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COMPOUNDS & ADVANCED SILICON
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Aixtron launches G10-GaN platform for power & RF devices

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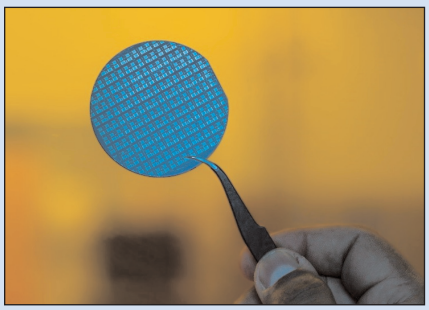
p12 Volvo has invested in Shanghai-based SiC power module maker Leadrive as it aims to go all-electric by 2030.



p18 The Indian Institute of Science in Bengaluru has developed a fully indigenous GaN power switch, developed in-house at the Centre for Nano Science and Engineering.

p54 First Solar Inc of Tempe, AZ, USA has broken ground its fifth fully vertically integrated factory in the USA, sited in Iberia Parish, Louisiana.

Cover image: At SEMICON Taiwan Aixtron launched its G10-GaN cluster MOCVD platform for GaN-based power & RF devices, Equipped with up to three process modules, it can deliver a record capacity of 15x200mm wafers, enabling a 25% cost reduction per wafer. **p33**

editorial

Deglobalization driving state funding

With the Russia–Ukraine war dividing international relations, trade war between US and China, and China aiming to integrate Taiwan by 2030, the trend is towards deglobalization by re-shoring overseas manufacturing and establishing or securing supply chains.

As well as luring Taiwanese foundry TSMC to invest in establishing fabrication plants in the USA and Europe, the USA's CHIPS and Science Act and the European Chips Act are allocating billions to reinvigorate onshore semiconductor manufacturing.

In compound semiconductors in particular, UK start-up Cambridge GaN Devices Ltd and US-based GaN power device firms including Navitas and GaN Systems are using TSMC for foundry manufacturing. However, US-based Transphorm makes its own GaN power devices, and in May was awarded a $15m contract from the National Security Technology Accelerator (NSTXL) to make GaN epiwafers for the project ECLIPSE.

Likewise, the Indian Institute of Science has created a "fully indigenous" GaN power switch, with the whole process — material growth, device fabrication and packaging — developed in-house (page 18). Strategic organizations in India "have a hard time procuring GaN transistors… It is impossible to import them beyond a certain quantity or power/frequency rating".

For GaN-based power & RF devices, at September's SEMICON Taiwan 2023, Germany-based Aixtron launched its G10-GaN cluster MOCVD platform, which has already been qualified for volume production of GaN power devices by a leading US device maker, says the firm (see page 33).

While the USA, Europe and Japan dominate the supply of critical manufacturing equipment, Russia and China dominate the supply of materials such as gallium, which is a strategic material for GaN and GaAs devices in defense applications. Following US-led restrictions on exports of advanced manufacturing equipment to China, on grounds of "national security" China on 1 August implemented new export control regulations on gallium and germanium materials. In late September, US-based AXT received initial permits for export of GaAs and Ge substrates from its China-based factories to certain customers (see page 34). However, China — which comprised 86% of global primary unrefined gallium production capacity in 2022 — could still cut off supply. The USA and Europe is hence investigating restarting gallium production as well as developing mining prospects.

Meanwhile, the European Committee of the Regions has launched the European Semiconductor Regions Alliance (ESRA) as a political network engaged to "strengthen Europe's capacity to produce semiconductors and microelectronics, reducing its dependency from supplies from third countries" (page 8). Despite aiming to leverage the EU Chips Act, the ESRA includes Wales, home to the Compound Semiconductor Cluster CSconnected.

Also, ams OSRAM is set to receive more than €300m over five years in subsidies from the German Federal and Bavaria State governments — via the European Commission's Important Projects of Common European Interest (IPCEI) program for funding digital and green initiatives. This will "support the European Green Deal and the autonomy of Europe in semiconductors" by expanding the optoelectronic manufacturing at the firm's Regensburg site (see page 41).

It may take years to see the effects of such funding, but in the meantime global supply chains are being decoupled and re-made, to accommodate the shifts in international trade relations.

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).

Regular issues contain:
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- feature articles (technology, markets, regional profiles);
- conference reports;
- event calendar and event previews;
- suppliers' directory.

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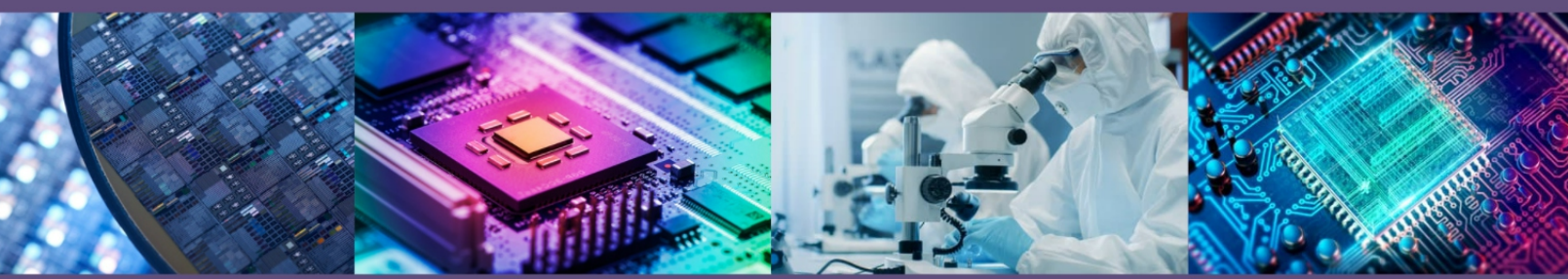

CSconnected is home to the world's first regional ecosystem based on the manufacture of compound semiconductor enabled hardware, located in south Wales

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news

Q2 smartphone production falls 6.6% year-on-year

After plunging by a record 19.5% year-on-year in first-quarter 2023, global smartphone production saw a second consecutive quarterly decline in Q2/2023, falling by about 6.6% year-on-year to 272 million units, according to market research firm TrendForce. First-half 2023 production was 522 million units, down 13.3% year-on-year. This represents a ten-year low for both individual quarters and the first half of the year.

TrendForce flags three key reasons behind this slump in production:

- the easing of pandemic restrictions in China failed to spur demand;
- the demographic dividend from the emerging Indian market has yet to translate into tangible demand;
- initially, it was estimated that brands would return to normal production levels as excess inventory was cleared, but the current economic downturn has kept consumer spending in check, undermining first-half production more than expected.

Transsion overtakes Vivo to enter top five

In a dramatic shake-up of global rankings, Transsion (including TECNO, Infinix, and itel) eclipsed Vivo to secure the fifth spot for the first time. Transsion's high production output benefited from a trifecta of inventory replenishment, new product launches, and its entry into mid-to-high end-markets, notes TrendForce. Demonstrating robust production performance since March, the firm's growth trajectory is poised to extend its momentum into Q3/2023. Meanwhile, Vivo (including Vivo and iQoo) is treading cautiously amid a sluggish global economy, which is evident in its conservative production plan: Vivo produced 23 million units in Q2 — a modest quarterly increase of 15% — and hence slipped to sixth place in the global rankings.

Q2 Production and Market Share Ranking of Top Six Global Smartphone Brands

Ranking	Brand	Production	QoQ	Market Share
1	Samsung	53.9	-12.4%	19.8%
2	Apple	42.0	-21.2%	15.4%
3	Xiaomi	35.0	32.1%	12.9%
4	Oppo	33.6	25.4%	12.3%
5	Transsion	25.1	71.9%	9.2%
6	Vivo	23.0	15.0%	8.5%

Apple closes gap with Samsung

Samsung continues to lead in production rankings, delivering 53.9 million units in Q2. However, it suffered a 12.4% quarter-to-quarter downturn. Amid global economic headwinds and fierce competition, coupled with a waning halo effect from its flagship phone releases earlier in the year, Samsung's Q2 performance lagged behind the same period last year. Although Samsung is set to roll out new foldable models in Q3, the impact on its overall growth is expected to be marginal, given the low sales volume compared with its Galaxy S series.

Apple's Q2 is typically the weakest quarter for production due to its transition between older and newer models. Output fell by 21.2% quarter-to-quarter to 42 million units in Q2/2023. The upcoming iPhone 15/15 Plus could face headwinds due to suboptimal yields in its CMOS image sensors, potentially impacting its Q3 production performance. Intriguingly, Apple and Samsung are neck-and-neck in their annual production projections. Should the iPhone 15 series outperform market expectations, Apple stands a good chance of ousting Samsung from its long-held position as the global market leader, reckons TrendForce.

Xiaomi (including Xiaomi, Redmi and POCO) produced 35 million units in Q2 — a seasonal uptick of 32.1%. This boom can be attributed to a strategic depletion of channel inventory coupled with the allure of new product launches. However, Xiaomi's channel inventory still runs high, setting the stage for a Q3 that is likely to mirror its Q2 performance.

On the other side of the spectrum, Oppo (including Oppo, Real, and OnePlus) primarily rode the wave of rebounding demand in Southeast Asia and other regions in Q2, so production was about 33.6 million units — marking a seasonal leap of 25.4%. With seasonal demands on the horizon, Oppo's Q3 production is poised for estimated growth of 10–15%, primarily targeting markets in China, South Asia, Southeast Asia, and Latin America, hot on Xiaomi's heels.

Production may fall further in second-half 2023

Demand in consumer markets such as China, Europe and North America has not shown a significant rebound as we move into second-half 2023. Even if economic indicators in the Indian market improve, it is still difficult to reverse the global decline in smartphone production. TrendForce says that the smartphone market may have undergone another shift in Q2 this year due to poor global economic conditions, so production for second-half 2023 may consequently be further reduced.

Looking ahead to 2024, the current economic outlook is not optimistic. TrendForce maintains its forecast of an annual increase in global production of just 2–3%, depending on regional economic trends. Whether this will further drag down production remains to be seen.

www.trendforce.com

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European Semiconductor Regions Alliance launched

Wales joins 27 regions in 12 EU member states to exploit EU Chips Act

On 7 September, the European Committee of the Regions (CoR) in Brussels, Belgium — in a signing ceremony hosted by the Minister-President of the Free State of Saxony (Freistaat Sachsen) Michael Kretschmer — launched the European Semiconductor Regions Alliance (ESRA) as a political network engaged to strengthen Europe's capacity to produce semiconductors and microelectronics, reducing its dependency from supplies from third countries.

The Alliance aims to identify and help remove the obstacles to the industry's strategic development by: improving the legal framework; promoting public and private investment; supporting the sharing of knowledge, best practices and innovation; fostering collaboration between regions; and developing strong and resilient integrated value chains in the semiconductor industry. A priority is to make the most of the EU Chips Act and to attract investment.

Against the backdrop of Europe's insufficient semiconductor resilience, high supply chain sensitivity and high dependence on semiconductor imports, a package of measures to strengthen the EU's semiconductor ecosystem was proposed by the European Commission on 8 February 2022 and approved by the European Parliament on 11 July 2023 and by the EU Council of Ministers on 25 July. The resultant EU Chips Act is intended to mobilize public and private investment of up to €43bn.

ESRA was initiated on 6 March by Saxony, whose Minister for Regional Development Thomas Schmidt is also the European Committee of the Regions' rapporteur on the EU Chips Act.

"For each segment of the global semiconductor value chain, it takes on average more than 20 countries involved in the direct supply chain to work closely together," notes Kretschmer. The global semiconductor shortage has exposed the dependence of regions and cities on supply from a limited number of companies and its vulnerability to export restrictions from third countries and other disruptions in the current geopolitical context. Europe's share of the global semiconductor market is currently 10% by value, far below its economic weight. The EU Chips Act aims to boost market share to 20% by 2030.

ESRA sees itself as a platform of the regions and partner of the European Commission in the implementation of the EU Chip Act. It wants to make an active contribution to strengthening Europe as a semiconductor location in global competition and to promote the competitiveness of the semiconductor industry in the regions of the European member states as well as in the entire EU.

"With ESRA, we are opening up new ways for regions to collaborate, research and innovate to ensure Europe's economic and digital sovereignty," says Kretschmer. Growing European semiconductor manufacturing is expected to secure industrial production in the EU as a whole and make it more competitive with the USA and China.

"After the adoption of the European Chips Act, it is now a matter of implementation, of establishing new production facilities, of strengthening research and of training skilled workers," says rapporteur Schmidt.

The aim of the alliance is hence to jointly strengthen growth and increase the competitiveness of the European semiconductor industry through:

- joint research and innovation, developing new technologies and applications;
- skills and talent development, promoting education and training programs;

● cluster development and cooperation, promoting regional clusters and cross-regional partnerships.

The 27 regions (from 12 EU member states, plus Wales) involved are: Baden-Württemberg, Bavaria, Hamburg, Hesse, Lower Saxony, Saxony, Saxony-Anhalt, Saarland, Schleswig-Holstein, and Thuringia in Germany; Andalusia, the Basque Country, Valencia, and Catalonia in Spain; Flevoland and North Brabant in the Netherlands; Carinthia and Styria in Austria; the Centro Region in Portugal; Flanders in Belgium; Auvergne-Rhône-Alpes in France; Piedmont in Italy, Tampere and Helsinki in Finland; South Moravia in the Czech Republic; Wales in the UK; and the Republic of Ireland.

"The participation of many regions in the launch event underlines the interest in increased cooperation at EU level in the field of microelectronics," notes Kretschmer. "The Alliance will make an important contribution to making Europe competitive in this key industry in the years to come."

In the jointly signed 10-point paper establishing the ESRA, the regions state the following objectives to:

● ensure the best possible and innovative support and competitive framework conditions for the regions within the framework of the European Chip Act, as well as a long-term definition of funds in the EU's Multiannual Financial Framework to increase European semiconductor production;
● achieve the greatest possible flexibility and speed in the examination and granting of state aid in the semiconductor industry;
● expand R&D and promote networking of research institutions in and between the various regions and develop unique technological features;
● develop and implement solution approaches for a more sustainable production of semiconductors in the context of the European Green Deal;
● ensure sufficient water and energy supply at the production sites as well as supply with all necessary, especially strategic and critical raw materials;
● strengthen cooperation in talent development as well as education and training of skilled workers, in the recruitment of non-European skilled workers as well as international university cooperation;
● cultivate and intensify cooperation of existing clusters;
● conduct events in cooperation with industry players;
● articulate and represent common interests of member regions vis-à-vis the EU Commission and EU institutions; and
● networking and coordination of the regions involved at the working level and networking with industry associations and other European networks.

Among the 27 signatories but outside the EU, Wales is home to CSconnected, the South Wales Compound Semiconductor Cluster. "The Welsh Government is ambitious for the semiconductor sector in the south-east of Wales and the objectives of the ESRA align with our Programme for Government and our Innovation Strategy, published earlier this year," notes Vaughan Gething, the Welsh Government's Minister for the Economy. "Joining the ESRA will provide new opportunities for Welsh companies to embed themselves in European supply chains, support innovation, collaboration and ultimately create a more resilient semiconductor sector," he adds.

"Europe remains Wales' closest and most important trading partner, and our new membership of the European Semiconductor Regional Alliance will support our International Strategy as we maintain a close and positive relationship with the European Union," says Wales' Representative on Europe Derek Vaughan, who signed the agreement on behalf of the Welsh Government.

https://cor.europa.eu/en
https://silicon-saxony.de/wp-content/uploads/2023/09/ESRA_10_Points_Paper.pdf

Altum RF showcases products at European Microwave Week

New GaAs and GaN devices for satcom, telecoms and E-band, radar, and test & measurement on show

Altum RF of Eindhoven, The Netherlands (which designs RF and millimeter-wave semiconductors for commercial and industrial applications) showcased its featured products and technical expertise at European Microwave Week (EuMW 2023) in Berlin, Germany (19–21 September).

With over 40+ gallium arsenide (GaAs) and gallium nitride (GaN) MMICs from the X-band to over 100GHz, Altum RF featured several products, including new components for satcom, telecoms and E-band, radar, and test & measurement markets. Highlights included:

SatCom/telecoms

● ARF1014: 27–31.5GHz GaN 12W power amplifier MMIC, 17dB power gain;
● ARF1114Q4: 17–23GHz driver amplifier, 24dB small-signal gain, 26dBm saturated output power (P_{sat}).

Radar

● ARF1020Q5: 9–11GHz GaN 10W power amplifier MMIC, 20dB power gain;
● ARF1211Q3: 6–14GHz low-noise/driver amplifier, 1.7dB noise figure, 20dBm output P1dB;
● ARF1108Q4: 8.5–12GHz amplifier, 23dB small-signal gain, 27dBm saturated output power (P_{sat}).

www.eumweek.com
www.altumrf.com

Guerrilla RF updates revenue guidance, targeting 30% growth in 2023 and 40% in 2024

Strategy refocused to achieve profitability by Q2/2024

Guerrilla RF Inc (GRF) of Greensboro, NC, USA — which develops and manufactures radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) for wireless applications — has revised its guidance for third-quarter 2023 revenue from $3–3.5m to $3.3–3.5m. Full-year 2023 revenue is now expected to exceed $15m ($14.6–15.4m), up about 30% on 2022.

Full-year 2024 revenue is expected to grow by 40% year-on-year to $21–26m, as previously announced design wins continue to ramp. Those design wins are expected to generate over $7m in annualized ongoing program revenue for 2024 and increasing through 2028. Also, gross margin should grow to over 60% for full-year 2024 as fixed costs are absorbed more efficiently.

During Q3/2023, Guerrilla RF announced a further advance of $1.5m under its existing credit facility and the initial advance of $1.75m under a new $4m loan facility with Salem Investment Partners LP. Guerrilla RF says that this new facility allows it to capture additional revenue upside, which has resulted in backlog rising to $6.11m as of 15 September, up 21.8% from $5.48m at the end of June 2023 and up 35.8% on $4.5m at the end of 2022, positioning the firm for its largest revenue quarter in its history.

In conjunction with securing additional funding to support its growth, management has continued to focus on reducing expenses that do not directly support increased near-term sales and/or gross margins. The firm has implemented cost savings, including voluntary salary reductions, further reducing salary expenses through attrition, elimination of non-essential expenses and other efforts. This is expected to reduce annualized expenses by $3–5m within the next several quarters. Guerrilla RF expects to substantially achieve breakeven on an operating basis, i.e. excluding interest expense, other non-operating expenses and non-recurring expenses, beginning second-quarter 2024 as revenues are expected to exceed $6m per quarter and fixed costs are absorbed more efficiently.

"Since 2013, Guerrilla RF has been investing in products, delivering high-performance RF solutions to demanding markets that value performance," says founder & CEO Ryan Pratt. "However, as the market environment has changed, it has become clear that profitability is more important than all-out growth. We have shifted our strategy accordingly to achieve breakeven status, beginning with the second quarter of 2024," he adds. "In light of anticipated 2024 revenue and operational profitability, management believes the company is significantly undervalued at approximately one times anticipated 2024 revenue."

www.guerrilla-rf.com

MACOM showcases new 70nm mHEMT and 100nm GaN process technologies at EuMW

Live demos of Ka-band TR MMIC and ultra-low-noise Ka-band LNA at European Microwave Week

At European Microwave Week (EuMW 2023) in Messe Berlin HUB27, Germany (19–21 September), MACOM Technology Solutions Inc of Lowell, MA, USA (which designs and makes RF, microwave, analog and mixed-signal and optical semiconductor technologies) hosted live product demonstrations featuring new metamorphic high-electron-mobility transistor (mHEMT) and gallium nitride (GaN) process technologies, namely:

- a Ka-band TR MMIC (100nm GaN technology);
- an ultra-low-noise Ka-band low-noise amplifier (70nm mHEMT technology).

Attendees had the opportunity to ask questions and interact with staff during these live demonstrations.

MACOM also showcased the following new products and capabilities:

- a 50GHz high-performance externally modulated fiber-optic link;
- a digitally controlled compact linearizer module platform for traveling-wave tube (TWT) amplifiers;
- a high-performance monolithic aluminium gallium arsenide (AlGaAs) PIN limiter for Ka-band;
- a connectorized AlGaAs single-pole two-throw high-power switch with driver up to 50GHz;
- 7kW to 150W MACOM Pure Carbide high-voltage L-band GaN power amplifiers; and
- 200W Doherty power amplifiers for C-band 5G applications.

MACOM's product management and applications engineering teams will also provide in-depth explanations of the solutions provided by its broad RF and microwave IC and modules portfolio.

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Volvo invests in China SiC power module maker Leadrive

Swedish car maker targets vertical integration to go all-electric by 2030

Volvo Cars Tech Fund, the corporate venture capital arm of Sweden-based Volvo Cars, has invested in Leadrive Technology of Shanghai, China, which was founded in 2017 and manufactures power electronics and control units for electric cars, specializing in designing and building power modules that use silicon carbide (SiC).

"Leadrive's technology demonstrates a lot of potential for the development of more efficient electric drivetrains," comments Volvo Cars Tech Fund's CEO Alexander Petrofski. "That potential closely aligns with our own focus on electrification." Volvo aims to become a fully electric car maker by 2030 and to be a climate-neutral company by 2040.

"Volvo Cars and Leadrive have been working very closely on the development of new-generation SiC technologies, which has built a firm stairway towards the strategic collaboration," says Leadrive's founder & CEO Jie Shen. "This is a great milestone in Leadrive's global strategy and demonstrates the huge potential of our cooperation in advanced electrification technology," he adds.

Focus on vertical integration

Focused on vertical integration to gain control over its electrification technology, Volvo says that its roadmap entails collaborating with relevant partners where it makes sense. It says that it has hence doubled down on critical technology investments in recent years and made key decisions on what it builds versus what it buys, for example by bringing the development and manufacturing of e-motors and inverters in-house while also developing its own battery management software. In addition, it is investing in the development and production of its own battery packs through Novo Energy, its joint venture with Northvolt, optimizing battery chemistry and integration in its cars.

"Together, these investments in batteries, e-motors, inverters and battery management software allow us to control the entire electrical propulsion system in our fully electric cars," says Volvo. "By working with firms like Leadrive, we can broaden our knowledge base and explore new exciting technologies."

Accelerating the transformation

"We started our Volvo Cars Tech Fund in 2018 to invest in companies and technology areas that transform the automotive industry, such as artificial intelligence, electrification, autonomous driving, sustainability and digital commerce," says the firm. "The Tech Fund makes strategic investments to help start-ups to thrive and jointly accelerate the transformation of the global mobility industry."

This latest investment by Volvo Cars Tech Fund is part of a new funding round by Leadrive, giving the Tech Fund a small minority stake in the firm.

www.volvocars.com
www.leadrive.com

Navitas presents silicon carbide technology at ICSCRM

GeneSiC power MOSFETs and Schottky MPS diodes span EV, data center, solar and appliance/industrial applications

At the International Conference on Silicon Carbide and Related Materials (ICSCRM 2023) in Sorrento, Italy (17–22 September), gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA presented two papers:

- 'New Generation SiC MPS Diodes with Low Schottky Barrier Height' by Aditi Agarwal, Siddarth Sundaresan, Jaehoon Park, Vamsi Mulpuri and Kailun Zhong; and
- '650V SiC Power MOSFETs with Statistically Tight V_{TH} Control and $R_{DS(ON)}$ of 1.92mΩ-cm^2' by Jaehoon Park, Siddarth Sundaresan, Aditi Agarwal, Vamsi Mulpuri, Nathaniel Walsh and Steven Smith.

Additionally, Navitas' senior VP of SiC technology & operations Dr Sid Sundaresan chaired the session on 'Devices 4: Short circuit, avalanche and reliability', which focuses on crucial topics in the field of SiC technology.

Navitas notes that its GeneSiC power devices — which are optimized for high-power, high-voltage and high-reliability SiC applications — address critical markets including electric vehicles, solar energy, energy storage, industrial applications, data centers, and consumer electronics. "With a voltage range spanning from 650V to 6.5kV, GeneSiC MOSFETs and Schottky MPS diodes offer performance and efficiency that pave the way for a more electrified and sustainable future," the firm adds.

"Navitas' presence at ICSCRM 2023 is a testament to the company's unparalleled expertise in SiC technology and its commitment to driving innovation in the industry," says Dr Ranbir Singh, Navitas' executive VP for the GeneSiC business line.

www.icscrm-2023.org
www.navitassemi.com

ST to supply third-generation 750V silicon carbide power MOSFET dice to BorgWarner

Viper power module used in traction inverter platforms for Volvo's EVs

STMicroelectronics of Geneva, Switzerland is to supply BorgWarner Inc of Auburn Hills, MI, USA (which provides sustainable mobility solutions for the vehicle market) with the latest third-generation 750V silicon carbide (SiC) power MOSFETs dice for their proprietary Viper-based power module, used in its traction inverter platforms for several current and future Volvo Cars electric vehicles (EVs).

"This collaboration will give Volvo Cars the opportunity to further increase the attractiveness of our electrical vehicles with longer range and faster charging," says Volvo Cars' chief operating officer & deputy CEO Javier Varela. "It will also support us on our journey towards being fully electric by 2030 and strengthen our increased vertical integration and our control of critical components," he adds.

"BorgWarner is pleased to partner with ST to supply our longstanding customer Volvo Cars with inverters for their next-generation of BEV platforms," says Stefan Demmerle, VP of BorgWarner Inc and president & general manager, PowerDrive Systems.

To fully leverage the performance of ST's SiC MOSFET dice, BorgWarner collaborated with ST's technical team to match their die with BorgWarner's Viper power switch, maximizing inverter performance and delivering a compact and cost-effective architecture. The collaboration targets the high-volume capability required by the rapidly growing EV market.

"We are committed to expanding SiC capacity and to reinforcing our SiC supply, including through vertical integration, as we ramp up volumes to support our global automotive and industrial customers in their shift to electrification and higher efficiency," says Marco Monti, president of ST's Automotive and Discrete Group.

ST's high-volume STPOWER SiC products are manufactured in its fabs in Italy and Singapore, with packaging and testing at its back-end facilities in Morocco and China. In October 2022, it announced it would expand its wide-bandgap manufacturing capacity with a new integrated SiC substrate manufacturing facility in Catania, Italy, home to the firm's power semiconductor expertise and the site of integrated SiC research, development and manufacturing.

www.borgwarner.com
www.st.com

KERI transfers SiC power semiconductor ion implantation evaluation technology to Hungary's SEMILAB

Device structure formed using only ion implantation without epitaxy for cost-effective mass production

Korea Electrotechnology Research Institute (KERI) — which is funded under the National Research Council of Science & Technology (NST) of South Korea's Ministry of Science and ICT — has transferred ion implantation and evaluation technology for silicon carbide (SiC) power semiconductors to metrology equipment firm SEMILAB ZRT of Budapest, Hungary.

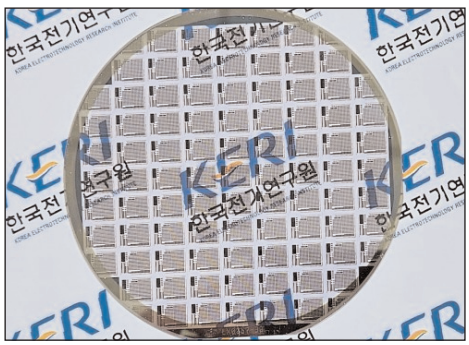
While SiC power semiconductors have many advantages, the manufacturing process is very challenging. Previously, the method was to create a device by forming an epitaxial layer on a highly conductive wafer and flowing current through that area. However, during this process, the surface of the epilayer becomes rough and the speed of electron transfer decreases. The price of the epiwafer itself is also high, which is a major obstacle to mass production.

To solve this problem, KERI used a method of implanting ions into a semi-insulating SiC wafer without an epilayer in order to make the wafer conductive.

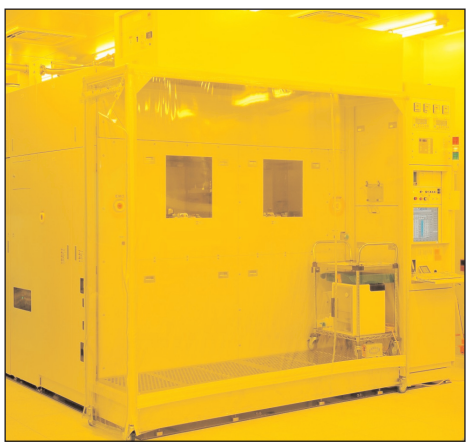
Since SiC materials are hard, they require very high-energy ion implantation followed by high-temperature heat treatment to activate the ions, making it a difficult technology to implement. However, KERI says that, based on its 10 years of experience in operating ion implantation equipment dedicated to SiC, it has succeeded in establishing the relevant technologies.

"Ion implantation technology can significantly reduce process costs by increasing current flow in semiconductor devices and replacing expensive epiwafers," says Dr Kim Hyoung Woo, director, Advanced Semiconductor Research Center, KERI. "This is a technology that increases the price competitiveness of high-performance SiC power semiconductors and contributes greatly to mass production."

Second from left, Dr Bahng Wook, executive director of KERI's Power Semiconductor Research Division; third from the left, Park Su-yong, CEO of Semilab Korea Co Ltd.



Semi-insulating SiC wafer.



Ion implantation equipment used in SiC power semiconductor processing.

The technology was recently transferred to SEMILAB, which has manufacturing plants in Hungary and the USA. With a 30-year history, SEMILAB owns patents for medium-sized precision measurement equipment and material characterization equipment, and possesses technology for semiconductor electrical parameter evaluation systems.

The firms expect that, through the technology transfer, they will be able to standardize high-quality SiC. SEMILAB plans to use KERI's technology to develop specialized equipment to evaluate the ion implantation process for SiC power semiconductors. "Through the development of specialized equipment, we will be able to progress in-line monitoring of implant processes on SiC wafers for immediate, accurate and low-cost production control of implant systems and in-line monitoring for pre-anneal implant," says Park Su-yong, president of SEMILAB Korea. "This will be a great foundation for stably securing a high-quality ion implantation mass-production process with excellent uniformity and reproducibility."

www.semilab.com
www.keri.re.kr/html/en

Toshiba ships first 2200V dual SiC MOSFET module

Migration of industrial equipment from 1000V to 1500V anticipated

Japan-based Toshiba Electronic Devices & Storage Corp (TDSC) — which was spun off from Toshiba Corp in 2017 — has begun volume shipments of what it reckons is the industry's first 2200V dual silicon carbide (SiC) MOSFET module for industrial equipment.

Using the firm's third-generation SiC MOSFET chips and with a drain current (DC) rating of 250A, the new MG250YD2YMS3 module is suitable for applications that use DC1500V, such as renewable energy power generation systems (photovoltaic power systems etc) and energy storage systems.

Such industrial applications generally use DC1000V or lower power, and their power devices are mostly 1200V or 1700V products, but Toshiba anticipates widespread use of DC1500V in the coming years.

Toshiba's MG250YD2YMS3, the first 2200V dual SiC MOSFET module.

