development efforts will combine Toray's material and fabrication technologies with IME's design, prototyping and evaluation technologies. This is expected to improve the simplicity and reliability of processes for applying high-heat-dissipating adhesive sheets and to enhance semiconductor quality, dependability and safety. Toray and IME aim to provide comprehensive solutions to SiC device manufacturers and to contribute to the uptake of high-efficiency SiC power semiconductors.

Toray will promote the joint research with support from the new Toray Singapore Research Center (TSRC, a department of Toray International Singapore Pte Ltd), which opened in June.

Toray offers electro-coating materials such as Semicofine non-photosensitive polyimide and Photoneece photosensitive polyimide which employ proprietary molecular design technology as well as FALDA adhesive film. Semiconductor, electronic component and display manufacturers rely heavily on these products because of their high reliability.

Since 2016, Toray has participated in several international consortia on IME's semiconductor packaging, deepening collaboration and achieving results through joint research

Toray and IME previously collaborated to develop a robust SiC power semiconductor module that incorporates high-heat-dissipation adhesive sheets from the FALDA lineup. General heat-dissipating adhesive materials using grease and solder have a large contact thermal resistance with the cooler, resulting in failure due to inadequate cooling of the semiconductors. Toray and IME resolved these problems by applying Toray's material to create the first prototype of a new SiC power semiconductor module using a heat-dissipating adhesive sheet with a very low contact thermal resistance (lower than conventional products). Durability tests at high temperatures (to estimate the reliability and service lives of power semiconductors connections subject to heat fatigue) confirmed that the module lasted for a significantly large number of power cycles.

In the joint research, Toray and IME will continue to prototype and evaluate devices to improve the simplicity and reliability of processes to employ high-heat-dissipating adhesive sheets in the drive for commercialization.

"We have long respected IME's prowess in SiC power semiconductor design and evaluation technology," comments Yuichiro Iguchi, corporate VP of Toray's Research Division. "We're delighted to collaborate with Singapore's government agencies on such public-private R&D projects. We look forward to accelerating efforts to overcome the challenges of applying advanced heat dissipation technology to enhance energy efficiency and help drive to sustainable economic growth," he adds.

"Our mutual capabilities come together in a complementary fashion to enable the co-development of novel heat-dissipating solutions," says IME's executive director Terence Gan. "Toray's R&D presence in Singapore will also help build a stronger R&D ecosystem in this part of the world."

www.a-star.edu.sg/ime
www.electronics.toray

Toshiba launches third-generation SiC MOSFETs

Tokyo-based Toshiba Electronic Devices & Storage Corp (TDSC) — spun off from Toshiba Corp in 2017 — has launched the TWxxNxxxC series of power devices, its third-generation silicon carbide (SiC) MOSFETs, delivering low on-resistance and significantly reduced switching loss.

Specifically, on-resistance per unit area ($R_{DS(ON)}A$) is reduced by about 43% by using a device structure with a built-in Schottky barrier diode developed for the second-generation MOSFETs, and also reduces feedback capacitance in the JFET region.

This allows a reduction of about 80% in the drain–source on-resistance x gate–drain charge ($R_{DS(ON)} \times Q_{gd}$) product (representing the relationship between conduction loss and switching loss). This cuts the switching loss by about 20%, and lowers both on-resistance and switching loss. The new products hence contribute to higher equipment efficiency, says Toshiba.

Ten products, five 1200V and five 650V products, are shipping now. Applications include: switching power supplies (servers, data centers, communications equipment etc); electric vehicle charging stations; photovoltaic inverters; and uninterruptible power supplies (UPS).

https://toshiba.semicon-storage.com

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Ancora raises NT$456m from ROHM, SAS, uPI and Delta

First-round funding to accelerate GaN power device development

Fabless design company Ancora Semiconductor Inc, an affiliate of Taiwan-headquartered power supply maker Delta Electronics Inc that focuses on gallium nitride (GaN) devices and their integration, has raised NT$456m in first-round funding from strategic investors Japan-based power semiconductor maker ROHM Co Ltd, SAS (Sino-American Silicon Products Inc) of Hsinchu, Taiwan, Taiwan-based IC design house uPI Semiconductor Corp, and Delta Electronics. The funding is expected to accelerate Ancora's GaN technology development.

"GaN is the future of power electronics, with benefits of faster switching frequencies, higher efficiency, and lower energy consumption. The ecosystem of GaN technology is evolving rapidly as applications are continuously emerging," says president Dr T.K. Shing. "We are thrilled to have ROHM, SAS and uPI as our strategic partners and investors. We are also grateful for the commitment by our parent company Delta, a leader in power and thermal management technologies and global provider of smart energy-saving solutions," he adds. "This powerful alliance will enable us to establish an ecosystem with strong partners in substrate materials, IC design, applications and system solutions, to expedite the adoption of GaN technology that promises unprecedented performance value."

Ancora's product line includes GaN discrete components, system-in-package (SiP) and system-on-chip (SoC). Delta's commitment to provide a wide range of smart energy-saving solutions that leverage its core competence in high-efficiency power electronics is expected to provide additional momentum and fuel Ancora's long-term growth. Also, the alliance and capital raising is expected to enable Ancora to increase production capability to serve the growing demand for GaN devices in consumer electronics, telecom and automotive applications. The ultimate goal is to maximize GaN performance to accelerate power technology innovation and contribute to achieve sustainable development based on energy efficiency.

www.ancora-semi.com
www.deltaww.com

Odyssey hits 1200V rating on vertical GaN power devices

Product samples in Q4/2022 for customer evaluation from Q1/2023

Odyssey Semiconductor Technologies Inc of Ithaca, NY, USA, which is developing high-voltage vertical power switching components based on proprietary gallium nitride (GaN) processing technology, says that it has reached its stated goal of 1200V rating on vertical GaN power field-effect transistors (FETs). The firm is now applying this validated technology to fabricate product samples in fourth-quarter 2022 for internal and customer evaluations, planned through first-quarter 2023.

Recently accomplished milestones are cited as:

- being on-track to build Gen1 product samples of 650V and 1200V power devices in Q4/2022;
- validating figures-of-merit for both 650V and 1200V power devices that will provide what is reckoned to be industry-leading efficiency with low on-resistance at high switching frequencies for reduced solution size;
- validating a process for large-scale device fabrication, currently in use to manufacture product samples;
- securing commitments from three customers to evaluate Gen1 product samples (expanded customer engagement is underway to confirm additional customers for product samples).

"We are emerging from process and materials R&D to delivering products at voltages that lateral GaN can't practically reach with economics unattainable by silicon and silicon carbide," says CEO Mark Davidson. "Our vertical GaN products will deliver high power conversion efficiency at almost 10x smaller than a silicon carbide transistor for the same application," he adds.

"We are not just fabricating test structures. We're building product samples that customers need," continues Davidson. "Odyssey continues to close new commitments for product samples as customers gain a full understanding of the capabilities of Odyssey's power devices. The company is uniquely positioned with the expertise and the IP portfolio to protect it. And with our own foundry in Ithaca, New York, we can innovate quickly and control our ability to supply products to customers."

Odyssey says that the market it is pursuing is large and fast growing. It claims that its approach to vertical GaN can offer an even greater improvement that silicon, silicon carbide (SiC) and lateral GaN cannot deliver. The 650V segment is the larger market today, expected to grow at a compound annual growth rate (CAGR) of 20%. But the 1200V product market segment is expected to grow faster (at 63% CAGR), becoming the larger market segment in the second half of this decade. Collectively, the 650V and 1200V power device market is expected to grow at a combined CAGR of 40% to about $5bn in 2027, according to market analyst firm Yole Développement.

www.odysseysemi.com

Altum RF launches 400W S-band power amplifier MMIC

Power amplifier developed in collaboration with TNO and WIN

In collaboration with Eindhoven-based research institute TNO (the Netherlands Organization for Applied Scientific Research in Delft), Altum RF (which designs high-performance RF to millimeter-wave solutions for commercial and industrial applications), has introduced a 400W S-band power amplifier monolithic microwave integrated circuit (MMIC), using the NP45-11 technology of compound semiconductor wafer foundry WIN Semiconductors Corp of Taoyuan City, Taiwan.

Operating at 2.8–3.3GHz, the amplifier delivers output power of 400W and power-added efficiency (PAE) of 50–55% and is suited to S-band radar applications. WIN's NP45-11 process is a 0.45μm RF gallium nitride on silicon carbide (GaN-on-SiC) high-electron-mobility transistor (HEMT) technology manufactured with enhanced moisture protection, enabling the use of a plastic package.

Altum RF's strategic relationship with TNO results in what are said to be leading-edge RF to millimeter-wave products and technology for commercial markets and applications. This collaboration allows Altum RF to commercialize some of TNO's unique technical capabilities.

"We are looking forward to industrializing this innovative S-band technology, and we see this as a logical extension of our catalog," says Niels Kramer, Altum RF managing director Europe & VP marketing. "Altum RF continues its strategic focus to expand our product portfolio from X-band and beyond," he adds.

"Building on more than 30 years of leading-edge phased-array HPA [high-power amplifier] research, it is impressive to see the outstanding performance this S-band power amplifier can achieve, using WIN Semiconductors' advanced GaN technology, and we are equally excited about the ability to commercialize it with Altum RF," comments Kemo Agovic, market director Information and Sensor Systems at TNO. "We expect even more innovations in the future with this solid strategic partnership," he adds.

"Both Altum RF and TNO have extensive experience using WIN's compound semiconductor technologies to achieve market-leading performance, and we are delighted to be the RF GaN technology partner for this new product," says David Danzilio, WIN's senior VP, technology & strategic marketing.

www.winfoundry.com
www.altumrf.com

Marelli and Politecnico di Torino co-developing GaN for high-voltage power converters

Power Electronics Innovation Center and Marelli Motorsport target multi-level 900V high-power inverter for electric traction

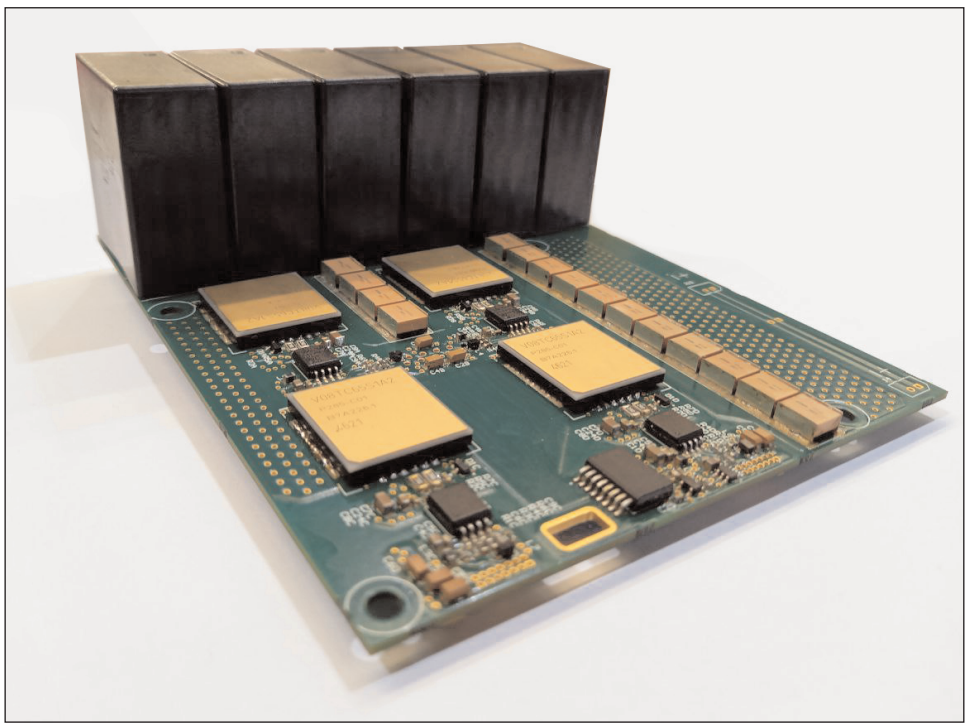
Marelli Motorsport — the motorsport business unit of automotive supplier Marelli, (which has extensive experience of developing hybrid and electric systems) — and the Power Electronics Innovation Center (PEIC) of Italy's Politecnico di Torino have announced a new collaboration on gallium nitride (GaN) technology for power electronics, targeting electric engines. The project is included in a wider framework research partnership between Marelli and Politecnico.

The collaboration is aimed at the design and prototyping of an innovative multi-level 900V high-power inverter for electric traction based on GaN technology.

GaN, which can reach unprecedented switching frequencies and low switching energy, allows a radical reduction of passive components (e.g. inductors, capacitors, transformers) while maintaining outstanding efficiency. In the last few years, GaN technology has been evolving rapidly in terms of conduction and switching performance. In addition, since lateral GaN devices are grown on standard silicon wafers, their cost is already highly competitive.

GaN technology is said to open new horizons in power converter design innovation, in which the collaboration has the aim to excel in terms of high-efficiency multi-level architectures, optimal and robust gate driving and device parallelization, high-frequency and high-temperature capacitor technologies, integration of capacitors and semiconductors on printed-circuit boards for cost reduction, advanced cooling solutions.

"The collaboration with Politecnico di Torino is enabling a more rapid pace of development with respect to innovative wide-bandgap technology applied to power converters," says Riccardo De Filippi, head of Marelli Motorsport. "In particular, GaN is proving to be very promising for what concerns high-frequency switching devices, even at very high voltage and power levels. It looks like the new technology can have a bright future in the automotive electrification market," he adds.



"The collaboration with Marelli is a further demonstration of the multiple benefits and synergies possible between university and industry when they join forces in fast tracking new technologies into cutting-edge device development," comments PEIC chairman Radu Bojoi.

The concept study started back in 2021 and, at present, it is in the prototyping phase, which is planning to undergo two development steps in 2022. The GaN component supplier selected for the prototype phase is VisIC Technologies Ltd of Ness Ziona, Israel.

"The project with Marelli and PEIC for the development of GaN-based multi-level-power inverters in electric vehicles illustrates the breakthrough of gallium nitride technology in the automotive industry," says VisIC's CEO Tamara Baksht. "VisIC's D^{3}GaN technology was developed for the high reliability standards of the automotive industry and offers the lowest losses per $R_{DS(on)}$. It also simplifies the system solution and enables high-efficiency and affordable power-train solutions," he adds. "It is definitely the next step for the automotive electrical driveline."

Beyond the motorsport domain (which is always at the forefront of innovation due to its capability to design and test technologies in a fast way and under challenging conditions), the know-how and technologies developed in the frame of this collaboration for Marelli will be crucial also for enabling a technological flow-down to series production technologies.

www.peic.polito.it
www.marelli.com

Transphorm wins ARPA-E contract for GaN-based four-quadrant switches with bidirectional current and voltage control

One FQS can replace multiple silicon devices

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and makes JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — has been awarded a contract by the Advanced Research Projects Agency-Energy (ARPA-E). Part of the ARPA-E CIRCUITS program and through a sub-contract from Illinois Institute of Technology, the project covers the supply of GaN-based four-quadrant switches (FQSes) for use in various power conversion applications including novel ones like current source inverters, cyclo-converters for drives and micro-inverters, matrix switching, and solid-state circuit breakers. Transphorm says that the initiative is the result of its GaN engineering expertise (specifically its bidirectional GaN) along with industry and university interest in further exploring the possibilities of lateral GaN switches.

Transphorm will prototype the FQS platform using its 650V GaN technology that continues to offer what is claimed to be the industry's highest threshold voltage (4V) in a 4-pin TO-247 package. The project is expected to be completed in less than a year.

True bidirectional GaN switch innovation

Transphorm's standard lateral GaN FETs inherently provide bidirectional current flow. However, certain applications such as current source inverters for motor drives, cyclo-converters and matrix converters also require bidirectional voltage control to effectively manage power flow. This capability is traditionally achieved by placing two FETs in series using the devices' body diode to steer and control current flow or via two insulated-gate bipolar transistors (IGBTs) and two diodes, thus requiring four devices.

Also called a true bidirectional switch, the FQS replaces the two-FET or the two-IGBT+two-diode approaches with a single device capable of realizing bidirectional voltage control and bidirectional current flow. The FQS uses two gates to block voltage of either polarity or pass current in either direction. And, as a single device, it reduces the number of parts required to achieve the desired result enabling higher power density, increased reliability, and overall system cost reduction.

"It is exciting to see the day approaching when GaN-based bidirectional switches will be ready for commercial production," comments emeritus professor Tom Jahns, FIEEE, NAE, at the University of Wisconsin - Madison. "Power electronics engineers have been anxiously anticipating the day when MOS-gated bidirectional switches will become available because they are the key to implementing promising power converter topologies that offer exciting opportunities for improving efficiency, power density and fault tolerance in many applications. They hold the potential to dramatically improve the commercial viability of new products including solid-state circuit breakers and integrated motor drives by making them significantly more compact and efficient than what is achievable using today's silicon-based switches," he adds.

"GaN adoption is at a point today when bringing an FQS bidirectional device to market makes sense," says Dr Rakesh Lal, technical fellow at Transphorm. "Lateral GaN technology enables compact FQS dies to be fabricated because the voltage-blocking region can be shared. This configuration cannot be realized with vertical power device technologies, such as with silicon or silicon carbide (SiC), which gives GaN FQSes a clear edge in performance and cost," he adds. "With our FQS, one gets true bidirectionality in a fast low-loss switch, which we believe will inspire next-generation power conversion products through the CIRCUITS program driven partnerships."

www.transphormusa.com

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Navitas launches first GaNSense half-bridge power ICs

MHz performance with 60% reduction in components and circuit size

Gallium nitride (GaN) power IC firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has launched the first GaNSense half-bridge power ICs, which are said to enable a new level of MHz switching frequencies while dramatically reducing the system cost and complexity compared with existing discrete solutions.

GaNSense half-bridge power ICs integrate two GaN FETs with drive, control, sensing, autonomous protection, and level-shift isolation, to create a fundamental power-stage building block for power electronics. This single-package solution is said to reduce component count and footprint by over 60% compared with existing discretes, which cuts system cost, size, weight and complexity. The integrated GaNSense technology enables what is claimed to be unprecedented autonomous protection for increased reliability and robustness, combined with loss-less current sensing for higher levels of efficiency and energy savings. The high integration levels also eliminate circuit parasitics and delays, making MHz-frequency operation a reality for a broad range of AC–DC-power topologies including LLC resonant, asymmetric half-bridge (AHB), and active-clamp flyback (ACF). The GaNSense half-bridge ICs are also a suitable fit for totem-pole PFC (power-factor correction) as well as motor-drive applications.

GaNSense half-bridge ICs are expected to have a significant impact in all Navitas target markets including mobile fast chargers, consumer power adapters, data-center power supplies, solar inverters, energy storage, and electric vehicle (EV) applications.

"After bipolar transistors were replaced by silicon MOSFETs in the late 1970s and early 1980s, the introduction of Navitas GaN technology represents the second revolution in power, with a huge increase in switching frequency and efficiency, and major reductions in system size and cost," states CEO Gene Sheridan. "Our initial GaNFast ICs enabled an increase from 50–60kHz to 200–500kHz, and now the GaNSense half-bridges elevate those benefits to the MHz range."

The initial family of GaNSense half-bridge ICs includes the NV6247, which is rated at 650V, 160mΩ (dual), and the NV6245C, rated at 275mΩ (dual), both in an industry-standard, low-profile, low-inductance 6mm x 8mm PQFN package. The NV6247 is immediately available in production with 16-week lead times, while the NV6245C is sampling to select customers and will be broadly available in production to all customers in fourth-quarter 2022. A wide range of package styles and power levels will become available in this GaNSense half-bridge IC family in the coming quarters.

www.navitassemi.com

Navitas chief operating officer/chief technology officer presents tutorial at PowerAmerica 2022

GaN power ICs add autonomous sensing and protection to increase efficiency and reliability

Navitas Semiconductor's chief operating officer/chief technology officer & co-founder Dan Kinzer presented the 75-minute tutorial 'Advancing GaN Power Integration: Efficiency, Reliability & Autonomy' at the 2022 Wide Band-gap (WBG) Summer Workshop (2–4 August) on North Carolina State University's Centennial Campus in Raleigh, NC, of PowerAmerica, a public–private research initiative established in 2014 between industry, government, national labs and academia dedicated to accelerating the adoption of wide-bandgap (WBG) silicon carbide (SiC) and gallium nitride (GaN) power electronics.

The presentation covers GaN device fundamentals and Navitas' proprietary AllGaN process design kit (PDK), before detailing practical applications, and the benefits of integrating GaN power with drive, plus control, sensing and protection, to enable the highest power density, efficiency and reliability.

Established in 2014, PowerAmerica (a member of Manufacturing USA) brings together leading innovators in WBG semiconductors. As a member of PowerAmerica, Navitas provides technical and material input for initiatives to help companies using power semiconductors to upgrade beyond legacy silicon. In return, Navitas has access to resources and relationships contributing to business growth. The tutorial workshop is being held in conjunction with PowerAmerica's 2022 Annual Meeting.

"GaNSense technology is optimized for revolutionary high-speed, soft-switching topologies such as totem-pole PFC [power factor correction], asymmetric half-bridge and active-clamp flyback," notes Kinzer. "Loss-less current sensing delivers the efficiency boost, and 6x faster fault-detection — with 'detect-to-protect' in only 30ns — means that systems can now be made as reliable as the GaN power ICs themselves."

www.poweramericainstitute.org

Navitas GaN ICs save first 100,000 tons of carbon dioxide emissions

Each GaNFast power IC saves 4kg CO_2 versus silicon chips

Gallium nitride (GaN) power integrated circuit firm Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland has announced what it says is the first saving of 100,000 tons of carbon dioxide (CO_2) emissions as GaN replaces legacy silicon chips.

GaN is reckoned to use up to 10x-lower CO_2 footprint to manufacture and ship compared with silicon, while reducing the end-application CO_2 footprint by up to 30%. Each GaN power IC shipped saves a net 4kg CO_2 in comparison, and GaN offers the potential to address a reduction of 2.6Gtons CO_2/year by 2050 — equivalent to the CO_2 generated by over 650 coal-fired power stations, over 6 billion barrels of oil, over 560 million ICE passenger cars — or the annual electricity use of over 470 million homes.

Based on Navitas' unit shipments, and third-party life-cycle assessment (LCA) of a 65W USB-C charger example, 100,000 tons is a conservative estimate of cumulative customer savings in CO_2 emissions. This also considers a six-month delay, accounting for shipping inventory and customer assembly.

Navitas completed a comprehensive analysis working together with EarthShift Global and completed an ISO14040/14044-compliant comparative LCA report quantifying the benefits of silicon power semiconductor components versus GaN power ICs and USB-C chargers using GaN power IC products.

"The analysis shows that GaN power ICs provide a step-function improvement in environmental impacts over the incumbent silicon solutions," says Anthony Schiro, VP quality & sustainability. "Over the next 5–10 years, the sustainability benefits will become significant in achieving global customer and nation net-zero goals," he adds.

"A total life-cycle assessment, spanning 'cradle-to-(beyond-the)-grave' presents a holistic view, and it is critical to understand energy-usage and CO_2 emissions from boule to device, and to ensure that we're not shifting impacts to other areas of concern," comments EarthShift Global's CEO Lise Laurin. "It's critical that we apply a rigorous, data-driven approach to provide genuine insight into systems, products and processes, and broader perspectives are central to achieving greater sustainability."

Founded in 2014, Navitas introduced what it claimed to be the first commercial GaN power integrated circuits. Its proprietary GaNFast power ICs integrate GaN power field-effect transistors (FETs) with drive, control, sensing and protection circuits, allowing systems to consume less energy, and minimize and reduce additional electronic components (e.g. magnetics, filters, capacitors), as well as mechanical components (e.g. PCB area, metal/plastic housing, aluminum heatsinks), which reduce oil/refinement demand, lowering shipping costs and CO_2 footprint.

Navitas published what it claims is the world's first GaN sustainability report 'Electrify Our World' to quantify the positive impact of GaN power semiconductors on climate change, based on global standards. Then in May 2021, Navitas became the world's first semiconductor company to be CarbonNeutral-certified.

www.earthshiftglobal.com
www.navitassemi.com

Navitas and JP showcase GaN & SiC at electronica India

Demos include ultra-fast GaN chargers, new GaN half-bridge ICs and silicon carbide MOSFETs

Navitas Semiconductor of El Segundo, CA, USA and Dublin, Ireland participated alongside official distributor JP Electronic Devices at electronica India 2022 in Greater Noida (21–23 September).

Navitas showcased its portfolio of wide-bandgap (WBG) semiconductors, which includes the latest family of gallium nitride (GaN) GaNSense half-bridge power ICs, which are said to enable a new level of MHz switching frequencies while dramatically reducing system cost and complexity compared with existing discrete solutions.

Also on show was technology from silicon carbide (SiC) firm GeneSiC (acquired in August), whose MOSFETs and diodes are optimized to meet the power, voltage and ruggedness demands of applications such as uninterruptible power supplies (UPS), solar inverters, wind turbines, industrial motors, smart grids, and electric vehicles (EVs).

"India and the southern Asian region are key markets for Navitas and electronica India provides an ideal platform to showcase our technologies to designers and engineers developing new generations of applications focused on efficiency and sustainability," says David Carroll, senior VP of worldwide sales.

www.jpegroup.com

HG enters into strategic cooperation framework agreement with GCL

Collaboration targets GaN power chips for new energy applications

Hong Kong-based HG Semiconductor Ltd has entered into a strategic cooperation framework agreement with Golden Concord Group Ltd, a company ultimately held under a discretionary trust with GCL Technology Holdings Ltd's founder, chairman & executive director Zhu Gongshan and his family members as beneficiaries.

HG and Golden Concord Group intend to initiate close cooperation in the application of gallium nitride (GaN) power chips in the field of new energy, including
(i) Golden Concord Group or its subsidiaries will be involved in equity of HG or its subsidiaries to establish in-depth cooperation;
(ii) the parties will establish a domestic new energy joint venture to tap into the application of GaN chips in new energy, including but not limited to technologies and equipment on charging/exchanging batteries, energy storage technology and related equipment and distributed solar inverters;
(iii) HG will provide technical support to the JV and jointly develop application products based on silicon-based power chips and third-generation semiconductors; Golden Concord Group will assist HG and the JV to enter into the new energy industry supply chain based on its leading position in the new energy industry.

Golden Concord Group is ultimately held under the investor family trust, which is the shareholder of GCL Technology, GCL New Energy Holdings Ltd, GCL System Integration Technology Co Ltd and GCL Energy Technology Co Ltd. Earlier, HG had entered into an investment agreement with Zhu or his wholly owned entity, pursuant to which HG can conditionally allot and issue 60 million subscription shares and 60 million warrants. Subsequent to the shares and warrants subscription, this strategic cooperation framework agreement again demonstrates Zhu's confidence in the development of HG's third-generation semiconductor business, and it is believed that the collaboration can give full play to the advantages of both parties in the industry, supply chain, talent, technology and other aspects, in order to achieve innovation and mutual benefits.

HG reckons that the strategic collaboration will further drive and strengthen its capabilities for promoting the application of third-generation semiconductor technology in the new energy sector, and enable it to gradually grow its business by leveraging the experience as well as the financial and industrial resources of Golden Concord Group, helping HG to build its talents, operations, technology, and research and development.

HG says that it aims to continuously pursue innovation and strive to form complementary industrial resources with Golden Concord Group while investing resources in the optimization and development of GaN-related products. HG believes that the cooperation will further drive new collaborative initiatives with Zhu, setting new heights in the development of GaN business in new energy.

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EPC opens motor drive design application center in Italy

Center of excellence in Turin to help customers exploit gallium nitride for motor drive applications

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 ICs for power management applications — has opened a new design application center near Turin, Italy, to focus on growing motor drive applications based on GaN technology in the e-mobility, robotics, drone and industrial automation markets. The specialist team will support customers in accelerating their design cycles and define future ICs for power management with state-of-the art equipment to test applications from 400W to 10s of kW.

Strategically located, Turin has a historical tradition in electric motors and motor drives, enabling the firm to draw on the local technical talent. EPC says that its engineers are

helping customers to reduce their design cycle times and adopt GaN for more efficient, smaller, lower-cost systems. Moreover, the center is exploring ways to exploit the potential of EPC's GaN technology in motor drive applications to enable a substantial increase in the efficiency of the motor, leading to higher-power-density designs than what has been possible with historically MOSFET-based designs.

EPC is collaborating closely with the Power Electronics Innovation Centre (PEIC), a cross-department entity in the Politecnico di Torino, by investing in shared R&D.

"Our new facility combines a comprehensive GaN product portfolio and design expertise offering customers a center of excellence that is unrivalled for motor drive applications," says new facility's head, EPC's director of motor systems & applications Marco Palma. "Its location is key too, as Europe is driving the green revolution in the e-mobility market, by using the Euro 7 standard in the short term and by banning internal combustion engines by 2035. This is definitely the right time to invest in higher-power-density motor solutions that avoid unnecessary energy waste."

www.epc-co.com

Keysight extends collaboration with Synopsys to validate complex RF and millimeter-wave design

Native integration of Synopsys Custom Compiler with PathWave RFIC Design optimizes power and performance and delivers 5G/6G designs more efficiently

Keysight Technologies Inc of Santa Rosa, CA, USA has extended its collaboration with Synopsys Inc of Mountain View, CA, USA — which provides electronic design automation (EDA) software, semiconductor IP and services for chip and electronic system design — with the integration of PathWave RFIC Design (GoldenGate) with Synopsys Custom Compiler design environment and Synopsys PrimeSim circuit simulation solutions. This will enable designers to validate complex radio frequency (RF) and millimeter-wave design requirements for 5G/6G system-on-chip (SoC) and subsystem designs in the Synopsys Custom Design Family.

"We are migrating our RF design environment to industry-leading commercial tools and workflows based on the Synopsys Custom Compiler design and layout solution," says Koji Tomioka, vice president at Asahi Kasei Microdevices Corp. "Keysight's RFIC design tool integrated with Custom Compiler provides best-in-class layout and simulation capabilities to design and verify our millimeter-wave radar chips," he comments. "We anticipate that the Synopsys–Keysight collaboration will save us time versus the maintenance of our in-house developed tools."

The complexity of design requirements for radio frequency integrated circuits (RFICs) that are used for wireless data transmission, such as transceivers and RF front-end components, continues to grow. Next-generation wireless systems target a range of new capabilities including higher bandwidth, more connected devices, lower latency and better coverage. To address these requirements, designers need to simulate and measure RF performance to a greater level of accuracy.

The integration of PathWave RFIC Design (GoldenGate) simulation software (which models complex integrated circuits) with Synopsys Custom Compiler (part of the Synopsys Custom Design Family of products) addresses this challenge by enabling designers to achieve power and performance optimizations and efficiently deliver 5G and 6G designs.

