ISSN 1752-2935 (online)

semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

Vol. 11 • Issue 8 • October 2016

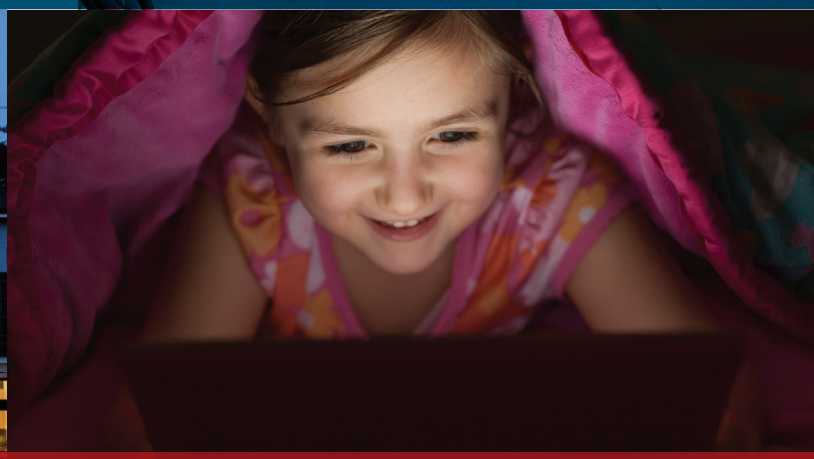
www.semiconductor-today.com

Using germanium as a bridge in III-Vs-on-silicon

Silicon carbide enters Formula E

First 60GHz RF SOI switch • Wolfspeed launches 1000V SiC MOSFET
Veeco reduces ALD investment • Aixtron sale under review

Lower Cost LEDs



Faster LED Adoption

Another breakthrough from Veeco. This time it's EPIK.

Introducing Veeco's new TurboDisc® EPIK700™ GaN MOCVD system

As global consumption for LED general lighting accelerates, manufacturers need bigger, better MOCVD technology solutions that increase productivity and lower manufacturing costs.

The EPIK700 MOCVD system combines Veeco's award-winning TurboDisc reactor design with improved wafer uniformity, increased productivity and reduced operations expenses to enable a cost per wafer savings of up to 20 percent compared to previous systems.

It also features a reactor with more than twice the capacity of previous generation reactors. This increased volume coupled with productivity advancements within the EPIK700 reactor, results in an unmatched 2.5x throughput advantage over previous reactors.

Learn how Veeco's TurboDisc EPIK700 GaN MOCVD system can improve your LED manufacturing process today.

The advantage is not just big. It's EPIK.

Contact us at *www.veeco.com/EPIK700* to learn more.

Veeco's New TurboDisc EPIK700 GaN MOCVD System

contents

Editorial 4

Markets News 6
Gallium demand to grow at 6% annually to 420t in 2020 • COB LED market for lighting rising at 4% CAGR to over $700m in 2021

Microelectronics News 8
MACOM & X-Microwave collaborate on faster, easier RF system design • Peregrine unveils first 60GHz RF SOI switches; UK team expands

Wide-bandgap electronics News 16
SiC enters Formula E • Wolfspeed launches first 1000V SiC MOSFET • Raytheon wins $14.9m Title III contract to enhance GaN process • Mentor Graphics joins WBGi power electronics consortium

Materials and processing equipment News 27
Aixtron sale blocked • Veeco reducing investment in ALD technology

LED News 36
Epistar quadrupling CSP LED chip capacity • BluGlass and Lumileds evaluation agreement enters Phase II • Patent lawsuit news

Optoelectronics News 52
Osram laser achieves lab record for brilliance • Hamamatsu expands • Canon develops first InP immersion grating • Infinera joins AIM Photonics • POET expanding in Singapore; partners with Luxmux

Optical communications News 58
Renesas launches first laser achieving stable 28G operation at 85°C

Photovoltaics News 60
Oxford PV raises £8.7m of Series C funding • Dyesol wins UK grant

Technology focus: Photovoltaics 64
InGaN solar cells with positive temperature coefficient

Technology focus: 2D materials 66
Two-dimensional GaN with graphene encapsulation

Technology focus: 2D materials 68
Electrically driven single-photon emission from atomically thin diodes

Technology focus: Nitride LEDs 70
Combatting droop with thick single quantum wells on semi-polar GaN

Technology focus: Nitride lasers 72
Reducing laser diode optical leakage with InGaN waveguides

Technology focus: III-Vs on Si — optoelectronics 74
Flip-chip hybrid external-cavity laser array on silicon platform

Technology focus: III-Vs on Si — optoelectronics 76
Germanium and silicon photonics

Technology focus: Nitride transistors 84
Silicon monoxide passivation for gallium nitride transistors

Market focus: GaN power devices 86
GaN power device market growing at 86% CAGR to $280m in 2021

Technology focus: GaAs transistors 88
Reducing subthreshold swing of gallium arsenide transistors

Technology focus: 2D transistors 90
Berkeley-led team fabricates transistor with record 1nm gate

Suppliers' Directory 92

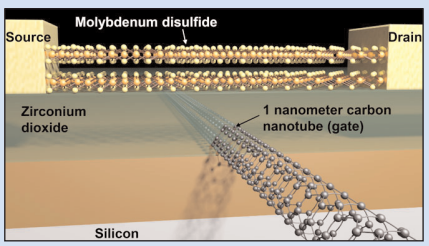
Event Calendar and Advertisers' Index 98

semiconductorTODAY
COMPOUNDS & ADVANCED SILICON

Vol. 11 • Issue 8 • October 2016

p13 Arralis has won the IT and Telecommunications Award as well as the overall Innovation of the Year prize for its 94GHz W-band radar chipset.

p53 Artist's rendition of new building no. 3 at Hamamatsu Photonics' Miyakoda Factory for expanding IR detector/emitter production.



p90 A Berkeley Lab-led team has fabricated a transistor with a record 1nm-long gate, using a carbon nanotube with an MoS_2 channel.

Cover: Japan's Rohm Semiconductor has introduced its silicon carbide inverter technology at the first race of the new 2016/2017 Formula E season in Hong Kong. With the start of season 3, Rohm is starting its official partnership with the Venturi Formula E team. **p19**

editorial

Slicing layers ever thinner

Following last issue's coverage of the integration of III-V light-emitting material with silicon photonics (including Intel's launch in August of its first Silicon Photonics 100G optical transceiver products) in the article on pages 76–82 of this issue we focus on research into how germanium can be used as a 'bridge' layer (forming a Ge/Si 'virtual substrate') to ease the integration of compound semiconductor material onto silicon photonic platforms, specifically for infrared light-emission. This even includes a Ge/SiGe-based LED, since light from germanium has a longer wavelength than that from silicon and is hence transmissible by silicon photonic waveguide structures.

Conversely, pages 74–75 report research by Oracle that uses flip-chip bonding for hybrid (rather than monolithic) integration of what it claims is the first surface-normal coupled laser array on a silicon-on-insulator photonics platform (forming a tunable hybrid external-cavity laser array).

Also in this issue we report research on two-dimensional materials. VerLASE Technologies has been awarded a US patent on using 2D materials to grow semiconductor structures that can down-convert InGaN-based blue/violet emitters into any color in the visible part of the spectrum, obviating the use of phosphors and quantum dots (see page 53).

In addition, on pages 68–69 we report the use of atomically thin layers of a transition-metal dichalcogenide (TMD) material (in this case WSe_2) as the active layer in a tunnel-junction device for single-photon emission.

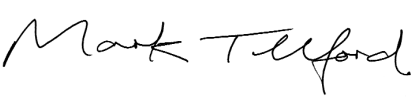
Meanwhile, in microelectronics, Berkeley Lab has used another TMD (MoS_2) as a channel material in a transistor with a gate (consisting of a carbon nanotube) with a record short length of just 1nm (see pages 90–91).