The MG250YD2YMS3 offers low conduction loss with a low drain–source on-voltage (sense) of 0.7V (typical, tested at I_D=250A, V_{GS}=+20V, T_{ch}=25°C). It also offers lower turn-on and turn-off switching loss of 14mJ (typical) and 11mJ (typical) respectively (tested at V_{DD}=1100V, I_D=250A, T_{ch}=150°C), an approximately 90% reduction against a typical 2300V silicon (Si) insulated-gate bipolar transistor (IGBT) module. These characteristics contribute to higher equipment efficiency. Realizing low switching loss also allows the conventional three-level circuit to be replaced with a two-level circuit with a lower module count, contributing to equipment miniaturization.

Applications in industrial equipment include: renewable energy power generation systems (photovoltaic power systems, etc); energy storage systems; motor control equipment for industrial equipment; high frequency DC–DC converter etc.

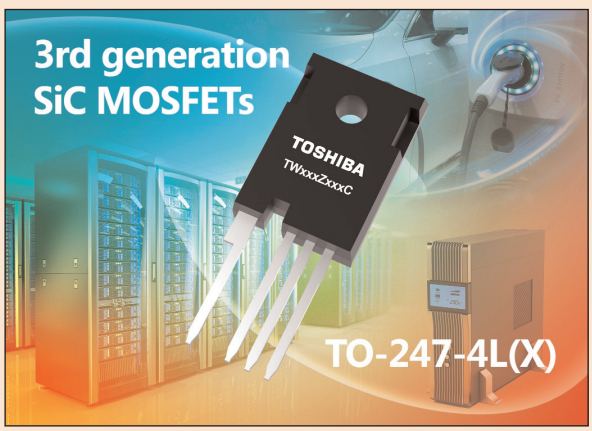
www.toshiba.semicon-storage.com

Toshiba releases third-generation SiC MOSFETs with reduced switching losses

New devices in 4-pin package offer improved MOSFET switching performance in industrial applications

Toshiba Electronics Europe GmbH of Düsseldorf, Germany is now shipping the TWxxxZxxxC series of ten silicon carbide (SiC) MOSFETs based on the firm's third-generation technology, targeted at reducing losses in a variety of industrial applications including switching power supplies for servers & data centers, electric vehicle (EV) charging stations, photovoltaic (PV) inverters and uninterruptible power supplies (UPS).

Devices in the TWxxxZxxxC series are the first Toshiba SiC products to be housed in a TO-247-4L(X) package with a fourth pin. This allows the provision of a Kelvin connection of the signal source terminal for the gate drive, reducing the parasitic inductance effects of the internal source wire and improving high-speed switching performance. Comparing the TW045Z120C with Toshiba's existing TW045N120C (3-pin TO-247) shows an improvement in turn-on loss of about 40% while the turn-off loss is improved by about 34%.



The new TWxxxZxxxC series includes five devices with a drain–source (V_{DSS}) rating of 650V and a further five devices rated at 1200V for higher-voltage applications. The typical drain–source on-resistance ($R_{DS(ON)}$) ranges between 140mΩ and 15mΩ. Combined with low gate–drain charge (Q_{GD}) values, this can enable low losses even in high-frequency applications. The devices are capable of delivering continuous drain currents (I_D) of up to 100A.

www.toshiba.semicon-storage.com/eu/semiconductor/product/mosfets/sic-mosfets.html

Infineon providing 1200V CoolSiC MOSFETs for Infypower's EV charger stations

Infineon Technologies AG of Munich, Germany is providing 1200V CoolSiC MOSFET power semiconductor devices to improve the efficiency of electric vehicle (EV) charging stations made by Infypower of Shenzhen, China. Since being founded in 2014, Infypower has focused on power electronics and intelligent control, and provides EV charging modules, smart energy routers, supercharging stations, and photovoltaic energy storage systems.

"The collaboration between Infineon and Infypower in the field of charging solutions for electric vehicles provides an excellent system-level technology solution for the local EV charging station industry," reckons Dr Peter Wawer, division president of Infineon's Green Industrial Power Division. "It will significantly improve charging efficiency, accelerate charging speed, and create a better user experience for owners of electric cars," he adds.

"With Infineon's more than 20 years of continuous advancement in SiC product offering and the strength of integrated technology, Infypower can consolidate and maintain its technological outstanding position in the industry by adopting state-of-the-art product processes and design solutions," comments Qiu Tianquan, president of Infypower China. "We can also set a new standard for charging efficiency of DC chargers for new energy vehicles."

SiC's high power density enables the development of high-performance, lightweight and compact chargers, especially for supercharging stations and ultra-compact wall-mounted DC charging stations. Compared with traditional silicon-based solutions, SiC technology in EV charging stations can increase efficiency by 1%, reducing energy losses and operating costs. In a 100kW charging station, this translates to 1kWh of electricity savings, saving €270 annually and reducing carbon emissions by 3.5 tons, and helping to drive the increasing adoption of SiC power devices in EV charging modules.

As one of the first SiC power semiconductor manufacturers to use trench-gate technology for transistors, Infineon has introduced a design that provides high reliability for chargers, it is claimed. Offering a high threshold voltage and simplified gate driving, the CoolSiC MOSFET technology has been subjected to marathon stress tests and gate voltage jump stress tests before commercial release and regularly afterwards in the form of monitoring to ensure high gate reliability.

By integrating Infineon's 1200V CoolSiC MOSFETs, Infypower's 30kW DC charging module is said to offer a wide constant power range, high power density, minimal electromagnetic radiation and interference, high protection performance and high reliability. It is hence reckoned to be well suited for the fast-charging demands of most EVs while providing 1% higher efficiency compared with other solutions on the market.

www.infypower.com

Collaboration on GaN-based PD3.1 notebook adapter

Taiwan-based power supply maker Chicony Power Technology is expanding its partnership with Infineon to boost the performance of its latest PD3.1 notebook adapter series. The two firms aim to provide end-customers with efficient power solutions, based on gallium nitride, with a smaller form factor and higher power density.

With the latest USB PD 3.1 standard, released in 2021, and Chicony Power's core competitiveness in power adapters, the firm selected Infineon's CoolGaN and CoolMOS technology to realize the new PD3.1 notebook power adapter series with what is claimed to be best-in-class performance. Due to the new topology, the new adapter series can provide no less than a 30% increase in power density and demonstrates what is said to be outstanding performance in switching and conduction losses. Compared with the 100W defined in USB 3.0, the new series can deliver up to 240W, and charges high-performance notebooks such as gaming computers and multimedia workstations via USB-C power delivery. The new power adapter series can be used as a universal power supply for multiple electronic devices.

"We use our unique expertise in GaN technology in applications and system solutions to make high-performance computing more efficient and more mobile," says Adam White, president of Infineon's Power and Sensor Systems Division. "Together with Chicony Power and our CoolGaN technology, we can realize the new power design capability for PD3.1 adapters, so that every user can easily contribute to decarbonizing the way we work with computers – without compromising on mobility for the sake of performance," he adds.

"Combined with Chicony Power's remarkable capabilities in power systems, the new PD3.1 product series has been achieved within a faster time to market," says Yang Wang, VP R&D at Chicony Power. "Power and size are key points for mobile workers. Gallium nitride and silicon semiconductors from Infineon are the perfect match to increase power density and reduce losses."

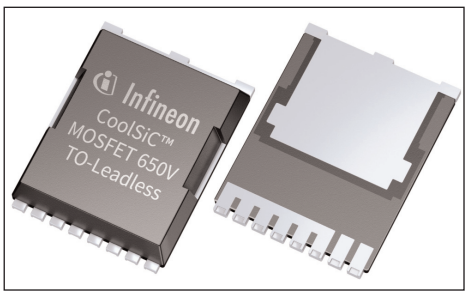
www.infineon.com

Infineon adds 650V TOLL portfolio to CoolSiC MOSFETs

TO leadless packaging enables better thermal performance, power density and easier assembly

As digitalization, urbanization and the rise of electro-mobility continue to shape the rapidly evolving world, the demand for power consumption is reaching unprecedented levels. Acknowledging energy efficiency as an important concern, Infineon Technologies AG of Munich, Germany is addressing these megatrends with its silicon carbide (SiC) CoolSiC MOSFET 650V in TO leadless (TOLL) packaging. The new SiC MOSFETs are enhancing Infineon's comprehensive CoolSiC portfolio and are optimized for the lowest losses, the highest reliability and ease-of-use in applications such as SMPS for servers, telecom infrastructure as well as energy storage systems and battery formation solutions.

The CoolSiC 650V high-performance trench-based power SiC MOSFETs are offered in a very granular portfolio to best suit different target applications. The new family comes in a JEDEC-qualified TOLL package featuring a low parasitic inductance, allowing for higher switching frequency, reduced switching losses, good thermal management, and automated assembly. The compact form factor enables efficient and effective usage of the board space, empowering system designers to achieve exceptional power density, it is reckoned.



Infineon's CoolSiC MOSFET 650V in TO leadless (TOLL) packaging, optimizing performance for various applications and offering high reliability, low losses and ease-of-use while enabling efficient power density and thermal management.

The CoolSiC MOSFET 650V showcases high reliability even in harsh environments, making them a suitable choice for topologies with repetitive hard commutation. The inclusion of .XT interconnect technology further enhances the devices' thermal performance by reducing the thermal resistance (R_{th}) and thermal impedance (Z_{th}). In addition, the new devices feature a gate threshold voltage ($V_{GS(th)}$) greater than 4V for robustness against parasitic turn-on, a robust body diode, and what is claimed to be the strongest gate oxide (GOX) on the market, resulting in extremely low FIT (failures in time) rates.

While a cut-off voltage ($VG_{S(off)}$) of 0V is generally recommended to simplify the driving circuit (unipolar driving), the new portfolio supports a wide driving interval of V_{GS} voltage within the range of –5V (turn-off) to 23V (turn-on). This ensures ease-of-use and compatibility with other SiC MOSFETs and standard MOSFET gate-driver ICs. This is paired with higher reliability, reduced system complexity, and the enablement of automated assembly, reducing system and production costs and accelerating time-to-market, says Infineon.

The new CoolSiC MOSFET 650V in TOLL industrial-grade discretes is available in various drain–source on-resistance ($R_{DS(on)}$) options from 22mΩ to 83mΩ and can be ordered now (107mΩ, 163mΩ and 260mΩ versions will be available on-demand).

www.infineon.com/coolsic-mosfet-discretes

Indian Institute of Science develops fully indigenous gallium nitride power switch

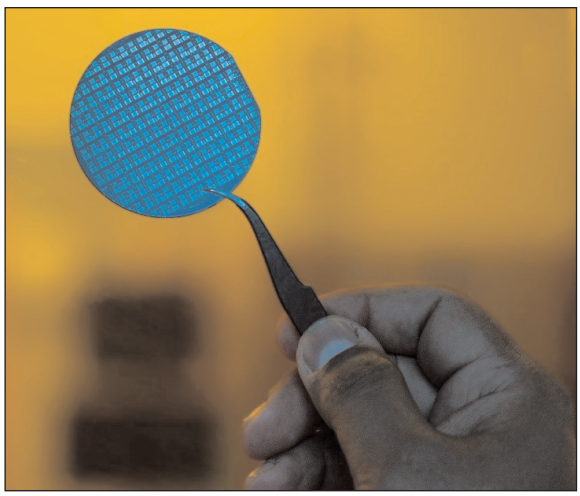
Centre for Nano Science & Engineering and Department of Electrical Engineering produce 8A, 200V normally-off cascode GaN-on-Si HEMT

The Indian Institute of Science (IISc) in Bengaluru has developed what it describes as a fully indigenous gallium nitride (GaN) power switch that can have potential applications in systems like power converters for electric vehicles and laptops, as well as in wireless communications (Baby R, Mandal M, Roy SK, Bardhan A, Muralidharan R, Basu K, Raghavan S, Nath DN, '8A, 200V normally-off cascode GaN-on-Si HEMT: From epitaxy to double pulse testing', Microelectronic Engineering (2023)). The entire process of creating the switch — from material growth to device fabrication to packaging — was developed in-house at IISc's Centre for Nano Science and Engineering (CeNSE).

"The material and devices are heavily import-restricted… We don't have gallium nitride wafer production capability at commercial scale in India yet," notes CeNSE associate professor Digbijoy Nath, corresponding author of the paper. "The know-how of manufacturing these devices is also a heavily guarded secret, with few studies published on the details of the processes involved," he adds.

To design the GaN power switch, the IISc team used a metal-organic chemical vapor deposition (MOCVD) technique developed and optimized over a decade by researchers in the lab of CeNSE professor Srinivasan Raghavan. The team was aided by Department of Electrical Engineering associate professor Kaushik Basu and his lab in fabricating an electrical circuit using these transistors and testing their switching performance.

GaN transistors typically operate in depletion mode — they are normally on unless a negative voltage is applied to turn them off. But power switches used in chargers and adapters need to work the other way around, in enhancement mode, i.e. normally off and not carrying current, and only turning on when a positive voltage is applied. To achieve this, the team combined the GaN transistor with a commercially available silicon transistor to keep the device normally off.



Two-inch GaN-on-silicon wafer with power transistors developed at IISc's CeNSE (photo: Ashutosh Vishwakarma).

"The packaging of the device was also indigenously developed," explains CeNSE PhD student Rijo Baby, first author of the paper. After packaging and testing, the team found that the device performance was comparable to state-of-the-art switches available commercially, with a switching time of about 50ns between on and off operation.

Going forward, the researchers plan to scale up the device dimensions so that it can operate at high currents. They also plan to design a power converter that can step up or step down voltages.

"If you look at strategic organizations in India, they have a hard time procuring GaN transistors… It is impossible to import them beyond a certain quantity or power/frequency rating," notes Nath. "This is essentially a demonstration of indigenous GaN technology development."

The work is funded by MeitY & DST Nano Mission through NNETRA, MoE (MHRD) through NIEIN, and SCL/ISRO.

www.sciencedirect.com/science/article/abs/pii/S0167931723001508
www.cense.iisc.ac.in/research/gan-technology

From left to right: Srinivasan Raghavan, Manish Mandal, Rijo Baby, Kaushik Basu, and Digbijoy N Nath (photo: Ashutosh Vishwakarma).

GaN Systems launches Gen4 GaN power platform

Efficiency and power density improvements unlock extra total system cost savings

GaN Systems Inc of Ottawa, Ontario, Canada (a fabless developer of gallium nitride-based power switching semiconductors for power conversion and control applications) has introduced its 4th generation GaN power platform, targeting markets including consumer electronics, data centers, solar energy, industrial, and automotive.

The technology is claimed to set a new power efficiency and compactness standard, delivering a performance boost and industry-leading figures of merit. For example, with Gen4 in an artificial intelligence (AI) server rack, 3.2kW power supplies at 100W/in^3 in 2022 are now achieving 120W/in^3 with efficiencies above Titanium levels.

The Gen4 platform is also claimed to deliver more total bill-of-material cost savings compared with traditional silicon and silicon carbide solutions.

"Our lead customers have already realized the benefits of our Gen4 platform," says CEO Jim Witham. "GaN Systems, in strategic collaboration with industry leaders like TSMC, has invested significantly to meet the ever-evolving demands of our customers," he adds. "We are pioneering a transformation in product offerings, packaging innovations, enriched functionalities, and unparalleled performance across our markets."

The Gen4 power platform is said to have the following benefits:

- >20% improvement in input and output figures-of-merit translates into reduced losses, enhanced efficiency and more cost-effective solutions.
- Increased granularity in device specification, combined with a wide range of packaging options, including PDFN, TOLL, TOLT, and Embedded — allowing the correct R_{ds} resistance and package combination for each application, consequently optimizing electrical and thermal system performance.
- 700V E-mode with what is claimed to be the industry's highest transient voltage rating (850V), significantly enhancing total system reliability and robustness. This rating enables the semiconductor components to withstand user environment anomalies, such as voltage spikes, ensuring uninterrupted and dependable performance.
- On-state resistance ranges enable power systems from 20W to 25,000W.

www.gansystems.com/

Navitas launches GaNSafe power platform

Fourth-generation GaN technology optimized for high-power data-center, solar/energy storage and EV applications

At a worldwide launch at the Marriot Taipei in Taiwan, gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA unveiled GaNSafe, a new, high-performance wide-bandgap power platform. Navitas has optimized its fourth-generation GaN technology for demanding, high-power applications in data centers, solar/energy storage and electric vehicle (EV) markets, where efficiency, power density, and robust, reliable operation are critical.

At the launch event, senior VP worldwide sales David Carroll and senior director business development Charles Bailley introduced the new GaNSafe platform to an invited audience of over 50 customer attendees, plus industry partners and international media.

The new fourth-generation GaN power ICs are manufactured in Hsinchu by long-term Navitas foundry partner TSMC. At the GaNSafe launch, Dr RY Su, manager of GaN Power Technology at TSMC, gave a special presentation on the future of GaN.

Navitas' GaNFast power ICs integrate gallium nitride power and drive, with control, sensing and protection to enable faster charging, higher power density and greater energy savings, with over 100,000,000 units shipped, and an industry-first 20-year warranty. Now, the new GaNSafe platform has been engineered with additional, application-specific protection features, functions and new, high-power packaging to deliver enabling performance under high-temperature, long-duration conditions.

The initial, high-power 650/800V GaNSafe portfolio spans a range of $R_{DS(ON)}$ from 35mΩ to 98mΩ in a novel, robust and cool-running surface-mount TOLL package, to address applications from 1000W to 22,000W. GaNSafe integrated features and functions include:

- Protected, regulated, integrated gate-drive control, with zero gate–source loop inductance for reliable high-speed 2MHz switching capability to maximize application power density.
- High-speed short-circuit protection, with autonomous 'detect and protect' within 50ns – four times faster than competing discrete solutions, it is reckoned.
- Electrostatic discharge (ESD) protection of 2kV, compared with zero for discrete GaN transistors.
- 650V continuous and 800V transient voltage capability to aid survival during extraordinary application conditions.
- Easy-to-use, complete, high-power, high-reliability, high-performance power IC with only four pins, to accelerate customer designs.
- Programmable turn-on and turn-off speeds (dV/dt) to simplify EMI regulatory requirements.

Unlike discrete GaN transistor designs, with voltage spikes, undershoot and specification breaches, GaNSafe is said to deliver an efficient, predictable, reliable system. Its robust 4-pin TOLL package has achieved the IPC-9701 mechanical reliability standard, and delivers simple, strong, dependable performance compared with multi-chip modules which require three times as many connections and have poor cooling capability, Navitas adds.

Navitas' market-specific system design centers offer complete platform designs with benchmark efficiency, density and system cost using GaNSafe products to accelerate customer time-to-revenue and maximize the chance of first-time-right designs. These system platforms include complete design collateral with fully tested hardware, embedded software, schematics, bill-of-materials, layout, simulation and hardware test results. Examples of system platforms enabled by GaNSafe technology include:

- Navitas' CRPS185 data-center power platform, which delivers a full 3200W of power in only 1U (40mm) x 73.5mm x 185mm (544cc), achieving 5.9W/cc, or almost 100W/in3 power density. This is a 40% size reduction versus the equivalent legacy silicon approach and reaches over 96.5% efficiency at 30% load, and over 96% stretching from 20% to 60% load, creating a 'Titanium Plus' benchmark.
- Navitas' 6.6kW 3-in-1 bi-directional EV on-board charger (OBC) with 3kW DC–DC. This 96%+ efficient unit has over 50% higher power density, and with efficiency over 95%, delivers up to 16% energy savings compared with competing solutions.

"Our original GaNFast and GaNSense technologies have set the industry standard for mobile charging, establishing the first market with high-volume, mainstream GaN adoption to displace silicon," claims CEO & co-founder Gene Sheridan. "GaNSafe takes our technology to the next level, as the most protected, reliable and safe GaN devices in the industry, and now also targeting 122kW power systems in AI-based data centers, EV, solar and energy storage systems," he adds. "Customers can now achieve the full potential of GaN in these multi-billion dollar markets demanding the highest efficiency, density and reliability."

The GaNSafe portfolio is available immediately to qualified customers, with mass production expected to begin in fourth-quarter 2023. Forty customer projects are already in progress with GaNSafe in data-center, solar, energy storage and EV applications, contributing to Navitas' $1bn customer pipeline.

www.semicontaiwan.org
www.navitassemi.com

Ugreen using Navitas's GaNFast ICs in first 5-port 300W GaN desktop charger

Latest collaboration between firms adds to Nexode series

Hong Kong-based Ugreen (which provides charging accessories) has partnered with gallium nitride (GaN) power IC and silicon carbide (SiC) technology firm Navitas Semiconductor of Torrance, CA, USA to launch what is reckoned to be the world's first 5-port 300W GaN desktop charger – the Ugreen Nexode 300W Desktop Charger.

"Navitas has been working closely with UGREEN for a long time," notes Charles Zha, VP & general manager of Navitas China. "This first 300W GaN desktop charger based on LLC structure can realize such astonishing power density with such small size," he adds.

"This high-powered charger incorporates Navitas's GaNFast chip and Ugreen's product design innovation," says Evan Li, vice president of Ugreen. "We look forward to strengthening our partnership with Navitas."

A new addition to the Ugreen Nexode series, the Nexode 300W Desktop Charger is a high-power device that can fast charge five devices simultaneously: four USB-C ports and one USB-A port. The single port output can deliver up to a maximum of 140W, which is sufficient to charge a 16" MacBook Pro from 0% to 56% in just 30 minutes, suiting the rapid charging of laptops, tablets, phones etc.

The charger supports PD 3.1 and QC3.0, along with other fast-charging protocols including PD/QC/SCP/FCA/AFC.

Ugreen Nexode 300W desktop charger is available for purchase for $269 in the USA on Amazon.com, and Ugreen.com. The recommended retail price for Amazon UK is £269.99 and €269.99 on Amazon EU.

www.ugreen.com
www.navitassemi.com

Spark Connected and Infineon unveil 500W industrial wireless charging module

Yeti 500W integrates Infineon's CoolGaN products

Spark Connected of Dallas, TX, USA (which develops wireless power technology for industrial, automotive, aerospace and consumer applications) and Infineon Technologies AG of Munich, Germany, have announced the market release of the Yeti 500W ready-to-integrate wireless charging module, targeted at industrial machinery, autonomous mobile robots, automated guided vehicles (AGVs), light electric vehicles (LEVs), e-Mobility and other power-intensive applications.

The Yeti 500W integrates Infineon's dual-core PSoC 63 Bluetooth Low Energy MCU for intelligent control and its CoolGaN products for improved efficiency and reduced EMI.

Available for customer sampling from third-quarter 2023, the Yeti 500W industrial wireless charging module features high-power capability, delivering up to 500W of power for efficient and fast charging. It also has what is claimed to be the industry's highest efficiency of over 95%. This not only reduces power losses but also facilitates thermal management, improving overall performance and durability. For a seamless user experience, the Yeti 500W offers misalignment tolerance of over 40mm in all directions, so reliable charging is ensured even if the orientation is not perfectly accurate. In addition, the module is widely compatible and can charge all common battery types and voltages.

This versatility makes it suitable for a wide range of industrial applications, offering convenience and adaptability. The Yeti 500W incorporates advanced features to ensure robust and safe operation. These include over-voltage and over-current protection to protect both the charger and connected equipment from potential damage or hazards. Furthermore, it is designed for easy integration into existing industrial systems, enabling fast time-to-market for companies looking to expand their charging infrastructure without significant disruption.

"We are excited to partner with Spark Connected and provide differentiated Bluetooth Low Energy microcontrollers and highly efficient power devices for their latest Yeti 500W industrial wireless charging module," says Tony Antonacci, senior director applications marketing at Infineon Technologies. "The Yeti represents a step forward in charging power and integration, enabling industries to improve their operations and move towards an energy-efficient wire-free future," he adds.

"Combining Spark's disruptive wireless power technology with Infineon's broad semiconductor portfolio, we are empowering industries to embrace the full potential of wireless charging, enabling truly autonomous systems and revolutionizing the way they operate," says Spark Connected's chief operating officer Ruwanga Dassanayake. "This production-grade module provides unparalleled efficiency and convenience, which we believe will usher in a new era of innovation and productivity to our customers."

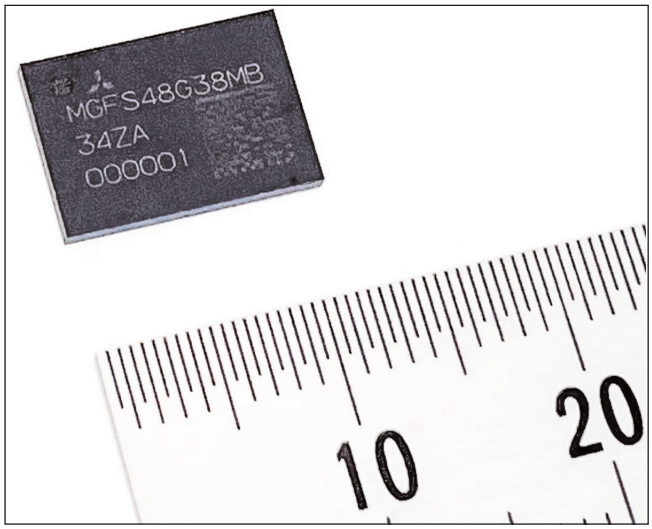
www.sparkconnected.com
www.infineon.com

Mitsubishi Electric to ship samples of GaN power amplifier module for 5G mMIMO base stations

Power-added efficiency of 43% over 400MHz range reduces base-station power consumption

Tokyo-based Mitsubishi Electric Corp says that on 21 September it will begin shipping samples of a new gallium nitride (GaN) power amplifier module that can help to reduce power consumption in 5G massive multiple-input multiple-output (mMIMO) base stations.

Providing high-speed, large-capacity communications, 5G mobile networks are becoming increasingly prevalent worldwide, with 5G mMIMO base stations installed predominantly in metropolitan areas. Since these base stations utilize multi-element antennas and a correspondingly high number of power amplifiers, highly efficient power amplifier modules play an important role in reducing their power consumption and manufacturing costs. In addition, the power amplifier module needs to deliver 3GPP-compliant low-distortion characteristics over a wide frequency range in order to be compatible with multiple countries' 5G mobile networks.



GaN power amplifier module for 5G massive MIMO base stations (MGFS48G38MB).

Mitsubishi Electric's new GaN power amplifier module can deliver an average output power of 8W (39dBm) over wide frequencies ranging from 3.4GHz to 3.8GHz. In particular, due to its power-added efficiency (PAE) of more than 43%, it is suitable for 64T64R mMIMO antennas (consisting of 64 transmitters/receivers, rather than 32T32R mMIMO's 32 transmitters/receivers). The high efficiency and low distortion result from Mitsubishi Electric's new GaN high-electron-mobility transistors (HEMTs). The wideband characteristics, in addition to the high efficiency, are realized using the firm's original circuit design and high-density packaging techniques.

www.mitsubishielectric.com

Transphorm's GaN powers first integrated micro-inverter PV systems by DAH Solar

Higher performance and efficiency in smaller, lighter form factor for solar panel systems

Transphorm Inc of Goleta, near Santa Barbara, CA, USA — which designs and manufactures JEDEC- and AEC-Q101-qualified gallium nitride (GaN) field-effect transistors (FETs) for high-voltage power conversion — says that its GaN platform is powering the first integrated photovoltaic (PV) systems from DAH Solar Co Ltd (Anhui Daheng New Energy Technology Co Ltd, a subsidiary of DAH Solar). The PV systems are used in DAH Solar's new SolarUnit product line.

DAH Solar credits Transphorm's GaN FETs with enabling it to produce smaller, lighter and more reliable solar panel systems that also offer higher overall power generation with lower energy consumption.

DAH Solar uses Transphorm's 150mΩ and 70mΩ GaN FETs in the SolarUnits' design architecture (both DC-to-DC and DC-to-AC power stages). The SolarUnits are available in three models with power outputs of 800W, 920W or 1500W and peak efficiencies of 97.16%, 97.2% and 97.55%, respectively. The GaN devices deliver higher switching frequencies and power density compared with incumbent silicon solutions.

Notably, the two FETs are available in PQFN88 performance packages that pair with commonly used gate drivers — features that helped DAH Solar to accelerate its design time.

"We view Transphorm as an authority in the field of GaN production and found their advanced GaN FETs to be the optimal devices for our new SolarUnit line," comments DAH Solar's general manager Yong Gu. "The devices are easy to design in and offer performance advantages that enable us to continue building on our legacy."

www.transphormusa.com/en/products
www.dahsolarpv.com

ROHM launches power-stage ICs with built-in 650V GaN HEMTs and gate driver

Japan-based power semiconductor maker ROHM Co Ltd has developed the BM3G0xxMUV-LB series of EcoGaN power-stage ICs with built-in 650V gallium nitride (GaN) high-electron-mobility transistors (HEMTs) and gate driver, optimized for primary power supplies (AC–DC, PFC circuits) inside industrial applications (such as data servers and office automation devices) and consumer applications (such as home appliances, AC adapters, PCs, TVs, refrigerators, and air-conditioners).

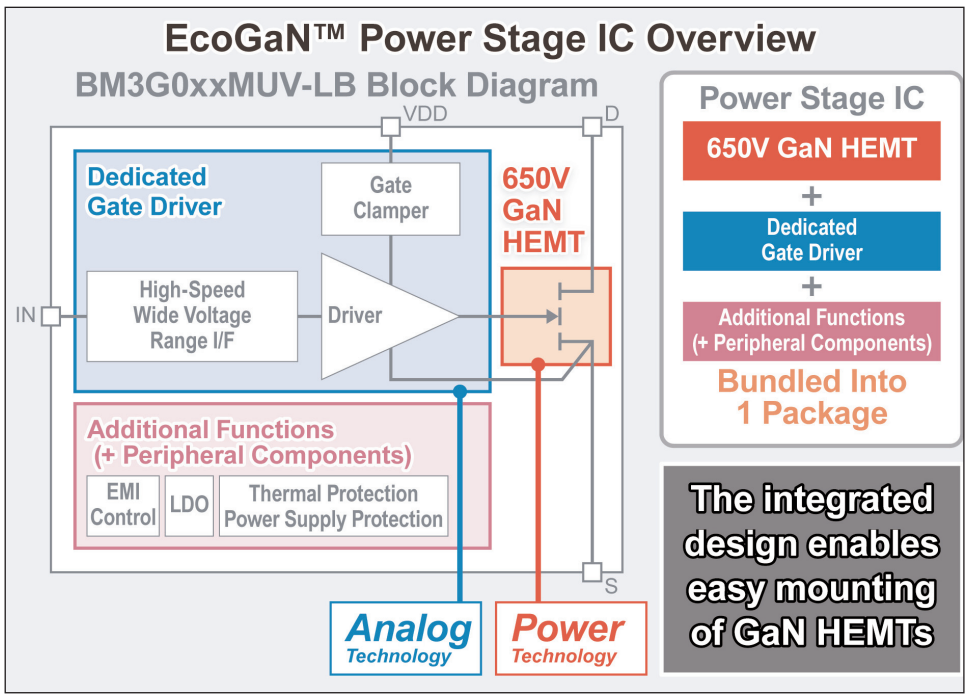
In the interests of sustainability, the consumer and industrial sectors are increasingly demanding greater energy savings. However, while GaN HEMTs are expected to significantly contribute to greater miniaturization and improved power conversion efficiency, the difficulty in handling the gate compared to silicon MOSFETs requires the use of a dedicated gate driver. In response, ROHM has developed power-stage ICs that integrate GaN HEMTs and gate drivers into a single package by leveraging core power and analog technologies, considerably facilitating mounting.