"Native integration of Keysight's PathWave RFIC Design (GoldenGate) with Synopsys' Custom Compiler extends our collaboration to address end-to-end workflows for increasingly complex wireless designs," says Niels Faché, VP & general manager of Keysight's PathWave Software Solutions. "This integration enables customers to access Harmonic Balance and Envelope simulation capabilities, as well as Keysight's Virtual Test Benches, to reliably compute error-vector magnitude (EVM) and adjacent-channel power ratio (ACPR) early in the chip design and verification process."

Integration of Keysight's PathWave RFIC Design (GoldenGate) into the Synopsys environment and Custom Compiler design workflow provides an enterprise-grade solution for RF and wireless design, delivering the following key benefits:

- complementary, high-capacity RFIC simulation solutions to validate complex SoCs with accurate electromagnetic (EM) models for RF and millimeter-wave design blocks;
- improved productivity with defined common test-benches, measurements and simulation setup;
- the ability to meet complex RF and millimeter-wave design requirements to facilitate the creation of 5G and 6G SoC and subsystem designs;
- compact test signals and fast distortion EVM simulations for both design and verification of RF circuits using modulated signals;
- an energy-efficient design that improves power optimization, thermal, mechanical heat stress and battery life.

Integration of Keysight's PathWave RFIC Design (GoldenGate) with Synopsys' Custom Compiler extends our collaboration to address end-to-end workflows

"To enable key differentiating advantages for 5G/6G designs, Synopsys is delivering robust RF design solutions that deliver best-in-class design, simulation and layout productivity workflows," says Aveek Sarkar, VP of engineering at Synopsys. "As a result of our strong relationship with Keysight, our customers can now take advantage of the complementary RFIC simulation products within the Synopsys Custom Design Family. The custom design flow enables a more productive design and verification solution that delivers significantly faster layout and design closure, providing designers an accelerated path to meet their speed, bandwidth and data throughput requirements and time-to-market targets."

This marks a continuation of Keysight's strategic partnership with Synopsys, which recently integrated Keysight's PathWave RFPro with the Synopsys Custom Compiler design environment, enabling customers to rapidly and accurately design wireless chips using TSMC's N6RF Design Reference Flow.

www.synopsys.com/rf-design.html
www.keysight.com/us/en/products

Keysight unveils device modeling software to enable one-stop design and development workflow

New model generator in PathWave Device Modeling (IC-CAP) 2023 automates workflow management

Keysight Technologies Inc of Santa Rosa, CA, USA has announced a new model generator (MG) environment that increases productivity for semiconductor device modeling with improved automation across the entire workflow.

Semiconductor device modeling engineers require automated tools to create accurate simulation models and process design kits (PDKs) for baseband and radio frequency (RF) integrated circuit (IC) designs that leverage both silicon (CMOS) and III-V compound semiconductor technologies.

"Keysight's device modeling 2023 software suite addresses the needs of customers who generate high-quality SPICE models in limited time," says Ma Long, manager of device modeling and characterization. "This new solution offers workflow and speed improvements and represents a significant advancement toward delivering a flexible and open environment that integrates all Keysight modeling technologies."

To address the growing needs of device modeling engineers, Keysight's device modeling 2023 software suite includes:

- PathWave Device Modeling (IC-CAP) 2023 features the MG, a new modeling flow manager that enables a one-click import of measured data, creation of trend plots, organization of the extraction flow, basic QA verification and documentation. IC-CAP also upgrades radio frequency gallium nitride (RF GaN) packages with support for the latest Compact Model Coalition (CMC) model versions, including improved extraction flows that account for trapping and thermal effects.
- PathWave Model Builder (MBP) 2023 introduces a new and exclusive link to Synopsys' PrimeSim HSPICE. This ultra-fast link enables optimization and tuning without any speed penalty and delivers access to HSPICE features such as CMC standard models and Verilog-A compiler for custom models.
- PathWave Model QA (MQA) 2023 enhances the new project template-based workflow with various template examples including statistical, corner, table and RF.
- Advanced Low-frequency Noise Analyzer (A-LFNA) 2023 delivers an integrated and compact measurement system through support of M9601A PXIe Precision Source/Measure Unit.

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Aixtron launches G10-SiC 200mm CVD system

Flexible dual-wafer 9x150mm and 6x200mm size targets transition of silicon carbide epitaxy to larger wafers

At the 19th International Conference on Silicon Carbide and Related Materials (ICSCRM) in Davos, Switzerland, deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has launched the G10-SiC high-temperature chemical vapor deposition (CVD) system for high-volume manufacturing of the latest-generation silicon carbide (SiC) power devices on 150/200mm SiC wafers.

The G10-SiC system is built on the firm's established G5 WW C 150mm platform and provides a flexible dual-wafer size configuration of 9x150mm and 6x200mm, which is reckoned to be instrumental for the transition of the SiC industry from 150mm (6-inch) to 200mm (8-inch) wafer diameter.

The new platform is built around the firm's proven automated wafer cassette-to-cassette loading solution with high-temperature wafer transfer. Combined with high-growth-rate process capabilities, the G10-SiC provides what is claimed to be best-in-class wafer throughput and throughput per square meter to efficiently use the limited cleanroom space available in semiconductor fabs.

The G10-SiC supports a large variety of device structures including single and double drift layer structures meeting stringent 150mm uniformity requirements of sigma values less than 2% for doping and thickness. The automated wafer loading reduces the risk of particle defects to a minimum, resulting in typical defect counts of <0.02/cm^2.

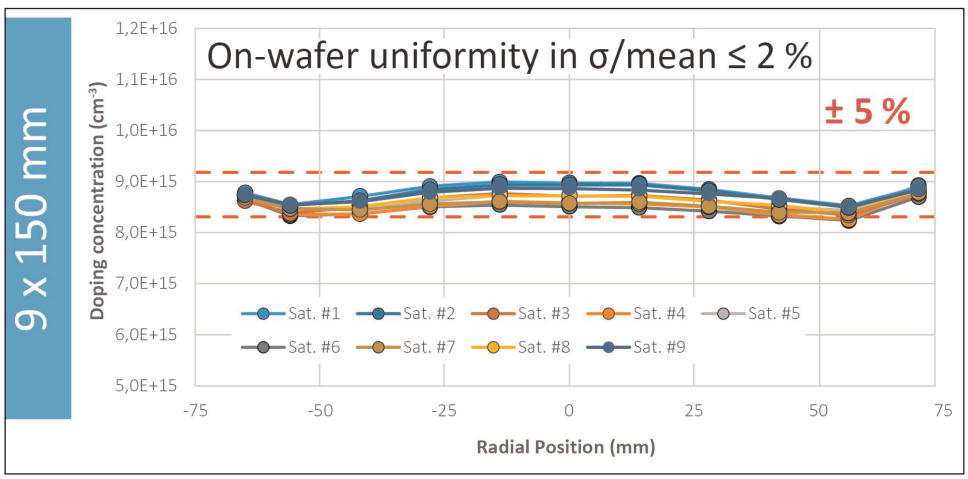
"This is a truly new-generation high-performance system. The new dual wafer size configuration fully supports the transition from today's 150mm wafer technology and safeguards the investments of our customer for the future," says Dr Frank Wischmeyer, Aixtron's vice-president SiC. "With the highest throughput available to date in this form factor, it maximizes the fab's productivity and capability to ramp even faster. At the same time, the newly developed in-situ top-side wafer temperature control (TTC) solution optimizes the wafer-level process control within a batch as well as from batch-to-batch. This results in predictable high yields meeting tight production specifications at competitive cost levels," he adds.

Aixtron's new G10-SiC high-temperature CVD system

Epitaxial layer uniformity is essential to meet a high yield at the device level. The high throughput of the system, paired with low consumption costs per processed wafer, results in the lowest cost per wafer in the industry, Aixtron claims.

"The positive feedback from our partners and customers after evaluation and production qualification of our new G10-SiC system has already generated additional customer interest," notes CEO & president Dr Felix Grawert. "The G10-SiC is becoming an important building block for our customers' worldwide production expansion, and we are committed to support this scaling with our system manufacturing, service and process support excellence."

www.icscrm2022.org
www.aixtron.com



OIPT launches alternative to CMP for epi-prep of silicon carbide substrates

Plasma polishing alleviates technical, environmental and supply chain issues of chemical-mechanical planarization

Plasma etch and deposition processing system maker Oxford Instruments Plasma Technology (OIPT) of Yatton, near Bristol, UK has unveiled a new alternative method of preparing silicon carbide (SiC) substrates for epitaxy. Plasma polishing for SiC substrates has been demonstrated as a superior and high-volume manufacturing (HVM)-compatible alternative to chemical-mechanical planarization (CMP), while alleviating significant technical, environmental and supply chain issues associated with CMP.

The Oxford Instruments' Plasma Polish Dry Etch (PPDE) process is a direct plug and play replacement for CMP and easily integrates into existing process flows. CMP has been the process of record for SiC substrate preparation for many years, but suffers from undesirable operational issues, and the industry as a whole is struggling to meet increasing demand for SiC substrates. Operating CMP in SiC substrate fabs has a large environmental footprint due to the semi-toxic slurry by-product, and the heavy water usage that the process demands is wasteful.

In addition, the polishing pads and speciality chemicals bring significant consumable cost in a challenging supply chain environment. Furthermore, the CMP process is inherently unstable as slurry chemicals and polishing pads are consumed, introducing drift into the process line. PPDE is a stable non-contact process, which reduces handling loss and allows for the processing of thinner wafers, producing more wafers per boule and enabling the progression to 200mm SiC substrates.

"There is a compelling technical and commercial case for choosing plasma surface preparation to produce epi-ready SiC substrates. From a technical perspective we have a route to thinner wafers with less bow and excellent epi-ready quality, a strong commercial case for taking cost and complexity out of the supply chain, in addition to providing a significantly cleaner greener process that is fab compatible and integratable," comments Plasma Technology's strategic business development director Klaas Wisniewski. "This is an incredibly attractive proposition that, as a technique compared to the current method, provides better results at lower cost, drops into the production flow like for like, and enables environmentally sustainable production of SiC devices."

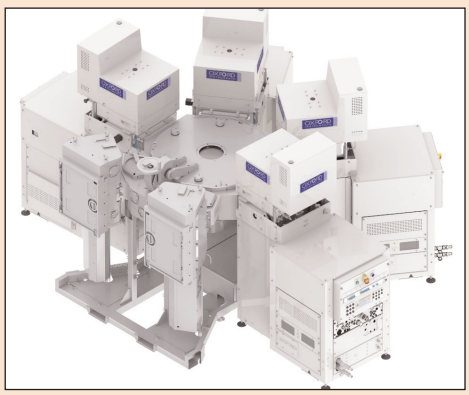
https://plasma.oxinst.com

SiC plasma epi-prep alternative to CMP validated

Feasibility study completed at tier-1 silicon carbide fab

After announcing its plasma alternative to chemical-mechanical planarization (CMP), Oxford Instruments Plasma Technology (OIPT) of Yatton, near Bristol, UK says that its non-contact plasma etch method of preparing silicon carbide substrates for epitaxy delivers comparable results to CMP but with lower operating expenditure (OPEX), higher device yield and a process window capable of supporting the transition to thinner wafers and therefore increasing wafers per boule.

The feasibility project, carried out at a tier-1 SiC semiconductor manufacturing fab using whole wafers, found that performance of the new plasma substrate preparation technique is already equivalent to CMP for epitaxy readiness.



"This validation outcome is a significant milestone in our goal of creating a more cost-effective and sustainable technique for preparing SiC substrates for epitaxy," says Klaas Wisniewski, Plasma Technology's strategic business development director.

"Our plasma epi-prep technology is hugely promising and currently compares favourably to existing alternatives, but has the potential to exponentially increase substrate production and meet the growing demand for SiC substrates in high-growth markets," he adds.

Oxford Instruments formally launched its plasma epi-prep solution at the International Conference on Silicon Carbide and Related Materials (ICSCRM/ECSCRM) in Davos, Switzerland (11–16 September). In the conference technical sessions, it presented its latest whole-wafer epi and device results utilizing its patented dry etch process.

https://icscrm2022.org

Automated single-wafer ashing of compound semis

Robotic handling protects wafers while superior temperature and process control provides complete precision ashing

Ashing, in which light-sensitive photoresist coating is removed and cleaned from an etched wafer, is one of the most important and frequently performed steps in chip fabrication. In this step, photoresist organics are 'burned off' using a processing tool in which monatomic plasma is created by exposing oxygen or fluorine gas at low pressure to high-power radio waves. Previously, wafer ashing was largely done using batch processing techniques to achieve the required throughput.

However, unlike silicon semiconductors, where wafers are mass produced in the standard 300mm size, compound semiconductors made of silicon carbide, gallium arsenide, gallium nitride and sapphire can vary in size between 100mm and 200mm in diameter. When this is the case, significantly better uniformity of photoresist removal is required, which means better temperature and process controls. As a result, most compound semiconductor wafer manufacturers require automated, single-wafer processing tools capable of fast ashing rates and high production levels.

"Today, semiconductor manufacturers are increasingly looking for a single-wafer ashing solution for both high-temperature photoresist removal and precision descum," says Wolfgang Pleyer, senior application engineer at PVA TePla of Munich, Germany, a provider of microwave and radio frequency (RF) plasma systems with US operations in California.

Microwave plasma ashing

For 50 years, most plasma tools have used RF for stripping photoresists. RF plasma etches the surface through a physical process that essentially bombards the surface with plasma in a specific direction.

"In the past, you could simply increase the DC bias and remove everything," says Pleyer. "But RF plasma is not as selective in attacking photoresist. Also, when the photoresist is removed, the underlying layers of the wafer may be sensitive and could be damaged with RF."

Today, microwave-based plasma tools produce a very high concentration of chemically active species and low ion bombardment energy, ensuring both a fast ash rate and a damage-free plasma cleaning. "Microwave tends to be quicker and produce higher ash rates than RF," says Pleyer.

Targeted photoresist removal using oxygen

Advanced microwave-based plasma ashing systems from manufacturers such as PVA TePla often utilize oxygen as the primary process gas. The oxygen ashes the wafers very selectively and attacks only the photoresist, leaving the rest of the wafer untouched.

Unfortunately, using a pure oxygen process is not always compatible with all types of wafer surfaces; some require a combination of gases.

"There can be other materials on, or within, the photoresist that cannot be stripped away completely with just oxygen alone," says Pleyer. "To resolve this issue, we may add some fluorine chemistry, usually CF4, mixed with the oxygen."

Because of the trend of using different materials in wafers, some metals are oxidized easily during the process, which is not desirable. Both hydrogen and oxygen gasses at low pressure can be used in such circumstances.

"Adding hydrogen will prevent the metals from oxidizing while the oxygen removes the photoresist," says Pleyer. "This is one thing we control very tightly during wafer ashing, and it requires excellent temperature uniformity to accomplish this task."

Working with MEMS devices requires the removal of SU-8 or similar epoxy-based negative photoresists. A challenge with negative photoresists is that parts exposed to UV become polymerized, while the remainder of the film remains soluble and can be washed away. Moreover, the chemical stability of SU-8 photoresist can also make it difficult to remove.

Removing SU-8 must be performed at lower temperatures. "You need to be below 100 degrees, and in certain cases below 50 degrees," says Pleyer. "More flexibility in the chemistry is also required, including potentially the use of fluorine and excellent control of the temperatures. All of this is much easier to accomplish with single-wafer processing."

According to Pleyer, customers may have a photoresist on a metal surface deposited between two metal surfaces requiring the removal of the photoresist from the side of the wafer. Due to its isotropic etch property, oxygen-based microwave plasma ashers can remove the photoresist in between the metal plates, unlike RF-based systems.

Ease of single-wafer automation

In manually loaded systems, the asher has a pull-out door where the wafers lie on the heating or cooling plane mounted on the entry door of the chamber. In automated systems, wafers are increasingly loaded into the chamber utilizing robotic handling.

"Today, customers want to reduce all human factors as chips continue to become more advanced," says Pleyer. "This requires automatic handling and loading using robotics and full control by a host computer. In some cases, the operator only needs to place the cassette onto

the load port, which will start automatically."

PVA TePla, for example, has designed its GIGAfab-A plasma system to be configurable for 200mm or 300mm wafers and a cluster tool with up to three process modules called the GIGAfab Modular. Both systems use open cassette as well as front-opening or standard mechanical load-stations. Wafer processing is thermoelectrically controlled from room temperature (RT) to 250°C. A unique planar microwave plasma source provides high ash rates over a wide temperature range.

With wafers becoming thinner, more reliable automated single-wafer processing equipment handles fragile wafers.

"Trying to handle the wafers physically without the use of robots can end poorly," says Ryan Blaik, sales manager of semiconductor and medical devices at PVA TePla in California.

Single-wafer processing also provides better temperature controls. "With batch processing, microwave radiation must heat all the wafers in a quartz boat, and the temperature can fluctuate during processing," says Blaik. "For a single-wafer processing system, wafers are brought into the chamber only after pre-heating, allowing a constant temperature to be maintained during processing."

In single-wafer processing, a descum process can be accomplished using the same tool. The primary difference between the two processes is the temperature the wafer is exposed to while in the plasma chamber.

"For descum, we want a low ash rate and good uniformity and process control," says Pleyer. "Because we are only targeting removal of residues, an ashing recipe at very high temperatures will not work. It is easier to accomplish using single-wafer ashing using a microwave-based plasma system."

As more semiconductor device fabrication continues to ramp up globally to meet an insatiable demand for chips, the need for control, efficiency and configurable solutions for wafer ashing will continue as the chips themselves increase in complexity and decrease in size. Automated, single-wafer microwave plasma systems provide chip fabricators with targeted and configurable ashing that meets the needs of an increasing array of wafer types, concludes PVA TePla.

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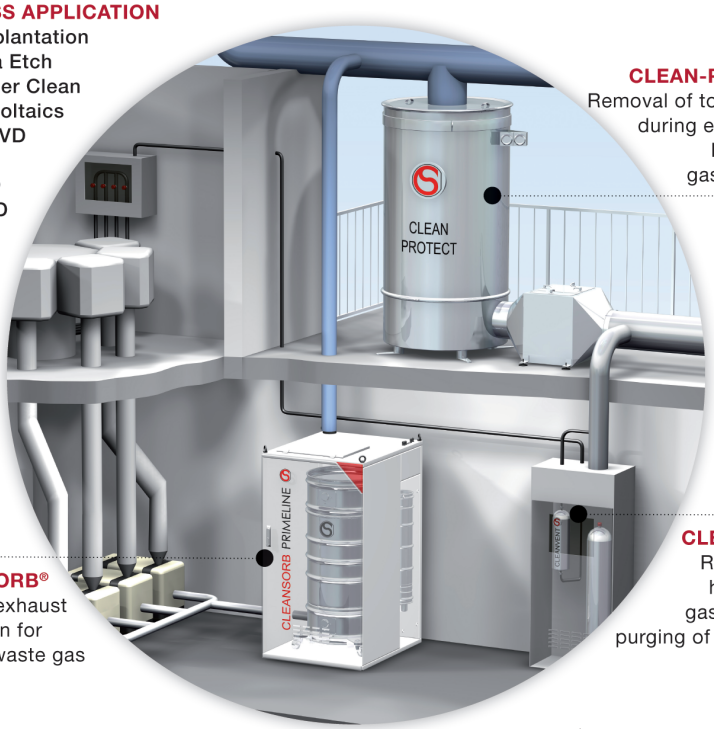

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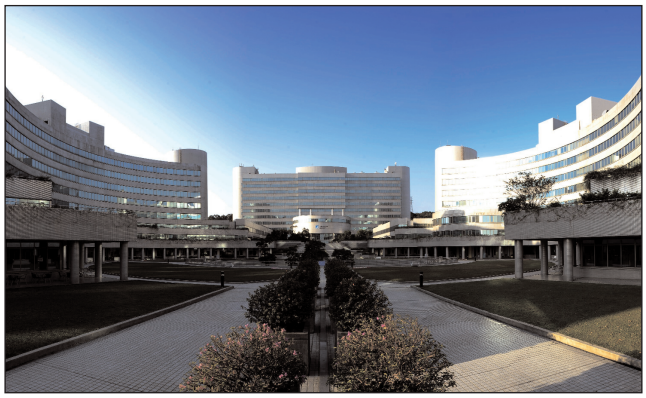
EVG expands collaboration with ITRI on heterogeneous integration process development

High-volume-systems to accelerate customers' process transfer from R&D to fabs

EV Group of St Florian, Austria — a supplier of wafer bonding and lithography equipment for semiconductor, micro-electro-mechanical systems (MEMS) and nanotechnology applications — has expanded its collaboration with the Industrial Technology Research Institute (ITRI) in Hsinchu, Taiwan on developing advanced heterogeneous integration processes.

With the support of Taiwan's Department of Industrial Technology (DoIT) of the Ministry of Economic Affairs (MOEA), ITRI established the Heterogeneous Integration Chip-let System Package Alliance (Hi-CHIP) to help create an ecosystem covering package design, testing and verification, and pilot production, to achieve the goal of supply chain localization and expand business opportunities. As a member of the Hi-CHIP Alliance, EVG has provided several of its most advanced wafer bonding and lithography systems, including the LITHOSCALE maskless exposure lithography system, EVG850 DB automated debonding system, and GEMINI FB hybrid bonding system. The installation of these high-volume-manufacturing platforms at ITRI's facility should help enable EVG's and ITRI's shared customers to accelerate the development and transfer of new heterogeneous integration processes from R&D to customers' fabs.

In semiconductor manufacturing, 3D vertical stacking and heterogeneous integration — the manufacturing, assembly and packaging of multiple different components and dies into a single device or package — are increasingly important for higher performance beyond transistor scaling. 3D and heterogeneous integration are enabling high-bandwidth interconnects in advanced packaging to achieve overall system performance gains, and thus have become a crucial driver for artificial intelligence (AI), autonomous driving and other high-performance computing applications. As a result, the MOEA is proactively following up and bridging the resources with national-scale R&D projects such as 'AI Chip Heterogeneous Integrated Module Advanced Manufacturing Platform' and 'Programmable Heterogeneous 3D Integration'.



ITRI's headquarters,

"As part of ITRI's mission to drive industrial development, create economic value, and enhance social well-being through technology R&D, we focused on developing new 3D and heterogeneous chip integration processes and forging close cooperation across the supply chain to enable continued development and growth of the semiconductor industry," says Dr Robert (Wei-Chung) Lo, deputy general director of Electronic and Opto-electronic System Research Laboratories at ITRI. "Having the same fully automated high-volume-manufacturing systems in our research facility that our customers have in their fabs, including these new wafer bonding and lithography solutions from EV Group, enables our customers to immediately transfer process recipes developed at ITRI to their own fabs – providing short ramp-up time from lab to fab," he adds.

EVG's LITHOSCALE maskless exposure lithography system.

"Key to our Triple-i philosophy of invent-innovate-implement is our focus on engaging with world-leading research institutes, like ITRI, to accelerate the development and commercialization of new technologies that drive future innovations in the semiconductor industry," says Hermann Waltl, executive sales & customer support director and member of the executive board at EVG. "Our ongoing collaboration with ITRI gives us access to world-class research expertise and further enhances our process support infrastructure in Taiwan, which EVG has significantly expanded over the years to better meet the growing needs and challenges that our customers and partners in the region face. This includes our exceptional process and application engineering team based in multiple locations across Taiwan, which complements the services provided at EVG's Heterogeneous Integration Competence Center at our headquarters in Austria."

www.itri.org.tw/eng
www.EVGroup.com

AlixLabs granted second US patent for Atomic Layer Etch Pitch Splitting (APS)

Vinnova-funded project to verify APS in fabrication and electrical characterization of nanowire test transistors

After being granted its first US patent (US10930515) on in February 2021, AlixLabs AB of Lund, Sweden was recently (on 23 August) granted its second patent (US11424130) by the US Patent Office for nanofabrication using its Atomic Layer Etch Pitch Splitting (APS) technique, a new method for manufacturing semiconductor components with a high degree of packing, eliminating several steps in the manufacturing process.

The patent covers methods to split nanostructures in half by a single process step using atomic layer etching (ALE). "Our key technology is based on a surprising discovery that sidewalls act as a topographical mask in atomic layer etch processes," notes chief technology officer & co-founder Dr Dmitry Suyatin. "This technology has been proven for such different materials as gallium phosphide (GaP), silicon (Si) and tantalum nitride (TaN) — all being critical materials to the semiconductor and optoelectronic industry," he adds.

AlixLabs says that the method can have a significant impact on the semiconductor industry by enabling sustainable scaling of electronic components and shrink chip designs further in a cost-effective way. The method is complementary for single-exposure immersion and extreme ultraviolet (EUV) lithography and corresponding multiple patterning technologies like self-aligned double and quadruple patterning (SADP and SAQP, respectively) as well as multiple exposure lithography-etch and directed self-assembly (DSA).

It is hence reckoned that APS can make components cheaper and less resource-intensive to manufacture, and open up a new path for more sustainable mass production of electronic products. It also makes it possible to manufacture semiconductor components accurately and efficiently with manageable wafer fab equipment investments.

"ALixLabs has been finalized a SEK1m Vinnova-funded project to verify the APS technology in the fabrication and electrical characterization of nanowire test transistor architectures this summer," notes R&D & operation manager Dr Amin Karimi.

"The strategy as we advance is to successfully transfer the APS technology to 300mm wafer processing and making it readily available for process demonstration for the leading IDMs and foundries," states CEO & co-founder Dr Jonas Sundqvist. "We don't only hope to cut cost in semiconductor manufacturing but also to reduce the energy and clean water demand and output of greenhouse gases during chip manufacturing considerably."

"We have more patent applications in the pipeline," concludes Suyatin.

www.alixlabs.com

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Palomar appoints new managing director for European operations

Retiree Josef Schmidl replaced by Thorsten Scheidler, sales director Europe for subsidiary SST Vacuum Reflow Systems

Photonics and microelectronic device assembly & packaging equipment maker Palomar Technologies Inc of Carlsbad, CA, USA has appointed Thorsten Scheidler as the new managing director for its European operations, effective 1 October. He replaces Josef Schmidl, who is retiring after more than 30 years with the firm.

Palomar says that Schmidl has been instrumental in opening up the European market to Palomar semiconductor packaging equipment and building the market.

Thorsten Scheidler.

He joined Hughes Aircraft in 1986 as a service and applications engineer. In 1995, Schmidl moved to sales and, two years later, he established the subsidiary Palomar GmbH in Erlangen, Germany. Since then, Schmidl has grown Palomar GmbH into an organization that provides sales and service support to customers in Europe, Russia, the Middle East, and Africa.

Thorsten Scheidler, sales director Europe for SST Vacuum Reflow Systems, has over 15 years of sales and technical support experience within the power electronics and semiconductor industries in Europe. He has been instrumental in implementing sales strategies for Palomar's subsidiary SST Vacuum Reflow Systems in the EMEA market.

www.palomartechnologies.com

MRSI launches MRSI-H1 and MRSI-HVM1 die bonders

MRSI-H/MRSI-HVM accuracy improved to 1μm

MRSI Systems (Mycronic Group) of North Billerica, MA, USA (which makes fully automated, high-precision, high-speed, flexible eutectic and epoxy die bonding systems) has launched the MRSI-H1 and MRSI-HVM1 die bonders with 1μm machine accuracy (to be available in the fourth-quarter 2022).

The MRSI-H1 and MRSI-HVM1 have been developed from the MRSI-H/MRSI-HVM platforms, further improving accuracy to the 1μm level and providing suitable solutions for increasingly demanding applications such as the mass manufacturing of silicon photonics and light detection & ranging (LiDAR). MRSI says that its die bonding solutions help customers to enable just-in-time supply and fast-pace innovations of critical components for high-growth market segments.

MRSI adds that the new products inherit the firm's tradition of combining accuracy, speed and flexibility to reduce NPI cost, improve production agility and hence increase return-of-investment for customers. They also come with MRSI's long proven product reliability and global customer support.

www.mrsisystems.com

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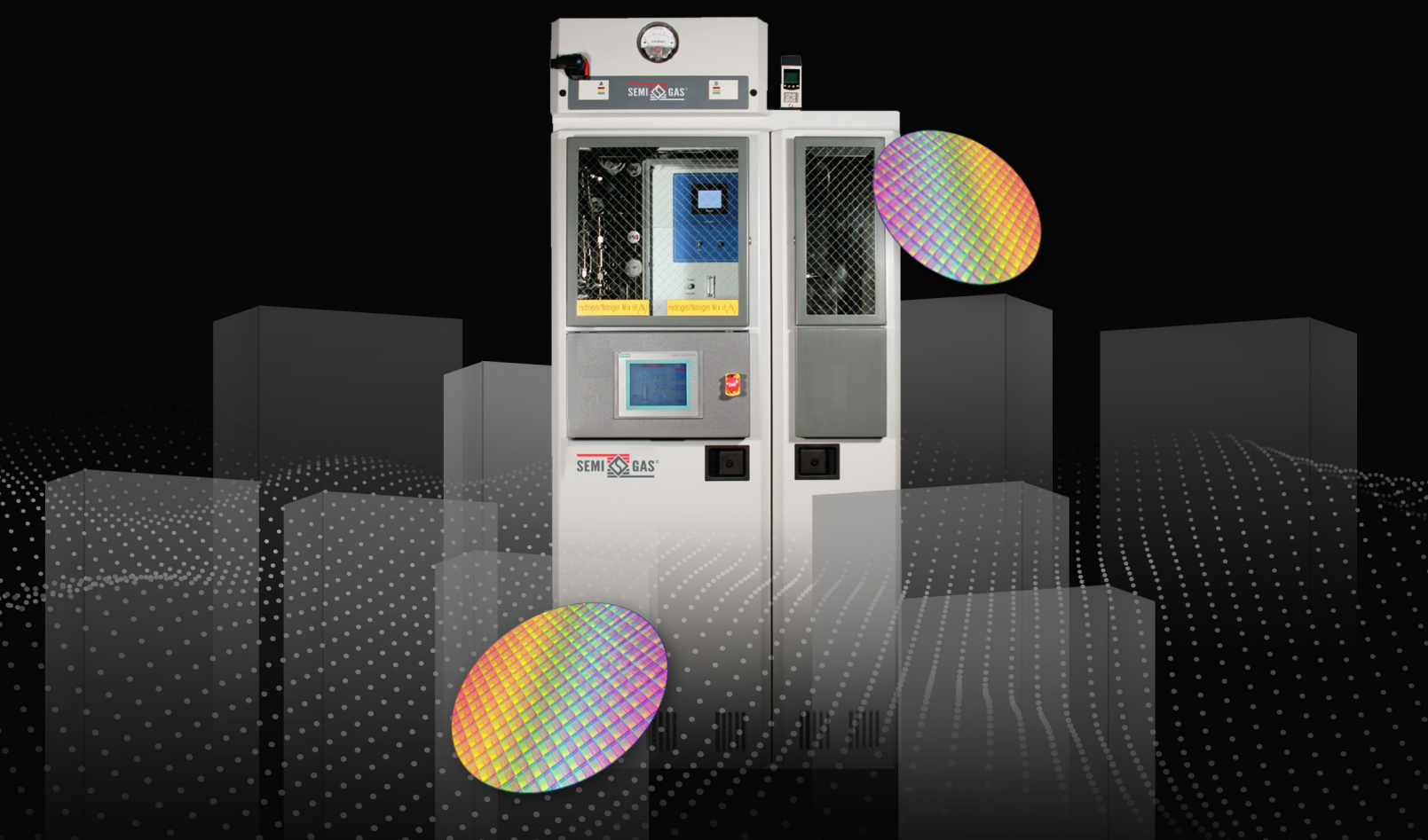

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Seoul Semiconductor alleges infringement of 12 LED patents by Feit

Permanent injunction sought against sales of lighting products

South Korean LED maker Seoul Semiconductor Co Ltd has filed a patent infringement lawsuit in the United States District Court for the Central District of California against the USA's largest light bulb maker Feit Electronic, asserting that Feit lighting products infringe 12 LED patents, and seeking a permanent injunction against the sales of those products.