Although the use of 2D materials in device research is burgeoning, adoption of 2D (or atomic-layer) technology for commercial production is still early stage. Deposition and process equipment maker Veeco Instruments has announced additional cost-reduction initiatives after deciding to significantly reduce future investments in its atomic layer deposition (ALD) technology development (page 30). This follows a delay in timing for revenue realization. Nevertheless, the firm still plans to retain its ALD intellectual property and technology capabilities and to continue to assess future market opportunities.

Meanwhile, fellow metal-organic chemical vapor deposition (MOCVD) system maker Aixtron says that Germany's Federal Ministry of Economics and Energy has withdrawn the Clearance Certificate (issued on 8 September) for China's Fujian Grand Chip Investment Fund's proposed offer made in May to acquire Aixtron, and announced a reopening of review proceedings (see page 31). Information available to the German Federal Government indicates that Aixtron's know-how also comprises security-related technologies (in particular for the defense sector) that could be revealed through the acquisition.

Fujian Grand Chip (FGC) is held 51% by Chinese businessman and private investor Zhendong Liu and 49% by Xiamen Bohao Investment Ltd. However, according the New York Times, concerns have a risen regarding possible links between Chinese state investment in both FGC and San'an Optoelectronics (China's largest LED maker). In early 2016, San'an failed to qualify Aixtron's new AIX R6 MOCVD system, leading to truncation of a large multi-system order and prompting a drop in Aixtron's share price. Hopefully the ministry's review will take weeks rather than months to preclude any further uncertainty.

Mark Telford, Editor
mark@semiconductor-today.com



semiconductorTODAY
COMPOUNDS & ADVANCED SILICON

Editor
Mark Telford
Tel: +44 (0)1869 811 577
Cell: +44 (0)7944 455 602
Fax:+44 (0)1242 291 482
E-mail: mark@semiconductor-today.com

Commercial Director/Assistant Editor
Darren Cummings
Tel: +44 (0)121 288 0779
Cell:+44 (0)7990 623 395
Fax:+44 (0)1242 291 482
E-mail: darren@semiconductor-today.com

Advertisement Sales
Darren Cummings
Tel: +44 (0)121 288 0779
Cell:+44 (0)7990 623 395
Fax:+44 (0)1242 291 482
E-mail: darren@semiconductor-today.com

Original design Paul Johnson
www.higgs-boson.com

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

***Semiconductor Today* (ISSN 1752-2935) is published free of subscription charge** in a digital format 10 times per year by Juno Publishing and Media Solutions Ltd, Suite no. 133, 20 Winchcombe Street, Cheltenham GL52 2LY, UK. See: www.semiconductor-today.com/subscribe.htm

AIXTRON
Our technology. Your future.

YOU THINK,

GaN POWER DEVICE MANUFACTURING REQUIRES HVM SOLUTIONS.

WE THINK THAT TOO.

THE NEW AIX G5+ C

DISCOVER THE NEW AIX G5+ C.

Introducing the G5+ C: built on Award Winning Planetary technology for best Single Wafer performance with Batch Reactor benefits – now coming with Cassette to Cassette wafer loading, In-Situ Reactor Cleaning and pre-qualified device processes.
Enabling full automation of your processes and a seamless integration into your Silicon line.

AIXTRON SE · info@aixtron.com · www.aixtron.com

HVM: High Volume Manufacturing

COB LED market for lighting applications to grow at 4% CAGR from $580m in 2016 to over $700m in 2021

Citizen and Cree seeing significant growth in horticultural market

The global market for chip-on-board (COB) LEDs used in lighting applications — including COB products belonging to ceramic and EMC packages — will rise at a compound annual growth rate (CAGR) of about 4% from $580m in 2016 to more than $700m in 2021, according to the '2016-2021 Global LED Industry Demand and Supply Database Report' by LEDinside (a division of TrendForce).

"COB LEDs are mainly for the commercial lighting market," notes Joanne Wu, assistant research manager at LEDinside. "However, recent technological advances have improved the reliability of high-power COB products, allowing them to gradually expand into various outdoor applications such as lighting equipment for mining sites and street lighting. COB and high-power LEDs are expected to have competitive advantages in the high-end lighting applications because they have advantages that mid-power LEDs lack in terms of design and brightness," she adds.

International LED suppliers (in contrast to China-based LED suppliers) offer COB product lines that are wider ranging, notes Wu. "Moreover, they have much higher standards regarding brightness of the light and quality and reliability of products," she adds. "International suppliers also control the crucial IP related to COB LEDs, so they tend to have more customers and are chosen by major lighting exporters."

China-based LED suppliers on the other hand offer bargain prices and have a large domestic market. Also, they are developing COB LEDs with EMC packages. These products are expected to contribute to the rapid growth of revenue related to COB LEDs for lighting applications.

Top COB LED suppliers by revenue in 2015.

1	Citizen Electronics
2	Cree
3	Sharp
3	Bridgelux
5	Lumileds
5	Nichia
7	Samsung
8	Sunpu
9	LED Teen
10	Luminus Devices

Japan's Citizen Electronics topped the worldwide revenue ranking of COB LED suppliers in 2015, while the USA's Cree took second place. Citizen was able to capture the largest market share via a very comprehensive product line strategy. Last year, Citizen and Cree invested heavily in high-brightness, bargain-priced COB products for specific applications, such as the 10W-and-under segment of the indoor commercial lighting market and the 50W-and-above segments of both the industrial and outdoor lighting markets. The two companies should also see significant growth in COB LED revenue in 2016 as they take their products into the horticultural lighting market.

Sharp and Bridgelux shared third place in the 2015 COB LED revenue ranking. With dual-color products and valuable patents, Sharp was able to push its COB LEDs into the commercial and medical lighting markets. Bridgelux's COB products, which are mainly for industrial lighting, are exceptional in quality, given their prices, reckons LEDinside.

Recent technological advances have improved the reliability of high-power COB products

Lumileds and Nichia were tied at fifth place in the 2015 ranking. By greatly expanding their product lines, both firms were able to significantly increase their COB LED revenues. Both suppliers are launching more products in second-half 2016 and are likely to again post large annual increases in their COB LED revenues.

Since 2014, Samsung has been focusing on developing COB products and making inroads into the lighting market. Consequently, the supplier significantly grew its COB LED revenue in 2015 and became the seventh largest supplier in the annual ranking.

"China-based suppliers such as Sunpu and LED Teen have been just as active as their international counterparts developing COB products," notes Wu. "Sunpo climbed to eighth place in the 2015 COB revenue ranking on the back of strong sales of its full-spectrum products for the horticultural application market. LED Teen has always been focusing on developing COB LEDs and has grown rapidly in recent years," she adds. "This year, LED Teen has improved its position in the high-end commercial lighting market by successfully launching its high-density, high-color rendering COB LED arrays."

Likewise, US-based LED maker Luminus Devices, which was acquired by China's San'an Optoelectronics in the 2013, has positioned itself as another supplier in the high-end commercial lighting market. Luminus Device currently has a production site in Xiamen, China. The plant is undergoing capacity expansion and will be an important revenue contributor, concludes the report.

www.ledinside.com

Infineon tops power semiconductor market, followed by Texas Instruments and STMicroelectronics, after 2.6% decline to $34bn in 2015

Overall revenue for the power semiconductor market globally fell by 2.6% to $34bn in 2015, due primarily to macroeconomic factors and application-specific issues, according to IHS Markit's 'Power Semiconductor Market Share Report — 2016' (which this year includes power ICs for the first time, as well as discrete power semiconductors and power semiconductor modules). Specifically, discrete power semiconductor product revenue declined 10.1% and power module revenues fell by 11.4%, while power integrated circuit (IC) revenue rose by 4.5%.

As part of IHS Markit's Power Semiconductor Intelligence Service, the report identifies Infineon Technologies as the leading power semiconductor manufacturer last year, with 12% of the market, Texas Instruments with 11% and STMicroelectronics with 6%.