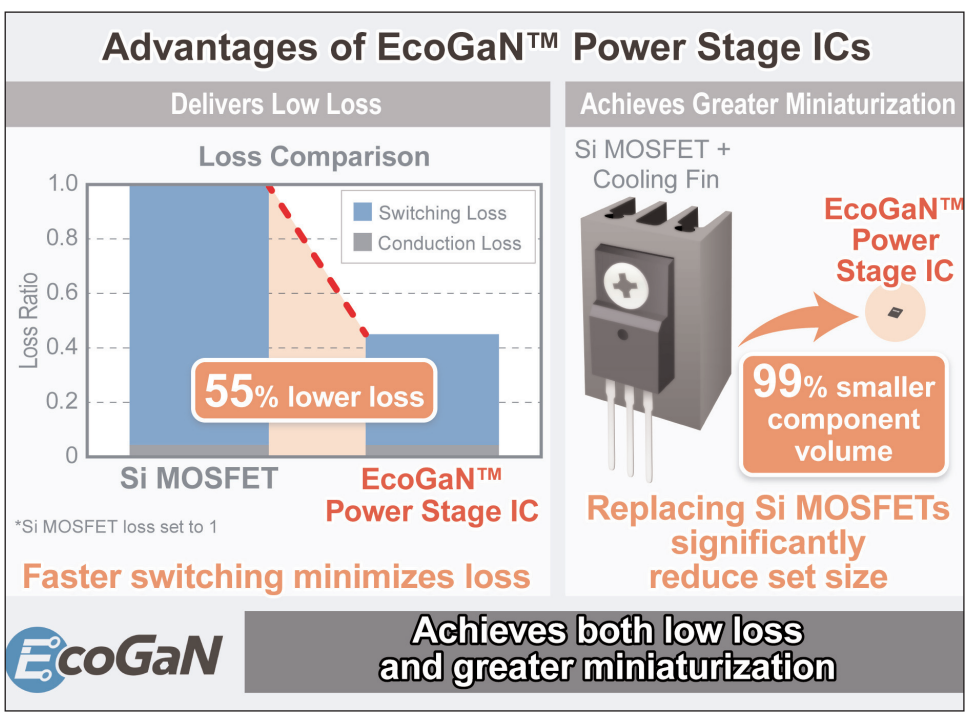
The BM3G0xxMUV-LB series (BM3G015MUV-LB, BM3G007MUV-LB) also incorporates additional functions and peripheral components designed to maximize GaN HEMT performance along with 650V GaN HEMTs. In addition, ROHM's features such as a wide drive voltage range (2.5V to 30V), short propagation delay, and fast start-up time enable compatibility with virtually any controller IC in primary power supplies, facilitating the replacement of existing silicon (super-junction) MOSFETs. This makes it possible to simultaneously reduce component volume and power loss by about 99% and 55%, respectively, achieving higher efficiency in a smaller size.

"GaN devices are attracting a great deal of attention in the industries as a device that greatly contributes to the miniaturization and energy saving of equipment," notes Isaac Lin, general manager, PSADC (Power Semiconductor Applications Development Center), at Delta Electronics Inc. "ROHM's new products have realized high speed and safe gate drive by using ROHM's original analog technology," he comments. "These products will further promote the use of GaN power devices."

Products and evaluation boards BM3G007MUV-EVK-002 (PFC 240W), BM3G007MUV-EVK-003 and BM3G015MUV-EVK-003 will be offered at online distributors DigiKey, Mouser and Farnell as they become available.

www.rohm.com/products/gan-power-devices/gan-hemt-power-stage-ics





Gallium Semi makes available first ISM CW amplifier

Broadband efficiency of >72% for ISM applications in standard air-cavity footprint with minimal tuning

Singapore-based Gallium Semiconductor — which designs and manufactures RF gallium nitride (GaN) solutions for 5G mobile communications, aerospace & defense, and industrial, scientific & medical (ISM) applications — has announced the availability of the GTH2e-2425300P ISM CW (continuous wave) amplifier, a 2.4–2.5GHz, 300W pre-matched discrete GaN-on-SiC high-electron-mobility transistor (HEMT). The GTH2e-2425300P is said to bring a new level of efficiency for a wide range of ISM applications including semiconductor plasma sources and microwave plasma chemical vapor deposition (MPCVD) equipment for synthetic diamond production.

"The GTH2e-2425300P sets a new standard for performance and ease-of-use in 2.45GHz ISM solid-state power design," comments Roger Williams, CEO of 3D RF Energy Corp. "Its internal matching enables a straightforward PCB design, whether that be for a 400W narrowband design with 76% efficiency or 300W design with 72–74% efficiency across the entire band," he adds. "It is well behaved in both class AB and class C, and its 17dB of gain at saturated power simplifies driver requirements."

Operating within the frequency range 2.4–2.5GHz and powered by a 50V supply rail, the GTH2e-2425300P yields an efficiency rating that is claimed to set benchmarks for RF power capabilities, with a peak efficiency of 76% (pulsed, 100µs, 10% duty cycle). Measured data shows a drain efficiency of over 72% under continuous wave operation. A fixed tune demonstration board can be ordered by qualified customers.

"Engineers are looking for a robust supply chain partner for long-term product availability and product support," says Angelo Andres, director of product marketing for Multi-Markets at Gallium Semiconductor. "We will continue to strengthen our portfolio for the ISM market to further support our customers."

Encased in an ACP-800 4L air-cavity plastic package, the GTH2e-2425300P is said to offer excellent reliability and thermal performance (0.67°C/W) with its Super-CMC (ceramic matrix composite) flange. It also simplifies integration into various systems, easing the development process for RF engineers. The GTH2e-2425300P is available now for order.

Gallium Semiconductor at EuMW

Gallium Semiconductor exhibited in at European Microwave Week (EuMW 2023) in Berlin, Germany (19–21 September). As well as the GTH2e-2425300P, Gallium Semiconductor showcased three new 250W L- and S-band radar products and a new DC-12GHz general-purpose broadband amplifier.

www.eumweek.com
www.galliumsemi.com

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Shin-Etsu Chemical launches QST substrates for gallium nitride power device growth

6” and 8” substrates available, with 12” in development

Shin-Etsu Chemical Co Ltd of Tokyo, Japan has announced the market launch of QST (Qromis Substrate Technology) — a composite material substrate licensed in 2019 exclusively from Qromis Inc of Santa Clara, CA, USA — for the growth of gallium nitride (GaN) power devices.

Since QST substrate is designed to have the same coefficient of thermal expansion (CTE) as GaN, it enables suppression of warpage and cracking of the GaN epitaxial layer and can hence enable large-diameter, high-quality thick GaN epitaxial growth. It is hence expected to be applied to power devices and RF devices (5G and beyond 5G), which have been growing rapidly in recent years, as well as to micro-LED growth for micro-LED displays.

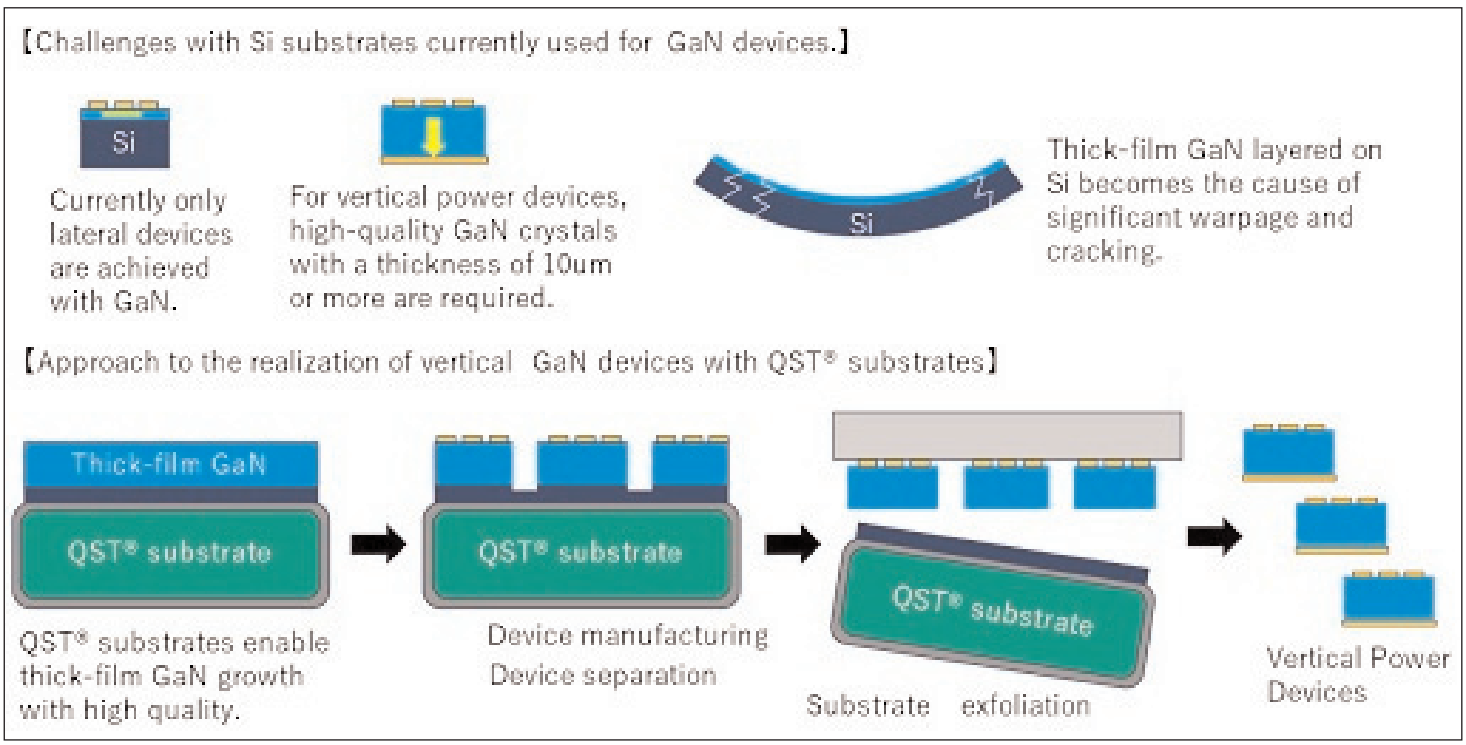
In addition to selling QST substrates, Shin-Etsu Chemical will also sell GaN grown QST substrates upon customer request. The firm currently has a line-up of 6”- and 8”-diameter substrates, and it is working on 12”-diameter substrates. Since 2021, for each respective application for power devices, RF devices and LEDs, sample evaluation and device development has been progressing with numerous customers in Japan and globally. Especially for power devices, continuous evaluation is underway for devices in the wide range of 650-1800V.

Shin-Etsu Chemical says that it has progressively made many improvements to QST substrates. An example is the significant reduction in defect density originating from the bonding process, enabling the supply of high-quality QST substrates. In addition, for the thicker GaN films that many customers have requested, the firm has promoted the provision of template substrates with optimized buffer layers, enabling customers to realize stable epitaxial growth of more than 10μm thickness. Furthermore, various results have been reported, including thick-film GaN growth exceeding 20μm using QST substrates and the achievement of 1800V breakdown voltage in power devices.

Moreover, Shin-Etsu Chemical and Oki Electric Industry Co Ltd have jointly developed technology for exfoliating GaN from QST substrates and bonding it to substrates made of different materials using Oki’s Crystal Film Bonding (CFB) technology. Up to now, most GaN power devices have been lateral devices, but CFB technology takes advantage of the characteristics of QST substrates to realize vertical power devices that can control large currents by exfoliating a thick layer of high-quality GaN from an insulating QST substrate. For customers that are manufacturing GaN devices, Shin-Etsu Chemical will provide QST substrates or GaN grown QST substrates and Oki Electric Industry will provide its CFB technology through partnering or licensing. The two firms hence hope to contribute to the advancement of vertical power devices.

Shin-Etsu Chemical gave a presentation on progress in QST product development at SEMICON Taiwan 2023 in Taipei (6–8 September).

www.semicontaiwan.org



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IQE and VisIC to co-develop D-Mode GaN power devices for electric vehicles

200mm GaN power epiwafers to be developed at IQE's UK facilities

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has announced a strategic collaboration with VisIC Technologies Ltd of Ness Ziona, Israel — a fabless supplier of power conversion devices based on gallium nitride transistors for high-voltage automotive applications — to develop high-reliability gallium nitride D-Mode (D-Mode GaN) power products for use in electric vehicles (EV) inverters. The 200mm (8") D-Mode GaN power epiwafers will be developed at IQE's UK facilities.

VisIC says that its D3GaN technology (Direct Drive D-Mode GaN) can reduce power consumption, increase reliability and enhance performance in electric vehicles. By combining VisIC's power electronics solutions with IQE's epitaxy, the partnership aims to accelerate the adoption of GaN-on-silicon technology in EVs, contributing to the evolution of sustainable transportation.

IQE says that the collaboration is another milestone in its strategy of diversifying into the high-growth power market, first announced at its 2022 Capital Markets Day. The firm sees significant opportunities in the GaN power epiwafer market in particular, which is forecast to reach $632m by 2027, according to market research firm Yole Group.

"This is another sign of the progress we are making in our diversification strategy, as we look to capture the significant growth opportunities in the GaN automotive power market, which is vital in supporting the transition to electric vehicles," says IQE's CEO Americo Lemos.

"Teaming up with IQE is a pivotal step towards reshaping the EV industry. Their track record of delivery in the sector and technological leadership means they are ideally placed for us to collaborate with to develop next-generation technology to power the electric vehicle revolution," comments VisIC's CEO & co-founder Dr Tamara Baksht. "Our D-Mode D^{3}GAN technology has the potential to transform electric vehicles, making them more efficient, reliable and sustainable," she claims. "The co-operation brings higher availability of ground-breaking technology for GaN-on-silicon and paves the way for a resilient supply chain to serve the automotive industry."

www.visic-tech.com

SweGaN gains former Ericsson CEO as senior advisor

Sven-Christer Nilsson to aid GaN-on-SiC epi maker's growth strategy

SweGaN AB of Linköping, Sweden, which develops and manufactures custom gallium nitride on silicon carbide (GaN-on-SiC) epitaxial wafers (based on a unique growth technology) for telecom, satellite communications, defense and power electronics applications, says that former Ericsson CEO Sven-Christer Nilsson – who is an investor and board member in leading tech companies – has joined it as a senior advisor.

Known for his strategic leadership abilities in high-tech industries, Nilsson is currently on several boards, including signal processing, sensor fusion and artificial intelligence (AI) processing firm CEVA Inc. Previously roles include: president & CEO of the Ericsson Group, chairman of the Swedish National Defense Materiel Administration, chairman of Swedish ICT Research AB, and chairman of The Public Service Broadcasting Foundation. He also served on the board of directors of telecom operators Sprint Inc and Telia AB. Nilsson is a member of The Royal Swedish Academy of Engineering Sciences and The Royal Swedish Academy of War Sciences.

"With significant interest in our GaN-on-SiC epitaxial solutions for RF and power components, SweGaN is on a strong trajectory to become a major player in the global GaN markets," reckons the firm's CEO & co-founder Jr-Tai Chen PhD. "Tapping Sven-Christer's extensive leadership and vast network, we believe he will add significant value and insights to our growth strategy."

Following an investment round in third-quarter 2022 led by global semiconductor investors and strategic partners and spurred by what is described as significant interest in volume orders from major customers, in early March SweGaN announced the construction of a new production facility in Linköping. The firm's strategy is closely aligned with the accelerated global demands for GaN-on-SiC epiwafers used in 5G telecoms infrastructure, satellite communications and high-voltage power for devices such as electric vehicles (EVs).

"As the European Union signals the need for developing a robust European semiconductor supply chain, SweGaN is poised to play a critical role in this eco-system," comments Nilsson. "SweGaN has a strong vision aimed at building a competitive and sustainable semiconductor company with their benchmark technology and continuous innovation," he adds. "I look forward to contributing to and being part of the SweGaN journey for this exciting yet geopolitically dynamic semiconductor era."

www.swegan.se

IQE's first-half revenue down about 40% year-on-year

Double-digit revenue growth expected in second-half 2023

For first-half 2023, epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has reported revenue of £52m, down 39.7% on a reported basis (and 42.6% at constant currency) from £86.2m in first-half 2022. This was within the revised guidance range of £50–56m provided on 17 May.

Wireless revenue fell by 51.9% from £46.6m to £22.4m, due mainly to weak global handset demand and supply chain inventory build-up.

Photonics revenue fell by 27.2% from £38.5m to £28m, due mainly to softness in the handset market and a slowdown in Asian telecoms infrastructure programs.

CMOS++ revenue rose by 43.1% from £1.1m to £1.6m, due to growth in silicon-based switches for power control.

Operating loss has more than doubled from £7.4m to £19.6m.

Adjusted non-GAAP EBITDA (earnings before interest, tax, depreciation and amortization) was –£5.7m, compared with +£12.3m in first-half 2022, adversely impacted by a reduction in sales and under-utilization of capacity, particularly in the Wireless business.

Despite halving from £8.3m, adjusted cash inflow from operations was still £4.3m, benefitting from management of working capital.

Total net cash capex and cash investment in intangibles rose from £7.6m to £8.5m, comprising: £5.2m investment in PP&E capex (up from £3.8m) prioritizing high-growth GaN power and display capacity (as set out at the time of the equity raise); £1.7m in purchase of intangibles of (down from £2.3m) related primarily to the ongoing systems transformation program; and £1.6m in ongoing investment in R&D (level on a year ago), focused on power electronics and micro-LEDs.

Compared with net debt of £6.7m at the end of June 2022 and £15.2m at end-December 2022, adjusted net funds improved to £5.3m at the end of June 2023. This follows completion of an equity raise of £29.7m (in net proceeds) on 18 May in order to strengthen the balance sheet and underpin strategic investment.

Also, on 17 May, IQE refinanced its undrawn multi-currency revolving credit facility with HSBC Bank plc of £27.3m ($35m), which has been extended to 1 May 2026.

Cost optimization

"In a challenging macro environment, we have taken decisive action to manage costs and deliver immediate efficiencies and longer-term margin benefits," says CEO Americo Lemos.

The optimized manufacturing plan for improved asset utilization includes:

- headcount reductions delivering about 10% in savings annually while retaining key skills for growth, with associated first-half 2023 restructuring costs of £1.2m;
- a reduction in non-labour costs to deliver greater than 20% in savings annually.

Global site optimization program

Consolidation of US MBE operations into the North Carolina site is on track to be completed by first-half 2024. Also ongoing is a review into optimizing IQE's global footprint to improve operational efficiency and profitability.

Diversification strategy

"We are accelerating our diversification strategy with new customer designs in GaN power electronics and broadening our market penetration into the China wireless market," notes Lemos. "By expanding our customer base across the breadth of our product portfolio and ramping in strategic growth areas, we are focused on improving future business performance."

Strategic highlights during first-half 2023 are listed as:

- commencing sampling for GaN power with two new customers for 650V devices;
- design wins with multiple customers to deliver wireless products to leading China cellular and Wi-Fi suppliers for growing China and India smartphone market;
- customer qualifications for high-speed data-center applications, with next-generation VCSELs to enable and support growth in the artificial intelligence (AI) markets;
- customer sampling and qualification in progress to supply automotive-grade LiDAR VCSELs for a major China-based customer;
- production of second-generation, high-performance VCSELs used in consumer mobile 3D sensing applications for customers;
- developing the industry's first 150mm (6") indium phosphide (InP) photonics device platform, targeting customers in the Cloud/AI data-center markets;
- development of new laser materials technologies for a leading handset maker for next-generation longer-wavelength consumer sensing applications;
- development of 200mm (8") red, green & blue (RGB) epiwafer products for micro-LED display qualification;
- developing frameworks and processes to adopt and align with the Task Force on Climate-Related Financial Disclosures (TCFD) with first TCFD Statement published in the 2023 Annual Report and Financial Statements;
- developing emissions targets in accordance with the Science Base Targets initiative (SBTi), with IQE on track to submit targets within the 24 month commitment window.

Current trading and outlook

IQE notes that the current temporary semiconductor industry downturn is stabilizing, with continued pockets of recovery expected in second-half 2023, albeit more slowly than anticipated at the time of the firm's full-year 2022 financial results. Specifically, IQE expects double-digit revenue growth in second-half 2023 versus first-half 2023, and to be profitable at an adjusted EBITDA level for full-year 2023.

Improvement is expected in 2024 as the supply chain normalizes and customer demand recovers.

www.iqep.com

New customer orders Aehr FOX-NP multi-wafer test and burn-in system for silicon carbide MOSFETs

US-based multi-billion-dollar semiconductor maker targets not only electric vehicles but also industrial, solar and other power applications

Semiconductor production test, burn-in and reliability qualification equipment supplier Aehr Test Systems of Fremont, CA, USA has received an initial customer order for a FOX-NP wafer-level test & burn-in system, multiple WaferPak Contactors, and a FOX WaferPak Aligner to be used for engineering, qualification and small-lot production wafer-level test & burn-in of silicon carbide devices.

The customer is a US-based multi-billion-dollar semiconductor supplier serving several markets including automotive, computing, consumer, energy, industrial and medical applications. The FOX-NP system, including the FOX WaferPak Aligner and initial WaferPaks, are scheduled to ship by the end of 2023, per the customer's requested accelerated schedule.

The FOX-NP system is configured with the new Bipolar Voltage Channel Module (BVCM) and Very High Voltage Channel Module (VHVCM) options that enable new advanced test and burn-in capabilities for silicon carbide power semiconductors using Aehr's proprietary WaferPak full-wafer Contactors. Aehr says that the new order highlights its continued progression within the growing silicon carbide global power market.

"After conducting a detailed financial evaluation and multiple onsite visits to Aehr's application lab, this new customer selected our FOX-P solution for engineering, qualification and production of their silicon carbide power devices. This evaluation included cost of ownership and system throughput, as well as device test, burn-in and stabilization coverage," says president & CEO Gayn Erickson. "As their production capacity increases, they told us that they will quickly move to our FOX-XP multi-wafer test & burn-in systems for high-volume production. In addition to the automotive electric vehicle device opportunity, this customer in particular sees the enormous opportunity for silicon carbide power devices in industrial, solar and other power applications."

William Blair forecasts that, in addition to the 4.5 million 6-inch-equivalent wafers that will be needed to meet the demand for electric vehicle-related silicon carbide devices in 2030, another 2.8 million wafers are needed to address industrial, solar, electric trains, energy conversion and other applications in 2030. "Most of these applications will be served with discrete MOSFETs in single die packages," says Erickson. "The cost of ownership of our solution proved to be more cost-effective and efficient for these devices than package part burn-in after the die are packaged in packages such as TO-247 or other discrete packages. This is a strong testimony of the advantage of wafer-level burn-in as a better alternative to package part burn-in. This expands our silicon carbide test and burn-in market even more, and this new customer helps expand Aehr's presence in this market as our total addressable market (TAM) continues to grow," he adds.

"Aehr's FOX-P systems and proprietary WaferPak full wafer Contactors enable our customers to do economical production volume test and reliability burn-in with processes such as high-temperature gate bias (HTGB) and high-temperature reverse bias (HTRB) very cost-effectively and ensure extremely high device quality," continues Erickson. "Our systems are typically used for long burn-in times lasting up to 24 hours or more. We can do this for under $5 per hour per wafer capital depreciation cost while testing and burning-in up to several thousand devices at a time per wafer. This is also in a test system footprint that is up to 94% less than a typical test system on a standard semiconductor wafer prober, which in a precious cleanroom wafer facility is extremely important and saves a great deal of cost."

"The FOX family of compatible systems including the FOX-NP and FOX-XP multi-wafer test and burn-in systems and Aehr's proprietary WaferPak full-wafer contactors provide a uniquely cost-effective solution for burning in multiple wafers of devices at a single time to remove early life failures of silicon carbide devices, which is critical to meeting the initial quality and long-term reliability of the automotive, industrial and electrification infrastructure industry needs," Erickson concludes.

www.aehr.com

Automated Riber MBE 412 system ordered for passivating GaAs-based quantum dot laser facets

Riber S.A. of Bezons, France says that a German industrial customer has placed a multi-million Euro order for an automated MBE 412 system, for delivery in 2024, to be used to produce optoelectronic devices. More specifically, the machine is designed to passivate laser facets, in particular gallium arsenide (GaAs)-based quantum dot lasers, covering a wide range of applications: LiDAR, fiber-optic communications, cloud networking, etc.

www.riber.com

Semilab and Fraunhofer IISB form long-term strategic partnership

Joint demo lab to develop SiC process control & metrology techniques

Metrology equipment firm Semilab ZRT of Budapest, Hungary has agreed to form a long-term strategic partnership with Fraunhofer IISB (Institute for Integrated Systems and Device Technology) in Erlangen, Germany. Within the framework of the cooperation, a demo lab will be opened with a focus on developing metrology and inspection solutions for wide-bandgap semiconductor materials.

Semilab describes itself as a strategic metrology supplier and innovation partner for wafer manufacturers and IC device makers in the More-than-Moore market segment, providing both in-line and R&D metrology solutions. Specifically, the firm provides non-contact capacitance–voltage (CV) metrology for silicon carbide (SiC), adding that its market share is growing for epitaxy thickness and resistivity monitoring.

Fraunhofer IISB specializes in wide-bandgap semiconductors and efficient power electronics, combining device expertise with complex system development, especially for e-mobility and sustainable energy supply. By bundling its activities in two business units Power Electronic Systems and Semiconductors, it spans the entire value chain, from basic materials through semiconductor device, process and module technologies, to complete electronics and energy systems. As a center of excellence in Europe for silicon carbide, IISB is said to be a pioneer in developing highly efficient power electronics, even for extreme requirements. This extends from material, through processing, to device development, supported by providing metrology solutions.

It is reckoned that the strategic partnership between Semilab and Fraunhofer IISB will allow the utilization of their respective resources and global networks to develop innovative silicon carbide processes and metrologies

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www.iisb.fraunhofer.de
www.semilab.com

GlobiTech selects Aixtron's G10-SiC CVD system for expansion into silicon carbide market

Silicon foundry to ramp SiC epiwafer production to high volume

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany says that it is supporting GlobiTech Inc of Sherman, TX, USA, one of the world's largest silicon-epitaxy foundries, to expand its business into silicon carbide (SiC) epitaxy.

The new G10-SiC chemical vapor deposition (CVD) system has enabled GlobiTech to quickly ramp its SiC epitaxy production into high volume to address the increasing demand for power epiwafers. Aixtron says that selection of the G10-SiC means a future-proof investment based on dual wafer-size configuration of 9x150mm and 6x200mm and what is claimed to be the highest throughput per fab space available in the SiC industry.

Officially introduced in September 2022, Aixtron claims that the G10-SiC has become the tool of record for both 150mm and 200mm SiC device makers as well as foundries like GlobiTech, the subsidiary of GlobalWafers Co Ltd, which manufactures silicon carbide and silicon epiwafers focused on power and electric vehicle (EV) market segments. GlobalWafers has 17 manufacturing and operation sites in nine countries, including a 200mm silicon-on-insulator (SOI) wafer factory in St. Peters, Missouri, and is in the process of a 300mm SOI expansion to address burgeoning radio-frequency (RF) applications.

"When one of the largest manufacturers and foundries like GlobiTech diversifies its business, it is a clear signal of a long-lasting trend in the semiconductor industry: conventional silicon is being replaced by silicon carbide in an ever-increasing number of applications," says Aixtron's CEO & president Dr Felix Grawert. GlobiTech choice of the G10-SiC as an enabler of its transition into the emerging SiC market "confirms our overall strategy and the prospects for further growth," he believes.

Aixtron's G10-SiC system, officially introduced in September 2022

GlobiTech is already in high-volume production using both the G5WW C and G10-SiC Aixtron systems, with continued installation capacity over the next years. Modeled after the silicon business, GlobiTech supplies both SiC substrates and SiC epitaxy to the market.

"In Aixtron, we have found a strong partner supporting us in our vision and plans to expand our business into the SiC epitaxy market – an important step as SiC technology is one of the fastest-growing semiconductor sectors," comments GlobalWafers' president Mark England. "Aixtron tools allow us to get the most wafers out of our current fab. And Aixtron's team understands what it takes to compete against silicon to grow this market while offering great customer support and service," he adds.

The G10-SiC is claimed to be the first SiC epitaxy tool on the market that enables high-volume production of SiC epiwafers. Since the G10-SiC offers both 9x150mm and 6x200mm batch configurations, it is reckoned to be instrumental for a market rapidly migrating from 6" (150mm) to 8" (200 mm) wafer diameters. The new platform is built around Aixtron'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, excellent epiwafer performance in terms of quality and uniformity, and the best throughput per square meter of fab space, yielding the lowest cost of ownership in the market. It is estimated that in 2023 the new G10-SiC will become Aixtron's top-selling product.

The G10-SiC offers a dual wafer-size configuration of 9x150mm and 6x200mm.

www.globitech.com

Aixtron launches G10-GaN MOCVD platform for power and RF devices

15x200mm capacity enables 25% cost reduction per wafer; material uniformity doubled

At the SEMICON Taiwan 2023 event in Taipei (6–8 September), deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has launched its new G10-GaN cluster metal-organic chemical vapor deposition (MOCVD) platform for gallium nitride (GaN)-based power and radio frequency (RF) devices, offering what is claimed to be best-in-class performance, an all-new compact design, and overall lowest cost per wafer.

"Our new G10-GaN platform has already been qualified for volume production of GaN power devices by a leading US device manufacturer," notes CEO & president Dr Felix Grawert. "The new platform delivers twice the productivity per cleanroom area than our previous product while enabling a new level of material uniformities, unlocking new levers of competitiveness for our customers," he adds. "GaN power devices are set to play a decisive role in reducing global CO_2 emissions by offering a much more efficient power conversion than conventional silicon, reducing losses by a factor of two to three. We expect this market to grow continually by the end of the decade and beyond. Today, GaN has already replaced silicon for fast chargers used in mobile devices, and we see an increasing demand for data centers or solar applications."

Aixtron has been developing GaN-on-Si processes and hardware for more than 20 years. Its AIX G5+ C planetary reactor was the first fully automated GaN MOCVD system due to In-Situ Cleaning and Cassette-to-Cassette automation. The all-new G10-GaN cluster solution builds on the same fundamentals while extending each single performance metric.

Aixtron's new G10-GaN MOCVD system.