Previously, in the Eastern District of Texas in 2019 and the Central District of California in 2020, Seoul Semiconductor secured permanent injunctions against several retailers selling Feit products.

However, the distribution of suspected infringing products has continued. For that reason, in 2022 Seoul filed a patent infringement lawsuit against a Feit distributor Ace Hardware, as well as a patent infringement lawsuit directly against

Feit, to cut off the distribution of products believed to be infringing Seoul's patents.

Seoul notes that it has a history of continually pursuing companies that infringe its patents. Based on Seoul's enforcement, in 2018–2019 the German District Court of Düsseldorf ordered multiple permanent injunctions and a recall of LED products made by Taiwanese LED package maker Everlight Electronics (the world's eighth largest LED maker). In June, Suwon District Court in Korea found Everlight guilty of criminal misappropriation of Seoul's trade secrets and industry technology, awarding the maximum criminal fines.

Seoul also prevailed in six-year litigation against Enplas Corp, the largest backlight unit (BLU) lens maker, when the US District Court for the Northern District of California ruled that Enplas willfully infringed Seoul's LED patent, and the US Supreme Court affirmed Seoul's victory in 2019. Civil damages by Enplas are still pending in another litigation.

www.SeoulSemicon.com

Seoul's Violeds UV-C disinfection applied to Genesis G90

Up to 99.9% of harmful germs removed within 10 minutes

UV-C LED lamps incorporating Violeds disinfection technology, developed by South Korean LED maker Seoul Semiconductor Co Ltd, have been installed in the armrest console box in the back of luxury sedan car maker Genesis' new model G90 (launched in first-half 2022) in order to disinfect passengers' belongings (in the aftermath of the COVID-19 era).

Depending on its models, 6–12 LED lamps are installed, eliminating up to 99.9% of harmful germs (E.coli, staphylococcus aureus, and pneumobacilli) in personal possessions within 10 minutes after the lid is closed (according to test results from Genesis' parent firm Hyundai Motor Company, validated by global testing and certification agency Intertek).

Violeds is a patented UV LED solution to prevent the growth of

Violeds UV-C LEDs applied in armrest console box of the Genesis G90.

germs and bacteria that was developed and applied by Seoul Semiconductor's subsidiary Seoul Viosys. According to 2021 data from market research agency Omdia, Seoul Viosys ranks first in the world in UV LED technology.

Seoul Viosys has developed air-sterilization solutions, as well as Violeds-based surface disinfection systems. In August 2021, the firm unveiled its solution to prevent the spread of the delta variant, since it is able to remove 99% of indoor airborne viruses. Based on the test results, at January's Consumer Electronics Show (CES 2022) in Las Vegas the firm demonstrated the process of disinfecting auto air-conditioning systems.

"Operating our own auto air and surface sterilization lab, we have done our utmost to further develop UV LED disinfection technology," says Seoul Semiconductor. "Acquiring the AEC-Q102 certification (the automotive LED reliability standard), Violeds technology will become an optimized solution for auto healthcare projects required by clients."

www.seoulviosys.com

Seoul Viosys demonstrates micro-LEDs at IFA

Stacked R/G/B structure enables high-resolution displays

At the Internationale Funkausstellung Berlin (IFA 2022) in Germany (2–6 September), ultraviolet LED product maker Seoul Viosys Co Ltd (a subsidiary of South Korean LED maker Seoul Semiconductor Co Ltd) presented micro-LEDs based on a laminated structure — which enables high-resolution displays — as well as its micro-LED display products.

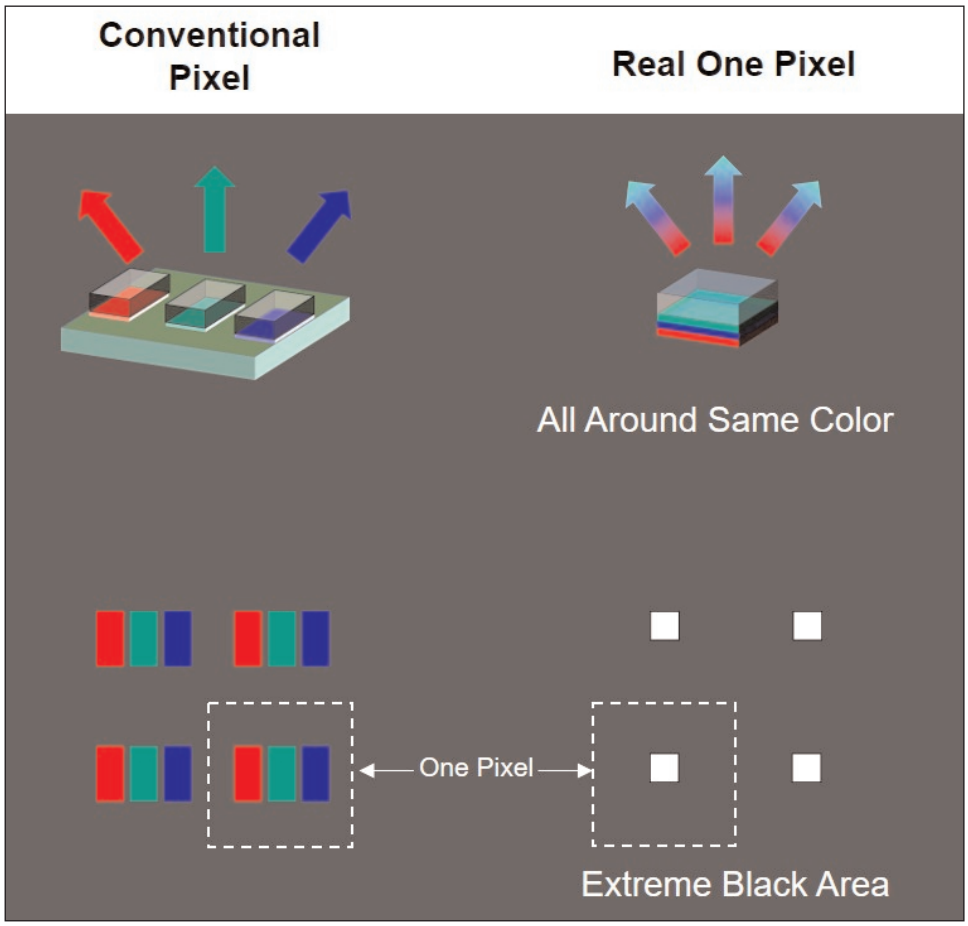
The stacked micro-LED has a unique structure in which three chips representing red, green and blue (R/G/B) are vertically arrayed instead of the usual horizontal array. The main difference from conventional micro-LEDs is that its R/G/B LEDs in the stacked structure emit colors as if they constitute a single pixel through perfect color mixing, it is claimed.

Seoul Viosys says that, due to the stacked structure, its micro-LED can achieve deep black color and a clear image. Also, as colors combining R/G/B are emitted externally from inside a pixel, viewers can see clear pictures without distortions from any direction, it adds.

The stacked micro-LED presented by Seoul Viosys at IFA is based on an innovative future technology that can manufacture 4K display screens between 100- and 200-inches. The company's booth exhibited two micro-LED displays, including a 54-inch high-resolution 0.625mm-pitch (P0.625) display and an 81.5-inch 0.9375mm-pitch (P0.9375) display.

Various products representing key production processes of Seoul Viosys's micro-LED, which had not been unveiled publicly, were also on display. By exhibiting epitaxial wafers and other products fabricated using high-level transfer technology for moving micro-LEDs to a display substrate, the firm will offer differentiated prices and quality, it is claimed.

In addition, Seoul Viosys exhibited its display LED techniques supporting its micro-LED technology (such as the molding technique that controls the moiré phenomenon) and highlighted details of the black color, the low-reflection technique that helps achieve vivid colors and high contrast ratios in the light, and the customized free form-factor design cabinet display that allows easy installation and replacement of micro-displays and change to various sizes.



Remarkable color mixing technique based on Seoul Viosys's technology.

As micro-LEDs must run stably on extremely low power, it is difficult to achieve technical innovation without LED growth technology. Seoul Viosys already owns quantum efficiency enhancement technology for 1μm-sized micro-LEDs through joint research with Nobel Laureate Shuji Nakamura, a professor at University of California Santa Barbara (UCSB) in the USA. The firm also operates entire processes, from the production of a red–green–blue light-emitting substrate to the manufacturing of devices and modules. Notably, WICOP (Wafer Integrated Chip on PCB), Seoul Viosys's original technology, was applied to its micro-LED. For producing micro-LEDs, WICOP enables the fabrication of micro-scale chips by using no additional parts such as wires. It also has high reliability due to process simplification.

"By securing WICOP, a source technology for micro-LED and mini-LED, and quantum efficiency enhancement technology, Seoul Viosys is now ready to address any customer requests," says president Hwang Jeong-hwan. "Seoul Viosys is introducing its products integrated for the purpose of providing a better solution to our customers, comprising LED, molding, and cabinet technologies," he adds.

https://b2b.ifa-berlin.com/en
www.seoulviosys.com

Lumileds' lenders agree debt reduction of $1.3bn, and $275m in loans

Voluntary Chapter 11 proceedings begun in USA and Netherlands

LED product and lighting maker Lumileds Holding B.V. has entered into a restructuring support agreement (RSA) with its major lenders to significantly de-leverage and strengthen its balance sheet by over $1.3bn (from about $1.7bn to $400m), consisting of takeback debt and post-petition loans, which will be combined into a five-year exit facility. Specifically, the agreement involves the injection of up to $275m of liquidity in debtor-in-possession (DIP) financing from certain lenders, in order to "accelerate the firm's growth and enable further investment in innovation to pursue additional strategic opportunities".

To efficiently implement the de-leveraging, a pre-packaged Chapter 11 plan involving only Lumileds' US and Dutch entities was filed on 29 August in the US Bankruptcy Court for the Southern District of New York. Lumileds' European, Asian and other foreign subsidiaries and affiliates were not included in the filing and are unaffected.

On 30 August, Lumileds received interim approval from the court for all the 'first day' motions related to the pre-packaged Chapter 11 filing. The approved motions immediately solidify the company's liquidity position and maintain global operations in their normal course throughout the financial restructuring.

As part of these motions, the court granted Lumileds access to the $275m DIP financing that, together with available cash reserves and cash provided by operations, should provide sufficient liquidity for Lumileds to continue meeting its ongoing obligations.

Specifically, Lumileds says that it will continue to deliver products and services to customers. The firm's vendors and suppliers will not be impaired and will be paid for all valid amounts owed as they come due. Also, employees will continue to receive their usual wages and benefits without interruption.

"Over the past few years, we have been hard at work transforming our cost structure and innovation pipeline, which has allowed us to capitalize more effectively on future market trends as a leader in the lighting industry," says Lumileds' CEO Matt Roney. "We have proactively taken steps to de-leverage our balance sheet, given the ongoing challenges presented by global supply constraints, COVID-related issues, and the crisis in Ukraine. This recapitalization will enable us to further accelerate our efforts as a market-leading innovator within the specialty lighting industry," he adds. "The most effective and efficient way to accomplish this is through a prepackaged Chapter 11 process that will be accompanied by a significant increase in our liquidity position. We appreciate the support of our lenders, who recognize the long-term value and enhanced potential Lumileds will create with a strengthened balance sheet."

"The approval of our first day motions is an important milestone in our recapitalization and financial restructuring efforts, which will allow us to operate in the normal course as we de-leverage our balance sheet and further position Lumileds to capture opportunities in the market and accelerate our growth," says Roney.

Lumileds expects to meet the requirements to emerge from the Chapter 11 process within about 60 days.

www.lumileds.com

Nichia's latest 280nm UV-C LED boosts flux by 80%

NCSU434C targets inactivation and sterilization of bacteria and viruses in industrial water and air

Nichia Corp of Anan City, Tokushima, Japan is starting mass production in December of another new high-radiant-flux UV-C LED to help target the inactivation and sterilization of various bacteria and viruses, specifically in industrial water and air applications.

With its small 3.5mm x 3.5mm size, the NCSU434C has what is claimed to be industry-leading radiant flux (110mW) and wall-plug efficiency (5.4%) compared with a UV-C LED of the same size, an ~80% flux improvement over its predecessor, enabling smaller and denser designs.

Nichia expects the NCSU434C to be implemented in various large-flow water and air disinfection equipment for inactivation of various viruses, including the new coronavirus and sterilization of bacteria. These levels of performance improvement further justify the immediate replacement of environmentally harmful mercury lamps with LED systems, Nichia reckons.

Nichia says that it aims to continue to develop not only deep-ultraviolet LEDs but also higher-power ultraviolet LEDs with improved performance to help solve various societal issues and to assist in achieving a mercury-free and carbon-free society through energy conservation.

www.nichia.co.jp/en/newsroom/2022/2022_09060

QustomDot and MICLEDI to co-develop polychromatic micro-LEDs via color conversion

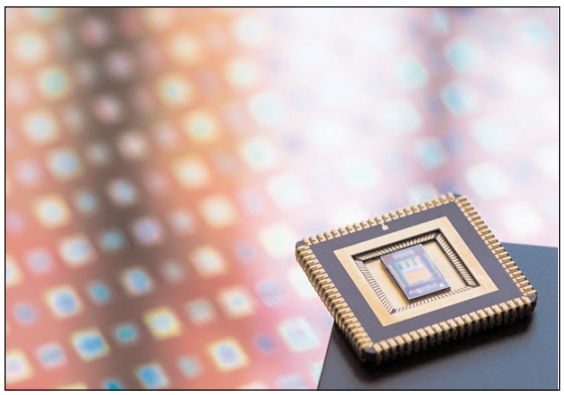
New color conversion solution driving growth of AR applications

Ghent University spin-off QustomDot (which combines quantum dot synthesis, surface engineering and ink/photoresist formulation into patterned color conversion layers for micro-LED displays) and MICLEDI Microdisplays B.V. of Leuven, Belgium — a fabless developer of micro-LED display modules for augmented reality (AR) glasses that was spun off from nanoelectronics research center IMEC in 2019 — have announced a joint development program to demonstrate full-color micro-LED integration in polychromatic pixel arrays.

MICLEDI's technology is based on a combination of III/V materials processing, 3D integration and 300mm silicon-based processing combined with a proprietary ASIC to provide a self-contained, compact monolithic AR display with high image quality and power efficiency.

The new technology addresses the growing demand for compact and energy-efficient micro-displays for AR applications.

New developments, such as this project, are supported by Flanders Innovation and Entrepreneurship (VLAIO). The Flanders-based consortium enables development of



Micro-LED arrays (blue GaN, 3μm pixel pitch) for polychromatic QD integration.

technology for micro-displays with high resolution and high brightness, combining:

- stable, RoHS-compliant quantum dot (QD) color conversion materials;
- a new micro-LED architecture tailored for high-efficiency color conversion;
- high-throughput QD transfer and patterning techniques on micron-sized pixels.

"Our patented method for producing RoHS-compliant QDs delivers high-quality and stable materials. This makes them effective for micro-LED applications, which will accelerate product development in this untapped market," reckons QustomDot's chief technology officer Willem Walravens.

"Polychromatic arrays are an important development for micro-LED products," says MICLEDI's chief technology officer Dr Soeren Steudel. "The manufacturing precision of MICLEDI's 300mm micro-LED approach is a perfect enabler for highly efficient color conversion. Our new pixel architecture has been optimized for high aperture (>60% aperture at a 3μm pixel pitch), which is a key requisite to achieve a high brightness with quantum dots," he adds.

"We are pleased to support the new micro-LED developments with IMEC's extensive technology background and know-how in the field of high-resolution patterning and transfer, states professor Geert Van Steenberge, R&D team leader at IMEC-UGent. "We will continue moving the state-of-the-art in pixel resolution, uniformity and process throughput."

www.micledi.com
www.qustomdot.com
www.imec.be

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NUBURU awarded USAF SBIR Phase II contract

NUBURU has been awarded an AFWERX Small Business Innovation Research (SBIR) Phase II contract by the US Air Force (USAF) to develop a blue laser-based 3D printing solution with area printing technology.

Established in 2017, AFWERX is the US Air Force's team of innovators who encourage and facilitate connections across industry, academia and the military to create transformative opportunities and foster a culture of innovation. Its mission is to solve problems and enhance the effectiveness of the service by enabling thoughtful, deliberate, ground-up innovation.

The goal of the new one-year project is to demonstrate improved speed and accuracy of a metal 3D printer based on NUBURU's blue laser technology. This new class of 3D printers will aim to offer micron-level resolution, increased part size and metal density, up to 100x build speed, with minimal to zero post-processing and part shrinkage.

"We are honored to bring the power of blue laser technology and next-generation 3D printing capabilities to the United States military through this contract," says CEO & co-founder Mark Zediker PhD. "By combining the absorption advantages of blue lasers with area printing technology, we aim to create larger-scale 3D printers that can offer up to 100x the printing speed of an infrared laser-based printer with full metal density. If we are successful, this could allow the military to build replacement parts for older aircraft that have been obsoleted by the original suppliers and can otherwise take months to procure. This would greatly diminish the time required to build and replace critical components and would allow aircraft to return to operational readiness more quickly," he adds.

"NUBURU has already pioneered metal welding applications within batteries, e-mobility and consumer electronics, and we are excited to continue expanding our capabilities into metal 3D printing, all with the same powerful blue laser technology," says executive chairman Ron Nicol. "This project will help to bring area printing, with its high-throughput capabilities and cost advantages, to key markets such as aerospace, automotive and more."

www.afwerx.com
www.nuburu.net

NUBURU raises $5m in convertible promissory notes

NUBURU Inc of Centennial, CO, USA (which specializes in high-power, high-brightness blue lasers for 3D printing and industrial use) has issued over $5m of convertible promissory notes and completed several milestones related to its merger (announced on 8 August) with Tailwind Acquisition Corp.

The notes provide immediate funding to maintain investment in the next-generation extreme-brightness AI laser product line and to pursue new technology development. Steps taken to build on the momentum of the proposed business combination transaction with TWND include adding a key capital markets advisor and completing diligence processes.

"Tailwind has completed its diligence, which was the final diligence-related milestone that could have triggered termination of the business combination," says NUBURU's CEO, co-founder & president Dr Mark Zediker. "We've removed a potential gating item to our merger and eliminated key conditionality relating to the business combination."

"In light of this successful financing, the previously announced funding agreement for up to $100m, and the absence of a minimum cash condition in our transaction, we remain excited about the opportunity this deal provides to both sets of stockholders," says TWND's CEO & director Chris Hollod. "We are continuing our positive momentum towards closing this deal in first-quarter 2023 [subject to stockholder approval and other customary closing conditions]."

The notes will convert into shares of NUBURU common stock immediately prior to, and subject to the occurrence of, the closing of the merger, which common stock will convert into common stock of the combined company at the closing. As stock holders of the combined firm, former holders of notes will also be eligible to receive shares of Series A preferred stock of the combined firm on the same terms as the TWND public stockholders. The conversion price is subject to an initial valuation cap of $350m for Nuburu as a private company.

Key milestones

TWND's sponsor (or one or more of its affiliates, members or third-party designees) has agreed to provide an incremental contribution to its trust account. TWND will contribute the lesser of $500,000 and $0.25 per share of common stock (not redeemed in connection with the extension) for the initial four-month extension ending on 9 January 2023, and the lesser of $50,000 and $0.025 per share for each of the two subsequent one-month extensions required to close the business combination.

Based on the combined anticipated financing sources including TWND's cash in trust (following redemptions), the preferred share structure designed to incentivize non-redemptions and the Lincoln Park Capital funding agreement for up to $100m (subject to the closing of the transaction and other conditions set forth in the purchase agreement between TWND, NUBURU and Lincoln Park Capital), the proposed transaction has no minimum cash requirement for closing.

BluGlass' Silicon Valley GaN laser fab now contributing to technical roadmaps

Short-loop development runs in progress after regulatory approvals

BluGlass Ltd of Silverwater, Australia — which has developed proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology for manufacturing devices such as laser diodes, next-generation LEDs and micro-LEDs for industrial, defence, display and scientific markets — says that its Silicon Valley production fab in Fremont, CA, USA now has several operational manufacturing processes for GaN laser diode development and is contributing to the firm's technical roadmaps.

GaN wafers shipped from BluGlass' Silverwater (NSW) facility have begun front- and back-end processing steps in the Silicon Valley fab, complementing and accelerating its contract manufacturing development.

The fab is also being utilized for short-loop development cycles, enabling BluGlass to test iterations of the key components of laser diodes — metals, facets and bonds — without requiring a full product. These in-house short-loops can be completed many times faster than processing cycles through contract manufacturers.

BluGlass' Silicon Valley GaN laser production fab.

BluGlass' Silicon Valley production fab has now been awarded all requisite regulatory approvals, including US Environment Protection Authority (EPA), air quality and waste management permits.

"Successfully bringing a semiconductor manufacturing fab online and up-to-speed in a new material class is an important milestone," says president Jim Haden. "Our captive fab is now contributing to our technical roadmaps, enabling us to speed product development while also reducing our cost base," he adds.

"By bringing core fabrication processes in-house, we reduce supply chain complexity and improve the quality and consistency of our laser diodes," continues Haden. "Each process we bring in-house is the equivalent of a specialist supplier being integrated into the business — reducing the complexity of co-ordinating efforts and problem-solving at multiple locations."

BluGlass says that it is steadily progressing towards commercial reliability with its 405nm and 420nm single- and multi-mode devices.

www.bluglass.com.au

BluGlass joins UCSB's Solid-State Lighting & Energy Electronics Center consortium

BluGlass has joined the University of California, Santa Barbara's (UCSB) Solid-State Lighting & Energy Electronics Center (SSLEEC) consortium, recognizing the firm's innovation in RPCVD epitaxy growth, novel laser architectures, and longer-wavelength GaN devices.

The SSLEEC is an invitation-only collaboration between industry leaders and UCSB's GaN researchers, including blue LED inventor and Nobel Laureate professor Shuji Nakamura and professor Steven DenBaars. The consortium focuses on developing new semiconductor technologies for energy-efficient lighting, disinfection, advanced mobile displays, augmented and virtual reality, communication, and power electronics. The SSLEEC works in collaboration and across scientific disciplines to address the most challenging problems in critical and timely areas of research.

The SSLEEC has been researching materials growth, simulation, characterization, device design and fabrication for high-efficiency LEDs and laser diodes for over 15 years. It is said to be one of the most successful business models between universities and industry partners in the sector, producing more than 150 patents over the past six years.

Consortium membership provides BluGlass with access to UCSB's faculty, facilities and specialist GaN researchers, which is expected to be invaluable in accelerating product development roadmaps for its blue and green laser diodes.

"We are delighted to be invited to join the world's leading GaN industry and academic consortium, which is a testament to the cutting-edge development being conducted at BluGlass," says the firm's president Jim Haden. "Our membership enables us to leverage the expertise of industry pioneers Drs Shuji Nakamura and Steven DenBaars; and to fast-track our advanced product roadmaps. It also enhances our credibility with potential customers and partners, reinforcing our expertise in GaN laser diodes," he adds.

II-VI changes name to Coherent Corp and launches new brand identity

Acquisition of Coherent Inc completed on 1 July

Engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA has announced the change of its corporate name to Coherent Corp as well as a new brand identity, after completing its acquisition on 1 July of Coherent Inc of Santa Clara, CA (which provides lasers and laser-based technology for scientific, commercial and industrial applications).

"We chose the name Coherent because it has the universal meaning of 'bringing things together', and an appeal that we believe will expand our brand recognition and ultimately lead to value creation," says Dr Vincent D. Mattera Jr, chair & CEO of Coherent Corp. "The broader meaning of the word coherent represents our diversity in thinking distilled into our clarity of purpose, our unity in action, and our broader sense of engagement by connection to our mission, vision, and values."

The new brand identity includes a new corporate logo that represents the atom, which is "foundational to what makes our products possible". The new name and brand identity reflect the combined company's strong heritage and long history while signaling a broadened scope and vision for the future, the firm adds. The organization will maintain II-VI's founding date of 1971 and its founding place and corporate headquarters as Saxonburg, Pennsylvania.

While the new corporate name and logo take effect immediately, the pre-merger companies' existing websites, social media platforms, and most product branding will continue for the near term as the transition to the new brand identity is executed over the coming months.

www.Coherent.com

II-VI extends CEO contract with Chuck Mattera to August 2030

II-VI Inc says that its board of directors, upon the recommendation of its Human Capital and Compensation Committee, has unanimously agreed to extend Dr Vincent D. 'Chuck' Mattera Jr's contract as CEO until 1 August 2030.

"Chuck's vision, energy and execution have driven our acquisition-related integration activities in the United States, Europe and Asia, thereby establishing additional growth engines that provide agility and sustainability to the company's operations," comments Dr Shaker Sadasivam, chairman of the Compensation Committee on the board. "His leadership has positioned the company into large and transformative global growth markets while continually increasing its worldwide reach, deepening its technology and IP portfolio, broadening its product roadmap and customer base, and building its brand as a market leader," he adds.

"I look forward with a great sense of mission to continuing to build on a strong record of excellence, to grow the company at a significant pace during this decade, and to set the stage for what may come next and beyond," says chair & CEO Mattera. "I recognize Dr Carl Johnson, the co-founder and first CEO of II-VI, and Fran Kramer, our chair emeritus and second CEO, along with members of our board of directors, our executive team, and employees around the world."

Mattera's long association with II-VI began when he initially served as a member of the board from 2000 to 2002. He joined the company as vice president in 2004 and served as executive VP from 2010 to 2013, when he became chief operating officer. Mattera was re-appointed to the board in 2012. In 2014, he became president & chief operating officer. In 2016, Mattera became the firm's third president & CEO in 45 years and continued as CEO when the roles of president and CEO were separated in June 2019. He was named chair & CEO in November 2021.

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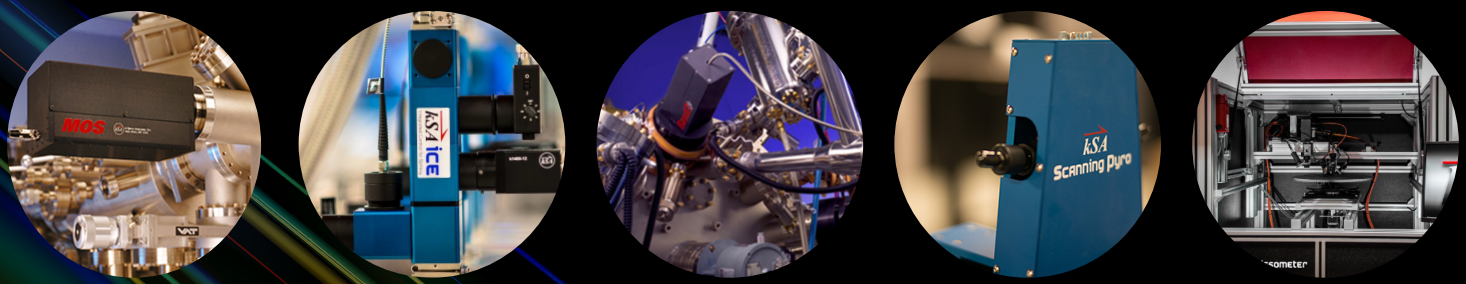

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TRUMPF introduces single-mode VCSEL platform for industrial sensing products

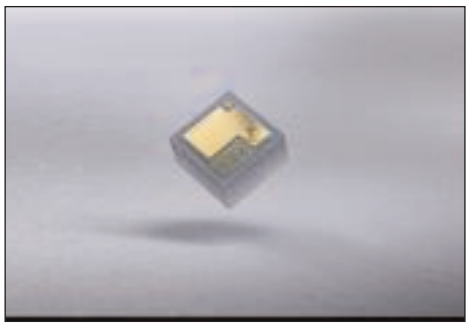
Multi-year contracts signed with leading players in oxygen sensing

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which manufactures vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for the consumer electronics, datacoms, industrial sensing, heating and automotive markets – has unveiled a new product platform for its single-mode VCSEL products for industrial and professional applications.

VCSELs for optical sensing in industrial applications or test & measurement equipment in laboratories must be efficient and highly accurate because of their role in quality management, being used in quality and safety monitoring systems. These needs are addressed with the new VCSEL platform. "It's great to see how the investments we made in the state-of-the-art manufacturing equipment are paying off, giving us optimum product and supply quality," says Ralph Gudde, VP marketing & sales. "Innovative product design and short product development cycles are addressing the rigorous demands on industrial applications, ranging from spectroscopic oxygen sensing to robust data communication links in CT scanners."

High output performance, but lower power consumption

The next generation of single-mode VCSEL products offers lower power consumption while maintaining high output performance, yielding higher energy efficiency. The single-mode VCSEL comes with a Gaussian-shaped beam profile and stable, linear polarization. The latter improves its illumination quality and resolution. Therefore, high-volume and highly integrated industrial applications are enabled with the new single-mode VCSEL, which is available in various wavelengths from 760nm to 855nm.



New product platform of single-mode VCSEL chip.

VCSEL suitable for industrial applications

Due to easy operation, temperature and wavelength stability, and polarization locking of the emitting light, TRUMPF says that its VCSEL products are suitable for industrial sensing technologies like spectroscopy and time-of-flight (ToF). "Our leading customers highly value our continuous investments and commitments in this industrial business," says Gudde. "We received several multi-year contracts from market leaders in oxygen sensing for our single-mode VCSEL solution in TO packages," he adds. For easy product integration in industrial environments and for the smart integration of additional features (such as temperature control), the VCSELs are available in various packaging options, such as hermetically sealed TO packages with TEC (thermo-electric cooler) and thermistor.

How the single-mode VCSEL serves many applications

VCSELs are used as a light source in various industrial processes and applications because they are highly reliable, and their light properties enable demanding sensing applications.