"While Texas Instruments previously led the market in 2014, the company was overtaken by Infineon Technologies in 2015, following its acquisition of International Rectifier and LS Power Semitech," says senior analyst Richard Eden. "Infineon was the leading global supplier of both discrete power semiconductors and power modules, and the fourth-largest supplier of power management ICs," he adds. "Infineon has been the leading supplier of discretes for several years, but overtook Mitsubishi Electric to lead the power module market for the first time in 2015, again, due to the International Rectifier and LS Power Semitech acquisitions."

According to the report, while Infineon Technologies' acquisition of International Rectifier was the largest acquisition last year, several other deals also changed the terrain of the power semiconductor market landscape. In 2015, MediaTek acquired RichTek, Microchip acquired Micrel, and NXP Semiconductors acquired Freescale Semiconductor. In addition, NXP Semiconductors created WeEn Semiconductors, a joint venture with Beijing JianGuang Asset Management Co. Ltd (JAC Capital). Also, CSR Times Electric merged with China CNR Corp to form CRRC Times Electric, and ROHM Semiconductor acquired Powervation.

"Companies were active in acquisitions for several reasons — especially the low financing cost in multiple regions of the world, which meant that borrowing rates in the United States and European Central bank were nearly zero," notes senior analyst Jonathan Liao. "In addition, the acquiring company typically increases its revenues and margins by taking the acquired company's existing customers and sales without incurring marketing, advertising and other additional costs."

https://technology.ihs.com

Gallium demand to grow at 6% annually to 420t in 2020

Growth of 16% for LEDs in general lighting to outweigh usage in ICs falling to 43% of market

The market for gallium in semiconductor/semi-insulating applications is set to rise at 6% annually to about 420 tons in 2020 as general illumination shifts away from incandescent-filament and fluorescent lamps to light-emitting diodes, according to the report 'Gallium: Global Market Trends and Prospects' from Merchant Research & Consulting Ltd.

In particular, the usage of gallium in LEDs for general lighting is set to grow at 16% per year. Meanwhile, the usage of gallium in integrated circuits is projected to remain most prominent, but to drop to 43% of the total. Consumption in LEDs for backlighting applications is unlikely to see robust growth due to the increased technical effectiveness of LEDs.

Despite the overall growth, the gallium market sees continuing oversupply. Between 2010 and 2013 Chinese capacity for production of primary gallium increased threefold in anticipation of surging demand for gallium nitride (GaN) LEDs for backlighting of liquid-crystal display (LCD) panels used in tablets, cell phones and TVs. The worldwide transition to LED general lighting over the next five years is poised to restore some balance to the gallium marketplace, but supply will likely remain more than adequate.

The worldwide transition to LED general lighting over the next five years is poised to restore some balance to the gallium marketplace

Japan is poised to take the lead in gallium consumption, although its market share will fall from 47% in 2014 to just over 40% in 2020, forecasts the report. Meanwhile, due largely to the increased usage in lighting, China's share is likely to surge to 35%.

www.marketpublishers.com

Skyworks' SkyOne Ultra 2.0 and SkyLiTE 2.0 front-end modules with SkyBlue technology addressing demand for increased power and data coverage

Skyworks Solutions Inc of Woburn, MA, USA (which manufactures analog and mixed-signal semiconductors) says that its portfolio of new SkyOne Ultra 2.0 and SkyLiTE 2.0 front-end modules are supporting high-power user equipment (HPUE) for mobile devices.

HPUE is a special class of user equipment for LTE cellular networks that improves cell range and increase coverage. Skyworks says that its complete RF front-end systems leverage its proprietary SkyBlue technology to deliver enhanced output power and meet HPUE certification requirements from TDD carriers. SkyOne Ultra 2.0 HPUE-compliant solutions are currently shipping at several customers while the SkyLiTE 2.0 HPUE-compliant devices will be available for ramps commencing in 2017. According to the latest report from the Global mobile Suppliers Association (GSA), 71 operators in 43 countries have commercially launched LTE service using TDD mode, with the unpaired spectrum expected to see growth in all regions.

"With smartphones supporting upwards of 20 frequency bands and more than 30 carrier aggregation combinations, there is an increasing need for innovative front-end solutions that address high-performance, cellular TDD-LTE applications," says VP of sales & marketing Carlos Bori. "Leveraging our systems expertise, Skyworks is collaborating with carriers and OEMs to develop highly integrated devices that solve increasingly complex RF challenges, meet the most demanding standards, and provide unparalleled performance," he adds.

"HPUE significantly increases TDD-LTE Band 41 coverage and is an important innovation that will benefit the global TDD-LTE ecosystem," comments Dr Ron Marquardt, VP of technology at Sprint. "HPUE will further unlock the advantages of the 2.5GHz spectrum, particularly as consumers require more capacity and faster data speeds."

SkyOne Ultra 2.0 is a highly integrated, single LTE SKU (stock keeping unit) solution that solves harmonically related carrier aggregation challenges through design while delivering high linear RF power as well as power-added efficiency. Skyworks claims that the platform not only improves performance in terms of power output and system efficiency, it also delivers this performance in the most compact size commercially available, supporting 22 bands in less than 240mm^2.

SkyLiTE 2.0 is a highly integrated module that incorporates the amplification, switching, Wi-Fi filtering and coupler functionality required to support all major FDD/TDD bands. With the addition of external duplexers, this family of solutions provides OEMs with a scalable and reconfigurable front-end system suitable for markets worldwide.

SkyBlue technology delivers envelope tracking (ET)-like system efficiency, but with a far simpler implementation method compared with traditional ET systems, says Skyworks. Utilizing the more conventional average power tracking (APT)-like approach, SkyBlue control is intuitive and has a rapid learning curve relative to ET calibration requirements, the firm adds.

www.skyworksinc.com/Products/622
www.skyworksinc.com/Products/1031
www.skyworksinc.com/Products_SkyBlue.aspx

Skyworks launches family of GPIO-controlled RF cellular switches

Skyworks Solutions Inc of Woburn, MA, USA (which makes analog and mixed-signal semiconductors) has introduced a family of GPIO-controlled, high-performance RF cellular switches for LTE and GSM applications. The SKY13581-676LF single-pole, double-throw (SP2T), SKY13582-676LF single-pole, triple-throw (SP3T) and SKY13626-685LF single-pole, four-throw (SP4T) are for LTE, while the SKY13597-684LF (SP4T) is for GSM.

The new family of switches is suitable for smartphones, data cards and MiFi hotspot applications. The devices are designed to operate over the complete cellular frequency range including support for Band 42 and Band 43 (up to 3.8GHz), allowing the use of one part for all band requirements. They also feature low insertion loss for higher transmission efficiency and what is claimed to be excellent harmonic performance with improved receiver sensitivity.

The SKY13581-676LF, SKY13582-676LF and SKY13626-685LF share a common layout and are pin-to-pin, footprint compatible, enabling faster development time.

www.skyworksinc.com/Product/3366/SKY13581-676LF
www.skyworksinc.com/Product/3191/SKY13582-676LF
www.skyworksinc.com/Product/3368/SKY13626-685LF
www.skyworksinc.com/Product/3367/SKY13597-684LF

GENxplor™

Discover The Future

GENxplor's open architecture improves ease-of-use, provides convenient access to effusion cells and is easier to service than other MBE systems

Finally, the Industry's First Fully-Integrated R&D MBE System

You've been asking for a more affordable, flexible, and easy-to-use MBE system, and Veeco has delivered with the GENxplor. Veeco's industry-leading MBE technology features a novel 'all-in-one' design that combines the reactor and electronics on a single frame, making it up to 40% smaller than other MBE systems, so you can save valuable lab space. Its efficient single frame design combines all vacuum hardware with on-board electronics to create high quality epitaxial layers on substrates up to 3" in diameter. The GENxplor allows you to concentrate on the future through cutting edge research for emerging technologies such as UV LED, high-efficiency solar cells and high-temperature superconductors. Discover more at **www.veeco.com/genxplor**

Veeco

Innovation. Performance. Brilliant.