Packed in a new, compact layout to take advantage of the smallest cleanroom space, the platform comes with novel reactor inlets, improving material uniformity by a factor of two for optimum device yields. On-board sensors are complemented by a new software suite and fingerprint solutions to ensure that the system consistently delivers the same performance run after run, between maintenance for all process modules – extending the equipment uptime by more than 5% compared with the previous generation.

The cluster can be equipped with up to three process modules, delivering a record capacity of 15x200mm wafers due to Planetary batch reactor technology – enabling a 25% cost reduction per wafer compared with previous products

The cluster can be equipped with up to three process modules, delivering a record capacity of 15x200mm wafers due to Planetary batch reactor technology – enabling a 25% cost reduction per wafer compared with previous products.

www.aixtron.com

AXT's Tongmei receives initial export permits from China for GaAs and Ge substrates

Tongmei working with authorities on permits for further customers

AXT Inc of Fremont, CA, USA — which makes gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials — says that its China-based manufacturing subsidiary Beijing Tongmei Xtal Technology Co Ltd has met the applicable legal and commercial requirements and has received its initial export permits from China's Central Ministry of Commerce to resume shipping gallium arsenide and germanium substrates to certain customers.

Since China's announcement of new export control regulations on gallium and germanium materials on 3 July and the subsequent implementation of those regulations on 1 August, AXT says that Tongmei has been working diligently with the appropriate Chinese authorities to ensure that it understands and abides by all rules and regulations set out in the new gallium and germanium export controls.

AXT says that its China-based manufacturing subsidiary Beijing Tongmei Xtal Technology Co Ltd has met the applicable legal and commercial requirements and has received its initial export permits from China's Central Ministry of Commerce to resume shipping gallium arsenide and germanium substrates to certain customers

Tongmei continues to work with the appropriate Chinese authorities to obtain the necessary permits for additional customers so that it can resume shipping gallium arsenide and germanium substrates to those customers in compliance with all export control regulations.

www.axt.com

Umicore collaborates with RENA Technologies to enhance germanium wafers

RENA ACE inception wafer processing technology to be integrated into Umicore's Ge mass production

Germanium product and materials solutions supplier Umicore Electro-Optic Materials (EOM) has established a strategic collaboration which aims to integrate the ACE inception wafer processing solution of RENA Technologies of Gütenbach, Germany into the on-going development of germanium (Ge) wafers for the space solar cell industry.

Umicore EOM has produced epi-ready, dislocation-free germanium substrates for III-V multi-junction solar cells for many decades, but RENA ACE technology has emerged as being pivotal for driving development forward, says the firm.

RENA's wafer processing solution features flexible process performance and single-side, full-surface processing. Umicore comments that the scalability for mass production aligns with its application and ramp-up plans.

Built on RENA's Inception platform, Umicore EOM and RENA have joined forces in a collaborative development program, aimed at technology enhancement and ensuring a seamless and efficient transition into mass production. The move is said to be key to the realization of both companies' expansion strategies.

"The RENA advanced wafer processing solution plays a crucial role in our manufacturing process, and RENA's technology will be a key enabler for the performance of our Ge wafers," comments Umicore EOM project manager Jinyoun Cho.

"Umicore is a reliable partner, and we are glad to support their expansion plans with our solution," comments Franck Delahaye, manager of business development at RENA.

https://eom.umicore.com
www.rena.com

Pictured: RENA Technologies' ACE Inception wafer processing system.

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Plasma-Therm acquires Thin Film Equipment

Plasma-Therm expands European footprint and strengthens portfolio for power device market

Plasma-Therm LLC of St Petersburg, FL, USA (which makes plasma-process equipment for the silicon and compound semiconductor markets) has acquired Thin Film Equipment SrL (TFE) of Binasco, Milan, Italy, which supplies physical vapor deposition (PVD) sputtering and evaporation process equipment and high-purity materials for thin-film applications.

"The acquisition of TFE reinforces Plasma-Therm's expanding footprint in Europe, a pivotal component of our long-term strategic growth initiative," says Plasma-Therm's CEO Abdul Lateef. "It also helps to significantly expand Plasma-Therm's portfolio in the power device market with TFE's suite of PVD tools tailored to meet the requirements of MEMS, power, RFID and other semiconductor applications."

Complementing its existing etch and deposition products and process solutions, Plasma-Therm says that TFE's PVD technologies enhance its ability to meet a wider spectrum of semiconductor manufacturing and R&D market demands. The added value of TFE's workforce expertise in PVD technology and power device market requirements further strengthens Plasma-Therm's customer service and support teams, it adds.

The power semiconductor market will grow to $6.3bn by 2027, according to market research firm Yole Group's 'Power SiC 2022' report. Plasma-Therm reckons that it is positioned to support this growth with the acquisition of TFE and the MRC Eclipse product line, which is used for depositing metal for interconnects, via fill, silicides, packaging (C4, die attach) and other processes.

"While TFE will continue to operate independently, we will work closely with Plasma-Therm to combine our strengths in plasma and PVD process technology for a more comprehensive product offering for our customers," says TFE's CEO Francesco Terenziani. "The acquisition will enable us to expand our R&D resources and customer service & support teams globally to deliver timely solutions to our valued customers."

www.thinfilmequipment.net
www.plasmatherm.com

Camtek buying FormFactor's FRT Metrology business for $100m

Inspection and 3D metrology equipment maker gains technology for advanced packaging and silicon carbide

Inspection and 3D metrology equipment maker Camtek Ltd of Migdal Haemek, Israel has agreed to acquire for $100m (subject to customary purchase price adjustments), the FRT Metrology business of FormFactor Inc of Livermore, CA, USA (a provider of test & measurement technologies along the full IC life-cycle — from metrology and inspection, characterization, modeling, reliability, and design de-bug, to qualification and production test).

FRT of Bergisch Gladbach, Germany is a supplier of high-precision metrology solutions for advanced packaging and silicon carbide. The acquisition is expected to leverage Camtek's and FRT's advanced technologies for advanced packaging and silicon carbide, which require new inspection and metrology steps in the semiconductor manufacturing processes.

With the addition of FRT's unique hybrid multi-sensor SurfaceSens technology, Camtek will be able to provide broader and more comprehensive solutions for inspection and metrology.

"We expect this acquisition to solidify Camtek's leading market position and contribute over $30m to the annual revenues in 2024 and be accretive within 12 months following the acquisition," says Camtek's CEO Rafi Amit. "We expect further synergies that will contribute to Camtek's overall growth prospects in 2024 and beyond," he adds.

"I'm extremely proud of the FRT team's innovation and growth since FormFactor's acquisition of this business in 2019," comments FormFactor's CEO Mike Slessor. "I'm also excited for the opportunity this team has to leverage Camtek's established scale and expertise in inspection and metrology to deliver the next stage of growth from this business," he adds. "FormFactor remains committed to developing and providing industry-leading test & measurement solutions for advanced packaging, helping enable the next phase of semiconductor innovation in applications like generative AI and co-packaged optics. We expect this transaction to maximize present and future FormFactor shareholder value by realizing a robust return on our investment while allowing us to focus our resources on strategic initiatives and industry-leading businesses where we have market leadership and significant scale."

The deal is expected to complete in fourth-quarter 2023, subject to the satisfaction of customary closing conditions.

www.formfactor.com

AlixLabs raises SEK40m to industrialize Atomic Layer Etching Pitch Splitting nanofabrication

Investors include Navigare Ventures, Industrifonden & FORWARD.one

AlixLabs AB of Lund, Sweden, which has developed an Atomic Layer Etching (ALE) Pitch Splitting technology (APS), has secured SEK40m in funding from investors including Navigare Ventures, Industrifonden, and FORWARD.one.

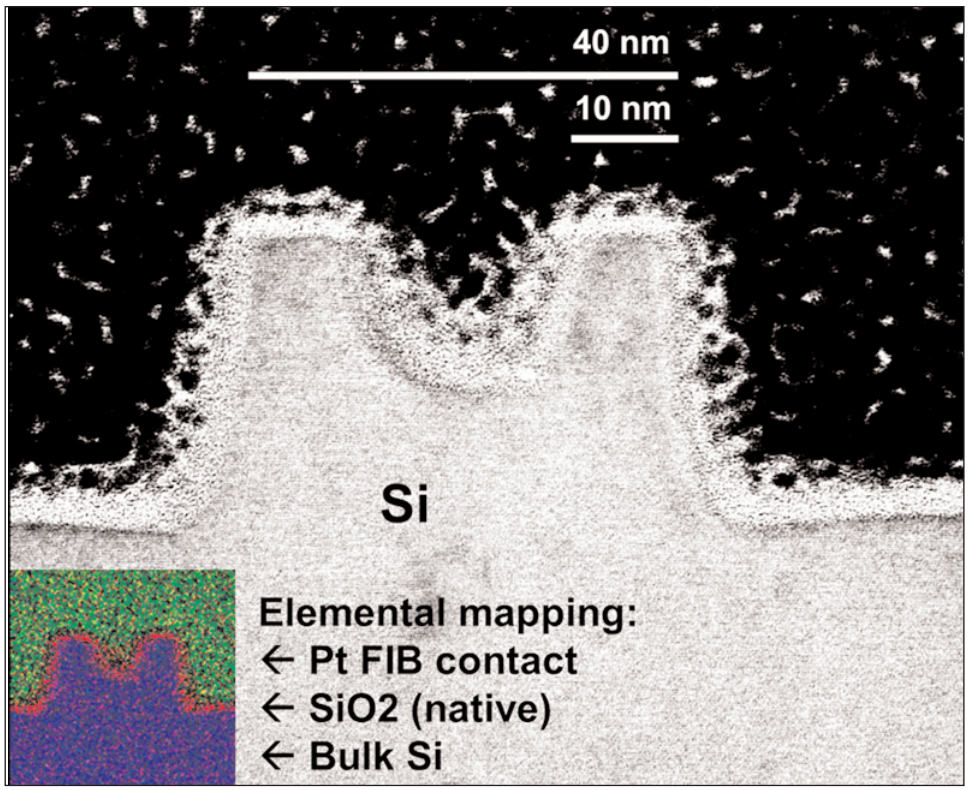
AlixLabs says that its ALE Pitch Splitting technology enables the precise division of nanostructures and hence a high degree of packing semiconductor components. This eliminates several steps in the manufacturing process, and significantly reduces energy consumption and emissions, addressing the rising costs associated with existing semiconductor manufacturing techniques.

"The infusion of capital not only validates our vision but also empowers us to bring our groundbreaking technology to the forefront of semiconductor manufacturing," says CEO Jonas Sundqvist. "This investment marks a significant milestone as we work towards our goal: to have our meticulously developed process adopted by circuit manufacturers in their most advanced production by 2025."

AlixLabs reckons that its innovation comes at an opportune moment, with the European Union's Chips Act allocating more than €43bn for semiconductor companies over the next five years.

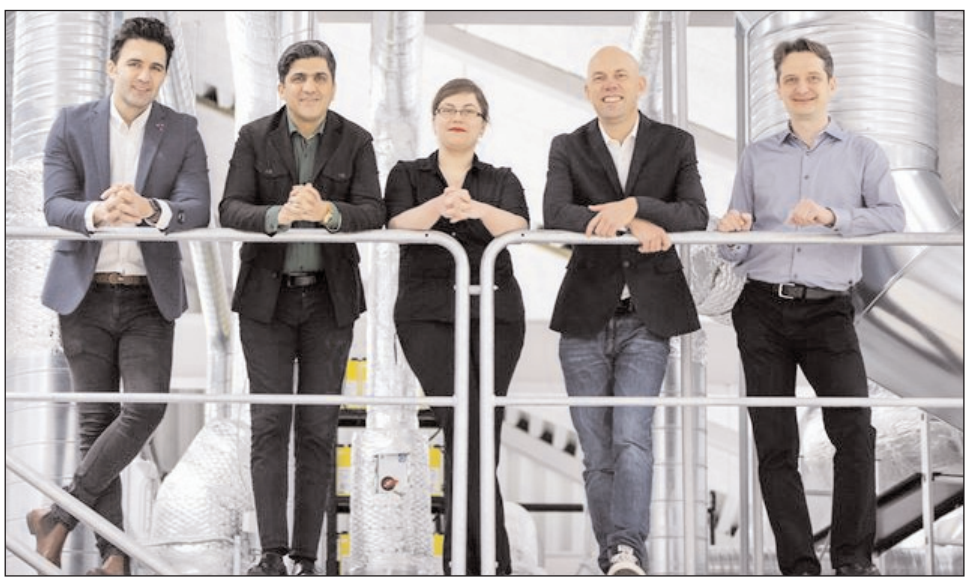
"AlixLabs has taken considerable steps in establishing itself as an emerging equipment manufacturer, contributing to the fast-growing European semiconductor industry," comments Navigare Ventures' investment manager Alex Basu. "We look forward to a continued partnership as they bring their technology to production in the coming years," he adds.

"At Industrifonden, we are committed to science-backed, scalable investments that have the power to drive meaningful change in society," states senior investment director Tobias Elmquist. "AlixLabs is redefining semiconductor manufacturing and we're proud to support them on their journey towards a more efficient and sustainable industry," he adds.



"The technology that AlixLabs has developed solves real problems for its semiconductor customers and adds a lot of value for them by reducing the complexity of making chips and making the process much cheaper while reducing the environmental impact of the process significantly," comments FORWARD.one partner Arjan Göbel.

www.alixlabs.com



Automotive semiconductor firm indie acquires EXALOS

indie's ADAS and User Experience portfolio gains near-IR & visible superluminescent LEDs and semiconductor optical amplifiers

Automotive semiconductor and software platform provider indie Semiconductor Inc of Aliso Viejo, CA, USA has acquired privately held EXALOS AG of Zürich, Switzerland, which was founded in 2003 and designs and manufactures light sources based on superluminescent light-emitting diodes (SLEDs) and external-cavity tunable lasers for optical coherence tomography and fiber-optic gyroscopes

Among several products developed and launched for demanding applications, EXALOS' field-proven SLEDs for fiber optic gyroscope and semiconductor optical amplifiers (SOAs) in particular are backed by 59 global patents and complement indie's laser and silicon photonics products, creating a portfolio targeting rapidly emerging autotech applications.

"EXALOS' differentiated solutions immediately expand indie's ADAS [advanced driver assistance systems] and User Experience product and technology offering to our global tier-one and automotive OEM customer base," says indie's co-founder & CEO Donald McClymont. "Specifically, indie can now leverage EXALOS' core superluminescent LED and SOA technologies to enable head-up display (HUD), high-brightness visible lighting and inertial measurement unit (IMU)-based navigational applications and, importantly, to extend our frequency-modulated continuous wave (FMCW) light detection and ranging (LiDAR) portfolio.

We are gaining a well-established team of 17 world-class engineers, including the industry's leading expertise in bright light sources based on a proprietary gallium nitride process. At a higher level, our acquisition of EXALOS represents another step in our quest to build a broadline autotech powerhouse," he adds.

EXALOS' differentiated solutions immediately expand indie's ADAS and User Experience product and technology offering. indie can now leverage EXALOS' core SLED and SOA technologies to enable HUD, high-brightness visible lighting and inertial measurement unit-based navigational applications and importantly to extend our FMCW LiDAR portfolio

"Given indie's global sales channels and demonstrated scalability, I am confident that together we can take our business to the next level, capitalizing on clear product synergies between us and extending our customer reach while preserving the EXALOS innovation engine," says EXALOS' CEO & founder Christian Velez.

Subject to terms and conditions of the definitive agreement, indie paid about $45m to EXALOS equity holders, consisting of 6.6 million indie Class A common shares. Also, if certain revenue-based performance targets are exceeded over a 24-month post-closing period, there is an opportunity for such holders to earn up to $20m more in cash or indie Class A common shares, at indie's election.

The deal has been approved by the boards of directors of both firms. The acquisition is expected to be financially neutral in 2023 and accretive to indie's 2024 results.

www.exalos.com
www.indiesemi.com

UV LED maker Nitek sues Photon Wave in USA

Nitek pursuing damages for willful patent infringement

UV LED maker Nitek Inc of Columbia, SC, USA has filed a patent infringement lawsuit against South Korea's Photon Wave Co Ltd in the Eastern District of Texas.

Nitek asserts that LED products made by ams OSRAM GmbH of Premstätten, Austria and Munich, Germany use Photon Wave's infringing LEDs.

Nitek also contends that Photon Wave has failed to cease selling infringing products, even after receiving continuous warning notices of the patent infringement. Therefore Nitek is not only seeking a permanent injunction against the sales of infringing products but also pursuing three times damages for willful patent infringement.

Nitek has previously won its patent lawsuit against another international LED maker, and continues its enforcement against other infringers. Columbia-based Nitek affiliate Sensor Electronics Technology Inc (SETi) (a division of South Korea's Seoul Viosys that makes UV-A, UV-B and UV-C deep-ultraviolet LEDs, emitting at wavelengths of 200–430nm) has also obtained a permanent injunction for patent infringement against UV LED firm Bolb Inc of Livermore, CA, USA, which was co-founded by former SETi employees. The effects of this permanent injunction order also apply to officers and employees of Bolb.

www.s-et.com
www.nitekusa.com
http://photonwave.co.kr

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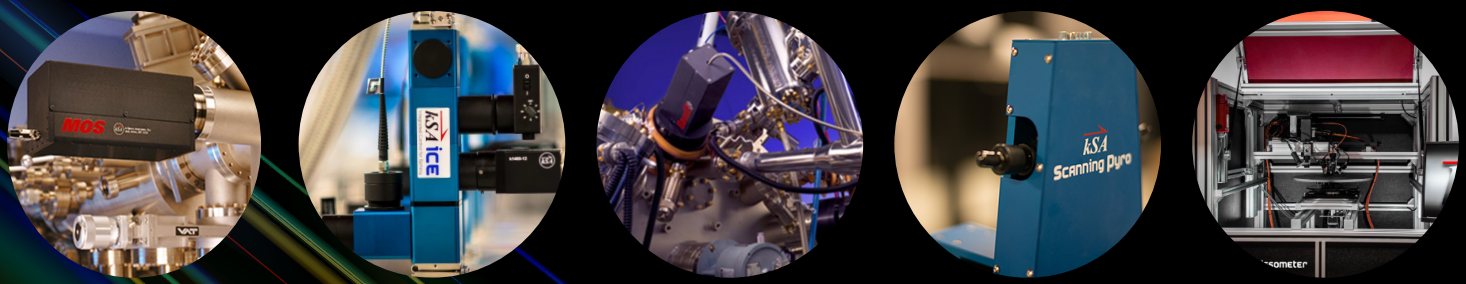

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ams OSRAM unveils ALIYOS LED-on-foil technology for automotive lighting

Customized, multi-segment area lighting in new configurations such as 3D structures or 'invisible' lights on curved panels

At the International Symposium on Automotive Lighting (ISAL 2023) in Darmstadt, Germany (25–27 September), ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has unveiled ALIYOS LED-on-foil technology, which it says opens up new possibilities for design freedom and creativity in automotive lighting.

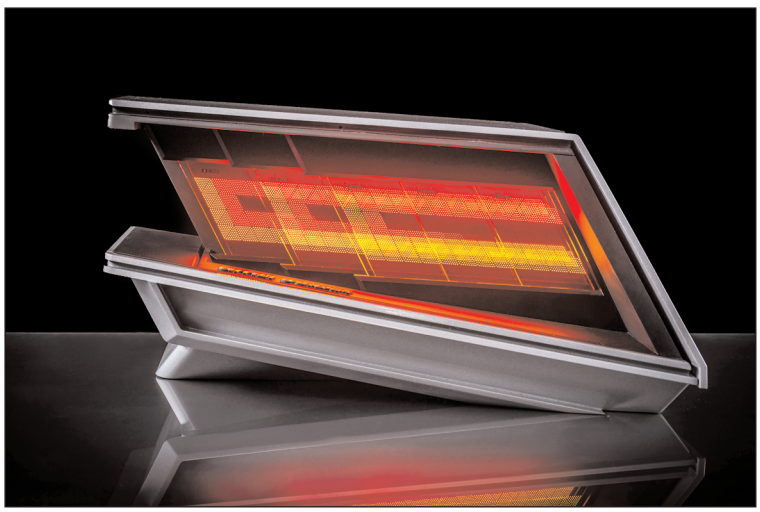
Using ALIYOS technology, car makers can "express brand personality" through exterior and interior lighting in previously unattainable ways, the firm adds, as well as introducing new three-dimensional lighting and animation effects for displaying dynamic individual messages and information signals to drivers and other road users.

"The introduction of advanced LED-on-foil technology marks a new revolution in the way that LEDs are applied in automotive lighting, giving customers exciting new opportunities to differentiate vehicle brands," says Gerald Broneske, VP global product marketing OS Automotive at ams OSRAM.

Transparent, flexible, thin LED lighting

ams OSRAM says that ALIYOS technology enables it to apply mini-LEDs on a thin, flexible and transparent substrate. The mini-LEDs can be arranged with a large degree of freedom to form individually addressable segments of any shape. They can be positioned to perform standard lighting functions such as a stop light or turn indicator, but with unique, custom shapes and animation effects. The mini-LEDs can also be used to display symbols, words, images or abstract patterns for decoration, information or warning.

Transparency, in combination with mini-LEDs, means that light can appear out of nowhere. In addition, multiple foil assemblies can be placed one behind the other to create new 3D lighting and animation effects.



Examples of the application of ams Osram's new ALIYOS LED-on-foil technology to automotive lighting.

ams OSRAM is now working with leading automotive tier-one suppliers and OEMs to explore the new possibilities in automotive interior and exterior lighting. One demonstration design exploits the transparency of the ALIYOS foil substrate to produce new 3D effects in rear lights: a transparent array of three ALIYOS LED foils mounted one behind the other creates a sense of depth.

Another design shows that ALIYOS LED-on-foil technology can be applied to curved body panels, and is invisible when turned off, creating the effect of 'Light out of nowhere'.

Due to the transparency, thinness and flexibility of ALIYOS technology, thousands of other new design possibilities are now open to car manufacturers, says the firm. Legal requirements, for example UN Regulation No. 148 for the brightness of rear light and stop lights as well as turn indicators, can be met through the application of ALIYOS technology, it adds.

Industrialization of the technology has begun. The aim is to enable the first cars to be equipped with ALIYOS technology by the end of 2025, and to have achieved qualification for compliance with automotive quality and safety standards by this time.

www.ams-osram.com/products/product-families/aliyos
www.ams-osram.com/technology/led-on-foil-technology

Germany and Bavaria governments to provide €300m IPCEI funding for ams OSRAM to expand opto R&D and manufacturing in Regensburg

ams OSRAM GmbH of Premstätten, Austria and Munich, Germany has received notice of substantial public funding – via the European Commission's Important Projects of Common European Interest (IPCEI) program for funding digital and green initiatives – from Germany's Federal Ministry for Economic Affairs and Climate Action (BMWK) and the Free State of Bavaria's Ministry of Economic Affairs, Regional Development and Energy. The application for public subsidies of more than €300m over five years is subject to final notice of the grant.

At an event at the German Federal Ministry for Economic Affairs and Climate Action on 18 September, ams OSRAM presented its project, launched within the scope of the IPCEI ME/CT (Microelectronics and Communication Technologies).

Funds will be invested mainly in R&D and manufacturing processes for optoelectronic semiconductors, creating 400 new jobs at the firm's site in Regensburg, joining 2700 existing staff. ams OSRAM will also invest in new cleanroom and laboratory facilities for research, development and pilot production – equipped for various applications (e.g. UV-C LEDs for disinfection and near-infrared emitters for LiDAR for autonomous driving), as well as applications in the context of Industry 4.0. Another focus will be micro-LEDs for use in an all-new type of display. ams OSRAM says that automation and artificial intelligence (AI) generally play a major role in Regensburg, enabling it to break new ground at its production facilities. The construction of the first pilot assembly line for 8" wafer production is currently underway in order to launch the cost-efficient large-scale production of micro-LEDs in the very near future.

"By expanding our development activities in the field of optoelectronic semiconductors, we can create room for innovation and accelerate the time to market for our products," says ams OSRAM's CEO Aldo Kamper. "At the same time, our investment is a clear commitment to Regensburg as an industrial hub, Bavaria as a high-tech location, and Europe as a hotbed of innovation," he adds. "Here we create new, energy-efficient products and production processes to drive digitalization and thus support the European Green Deal and the autonomy of Europe in semiconductors. In line with our future-oriented 'Re-Establish the Base' program, we will continue to build on ams OSRAM's market-leading core competency and shape the future of the semiconductor market from this Bavarian city," he adds.

www.ams-osram.com

ams OSRAM provides sub-assembled RGB lasers to TriLite

In a technology collaboration, ams OSRAM will provide sub-assembled RGB laser diodes to 'light up' the Trixel 3 laser beam scanner (LBS) of TriLite of Vienna, Austria.

Claimed to be the world's smallest projection display, the Trixel 3 LBS is lightweight, bright and accurate. It has ultra-low power consumption (<320mW) for all-day use, and full color support (>200% over sRGB). Trixel 3 enables augmented reality (AR) solutions for smart glasses and a wide range of consumer applications.

"Our ecosystem strategy focusses on partnering with world leaders to ensure top quality and reliable mass manufacturing," says TriLite' CEO Dr Peter Weigand. "We chose ams OSRAM as one of our technology partners due to its laser light sources' class-leading power and efficiency, which perfectly align with the brightness, contrast and high-performance requirements of our Trixel 3 LBS projector," he adds.

"Trixel 3's compact design paves the way for widespread adoption of 'always-on' consumer AR glasses," says Dr Jörg Strauss, senior VP & general manager of ams OSRAM's Visualization & Sensing business line. "OSRAM's laser diodes offer the key specifications essential for achieving the small form factor of Trixel 3."

TriLite says it designs for seamless mass manufacturing, incorporating customized standard components and utilizing high-volume production equipment. The result is an ultra-compact optical display engine with a brightness of 15 lumens, ensuring readability even in direct sunlight. Low system latency allows AR images to blend naturally with the wearer's surroundings and movements, providing immersive AR. Furthermore, Trixel 3 is fully compatible with state-of-the-art waveguides without requiring any relay optics, effectively saving space and reducing weight.

The ultra-compact and lightweight Trixel 3 laser beam scanner (LBS) optical display engine combines a single 2D MEMS mirror, all optical components, and the unique Trajectory Control Module (TCM) that shifts light module complexity from hardware to the software domain. The LBS module weighs under 1.5g and its volume is under $1cm^3$.

Joining TriLite's expanding ecosystem of manufacturing partners, ams OSRAM's expertise and laser diodes — paired with high-volume manufacturing capabilities — strengthen TriLite's vision for the future of AR smart glasses, the firm reckons.

www.trilite-tech.com

BluGlass appoints full-time CFO to support growth

Samuel Samhan brings experience in scaling high-growth businesses to profitability

BluGlass Ltd of Silverwater, Australia — which develops and makes gallium nitride (GaN) blue laser diodes based on its proprietary low-temperature, low-hydrogen remote-plasma chemical vapor deposition (RPCVD) technology — has appointed Samuel Samhan as chief financial officer on a full-time basis, effective immediately.

Samhan has more than 20 years of experience in financial leadership and commercial operations. He was previously chief operating & financial officer at global health platform Digital Wellness. Other roles include head of commercial and business transformation at Vitality Works – Sanitarium Workplace Health and Wellness, and commercial manager at Evolution Healthcare Group.

Samuel Samhan.

Samhan replaces part-time CFO Rob Ambrogio, who resigned from the position to pursue personal projects.

"Sam brings hands-on experience transforming financial and commercial operations to significantly increase profitability," says CEO Jim Haden. "Given our commercialization progress, we felt the time was right for a full-time CFO, and Sam's domestic and international expertise in business model innovation and cost-effective strategies will be invaluable as we continue to scale our laser production capability to meet unmet market needs and grow revenues," he adds.

"I'd like to thank Rob for his significant contribution to the company over the past year, supporting the broader leadership team as we expanded our operations across the US and Australia," Haden continues.

"In addition to scaling customer orders and revenues, I see further growth opportunities for the business as it continues to expand its product portfolio," comments Samhan.

Samhan holds a Bachelor of Business (Accounting), Master of Business Administration, and is a graduate of the Australian Institute of Company Directors.

www.bluglass.com.au

BluGlass wins custom GaN laser order from repeat customer

US-based research lab to use lasers for testing in high-power scientific applications

BluGlass has received a custom GaN laser project order from a repeat customer that is a leading USA-based research laboratory.

The order encompasses BluGlass' multi-mode GaN lasers in custom laser bars for testing in high-power scientific applications. The bars will also feature custom lenses, attracting a higher average selling price (ASP).

"This custom order further validates our unique go-to-market approach, and market differentiation," believes CEO Jim Haden. "Our flexible form factors and custom manufacturing capability are helping our customers solve complex challenges and enable novel applications in large and growing industry verticals. Our packaging and manufacturing flexibility is also enabling us to establish ourselves as a partner-of-choice, providing a platform for our lasers to be designed into new applications as well as growing our early product revenues," he adds. "We are very encouraged to receive this order from an existing laser project customer, as we develop our track-record and progress to larger volume and recurring orders."

www.bluglass.com

Xenics expands operation in North America to West Coast USA

Photonis Advanced Imaging senior worldwide VP sales & marketing appointed NA sales director

Xenics of Leuven, Belgium (owned by Photonis Group of Mérignac, France since December 2022) — which designs and manufactures long-wavelength infrared (LWIR) and indium gallium arsenide (InGaAs)-based short-wavelength infrared (SWIR) imagers, cores and cameras — says that it is starting a new chapter in its 23-year history by deploying additional resources in North America, consolidating its efforts to enhance local sales and support for its growing customer base. This complements its existing resources in the South-East and North-East regions of the USA.

Frédéric Aubrun, senior worldwide VP sales & marketing of Photonis Advanced Imaging business unit, has re- located to West Coast USA after being appointed as sales director for North America in order to focus on customer proximity, increased sales and additional support capabilities. He assumes responsibility for the North American local sales and support team management of advanced imaging activities as well as expanding the company's footprint, increasing the customer base and the local resources in the North American regions. The firm says that, under his management, the team has built a successful track record in Europe and APAC since he joined Xenics in 2018, in term of customer satisfaction, support efficiency and market responsiveness. In addition to his responsibility in the North American market, Aubrun will also continue to support a limited number of focus sales accounts in the Europe region.

The firm notes that, due to the specifics and dynamics of the camera market in North America, local resources in the same time zone are critically important to assist users and customers through their evaluation, test and implementation stages. On top of supplying products, the service and support provided by the team is expected to add significant value to customers, users and partners to maximize the performance of their systems at the right cost.

"The expansion of Photonis advanced imaging solutions in the North American market is a significant step towards our commitment in providing the best solutions and support to our customers, users and partners in this important region," comments Paul Ryckaert, executive general manager, Photonis Advanced Imaging business unit.

www.xenics.com
www.photonis.com

NUBURU extends independent chairman's role to executive chairman

Ron Nicol to scale commercial efforts, while CEO Mark Zediker focuses on production and development

NUBURU Inc of Centennial, CO, USA — which was founded in 2015 and develops and manufactures high-power industrial blue lasers — says that its board of directors has appointed Ron Nicol as executive chairman. After joining the firm as a director in 2020, Nicol has been the independent chairman of the board since earlier this year. In his newly extended role, he will prioritize scaling commercial efforts as well as executive administrative functions.