In industrial robots for example, optical encoders serve as high-precision position control sensors. With its high-quality Gaussian-shaped beam profile and polarization-controlled emitted light, the next-generation single-mode VCSEL serves this application as a coherent light source. The reliability of the single-mode VCSELs leads to a high service life of 10 years or more.

When it comes to in-situ measurements, VCSELs serve as reference lasers in FTIR (Fourier transform infrared) spectrometers, enabling the quick identification of compounds in the environment. FTIR analysis is used in automotive, pharmaceutical, biomedical or clinical fields. The wavelength and power stability over time make the VCSEL the perfect infrared light source for this application.

Another application field is in CT scanners in the medical field, in which the single-mode VCSEL serves as an optical link to read out detectors and, in doing so, replaces copper interconnects.

www.trumpf.com/s/VCSEL-solutions

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TRUMPF and KDPOF partner on components and networks for automotive datacoms

Firms working on new standards using 980nm VCSELs for greater robustness and service life

TRUMPF Photonic Components GmbH of Ulm, Germany (part of the TRUMPF Group) — which manufactures vertical-cavity surface-emitting lasers (VCSELs) and photodiodes for the consumer electronics, datacoms, industrial sensing, heating and automotive markets — and fabless semiconductor supplier KDPOF of Tres Cantos, Madrid, Spain — a supplier for automotive gigabit connectivity over POF (plastic optical fiber) — have become strategic partners on automotive datacom solutions.

Both companies pursue the goal of implementing optical data communication standards and solutions for the automotive industry, so they are combining their knowledge in the field of components and networks for optical data communication.

"With our strategic partnership we are going one step further and aim to establish VCSELs [vertical-cavity surface-emitting lasers] and optical networks as indispensable parts in future cars," says KDPOF's chief technology officer Rubén Pérez-Aranda. "Having a supplier like TRUMPF as a partner in working groups enriches the discussion with deep manufacturing and design knowledge of VCSEL and photodiodes components."

Autonomous driving cars benefit from VCSEL technology

Due to the push in the automotive sector towards autonomous driving, a large amount of data must be processed in cars. Consequently, optical interconnects are required to manage the data flow, acting as a nervous system connecting sensors and electronic brains, while meeting tight electro-magnetic interference requirements. "After a long-term cooperation, it's great to enter a strategic partnership with KDPOF now, combining our long-term expertise to shape the future of data communication within car networks," says Joseph Pankert, VP product management at TRUMPF Photonic Components. "Our long-term studies have already proven that 980nm VCSELs can operate at much higher temperatures while maintaining excellent reliability. This is exactly what the automotive industry is demanding, and therefore we support the movement towards a new, long-wavelength standard."

Demanding application in automotive sector

Compared with datacenters, automotive applications require not only a much wider range of operating temperatures (from –40°C up to +125°C) but also an interconnect length of even less than 40m. For superior robustness against wear-outs and random failures, the 980nm VCSEL is recognized as the preferred wavelength for the new standard. Next to performance characteristics, 980nm enters into existing OM3 fibers with only limited dispersion loss.

Official standard on its way

Both TRUMPF and KDPOF are participants in the IEEE P802.3cz taskforce. The current draft approved in IEEE 802.3 working group ballot for automotive optical multi-gigabit data transmission provides optical specifications that make use of reliable light sources based on proven longer-wavelength technology. Driver assistance and autonomous vehicle operation will benefit from equipment made of standardized components, it is reckoned. "The automotive industry is a very demanding," notes Pérez-Aranda. "The IEEE 802.3 standard is therefore focusing on highly reliable conditions that delivers a service life of 15 years and more."

TRUMPF Photonic Components exhibited at the 48th European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (19–21 September), where TRUMPF and KDPOF gavea joint presentation on '980nm VCSELs: New standard in automotive' on the market focus stage.

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Scintil Photonics completes second funding round with investment from Applied Ventures ITIC

Extra funds to expand global sourcing and accelerate market deployment in Americas and Asia–Pacific

Scintil Photonics of Grenoble, France and Toronto, Canada, a fabless developer of silicon photonic integrated circuits (integrated laser arrays, 800Gb/s transmitters and receivers, tunable transmitters and receivers, as well as optical I/O for near chip and chip-chip communication), has completed its second round of funding by securing additional investment from Applied Ventures ITIC Innovation Fund L.P., a fund jointly created by Applied Ventures LLC (venture capital arm of Applied Materials) and ITIC–Taiwan (Industrial Technology Investment Corporation, the venture capital arm of Taiwan's Industrial Technology Research Institute (ITRI). Robert Bosch Venture Capital (RBVC) led the original round in June, with support from historic investors Innovacom, Supernova Invest and Bpifrance (through its Digital Venture fund). With this new investment, the firm's total funding has reached €19m.

Scintil Photonics' IC solutions aim to significantly enhance traditional high-speed optical communications from rack-to-rack to chip interconnections. The firm's proprietary III-V Augmented Silicon Photonic Integrated Circuit (ASPIC) is a single-chip solution that uses standard silicon photonics processes (available at CMOS commercial foundries) with III-V optical amplifiers and lasers integrated on the backside of the silicon photonic circuits. This unique all-in-one integration enables ultra-high-speed communications, due to high parallelization and higher bit rates, e.g. from 800Gb/s to 3200Gb/s, helping the multi-billion-dollar electronics industry overcome the slowing of Moore's Law with the integration of very high-speed optical communications.

The company will use the additional funds to improve its global industrialization footprint and speed up the commercialization of its products in the Americas and Asia–Pacific.

"Scintil Photonics is very happy to welcome Applied Ventures and ITIC. By teaming with such strong semiconductor industry players we can access the very robust industrial ecosystem in the Americas and Asia-Pacific," says president & CEO Sylvie Menezo. "Their support will also bring great opportunities to deploy products to customers in those regions," she adds.

"Silicon photonics-based optical chips with integrated lasers represent a major new opportunity in the data-center, high-performance computing (HPC), cloud systems and telecom markets," believes Anand Kamannavar, VP & global head of Applied Ventures. "Scintil is a great example of our strategy to invest in the Materials to Systems stack. We are excited to be working with its team in advancing the technology with key market leaders in the HPC space," he adds.

Investment in Scintil Photonics presents "a huge opportunity for next phase integration of very high-performance systems in data-center and cloud computing," comments ITIC president & CEO Michel Chu. "This investment illustrates our commitment to supporting the most promising technologies worldwide."

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ELPHiC sampling InP integrated optics/electronics PIN receiver, eliminating APDs

Sampling dates for EML for 224Gb/s applications to be announced soon

Fabless firm ElectroPhotonic-IC Inc (ELPHiC) of Ottawa, Ontario, Canada, which provides indium phosphide (InP) optoelectronic chips, has made available samples of its integrated optics/electronics receiver. This follows sampling of its 10G 1271 laser for ONU applications (which has shown high reliability, the firm says).

ELPHiC has developed optoelectronic integration technology, leading to InP chips enabling higher performance, lower power consumption and increased reliability for lasers and PIN receivers. This integration eliminates the need for avalanche photodiodes (APDs), reducing the cost of the receiver.

ELPHiC will also soon announce sampling dates for its EML for 224Gb/s applications.

"By integrating key optical and electronic elements on the same InP semiconductor substrate with the analog amplification circuitry, we create an architectural shift in building optics chipsets that significantly improve performance and power, lower cost, and reduce module form factor," says CEO Jim Hjartarson. "Our patented PIN architecture also allows for sensitivity levels comparable to those of APDs," he adds.

"The demand for lasers and receivers from module manufacturers of PON and datacom markets has seen an unprecedented increase over the past three years," says Christian Ilmi, VP worldwide sales, who recently joined ELPHiC from the optical module manufacturing industry. "The recently announced government funding for PON deployments will add even more pressure to this demand. ELPHiC's timing for cheaper and more effective optics could not be better," he adds.

"Finally, the promise of monolithic integration of optical devices and electronics is coming to market," says Joe Costello, chairman of the board and a Silicon Valley veteran. "With the benefits of ELPHiC's technology, the performance of optical links in PON, data centers and other emerging innovative markets will take a giant leap forward."

www.elphic.com

III-V Epi produces InP-based telecoms laser structures for University of Surrey

Temperature-insensitive operation to eliminate cooling systems

III-V Epi Ltd of Glasgow, Scotland, UK — which provides a fast-turnaround molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) service for custom compound semiconductor wafer design, manufacturing, test and characterization — has produced experimental telecoms laser structures targeting temperature-insensitive operation. The epitaxy development was for the University of Surrey, funded by a UK Engineering and Physical Sciences Research Council (EPSRC) Impact Acceleration Account.

"The team at III-V Epi is helping us to develop robust and practical indium phosphide (InP)-based epitaxial wafers for telecoms lasers that eliminate the need for expensive, energy-hungry cooling systems," says lead researcher professor Stephen Sweeney at the University of Surrey, who is managing the project. "III-V Epi provided design and engineering expertise in the choice of material systems and manufacturability, which informed our design simulations," he adds.

Stephen Sweeney.

"III-V Epi went on to produce wafers by MOCVD for the university to process, test and further optimize. The resulting lasers will be a breakthrough in the industry, with this development enabled by III-V Epi's world-class service and expertise."

The University of Surrey is one of 36 institutions with an EPSRC Impact Acceleration Account, which provides rapid access to funds from UK Research and Innovation (UKRI) for knowledge exchange, innovation and impact — such as proof-of-concept, commercialization and market validation projects of this type.

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Vector Photonics hires operations manager

Vector Photonics Ltd of Glasgow, Scotland, UK says William 'Junior' Coyle has joined it as operations manager, helping to drive commercialization of its all-semiconductor photonic-crystal surface-emitting laser (PCSEL) technology for datacoms and adjacent optics markets.

Coyle has industrial, engineering management experience at medical, semiconductor, optoelectronic and gas sensing manufacturers.

"Junior is a highly experienced and well-respected, engineering manager and team leader," comments CEO Neil Martin. "He has extensive knowledge of operations, NPI [new product introduction], quality and process engineering. His experience includes many high-tech industries and spans the entire process, from defining project charters through to workstream planning, budgeting, risk analysis, testing and characterization," he adds. "He has exceptional analytical skills, which he has used for yield improvement, and he is conversant with all current regulations, standards and compliance responsibilities. He will play a critical role in the continued commercialization of our all-semiconductor PCSEL technology."

Coyle joins Vector Photonics from medical device manufacturer Terumo Aortic, where he led UK site development. Previously, he established a cleanroom environment at SST Sensing, as quality manager, increasing yield in aerospace oxygen sensors. He has also held senior engineering management roles at Intense, Alcatel and National Semiconductor.

Coyle has a Bachelor of Electronics from Paisley University and HNCs in Social Science, Meachatronics and Electronics from James Watt College. His industrial training includes a Green Belt in continuous improvement and lean manufacturing.

Darren Blair joins Vector Photonics as engineering technician

Vector Photonics says that Darren Blair has joined it as engineering technician, helping to design, develop and build test equipment that supports the commercialization of its PCSEL technology.

Blair has a PDA in Marine Management and HND in Marine Engineering from the City of Glasgow College. He is now doing a Graduate Apprentice in Engineering whilst at Vector Photonics, which will lead to a degree from Heriot Watt University.

"Darren joins Vector Photonics as a graduate apprentice. This is a new training route for the photonics industry, but one we hope unlocks a wider pool of available talent," says principal development engineer Dr Calum Hill. "Having had incredible responsibility at a young age, such as for the safe running of a ship alongside the duty engineer, the apprenticeship will help him develop his outstanding leadership and management skills," he adds.

"Darren learnt to operate and maintain onboard mechanical and electrical systems, including fault diagnosis, and produced scheduled maintenance reports for the chief engineer to log," Hill continues. "He completed his Standards of Training, Certification and Watchkeeping (STCW) qualifications for sailing ocean-going vessels."

www.vectorphotonics.co.uk

Principle development engineer presents paper at ECOC

In the 8th International Symposium for Optical Interconnect in Data Centres at the ECOC exhibition and conference in Basel, Switzerland (19–21 September), Vector Photonics' principle development engineer Dr Calum Hill gave an invited talk on 21 September on 'PCSELs at multiple wavelengths for high-bandwidth communications'.

Vector Photonics says that the invitation to present is a testament to the importance that its all-semiconductor PCSELs (photonic crystal surface-emitting lasers) can play in resolving many of the challenges faced by the datacoms industry as bandwidth requirements increase — namely power consumption, latency, physical connection size and costs. Senior executives from companies such as NVIDIA, ADVA, Infinera, Huawei, BT and IBM are presenting alongside Vector Photonics, as well as numerous universities from around the world.

"Hyperscale data centers require at least 800Gbs data transmission interconnects to keep up with growing demand for cloud services," says Hill. "This is at the limit of current pluggable optics technology. Vector Photonics' PCSELs more easily enable co-packaged optics solutions, where the optical functionality is integrated onto the ASIC (application-specific integrated circuit) to improve overall system performance, whilst reducing system energy consumption and cost," he adds.

"The CW (continuous wave) PCSELs, required for these bandwidths, operate in the O-band as a high-power seed laser for multiple data channels," continues Hill. "Their surface emission gives far better power scaling and beam divergence than conventional solutions, as well as simpler silicon photonics fabrication. Furthermore, the structure of a PCSEL is not dependent on the base epitaxy used, allowing PCSELs to be made at multiple different wavelengths for different communication needs."

Live demo at ECOC of Ayar Labs' SuperNova multi-wavelength optical source leveraging Sivers Photonics' CW-WDM-compliant DFB laser array

Sivers Photonics CTO presents 'Advanced InP DFB Laser Sources for Silicon Photonics Hybrid Integration'

At the European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (19–21 September), a joint live demonstration showcased Sivers Photonics' 8-wavelength distributed feedback (DFB) laser array integrated into the SuperNova multi-wavelength remote optical source of Ayar Labs of Santa Clara, CA, USA, whose integrated optical I/Os are targeted at artificial intelligence (AI), cloud, high-performance computing (HPC), 5G and light detection & ranging (LiDAR). Teams from Sivers Photonics and Ayar Labs will be available throughout the event to take attendees through the live demonstration.

As founding and promoter members of the Continuous-Wave Wavelength Division Multiplexing Multi-Source Agreement (CW-WDM MSA), the solutions from Sivers Photonics and Ayar Labs are both fully MSA compliant.

Established in 2020, the CW-WDM MSA was formed to standardize WDM CW sources in O-band for emerging advanced integrated optics applications that are expected to move to 8, 16 and 32 wavelengths. Such higher wavelength counts are needed for emerging applications such as AI, high performance computing and high-density optics, and enable a leap in performance, efficiency, cost and bandwidth scaling compared with previous technology generations. The silicon photonic die market is forecasted to grow to $1.1bn by 2026, according to the 'Silicon Photonics, Market and Technology Report 2021' by Yole Dévelopment.

In addition, on the Market Focus stage in the exhibition area, Sivers Photonics' chief technology officer Andrew McKee presented the talk 'Advanced InP DFB Laser Sources for Silicon Photonics Hybrid Integration'.

www.ecocexhibition.com
www.ayarlabs.com
www.sivers-semiconductors.com
www.cw-wdm.org

Sivers Photonics receives $1m follow-on order for optical sensing lasers

Total orders from Fortune 100 customer rise to SEK34m in 2022

Sivers Semiconductors AB of Kista, Sweden (which supplies chips and integrated modules) says that its subsidiary Sivers Photonics (formerly CST Global of Glasgow, Scotland, UK) has received a new order, worth $955,000 (about SEK10m), from its first established US Fortune 100 customer.

The order covers the design, development and supply of semiconductor laser devices for use in advanced optical sensing applications. Sivers Photonics has been working with this key customer for over three years.

"We are pleased to continue to contribute as key supplier to this customer, as we look towards supporting them with the volume production," says Sivers Photonics' managing director William McLaughlin. "This new order brings the total order value for this customer to approximately SEK34m during 2022," he adds.

"In 2022 we are exceeding record levels sales volumes for a single year with this Fortune 100 customer and orders now totaling over SEK130m in development fees since the start of the project," says Sivers Semiconductors' group CEO Anders Storm. "This order underpins the deep working relationship we have with this customer and yet again strengthen our belief in a favorable future volume phase."

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OIF members showcasing interoperability for critical networking technologies at ECOC

Record number of firms demonstrating interoperability in 400ZR; co-packaging architectures, CEI-112G & -224G and CMIS

During the European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (19–21 September), the Optical Internetworking Forum (OIF) hosted the largest ever interoperability showcase, with nearly 30 member companies participating in demonstrations in four critical areas: 400ZR optics, co-packaging architectures, Common Electrical I/O (CEI) architectures and Common Management Interface Specification (CMIS) implementations.

OIF experts also participated in the Market Focus program at ECOC, discussing its work in CMIS in one session, which defines current and future generations of management control for optical and copper modules, and a second session addressing the successful development of 400ZR optics, and OIF's work to define 800ZR/LR.

"The high level of participation in this year's interoperability demonstration at ECOC demonstrates the global importance of OIF's work and the collective efforts of its members to showcase how their solutions establish an ecosystem and work together to drive implementation of next-generation capabilities," says Mike Klempa of Alphawave IP Group, and chair of the OIF Physical & Link Layer Interoperability Working Group.

The interoperable optical networking solutions demo — live and static — at ECOC featured 28 OIF member companies (a record number of participants): Alphawave IP; Amphenol; Applied Optoelectronics Inc; Cadence Design Systems; Ciena; Cisco; Corning; Credo; EXFO; Fujitsu Optical Components; Juniper Networks Inc; Keysight Technologies; Lumentum; Marvell; MaxLinear Inc; Microchip Technology Inc; Molex; MultiLane Inc; Nokia; O-Net Communications; Senko Advanced Components Inc; Sumitomo Electric Industries Ltd.; Synopsys Inc; TE Connectivity; US Conec; VIAVI Solutions Inc; Wilder Technologies; and Yamaichi Electronics.

400ZR demo

OIF's 400ZR project is proving successful in facilitating new and simplified architectures for high-bandwidth inter-datacenter interconnects and promoting interoperability among coherent optical module manufacturers. This 400ZR interop demo shows a full implementation across an 80km DWDM ecosystem using multiple form-factor pluggable modules, 400GbE routers, a 75GHz C-band open line system, and test equipment solutions from multiple vendors. The demo provides evidence of widescale 400ZR deployment readiness based on a broad ecosystem of interoperable solutions.

Co-packaging demo

While individual companies consider options to optimize power and density, OIF has seen the need to lead industry standardization discussions for co-packaging architectures that promise to reduce power consumption and increase bandwidth edge density. OIF is leading the industry's interoperability discussions for co-packaging solutions and will showcase its progress with multi-party demonstrations of its 3.2T Module project and External Laser Small Form Factor Pluggable project (ELSFP). A variety of interoperable components that enable co-packaging will be shown, along with a system implementation.

This 400ZR interop demo shows a full implementation across an 80km DWDM ecosystem. The demo provides evidence of widescale 400ZR deployment readiness based on a broad ecosystem of interoperable solutions

Common Electrical I/O (CEI) demo

OIF says that it played a lead role in moving the industry to the next generation by developing electrical interface specifications for 112Gbps per differential pair. Multiple live demonstrations featuring interoperability amongst 14 participating members prove the critical role that OIF serves as well as the developing supplier ecosystem. The CEI-112G demonstrations in the OIF booth will feature multi-party silicon supplier interoperability over various channels, including mated compliance boards, PCB channels, direct attach copper cable channels, a cabled backplane and even fiber. Each configuration demonstrates the technical viability of 112Gbps operation, along with multiple industry form factors, including OSFP and QSFP-DD. The demo also shows a measured far-end eye diagram on an oscilloscope with analysis to show an example of the silicon signal integrity that is typically required going through the large variety of channels on display.

OIF says that, as the industry looks forward to higher data rates and increased throughput for the next generation of systems based on 224Gbps per lane, new specifications and technologies will be required. OIF, where the optical networking industry's interoperability work gets done, is leading the charge on 224G hardware interconnection application spaces and definitions, unveiling publicly at ECOC the first live 224G demo.

CMIS implementations demo

The Common Management Interface Specification (CMIS) is now established as the management interface of choice for next-generation pluggable modules, capable of managing both simple and advanced modules. CMIS provides a well-defined common mechanism to initialize and manage optical and copper modules while still providing the ability to support custom functionality. This commonality makes integration into different host platforms easier for both the host vendor and the module vendor. The CMIS demo consists of four separate demonstrations that show how modules can be managed and initialized, how modules can support multiple independent services (breakout) and how module firmware can be easily upgraded.

OIF @ ECOC 2022 Market Focus

- *'CMIS – Management control of optical modules'* by Gary Nicholl, Cisco, OIF Physical & Link Layer Working Group Management co-vice chair, secretary/treasurer and board member.

CMIS addresses the industry's need for commonality in managing pluggable modules, and it has been widely and successfully adopted across the industry. As the complexity of pluggable modules continues to increase and the industry continues a trend towards third-party pluggable modules, the management interface is becoming as important an interoperability interface as the electrical and optical interfaces (where the OIF has been actively involved for many years). This session provides a high-level overview of CMIS, explains the reasons why the effort was transferred to the OIF, discusses the current status of CMIS within the OIF and highlights some of the new CMIS features that the OIF will be working on during the upcoming year, such as adding support for co-packaging/External Laser Small Form Factor Pluggable (ELSFP) projects and electrical link training.

400ZR coherent deployment is underway, showing that a strong ecosystem already exists for this new interoperable standard developed by the OIF. An OIF expert gave an overview of 400ZR and discuss its deployment status, including continued optimization

- *'Deployment of 400ZR and the ongoing OIF work to define 800ZR/LR'* by Karl Gass, OIF Physical & Link Layer Working Group Optical vice chair.

400ZR coherent deployment is underway, showing that a strong ecosystem already exists for this new interoperable standard developed by the OIF. In this presentation, an OIF expert gave an overview of 400ZR and discuss its deployment status, including continued optimization. The presentation then gave an overview of current 800ZR and 800LR technical work to create the next core network architecture components and bring coherent networking into the data center.

www.oiforum.com
www.ecoc2022.org

POET participates in multiple sessions at ECOC

Focus on passive alignment of lasers on Optical Interposer platform

POET Technologies Inc of Toronto, Ontario, Canada — a designer and developer of the POET Optical Interposer and photonic integrated circuits (PICs) for the data-center and telecom markets — says that representatives from the firm participated at the European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (18–22 September), where the company also exhibited.

In the session 'Non-Linear Devices and Packaging', principal engineer Dr Simon Goh is presenting a paper on the passive alignment of lasers on the POET Optical Interposer.

A concurrent symposium 'Hybrid Integration of III-V Devices with Silicon-based Waveguides (Si, SiN, SiO_2)' was co-organized by POET technical staff member Dr Lucas Soldano. Chairman & CEO Dr Suresh Venkatesan was also a participating speaker.

Additionally, Dr Michal Lipson, professor of physics at Columbia University and a nominee to POET's board of directors, led a tutorial 'The State of the Art and Challenges of Silicon Photonics Today'.

"Hybrid Integration is one of the critical and important topics of discussion among professionals in the photonics industry today," says Venkatesan. "It is widely understood that neither conventional discrete assembly nor conventional silicon photonic integrated circuits (PICs) are up to the challenges of scalability in volume, cost and power consumption that are required for increasing speeds and bandwidth in data and telecommunications, much less the high-volume applications for photonics in optical computing, wearables and automotive LiDAR [light detection & ranging]," he adds. "We recognized these challenges years ago, which is why the POET Optical Interposer is the only true hybrid wafer-level, chip-scale platform that integrates electronic and photonic devices in a fully CMOS-compatible assembly process that meet these challenges and is available today to companies that need integration solutions."

www.ecocexhibition.com
www.poet-technologies.com

Lumentum exhibits optical communication portfolio at ECOC 2022

Spotlight on telecom solutions and laser chips for next-generation mega data centers

In its own stand as well as partner OIF's stand at the European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (18–22 September), Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) participated in eco-system partner demonstrations and highlighting its portfolio of optical communication solutions for current and future network applications, as detailed below.

High-speed optical transmission portfolio

Lumentum's suite of 100–800Gbps optical components provides performance-optimized discrete components, narrow-linewidth lasers, high-baud-rate coherent modulators and receivers, as well as integrated components for QSFP-DD, OSFP, CFP2 and other small-form-factor pluggable coherent transceivers.

● *Ultra-narrow-linewidth nano-Integrable Tunable Laser Assembly (nITLA)*: Lumentum continues to scale production of its nITLA product line, leveraging the advantages of its external-cavity-based laser into a compact form factor critical for coherent modules. Low power consumption, superior phase noise performance and compact size ensure that the nITLA can support long-reach and higher-baud-rate applications for the next generation of coherent transmission systems.

● *Digital coherent optics (DCO) modules*: Leveraging its optics and depth of vertical integration, Lumentum delivers DCO modules for customers seeking turnkey solutions that support transmission rates of 100–400Gbps. The firm says that it effectively balances cost, power and performance using open-standard and proprietary forward-error correction (FEC) to support campus, data-center interconnect (DCI), long-haul, and metro-ROADM mesh network applications.

Lumentum is in the final stages of completing a significant increase in 10G T-SFP+ manufacturing capacity to support the transition of MSOs from hybrid fiber coax to distributed access architecture

● *Tunable transceivers*: Lumentum is in the final stages of completing a significant increase in 10G T-SFP+ manufacturing capacity to support the transition of multi-service operators (MSOs) from hybrid fiber coax to distributed access architecture. Upgrading to a single tunable module from fixed modules simplifies service providers' logistical management and reduces overall operational costs. Lumentum's tunable transceiver portfolio also includes TSFP28 solutions that support 25G data rates for expanded capacity, placing it in a leading position to fulfill market demand for these products in 5G wireless front-haul applications.

400ZR transceivers designed into OIF 400ZR interoperability and Common Management Interface Specification (CMIS) demonstrations

● *400ZR interoperability demo*: Lumentum demonstrated 400ZR transceivers in switch/router ports and test equipment in both QSFP-DD and OSFP form factors, transmitting over an amplified 75GHz-spaced DWDM optical link compliant with the OIF 400ZR Implementation Agreement (IA). The firm's 400ZR transceivers provide connectivity in DCI and other applications at a data rate of 400Gbps. The electrical, thermal and communications interfaces comply with the OIF 400ZR IA and QSFP-DD/OSFP MSAs and work with the current generation of switches and routers supporting QSFP-DD and OSFP transceivers enabling direct IP over DWDM for customers looking to expand capacity and reach.

● *CMIS implementations demo*: Additionally, Lumentum 400ZR transceivers will be demonstrating the new benefits of CMIS control through firmware upgrades via common data block commands and coherent diagnostics via the flexible coherent CMIS versatile diagnostic monitoring interface.

Enhanced and expanded telecom transport solutions

● *Multiplexers, demultiplexers and multi-cast switches*: Lumentum offers a complete line of multiplexer, demultiplexer and multicast switch solutions as part of its comprehensive subsystems portfolio.

● *High-port-count TrueFlex Twin WSS platform*: Lumentum's Twin WSS platform offers enhanced performance. Advancements to its core technology, manufacturing processes and supply chain robustness drive cost-effective volume production within Lumentum's manufacturing facilities. The platform delivers a uniformly high standard of performance and supports multiple port configurations. As the platform maintains form-factor compatibility with existing products, customers can rejuvenate and refresh their system's capabilities over its lifecycle for the decade ahead.

Laser chips for next-generation of mega data centers

Hyperscale data centers continue to scale, driving demand for next-generation speeds. Lumentum offers a range of laser solutions to address data-center networking, artificial intelligence (AI) and machine learning (ML) cluster networking, and optical I/O needs.

● *200G PAM4 externally modulated lasers (EMLs)*:
By leveraging Lumentum's EML chips, customers can deliver high-speed modules in high volumes while reducing costs and power per bit. Lumentum's 200G EMLs are sampling today and are expected to be in volume production by early 2023.

● *100G PAM4 directly modulated lasers (DMLs)*:
Designed for rigorous and cost-effective applications, Lumentum's DMLs for 2x400G FR4 and 400G DR4/FR4, and 800G DR8/PSM8 improve bandwidth from previous generations. These compact chips enable lower costs and complexity relative to comparable silicon photonics (SiPh)-based transceivers. Beta samples are available now.

● *CW lasers*:
Lumentum is sampling a range of optical power CW lasers to support SiPh-based transceiver applications and external laser sources (ELS) for co-packaged optics (CPO) solutions. Utilizing its indium phosphide (InP) technology platform, Lumentum offers high-volume 40mW CW lasers. Additionally, the firm's new 75mW laser integrates an on-chip semiconductor optical amplifier, allowing it to cover 2x100G lanes at high temperatures for next-generation data-center applications. With its 350mW ultra-high-power CW lasers, Lumentum is a provider of CPO applications; limited sampling is available now.

Beta samples of Lumentum's 100G VCSELs are expected to be available in 2023 at 850nm, 880nm, 910nm and 940nm wavelengths and support parallel and shortwave wavelength division multiplexing

● *Vertical-cavity surface-emitting lasers (VCSELs)*:
Beta samples of Lumentum's 100G VCSELs are expected to be available in 2023 at 850nm, 880nm, 910nm and 940nm wavelengths and support parallel and shortwave wavelength division multiplexing (WDM) applications, including 64GFC and 128GFC, extended-temperature 50Gbps, and cost-effective active optical cables. For 25G NRZ and 50G PAM4 applications at 850nm wavelength, Lumentum's VCSELs are available now and shipping in volume with high production capacity to meet strong demand from the cloud market. In addition, Lumentum's high-bandwidth, wide-wavelength-range indium gallium arsenide (InGaAs) PIN photodiodes for multimode receivers at data rates up to 100Gbps are available today.

www.lumentum.com

Lumentum presents solutions at ECOC

Addressing high-speed optical transmission, as well as workplace diversity and inclusion

At the European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (18–22 September), several of Lumentum's thought leaders presented on a wide range of topics, including solutions for current and future optical network applications as well as creating diversity, inclusion and belonging within the workplace.

Workshops and papers presented at ECOC 2022 included the following:

● 'Tunable optics for front-haul networks' — Moving from optical components in RAN to optical components for RAN Workshop. Speaker: David Lewis, Lumentum technologist, Optical Communications.

● 'Diversity in action: creating a diverse and inclusive workplace, a place for all to belong' — Special Workshop.
Speaker: Janet Wong, Lumentum independent board director; panel chair: Grace Lee, Lumentum executive VP, chief human resources officer; workshop organizer: Selina Farwell Ph. D., Lumentum senior principal chip engineer, Transmission.

● 'High Power, Circular Beam CW DFB Laser using BEX Layer' — paper.
Speaker: Shoko Yokokawa, Lumentum senior engineer, Laser Semiconductor.

● 'Silicon Photonics IQ Modulator Targeted for 800ZR Data Center Interconnection' — paper.
Speaker: Jian Wang, Lumentum principal design engineer, Telecom.