4900 Constellation Drive | St. Paul, MN 55127
Phone: (651) 482-0800 | info@veeco.com

MACOM and X-Microwave collaborate to enable faster, easier design of RF systems

X-Microwave's online simulation and prototyping platform to offer building blocks pre-configured with MACOM's MMICs

MACOM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for analog RF, microwave, millimeter-wave and photonic applications) and modular system design firm X-Microwave LLC of Round Rock, TX, USA have announced the availability of MACOM-based RF components for use with X-Microwave's online simulation and prototyping platform. Pre-configured with MACOM's MMICs, the drop-in and cascadable components (X-MWblocks) enable designers to quickly and easily architect modular, end-to-end RF systems.

MACOM's support for the X-Microwave platform equips designers to take advantage of its MMIC performance, with the added ability to interconnect hundreds of compatible, pre-characterized X-MWblock components with solderless, building block flexibility. This reduces evaluation and design complexity and enables designers to accelerate their time to market, says MACOM. With this collaboration, X-Microwave users can now take advantage of a broad selection of MACOM MMICs, spanning amplifiers, mixers, frequency multipliers, octave-band voltage-controlled oscillators (VCOs), RF switches, voltage variable attenuators and phase shifters.

"Through our collaboration with X-Microwave, designers now have the ability to leverage all of these benefits in a manner that can dramatically accelerate their system prototyping and shorten design cycles," says Graham Board, MACOM's senior director, RF and Microwave.

"X-Microwave is committed to optimizing the design process for RF engineers through every phase of the development process," says X-Microwave's president & CEO John Richardson. "With the addition of MACOM MMICs to our component ecosystem, X-Microwave users are assured leading-edge RF performance and quality from the foremost innovator in the RF and microwave industry," he adds.

MACOM showcased its new portfolio of MMICs and its collaboration with X-Microwave at European Microwave Week (EuMW 2016) in London, UK (4–6 October).

www.eumweek.com
www.xmicrowave.com/products/by-manufacturer/macom-mmics-x-mwblocks
www.macom.com

MACOM debuts 27 new DC–100GHz MMICs

At European Microwave Week (EuMW 2016) in London, UK (4–6 October), MACOM debuted 27 new monolithic microwave integrated circuits (MMIC) products comprising what is claimed to be the industry's most extensive portfolio of DC–100GHz MMICs for test & measurement, SatCom, aerospace & defense, wired broadband, and industrial, scientific & medical (ISM) applications.

MACOM says that, leveraging foundry technologies and proprietary in-house processes, it has pioneered a new class of high-performance MMICs spanning product categories from amplifiers, frequency converters and control products to frequency sources and detectors, encompassing the entire block diagram from signal generation, amplification and conditioning to conversion and monitoring.

The new MMIC families comprise:

- *Gain block & low-noise amplifiers* — Two wideband amplifiers fully matched and current-adjustable amplifier solutions for multi-market applications;
— Family of low-noise amplifiers providing performance and versatility enabling accelerated time-to-market.
- *Wired broadband amplifiers* Family of amplifiers designed specifically for DOCSIS 3.1 CATV infrastructure applications requiring high gain, superior linearity and low noise figure.
- *Wideband power amplifiers* High-power MMIC amplifiers covering DC–22GHz for test & measurement, electronic warfare, and radar applications.
- *SatCom power amplifiers* High-linearity family of power amplifiers for SatCom applications featuring a highly integrated L-band device supporting longer battery life.
- *Voltage-controlled oscillators* Octave-band VCOs suited to test & measurement, aerospace & defense, and communications systems.

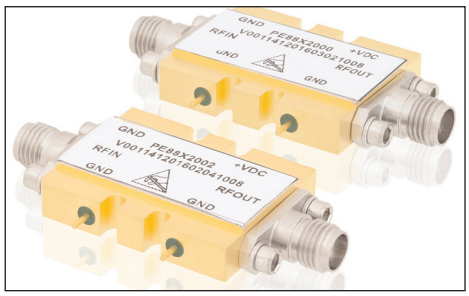
"Continued consolidation in the semiconductor industry has disrupted the MMIC supplier ecosystem and left customers with fewer credible, reliable sources for high-performance MMICs," states Graham Board, senior director, Multi-Market Products. "MACOM is meeting this challenge head on by increasing our investment in advanced MMIC technologies and aggressively expanding our MMIC product portfolio. As the only pure-play RF, microwave and millimeter-wave supplier with a proven heritage of semiconductor industry leadership — built over six-decades — MACOM is committed to being the trusted, long-term supplier of choice for the next generation of high-performance MMICs."

Pasternack launches series of GaAs pHEMT MMIC active frequency multipliers spanning 8–46GHz

Pasternack Inc of Irvine, CA, USA (which makes both passive and active RF, microwave and millimeter-wave products) has launched a series of active frequency multipliers that simplify system designs by offering high output power levels.

The active frequency multipliers are key building block components used in local oscillator (LO) chains for radar, communication receivers and frequency sources to extend frequencies and achieve optimal performance. The firm adds that they support multiple markets and applications including electronic warfare, electronic countermeasures, point-to-point radio, VSAT radio, test instrumentation and telecom infrastructure.

The PE88X-series active frequency (x2) multipliers double input



frequencies ranging from 4GHz to 23GHz up to desirable millimeter-wave output frequencies from 8GHz to 46GHz. The new designs use highly efficient gallium arsenide (GaAs) pseudomorphic high-electron-mobility transistor (pHEMT) technology with integrated amplifiers that produce high output power levels up to +17dBm with what is claimed to be excellent fundamental and harmonic suppression. This can eliminate the need for an external LO buffer amplifier stage and additional support circuitry.

The active frequency multipliers require a single +5V DC supply. Input/output RF ports are matched for 50Ω and are DC blocked. The compact drop-in package assemblies are hermetically sealed and support field-replaceable 2.92mm connectors. All models are RoHS- and Reach-compliant and designed to meet MIL-STD environmental test conditions.

The active frequency multipliers are in-stock and ready for immediate shipment. "Active multipliers usually require long manufacturing cycles, but Pasternack offers all three models ready to ship right off the shelf," notes active components product manager Tim Galla.

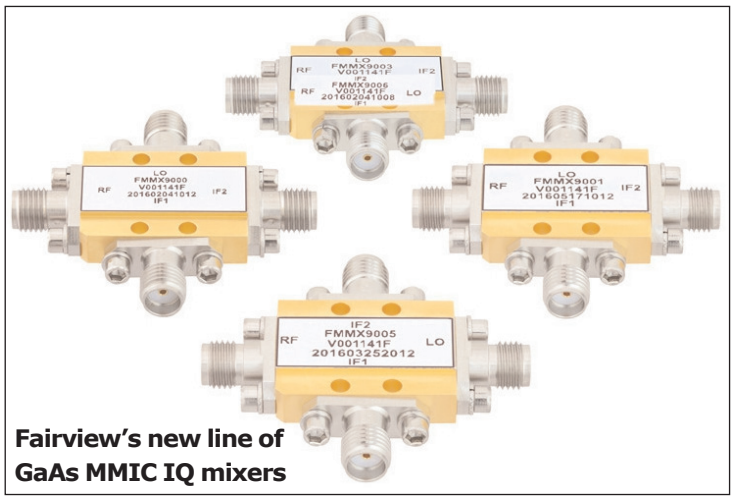
www.pasternack.com

Fairview debuts new line of GaAs MMIC IQ mixers

Fairview Microwave Inc of Allen, TX, USA, which supplies on-demand microwave and RF components, is debuting a new product family of seven unique models of IQ mixer models with RF and LO frequency bands ranging from 4GHz to 38GHz and in-phase and quadrature IF bandwidths ranging from DC to 4.5GHz.