Nicol's executive experience spans over 40 years and is paired with a background in physics and the Nuclear Navy. He has been a senior advisor to Boston Consulting Group since 2016 where, prior to that, he was a longtime senior partner and managing director leading the Technology, Media & Telecommunications practice.

Ron Nicol.

NUBURU's CEO & co-founder Dr Mark Zediker will focus on scaling production capacity to meet existing as well as expected customer demand. In addition, he will continue to lead NUBURU's technology and development efforts centered around the introduction of multi-kilowatt and single-mode blue laser systems, as well as identify strategic and opportunistic projects in the defense and government markets.

"Scaling NUBURU's commercial efforts is critical for the company's growth strategy as a public company," comments Nicol.

"Having Ron in an active management position will allow us to double down on our efforts to scale the business," says Zediker. "Our commercial success goes hand-in-hand with production and delivery of cutting-edge technology."

www.nuburu.net

Vector evaluating Sivers' InP100 epitaxial material for surface-coupling laser project

Initial order includes laser fabrication and life testing

IC and integrated module supplier Sivers Semiconductors AB of Kista, Sweden says that its subsidiary Sivers Photonics of Glasgow, Scotland, UK has received an initial order from Vector Photonics Ltd (which was spun off from the University of Glasgow in 2020) for the evaluation of epitaxial material — manufactured on Sivers' InP100 platform — for a new, next-generation surface-coupling laser project.

The order, which includes laser fabrication and life testing, will be the first time that both Glasgow-based companies have worked together on a collaborative project. The collaboration with Sivers Photonics means that the project will be fulfilled entirely within the Scottish photonics cluster.

"Vector Photonics operates a 'fabless' business model, outsourcing wafer fabrication to semiconductor foundry partners around the world," notes Vector's sales & marketing director Euan Livingston. "Sivers Photonics is an ideal fabrication partner for Vector Photonics in every aspect. Furthermore, the proximate location of the businesses supports a particularly close working relationship, with clear benefits to in-depth development and R&D working."

"Vector Photonics' fabless business model is established and proven for prototype, pre-production and production requirements and volumes. It builds resilience, flexibility and scalability into our supply chain; allows for rapid scaling; and frees up the company to focus on developing high-value application IP in datacoms and wider markets," Livingston continues. "The order with Sivers Photonics helps to establish the required quality and life testing of our laser materials and is a significant part of our ongoing commercialization of surface-coupling laser devices," Livingston adds.

"We are delighted to partner with Vector Photonics on this project, using our expertise to support the commercialization of next-generation surface-coupling lasers whilst also continuing to strengthen Scotland's strong position as a global leader in photonics," says Andy McKee, chief technology officer & interim managing director at Sivers Photonics. "Following the successful wafer fabrication and testing phases and utilizing our proven foundry capabilities, we will enable Vector Photonics to deliver to their customers at scale," he adds.

"Surface-coupling lasers offer great performance by reducing power consumption, latency, size and costs and will be a great solution for the data-center market," reckons Sivers Semiconductors' CEO Anders Storm.

www.vectorphotonics.co.uk
www.sivers-semiconductors.com

III–V Epi CTO Richard Hogg co-leading European Semiconductor Laser Workshop

ESLW precedes European Conference on Optical Communications at the University of Glasgow

III–V Epi Ltd of Glasgow, Scotland, UK — which provides a molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD) service for custom compound semiconductor wafer design, manufacturing, test and characterization — says that its chief technology officer professor Richard Hogg is helping to lead the 46th European Semiconductor Laser Workshop (ESLW 2023), which is hosted on 30 September at the University of Glasgow's Sir Charles Wilson Building.

ESLW takes place alongside the 49th European Conference on Optical Communications (ECOC 2023) in Glasgow (1–5 October).

Hogg, who is Professor of Photonics at Aston University, is sharing the leadership on the ESLW Organizing Committee with Conference chair Dr Scott Watson, Programme Committee chair Dr Kevin Gallacher, and professor Stephen Sweeney.

ESLW's keynote speaker this year is professor Eric Tournie, from France's University of Montpellier. The invited speakers are Alessia Pasquazi of the UK's Loughborough University; Sylvie Menezo of SCINTIL Photonics, France; Una Marvet, of Alter Technology in the UK; Dag Schmidt of Menlo Systems in Germany; Paul Crump of Germany's Ferdinand-Braun-Institut; and Kouichi Akahane of Japan's NICT (National Institute of Information and Communications Technology).

Workshop topics include dynamic phenomena in semiconductor lasers; long-wavelength lasers, including quantum cascade lasers (QCLs) and interband cascade lasers (ICLs); photonic crystal, nanoscale, and surface-emission lasers; all-optical processing; new material systems, structures, and technologies; laser comb and millimeter-wave generation; optical amplifiers; photonic integrated circuits (PICs), integrated devices and lasers on silicon.

www.eslw.eu
www.iii-vepi.com

ATU partners with Tyndall and Ulster University to explore economic opportunities of EU Chips Act

Northwest of Ireland attended by Eblana Photonics, Cirdan, Yelo, Causeway Sensors, Allstate, Kelsius, Firecomms and Nuprint

On 18 September at the Atlantic Technological University (ATU) campus in Letterkenny, Ireland, a multi-stakeholder event spearheaded by ATU, in partnership with Tyndall National Institute and Ulster University (UU), explored the economic opportunities presented by the newly adopted EU Chips Act.

Recent semiconductor supply chain disruptions have led to a critical supply shortage, exposing Europe's over-reliance on imports. Through the Chips Act, designed to boost self-sufficiency, the European Union aims to double its current global market share to 20% by 2030.

Using case studies and panel conversations, 'NW of Ireland and the Opportunity in the Global Semiconductor Value Chain' brought together business leaders, policymakers, academia and elected officials to explore how Ireland can position itself as a leader in photonics and semiconductor research and manufacturing while simultaneously addressing the deficits in high-value employment and research infrastructure in the Northwest of Ireland. Industry representatives in attendance included Eblana Photonics, Cirdan, Yelo, Causeway Sensors, Allstate, Kelsius, Firecomms, and Nuprint.

During the event, invitees could engage with speakers and international experts who shared their knowledge and expertise including Dr Wyn Meredith, chair of the South Wales Compound Semiconductor Cluster, and Valerie Moreau of the Laval Mayenne Technopole in France.

"This cross-border initiative unites universities, research institutes and industry across Ireland to catalyse research, develop new technologies, drive productivity, create jobs, increase STEM diversity, and strengthen the regional economy," says ATU president Dr Orla Flynn. "With the generous support of stakeholders including the IDA [Ireland's foreign direct investment agency], Enterprise Ireland, local authorities, and industry partners, this consortium has the potential to play a pivotal role in boosting the competitiveness of the semiconductor industry across the island of Ireland," he believes.

Left to right: Dr Stephen Seawright, ATU; Peter Smyth, Tyndall; professor William Scanlon, Tyndall; Dr Nick Timmons, ATU; Gerry Kindlon, Seagate; Maria Gallagher, ATU; and Peter Devine, UU.

"This is an exciting knowledge exchange opportunity to further cooperation between third-level institutions in the Northwest," comments professor Liam Maguire, pro vice-chancellor Research at UU, who highlights how the collaborative provision of cross-border education could significantly boost the regional semiconductor talent pool. "Through collaborative research and development initiatives, as well as training and education programs, we can support resilient semiconductor supply chains that foster innovation and investment into our communities through an inclusive workforce," he adds.

Speaking on behalf of the Smart Nano NI cluster, led by data storage company Seagate Technology, Matt Johnson, senior VP wafer process engineering and systems, commented: "This new all-island collaboration will complement the Smart Nano NI cluster in developing advanced prototyping and smart manufacturing technologies across Northern Ireland. Key to success will be the combined expertise of our companies and the advancement of talent and research infrastructure. We are delighted to be involved in this exciting project which has the potential to put the border region on the global map for semiconductor technology," he adds.

"The recent adoption of the EU Chips Act presents a unique and timely opportunity for Ireland to bolster its leadership in semiconductors and photonics," reckons Tyndall's CEO professor William Scanlon. "Ireland must act now to build on its well-established strategic advantages in the sector, and mobilizing public–private R&D partnerships to lead and leverage cumulative expertise is critical for our future economic success," he adds. "Our alliance with ATU and UU represents a significant step forward in our ongoing efforts to accelerate north–south research and innovation in support of a diverse and growing, internationally competitive semiconductor industry."

www.tyndall.ie
www.atu.ie

PhotonVentures raises €60m to invest in Europe's photonic chip start-ups

PhotonDelta-backed fund aims to more than double in size by 2024

PhotonVentures has launched a venture capital fund aimed at early-stage photonic chip start-ups and scale-ups. €60m was raised in its first financing round, with Netherlands-based PhotonDelta as the lead investor (via the transfer of its portfolio to PhotonVentures) alongside numerous private investors. PhotonVentures plans to raise a total of €100–150m, with its final close set for the start of 2024.

PhotonVentures is an independent deep-tech venture capital firm that has been spun off from PhotonDelta, which was founded in 2014 as a growth accelerator for the integrated photonic chip industry in the Netherlands and Europe. PhotonDelta has since invested in photonics companies and R&D, establishing a cross-border ecosystem of organizations that research, design, develop and manufacture solutions with integrated photonic chip technology. Last year, PhotonDelta secured €1.1bn in public and private investment to scale up production, build 200 start-ups, create new applications for photonic chips and develop infrastructure and talent.

As strategic partners, PhotonVentures and PhotonDelta aim to support the rapid growth of Europe's photonics industry.

Leveraging the PhotonDelta integrated photonics ecosystem to accelerate European start-ups and scale-ups, PhotonVentures' investment strategy will prioritize Series A rounds, providing investments of €1–2.5m each. The fund is planning to initially invest in 15 European deep-tech companies that have potential to grow internationally in their sectors. The start-ups should have an integrated photonics-based MVP (minimum viable product) connected to the European ecosystem.

The PhotonVentures board consists of Joachim de Sterke, Pieter Klinkert and Rijkman Groenink. de Sterke has a financial, legal and technical background with long-term investment experience. As co-founder & chief financial officer of PhotonDelta he was responsible for the entire investment process and guidance of the young companies in the ecosystem. Klinkert joined PhotonDelta in 2021. He was previously investment manager at OostNL and held positions in financing and corporate investment at various banks. Groenink is a former banker with experience in the financial sector.

"There are hundreds of incredibly promising start-ups and scale-ups driving development and application of photonic chips that need investment and support to take the next step on their journey. PhotonVentures fulfils this need; it is the only fund geared directly towards photonic chip start-ups and scale-ups," comments de Sterke. "Our aim is to play an instrumental role in making Europe a global leader in integrated photonics. We will continue to expand our fund to enable us to invest in scores of start-ups over the next few years," he adds.

"The integrated photonics industry is growing quickly but is short of investors with the knowledge and funding to back the sector's ambitions," notes René Penning de Vries, chairman of PhotonDelta's supervisory board. "This is why creating the specialized fund PhotonVentures marks a significant milestone for the photonics industry," he adds. "By transferring its existing portfolio, PhotonDelta was able to leverage its assets to attract more funds and kickstart the creation of PhotonVentures."

www.photondelta.com

Hyper Photonix announces new manufacturing facility in Bengbu, China

Production of 400/800G transceivers to ramp to 50,000 units/month by end 2023, then several 100,000 units/month by end 2024

Optical transceiver designer and manufacturer Hyper Photonix Ltd of Bellevue, WA, USA has announced an expansion of its manufacturing capabilities, marked by the inauguration this June of a gigafactory in Bengbu, Anhui province, China. Encompassing 120,000ft^2 and backed by a multi-million-dollar investment, the new facility aims to meet the surging demand for optical transceivers in the hyper-scale data-center and artificial intelligence (AI) markets.

The firm is ramping up production of 400G and 800G transceivers, and preparing for future volume production of 1.6T products. Production ramp up is planned to reach 50,000 units per month by the end of 2023, rising to several 100,000 units/month by end 2024.

Hyper Photonix's president & founder Ming Yang believes that the accelerated integration of silicon photonics in optical transceivers will be critical to meet the fundamental challenges facing the industry. "Our company's Hyper Silicon photonics technology platform — combined with in-house chip-to-transceiver design, manufacturing and testing competencies — ensures that our company is well positioned to provide volume solutions at a compelling price point and empower the rapid deployment of AI/ML in hyperscale data centers globally," he reckons.

Plans are underway to establish production lines outside of China by mid-2024 to mitigate risks to production flow and to offer customers alternative sourcing at enhanced value.

Hyper Photonix showcased live demonstrations of its multiple Hyper Silicon enabled transceivers in the Ethernet Alliance's booth at the 49th European Conference on Optical Communications (ECOC 2023) in Glasgow, Scotland, UK (2–4 October), where it is also participated in a series of interoperability demonstrations.

www.ecocexhibition.com
www.hyperphotonix.com

POET and JV partner SPX demonstrate 800G OSFP optical transceivers at CIOE

Live demo in cooperation with lead customers Luxshare-ICT

At the 24th China International Optoelectronics Expo (CIOE 2023) in Shenzhen (6–8 September), POET Technologies Inc of Toronto, Ontario, Canada — designer and developer of the Optical Interposer, photonic integrated circuits (PICs) and light sources for the data-center, telecom and artificial intelligence (AI) markets — gave live demonstrations of end-to-end optical solutions for 800G, 400G and 200G optical transceivers using its highly integrated optical engines.

Specifically, in cooperation with one of its lead customers Luxshare-ICT, POET — along with its joint venture partner Super Photonics Xiamen (SPX) — is showcasing a live demonstration of the performance of Luxshare's 800G OSFP transceiver that incorporates POET's 800G Rx optical engine. POET and SPX are presenting additional live demonstrations of optical engines for 800G, 400G and 200G transceivers operating over a wide temperature range and 2–10km of single-mode fiber transmission. The demonstrations of linked optical engines on both the transmit and receive ends of the fiber are said to highlight the end-to-end performance and product readiness of POET's optical engines and allow customers to experience the simplicity and compact design of the products.

POET also gave a live demonstration of its own prototype 400G transceiver module in a QSFP-DD package, complete with a POET Infinity chiplet, a 400G Rx optical engine with integrated TIA, a digital signal processor (DSP), TEC controller, fiber attach and housing. Also on display are a mechanical sample of POET's own 800G transceiver module with two POET Infinity chiplets, an 800G Rx optical engine with integrated TIA, and an 800G DSP in a QSFP-DD package, scalable to 1.6T in an OSFP package.

"We are already seeing significant customer interest to test and use our engines in transceivers from 100G to 800G and even 1.6T speeds," says Dr Mo Jinyu, senior VP/general manager of POET Asia. "The live demos at CIOE will help further boost customer confidence in our one-of-a-kind approach to photonics integration, the superior, real-time performance of our optical engines and reliability of POET's products that are assembled and sold in China by SPX," he adds.

Mo also spoke about POET's products and innovations at the collocated ICCSZ Conference on 5 September.

www.cioe.cn/en
www.poet-technologies.com

Astrape Networks secures €1.6m in pre-seed funding

Eindhoven spin-off to develop PIC-based technology for more energy-efficient data centers

Astrape Networks — a startup founded in 2022 at the High Tech Campus, Eindhoven, The Netherlands that uses integrated photonics to build optical networks — has secured a pre-seed funding round of €1.6m from a consortium of investors and loan providers, including Brabantse Ontwikkelings Maatschappij (BOM), Rabobank, Brabant Startup Fonds, TTT Smart Industries, Shift Invest and PhotonDelta.

Astrape says that it can hence begin to develop the technology needed to drive the data centers and optical networks of the future, specifically using photonic integrated circuits (PICs) to build faster, cooler and more energy-efficient data centers.

Since existing data networks convert electronic signals into optical signals and back again multiple times, switching between electrical and optical signals consumes large amounts of energy in data centers, especially as there are estimated to be more than 5 billion Internet users in 2023. Astrape therefore aims to eliminate multiple electrical-optical conversions by only converting to optical at the network edge. At current network speeds, that would generate an estimated energy savings of 20%. Based on anticipated future speeds, that could rise to around 60%.

"With the first investment, we will be able to demonstrate the technology in a relevant environment, taking it from laboratory scale to engineering scale," says CEO Francesco Pessolano. "This will show that the technology is viable and keeps its performance and power saving promises in an industrial setting," he adds. "The investment is key for building a strong core engineering team in networking and photonics that will enable us to develop further towards our first product."

The result of years of R&D at the Eindhoven University of Technology (yielding technology that was demonstrated there in 2021), Astrape was launched through a venture building program by European deep-tech venture builder HighTechXL and Netherlands-based photonic chip industry growth accelerator PhotonDelta, with support from The Gate — a launch-pad for tech startups in Brainport Eindhoven.

"This investment is an important endorsement for the photonics venture building program set up by HighTechXL and PhotonDelta," comments PhotonDelta's chief financial officer Laurens Weers. "The joint program enables start-ups working with integrated photonics — such as Astrape Networks — to get off the ground, create new use-cases for the technology and strengthen the Netherlands' position as a world leader in integrated photonics."

www.astrape.net

Infinera plans ICE-X coherent pluggables and InP components complying with Build America, Buy America

Firm committed to maintaining opto fabs in USA

Infinera Corp of San Jose, CA, USA — a vertically integrated manufacturer of digital optical network systems — plans to make available ICE-X intelligent coherent pluggables and compound semiconductor components that will be manufactured in the USA and compliant with the Build America, Buy America requirements issued in August by the US Commerce Department for the Broadband Equity, Access and Deployment (BEAD) program.

Leveraging its domestic optical compound semiconductor fabrication facility in California and testing & packaging facility in Pennsylvania, Infinera says that its coherent optical solutions enable network operators to efficiently scale their networks, driving down cost per bit and power per bit while helping them meet Build America, Buy America requirements. US-based semiconductor production also provides improved supply chain security and resiliency, the firm adds.

Infinera says that its suite of indium phosphide (InP) based vertically integrated ICE-X intelligent coherent pluggables provide network operators the performance, scale and efficiency that is critical to drive down network operating costs and to enhance service agility. As a critical part of network infrastructure, the solutions are optimized for metro, middle-mile, and access and aggregation networks that enable operators to expand their broadband infrastructures while helping them to address Build America, Buy America requirements for the BEAD program.

"We remain committed to investing in and keeping optical semiconductor fabrication in the US," states CEO David Heard. "By leveraging our vertically integrated US-based development, fabrication and manufacturing capabilities, we can do our part to enhance national security and improve supply chain resiliency for important semiconductor technologies."

www.infinera.com/innovation/icex-coherent-optical-pluggables

EFFECT Photonics verifies fully integrated InP PIC in digital ITLA for coherent applications

Photonic integrated circuit features support for 100G, 400G & 800G ZR

EFFECT Photonics b.v. — a spin off from the Technical University of Eindhoven (TU/e) in The Netherlands that develops DWDM optical system-on-chip components for mobile networks and data-centers — has announced verification of its fully integrated tunable laser InP-based photonic integrated circuit (PIC), the core enabler powering its digital Pico Integrated Tunable Laser Assembly (pITLA).

As a core component of coherent optical systems enabling dense wavelength division multiplexing (DWDM), tunable lasers allow network operators to expand their network capacity without expanding the existing fiber infrastructure. With this milestone, the firm's tunable laser InP-based PIC has passed a series of tests showing required performance items outlined by IEEE Std. 802.3-2022, 100GBASE-ZR.

EFFECT Photonics says that, unlike tunable laser assemblies currently available, the core of its digital pITLA is a tunable laser implemented fully as a monolithic integrated InP PIC. This enables advantages such as the ability to achieve a compact footprint, higher assembly yields, and ease of integration into pluggable form factors. The InP PIC is claimed to be the only solution to integrate the gain section, laser cavity, optical amplifier and wavelength locker into one chip. By incorporating these functions on a single chip and including the control functions in the assembly, the user can easily communicate and control the laser by simply providing digital commands.

"In the last decade, the industry has made impressive strides in reducing the size of crucial coherent optical functions, making way for digital coherent modules. EFFECT Photonics pITLA sets a new precedent in photonic integration by eliminating the need for external micro-optics for control of tunable lasers," claims CEO Roberto Marcoccia. "Our monolithic approach maintains all vital functions while drastically reducing the device's overall size to a smaller form factor previously unattainable."

Purposely designed to simplify the design of small-form-factor pluggables, the integrated InP PIC is the foundation of EFFECT Photonics' new pITLA, providing a blend of power, cost-effectiveness and compactness. It paves the way for the cost-efficient design of coherent pluggables, opening up new possibilities for the industry, claims the firm.

www.effectphotonics.com/products/sub-assemblies/ptla

IQE launches first 6" InP DFB laser platform for AI and data-center applications

Process-ready epi platform developed in collaboration with Glasgow's James Watt Nanofabrication Centre and Kelvin Nanotechnology

Epiwafer and substrate maker IQE plc of Cardiff, Wales, UK has announced what it says is the industry's first 150mm (6") indium phosphide (InP) platform enabling the scaled production of electro-optic devices at the core of artificial intelligence (AI), machine learning and cloud data-center networks.

In collaboration with the University of Glasgow's James Watt Nanofabrication Centre and its commercial arm Kelvin Nanotechnology (a supplier of nanofabrication services for prototyping and production), IQE has developed a process-ready 6" distributed feedback (DFB) InP laser wafer platform, enabling customers to deliver high-volume laser solutions supporting the rapid growth in high-speed optical data links.

IQE says that its data infrastructure semiconductor materials are employed across a diverse range of transceiver platforms. As a pioneer in InP, it is further demonstrating the technology's scalability, enabling a step change in volume manufacturing to satisfy an increasing demand for DFB lasers. The firm adds that this also ensures that optical interconnect technology remains cost competitive, as network traffic scales to meet the requirements of generative AI and data-intensive applications.

"We are pleased to be able to offer our data-infrastructure customers an industry-first: laser epitaxy on a 6" InP wafer platform," says Peter Rabbeni, senior VP, IQE's Communications Infrastructure & Security business unit. "Scaling our current laser materials technology to deliver a fab-ready service at this size provides an immediate competitive advantage and faster time to market," he adds.

"We are delighted to be able to demonstrate a DFB grating technology fully deployed on a 6" InP platform with high yield and uniformity, and we look forward to working with IQE in bringing this capability to the market," comments Kelvin Nanotechnology's CEO Dr Brendan Casey.

www.iqep.com
https://kntnano.com

OpenLight samples fully integrated 2xFR4 PASIC photonic integrated circuit

Heterogeneous integration of lasers and electro-absorption modulators simplifies customer product development

OpenLight of Santa Barbara, CA, USA (which launched as an independent firm in June 2022, introducing the first open silicon photonics platform with heterogeneously integrated III-V lasers) has made available samples of a fully integrated 2x FR4 Photonic Application Specific Integrated Circuit (2xFR4 PASIC). Its PASIC technology integrates all the components of silicon photonics devices, both active and passive components, into one chip.

Designed to meet the ever-evolving demands of data-center and AI cluster connections, the new 2xFR4 PASIC 800G photonic integrated circuit (PIC) harnesses the power of heterogeneous integration, combining lasers and electro-absorption modulators for what is claimed to be unparalleled performance and versatility with the cost and reliability of traditional silicon photonics. This addresses the growing demand for faster data processing, reduced power consumption, simplified product development, and cost savings in critical computing environments. OpenLight says that, with this PASIC, it is enhancing its offerings by introducing coarse wavelength division multiplexing (CWDM) capabilities to its family of reference designs.

The 2xFR4 PASIC integrates all essential components into a single chip, replacing up to 16 individual components that would otherwise require assembly steps with disparate parts and complex back-end manufacturing processes adding cost and large capital equipment expenditures. This results in simplified supply chain logistics and straightforward manufacturing processes that drastically reduce power consumption and overall costs compared with other solutions.

"With our revolutionary integration of lasers and electro-absorption modulators, 2xFR4 PASIC epitomizes our dedication to simplifying complexity, reducing costs, and setting new standards in efficiency," says CEO Dr Adam Carter. "We're providing our customers with a validated reference design that not only accelerates their time to market but also empowers them to take control of their destiny in the supply chain," he adds.

"We are excited to be the manufacturing partner for OpenLight and look forward to this cutting-edge, validated reference design accelerating our mutual customer's product development with tested samples and ready design files saving substantial time and cost," says Russell Ellwanger, CEO of Tower Semiconductor. "This fully integrated solution incorporating lasers and electro-absorption modulators is a testament to our strong partnership and joint commitment to investing toward the adoption of silicon photonic technology in high-volume manufacturing."

Customers can use the 2xFR4 PASIC validated reference design to build products without having to design, engineer, and test their own solutions.

OpenLight offers tested samples, comprehensive test results, and design files, potentially saving customers up to 18 months of engineering work compared to designing from scratch, it is reckoned, significantly reducing time to market for customers.

www.openlightphotonics.com

QSFP-DD MSA unveils hardware specification revision 7.0

Introduction of 1.6Tbps pluggable QSFP-DD module variant to boost performance, scalability and power handling

At the European Conference on Optical Communications (ECOC 2023) in Glasgow, Scotland, UK, the Quad Small Form Factor Pluggable Double Density (QSFP-DD) Multi-Source Agreement (MSA) group announced the release of a hardware specification revision 7.0. This updates the existing QSFP-DD MSA specification and introduces the QSFP-DD1600 module variant to drive further improvements in performance, scalability and power handling.

The new specification maintains the form factor's eight electrical lanes, with each lane operating at the new higher 200Gbps rate to provide an aggregate module bandwidth capacity of 1.6Tbps. The 1.6Tbps host port maintains backwards compatibility with the entire family of QSFP and QSFP-DD modules and cables. This provides the high degree of flexibility that end users and system designers have come to expect from QSFP and QSFP-DD, easing their network port speed migrations.

The new release includes enhancements to further improve the power handling capability of QSFP and QSFP-DD form factor's small faceplate profile and the QSFP-DD's riding heatsink feature. The combination of these features enables system designers to more efficiently cool the majority of modules as well as support even higher-power modules that may be required in next-generation high-density Ethernet switch platforms, supporting all module variants such as coherent 1600ZR modules.

The new QSFP-DD1600 specification maintains the existing port density enjoyed by systems utilizing QSFP-DD currently, and fully utilizes the faceplate to efficiently use the rack-space that is expected from next-generation capacity switches.

"Network operators are continuing to push the QSFP-DD form factor to meet the expectations of next-generation systems while maintaining backward compatibility," says MSA co-chair Scott Sommers. "This is a critical step for the operational strategy of next-generation deployments," he adds.

"The design flexibility that the QSFP-DD form factor enables with its riding heatsink and small faceplate profile maximizes the available air flow and provides engineers the flexibility to meet the challenges for the next generation of system design," says MSA co-chair Mark Nowell. "QSFP-DD continues to be the cornerstone of high-performance, high-density pluggable optics for the foreseeable future."

This new specification extends the QSFP-DD leadership to 1.6Tbps, with broad support from component manufacturers to end users, and continues the market leadership for QSFP-DD from its original 400G and now 800G adoption, says the group.

A new whitepaper focusing on the thermal enhancements, including the resulting reduction of system power of QSFP-DD1600, is available on the QSFP-DD MSA website.

The QSFP-DD MSA is supported by more than 60 companies addressing the technical challenges of achieving a double-density interface and ensuring mechanical, electrical, thermal and signal integrity interoperability for the next generation of networking equipment.

www.qsfp-dd.com

Coherent unveils first 140GBaud optical subassembly to enable 800G in ultra-compact pluggable form factors

140GBaud IC-TROSA combined with Marvell's Orion coherent DSP to transmit 800G

Materials, networking and laser technology firm Coherent Corp of Saxonburg, PA, USA has launched its 140GBaud integrated coherent transmitter-receiver optical subassembly (IC-TROSA), which is claimed to be the first to enable 800G QSFP-DD and OSFP digital coherent optics (DCO) pluggable transceivers for high-speed data-center interconnects and metro networks.

Artificial intelligence and machine learning (AI/ML) applications are accelerating the exponential growth of data-center traffic in cloud networks, driving the demand for efficient bandwidth upgrades in data-center interconnects and optical transport networks. The 140GBaud IC-TROSA is claimed to be the first to enable 800Gbps ZR/OpenZR+ transmission in data-center interconnects and metro communications networks in the ultra-dense QSFP-DD and OSFP pluggable form factors. The IC-TROSA is a highly integrated coherent optics subassembly with embedded optical amplification that can deliver high transmitter output power with low power dissipation, enabling DCO modules that can plug directly into routers. The solution is said to lower the total cost of network ownership for hyperscalers and service providers by eliminating an entire layer of transponder equipment.

"This 140GBaud IC-TROSA follows the 64GBaud IC-TROSA introduced in March 2020, which was also an industry first," says Matthias Berger, VP, coherent technology, at Coherent. "We continue to advance the state of the art of optical transmission in core networks by leveraging the inherent capabilities of our indium phosphide technology platform. Indium phosphide photonic integrated circuits are differentiated by their high output power, which enables disruptive use cases such as IP-over-DWDM in metro networks."

Coherent's IC-TROSA was combined with the Orion digital signal processor (DSP) from Marvell to demonstrate the performance capabilities of a complete transceiver solution for 800Gbps transmission.

"Marvell's close collaboration with Coherent has enabled us to showcase the power of the combination of technologies from two leading companies," says Samuel Liu Sr, director, product line management, coherent DSP at Marvell. "Together, the 140GBaud IC-TROSA and the Orion coherent DSP enable pluggable transceivers for 800Gbps with more than 500km reach, allowing data-center interconnects to scale network capacity quickly and economically so as to accommodate the surging traffic from AI/ML and other distributed, data-intensive workloads."

The 140GBaud IC-TROSA is a complete coherent optical engine that includes a wavelength-tunable laser, optical amplifiers, modulators, drivers, a coherent mixer, a photodiode array, and transimpedance amplifiers (TIAs). It features an embedded microcontroller, DAC/ADCs, and a simple digital communication interface for all control and monitoring. The module supports symbol rates of up to 140GBaud and multiple modulation formats, including QPSK, 8QAM, 16QAM, 32QAM and 64QAM. It is designed to meet the requirements of the OIF IC-TROSA Implementation Agreement (Type-2 version). Alpha samples of the 140GBaud IC-TROSA are available now, and the product will be generally available in mid-2024.

Coherent exhibited at the European Conference on Optical Communications (ECOC 2023) in Glasgow, Scotland, UK (2–4 October). At the conference, Coherent showcased the most recent additions to its portfolio of differentiated solutions for telecom and datacom optical networks.

www.ecocexhibition.com

Ethernet Alliance's ECOC demonstration spotlights Ethernet's scaling to 800Gb/s

Interactive multi-vendor interoperability demonstration involves AMD, Amphenol, Cisco, Hyper Photonix, Keysight, Synopsys, Teledyne and Xena

The Ethernet Alliance has unveiled details of its multi-vendor interoperability demonstration in booth #460 at the European Conference on Optical Communication (ECOC 2023) in Glasgow, Scotland, UK (2–4 October).