● '420Gbps PAM8 Operation Using 93GHz Bandwidth Lumped-Electrode Type EA-DFB Laser at 50°C beyond 400Gbps/lane' — paper. Speaker: Hideaki Asakura, Lumentum specialist, R&D device, Datacom.

● 'Superior Lowest TDECQ (3.3dB at 106Gbps, 4.4dB at 112Gbps) under PAM-4 Operation at up to 85°C with High Extinction Ratio (4dB) in 1.3μm Uncooled Directly Modulated InGaAlAs MQW-BH Lasers' — paper.
Speaker: Kouji Nakahara, Lumentum senior engineer, R&D device, Datacom.

www.ecocexhibition.com

Lumentum's 200G PAM4 externally modulated lasers win ECOC Data Center Innovation/Best Product Award

Latest 200G EMLs enabling transition to 800G and 1.6T for next-generation data centers

Lumentum Holdings Inc of San Jose, CA, USA (which designs and makes optical and photonic products for optical networks and lasers for industrial and consumer markets) says that its 200G PAM4 externally modulated lasers (EMLs) has received the Industry Awards for the Data Center Innovation/Best Product category at the European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (18–22 September).

Hyperscale cloud operators need reliable, low-power and low-cost solutions that enable higher-speed data links within their next-generation data centers. Lumentum says that its first-to-market 200G PAM4 EMLs leverage 30 years of technology expertise to deliver industry-leading performance and quality to data-center operators seeking to scale their data centers for future needs.

"Lumentum has led the industry through multiple generations of increased intra-data-center transmission rates leveraging market-leading innovation and exceptional quality," claims Wupen Yuen, senior VP & general manager, Datacom. "We are excited to work with customers and data-center operators to accelerate their transition to the next generation of switching and architectures with our 200G PAM4 EMLs."

Lumentum manufactures EMLs in its internal high-volume indium phosphide (InP) wafer fab in Japan. Its EMLs are photonic integrated circuits that consist of a distributed feedback laser (DFB) monolithically integrated with an electro-absorption modulator (EAM), providing a single high-performance laser transmitter chip. Providing high modulation bandwidth and excellent extinction ratio, Lumentum's 200G PAM4 EMLs minimize input voltage swings to reduce the power consumption of related ICs. They provide what is claimed to be superior waveform quality for PAM4 and the potential for PAM6 or PAM8 operation, resulting in an even higher transmission capacity than 200G per wavelength. Lumentum is planning CWDM and LAN-WDM 4-channel support for various system architecture needs.

The 100G PAM4 EMLs are in volume production and already leading the transition to bit rates of 400G and 800G, says Lumentum. The latest 200G EMLs will enable the transition to 800G and 1.6T for next-generation data centers.

www.ecocexhibition.com
www.lumentum.com/en/optical-

MACOM appoints Jihye Whang Rosenband to board

Independent director Gil VanLunsen retires after 12 years on board

MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes analog RF, microwave, millimeter-wave and photonic semiconductors, components and subassemblies) has appointed Jihye Whang Rosenband as an independent director to its board of directors, serving on its Audit and Nominating & Governance Committees. Her appointment is the culmination of a search process led by the board's Nominating and Governance Committee, which involved over a dozen potential candidates.

Rosenband has over 20 years of semiconductor and technology industry experience in various advisory, management and engineering roles. Most recently, she was CEO of SPGL Acquisition Corporation. She has been an independent advisor to various companies in the semiconductor and information technology sectors since 2017. Earlier in her career, Rosenband served in various corporate strategy, business development and engineering roles at HPE Aruba Networks, RPX Corp, MACOM and Hittite Microwave Corp. She holds a B.S. and M. Eng. in Electrical Science and Engineering from Massachusetts Institute of Technology and an MBA from Stanford University.

"Jihye has outstanding business acumen and her extensive experience in compound semiconductors, as well as in the hardware and information technology industries, will greatly benefit our board," comments chairman John Ocampo. "She has an established track record of success at both management and executive levels, and we look forward to her future contributions."

MACOM also announced that independent director Gil VanLunsen will be retiring from its board, effective 31 January 2023. VanLunsen has served as a director on the board since August 2010. During his 12-year tenure, he has provided leadership and insights on accounting, financial and governance matters.

"I would like to express my sincere gratitude and thanks to Gil for his many contributions to MACOM and I congratulate him on his distinguished career," comments Ocampo. "Gil's leadership and steady guidance have been instrumental to our growth and to the creation of stockholder value."

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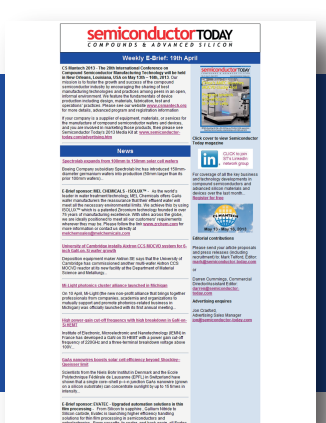

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Source Photonics' telecom-grade 400G QSFP-DD and 100G QSFP28 PAM4 products win ECOC Industry Award for Optical Transport

OTU dual-rate 100G and 400G transceivers extends applications of client optics from cloud data centers to optical transport markets

At the European Conference on Optical Communications (ECOC 2022) in Basel, Switzerland (19-21 September), Source Photonics Inc of West Hills, CA, USA (which provides optical connectivity products for hyperscale data-center and optical transmission applications) has won the 2022 Industry Award in the category of Optical Transport for its family of telecom-grade 400G QSFP-DD and 100G QSFP28 PAM4 products for dual-rate OTU transmission.

ECOC created the fiber communication industry awards in six categories to put the spotlight on technology and product commercialization within the industry. The awards recognize and highlight key industry achievements in advancing optical components, photonic integration, optical transport, networking, data-center innovation and FTTx access.

"The availability of the OTU dual-rate 100G and 400G transceivers extends the applications of client optics from cloud data centers to optical transport markets with fast-switching protection, while improving the link performance and reducing the power consumption at the same time," says chief engineer & chief technology officer Dr Frank Chang. "This represents a significant breakthrough for extending 100G PAM4 technology into OTN transport area, and this award is a testament of our continued commitment and leadership position in optical transport market. Now service providers can connect routers directly to optical transport networks without client interfaces, and this type of network architecture achieves huge savings in upfront costs and ongoing expenses," Chang continues.

At the ECOC exhibition, along with its industry partners, Source Photonics showcased live demonstrations of its 100G QSFP28 and 400G DR4 QSFP-DD OTU dual-rate transceivers running error-free operation with OTN traffic.

"VIAVI Solutions has a long tradition of working with Source Photonics to help them design, demonstrate and release next-generation transceiver products to market," says director, Viavi Lab & Production Strategy, VIAVI Solutions. "We jointly demonstrate the OTN capabilities at 100G and 400G PAM4 using VIAVI's ONT-800 platform. Using the comprehensive traffic generation and analysis capabilities of the ONT, it demonstrates 400G OTN traffic can be successfully transmitted over optical fiber using Source Photonics' client optics, and they fully aligned with the appropriate OTN standards," he adds.

"We are pleased to partner with Source Photonics to demonstrate our state-of-art 7nm Centenario 112G PAM-4 DSP operating inside 100G QSFP28 transceivers at OTU rates with fast locking capability," says Khushrow Machhi, senior director of marketing of the Physical Layer Products Division at Broadcom, "Broadcom continues to innovate and drive new requirements of 100G PAM-4 DSP to satisfy the unrelenting quest for optical transport applications that will enable the industry-leading 100G PAM4-based modules for service provider and carrier OTN networks," he adds.

This represents a significant breakthrough for extending 100G PAM4 technology into OTN transport area... Now service providers can connect routers directly to optical transport networks without client interfaces

"This is a well-deserved recognition for a company that has long been at the forefront of optical transport technology and we take great pride that the company selected the Marvell Porrima PAM4 DSP for its telecom-grade 400G QSFP-DD DR4/FR4 module," says Xi Wang, VP of marketing, Optical Connectivity at Marvell. "The Porrima PAM4 DSP delivers unprecedented levels of performance and power efficiency for both service providers and emerging performance-centric applications at the network edge. Innovations in optics continue to play a fundamental role in the evolution of the cloud and we look forward to further collaboration with Source Photonics," he adds.

"We're pleased that our SN solutions are featured in their 400G PAM4 OTN demo at ECOC," says Yohei Sato, VP of sales, SENKO, "The SN connector is a perfect fit for 400G QSFP-DD DR4 transceivers that can double transceiver faceplate density and support the future exponential bandwidth demand in the service provider market."

"Source Photonics understands what service providers need right now, and it has responded with high-performance PAM-4 DSP-based transceiver solutions to meet those needs," comments Andrew Schmitt, founder & directing analyst at Cignal AI. "Source Photonics' PAM-4 technology can extend to support OTN connections outside of the cloud data center to deliver a highly integrated, cost-effective solution that is easy to assemble."

www.sourcephotonics.com

Source Photonics receives ECOC Industry Award for 50G PAM4 SFP56 transceivers for 5G front-haul wireless deployment

50Gbps SFP56 optical modules empower next-generation cost-effective front-haul connectivity

At the European Conference on Optical Communications (ECOC 2022) in Basel, Switzerland (19–21 September), Source Photonics Inc of West Hills, CA, USA (which provides optical connectivity products for access and datacom applications) has received the 2022 Industry Award in the category of Innovative FTTx products.

ECOC created the fiber communication industry awards in six categories to put the spotlight on technology and product commercialization within the industry. The awards recognize and highlight key industry achievements in advancing optical components, photonic integration, optical transport, networking, data-center innovation and innovative FTTx products.

To meet the most pressing bandwidth requirements of global 5G customers, Source Photonics officially released the 50G PAM4 SFP56 product for upgrading 5G front-haul networks from March. The initial products are 50G LR and FR PAM4 transceivers using analog CDRs, which supports 10km and 2km transmission distances. The 50G SFP56 achieves 50% port savings by upgrading the rate of one 25Gb/s eCPRI transceiver to 50Gb/s, creating flexibility for further improvement of wireless forward bandwidth. This is claimed to be the industry first in product commercialization to apply PAM4 signaling into analog CDR (clock & data recovery). The product meets the range of industrial temperature applications with power consumption of as low as 1.5W.

As global operators accelerate the deployment of 5G networks, promote the differentiated application of 5G multi-services and release more spectrum resources, 5G networks present higher bandwidth requirements for front-haul. Source Photonics has subsequently extended the SFP56 product portfolio to cover 50GBASE-LR, 50GBASE-ER, 50GBASE-BR10, 50G CWDM6, 50GBASE-BR40 and other optical interfaces. The application scenarios range from 10km to 40km, from dual fiber to single fiber with bi-directional transmission and from multiple rate support for backward compatibility with prior generations of 25G SFP28 and 10G SFP+ optical transceivers.

The product series use the 25G DFB (distributed feedback) laser developed in house by Source Photonics to provide low power consumption, short latency, and cost-effective transceiver solutions for 5G front-haul networks. Source Photonics says that it has conducted in-depth cooperation with the world's leading 5G equipment manufacturers, and that qualification has been progressing smoothly. The initial deployment of SFP56 is expected to ramp up volume in 2023.

Source Photonics' product portfolio of SFP56 transceivers for 5G front-haul includes:

- SFP56 50GBASE-LR: 50G PAM4 DML design, supports 10km transmission, compliant with IEEE P802.3cd standards;
- SFP56 50GBASE-BR10: single fiber with bi-direction transmission, supports 10km transmission, compliant with IEEE P802.3cp standards;
- SFP56 50G CWDM: supports six CWDM wavelengths with extended temperature, compliant with ITUT-G.695 CWDM definition, supports 10km transmission;
- SFP56 50GBASE-ER: 50G PAM4 EML design, supports 10km transmission, compliant with IEEE P802.3cd standards;
- SFP56 50GBASE-BR40: single fiber with bi-direction transmission, supports 30km and 40km transmission, compliant with the IEEE P802.3cp standards.

Source Photonics at ECOC 2022 exhibition

At the ECOC exhibition, Source Photonics showcased a live demonstration of its full family of 50G SFP56 transceivers with Multilane's ML4079E BERT platform.

www.ecocexhibition.com
www.sourcephotonics.com

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Coherent launches 200G InP EMLs for high-speed data-center transceivers

Electro-absorption modulated lasers target transceiver modules operating at 800Gbps (4 lane) and 1.6Tbps (8 lane)

Coherent Corp of Saxonburg, PA, USA, which provides photonics technology for communications and aerospace & defense applications, has launched its 200Gbps indium phosphide (InP) electro-absorption modulated lasers (EMLs) for high-speed data-center transceivers.

The growing demand for 400G and 800G transceivers and the anticipated demand for next-generation 1.6Tbps transceivers for intra-data-center communications are rapidly driving a technology shift toward advanced EML devices that maintain transmission reach at higher bit rates. Coherent says that its EML devices are designed for high reliability and high signal integrity, enabling transceiver modules operating at data rates of 800Gbps (with 4 lanes) and 1.6Tbps (with 8 lanes) for the explosive growth in high-speed data-center connectivity.

"We developed a high-performance EML chip with a monolithically integrated electro-absorption modulator and laser that can be mounted in a low-cost non-hermetic package. This design provides our customers with the most advanced, robust and cost-competitive laser devices for their 800G and next-generation 1.6T datacom transceiver designs," says Dr Karlheinz Gulden, senior VP, Laser Components & Subsystems business unit. "Our world-class and highly reliable InP technology platform is 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 new EML devices enable the 800Gbps transceivers of today and the 1.6Tbps transceivers of tomorrow."

Coherent's portfolio of InP components includes application-specific Fabry–Pérot lasers, directly modulated lasers (DMLs) and tunable lasers. It also includes photodiodes for high-speed receivers and power monitoring.

www.Coherent.com

Coherent's 400G ZR+ QSFP-DD-DCO transceiver wins ECOC Industry Award for Optical Integration

Output power of 0dBm enables IP-over-DWDM in metro and regional optical transport networks

Coherent's 400G ZR+ QSFP-DD-DCO optical transceiver won the Industry Award for Optical Integration at the European Conference on Optical Communication (ECOC 2022) in Basel, Switzerland (19–21 September).

The 400G ZR+ transceiver's high transmit output power of 0dBm enables true IP-over-DWDM deployments in metro and regional optical transport networks, eliminating an entire layer of optical equipment and thereby significantly reducing both capital and operational expenditures for network operators.

"This award for optical integration speaks to our ability to transform line cards into industry-standard pluggable modules," says chief marketing officer Dr Sanjai Parthasarathi. "The availability of 400G with such high output power in a QSFP-DD form factor is a game-changer due to its compatibility with router interfaces. Now, service providers can connect routers directly to access, metro and regional optical transport networks without client interfaces. This IP-over-DWDM network architecture achieves huge savings in upfront costs and ongoing expenses."

The 400G ZR+ QSFP-DD-DCO transceiver is based on proprietary indium phosphide (InP) technology, which is an intrinsic enabler of the transceiver's 0dBm output power. Furthermore, InP components consume a low enough amount of power to be suitable for the small QSFP-DD form factor.

In March, Windstream Wholesale announced that it had completed field trials (over a 1000km link between Phoenix and Los Angeles) using the 400G ZR+ QSFP-DD-DCO transceiver from Coherent. Windstream also demonstrated transmission over up to 24 cascaded reconfigurable optical add/drop multiplexers (ROADMs) in a lab environment.

Coherent showcased the 400G ZR+ QSFP-DD-DCO transceiver in a live demonstration at ECOC. Also, at ECOC's Market Focus, director of product management Dr Gert Sarlet presented the talk 'Coherent Optics in Client Pluggable Form Factor Enables IP-over-DWDM in Disaggregated Transport Networks'.

www.ecocexhibition.com

Coherent launches I-Temp micro-pump lasers

Extended-temperature operation in broadband optical access networks

Coherent Corp of Saxonburg, PA, USA, which provides photonics technology for communications and aerospace & defense applications, has launched its I-Temp micro-pump lasers for extended ambient temperature operation in broadband optical access networks.

The growing demand for broadband services is bringing fiber-optic networks closer to subscribers, with environmentally hardened equipment deployed in uncontrolled ambient environments where space is constrained and the availability of power is strictly limited, notes the firm. Coherent's new I-Temp micro-pump lasers are now capable of operating over the extended temperature range of –40°C to +85°C, enabling optical amplifiers deployed at the network edge to withstand extreme weather conditions.

"The combination of small size, wide operating temperature, and low power consumption makes the I-Temp micro-pump a perfect solution for environmentally hardened optical amplifiers installed, for example, on utility poles," says Dr Richard Smart, senior VP, ROADM business unit. "The I-Temp micro-pump leverages differentiated technology at every level of its vertically integrated design, including our gallium arsenide (GaAs) semiconductor laser technology platform, with its proven reliability through decades of field deployments."

The I-Temp micro-pumps maintain a steady output power of 400mW with less than 2W of power consumption and remain optimally wavelength-locked with a fiber Bragg grating, without the need for an internal cooler. They are available with 80μm PM980 polarization-maintaining fibers and 125μm HI 1060 bend-insensitive single-mode fibers.

www.Coherent.com

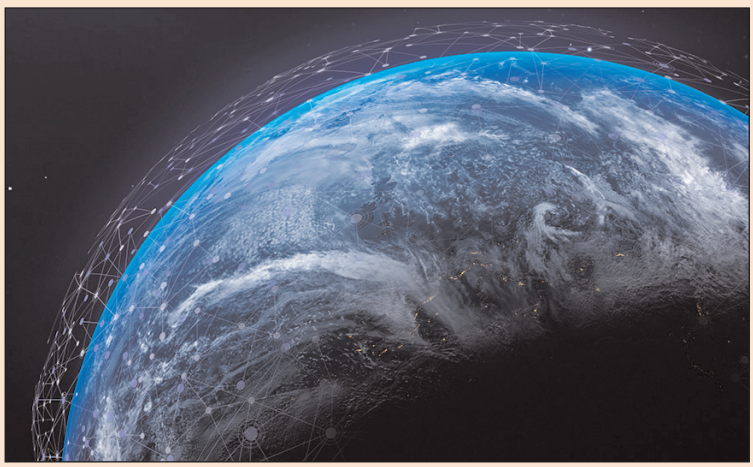
Coherent wins DARPA contract to develop coherent optical transceivers for Space-BACN program

Low-cost, high-speed, reconfigurable laser-based data links between LEO satellite constellations

Coherent has won a contract to develop coherent optical transceiver technology for the Space-Based Adaptive Communications Node (Space-BACN) program of the US Defense Advanced Research Projects Agency (DARPA).

The aim of Space-BACN is to create low-cost, high-speed, reconfigurable laser-based data links that will enable communications between various government and private-sector low-Earth-orbit (LEO) satellite constellations.

Various incompatible and often proprietary optical inter-satellite links (OISLs) prevent LEO satellite arrays from readily sharing information, keeping proliferated space from reaching its full potential. Coherent is specifically tasked with designing and fabricating coherent optical transceivers for a reconfigurable modem compatible with most existing single-wavelength communications protocols and able to readily adapt to work with new waveforms as they are introduced. The goal is to support multiple optical waveforms at total data rates of up to 100Gbps on a single wavelength, while simultaneously meeting stringent size, weight, power and cost (SWaP-C) constraints.



"Advances in digital technology, together with falling launch costs, have made it possible for many groups to launch 'constellations' of compact satellites possessing a multitude of capabilities, enabled by high-speed laser communications," notes Dr Chris Koeppen chief technology officer. "Beyond just defense applications, these satellite arrays offer tremendous potential for low-cost global communications, sensing, imaging, space exploration, and more."

The current award to Coherent is a Phase 1 contract within Technical Area 2 (TA2) of the SpaceBACN development program. TA2 is focused on modem architecture. Coherent already participated in Phase 0 of TA2, which involved developing the architectural design for these components, and was selected for Phase 1 based on the success of that work.

www.coherent.com

First Solar investing $1.2bn to scale up production of US-made PV modules by 4.4GW

$1bn for new 3.5GW$_{DC}$ plant in US Southeast, plus $185m to expand Northwest Ohio plant by 0.9GW$_{DC}$

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA plans to invest up to $1.2bn in scaling production of American-made photovoltaic (PV) solar modules, supporting the USA's transition to a decarbonized future. The investment is forecasted to expand the firm's ability to produce American-made modules for the US solar market to over 10GW$_{DC}$ by 2025.

As part of its push to scale US production of solar modules, the firm intends to build its fourth, fully vertically integrated domestic factory, with an annual capacity of 3.5GW$_{DC}$, in the US Southeast. First Solar (the only US-headquartered company among the world's ten largest solar manufacturers) expects to invest up to $1bn in the new factory, which (contingent upon permitting and pending approval of various federal, state, regional and local incentives) is expected to commence operations in 2025.

Additionally, the firm will invest $185m in upgrading and expanding its Northwest Ohio manufacturing footprint (currently the largest vertically integrated complex of its kind in the Western Hemisphere) by 0.9GW$_{DC}$. As part of its plans, First Solar will invest in expanding the capacity of its two operating facilities in Perrysburg and Lake Township, Ohio, by 0.6GW$_{DC}$ to 3.6GW$_{DC}$ of annual Series 6 module capacity. The firm will also expand its third Ohio factory (which is expected to be commissioned in first-half 2023) to 3.5GW$_{DC}$ of annual Series 7 module capacity. The expansion will increase First Solar's total investment in its Ohio manufacturing facilities to over $3bn, with a cumulative annual production capacity of over 7GW$_{DC}$ by 2025.

First Solar estimates that the new investment will add at least 850 new manufacturing jobs, taking its total number of direct jobs in the USA to over 3000 people in four states by 2025 (believed to make it the largest employer in the American solar manufacturing sector). By 2025, First Solar is also expected to support an estimated 15,000 indirect and induced jobs as a result of its ongoing and future manufacturing operations.

"In passing the Inflation Reduction Act of 2022, Congress and the Biden–Harris Administration has entrusted our industry with the responsibility of enabling America's clean energy future and we must meet the moment in a manner that is both timely and sustainable," says CEO Mark Widmar. "This investment is an important step towards achieving self-sufficiency in solar technology which, in turn, supports America's energy security ambitions, its deployment of solar at scale, and its ability to lead with innovation," he adds. "Our manufacturing presence in the US is expected to directly and indirectly support over 18,000 jobs across the country by 2025, while our manufacturing investment will add an estimated $3.2bn in value to the US economy, reflecting the impact of solar manufacturing on our country."

While we have made no decisions at this time, we continue to evaluate further investments in incremental capacity and could announce further expansion plans in the future

On its last earnings call on 28 July, First Solar announced a record bookings backlog of 44.3GW$_{DC}$. The firm has seen demand for its thin-film photovoltaic solar modules driven by its ability to provide long-term supply certainty, lower political and compliance risk, and access to its best available technology through its agile contracting approach.

"While we have made no decisions at this time, we continue to evaluate further investments in incremental capacity and could announce further expansion plans in the future," notes Widmar. "Any such decision would be developed on a solid foundation of strong demand, a repeatable vertically integrated manufacturing template, a proven technology platform, and a robust balance sheet."

Designed and developed at its R&D centers in California and Ohio, First Solar's thin-film PV modules are claimed to set industry benchmarks for quality, durability, reliability, design and environmental performance. The company continues to optimize the amount of semiconductor material used by enhancing its vapor deposition process through continued investment in R&D focused on more efficient module technology with a thinner semiconductor layer. First Solar also operates a recycling program that provides closed-loop semiconductor recovery for use in new modules.

In addition to its Ohio manufacturing facilities, First Solar also operates factories in Vietnam and Malaysia, and is building its first new manufacturing facility in India (with a capacity of 3.3GW), which is scheduled to begin operations in second-half 2023. On completion of its expansion plans in the USA and India, the firm expects to have over 20GW$_{DC}$ of annual global manufacturing capacity in 2025.

www.firstsolar.com

First Solar to supply 600MW of Series 7 CdTe PV modules to Azure Power

Launch customer for modules made in India by First Solar

First Solar Inc of Tempe, AZ, USA has agreed to supply 600MW$_{DC}$ of its cadmium telluride (CdTe) thin-film photovoltaic (PV) solar modules to independent sustainable energy solutions provider and renewable power producer Azure Power Global Ltd of New Delhi, India.

The agreement is the first for production from First Solar's new manufacturing facility in Tamil Nadu, India, which is expected to be commissioned in second-half 2023. Azure is expected to take delivery of First Solar's Series 7 photovoltaic (PV) solar modules from fourth-quarter 2023 to 2025.

"Having a long-term agreement with global solar modules technology leaders like First Solar is key to de-risking our supply side with the latest technology available in the market," says Azure Power's acting CEO Rupesh Agarwal.

First Solar's vertically integrated manufacturing facility near Chennai is projected to have an annual nameplate capacity of 3.3GW$_{DC}$ and is expected to produce a version of the Series 7 module optimized for the Indian market. Unique among the world's ten largest solar manufacturers for being the only US-headquartered company, First Solar produces its thin-film PV modules using a fully integrated, continuous process under one roof.

Azure Power developed India's first utility-scale solar project in 2009 and, since then, it has been developing and operating large utility-scale renewable energy projects in the country. "Our relationship with Azure Power goes back over a decade and we are pleased that it is the launch customer for a product that has not only been designed for India but made in India, for India," says First Solar's chief commercial officer Georges Antoun. "This deal demonstrates how experienced developers and independent power producers in India are increasingly taking a strategic view on procurement and securing long-term commitments that help tackle the risks of short-term pricing and supply volatility," he adds. "When working with First Solar, they benefit from certainty of pricing and supply, and a technology that is advantaged in India's operating environments."

First Solar's thin-film PV modules are reckoned to have a carbon footprint 2.5 times lower and a water footprint three times lower than the average crystalline silicon solar panel made with cells produced in China. Additionally, First Solar is the only company among the ten largest solar manufacturers globally to be a member of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to supporting the rights and well-being of workers and communities in the global supply chain.

www.azurepower.com
www.firstsolar.com/en/Modules/Series-7

Malaysia's Solarvest orders 93MW of modules

Selangor, Perak and Kedah projects part of Large Scale Solar Program

First Solar is to supply Solarvest Holdings Berhad of Kuala Lumpur, Malaysia, a clean energy specialist and turnkey engineering, procurement, construction and commissioning (EPCC) service provider in South-East Asia, with 93MW$_{DC}$ of its CdTe thin-film PV modules.

For delivery between August and November, the modules will power four projects being built as part of Malaysia's Large Scale Solar Program (LSS). Solarvest will use First Solar Series 6 modules for projects in the Malaysian states of Selangor, Perak, and Kedah. About 75MW of the order is expected to be sourced from First Solar's manufacturing facility in Kulim, Malaysia. Founded in 2012, Solarvest pioneered grid-connected solar installations in Malaysia and has deployed about 400MW.

"We're thrilled to be using First Solar's thin-film technology, including solar panels made in Penang, to power our projects in Malaysia," says Solarvest's executive director & group CEO Davis Chong. "The use of these advanced solar panels will further accentuate the advantage our engineering solutions bring in terms of maximizing energy yields," he adds.

"This is also part of our strategy to mitigate concentration risk in relation to our procurement practices, especially given the uncertainties in the global supply chain today," Chong continues. "The sourcing diversification promotes greater stability for Solarvest as we continue to scale up."

"First Solar has a longstanding presence in Malaysia and we're proud that our module technology will play a role in helping the country meet its clean energy goals," says Adam Smith, First Solar's VP of global business development. "This deal represents our commitment to deploying our high-performance and eco-efficient module technology at scale in Malaysia."

First Solar has had a presence in Malaysia since 2007 and currently operates a 3.3GW$_{DC}$ manufacturing plant in Penang.

www.solarvest.my/portfolio/large-scale-solar

VCSEL market to grow at 19.2% CAGR from $1.6bn in 2022 to $3.9bn in 2027

The datacom sector of the VCSEL market is growing at 22.2%, regaining the lead from a mobile & consumer sector growing at 15.7%, says Yole Intelligence.

According to Yole Intelligence's annual 'VCSEL – Market and Technology Trends 2022' report, the vertical-cavity surface-emitting laser (VCSEL) market is reckoned to have almost doubled since 2018. Furthermore, it should rise at a compound annual growth rate (CAGR) of 19.2% from $1.6bn in 2022 to $3.9bn in 2027. In particular, by application during 2022-2027, the datacom sector should grow at a CAGR of 22.2% from $782m to $2.1bn (regaining its supremacy in 2023 and dominating the market), while mobile & consumer grows at a 15.7% CAGR from $840m to $1.7bn.

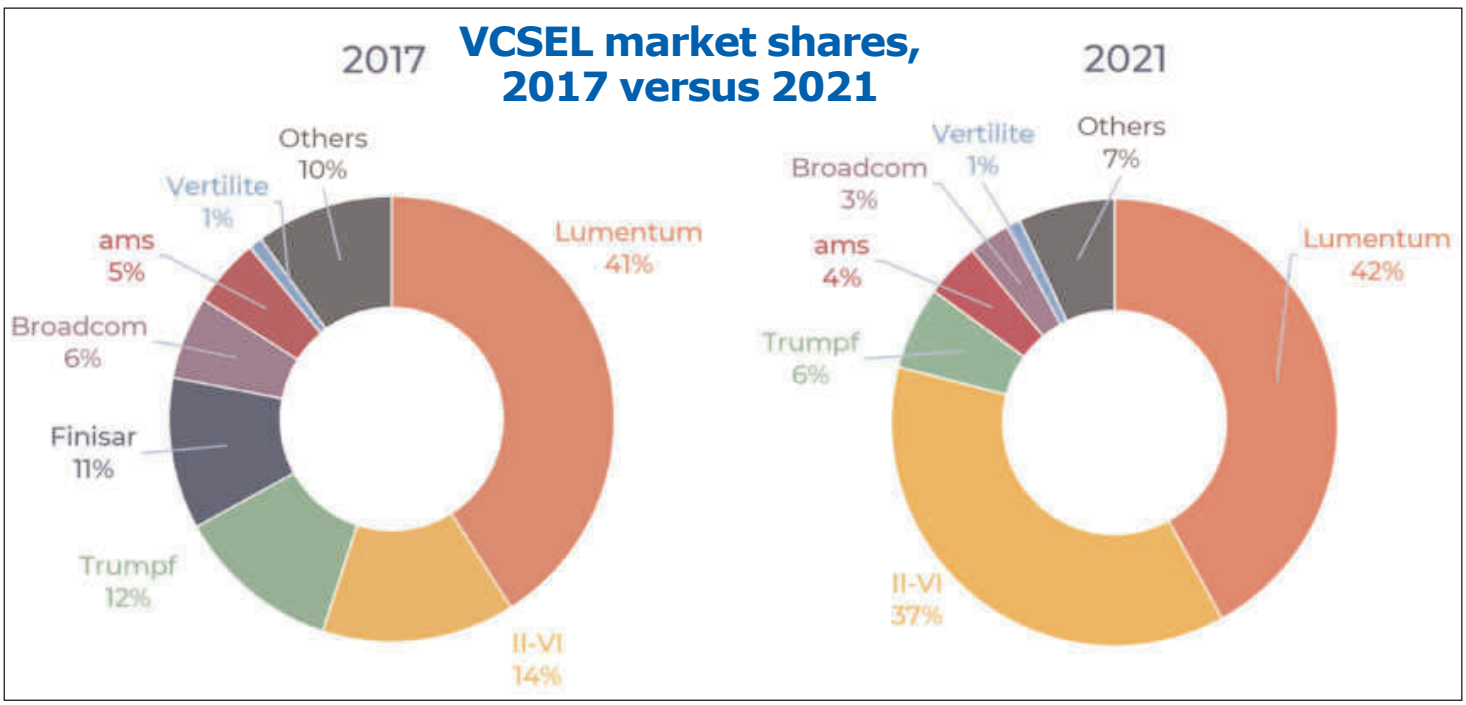
In the past, the VCSEL market was driven by the datacom sector, the technology's first volume application. In November 2017, Apple released the iPhone X, embedding VCSELs for face recognition, which changed the game. In 2018, mobile and consumer became the largest market for VCSELs, reaching $440m. Other smartphone makers soon joined this trend, but then stopped using these components a few years later in favor of under-screen fingerprint sensors. Apple remains almost the only player integrating VCSELs.