The new monolithic microwave integrated circuit (MMIC) IQ mixers (IQ modulators) utilize gallium arsenide (GaAs) MESFET process technology that integrates a pair of matched double-balanced mixer cells, a 90° hybrid and a 0° splitter/combiner that is said to produce exceptional amplitude and phase balance performance. This level of integration offers size and performance advantages compared with discrete module assemblies.

With the addition of an external 90° IF hybrid module, these IQ mixers can be used as either a single-sideband up-converter mixer or an image reject down-converter



Fairview's new line of GaAs MMIC IQ mixers

mixer. Image rejection and sideband suppression can reduce overall system cost and complexity by removing the need for pre-selection filtering. Typical applications include point-to-point and point-to-multipoint radio, VSAT, military radar, electronic warfare, satellite communications, test equipment, and sensors.

Performance as an image reject mixer (IRM) includes low conversion loss that ranges from 7.5dBm to 10dBm, high image rejection up to 35dB typical, and LO-to-RF isolation as high as 42dB typical. The IQ mixer designs offer linearity with input 1dB compression as high as +20dB typical and input IP3 as high as +35dB typical. LO drive power ranges from +15dBm to +19dBm.

The compact and rugged drop-in package designs are hermetically sealed with field-replaceable connectors and are guaranteed to meet MIL-STD-883 test conditions for humidity and temperature cycle.

All seven models are available from stock and available for immediate shipment.

www.fairviewmicrowave.com/rf-products/iq-mixers.html

Anokiwave becomes guest member of 3GPP to promote development of global 5G standard

Anokiwave Inc of San Diego, CA, USA, which provides highly integrated silicon core chips and III-V front-end integrated circuits for millimeter-wave (mmW) markets and active electronically scanned array (AESA)-based terminals, has joined the 3rd Generation Partnership Program (3GPP) as a guest member. The firm reckons that membership of 3GPP will continue to advance its position in the mmW 5G market as future specifications and standards are developed for 5G.

3GPP unites seven telecoms standard development organizations and provides their members with a stable environment to produce the reports and specifications that define 3GPP technologies. The 3GPP scope includes managing the evolving standards for 5G. The 3GPP Technical Specifications Group recently agreed on a detailed workplan for its first release of 5G specifications (Release 15) which includes a decision point in December in which 3GPP will plan system architecture features to be included in Release 15 in 2018. As a guest member, Anokiwave will be able to contribute to the architecture discussions as one of the first companies to have launched mmW 5G ICs in the marketplace. 3GPP expects full phase-1 5G deployments to begin in 2020.

Having released the first Ka-band silicon quad core IC for 5G active antenna systems, Anokiwave says that its patent-pending IP blocks implemented in silicon technology enable low-cost hybrid beam forming for multi-antenna arrays with high energy efficiency, low latency beam steering, and low system sensitivity.

"Anokiwave is in a unique position, working with 5G market drivers to establish system specifications that I believe we will ultimately see in the 3GPP Release 15," says CEO Robert Donahue.

www.3gpp.org
www.anokiwave.com

FenComp to represent Anokiwave in Finland

Anokiwave has signed a representative agreement with FenComp, which is located in Oulu area, Finland. The agreement aligns with Anokiwave's goal to support new customers and opportunities for its highly integrated active antenna IC solutions in Finland.

FenComp, which has over 25 years of experience in the telecoms, aerospace & defense (A&D), and industrial markets, is focused on technical sales for RF, microwave and power products.

"This agreement strengthens the technical support we can provide to customers in Finland and increases our ability to promote our active antenna IC solutions in the region," says chief operating officer Carl Frank. "FenComp's mission to innovate solutions for their customers, coupled with excellent technical resources, makes them ideally positioned to drive the adoption of our products into the 5G, radar, SatCom, and satellite markets."

Anokiwave adds chief operating officer

Anokiwave has announced the latest addition to its leadership team with the appointment of Carl Frank to the new position of chief operating officer (effective July), reporting directly to CEO Robert Donahue.

Frank will be responsible for the execution of Anokiwave's worldwide growth strategy, as well as assume responsibility for the worldwide marketing, sales and operations organizations.

Previously, Frank was VP of business development, responsible for identifying growth opportunities and for driving corporate strategies that created long-term value through close working relationships with strategic customers.

Over the last 10 years, Frank has

held leadership positions in business development and operations at TRX Systems, Honeywell Technology Solutions, and Techno-Sciences. In these roles, he managed cross-functional teams to introduce and grow new technology service and product offerings in commercial and military markets. Prior to working in the technology industry, Frank served for 20 years in the US Coast Guard in leadership positions at sea and in program management positions ashore.

"Carl is uniquely qualified to drive strategic prioritization and growth within Anokiwave," believes Donahue. "Carl has a long proven record of relentless passion and aptitude for forging new strategic alliances with customers, and will be a valuable asset as we continue to grow into new 5G, SatCom and radar markets," he adds. "Anokiwave and its customers will benefit significantly from Carl's leadership, commitment to excellence, and proven record of professional success in partnerships."

Frank holds a BS degree in Marine Engineering from the US Coast Guard Academy and MS degrees in Naval Architecture, Mechanical Engineering and the Management of Technology from Massachusetts Institute of Technology.

Arralis launches new W-band MMICs

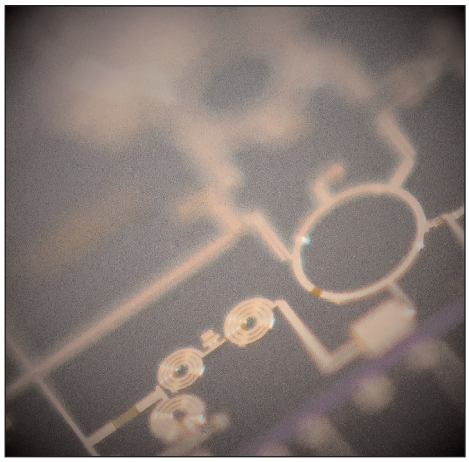
Arralis Ltd of Limerick, Ireland, which designs and manufactures RF, microwave and millimetre-wave devices, modules and antennas up to and beyond 110GHz (the W-band) for aerospace and security market, has added new monolithic integrated circuit (MMIC) devices to its product range. The new power amplifier, image cancellation mixer and variable attenuator come in response to new advance system requirements, says the firm.

Power amplifier

The TU-W1330305 is a 4-stage MMIC power amplifier that covers frequencies of 92–96GHz. It provides up to 20dB of flat, stable gain, and a power output of more than 18dBm from a 4V supply voltage and low current of just 210mA.

Image cancellation MMIC mixer (92–96GHz)

The TU-W1340310 is an I/Q MMIC diode mixer with integrated quadrature coupler for single-sideband up-converter operation. Fabricated using gallium arsenide (GaAs) Shottky diode technology, it is



designed for output frequencies of 92–96GHz using either fixed IF and varying LO (86–90GHz) or fixed LO and varying IF (2–6GHz) signals. The circuit employs a double rat race configuration to effectively cancel image signals without filtering and offers what is claimed to be superior signal-to-noise performance.

GaAs pHEMT MMIC attenuator/ SPST switch (90–100GHz)

The TU-W1401601 is a GaAs pseudomorphic high-electron-mobility transistors (pHEMTs) diode based single-pole single-throw (SPST) switch and variable attenuator with a single input and output. The attenuation value can be adjusted to any value within the specified attenuation range. The chip is manufactured on a 50μm substrate with 100μm gate length. All bond pads and the die underside are gold plated. The control voltage ranges from +1.5V to –1.5V (the latter giving maximum attenuation).

A packaged version of each device is also available with WR10 waveguide input and output on request.