"Scaling from 10Mb/s to now 800Gb/s during the past 50 years, Ethernet continues to surprise and surpass competitive technologies by creating a more efficient whole network architecture from the data center to edge devices," says David J. Rodgers, chair of the Ethernet Alliance's Events & Conferences Committee.

The Ethernet Alliance returns to ECOC with support from companies representing the entire Ethernet landscape. Members participating in its interactive interoperability demo are AMD, Amphenol Corp, Cisco Systems Inc, Hyper Photonix Ltd, Keysight Technologies Inc, Synopsys Inc, Teledyne LeCroy Inc, and Xena Networks Inc.

The Ethernet Alliance's exhibit at ECOC encompasses a broad cross-section of Ethernet products and solutions. With speeds ranging from 10GbE to 800GbE, among the technologies comprising its demo are copper and optical cabling and interconnects, switches, routers, transceivers, test & measurement equipment, and pluggable form factors such as OSFP, QSFP-DD, QSFP, and SFP.

"AMD is committed to its strategic collaboration with the Ethernet Alliance and its partners to demonstrate the capabilities of 800G interoperability using AMD Versal Premium silicon and IP. The move towards 800G Ethernet is a vital step for the communications industry as the demands of next-generation connectivity experiences increase the need for sustainable evolution of network infrastructure," says Harpinder Matharu, senior director, wired and wireless group (WWG), AMD.

"Our range of 400G and 800G Hyper Silicon photonics transceivers will be featured in this industry-wide demonstration, highlighting our dedication to seamless integration and interoperability across various host switching platforms and test equipment solutions," says Xavier Clairardin, CEO of Hyper Photonix.

"Keysight is showcasing the latest 400/800 gigabit Ethernet speeds across a variety of interconnects, both optical and electrical, including 400ZR+, and 1.5m Direct Attach Copper (DAC) cables, featuring auto-negotiation/link training connectivity," says Ram Periakarrupan, VP & general manager of Keysight's Network Applications and Security group.

"The rise of AI-intensive workloads is driving significantly higher processing performance and energy-efficiency requirements in hyperscale data centers. Innovations in the Ethernet standard are critical to meeting the bandwidth and data connectivity needs of these systems," says John Koeter, senior VP of marketing & strategy for IP, at Synopsys. "As a member of the Ethernet Alliance, Synopsys provides trusted, standards-compliant Ethernet IP solutions for data rates up to 1.6T that enable wide interoperability for high-performance computing and data-center SoCs," he adds.

"The intersection of 800 Gigabit Ethernet with breakthroughs in artificial intelligence and machine learning has put tremendous demands on assuring interoperability in network infrastructure. The critical first step in interop is link connectivity. Teledyne is pleased to showcase 800GE link connectivity via the M1288, the industry's first platform that can analyze and debug large traces of 800GE Auto Negotiation and Link Training," says Nick Kriczky, VP of products & services, Teledyne LeCroy. "Teledyne LeCroy is excited to be working with the Ethernet Alliance to support these industry requirements and demonstrate how Auto Negotiation and Link Training can be tested and verified."

www.ecocexhibition.com
www.ethernetalliance.org

First Solar breaks ground on $1.1bn 3.5GW Louisiana factory

Plant to create over 700 direct manufacturing jobs in Louisiana

Cadmium telluride (CdTe) thin-film photovoltaic (PV) module maker First Solar Inc of Tempe, AZ, USA has broken ground its fifth fully vertically integrated factory in the USA. Sited in Iberia Parish, Louisiana (as announced on 10 August), the ceremony was attended by the Governor of Louisiana John Bel Edwards and other dignitaries from the state.

Believed to be the largest capital investment in the area's history, the manufacturing facility represents an investment of about $1.1bn in expanding the USA's capacity to produce photovoltaic solar panels. Expected to start commercial shipments by first-half 2026, it is forecasted to grow First Solar's nameplate manufacturing capacity by 3.5GW to about 14GW in the USA and 25GW globally in 2026.

When completed, the fully vertically integrated manufacturing facility will cover over 2 million square feet and is designed to transform a sheet of glass into a ready-to-ship Series 7 module in about 4.5 hours, producing over one dozen new solar panels every minute.

First Solar's investment is expected to create over 700 new direct manufacturing jobs in Louisiana. Already believed to be the largest employer in America's solar manufacturing sector, with more than 2500 staff across the country, the firm expects to have over 4000 direct employees in the USA by 2026.

"We are creating enduring value for the US by building a robust solar manufacturing base and the value chains that enable it," says First Solar's CEO Mark Widmar. "This delivers jobs and economic value today, and establishes the foundations needed for the country to enter the next decade with a secure supply of solar energy technology."

First Solar has broken ground on its manufacturing facility in Iberia Parish, Louisiana, its fifth fully vertically integrated factory in the USA: (from left to right) Louisiana Economic Development's secretary John Pierson; First Solar's chief manufacturing officer Kuntal Kumar Verma; First Solar's chief people & communications officer Caroline Stockdale; Iberia Parish president M. Larry Richard; Governor of Louisiana John Bel Edwards; Mark Widmar; First Solar's CEO John Bel Edwards; First Solar's chief commercial officer Georges Antoun; First Solar's general counsel & secretary Jason Dymbort; and First Solar's chief supply chain officer Mike Koralewski.

Since the start of this decade, First Solar has embarked on a $4.1bn manufacturing expansion strategy that has seen it grow from about 6GW of global nameplate capacity in 2020 to 13GW operational today, with about 12GW of nameplate capacity expected to come online in the USA and India between second-half 2023 and 2026. In addition to the Louisiana facility, First Solar commissioned its third Ohio factory earlier this year and is expected to complete its new facility in Alabama and the expansion of its existing Ohio footprint in 2024. The firm also expects its new facility in India to begin commercial production in fourth-quarter 2023. Additionally, it is investing up to $370m in a dedicated R&D innovation center in Perrysburg, Ohio, which is expected to be completed in 2024.

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Rudolph Libbe Inc will serve as the general contractor for the project and has already engaged with Lafayette-headquartered LEMOINE to assist with early site work. The new facility is expected to create 500 construction jobs in Louisiana over the next 18 months.

www.firstsolar.com

5N Plus' AZUR triple-junction solar cells powering largest long-duration energy storage project

Specialty semiconductor and performance materials producer 5N Plus Inc of Montreal, Québec, Canada says that, via its subsidiary AZUR SPACE Solar Power GmbH, it supplied the triple-junction solar cells utilized to help deliver the world's largest and highest-efficiency next-generation long-duration solar energy storage project, now officially declared open.

RayGen's flagship power plant in Carwarp, Victoria, Australia was officially inaugurated and declared open on 31 August, delivering 4MW solar and 2.8MW/50MWh storage capacity, making it the world's largest and lowest-cost next-generation long-duration energy storage projects, it is reckoned.

AZUR's high-efficiency solar cells are key components of Australian solar-and-storage company RayGen's proprietary solar technology. Sunlight, concentrated by tracking mirrors onto RayGen's solar receiver, is converted by an array of RayGen solar modules, tiled with AZUR cells, into electricity and by-product heat. The heat offers synergy with RayGen's water-based electro-thermal energy storage.

"AZUR's high-efficiency, high-performance solar cells enable RayGen to provide energy on a large scale, both consistently and on short-notice, with minimal environmental impact," says 5N Plus' president & CEO Gervais Jacques. "We look forward to continuing to support RayGen as they pursue additional utility-scale projects critical to the energy transition."

www.5nplus.com
www.raygen.com

Longroad adds 2GW order to existing 3.7GW framework agreement with First Solar

US-based renewable energy developer, owner and operator Longroad Energy Holdings LLC has agreed to procure an additional 2GW of cadmium telluride (CdTe) thin-film photovoltaic (PV) modules made by First Solar Inc of Tempe, AZ, USA. To be delivered between 2027 and 2029, the order builds on an existing 3.7GW framework agreement and increases Longroad Energy's total procurement of First Solar modules to about 8GW since 2017.

"Longroad Energy and First Solar share a longstanding partnership that's based on shared values and a common vision for a sustainable energy future," says Longroad Energy co-founder & chief operating officer Michael Alvarez. "By expanding our procurement of First Solar's advanced thin-film technology, we are extending our commitment to responsibly produced renewable energy technologies and to American solar manufacturing and domestic value chains."

First Solar claims that its PV modules have the lowest carbon and water footprint of any commercially available PV module currently, and that it is the first PV manufacturer to have its product included in the Electronic Product Environmental Assessment Tool (EPEAT) global registry for sustainable electronics.

First Solar is the only one of the world's ten largest solar manufacturers 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, and the firm says that it has zero tolerance for forced labor in its manufacturing or its supply chains. First Solar believes it is first to have conducted third-party social audits across its operational global manufacturing footprint.

"Our ability to deliver certainty of pricing and supply, domestic manufacturing and supply chains, and a responsibly made solar module optimized for energy provides the value customers, such as Longroad, seek," reckons First Solar's chief commercial officer Georges Antoun. "We look forward to growing this partnership."

Since the start of this decade, First Solar has embarked on a manufacturing expansion strategy that has seen it grow from about 6GW of global operational nameplate capacity in 2020 to 13GW now, with further expansion expected to increase that to 25GW in 2026. First Solar commissioned its third Ohio factory earlier this year and is expected to complete a new facility in Alabama and the expansion of its existing Ohio footprint in 2024. The firm has also announced that it will complete a fifth US facility, to be located in Louisiana, in first-half 2026. Additionally, it is investing up to $370m in a dedicated R&D innovation center in Perrysburg, Ohio, to be completed next year.

www.longroadenergy.com
www.firstsolar.com

Auger recombination's impact on InGaN LED efficiency

Research suggests that efficiency droop at high current is affected more by carrier localization than by point defects.

Researchers based in the UK and Ireland report that Auger recombination in indium gallium nitride (InGaN) multiple quantum wells (MQWs) is enhanced by carrier localization effects rather than defect assistance, according to their theoretical and experimental work [R. M. Barrett et al, ACS Photonics, 2023, vol10, no.8, p2632]. Auger recombination is seen as a major culprit for droop in internal quantum efficiency (IQE) and external quantum efficiency (EQE) at high carrier concentrations, as seen at high current injection.

The team from University of Manchester in the UK, University College Cork in Ireland, and University of Cambridge in the UK, comment: "Good quantitative agreement between measurement and calculated IQE has now been demonstrated, showing that Auger recombination, enhanced by the localization of carriers but without any defect assistance, is sufficient to explain droop in the green-emitting QWs studied here."

They add: "The peak IQE values of ~70% reported here under resonant excitation for samples that are designed to vary in point defect density and elsewhere show that there is limited scope for further improvement of maximum recombination efficiency within the active region of green-emitting QWs."

The team thus believes that the focus should be on reducing expected carrier densities in LED operation towards the region of peak IQE. Although one might expect non-polar and semi-polar crystal orientation to improve droop effects, due to a faster recombination rate (sub-ns, as opposed to 10–100ns in the c-plane structures studied), this has not been realized experimentally.

The team suggests that there is more scope for improvement from focusing on aspects other than recombination within the active region: "For instance, improving the efficiency and homogeneity of carrier injection into the active region or reducing current leakage is likely to yield greater increases in EQE. This work also indicates that the most productive route to reducing droop is to target active region designs that reduce carrier density in individual QWs, such as the increased QW area or QW number or a more even distribution of carriers between QWs, rather than trying to reduce Shockley–Read–Hall (SRH) recombination in the active region."

LEDs work by injecting electrons and holes into an active region where they recombine, releasing their energy as photons. Unfortunately there are other ways

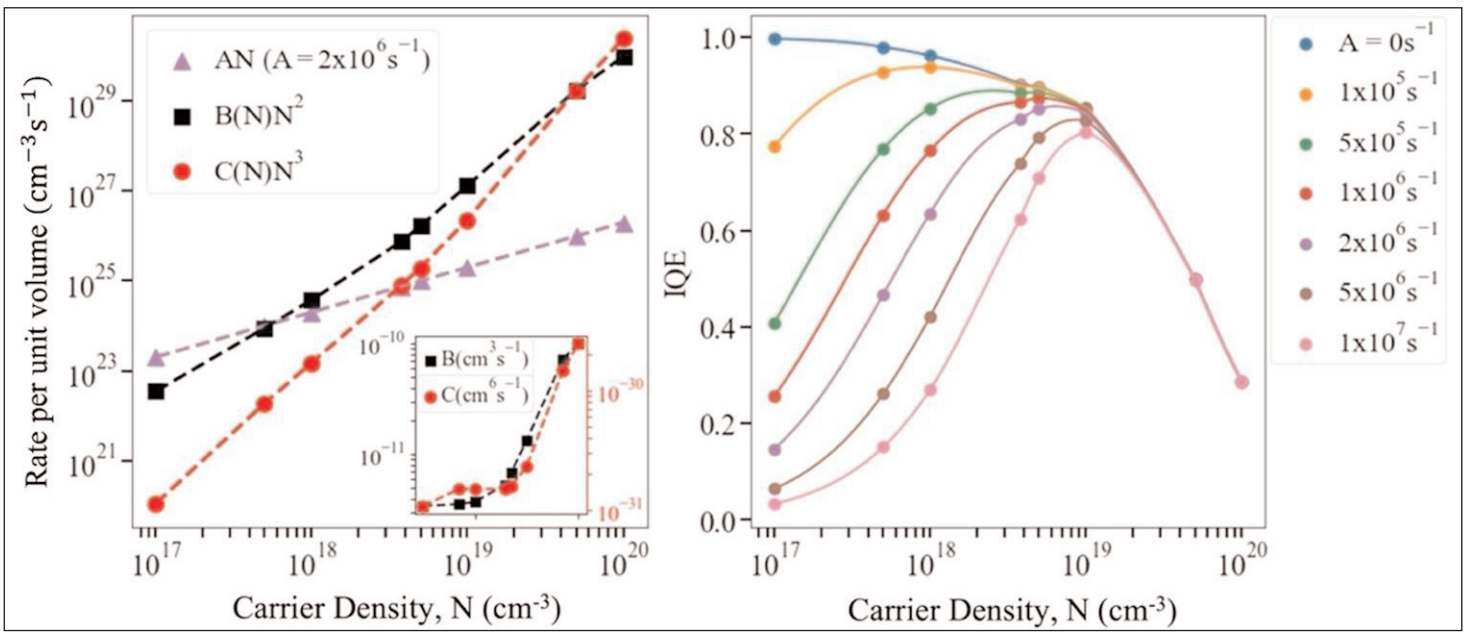

Figure 1. (a) SRH (AN), radiative (B(N)N^2), and Auger (C(N)N^3) recombination rates for a 15% indium, 3nm-wide (In,Ga)N/GaN QW. B(N) and C(N) from the group's theoretical calculations. A coefficient is taken as constant based on literature. Inset: B(N) and C(N), averaged over two microscopic alloy configurations. (b) Calculated IQE curves for range of SRH A coefficients.

to release their energy. One way is through intermediate energy levels provided by defects — a process described by the SRH recombination mechanism. Another way is for an electron–hole pair to transfer their energy by give a kick to another carrier — Auger recombination. These SRH and Auger processes sap the desired effect of emitting photons in a desired wavelength range.

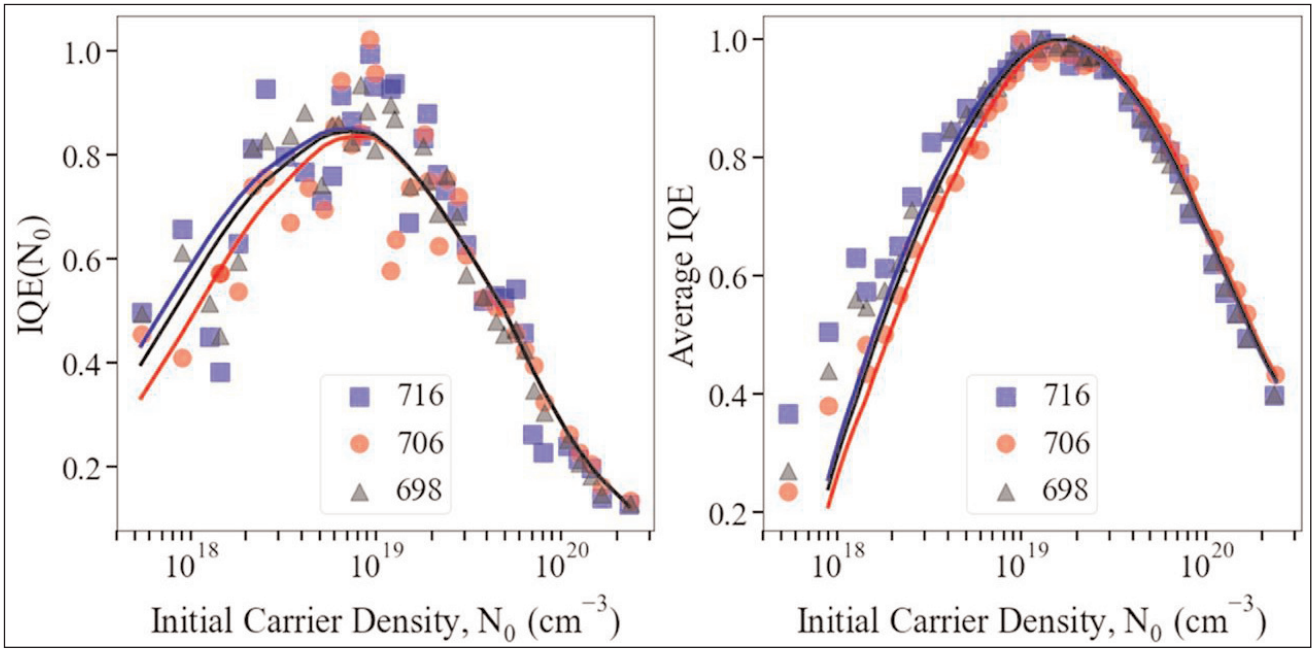

Figure 2. Comparison of calculated (lines) and experimentally measured (symbols) values of (a) IQE and (b) average IQE during pulse. For both (a) and (b), experimental data has been scaled vertically to fit calculated values since measurements only determine relative, not absolute, IQE. Each sample labeled by growth temperature in °C.

The ABC model commonly used to describe these effects attributes the rates of these processes to a linear (SRH, AN), quadratic (radiation of photons, BN^2), and cubic (Auger, CN^3) dependence on the carrier density (N). The internal quantum efficiency (IQE), as measured usually in luminescence experiments, is the ratio of recombination into photons (BN^2) to the total recombination process ($AN+BN^2+CN^3$).

The rationale for the powers is that SRH depends on a single carrier, hence the single power, radiation on two carriers, so a double power, and Auger on three carriers... These indeed are the expected behaviors at low carrier densities, but other effects come into play at higher concentrations, and one expects a functional dependence of the ABC coefficients on N (Figure 1).

The team used theoretical 'tight-binding' calculations, which involved modeling about 82,000 atoms to find the expected alloy fluctuations and corresponding carrier localization effects.

To validate the theory, the researchers studied 5-period InGaN multiple quantum wells, with the wells grown at three different temperatures — 716°C, 706°C and 698°C. One expects the lower-temperature growth to result in a higher defect density in the wells, and hence higher rates of SRH recombination.

Another effect impacts the higher-growth-temperature samples: larger gross well width fluctuations (GWWFs). The team comments: "These GWWFs are expected to reduce the vulnerability of the QWs to recombination at point defects." This again reduces the expected SRH rate from samples processed at high growth temperature.

The structures were grown by metal-organic chemical vapor deposition on GaN/sapphire templates. The GaN pseudo-substrate layer was around 4μm thick. The wells had an estimated indium content of 17%. The InGaN wells were 3nm, and the GaN barriers were 7nm. The GaN barriers were grown using two temperature steps.

Pulsed photoluminescence was used to study the samples. The excitation wavelength of 400nm came from frequency-doubled titanium-doped sapphire (Ti:sapphire) laser. The pulse width was 150fs, delivered at 250kHz repetition rate. The excitation spot was 20μm diameter with an energy density per pulse in the range 1.5–650μJ/cm^2. Emissions were collected from the center area over a 5μm diameter for 700ns after the pulse.

By studying the time-dependence of the luminescence and relating the emitted radiation to the decay in the carrier concentration, the team extracted the relation of IQE (Figure 2) to the initial carrier concentration (N_0). The larger scatter in the data was the result of the need to numerically differentiate in the extraction procedure.

The researchers point out that the behavior above 101^9/cm^3 carrier concentration effectively does not involve any fitting parameters (except for determining N0). The range for A derived from the lower carrier densities was 2–4x10^6/s. ■

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Author: Mike Cooke

Silicon-based InAs QD laser operation above 150°C

Devices also show ultra-high thermal stability of thresholds and slope efficiency.

Institute of Semiconductors and University of Chinese Academy of Sciences in China have claimed record-high continuous wave (CW) operating temperatures of up to 150°C for 1.3μm wavelength indium arsenide (InAs) quantum dot (QD) lasers directly grown on on-axis silicon (001) substrates [Zunren Lv et al, Optics Express, v31, p24173, 2023]. The devices on silicon (Si) also demonstrated ultra-high thermal stability with effectively constant threshold currents and slope efficiencies over wide temperature ranges.

The team attributes their results to a combination of a low threading dislocation density (TDD) gallium arsenide (GaAs) buffer layers, a high-gain QD active region, and p-type modulation doping.

The researchers comment: "We believe that this work demonstrates the great prospect of Si-based direct epitaxial QD lasers in realizing low power consumption, miniaturization and low-cost silicon photonics chips, which provides a strong driving force for the development of low-cost and high-performance silicon photonic integrated circuits (PICs)."

The team foresees prospects for low cost, low power and high integration of QD laser diodes (LDs) allied with complementary metal–oxide–semiconductor (CMOS) electronic processing units for high-capacity data transmission, high-performance optical computing and high-precision light detection and ranging (LiDAR). Stability of the laser diodes at high temperature is particularly critical when such devices are placed next to heat-generating high-speed CMOS computer processing units (CPUs).

The researchers used molecular beam epitaxy (MBE) on gallium phosphide on silicon (GaP/Si) templates to produce the QD laser materials (Figure 1). The templates were free of anti-phase domains.

The team took particular care in growing the buffer layers to reduce defect densities in the upper

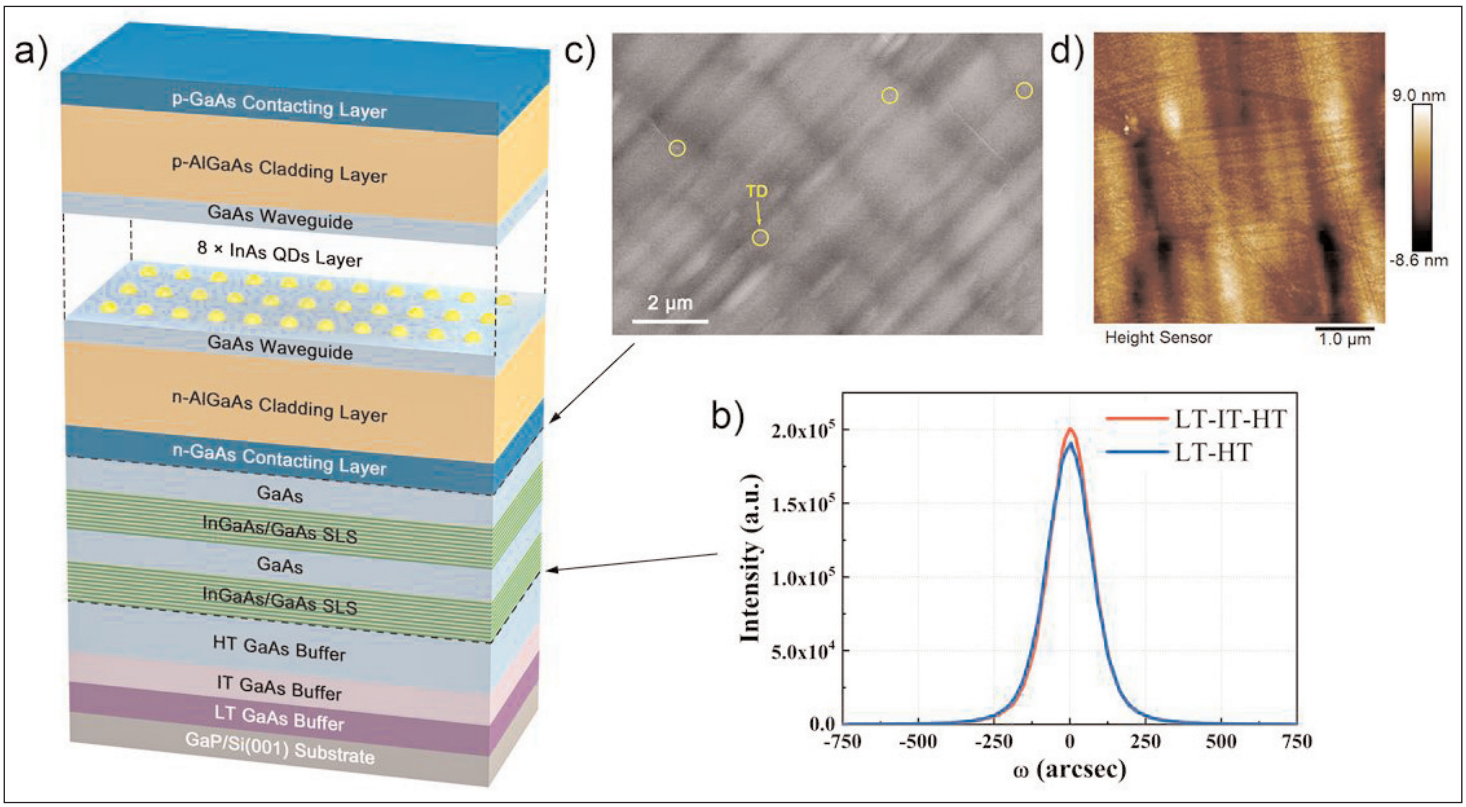

Figure 1. (a) InAs/GaAs QD laser epitaxial structure on on-axis Si (001) substrate. (b) Comparison of x-ray rocking curves of 1.6μm GaAs buffer layers grown by two-step and three-step temperature processes. (c) Electronic channel contrast imaging (ECCI) of 3μm GaAs buffer interface. (d) Atomic force microscope (AFM) image of 3μm GaAs buffer interface within 5μmx5μm field.

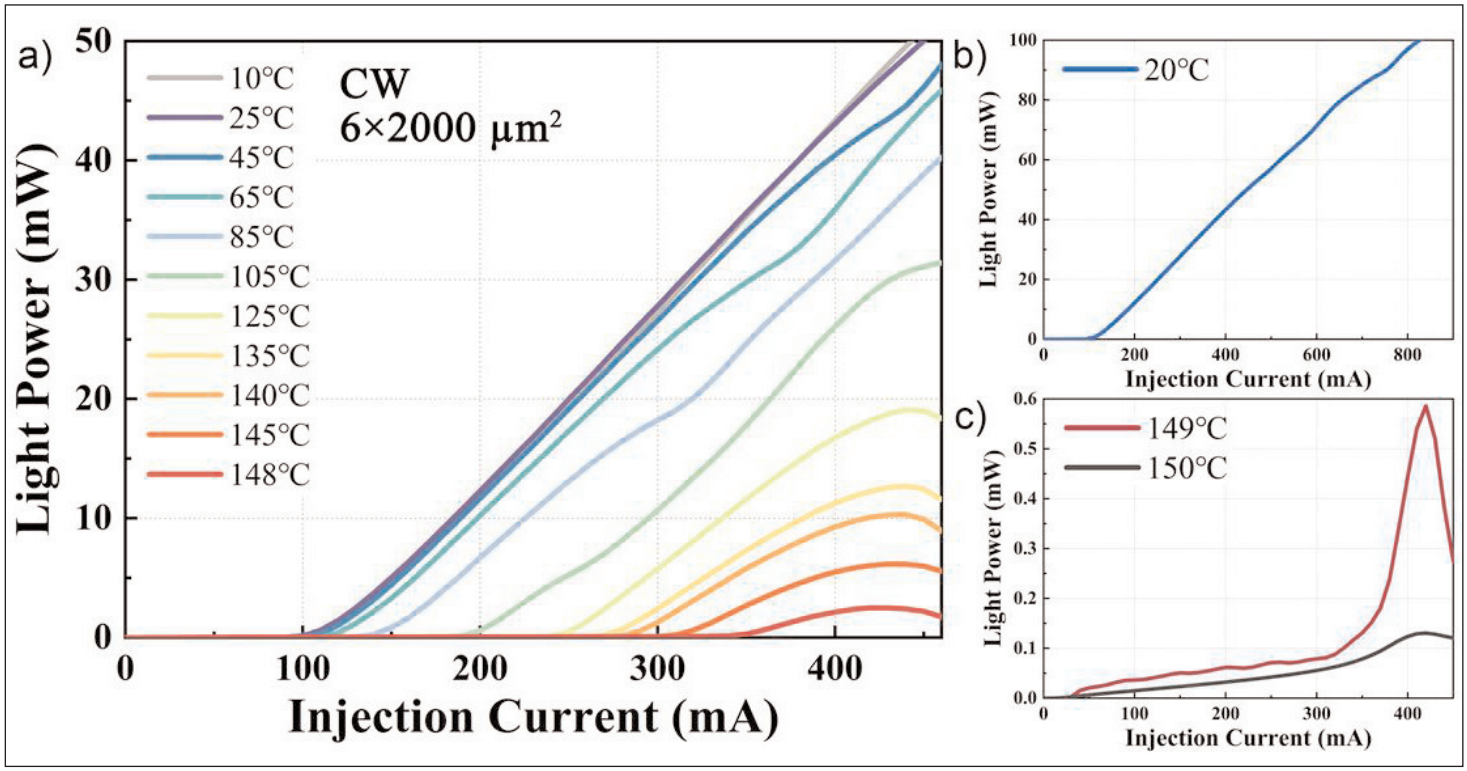

Figure 2. Temperature-dependent CW power–current curves from 10°C to 150°C for 6μmx2000μm QD laser.

device layers. The first three layers were grown at low (LT, 30nm), intermediate (IT, 70nm), and high (HT, 1500nm) temperatures of 400–500°C, 500–600°C and 600–700°C, respectively. The injection of the IT step reduced the full-width at half-maximum (FWHM) of one x-ray rocking curve to 173.3arcsec, compared with 182.3arcsec for a two-step 100nm LT + 1500nm HT buffer. The threading dislocation density (TDD) was also reduced 10.9% to $1.01x10^8/cm^2$ from using the three-step buffer process.