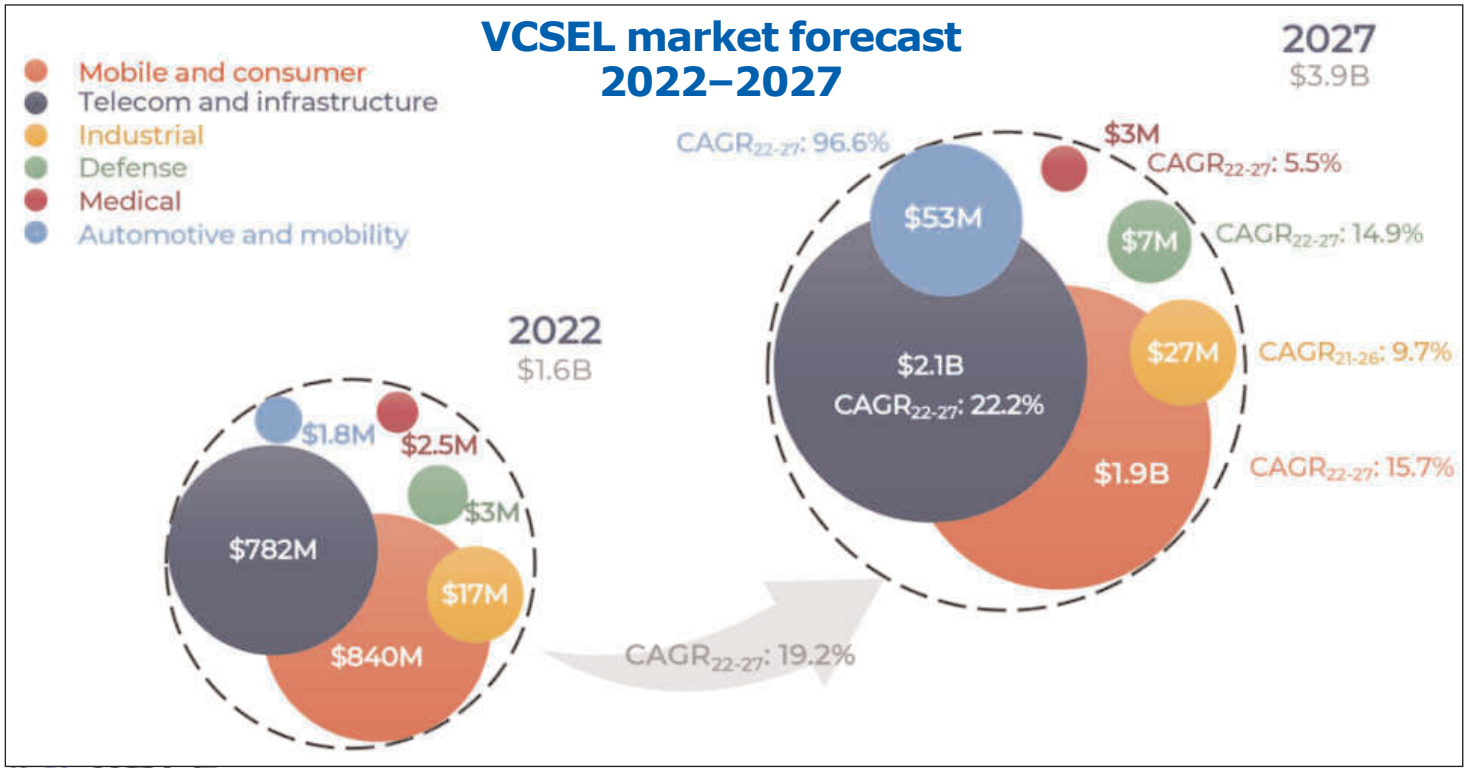
Development of VCSEL market from an oligopoly to a duopoly

The VCSEL ecosystem has changed drastically since 2017, when the market was an oligopoly (dominated mainly by Lumentum, though several other players had significant market shares). By 2022, the VCSEL ecosystem had become a duopoly, with Lumentum and II-VI collectively taking 80% market share.

So, what happened during those five years? Lumentum was the only supplier qualified by Apple at that time. Finisar was still in R&D and struggling to qualify products for Apple. Other players were involved with other smartphone makers or supplying VCSELs for proximity sensors. Then, Coherent (formerly II-VI) acquired Finisar. Lumentum and II-VI are still the only players qualified by Apple for 3D sensing.

At the same time, the leaders also acquired other companies, such as Oclaro and Coherent, amongst several others. This reinforced their positions in the optical communication market, vertically integrating from the VCSEL device to the entire transceiver module.





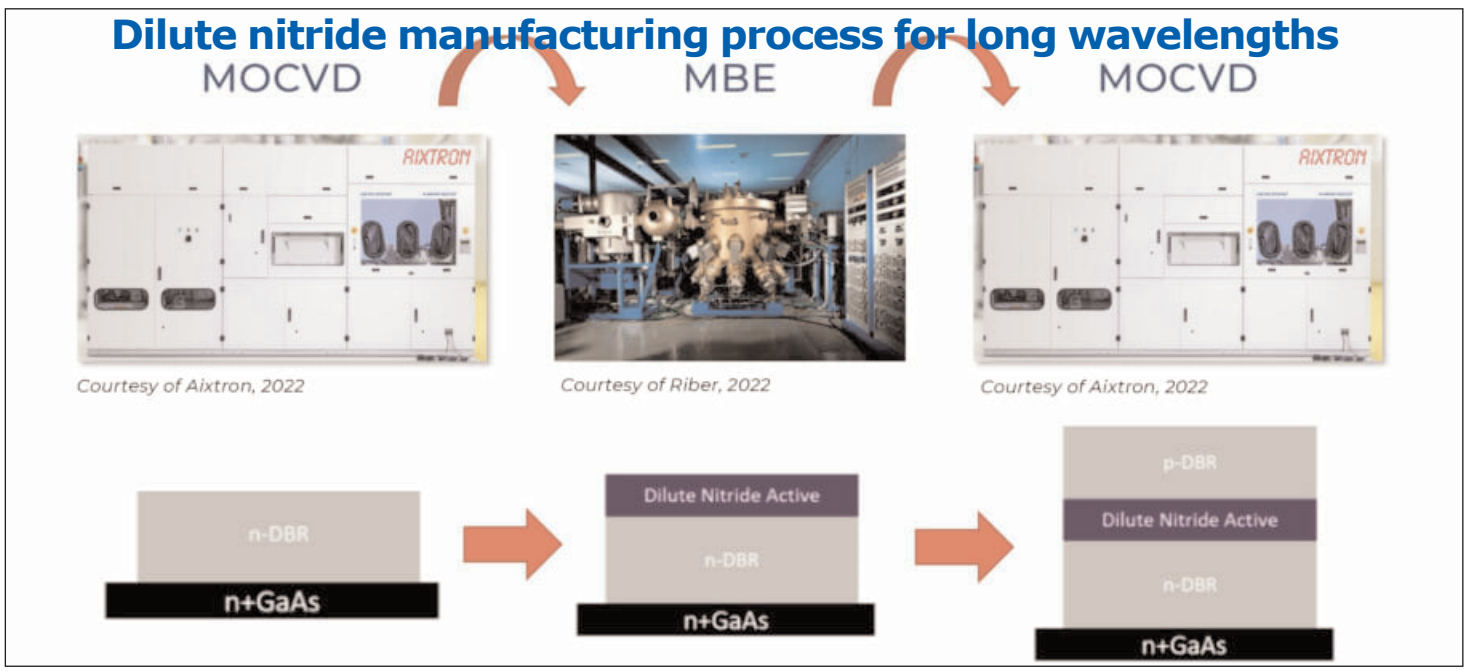
8" wafers and wavelength shift from 940nm to 1380nm to be the next technology changes

Two major changes are expected in the coming years. In May, IQE demonstrated its first 8" wafers based on germanium instead of gallium arsenide (GaAs). These may not be needed to answer a sudden rise in VCSEL demand but to make possible the integration of photonics devices with CMOS technology. It also gives a potential roadmap toward 12" wafer manufacturing in the long term.

The second major change is the use of dilute nitride active layers to shift the emission wavelength from 940nm to 1380nm, which is needed to enable the integration of VCSELs behind organic light-emitting diode (OLED) displays (which are transparent at this wavelength).

"The iPhone 14 Pro, which was presented in September 2022, embeds a proximity sensor under the display but it could use a laser diode and InGaAs [indium gallium arsenide] photodetector based on InP substrate waiting dilute nitride technology for VCSELs to be ready," says Pierrick Boulay. "As expected, the first long-wavelength application is a proximity sensor under the display, reducing the notch size on iPhones. Further 3D sensing applications could happen later". ▯

www.yolegroup.com/product/report/vcsel---market-and-technology-trends-2022



Nanorod blue LED sidewall passivation

Researchers claim highest efficiency achieved so far at the nano-scale.

Researcher based in South Korea have developed a sol–gel sidewall passivation process for blue indium gallium nitride (InGaN) quantum well (QW) nanorod light-emitting diodes (nLEDs) with enhanced external quantum efficiency (EQE) over plasma-enhanced atomic layer deposition (ALD) [Mihyang Sheen et al, Nature, v608, p56, 2022].

Indeed, the team from Samsung Display, Korea Institute of Energy Technology (KENTECH), Pusan National University, and Samsung Electronics, claims that "the fabricated nLEDs showed an EQE of 20.2±0.6%, the highest EQE value ever reported for the LED in the nanoscale"; and that the value "is higher than the best EQE value of the μLED structure even at a larger size."

The researcher believe that their work will accelerate the implementation of nLEDs in next-generation displays. Other potential benefits could be seen in solid-state lighting, optical data communication and photonic deployments, along with high-pixel-density display applications such as augmented/extended reality, which can be difficult to realize with liquid crystal technology.

Sidewall passivation becomes increasingly critical as device dimensions

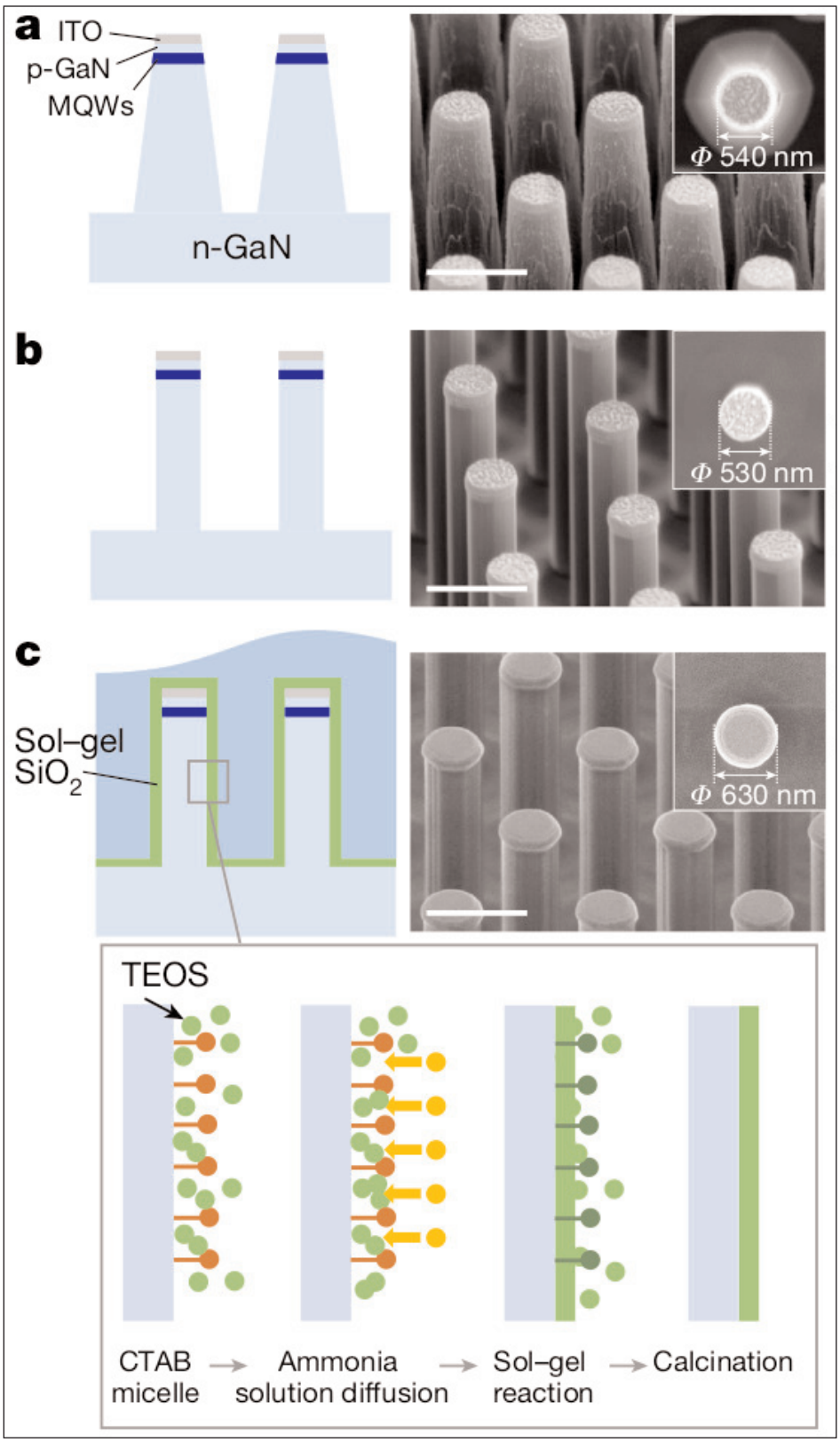


Figure 1. Schematics and corresponding scanning electron microscopy images of nLEDs fabricated by means of conventional top-down processing methods. Dry etching (a), wet etching (b) and deposition of SiO_2 surface passivation layer by means of sol-gel method (c). Scale bars, 1μm. Inset: schematic of sol–gel reaction on GaN LED nanorod. Scale bars, 500nm (left) and 200nm (right).

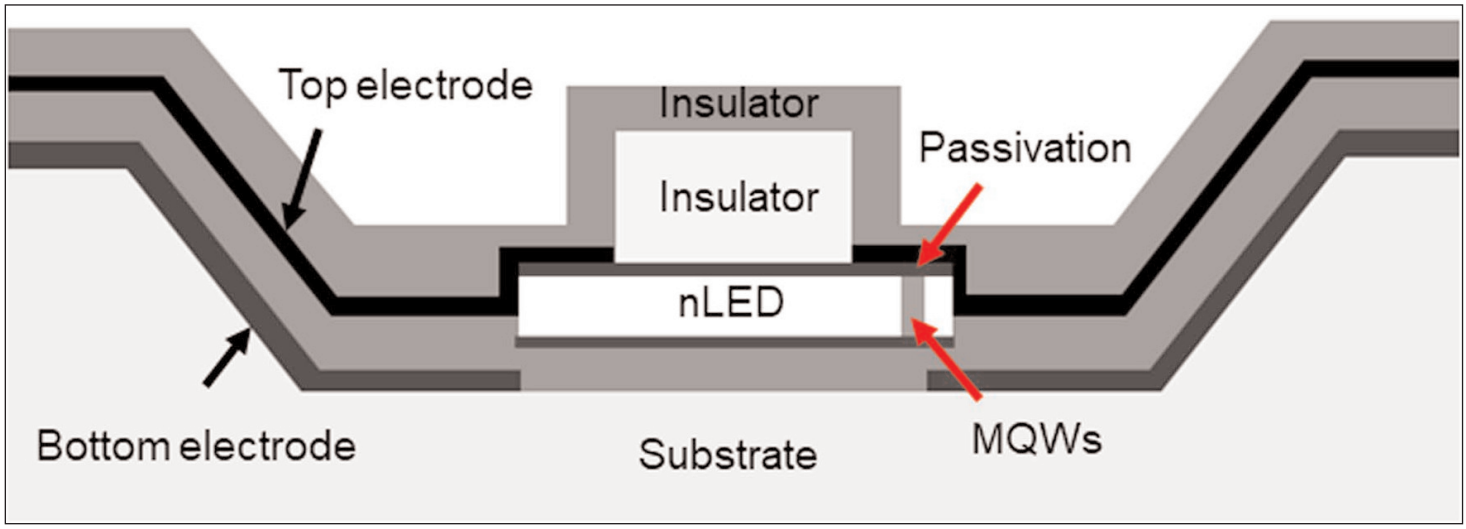


Figure 2. Schematic diagram of the nLED pixel structure.

reduce since the surface area/volume ratio increases. Without suitable passivation, the EQE decreases through non-radiative electron–hole recombination at sidewall defects.

The material used for the nLEDs consisted of 8x(InGaN/GaN) multiple quantum wells (MQWs) between p- and n-GaN layers grown on 4-inch c-plane sapphire using metal-organic chemical vapor deposition (MOCVD). The structure also included a top layer of indium tin oxide (ITO) transparent conductor.

The 600nm-diameter nanorod structures were fabricated using nanoimprint lithography, inductively coupled plasma etch, and potassium hydroxide wet etch to remove surface damage. The wet etch also transforms the trapezoidal profile of the dry etched nanocolumn, giving more vertical sidewalls (Figure 1).

The sidewall insulation consisted of two layers designed to meet the needs of display products for high efficiency, good reliability and processability. The inner passivation layer was 60nm silicon dioxide (SiO_2); the outer etch-stop layer was 20nm aluminium oxide (Al_2O_3). These materials were chosen for their high transparency, low leakage current and high bandgap energy.

The researchers were keen to minimize added surface damage so they developed the low-temperature sol-gel method to apply the inner passivation. "Performing the sol–gel process at room temperature could minimize the atomic reaction between the GaN surface and the SiO_2 layer and enhance the optical properties of the nanorods by passivating the dangling bonds," the team writes.

The sol-gel process began with the nanorod wafer being dipped into an ethanol/deionized water solution to which was added cetyltrimethylammonium bromide (CTAB), forming micelles, and then an ammonia solution and the tetraethyl orthosilicate (TEOS) precursor for the SiO_2 passivation. The sol–gel reaction saturated at around 23nm thickness. The full 60nm thickness was achieved by repeating the process.

One disadvantage of the sol–gel technique is the tendency toward by-product residue. The researchers tackled this by baking the sol–gel SiO_2 film with the aim of good reliability through completing the reaction and eliminating reaction residues. The team reports that it is working on process optimization.

The use of sol-gel SiO_2 deposition on the nanorods was found to enhance blue photoluminescence (PL) by ~13x over rods with the SiO_2 applied using more conventional plasma-enhanced ALD. Also, the PL decay

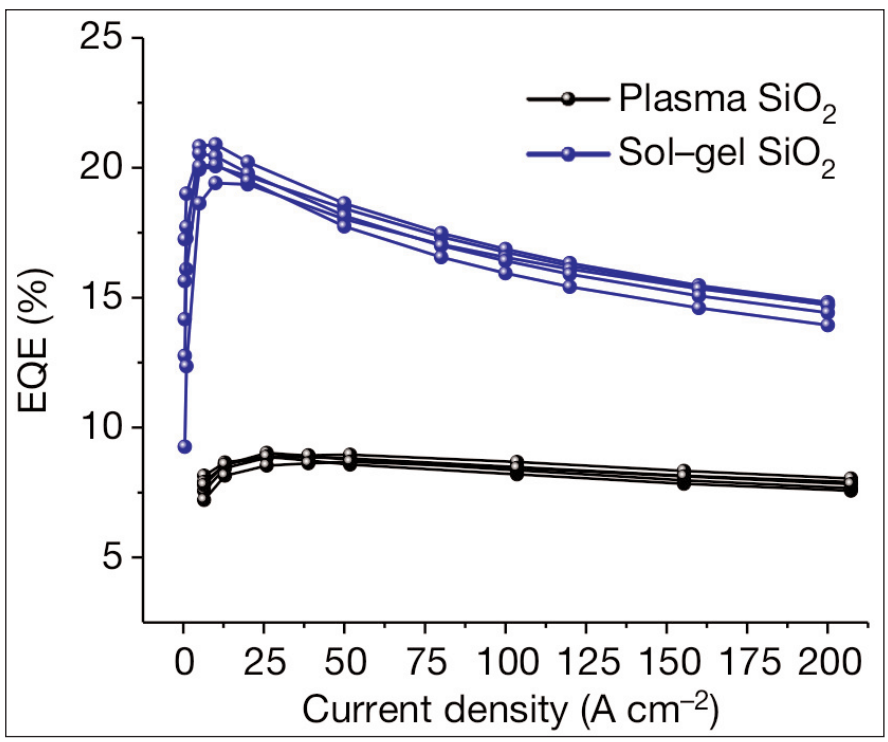


Figure 3. EQE versus current density for nLEDs.

lifetime increased to 101.4ns, compared with 24.2ns for ALD passivation. The longer lifetime indicates more electron-hole recombination into photons as opposed to non-radiative routes.

The nanorod nLEDs were separated from the growth wafer using a diamond cutter and dispersed in solution for inkjet printing into pixel structures. The nanorods were aligned horizontally between two bottom electrodes using a dielectrophoretic force. Transparent top electrodes provided electrical biasing. The resulting pixel structures contained an average of 6 and 9 nanorods for the ALD and sol-gel passivation, respectively.

The researcher estimated the light extraction efficiency of the pixel structure at 25%, using finite-difference time-domain simulations. External quantum efficiency (EQE) measurements on 60-pixel arrays gave peak values of ~20% for the sol-gel nanorods and ~9% for the ALD passivation (Figure 3). Using the estimate for the light extraction efficiency, the corresponding internal quantum efficiencies (IQEs) were estimated at 81% and 36% for sol–gel and ALD passivation, respectively.

The team deployed a wide range of material analysis techniques, such as photoluminescence (PL), electroluminescence (EL), cathodoluminescence (CL) and electron energy-loss spectroscopy (EELS) to track down the problems with the plasma-enhanced ALD passivation, concluding that "the VGa–ON–2H complex is the dominant defect generated in the sidewalls of the nanorods during the plasma-enhanced ALD SiO_2 passivation, wherein a hydrogen-containing precursor is used."

The plasma-enhanced ALD process also induces amorphization at the InGaN quantum well surfaces and creates point defects on the sidewalls of the GaN nanorods. These factors increases the Shockley–Read–Hall (SRH) electron-hole recombination mechanism through non-radiative recombination centers (NRCs) on the sidewalls of the InGaN QWs.

By contrast, "the sol–gel process provides effective passivation for the GaN surfaces because the SiO_2 nanoparticles are adsorbed on the GaN surface after the sol–gel reaction," the team explains, adding: "Thus, the atomic interaction with the GaN surface is minimized and only dangling bonds of the surfaces are passivated, resulting in a low leakage current, decreased NRC regions and high EQE." ▯

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Enhancing MOCVD N-polar LEDs

Researchers optimize quantum barrier growth to reduce hexagonal hillock formation and zincblende inclusions

Jilin University and Zhengzhou University in China have reported progress in enhancing the performance of indium gallium nitride (InGaN) light-emitting diodes (LEDs) grown by metal-organic chemical vapor deposition (MOCVD) in the nitrogen- rather than gallium-polar direction [Yang Wang et al, Optics Letters, v47, p3628, 2022]. The researchers hope that their efforts "will facilitate the development of N-polar GaN-based long-wavelength light-emitting devices for application in micro-LED displays."

The potential advantages of using N-polar III-nitride material include an enhanced incorporation of indium atoms, allowing longer wavelengths to be emitted.

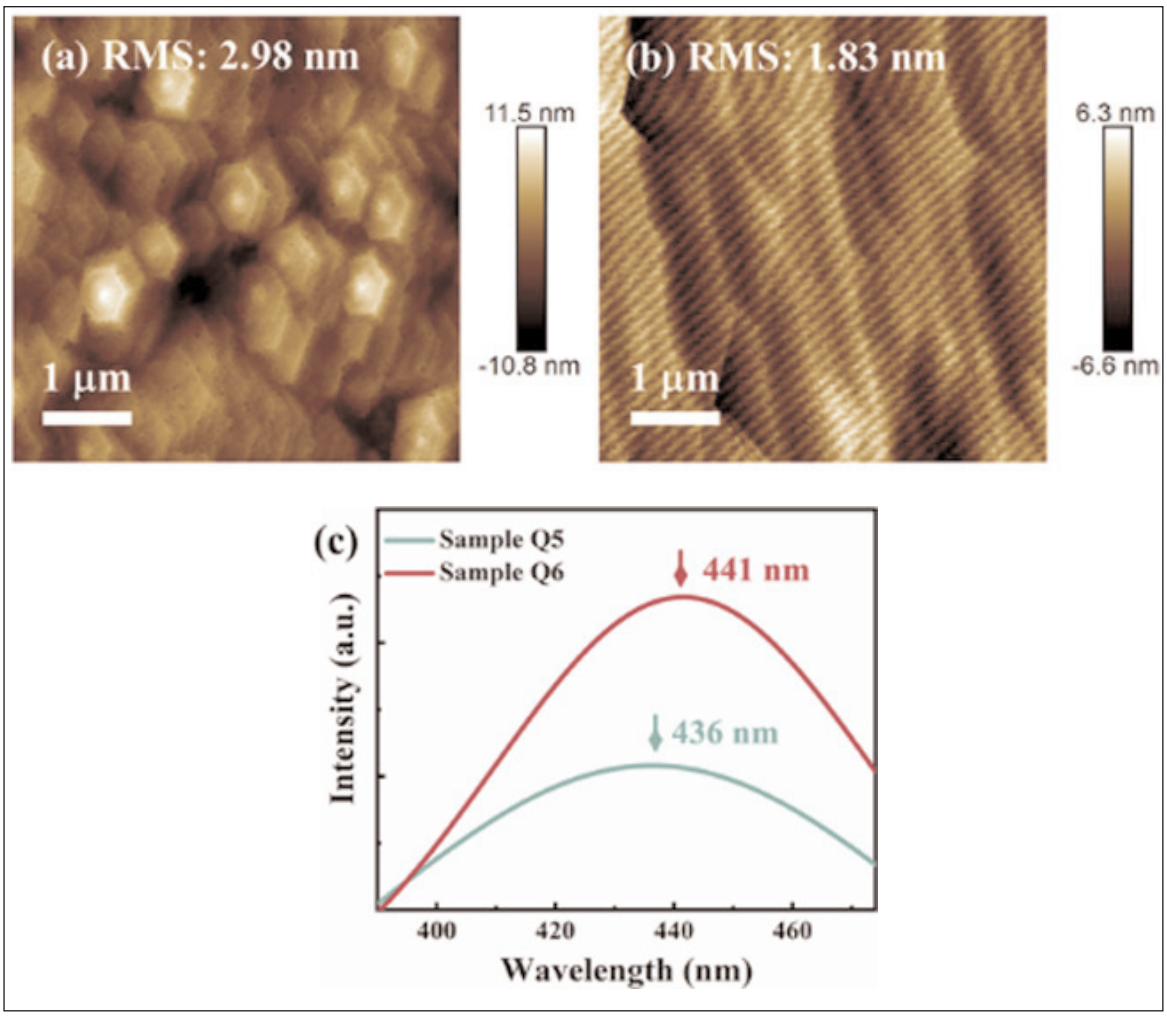

Figure 1. Surface AFM images of N-polar InGaN/GaN DQW samples with 785°C QW, and QBs grown (a) without (Q5) and (b) with (Q6) 1slm hydrogen in the carrier gas. (c) Fitted room-temperature PL spectra.

Another benefit in N-polar devices comes from the reversal of the electrical fields arising from the differences in charge polarization of the various III–N bonds in the different heterostructure layers. In Ga-polar material these fields inhibit electron-hole recombination into photons due to the quantum-confined Stark effect (QCSE). The N-polar field reversal of the fields weakens the QCSE.

The polarization field reversal also eliminates the barrier to electron injection into the quantum well (QW) active region, while also increasing the barrier against electron overflow from the QW into the p-type hole injector structure.

Despite these advantages for N-polar devices, the Ga-polar structure still has greater luminous efficiency, which the team hopes will be overtaken in the future by N-polar structures.

Problems for N-polar material include high concentrations of carbon and oxygen impurities, inclusion of zincblende crystal phase material in the target wurtzite crystal structure, and the formation of hexagonal hillocks on the growth surface. The zincblende inclusions tend to result in triangular bulges on the surface of N-polar samples.