"We recently launched the world's first W-band up- and down-converters," said chief technology officer Mike Gleaves, speaking at European Microwave Week (EuMW 2016) in London, UK. "We expect the same success with these new devices". Arralis displayed products including smart beam-steering antenna technology, new communications and radar modules, and a unique GNSS antenna with a very low SWaP specification.

www.arralis.com

Arralis wins The Irish Times Innovation of the Year Award 2016

At the Irish Times Innovation Awards ceremony at the Royal Hospital Kilmainham in Dublin on 5 October, Arralis Ltd of Limerick, Ireland — which has a design center in Belfast and manufactures RF, microwave and millimetre-wave devices, modules and antennas up to and beyond 110GHz (the W-band) for aerospace/satellite and security markets — won the IT and Telecommunications Award as well as the overall prize for Innovation of the Year for its 94GHz radar chipset.

Arralis' 94GHz radar chipset has a wide range of applications including aiding unmanned landings by spacecraft, drone guidance systems, air defence systems, airport radar and driverless cars, as well as Internet and next-generation 5G telecoms.

Pictured at the The Irish Times Innovation Awards presentation: Eamonn Boland, Marie Bourke, Barry Lunn, Valerie Somers and Denver Humphrey of Arralis.

The awards ceremony showcased Ireland's top innovative talent in various sectors after receiving applications from more than 300 companies. The event was attended by more than 220 people including Mary Mitchell O'Connor, Ireland's Minister for Job, Enterprise and Innovation.

As overall winner, Arralis also will receive a communications and advertising package from The Irish Times that is worth in excess of €150,000, as well as a University College Dublin (UCD) Smurfit Business School scholarship for an Executive Education program that will commence in 2017.

www.irishtimes.com/business/ul-based-arralis-wins-innovation-of-the-year-1.2818361

Peregrine's UK team moves into larger office

Working area and lab space quadrupled to accommodate 90% growth in two years

Peregrine Semiconductor Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) — says that its UK team has moved into a larger office at 1420 Arlington Business Park in Theale, Berkshire (in the heart of the Thames Valley). The new 4600ft^2 office quadruples the working area and laboratory space (including two fully equipped labs) to better accommodate the UK team's 90% growth since Peregrine's acquisition by Japan's Murata in December 2014.

"Our team had outgrown our old facility — both in seating capacity and in lab space to accommodate new product development," says Mark Moffat, managing director of Peregrine Semiconductor Europe. "Our new home not only better suits our current team, but it has the capacity for our projected growth," he adds. "With a prime location in the Thames Valley, we are able to tap into the abundance of talent in this region and build a team that is driving Peregrine's growth in areas like 5G and power management."

In addition to the UK office, Peregrine has offices in Arlington Heights, Illinois; Seongnam-si, South Korea; and Shanghai, China.

Peregrine launches monolithic 100W RF SOI power limiter

Peregrine Semiconductor has launched the UltraCMOS PE45361 monolithic 100W power limiter. The next generation in Peregrine's power limiter product family, the PE45361 builds on the firm's 50W UltraCMOS power limiters and adds higher pulsed power handling, a lower limiting threshold and positive threshold control.

UltraCMOS power limiters provide a monolithic alternative to discrete, PIN-diode limiters based on gallium-arsenide (GaAs) technology and protect devices against excessive RF power, intentional jamming and ESD events. The PE45361 is said to deliver reliable and repeatable power protection to sensitive low-noise receivers for test & measurement equipment and wireless-infrastructure transceivers.

"Peregrine's monolithic power limiters offer our customers a novel and robust approach to excessive RF power protection," says director of marketing Kinana Hussain. "The introduction of the PE45361 builds upon the key RF performance and bill of materials (BOM) cost advantages of our UltraCMOS limiters, while providing 100W power handling and low limiting threshold to protect sensitive low-noise amplifiers (LNAs)."

Compared with PIN diodes, it is claimed, UltraCMOS power limiters provide a 10–100x improvement in response-and-recovery time, deliver 10–40dB linearity (IIP3) improvement and offer a 20x improvement in ESD protection. In addition, UltraCMOS power limiters are 8x smaller than the board space required by PIN-diode solutions, the firm adds. Finally, the limiting threshold can be adjusted through a low-current voltage control pin (V_{CTRL}), eliminating the need for external components such as DC blocking capacitors, RF choke inductors and bias resistors.

Like other UltraCMOS power limiters, the PE45361 features two operating modes — power limiting and power reflecting — to maximize performance and flexibility. These modes can be selected through the programmable V_{CTRL} pin. In power-limiting mode, the device is invisible to the load. When the incoming RF signal power exceeds the limiting threshold set through the V_{CTRL} pin, the device limits the input RF power. Power-reflecting mode is used in more extreme conditions, and the device reflects most of the incident power back to the source.

Covering a wide frequency range from 10MHz to 6GHz, the PE45361 power limiter provides power protection for high-performance, power-limiting applications. It features a high pulsed power handling up to 50dBm and 100W, an adjustable limiting threshold from 5dBm to 13dBm and a positive threshold control from 0V to 0.3V. The PE45361 delivers low insertion loss of 0.95dB at 6GHz and high return loss of 15dB at 6GHz (and 0.5dB and 20dB, respectively, at 3GHz). With a fast response time of 1ns and a speedy recovery time of 20ns, it exhibits high linearity of 37dBm IIP3 and ESD protection of 3kV HBM.

Samples and evaluation kits are available now. Offered in a compact 12-lead 3mm x 3mm QFN package, the PE45361 is $4.80 each for 10,000-unit orders.

www.psemi.com

Peregrine unveils first 60GHz RF SOI switches

CMOS-based high-frequency portfolio extended from 40GHz to 60GHz

Peregrine Semiconductor Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) — has launched the UltraCMOS PE42525 and PE426525, which are claimed to be the first RF SOI switches to operate up to 60GHz. The firm says that the two switches significantly extend its high-frequency portfolio into frequencies previously dominated by gallium arsenide (GaAs) technology.

Supporting a wide frequency range from 9kHz to 60GHz, the PE42525 and PE426525 are reflective single-pole double-throw (SPDT) RF switches delivering a fast switching speed of 8ns and RF T_{RISE}/T_{FALL} time of 4ns, and low power consumption of 450nA. At 50GHz, the PE42525 and PE426525 exhibit high port-to-port isolation of 38dB, low insertion loss of 1.9dB, high power handling, high linearity, and ESD protection of 2kV HBM. The PE426525 has an extended temperature range that spans –55°C to +125°C.

The PE42525 is suitable for test & measurement equipment, microwave-backhaul solutions and higher-frequency switching in 5G systems. The PE426525 has an extended temperature range, making it suited to harsh-environment applications such oil & gas exploration and other industrial markets.

"From 26.5GHz to 40GHz and now 60GHz, Peregrine's high-frequency portfolio continues to reach frequencies and performance levels previously considered unattainable in RF SOI," says director of marketing Kinana Hussain. "The PE42525 and PE426525 are proof that RF SOI can deliver a high-performing, reliable and fast switching solution at microwave frequencies. As more applications demand higher-frequency products, Peregrine will continue to break more barriers in RF SOI."

The new 60GHz switches join Peregrine's high-frequency product portfolio, which includes multiple switches, an image-reject mixer, and monolithic phase and amplitude controllers (MPACs). Its proprietary UltraCMOS technology platform enables these products to reach high frequencies without compromising performance or reliability, the firm adds.

The PE42525 and PE426525 are each available as a flip-chip die with 500μm bump pitch — reckoned to be the best form factor for high-frequency performance, as it eliminates performance variations due to wire-bond length.

Samples and evaluation kits are available now. For 1000-unit orders, the PE42525 die costs $40 each and the PE426525 $48 each.

www.psemi.com

Peregrine's PE42723 high-linearity RF switch wins 2016 ECN IMPACT Award in Market Disruptor category

Peregrine Semiconductor Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) — says that its UltraCMOS PE42723 high-linearity RF switch has won an ECN IMPACT Award in the market disruptor category. In addition, the PE42723 switch was named a finalist in the microwaves & RF category, and the PE29100 gallium nitride (GaN) field-effect transistor (FET) driver was recognized as a finalist in the power sources & conditioning devices category.