Further measures to promote dislocation annihilation included the growth of InGaAs/GaAs strained layer superlattice dislocation filters and cyclic thermal annealing. ECCI analysis gave a TDD of $4.3x10^6/cm^2$ for the complete 3μm GaAs buffer. The root-mean-square surface roughness was 2.46nm, according to AFM.

The active region in the device layers consisted of eight layers of self-assembled InAs/GaAs QDs. The InAs dots in one layer were covered by a 4nm InGaAs strain-reducing layer, and 45nm GaAs. The layers were separated by 6nm p-type modulation-doped barriers. The hole concentration was of order $1x10^{18}/cm^3$, or about 14 holes per QD.

The cladding layers were 1.4μm aluminium gallium arsenide ($Al_{0.4}Ga_{0.6}As$), suitably doped. The top contact layer consisted of 300nm p-GaAs.

The material was fabricated into ridge-waveguide lasers with titanium/platinum/gold (Ti/Pt/Au) and gold-germanium/nickel/gold (AuGe/Ni/Au) for the p-type and n-type electrodes, respectively. Electrical isolation was provided by 350nm silicon dioxide. The material was thinned to 100nm thick and cleaved to give different cavity lengths. One facet was coated with 95% reflective material.

The room-temperature CW threshold current density was $933.3A/cm^2$ for a 6μmx1000μm laser, and $654.9A/cm^2$ for a wider 30μmx1500μm device. The emission wavelength was around 1316nm. The light output power of the wider laser diode reached 91.6mW saturation with a slope efficiency of 0.2W/A. The narrower device had a slightly higher slope efficiency of 0.22W/A, and almost reached 50mW output power.

A 6μmx2000μm device was able to maintain CW lasing up to 150°C with a maximum output of 0.13mW (Figure 2). The researchers comment: "To the best of our knowledge, these results represent the highest O-band CW operating temperatures for any lasers grown directly on silicon substrates including 119°C for offcut silicon and 108°C for on-axis silicon."

The emission wavelength of this device red-shifted to longer wavelengths at higher temperatures, going from 1313.1nm at 15°C to 1345nm at 85°C. At 125°C and 145°C, the wavelength reached 1375nm and 1377.5nm, respectively.

To avoid self-heating effects, the team also studied the lasers under pulsed current injection at different temperatures (Figure 3). For example, at 150°C the 6μmx2000μm QD laser had a saturation light output power of 12.3mW, rather than the 0.13mW for CW operation.

The threshold current for pulsed operation was essentially constant over the range 10–75°C, corresponding to an infinite characteristic temperature ($T_0=\infty$).

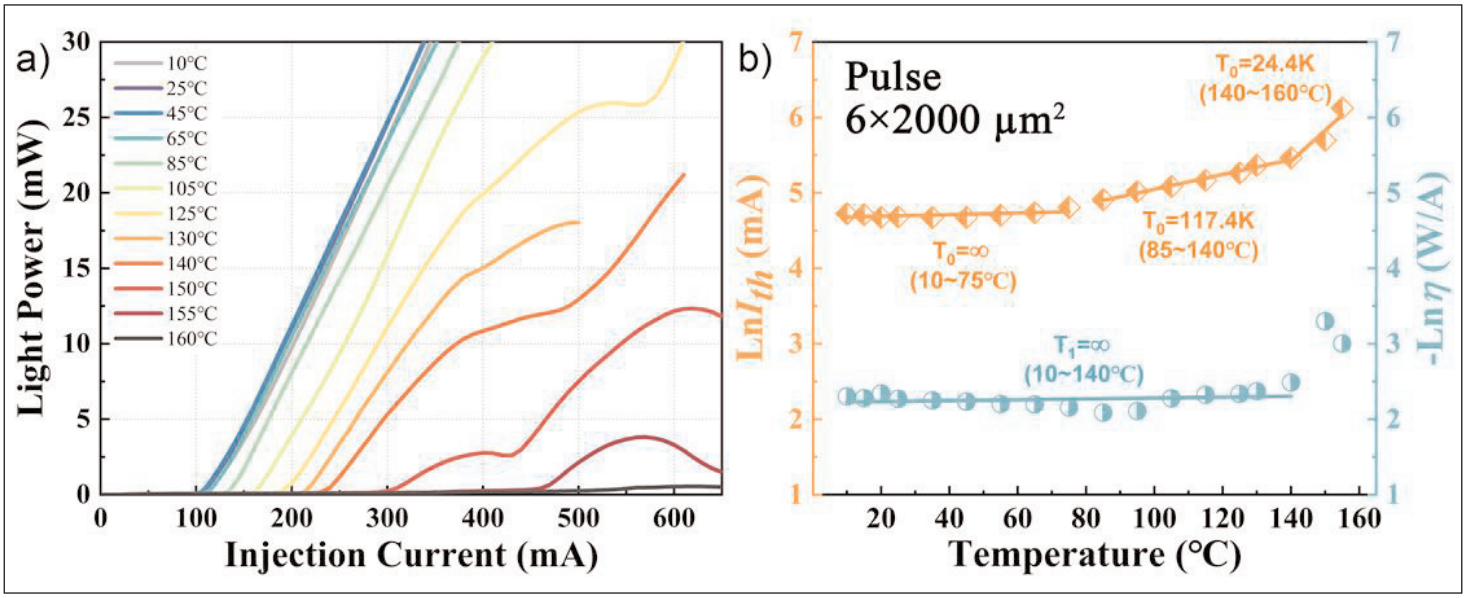

Figure 3. (a) Temperature-dependent pulsed power–current curves from 10°C to 160°C for 6μmx2000μm QD laser. (b) Threshold current and slope efficiency versus temperature.

The researchers comment: "This is consistent with the reported highest temperature stability results for GaAs-based QD lasers and is of great value for silicon PICs."

The characteristic temperature of the slope efficiency degradation with temperature (T_1) was infinite, i.e. no degradation, over the wider 10–140°C range.

A wider 10μmx2000μm QD laser had more than 25mW output power at 150°C, and 2mW at 160°C, under pulsed injection.

A final variation reported by the team was a reduction in the number of QD layers to five. Comparing the performance of 10μmx2000μm devices, the pulsed threshold current density at 25°C for 5-layers was 90A/cm^2, a little lower than the 8-layer 99A/cm^2 threshold. However, the 5-layer laser diode only reached 120°C before failing to lase. The T_0 characteristic was also reduced from infinity for the 8-layer device in the 15–75°C range to 142K for 5 layers.

The team comments: "These results suggest that high-quality multi-layer QDs can significantly enhance the high-temperature performance of Si-based devices." ■

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MOCVD mid-to-long wavelength IR quantum cascade lasers on Si

Prospects for chip-scale, reliable and mass-producible PICs.

Researchers in the USA report 8.1µm-wavelength quantum cascade lasers (QCLs) grown on silicon (Si) by MOCVD [S. Xu et al, Appl. Phys. Lett., v123, p031110, 2023]. The team from University of Wisconsin Madison, University of Illinois Urbana-Champaign and MicroLink Devices Inc, comments: "There are no prior reports of QCLs grown by metal-organic chemical vapor deposition (MOCVD) on silicon substrates."

Such integration on silicon could lead the way to chip-scale, reliable and mass-producible photonic integrated circuits (PICs). The researchers contrast this with other integration methods such as wafer bonding: "Hybrid integration methods rely on accurate alignment for efficient waveguide-to-laser optical coupling, which, in turn, requires tight fabrication processing tolerances. Direct integration onto silicon by heteroepitaxy enables the potential for mid-infrared (IR) optoelectronics integrated with mature CMOS-compatible silicon platforms at low cost and with high throughput."

Mid-infrared QCLs are typically grown on indium phosphide (InP). The team took particular care in creating a virtual InP substrate on silicon, using a combination of molecular beam epitaxy (MBE) and MOCVD. MOCVD is preferred over MBE in production. The researchers comment: "The technical challenge remaining is to overcome the defects and epitaxial growth-related issues, which arise from the large lattice-constant and thermal-expansion mismatch between native substrates, such as InP and silicon (e.g. ~8% lattice mismatch and ~50% thermal-expansion coefficient mismatch)."

The arsenide part of the template structure (Figure 1) was grown using solid-source MBE on commercial (001) GaP/Si templates, supplied by NAsPIII/V GmbH. The substrate was nominally on-axis, compatible with high-throughput industrial-scale CMOS electronics production. The initial layers consisted of an indium gallium arsenide (InGaAs) dislocation filter layer (DFL) sandwiched in GaAs. The researchers sacrificed some potential for threading dislocation density (TDD) reduction by keeping the initial arsenide layers to 0.5µm thickness. The GaAs layers were grown in two steps, initially at a low 500°C temperature, and then a higher temperature (580/610°C for the lower/upper layers, respectively). One motivation for this, in the case of the upper layer, was to avoid out-gassing of indium from the InGaAs DFL.

The overlying InP metamorphic buffer layer (MBL) part of the template was grown by MOCVD, and included four further DFLs, consisting of three 2nm/37nm InAs/InP pairs.

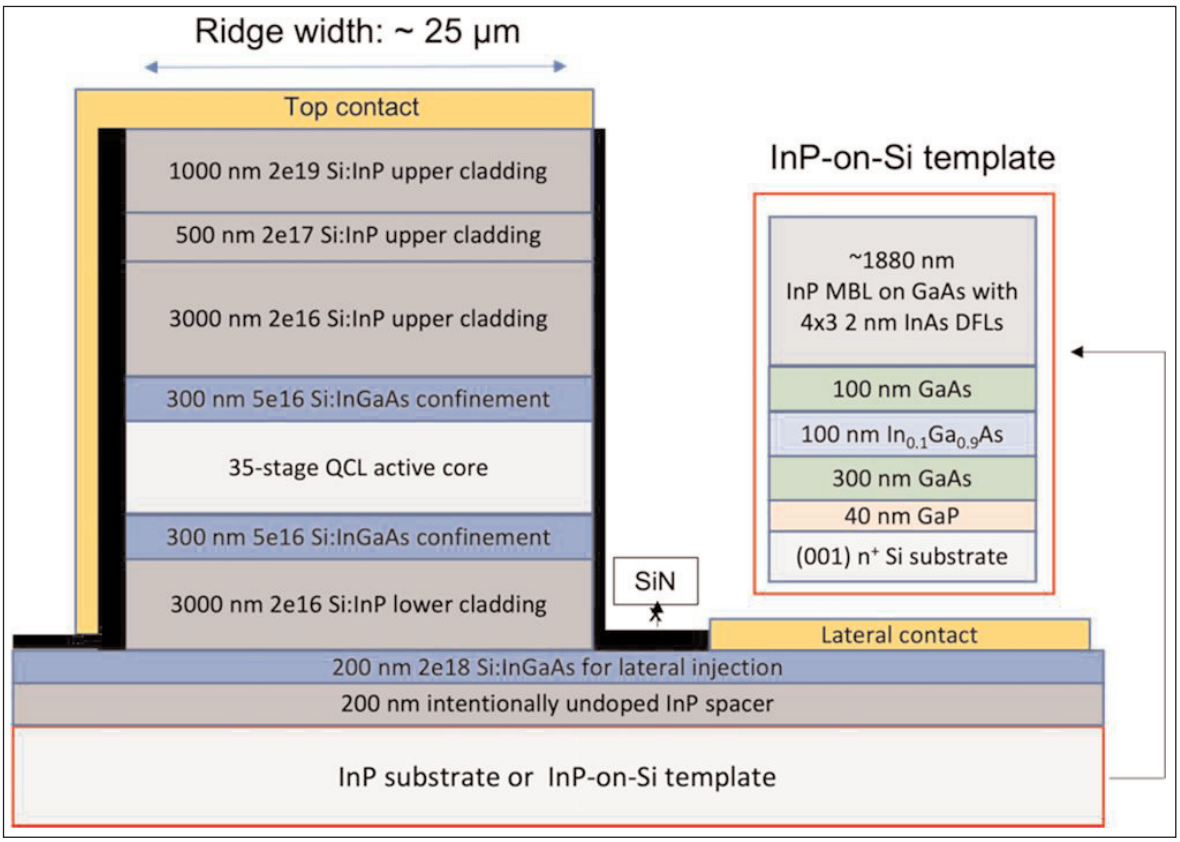

Figure 1. Full 35-stage, lattice-matched QCL structure, with 25µm-wide ridge and lateral-current injection architecture, grown on InP substrate or on InP-on-Si composite template. Inset: structural details of InP-on-Si template with InAs dislocation filter layers (DFLs).

The QCL was completed using MOCVD, giving a total epitaxial thickness, including metamorphic buffer and laser layers, of around 13μm. The QCL/Si showed no cracking, which the team suggests could be due to two factors: the small 1.7cmx1.7cm sample size, and the 800μm thick silicon substrate alleviating curvature accumulation. The TDD of the arsenide part of the template was estimated at $1.0x10^9/cm^2$. The InP MBL reduced this to $7.9x10^8/cm^2$.

The material was fabricated into 25μx3mm ridge-waveguide lasers. The silicon substrate was thinned to 70μm by mechanical lapping before cleaving into laser bars. The facets were uncoated during testing (Figure 2).

The threshold current density under pulsed operation was 22% lower on silicon than for a device grown on a bulk InP substrate in the same process run: in figures, $1.50kA/cm^2$ compared with $1.92kA/cm^2$, respectively. The researchers comment: "This may reflect a reduced silicon-dopant incorporation within the active-core superlattice layers due to either preexisting defects or a difference in the surface growth temperature for the silicon and InP substrates. In addition, non-uniform growth around the defect sites could potentially reduce the carrier mobility and tunneling efficiency, which would account for the higher series resistance observed for the devices grown on silicon."

The higher series resistance was seen in the higher voltage needed to deliver a given current injection in the Si-based QCL. Despite the higher series resistance, the Si-based QCL also delivered a higher peak light output power: 1.64W and 1.47W for the Si- and InP-based devices, respectively. The corresponding slope efficiencies were 0.72W/A and 0.65W/A, and wall-plug efficiencies were 2.85% and 2.50%.

The spectral analysis of the emissions showed multiple modes in the wavelength range 7.6–8.3μm. The largest peaks were around 8.1μm and 8.0μm for the InP- and Si-based devices, respectively. These wavelengths are a little shorter than the 8.2μm design target. The researchers suggest that the differences could be due to local growth variations affecting layer thickness, as indicated in x-ray diffraction analyses.

Performance measured at heat-sink temperatures of 293–353K gave characteristic temperatures for the degradations of threshold current (T_0) and slope efficiency (T_1) of 167K and 320K, respectively, for the QCL/Si. The QCL/InP had characteristics of 163K, T_0, and 214K, T_1. ■

https://doi.org/10.1063/5.0155202

www.nasp.de/about_us.html

Author: Mike Cooke

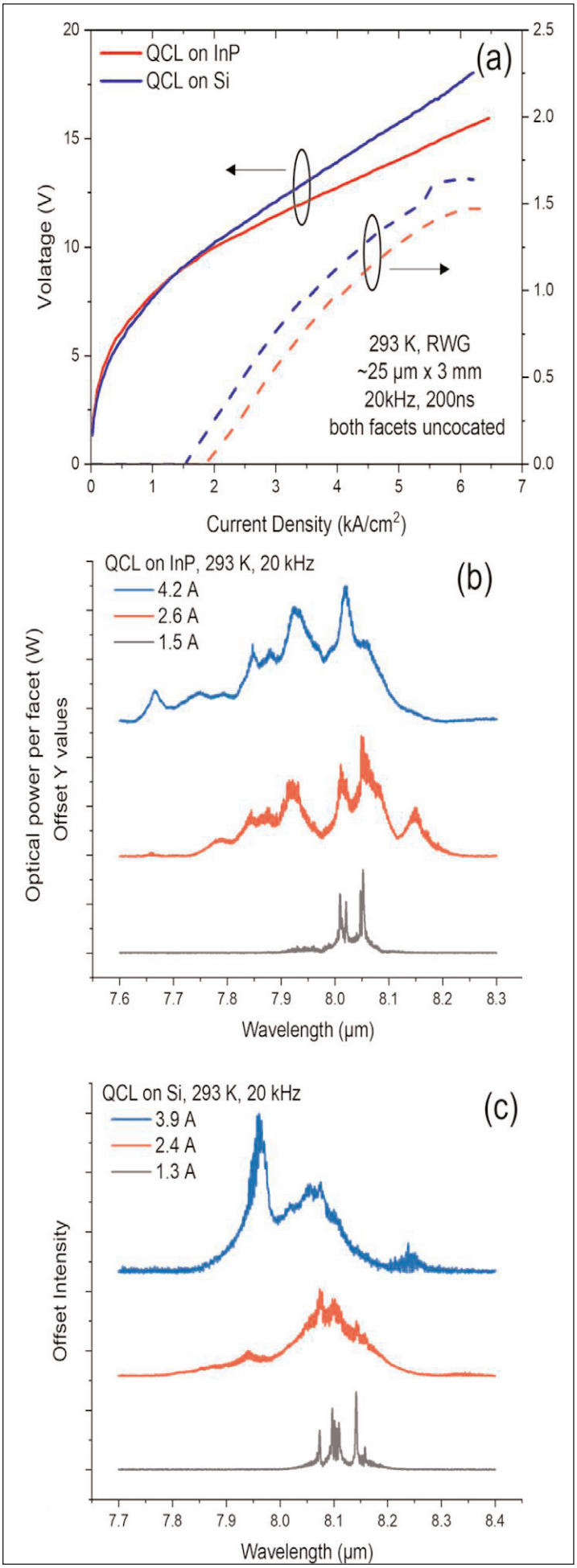

Figure 2. (a) Light output power and applied voltage versus current density of devices on InP and on Si substrate, at room temperature under pulsed operation. Emission spectra for lasers on (b) InP and (c) on Si, at different drive-current levels.

Spalling-induced GaN lift-off and transfer

Boron nitride van der Waals and nickel spalling layers enable transfer of a 4-inch diameter film.

Air Force Research Laboratory, KBR Inc and Agnitron Technology in the USA have applied spalling-induced van der Waals (vdW) epitaxial lift-off (ELO) and transfer methods to 4-inch gallium nitride (GaN) films [Michael Snure et al, Journal of Applied Physics, v134, p025307, 2023].

VdW materials — such as graphite/graphene, molybdenum disulfide, and sp^2-bonded boron nitride (BN) — have strong chemical bonds in two dimensions, but weaker van der Waals bonds in the third dimension. The researchers grew GaN on sapphire, using BN as an intermediate lift-off layer. The weak vdW bonds act like a sort of Velcro, enabling GaN to be separated without cracking from its growth substrate with suitable encouragement from a nickel (Ni) spalling layer.

The researchers describe their aims in their 2D material-based layer transfer (2DLT) work: "In developing a process to integrate GaN on sapphire epitaxial films,

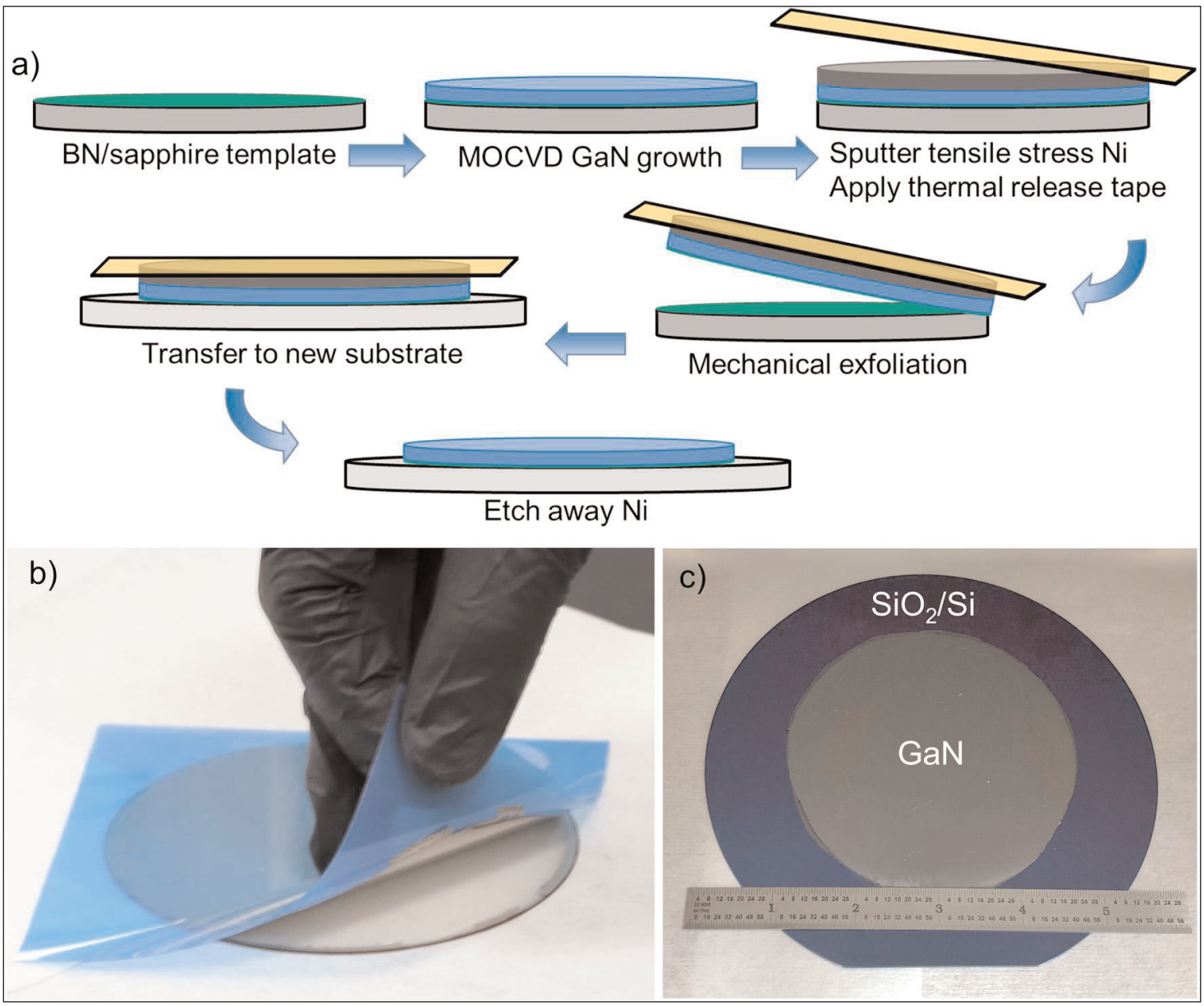

Figure 1. (a) Schematic process flow for transfer process. Images of (b) mechanical exfoliation step and (c) full 4-inch GaN film transferred to SiO_2/Si wafer.

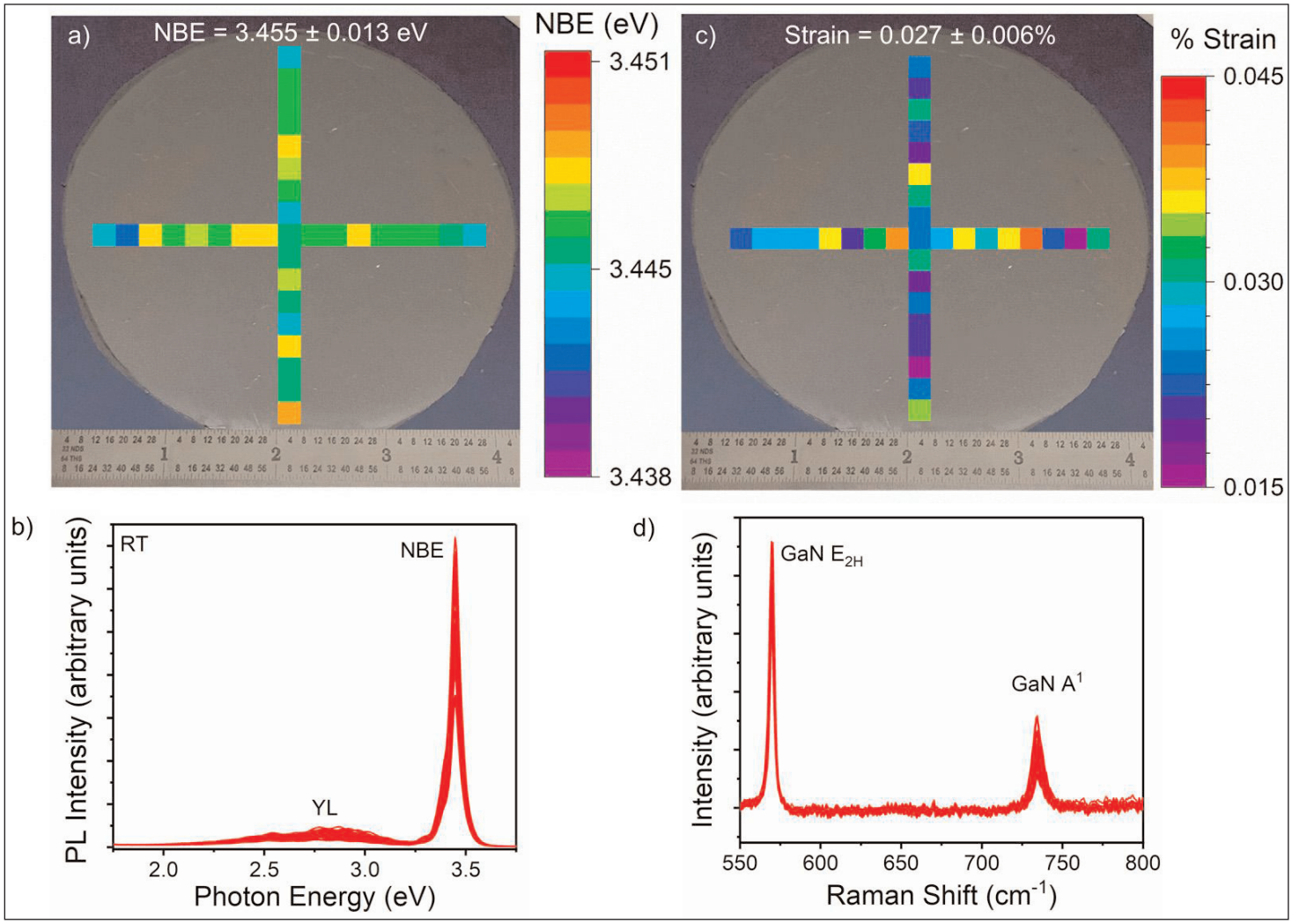

Figure 2. (a) Near-band-edge (NBE) photoluminescence (PL) peak position and (b) % strain measured by Raman spectroscopy. Plots of all GaN (c) PL and (d) Raman spectra.

achieving a high-yield, rapid and controlled lift-off and transfer is necessary." The hope is to improve performance, reduce costs, and develop new electronics structures for higher-power and more efficient radio frequency (RF) and light-emitting devices.

The choice of boron nitride as the vdW layer was motivated by its higher stability and material compatibility with GaN growth, compared with other potential vdW materials. BN is also the only one that is a dielectric, rather than being electrically conducting in some way. The team comments: "For the 2DLT process to become a viable commercial option, it will need to be scalable, fast and high yield. So far, growth and transfer of GaN have been mostly limited to smaller areas with a few reports on epitaxial growth and transfer at the 2-inch wafer scale using BN."

The researchers grew BN films on 4-inch c-plane sapphire substrate, using metal-organic chemical vapor deposition (MOCVD). The precursors were triethylboron (TEB) and ammonia (NH_3) in hydrogen carrier gas. The substrate was not subjected to surface preparation before loading into the MOCVD system. The sapphire surface was prepared in the reaction chamber by nitridation at 900°C, creating a thin aluminium oxynitride (AlON) layer to promote nucleation of BN.

The BN layer itself was grown for 15 minutes at 1200°C. The growth pressure was 20Torr, and the V/III ratio 3500. The result was 5–6 layers of BN, or around 2nm thickness. Since the BN was both the release layer and template for further III–N growth, it was critical that the layer was uniform and smooth. According to the x-ray reflectance measurements at 5mm intervals, the BN thickness was 2.03±0.03nm. The root-mean-square surface roughness was of order 0.25nm, according to atomic force microscopy (AFM).

Further MOCVD growth involved layers of AlN and GaN with trimethyl- precursors being used for the metal supply. Ammonia continued as the nitrogen source. AlN layers were grown at 1090°C, 60Torr and 2200 V/III ratio. The GaN was grown in three-steps on a 20nm AlN nucleation layer: 3D growth at 1090°C, high-temperature recovery at 1195°C, and fast growth at 1090°C. The first two steps were designed to reduce dislocations by producing 3D islands, which were then laterally coalesced to produce a uniform 1.9μm film.

The AlN nucleation layer thickness was optimized for

good GaN quality with low residual strain. Thin AlN layers risk creating voids in coverage of the underlying BN, impacting GaN growth quality. Thicker layers suffer from surface roughness while also increasing the strain in the overlying GaN, factors that reduce crystal quality. The x-ray rocking curves indicated crystal quality comparable to other reports of GaN growth on vdW materials: 0.14 and 0.286° full-width at half-maximum (FWHM) for the (002) and (102) crystal planes, respectively.

The wafer was prepared for the spalling-induced vdW lift-off and transfer process (Figure 1) by cleaning the GaN surface with solvent and oxygen plasma ashing. Nickel (Ni) was applied by radio frequency (RF) magnetron sputtering at 300W and 5mTorr pressure of the argon working gas. The nickel layer introduced tensile stress, enabling spalling removal of the GaN layer from the substrate. According to tests on silicon, a 4μm introduced 400MPa stress on average. The thickness of the Ni film had to supply enough energy to break the vdW bonds, releasing the GaN for lift-off, but not too much, to avoid cracking. The best results came from a 2μm Ni layer.

Thermal release tape (TRT) was used as a handle for the spalling release by exfoliation. The exfoliation process was initiated by scribing the edge of the GaN film. The lift-off process took less than 15 seconds. The TRT/Ni/GaN stack was then transferred to a 6-inch silicon dioxide/silicon (SiO_2/Si) substrate, using double-sided tape.

Once the stack was in place, the TRT was removed, and the nickel stripped by Transene Company Inc's Ni etchant TFB. The transferred films showed only a slight increase in x-ray rocking curve FWHMs. The team reports: "The most significant broadening is in the upper left region and near the edges, which is correlated with a visible crack in the upper left region caused by the transfer process."

The researchers studied the optical properties of the transferred GaN layer transferred on the SiO_2/Si wafer. The NBE PL peak position showed slightly higher variation, compared with the grown layer on BN/sapphire, while having about the same average value.

The most striking difference was in the strain values derived from Raman peak shift measurements. The GaN grown on BN/sapphire had about 0.25% compressive strain. During transfer, the presence of the 2μm Ni film was found to give 0.151% tensile strain to the GaN. The final layer after transfer was almost completely relaxed. It has been found by the team previously that Ni layers greater than 5μm leave tensile stress in the transferred GaN.

The researchers comment: "This stepwise relaxation can be beneficial, reducing the formation of cracks that occur during the strain release." ■

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Balancing charge to boost Ga_2O_3 breakdown beyond 10kV

Result beats previous Ga_2O_3 device reports, along with giving thermal stability up to 200°C.