The team has previously found some success in

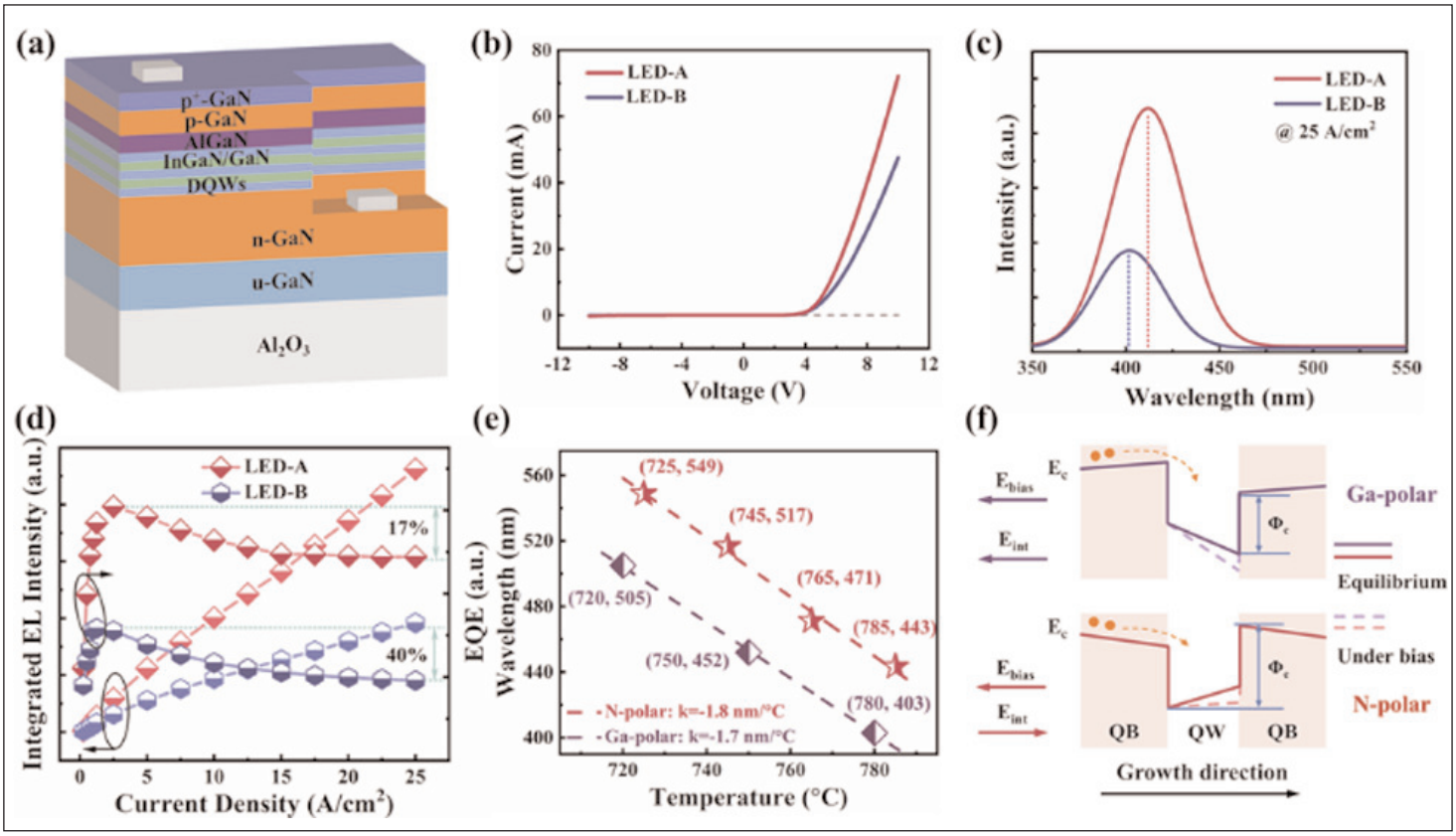

Figure 2. (a) Schematic diagram of the N-polar InGaN/GaN LED. (b) Current–voltage characteristics of LED-A and LED-B (reference sample). (c) Electroluminescence (EL) spectra of LED-A and LED-B under driving current density of 25A/cm^2. (d) Integrated EL intensity and relative external quantum efficiency (EQE) of LED-A and LED-B versus driving current density. (e) Emission wavelengths at 10K of N-polar (red) and Ga-polar (purple) DQWs versus QW growth temperature; dotted lines represent linear fit. (f) Conduction-band diagrams of Ga- and N-polar InGaN/GaN QWs at equilibrium and in biased state, showing directions of polarization electric field and applied electric field; Φ_ε represents overflow barrier for electrons from QW towards p-type layers.

reducing carbon/oxygen impurity incorporation by mainly optimizing the V/III precursor supply ratio. The new work mainly focused on reducing zincblende inclusion and hexagonal hillock formation.

The researchers grew N-polar InGaN/GaN double QW (DQW) samples on 2μm-thick N-polar GaN templates on misoriented sapphire.

One strategy deployed by the team, mainly aimed at reducing zincblende inclusion, was to increase the quantum barrier (QB) growth temperature from 845°C to 945°C. The QWs were grown at 745°C. The higher QB growth temperature reduced root-mean-square (RMS) surface roughness to 3.07nm from 11.9nm in the lower-QB-temperature sample, according to atomic force microscopy (AFM) over a 5μmx5μm field.

The researchers comment: "The zincblende-phase inclusions were eliminated due to the increase in the mobility of surface adatoms at elevated temperature."

Photoluminescence on the samples showed the effect of reduced hillock formation and zincblende inclusion in the form of increased emission and a red-shift in wavelength by 6nm. "The red-shift of the emission wavelength can be attributed to the elimination of zincblende-phase inclusions, which increases the indium incorporation efficiency of the DQWs," the researchers explain.

Moves to tackle hillock growth included using hydrogen rather than nitrogen as the carrier gas during QB growth. Hydrogen has a high affinity with N-polar surfaces. The team reports: "Owing to the reduction of the diffusion barrier to adatoms on the sample surface achieved by higher hydrogen coverage, the hexagonal hillocks were effectively eliminated, and the surface RMS roughness was further reduced."

However, a complete switch to hydrogen carrier resulted in triangular step edges on the surface, due to the different speeds of step edge propagation in different directions. The higher adatom incorporation with hydrogen carrier gas aggravates this effect. The RMS roughness with a complete switch to hydrogen was 2.29nm. A sample with a partial replacement of hydrogen in the nitrogen carrier gas at the rate of 1 standard liter per minute (slm) enabled an RMS reduction to 1.51nm.

The addition of hydrogen to the carrier gas during QB growth resulted in still higher emission peaks and a

further red-shift of around 9nm. The partial hydrogen addition resulted in a somewhat higher peak than the complete switch to hydrogen.

Increasing the QW growth temperature from 745°C to 785°C shifted the PL peaks from green light with longer than 500nm wavelength to blue at 436nm and 441nm with QBs grown at high temperature without and with 1slm hydrogen in the carrier gas, respectively (Figure 1). The corresponding surface morphologies were 2.98 and 1.83nm RMS. "This demonstrates that the surface morphology of N-polar DQWs has a minor dependence on the QW growth temperature in the temperature range of our experiment," the team comments.

The researchers also fabricated LEDs from the 436/441nm PL emitting materials (Figure 2). The longer-wavelength material was grown with hydrogen in the carriers gas during QB growth, giving a device labeled LED-A. The reference LED-B was grown without hydrogen in the QB carrier. The LED-A demonstrated much lower series resistance, giving higher current for a given potential bias.

The team comments: "Compared with LED-B, LED-A exhibits significantly improved EL intensity and a longer emission wavelength, which is consistent with the PL measurement results for DQWs before and after optimization."

The optimized LED-A also showed a ~92% higher external quantum efficiency (EQE) peak relative to LED-B. After the peak, the EQE droop at 25A/cm^2 injection was 17% and 40% for LED-A and LED-B, respectively. "The significant alleviation of the efficiency droop in LED-A is ascribed to the enhanced carrier confinement brought by the optimized DQWs," the team explains.

The researchers also fabricated N-polar and Ga-polar LEDs with varied QW growth temperatures to tune the indium incorporation, and thus the emission wavelength. The N-polar devices showed around 57nm red-shift in emission wavelength relative to Ga-polar devices with QWs grown at the same temperature.

The team comments: "Theoretical studies indicated that the In atoms in N-polar InGaN are covered by an N–H surface layer, preventing In desorption or replacement by Ga atoms, which is not the case in Ga-polar InGaN." ▯

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Color-tuning in V-groove InGaN micro-LEDs

Single device capable of covering sRGB monitor, printer, internet color space.

Researcher Matthew Hartensveld of US-based firm Innovation Semiconductor Inc has demonstrated indium gallium nitride (InGaN) micro-LEDs capable of emitting tunable colors across the blue-to-red visible range from 425nm to 640nm [Optics Express, v30, p27314, 2022]. The devices are capable of covering the 1996 HP/Microsoft 'standard' red–green–blue (sRGB) color space for use on monitors, printers and the internet.

Although V-grooves have previously been found to enhance LED performance through improved carrier injection and minimizing charge recombination in threading dislocations, Hartensveld claims to be the first to use V-grooves to achieve color-tunable emission.

Hartensveld sees potential for the proposal to be deployed in full-color displays, offering high efficiency, environmental ruggedness, greater scaling, and higher brightness over competing technologies. Up to now, proposals for μLED displays tend to use different material families to achieve the different colors: aluminium indium gallium phosphide (AlInGaP) for red, and InGaN for blue and green. Such an approach is difficult to integrate at low cost. Further, the efficiency of AlInGaP μLEDs suffers from higher losses associated with sidewall leakage, relative to InGaN devices.

Rather than reducing defects, the devices used the resulting V-grooves nucleated at threading screw dislocations to give regions with different indium content and band structure (Figure 1), resulting in different emission wavelengths. Away from the V-groove green light was emitted, while deep in the grooves lower indium incorporation through the semi-polar facet gave blue light. At the same time, strain relaxation near the groove increased indium incorporation, resulting in red emission.

Hartensveld comments: "Past works have sought to minimize V-groove inclusion, though a growing body of recent reports suggest the overall benefits to V-groove inclusion due to the ability to provide an energy barrier to minimize carrier recombination in threading dislocations and provide strain relief through a free surface depression."

Metal-organic chemical vapor deposition (MOCVD) on sapphire was used to create green InGaN multiple quantum well (MQW) LED structures with V-groove densities greater than $4x10^8/cm^2$. The stack included n-GaN beneath the MQW layer, and a p-AlGaN electron-blocking layer (EBL) and p-GaN above the MQW layer. The EBL uniformly coats the V-groove and planar regions, while the p-GaN fills in the groove, planarizing the surface.

Cathodoluminescence spectra showed blue (~425nm) and red (~619nm) emissions, along with the main green (~535nm) emission. The proportions depended on where the electron beam was focused — near or away from the V-grooves. There were also violet (~400nm)

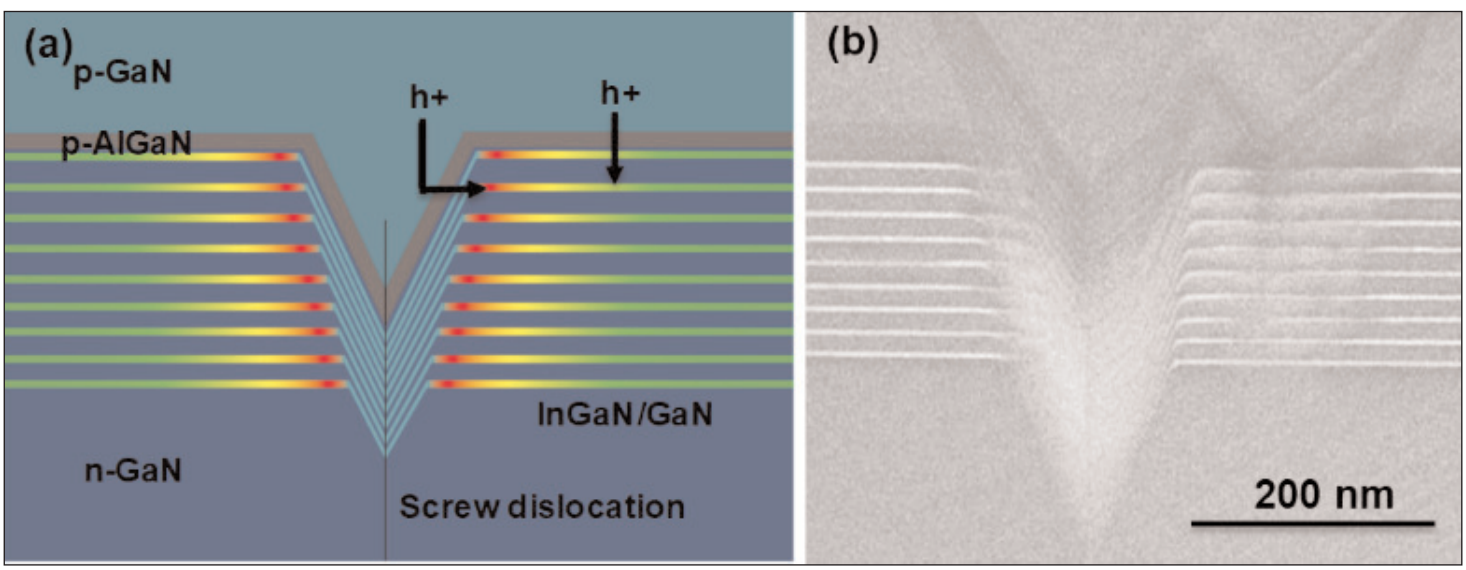

Figure 1. (a) Schematic of V-groove in color-tunable LEDs showing varying indium content and hole injection pathways, (b) transmission electron micrograph of grown structure showing V-groove.

and yellow components (~565nm).

Hartensveld fabricated μLEDs of diameters ranging from 500μm down to 2μm. The mesa plasma etch was followed with hydroxyl-based wet etch treatment to repair sidewall damage. The n-type electrode consisted of titanium/aluminium/nickel/silver. The p-type electrode was nickel.

The turn-on voltage of the devices was around 2V, and the ideality factor 2.5. Hartensveld believes that the ideality could be improved with optimized p-type metallization. The smaller devices naturally carried a smaller current for a given voltage, but a higher current density.

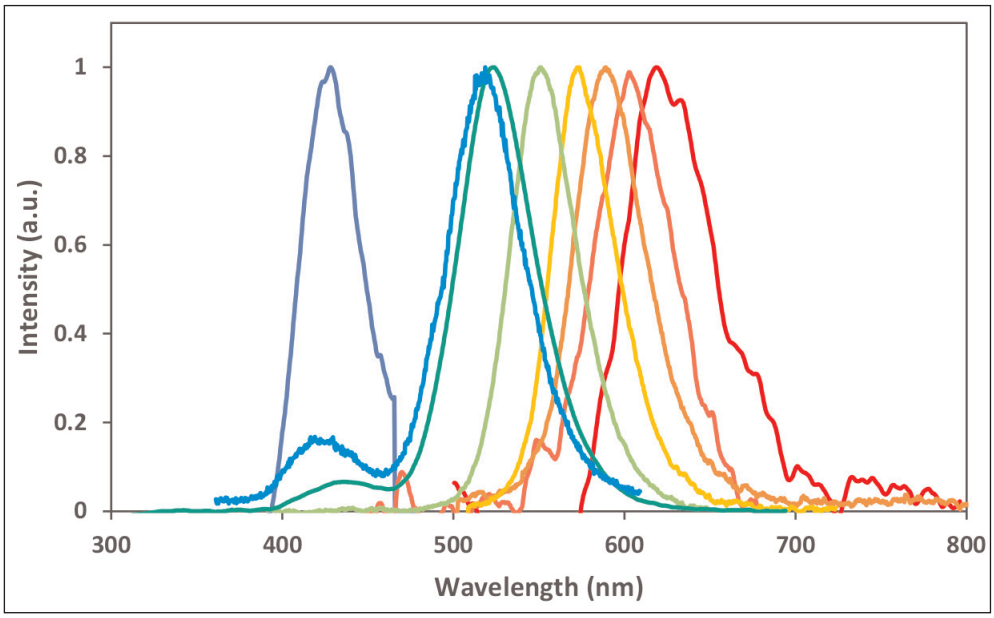

Figure 2. EL spectra plot of color-tunable μLEDs.

The color content of the electroluminescence (EL) emission depended on the current injection level, with red predominating at low current and blue at high current (Figure 2). "The applied current densities for the 35μm μLEDs have an approximate value of ~$6x10^{-5}$ for red and ~$8x10^{-2}$mA/μm^2 for blue," Hartensveld reports. He also proposes that differences in brightness due to the different current levels could be compensated through pulsed injection with different duty cycles.

At low current, the hole injection is laterally across the V-groove to the nearby high-indium-content InGaN MQW region. At higher current, the injection becomes more vertical. These effects are attributed to lower charge polarization of the semi-polar facets of the V-groove resulting in a lower hole barrier presented by the EBL. As the applied bias increases, the quantum-confined Stark effect (QCSE) is reduced, enabling vertical injection, first away from and then in the V-grooves.

For a display, one needs the three primary colors: red, green, and blue. The devices with more than 200 m suffered from not being able to achieve sufficient current density for a pure blue, ending up with cyan from a mixing effect with green.

In smaller devices, good red and blue colors were achieved, but the green corner of the 1931 CIE triangle was somewhat away from the desired edge of the chart (Figure 3). However, the triangle does just cover the sRGB space. Hartensveld believes that the green output could be optimized for greater coverage in future. He also points out that the red performance is comparable to that obtained by europium (Eu) doping.

The largest 500μm μLEDs were subjected to wall-plug efficiency (WPE) characterization with a green emission peak at 3%. At the lower initial turn-on currents needed for red emission, the WPE was ~0.6%. Higher currents for blue suffered from efficiency droop to ~1.15% WPE. Hartensveld compares these values to the external quantum efficiency (EQE) reports of 0.2% for red LEDs on porous GaN, and 0.56% for strain-engineered amber LEDs.

Hartensveld has hopes of maximizing the WPE through suitable packaging, along with other optimizations, given that the present record-efficiency red InGaN LED structure uses V-grooves in its design. ▯

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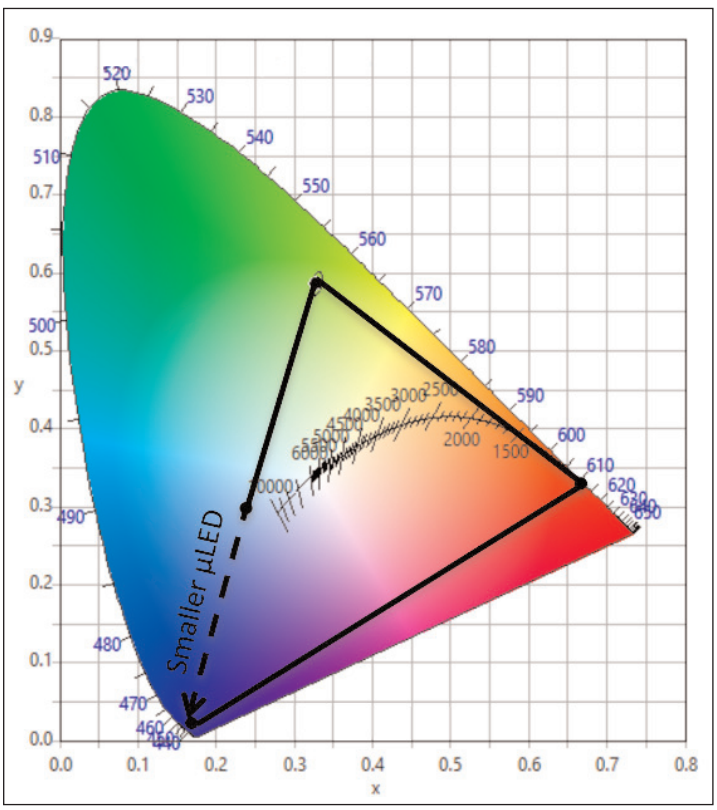

Figure 3. 1931 CIE color chart.

MOCVD Ohmic InGaN tunnel junction growth

Structure displays linear conduction under both forward and reverse bias.

North Carolina State University (NCSU) in the USA has reported progress in creating metal-organic chemical vapor deposition (MOCVD) indium gallium nitride (InGaN) tunnel junctions (TJs) with Ohmic conduction in the forward and reverse directions [B. G. Hagar et al, Appl. Phys. Lett., p121, p052104,2022]. The team comments : "We are not aware of any previous MOCVD-grown III–nitride TJs that display linear conduction in both forward and reverse biases." While better TJ behavior is seen in molecular beam epitaxy structures, MOCVD is preferred in manufacturing.

Tunnel junctions have been proposed as solutions to various problems of III–nitride (and other) semiconductor devices such as multi-color light-emitting diode (LED) and multi-junction solar cell (MJSC) structures.

The NCSU team suggests that its achievement could be due mainly to the combination of three factors: a constant magnesium (Mg) concentration across the p/n layers allowed abrupt electron and hole concentrations at the junction interface; a constant Mg concentration reduced Mg diffusion, avoiding smudging of the junction; and Mg doping on the n side of the TJ created deep levels within the bandgap that enhances tunneling under forward-biased conditions.

The researchers explain the last factor: "Mg in GaN forms two levels within the bandgap: the Mg acceptor level is about 180–200meV above the valence band while another deep donor level exists at around 400–440meV below the conduction band. This deep donor level has been attributed to a Mg and nitrogen vacancy complex (Mg–V_N). The transition between those two levels is responsible for the blue band emission, around 2.8eV, that is typically observed in the heavily doped p-GaN film."

The same sort of behavior, or even better, is expected in InGaN. Generally, the hole concentration in p-InGaN is higher than for p-GaN doped with the same concen-

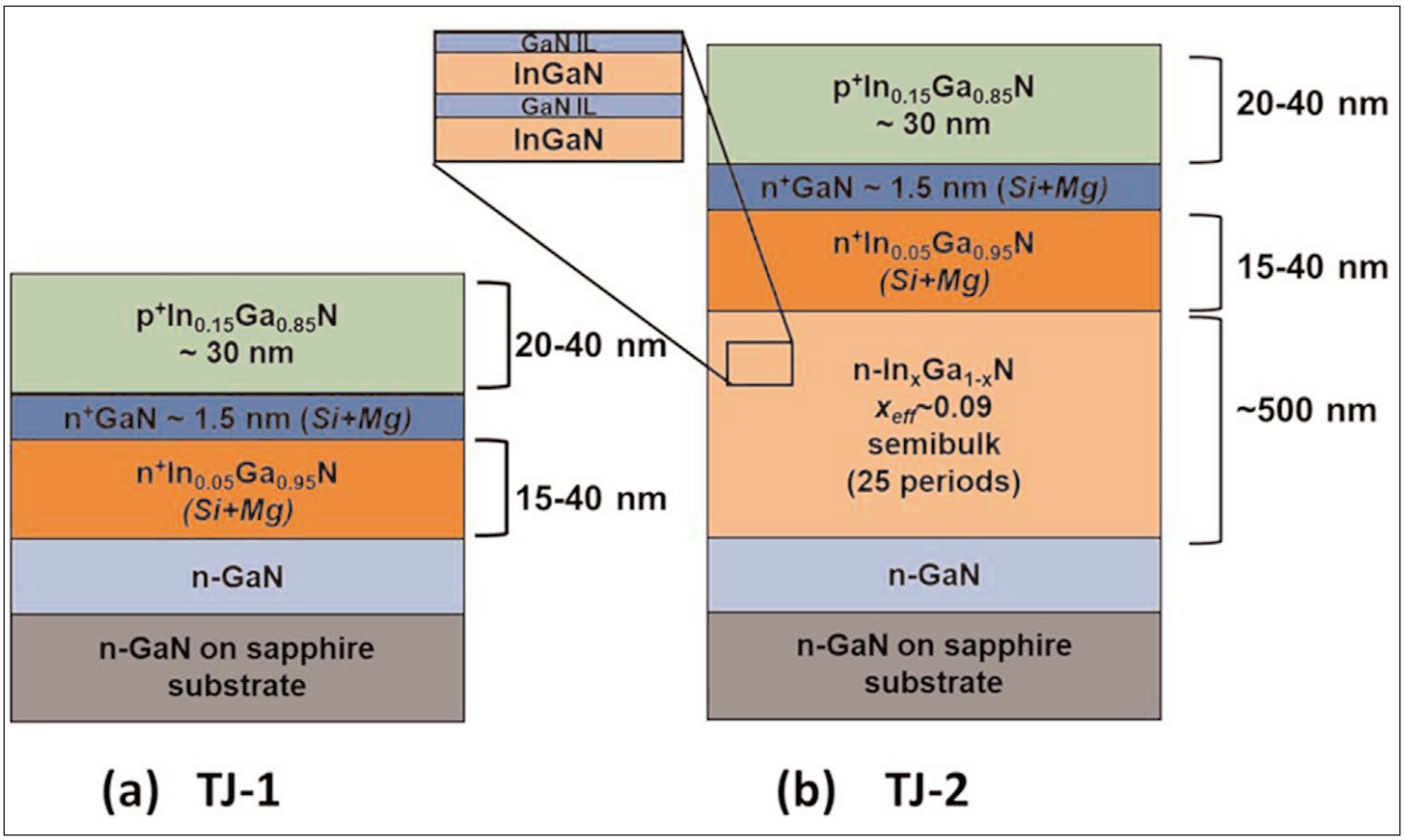

Figure 1. Schematic representation of (a) TJ-1 on GaN, and (b) TJ-2 on 25-period semi-bulk InGaN template. Period defined as InGaN and GaN interlayer (IL) pair.

tration of Mg. Thus, the researchers found that they did not need the very high Mg concentrations used by others (~10^{20}/cm^3), which can lead to pyramid defects. The NCSU Mg doping level was in the low-to-mid 10^{19}/cm^3 range.

Designing InGaN TJ structures with constant Mg doping avoids particular problems of MOCVD growth such as a delay in incorporation after the source starts to be supplied, and the memory effect where Mg continues to be incorporated after the supply is switched off. The memory effect may be due to temporary absorption of Mg on the reactor chamber wall. The delay and memory effects affect the abruptness of the doping profile. The n-type dopant (silicon) is not as subject to these effects. Sharp doping profiles are particularly critical in TJs where a very thin depletion layer is needed to increase tunneling probabilities.

Magnesium in GaN forms two levels within the bandgap: the Mg acceptor level is about 180–200meV above the valence band while another deep donor level exists at around 400–440meV below the conduction band. This deep donor level has been attributed to a Mg and nitrogen vacancy complex (Mg–V_N). The transition between those two levels is responsible for the blue band emission, around 2.8eV, that is typically observed in the heavily doped p-GaN film. The same sort of behavior, or even better, is expected in InGaN. Generally, the hole concentration in p-InGaN is higher than for p-GaN doped with the same concentration of Mg

The epitaxy was performed on commercial 5μm n-GaN on sapphire templates. The MOCVD was carried out in a home-made reactor with the substrate rotating under alternating streams of group-III and group-V precursor supplies (trimethyl metal-organics and ammonia, respectively) in hydrogen/nitrogen carriers. The silicon (Si) and magnesium (Mg) n- and p-type dopants came in the forms of silane (SiH_4) and bis(cyclopentadienyl)magnesium (Cp_2Mg), respectively.

The researchers made two sets of TJs: one set on GaN, the other on an InGaN 'semi-bulk' (SB) template layer (Figure 1). The latter was prepared by growing a series of thick InGaN layers separated by a thin high-temperature GaN layer, which aimed at backfilling V-pits generated during the relaxation of the InGaN. The indium content was controlled by the growth temperature during the InGaN MOCVD.

The TJ consisted of n^+-$In_{0.05}Ga_{0.95}N$ and p^+-$In_{0.15}Ga_{0.85}N$. The n^+ layer used a Si+Mg co-doping strategy. The Mg flow was constant during the entirety of the TJ growth. Activation of the p-type layers was through 750°C annealing for 20 minutes in nitrogen. Test devices were fabricated with 400μmx400μm etch mesas and standard n- and p-type Ohmic contact metal electrodes.

The epitaxial structure resulted in strained TJs, which took advantage of the resulting piezoelectric field to bend the band structure, narrowing the depletion layer thickness.

The current-voltage behavior was non-rectifying and linear, i.e. 'Ohmic', in both structures (Figure 2). There was a wide spread in the results over at least

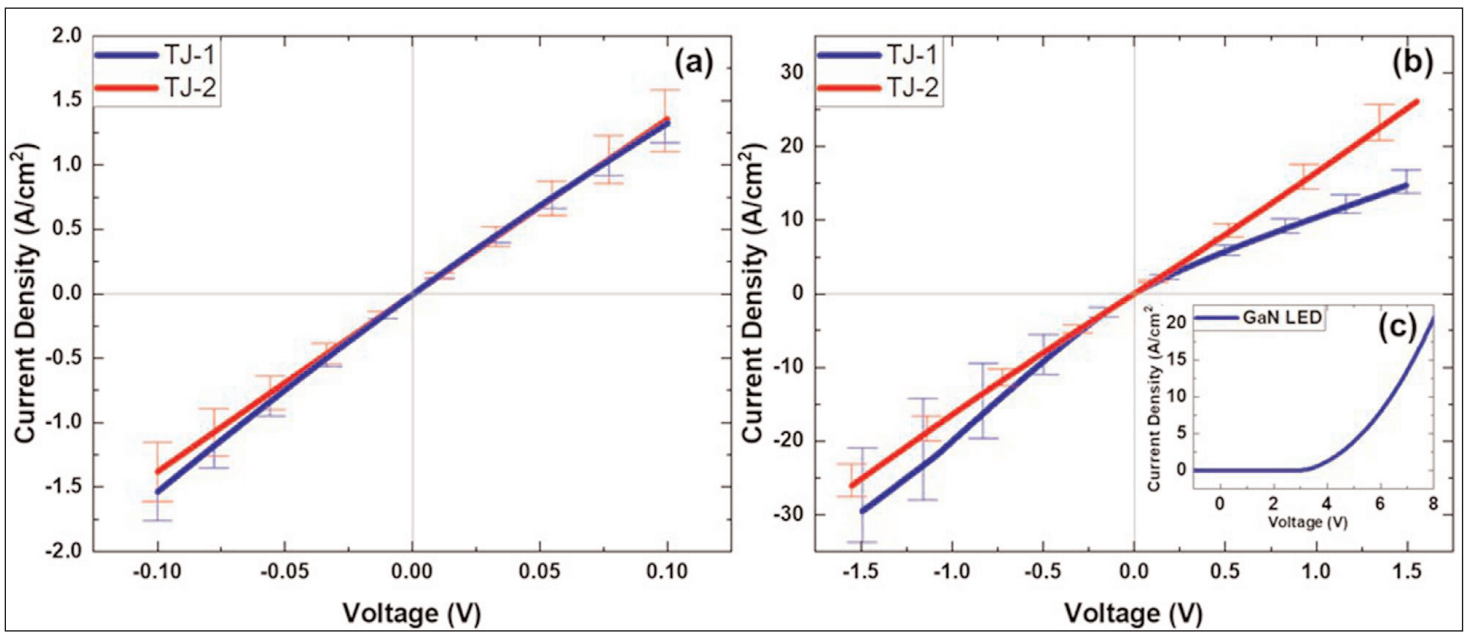

Figure 2. Current-voltage curves of TJ-1 (blue) and TJ-2 (red) at (a) low bias and (b) high bias with (c) inset showing MQW-based LED structure performance using identical mesa and metallization processes.