The ECN IMPACT Awards recognize the products and services that have the greatest impact on the electronic components industry. The market disruptor category highlights a product that forever changed the electronic engineering industry or a particular vertical within the industry.

"Products like the PE42723 enable the cable industry to deliver equipment that is fully compliant with today's stringent communication standards," says director of marketing Kinana Hussain.

The PE42723 is an RF switch that is claimed to have the highest linearity specifications on the market. An upgraded version of the PE42722, the new RF switch offers enhanced performance in a smaller package. Like its predecessor, the PE42723 exceeds the linearity requirements of the DOCSIS 3.1 cable industry standard and enables a dual upstream/downstream band architecture in next-generation cable customer premises equipment (CPE) devices.

The PE29100 is claimed to be the world's fastest GaN FET driver. Based on Peregrine's UltraCMOS technology, the new GaN driver is targeted at enabling design engineers to extract the full performance and speed advantages from GaN transistors. Designed to drive the gates of a high-side and a low-side GaN FET in a switching configuration, the PE29100 delivers what are claimed to be the industry's fastest switching speeds, shortest propagation delays and lowest rise and fall times to AC–DC converters, DC–DC converters, class D audio amplifiers, and wireless-charging applications.

www.psemi.com/products/rf-switches/pe42723
www.psemi.com/products/gan-fet-driver/pe29100

X-FAB deploys high-temperature implanter to provide high-volume 6-inch SiC foundry

X-FAB Silicon Foundries of Erfurt, Germany — an analog/mixed-signal IC, sensor and micro-electro-mechanical systems (MEMS) foundry — says that, in collaboration with the US Department of Energy (DOE) and the PowerAmerica (the Next Generation Power Electronics National Manufacturing Innovation Institute, led by North Carolina State University), it has deployed a high-temperature implanter at its facility in Lubbock, Texas, which is said to be the world's first semiconductor foundry to support 6-inch silicon carbide (SiC) production.

Leveraging its existing, high-volume silicon production lines, X-FAB says that it can uniquely offer the economies of scale needed to encourage widespread adoption of power devices based on SiC substrates. It is hence fully equipped to provide a responsive, market-scalable and cost-effective manufacturing capability.

X-FAB's SiC foundry also draws on the firm's reputation for serving the most challenging applications. It is expected that the automotive and industrial sectors will drive SiC uptake, and X-FAB says that this is where it has decades' of insight and experience, delivering key technologies with high degrees of differentiation.

"Through the installation and qualification of this high-temperature implanter we are now ready to support our SiC customers as they move from prototyping to volume production in 2017. This means that they will be right at the forefront of the transition of SiC to 6" wafers," says Andy Wilson, X-FAB Texas' director of strategic business development. "The ongoing backing of the DOE and PowerAmerica has proved instrumental in getting us to this next stage, helping X-FAB to make a major impact in relation to this exciting new technology and ensuring that its potential is fully realized."

www.xfab.com

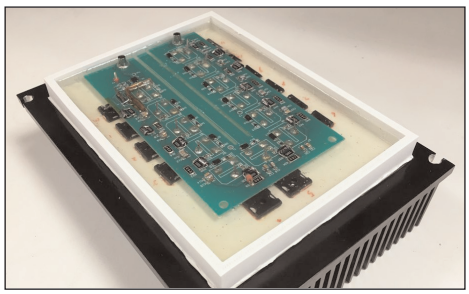
NCSU's FREEDM Systems Center develops low-cost silicon carbide high-voltage switch

Super-Cascode power switch promises 2.4–15kV breakdown voltages

Researchers at North Carolina State University (NCSU) have created a high-voltage and high-frequency silicon carbide (SiC) power switch that could cost much less than similarly rated SiC power switches, it is reckoned. The findings could lead to early applications in the power industry, especially in power converters such as medium-voltage drives, solid-state transformers, and high-voltage transmissions and circuit breakers.

Wide-bandgap semiconductors such as SiC show potential for use in medium- and high-voltage power devices because of their capability to work more efficiently at higher voltages. Currently though, their high cost impedes their widespread adoption over the prevailing workhorse and industry standard — silicon-based insulated-gate bipolar transistors (IGBT) — which generally work well but incur large energy losses when they are turned on and off.

However, the new SiC power switch could cost about half the estimated cost of conventional high-voltage SiC solutions, say Alex Huang and Xiaoqing Song, researchers at NCSU's FREEDM Systems Center, a US National Science Foundation (NSF)-funded engineering research center (ERC). Besides the lower cost, the high-power switch maintains the SiC device's high-efficiency and high-switching-speed characteristics, i.e. it doesn't lose as much energy when it is turned on or off.



FREEDM Super-Cascode power switch.

The FREEDM Super-Cascode power switch combines 12 smaller SiC power devices in series to reach a power rating of 15kV and 40A. It requires only one gate signal to turn it on and off, making it simple to implement and less complicated than IGBT series-connection-based solutions. The power switch is also able to operate over a wide range of temperatures and frequencies due to its proficiency in heat dissipation (a critical factor in power devices).

"Today, there is no high-voltage SiC device commercially available at voltage higher than 1.7kV," says Huang, Progress Energy Distinguished Professor and founding director of the FREEDM Systems Center. "The FREEDM Super-Cascode solution paves the way for power switches to be developed in large quantities with breakdown voltages from 2.4kV to 15kV."

● Xiaoqing Song (a Ph.D. candidate at the FREEDM Systems Center under Huang's supervision) presented the paper '15kV/40A FREEDM Super-Cascode: A Cost Effective SiC High Voltage and High Frequency Power Switch' at the IEEE Energy Conversion Congress & Exposition (ECCE 2016) in Milwaukee (18–22 September).

www.freedm.ncsu.edu

Monolith makes available 1200V SiC Schottky engineering samples

Monolith Semiconductor Inc of Round Rock, TX, USA has announced the availability of engineering samples of 1200V, 5A and 10A silicon carbide (SiC) Schottky diodes in a TO-220 package.

Manufactured in the 150mm SiC foundry of X-FAB Texas, the SiC diodes feature zero reverse recovery current and what is claimed to be superior avalanche ruggedness, excellent surge current capability and low leakage currents at high temperatures. Monolith says that its collaboration with the US Department of Energy (DOE) and Power America (the Next Generation Power Electronics National Manufacturing Innovation Institute, led by North Carolina State University) has been key in achieving manufacturing of the SiC devices.

"While the benefits of SiC devices in improving the efficiency and reducing the size, weight and volume of power electronic systems is well known, the adoption has been slow due to the high cost of these devices," says Monolith's CEO Dr Sujit Banerjee. "Manufacturing these SiC diodes in a high-volume silicon manufacturing facility will enable us to provide cost-effective, high-performance and high-reliability SiC devices," he adds.

"The superior switching performance of these diodes will reduce losses by over 50% compared to silicon diodes, resulting in higher energy efficiency in power electronic applications such as solar inverters, motor drives and power supplies," says Dr Kiran Chatty, VP of Product Development.