Researchers based mostly in the USA report lateral gallium oxide (Ga2O3) Schottky barrier diodes (SBDs) with a charge-balancing nickel oxide (NiO) reduced surface field (RESURF) structure that boosted breakdown voltages (BVs) to more than 10kV [Yuan Qin et al, IEEE Electron Device Letters, v44, p1268, 2023]. The BV performance was thermally stable with more than 10kV blocking up to 200°C.

The team from Virginia Polytechnic Institute and State University, University of Southern California, the US Naval Research Laboratory in the USA and Novel Crystal Technology Inc in Japan reports: "Our RESURF Ga_2O_3 SBDs show the highest BV, and the operational temperature is among the highest in multi-kilovolt Ga_2O_3 devices."

The researchers see potential for their SBD design in medium- and high-voltage, high-temperature applications. The medium-voltage range above 1kV covers deployment in electric grid, motor drive, and renewable energy processing. The market is presently dominated by silicon bipolar technology, which suffers from slow switching speed.

The SBDs (Figure 1) were fabricated on Ga_2O_3 substrates with an n-type Ga_2O_3 epitaxial layer. The anode region doping was boosted using silicon ion implantation, which was activated by 925°C annealing in nitrogen. The cathode was titanium/gold (Ti/Au) annealed at 475°C, and the anode nickel/gold (Ni/Au). Between the cathode and anode formations, the device region was isolated using nitrogen ion implantation.

The aim of the sputtered NiO RESURF structure was to balance depletion charges in the n-Ga_2O_3 channel at high voltage. Depletion at high forward bias shrinks the effective cross-sectional area for current flow, increasing on-resistance (R_{on}).

The p-type hole concentration of NiO has been found

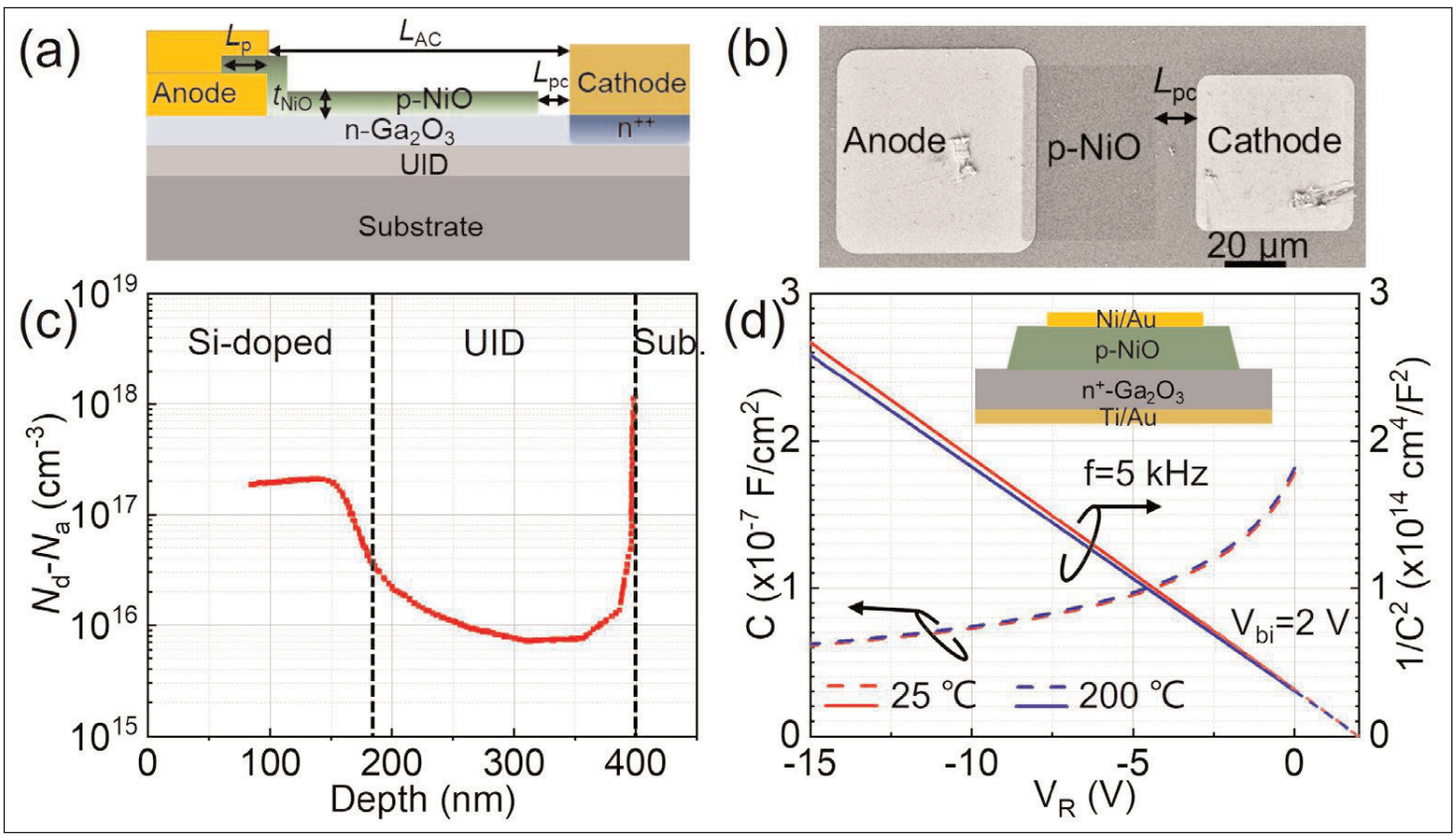

Figure 1. (a) Schematic cross-section and (b) top-view scanning electron microscope (SEM) image of fabricated lateral Ga_2O_3 RESURF SBD. (c) N_d–N_a depth profile of Ga_2O_3 epilayers (initial depletion width of Schottky contact ~85nm). (d) Capacitance–voltage (C–V) and $1/C^2$–V characteristics of vertical NiO/Ga_2O_3 diode at 25°C and 200°C.

to be controlled via the oxygen partial pressure during sputtering. The researchers comment: "To reduce the impact of t_{NiO} variation on charge balance and enable a larger process latitude, a lower N_a is preferred."

The team used a pure argon atmosphere, to reduce the hole concentration as much as possible, and the sputtering from a NiO source was carried out at room temperature. The p-NiO was annealed at 275°C in nitrogen gas.

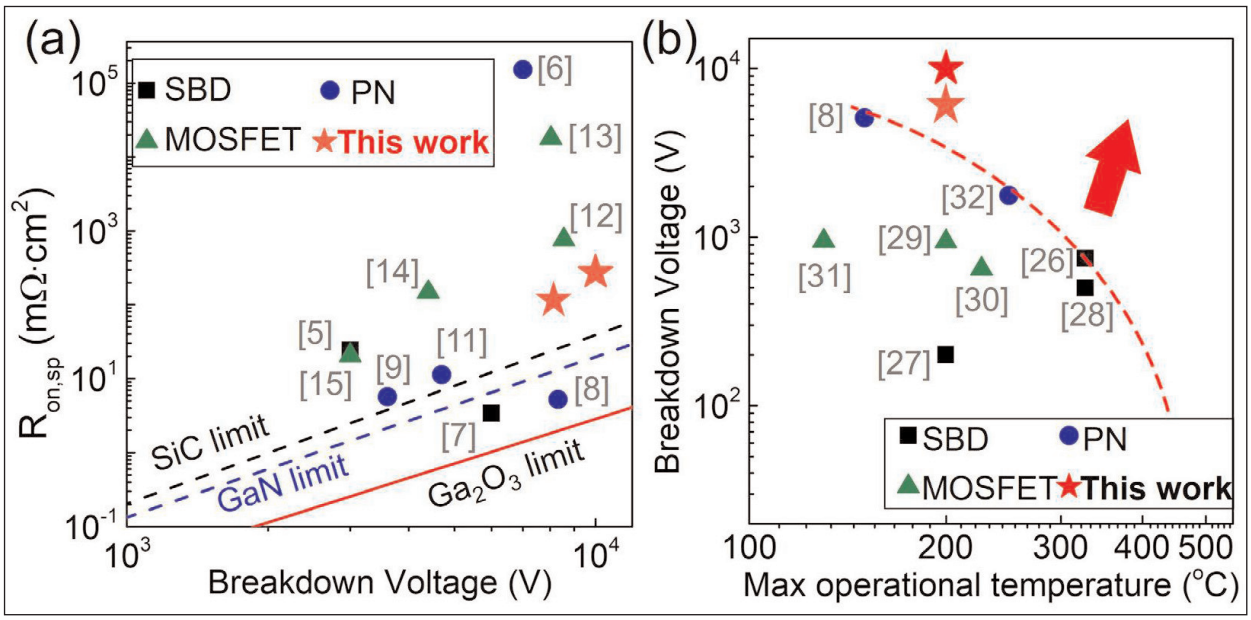

Figure 2. Benchmarks of team's device ("This work") against competition: (a) differential specific on-resistance ($R_{on,sp}$) versus BV for reported Ga_2O_3 SBDs, p–n diodes, and transistors with BV more than 3kV. (b) The BV versus maximum operational temperature for reported high-temperature Ga_2O_3 SBDs, p–n diodes, and transistors with BV more than 100V. Dotted line shows approximate boundary of prior data. Arrow shows desirable target. Note that 10kV BV of higher-BV device reflects measurement limit rather than actual BV.

From capacitance–voltage measurements on a p-NiO/n-Ga_2O_3 vertical p–n heterojunction diode, the researchers estimate that the acceptor concentration (N_a) from the NiO sputtering process was $8x10^{17}/cm^3$ at 25°C.

The thickness of the NiO device RESURF layer (t_{NiO}) was designed to keep the charge imbalance margin below 15%. There was also a gap (L_{pc}) between the p-NiO RESURF layer and the cathode to avoid punch-through and leakage conduction. The NiO material was also extended onto the anode surface to a distance of 5μm. The anode was then covered with a second Ni/Au application.

The device was then annealed at 275°C to stabilize the acceptor concentration and to reduce NiO/Ga_2O_3 interface states. Passivation with photoresist completed the SBD processing.

A 75nm NiO RESURF layer enabled the team's SBDs with anode–cathode distances (LAC) of 30μm and 50μm to exceed 10kV breakdown voltage, the measurement limit of the test equipment. The average electric field (E_{ave}) in the drift region between the anode and cathode was thus more than 3.3MV/cm. For the 30μm L_{AC} SBD, a reference device without the NiO RESURF structure only achieved a BV of 2.8kV.

Leakage current at 10kV reverse bias was $2x10^{-6}$A/mm, ten times lower than reported for gallium nitride SBDs.

A 17μm L_{AC} device had more than 8kV BV, corresponding to an Eave of 4.7MV/cm. The BV reduced to 6.1kV at 200°C, giving 3.6MV/cm Eave.

The researchers comment: "The BV's negative temperature coefficient (η_T) suggests the lack of avalanche breakdown and implies a trap-assisted breakdown mechanism." The team points out that the achieved range of E_{ave} exceeds the critical fields for GaN and silicon carbide (SiC). GaN lateral SBDs have been reported with ~1MV/cm E_{ave} and 10kV BV.

The RESURF structure had a negative impact on (differential) R_{on}, increasing it by about a factor of 2, relative to Ga_2O_3 SBDs without RESURF.

The Baliga figure of merit (FOM, BV^2)/R_{on}), which balances the effect of breakdown and forward current flow, is improved for the RESURF devices by a factor of more than 5, compared with reference SBDs without.

Electrical parameters, such as turn-on voltage (V_{on}), Schottky barrier height, and ideality factor, were similar for all devices, coming in at around 1V, 0.74eV, and 1.2, respectively.

Increasing the operating temperature to 200°C almost doubled R_{on}, while V_{on} reduced to 0.7V. The on/off ratio was more than 10^6, even at 200°C.

The researchers present benchmarks of the BV and $R_{on,sp}$/maximum operation temperature (Figure 2). The researchers comment: "The Baliga's FOM of 17μm-L_{AC} devices is 906MW/cm_{AC} at 25°C. The FOM of the 200°C-operational, 10kV-class device (L_{AC} = 30μm) is at least 370MW/cm^2 at 25°C (the true FOM is expected to be much higher due to BV > 10kV)." ■

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www.novelcrystal.co.jp/eng

Author: Mike Cooke

Gallium oxide flash memory

Device demonstrates memory window of 4V and 5000s retention time.

King Abdullah University of Science and Technology (KAUST) in Saudi Arabia and the Indian Institute of Technology have claimed the first demonstration of an ultrawide-bandgap β-Ga_2O_3 flash memory [Vishal Khandelwal et al, Jpn. J. Appl. Phys., v62, p060902, 2023].

Ultrawide-bandgap materials like Ga_2O_3 are being projected for use in a wide and varying range of transparent, flexible, high-power, RF and extreme-environment electronics, along with ultraviolet (UV) photonics.

The flash memory device (Figure 1) was fabricated on a 50nm n-Ga_2O_3 layer on sapphire grown by pulsed laser deposition (PLD) from a silicon-doped Ga_2O_3 target. The growth temperature was 700°C, and the oxygen partial pressure was 4mTorr. The resulting film carrier concentration and mobility were $5x10^{18}/cm^2$ and $0.35cm^2/V\text{-}s$, respectively, according to Hall measurements.

The fabrication sequence began with source/drain (S/D) formation using direct current (DC) and radio frequency sputtering of titanium (Ti) and gold (Au). The drain contact was 200μm diameter.

The aluminium oxide (Al_2O_3) tunneling (bottom) and blocking (top) layers were formed using atomic layer deposition (ALD). The titanium nitride (TiN) floating gate metal was applied using conventional photolithography/lift-off techniques. The inner and outer diameters were 240μm and 260μm, respectively.

The TiN/Ti/Au control gate was created using sputtering and photolithography. The inner and outer diameters were 220μm and 280μm, respectively. The effective gate length was around 30μm. The device was completed by etching away excess Al_2O_3 to expose the S/D contacts.

The memory operation of the device used voltage pulses to charge and discharge the floating gate, enabling shifts in the threshold voltage (V_{TH}) from negative, normally-ON, to positive, normally-OFF (Figure 2). The memory state could then be determined by the resistance between the source and drain.

Negative charge from injected electrons on the floating gate depletes the underlying n-Ga_2O_3 channel, increasing the resistance and V_{TH}.

Given that p-type conductivity is not presently achievable on the Ga_2O_3 platform, the researchers believe the erase process is derived solely from ejecting electrons from the floating gate rather than hole injection, as implemented on silicon-based flash memory. The team suggests that post-deposition annealing (PDA) steps could improve the tunnel oxide layer for memory operations by minimizing trap density at the Al_2O_3/Ga_2O_3 interface.

The injected electrons are pulled onto the floating gate by a positive pulse on the control gate. A +17V 100ms pulse gave a V_{TH} of +0.3V from a virgin value of ~4.5V. Subsequent erase steps with negative pulses ejecting electrons from the floating gate did not restore the virgin threshold, but a memory window of more than 3V was obtainable, using ±15V pulses. The states were retained on the scale of 5000s (1.4 hours).

The researchers suggest that suitably programmed devices could be used as standalone normally-OFF low-voltage transistors. Further, given the difficulty in achieving p-type conductivity, CMOS-like power-efficient

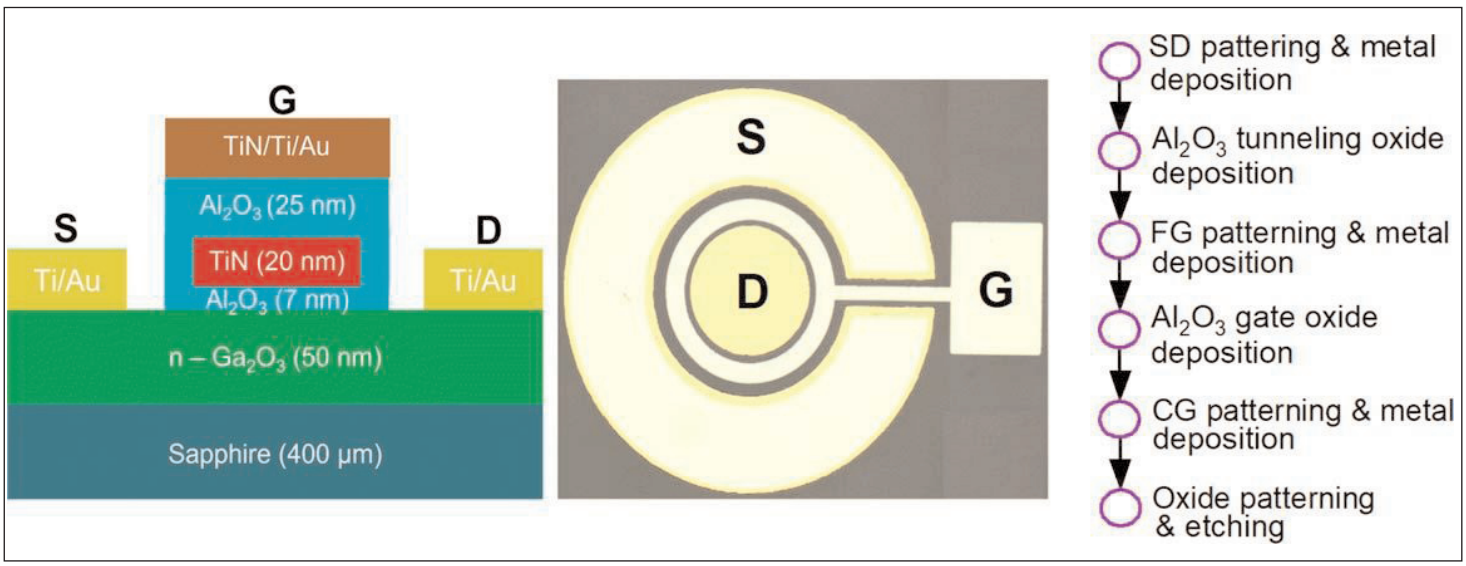

Figure 1. Flash memory device: (a) cross-sectional schematic; (b) top microscopic view; (c) fabrication process flow.

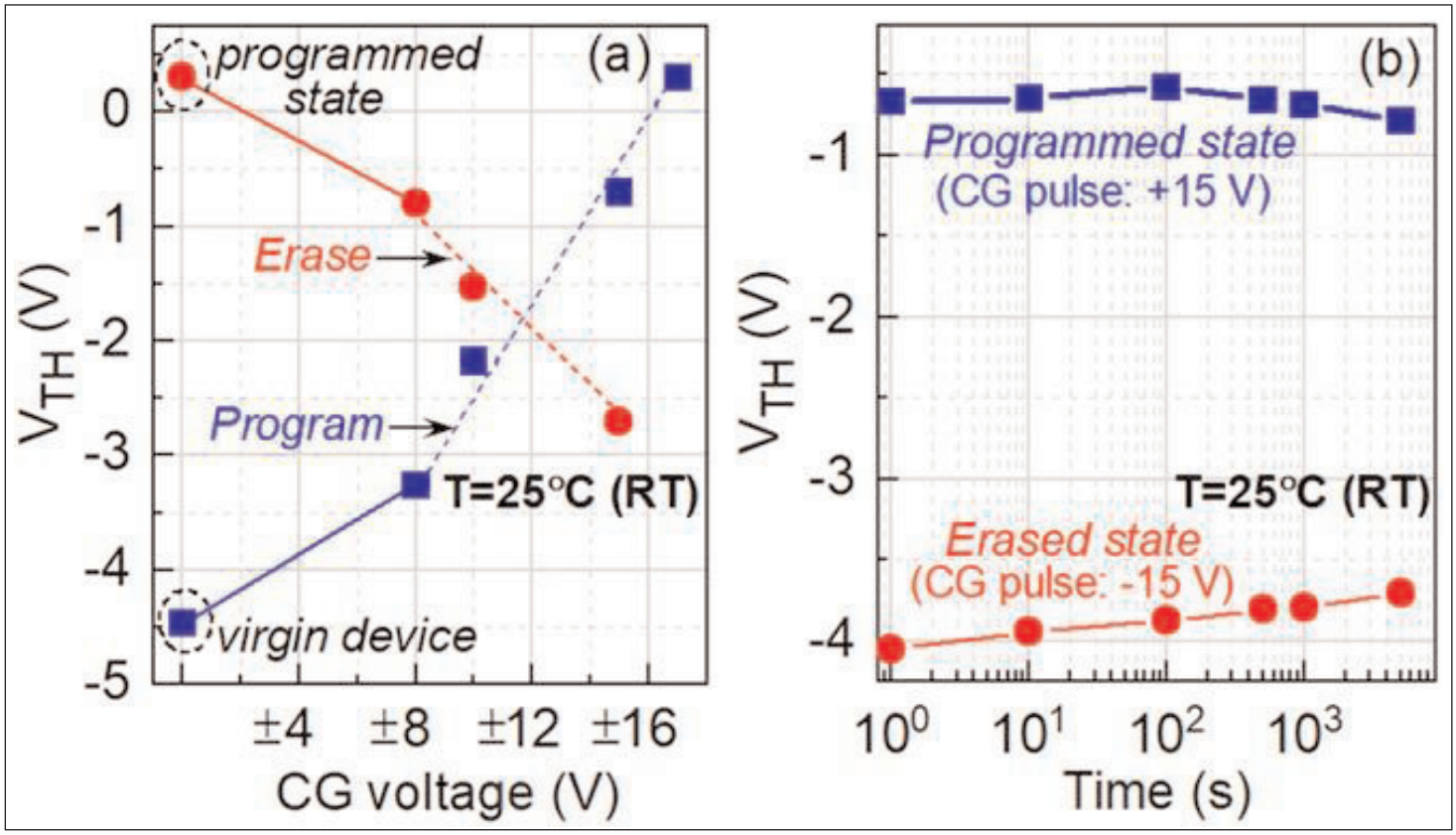

Figure 2. Flash memory characteristics at room temperature, 25°C: (a) V_{TH} after program and erase operations; (b) retention characteristics.

logic circuitry could come from combining normally-ON and programmed normally-OFF transistors.

The team explains: "Thus, the logic circuitry for controlling the β-Ga_2O_3 power converters can be realized using a suitable connection of virgin/erased (normally-ON) β-Ga_2O_3 flash memory device with a programmed (normally-OFF) β-Ga_2O_3flash memory device. Consequently, the power converters and their logic control circuitry can be monolithically integrated into a standalone β-Ga_2O_3 substrate." ■

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www.riber.com

SVT Associates Inc
7620 Executive Drive,
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Fax: +1 952 934 2737
www.svta.com

Temescal, a division of Ferrotec
4569-C Las Positas Rd,
Livermore, CA 94551,
USA
Tel: +1 925 245 5817
Fax: +1 925 449-4096
www.temescal.net

Veeco Instruments Inc
100 Sunnyside Blvd.,
Woodbury, NY 11797,
USA
Tel: +1 516 677 0200
Fax: +1 516 714 1231
www.veeco.com

7 Wafer processing materials

Kayaku Advanced Materials Inc
200 Flanders Road,
Westborough, MA 01581,
USA
Tel: +1 617 965 5511
www.kayakuam.com

Praxair Electronics
(see section 5 for full contact details)

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

8 Wafer processing equipment

Evatec AG
Hauptstrasse 1a,
CH-9477 Trübbach,
Switzerland
Tel: +41 81 403 8000
Fax: +41 81 403 8001
www.evatecnet.com

EV Group
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Fax: +44 (0) 1389 879 042
www.logitech.uk.com

Plasma-Therm LLC
(see section 6 for full contact details)

SAMCO International Inc
532 Weddell Drive,
Sunnyvale, CA, USA
Tel: +1 408 734 0459
Fax: +1 408 734 0961
www.samcointl.com

SPTS Technology Ltd
Ringland Way, Newport NP18 2TA,
Wales, UK
Tel: +44 (0)1633 414000
Fax: +44 (0)1633 414141
www.spts.com

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Schleißheimer Strasse 90,
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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

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

Veeco Instruments Inc
(see section 6 for full contact details)

9 Materials & metals

Goodfellow Cambridge Ltd
Ermine Business Park, Huntingdon,
Cambridgeshire PE29 6WR, UK
Tel: +44 (0) 1480 424800
Fax: +44 (0) 1480 424900
www.goodfellow.com

PLANSEE High Performance Materials
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Austria
Tel: +43 5672 600 2422
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www.plansee.com

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USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

10 Gas and liquid handling equipment

Cambridge Fluid Systems
12 Trafalgar Way, Bar Hill,
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Fax: +44 (0)1954 786818
www.cambridge-fluid.com

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Vacuum Barrier Corporation
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Fax: +1 781 933 9428
www.vacuumbarrier.com

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Tel: +1 602 282 1000
www.versummaterials.com

11 Process monitoring and control

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

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

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

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WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)
Bregstrasse 90,
D-78120 Furtwangen im Schwarzwald,
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Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

12 Inspection equipment

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

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

13 Characterization equipment

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Lincoln, NE 68508, USA
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Fax: +1 402 477 8214
www.jawoollam.com

Lake Shore Cryotronics Inc
575 McCorkle Boulevard,
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14 Chip test equipment

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Fax: +1 203-250-7389
www.riff-co.com

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

15 Assembly/packaging materials

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

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

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

Materion Advanced Materials Group
2978 Main Street,
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Fax: +1 716 833 2926
www.williams-adv.com

16 Assembly/packaging equipment

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Fax: +1 508-832-0506
www.pi.ws
www.pi-usa.us

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17 Assembly/packaging foundry

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San Diego, CA 92127, USA
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Fax: +1 8586 74 4681
www.quikicpak.com

18 Chip foundry

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UK
Tel: +44 (0) 1698 722072
www.cstglobal.uk

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

19 Facility equipment

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

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Fax: +1 781 933 9428
www.vacuumbarrier.com

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20 Facility consumables

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www.plansee.com

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USA
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Fax: +1 410 506 8749
www.gore.com

21 Computer hardware & software

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

Semiconductor Technology Research Inc
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22 Used equipment

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www.tecdia.com

24 Resources

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USA
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www.semi.org

Yole Développement
69006 Lyon,
France
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www.yole.fr

event calendar

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14–16 October 2023
SPIE/COS Photonics Asia 2023
Beijing International Convention Center, Beijing, China
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/photonics-asia

14 November 2023
ALD TechDay at SEMICON Europa 2023, Powered by Beneq
ICM (Internationales Congress Center München), Munich, Germany
E-mail: semieurope@semi.org
www.semiconeuropa.org/program/ALD_TechDay

12–17 November 2023
14th International Conference on Nitride Semiconductors (ICNS-14)
Hilton Fukuoka Sea Hawk, Fukuoka, Japan
E-mail: secretary@icns14.jp
www.icns14.jp

14–17 November 2023
SEMICON Europa 2023
Messe München, Munich, Germany
E-mail: semiconeuropa@semi.org
www.semiconeuropa.org

14–18 October 2023
2023 IEEE BiCMOS and Compound Semiconductor Integrated Circuits and Technology Symposium (BCICTS)
Monterey, CA, USA
E-mail: cs@cshawevent.com
www.bcicts.org

24–26 October 2023
SPIE Photonex 2023
Scottish Event Campus (SEC), Glasgow, UK
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/photonex

29 October – 2 November 2023
IEEE Energy Conversion Conference & Expo (ECCE 2023)
Music City Center, Nashville TN, USA
E-mail: ECCE2023TPC@GMAIL.COM
www.ieee-ecce.org/2023

9–13 December 2023
69th annual IEEE International Electron Devices Meeting (IEDM 2023) – 'Devices for a Smart World Built Upon 60 Years of CMOS'
Hilton San Francisco Union Square Hotel, San Francisco, CA, USA
E-mail: iedm-info@ieee.org
www.ieee-iedm.org

13–15 December 2023
SEMICON Japan 2023
Tokyo Big Sight, Tokyo, Japan
E-mail: semicon@sakurain.co.jp
www.semiconjapan.org

27 January – 1 February 2024
SPIE Photonics West 2024
The Moscone Center, San Francisco, CA, USA
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/photonics-west

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18–22 February 2024
2024 IEEE International Solid- State Circuits Conference (ISSCC 2024)
San Francisco, CA USA
E-mail: Issccinfo@yesevents.com
www.isscc.org

25-29 February 2024
IEEE Applied Power Electronics Conference (APEC 2024)
Long Beach CA, USA
E-mail: apec@apec-conf.org
https://apec-conf.org

24–28 March 2024
Optical Fiber Communication Conference and Exposition (OFC 2024)
San Diego Convention Center, San Diego, CA, USA
E-mail: ofc@mcievents.com
www.ofcconference.org

7–11 April 2024
SPIE Photonics Europe 2024, co-located with SPIE Optical Systems Design 2024
Palais de la Musique et des Congrès,
Strasbourg, France
E-mail: customerservice@spie.org
www.spie.org/conferences-and-exhibitions/photonics-europe

30 April – 2 May 2024
27th annual Components for Military & Space Electronics conference & exhibition (CMSE 2024)
Four Points by Sheraton (LAX), Los Angeles, CA, USA
E-mail: info@tjgreenllc.com
www.tjgreenllc.com/cmse

20–23 May 2024
2024 CS MANTECH: International Conference on Compound Semiconductor Manufacturing Technology
JW Marriott Starr Pass Resort,
Tucson, AZ, USA
E-mail: registration@csmantech.org
www.vlsisymposium.org

12–23 June 2024
2024 IEEE Symposium on VLSI Technology and Circuits
Hilton Hawaiian Village Waikiki Beach Resort,
Honolulu, HI, USA
E-mail: vlsi@vlsisymposium.org
www.vlsisymposium.org

16–21 June 2024
2024 IEEE/MTT-S International Microwave Symposium (IMS 2024)
Washington DC, USA
E-mail: exhibits@horizonhouse.com
www.ims-ieee.org/about-ims/past-and-future-ims

9–11 July 2024
SEMICON West 2024
Moscone Center,
San Francisco, CA, USA
E-mail: semiconwest@semi.org
www.semiconwest.org

22–24 July 2024
38th North American Conference on Molecular Beam Epitaxy (NAMBE 2024)
Tufts University, Boston, MA, USA
E-mail: della@avs.org
www.nambe2024.avs.org

22–26 September 2024
ECOC 2024: European Conference on Optical Communication
Frankfurt am Main, Germany
E-mail: michelle.dampier@nexusmediaevents.com
www.ecocexhibition.com/future-dates

16–20 February 2025
ISSCC 2025: IEEE International Solid- State Circuits Conference
San Francisco, CA USA
E-mail: issccinfo@yesevents.com
www.isscc.org

15–20 June 2025
2025 IEEE/MTT-S International Microwave Symposium (IMS 2025)
San Francisco, CA, USA
E-mail: exhibits@horizonhouse.com
www.ims-ieee.org/about-ims/past-and-future-ims

7–9 October 2025
SEMICON West 2025
Phoenix, AZ, USA
E-mail: semiconwest@semi.org
www.semiconwest.org

15–19 February 2026
2026 IEEE International Solid- State Circuits Conference (ISSCC 2026)
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