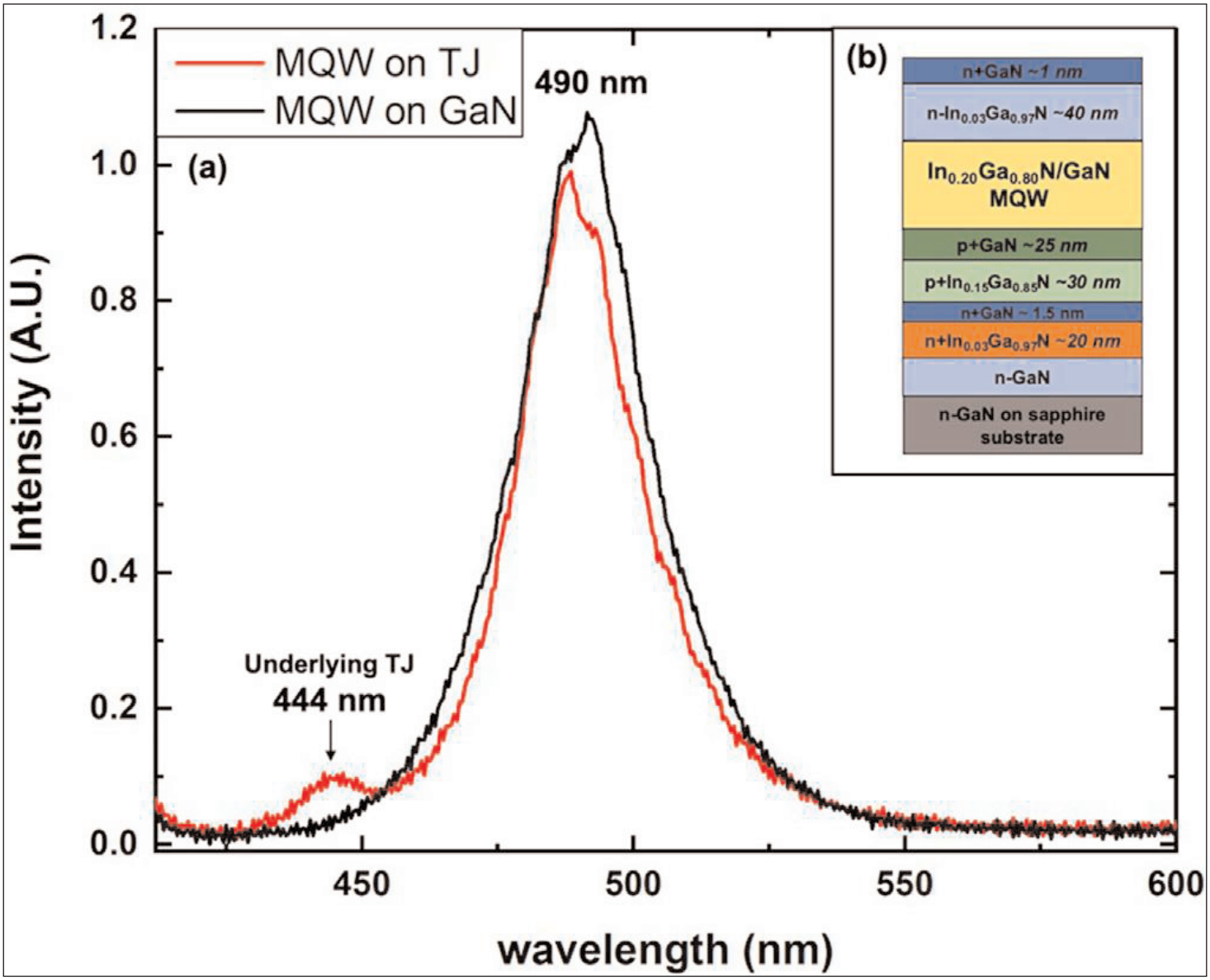

Figure 3. (a) Photoluminescence of MQW grown on TJ structure (red), compared to similar emitting MQW on GaN (black). (b) Schematic of MQW on TJ.

10 devices for each data point. The team suggests that this could be "due to a lack of a thick contacting layer as well as slight variations in the thickness and indium composition across the samples, especially for the p^+ $In_{0.15}Ga_{0.85}N$ film, which can be critical in the achieved hole concentrations." The researchers add: "Such a lack of uniformity is expected in a home-built MOCVD system."

In the low-current region up to ±0.1V bias, the resistivity of both structures was around $8x10^{-2}\Omega$-cm^2. At higher bias, ±1.5V, the resistances deviated: the reverse-bias resistivities were in the range 5–$6x10^{-2}\Omega$-cm^2; and the forward-bias values were $1x10^{-1}$ and $6x10^{-2}\Omega$-cm^2 for TJ-1 and TJ-2, respectively.

The researchers point out that the forward-bias behavior is in contrast to previously reported results for MOCVD-grown TJs that had a backward diode behavior, rather than their TJs with similar behavior in both forward and reverse directions.

The team also report photoluminescence results from an LED structure with buried TJ on GaN, as in TJ-1, which allows inversion of the usual LED structure with the p-side below the n-side (Figure 3). Such an LED structure has been proposed as a way to access the desirable performance of N-polar devices which have the crystal orientation and strain-dependent electric fields reversed. One has to remember that buried p-GaN layers can be difficult to activate, since this requires expulsion of hydrogen from the layer. This is easier if the p-GaN is the top layer, dictating the usual structure. The NCSU team says it is working on fabricating buried TJ LEDs for future publication. The photoluminescence result showed comparable emission of the MQW-buried TJ with a conventional MQW-top p-GaN layer structure. ▯

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Lateral polarization GaN HEMTs

N-polar electrical isolation can be used to avoid mesa etch or ion implant damage.

Researchers in China and Saudi Arabia propose lateral modulation of the charge polarization of III–nitride material as a more effective route to electrically isolate high-electron-mobility transistors, compared with mesa etching or ion implantation [Yijun Dai et al, Appl. Phys. Lett., v121, p012104, 2022].

Current leakage occurs in mesa etched structures through surface damage. Ion implantation needs high-temperature annealing to repair crystal structures, which can result in poor thermal stability and introduction of deep-level defects.

"Structures of polarization-isolated high-electron-mobility transistors (PI-HEMTs) exhibit significantly reduced isolation leakage currents by up to nearly two orders of magnitude at 50V voltage bias compared to the state-of-the-art results," the team from Ningbo Institute of Materials Technology and Engineering and University of Chinese Academy of Sciences, China, and King Abdullah University of Science and Technology (KAUST), Saudi Arabia, comment.

The PI-HEMTs used a lateral polarity structure (LPS) with N-polar material providing isolation between III–polar HEMT regions (Figure 1). The two-dimensional electron gas (2DEG) at the aluminium gallium nitride (AlGaN) barrier/gallium nitride (GaN) channel interface usual in III-polar structures is expected in the N-polar isolation regions to be depleted owing to the Fermi level being below the conduction band.

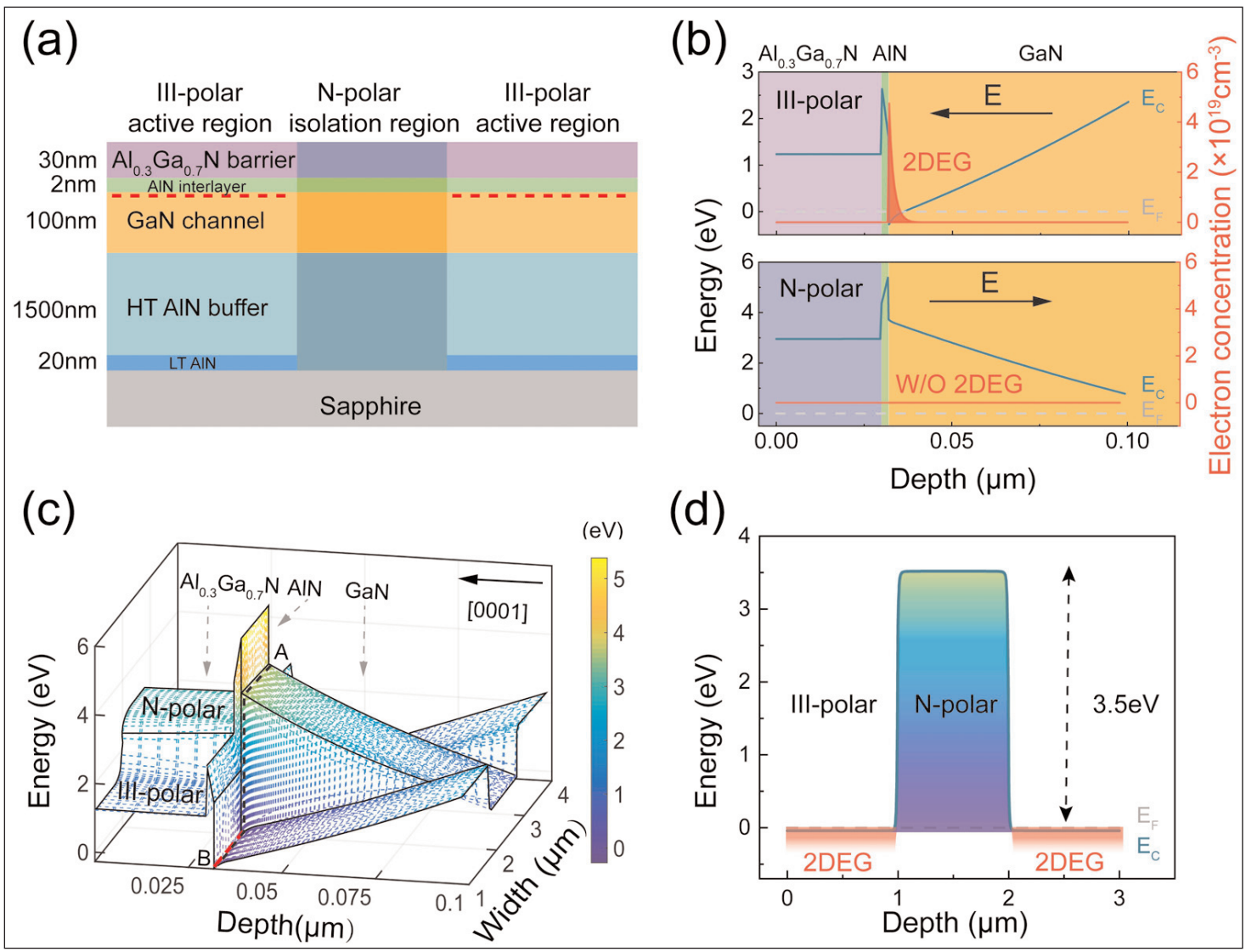

Figure 1. (a) Cross-sectional PI-HEMT scheme. Red dashed line represents 2DEG. (b) Band diagrams. (c) Three-dimensional mapping of conduction band showing barrier height between III- and N-polar GaN of PI-HEMT structure with 1μm N-polar width (i.e. isolation spacing). (d) Conduction band diagram extracted from dashed line A–B in (c).

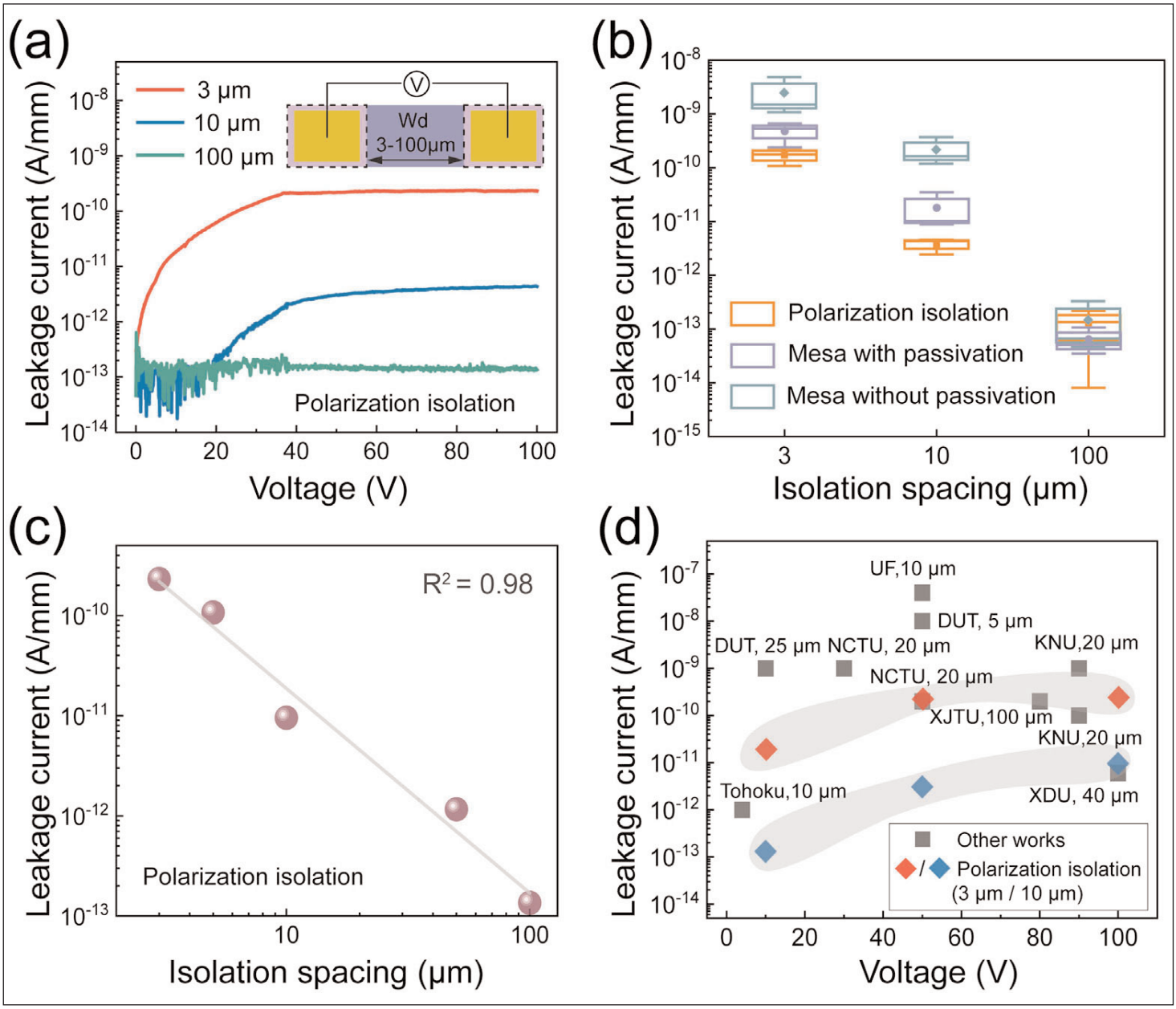

Figure 2. (a) Leakage versus voltage for PI-HEMT structures. (b) Comparison of PI- with mesa-isolated III-polar HEMT structures with various isolation spacings at 100V bias; (c) leakage versus isolation spacing of PI-HEMT at 100V bias. (d) Benchmarking of leakage versus voltage against state-of-the-art results.

"Due to inversion of the spontaneous polarization direction, the polarization-induced electric field in the III-polar structure is opposite to that of the N-polar structure," the researchers explain.

The N-polar material therefore can be used to electrically isolate the III-polar 2DEG. The team estimates the induced barrier height at 3.5eV, "significantly larger than the conduction-band offset between AlN and GaN".

The team sees their work as potentially leading to GaN power electronic arrays and monolithic microwave integrated circuits (MMIC) with high breakdown voltage and high-density chip integration. Enhanced isolation will enable GaN technology to leverage the full benefit of its high breakdown voltage, fast switching speed, and continued operation at high temperature (HT).

Other devices that could benefit from LPS include super-junctions, Schottky barrier diodes (SBDs), MESFETs, and photodetectors.

The sources for metal-organic chemical vapor growth of the HEMT material on 2-inch sapphire were trimethyl-Ga/Al and ammonia (NH_3).

The PI-HEMT material growth differed from the usual HEMT process by using a patterned rather than uniform 20nm low-temperature AlN nucleation layer. Care was taken to apply identical surface pre-treatments to the PI-HEMT nucleation layer and a reference regular HEMT structure, grown with uniform AlN nucleation.

The material on AlN nucleation was III-polar, while that on the bare sapphire was N-polar. The transition between the materials was of the order of a few

nanometers, according to high-resolution transmission electron microscope analysis.

The III-polar structure resulted in a 2DEG with $1.5x10^{13}/cm^2$ carrier concentration and $1277cm^2/V-s$, and 326Ω/square sheet resistance.

The team reports: "Due to the large lattice mismatch between the GaN channel and AlN buffer, the quality of the GaN channel layer is deteriorated, leading to scattering effects and reduced carrier mobility."

The PI-HEMT was fabricated by electron-beam evaporation and annealing of titanium/aluminium/nickel/gold source/drain electrodes and nickel/gold gate deposition.

The isolation performance was measured between two HEMT III-polar regions separated by 100μm, 10μm and 3μm N-polar regions. The applied bias reached up to 100V. For PI, the isolation leakage was fairly steady above 40V. The 100μm leakage was of the order 10^{-13}A/mm at 40V and above. Reducing the gap increased the current to $2x10^{-12}$ and $2x10^{-10}$A/mm, respectively, for the shorter 10μm and 3μm gaps.

Comparison was made with uniform HEMT regions, isolated with the usual plasma etching process to a depth of 120nm. Some of these samples also were treated with hydrogen chloric acid passivation. These had a similar isolation performance to the PI samples with 100 m gaps. However, differences became apparent for the shorter gaps with the PI sample significantly outperforming both the mesa structure with and without passivation (Figure 2).

The improved isolation of the PI-HEMT structure led to an expected enhancement of the two-terminal breakdown characteristics. The breakdown for the PI-HEMT structure with 3μm isolation was 2680V, compared with 1380 and 1644V for mesa isolation without and with passivation, respectively.

Increasing the isolation width to 10μm gave breakdowns below 3000V for the mesa isolations, while the PI structure did not suffer breakdown at this level. No breakdown was observed at 3000V for any of the samples with 100μm isolation. "The results suggest that the polarization isolation is highly advantageous in high-density high-power device integration," the team observes.

The 3μm gate-length PI-HEMTs had a rather negative threshold (normally-on/depletion-mode) of −6.1V. The researchers see this as being mainly due to the thick 30nm AlGaN barrier. The source-gate and gate–drain distances were 2μm and 3μm, respectively.

The off-state leakage was $\sim 2x10^{-8}$mA/mm, giving an on/off current ratio of order 10^9. The off-state was dominated by gate leakage current. The subthreshold slope was 61mV/decade, close to the theoretical minimum of 60mV/decade.

The researchers comment: "The result unambiguously demonstrates the excellent leakage suppression of the PI-HEMT device, revealing the unique advantage of utilizing polarization modulation to tune the 2DEG in-plane." ▯

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Selective-area p-doping by Mg implant then UHP anneal yields kV-class, low-ON-resistance vertical GaN junction barrier Schottky

NC State, Adroit Materials and Polish Academy of Sciences achieve record breakdown voltage and on-resistance.

By using a unique technique for doping gallium nitride (GaN) in a controlled way, researchers at North Carolina State University and spin-off Adroit Materials Inc of Cary, NC, USA plus the Institute of High-Pressure Physics at the Polish Academy of Sciences have created new high-power electronic devices that are said to be more energy efficient than previous technologies (Khachariya et al, 'Vertical GaN Junction Barrier Schottky Diodes with Near-ideal Performance using Mg Implantation Activated by Ultra-High-Pressure Annealing', Applied Physics Express; DOI: 10.35848/1882-0786/ac8f81).

"Many technologies require power conversion," says first author Dolar Khachariya, a former Ph.D. student at NC State. "For example, the technology might need to convert AC to DC, or convert electricity into work — like an electric motor. And in any power conversion system, most power loss takes place at the power switch," he adds.

"Developing more efficient power electronics like power switches reduces the amount of power lost during the conversion process," says Khachariya, who is who is now a researcher at Adroit Materials. "This is particularly important for developing technologies to support a more sustainable power infrastructure, such as smart grids," he adds.

"Our work here not only means that we can reduce energy loss in power electronics, but we can also make the systems for power conversion more compact compared to conventional silicon and silicon carbide electronics," says co-author Ramón Collazo, associate professor of materials science and engineering at NC State. "This makes it possible to incorporate these systems into technologies where they don't currently fit due to weight or size restrictions, such as in automobiles, ships, airplanes, or technologies distributed throughout a smart grid."

In a paper published in 2021, the researchers outlined a technique that uses ion implantation and activation to dope targeted areas in GaN materials. In the new paper, the researchers have demonstrated how this technique can be used to create actual devices. Specifically, the researchers used selectively doped GaN materials to create junction barrier Schottky (JBS) diodes.

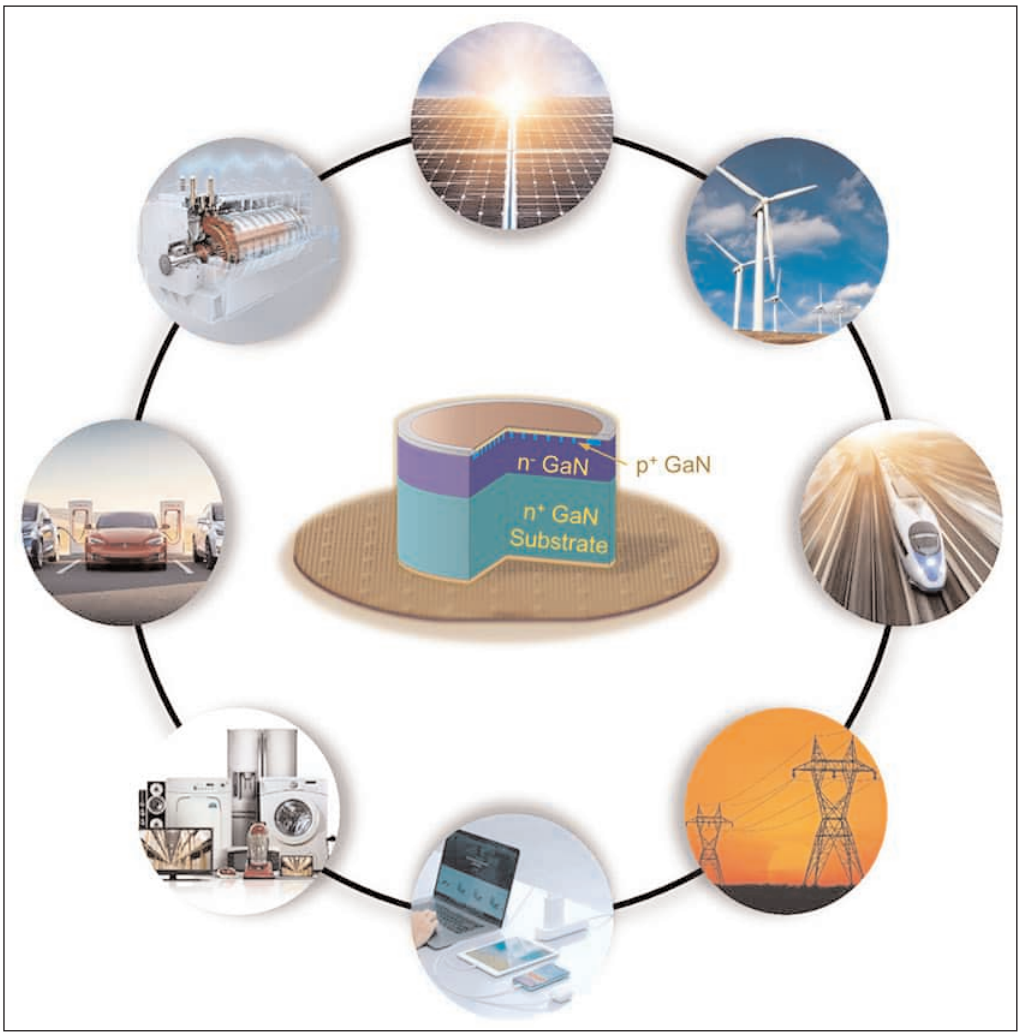
"Power rectifiers, such as JBS diodes, are used as switches in every power system," Collazo says. "But historically they have been made of the semiconductors silicon or silicon carbide, because the electrical properties of undoped GaN are not compatible with the architecture of JBS diodes," he adds.

"We've demonstrated that you can selectively dope GaN to create functional JBS diodes, and that these diodes are not only functional but enable more power-efficient conversion than JBS diodes that use conventional semiconductors. For example, in technical terms, our GaN JBS diode, fabricated on a native GaN substrate, has record high breakdown voltage (915V [corresponding to a maximum electric field of 3.3MV/cm]) and record low on-resistance."

The JBS has an ideality factor of 1.03, a turn-on voltage of 0.75V, and a specific differential ON-resistance of 0.6mΩ·cm^2.

"We're currently working with industry partners to scale up production of selectively doped GaN, and are looking for additional partnerships to work on issues related to more widespread manufacturing and adoption of power devices that make use of this material," Collazo says.

The paper was co-authored by Spyridon Pavlidis, an assistant professor of electrical and computer engineering at NC State; Shashwat Rathkanthiwar, a post-



doctoral researcher at NC State; Shane Stein, a Ph.D. student at NC State; Hayden Breckenridge, a former Ph.D. student at NC State; Erhard Kohn, a research associate at NC State and emeritus professor of Ulm University in Germany; Zlatko Sitar, Kobe Steel Distinguished Professor of Materials Science and Engineering at NC State and the founder of Adroit Materials; Will Mecouch, Seiji Mita, Baxter Moody, Pramod Reddy, James Tweedie and Ronny Kirste of Adroit Materials; and Kacper Sierakowski, Grzegorz Kamler and Michal Bockowski of the Institute of High-Pressure Physics at the Polish Academy of Sciences.

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www.samcointl.com

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Fax: +44 (0)1633 414141
www.spts.com

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85748 Garching, Germany
Tel: +49 89 32007 0
Fax: +49 89 32007 162
www.suss.com

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1024 Ecublens,
Switzerland
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Fax +41 21 694 35 01
www.synova.ch

TECDIA Inc
2700 Augustine Drive, Suite 110,
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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

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Fax: +44 (0) 1480 424900
www.goodfellow.com

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Austria
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10 Gas and liquid handling equipment

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www.iemtec.com

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11 Process monitoring and control

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www.wepcontrol.com

12 Inspection equipment

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www.bruker.com

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Fax: +1 510 456-2498
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13 Characterization equipment

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www.jawoollam.com

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14 Chip test equipment

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www.tek.com

15 Assembly/packaging materials

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17 Assembly/packaging foundry

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18 Chip foundry

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19 Facility equipment

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20 Facility consumables

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USA
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Fax: +1 410 506 8749
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21 Computer hardware & software

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22 Used equipment

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24 Resources

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Berlin, Germany
E-mail: carolin.geppert@conventus.de
www.iwn2022.org

16–19 October 2022
28th International Semiconductor Laser Conference (ISLC 2022)
Kunibiki Messe, Matsue, Japan
E-mail: islc2022@or.knt.co.jp
www.islc2022.org

16–19 October 2022
2022 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
Sheraton Phoenix Downtown, Phoenix, AZ, USA
E-mail: cs@cshawevent.com
www.bcicts.org

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

23–27 October 2022
4th IEEE Workshop on Gallium Oxide and Related Materials (IWGO 2022)
Saihokukan Hotel, Nagano, Japan
E-mail: secretary@iwgo2022.org
www.iwgo2022.org

7–8 November 2022
PIC Summit Europe
Eindhoven, the Netherlands
E-mail: maartje@picsummiteurope.com
www.picsummiteurope.com

7–9 November 2022
9th IEEE Workshop on Wide Bandgap Power Devices & Applications (WiPDA 2022)
Sonesta Redondo Beach and Marina, Redondo Beach. CA, USA
https://wipda.org

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

18–20 November 2022
3rd International Congress on Optics, Electronics, and Optoelectronics 2022 (ICOEO-2022)
Xiamen Software Park Fliport Hotel, Xiamen, China
E-mail: sally@istci.org
www.istci.org/icoeo2022

3–7 December 2022
68th annual IEEE International Electron Devices Meeting (IEDM 2022)
Hilton San Francisco Union Square hotel, San Francisco, CA, USA
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www.ieee-iedm.org

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14–16 December 2022
SEMICON Japan 2022
Tokyo Big Sight, Tokyo, Japan
E-mail: jcustomer@semi.org
www.semiconjapan.org/en

1–3 February 2023
SEMICON Korea 2023
COEX, Seoul, South Korea
E-mail: semiconkorea@semi.org
www.semiconkorea.org/en

19–23 February 2023
2023 IEEE International Solid- State Circuits Conference (ISSCC 2023)
San Francisco, CA USA
E-mail: Issccinfo@yesevents.com
www.isscc.org

5–9 March 2023
Optical Fiber Communication Conference and Exhibition (OFC 2023)
San Diego Convention Center, San Diego, CA, USA
E-mail: custserv@optica.org
www.ofcconference.org

17–21 March 2023
4th International Congress on Advanced Materials Sciences and Engineering (AMSE-2023)
Hilton Vienna Danube Waterfront,
Vienna, Austria
E-mail: eve@istci.org
www.istci.org/amse2023

19–23 March 2023
IEEE Applied Power Electronics Conference and Exposition (APEC 2023)
Orange County Convention Center,
Orlando, FL, USA
E-mail: apec@apec-conf.org
www.apec-conf.org

20–21 March 2023
China Semiconductor Technology International Conference (CSTIC) 2023, in conjunction with SEMICON China 2023
Shanghai, China
E-mail: cstic@semichina.org
www.semiconchina.org/en/5

22–24 March 2023
SEMICON China and FPD China 2023
Shanghai New International Expo Centre, China
E-mail: semichina@semi.org
www.semiconchina.org/en

26–30 March 2023
2023 IEEE International Reliability Physics Symposium (IRPS)
Hyatt Regency, Monterey, CA, USA
E-mail: IRPSreg@ieee.org
www.irps.org

7–12 May 2023
2023 Conference on Lasers & Electro-Optics (CLEO)
San Jose Convention Center, San Jose, CA, USA
E-mail: CLEO@compusystems.com
www.cleoconference.org

21–25 May 2023
LightFair 2023
Javits Center, New York, USA
E-mail: michellem@lightfair.com
www.lightfair.com

23–25 May 2023
SEMICON Southeast Asia (SEMICON SEA 2023)
Setia SPICE Convention Centre & Arena, Penang, Malaysia
E-mail: semiconsea@semi.org
www.semiconsea.org

Microwave Week
11–13 June 2023
2023 IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2023)
San Diego Convention Center, San Diego, CA, USA
E-mail: support@mtt.org
www.rfic-ieee.org

11–16 June 2023
2023 IEEE/MTT-S International Microwave Symposium (IMS 2023)
San Diego Convention Center, San Diego, CA, USA
E-mail: exhibits@horizonhouse.com
www.ims-ieee.org/ims2023

11–16 June 2023
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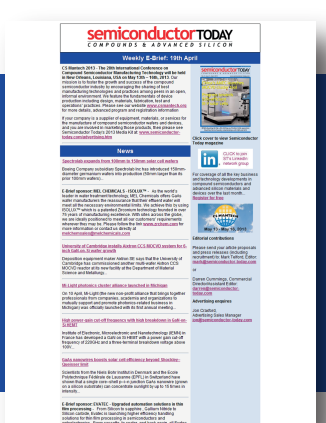

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