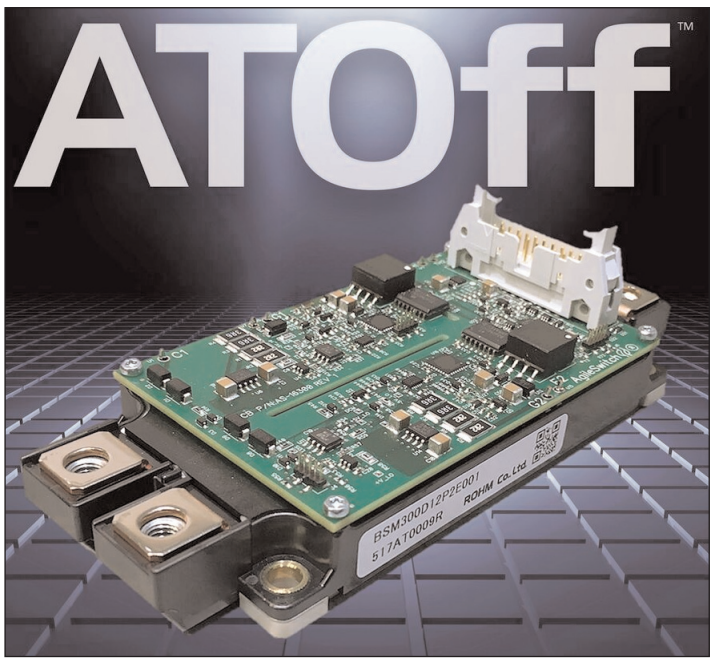
www.monolithsemi.com

AgileSwitch to be awarded patent for Augmented Turn-Off SiC module switching

AgileSwitch LLC of Philadelphia, PA, USA — which produces plug-and-play, programmable silicon IGBT and silicon carbide (SiC) MOSFET gate drive assemblies to address demands for higher performance and functionality at higher voltages and currents — has 'allowed patent claims' related to its proprietary Augmented Turn-Off (ATOff) switching technique. The firm expects the formal patent to be awarded within the next 60-90 days.

ATOff addresses two significant impediments to the implementation of SiC modules in high-power applications. By reducing both turn-off spikes and ringing both under normal operation as well as short-circuit conditions (DSAT), SiC MOSFET modules can be operated in the higher frequencies that enable dramatic increases in power conversion density. A whitepaper describing the performance improvements attained using ATOff is available for download from AgileSwitch's website.

ATOff technology has been incorporated into AgileSwitch's first SiC gate drive assembly. The software-configurable EconoDual Electrical Master 3 (EDEM3) is optimized for driving SiC MOSFETs up to 1200V currently offered by Rohm Co Ltd. The EDEM3 provides up to 15A of peak current at an operating frequency up to 100kHz. The driver includes isolated HI- and LO-side DC/DC converters and monitors seven fault conditions that are reported as a combination of the three fault lines via the 20-pin control header. Applications for the EDEM3 include: solar/PV inverters, wind turbines, energy storage, battery charging, induction heating/welding, electric vehicles (HEV/EV), trains and other traction vehicles.



AgileSwitch intends to incorporate ATOff technology into new gate drivers for 62mm SiC MOSFETs from Wolfspeed, Semikron, Microsemi and others.

"SiC MOSFETs are bringing the promise of improved efficiency and size in power conversion systems, but complexity of designing drivers makes it very challenging for OEMs to take full advantage of these improvements," says CEO Rob Weber. "Our drivers using Augmented Turn-Off are providing OEMs with a fully-integrated solution."

Pricing is $150 (in OEM quantities). Delivery is 1–2 weeks after receipt of order.

www.agileswitch.com

Rohm's third-generation SiC Schottky barrier diodes reduce V_F while increasing surge resistance

Rohm of Kyoto, Japan has made available its 3rd-generation SiC Schottky barrier diodes (SBDs), optimized for power supply PFC (power factor correction) circuits in servers and high-performance PCs.

In recent years, there has been a demand for power components that provide higher efficiencies in order to improve power conversion efficiency and energy savings in the power electronics market (which includes industrial power supplies, solar power systems, electric vehicles, and home appliances). Compared with conventional silicon products, SiC devices feature superior material characteristics, making them preferable for power applications. In particular, in equipment such as servers (where maximum power supply efficiency is demanded), the high-speed recovery characteristics of SiC SBDs have proven effective in increasing device efficiency when used in PFC circuits. Surge current resistance is also an important consideration in high-power applications.

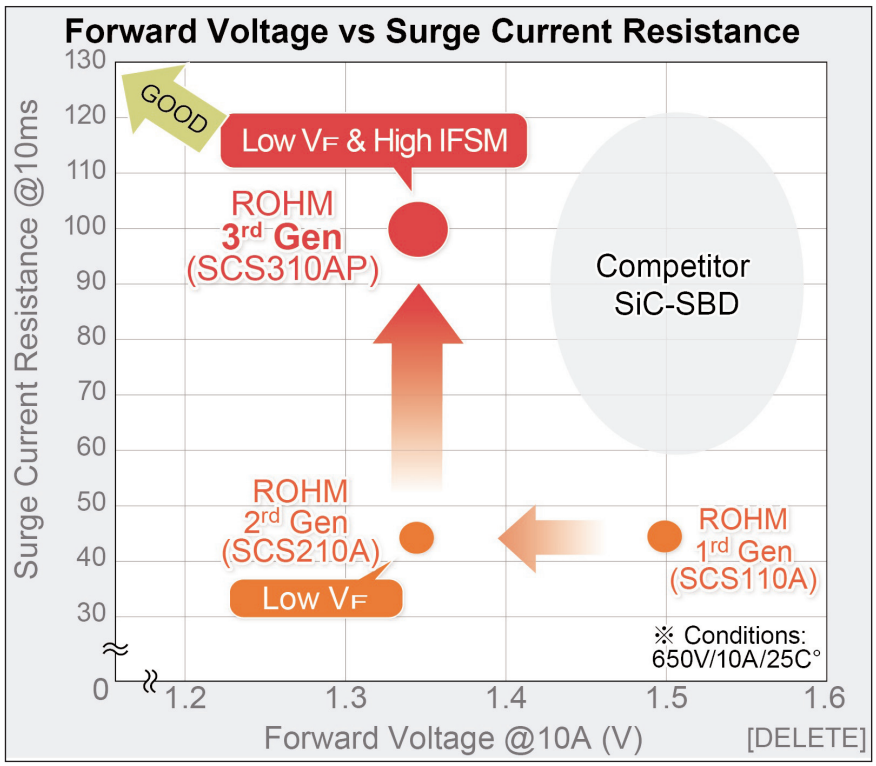
Rohm says that its 1st- and 2nd-generation SiC SBDs continue to be well received in the industry. However, to expand applicability, the new SCS3 3rd-generation SiC SBD series adopts optimized processes and a new JBS (junction barrier Schottky) device structure that improves on the industry-low forward voltage (V_F) characteristics of Rohm's 2nd-generation SiC SBDs (from V_F = 1.55V to 1.44V @ 150°C, both with V_F=1.35V@25°C).

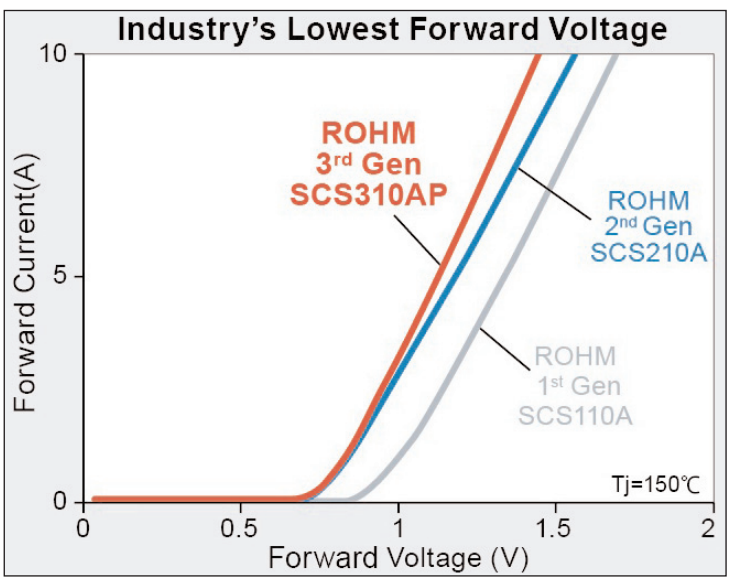
Generally, as forward voltage is reduced, reverse current leakage increases. However, Rohm's new JBS structure minimizes leakage current along with forward voltage characteristics, resulting in 20x less leakage compared with 2nd-generation SiC SBDs at the same rated voltage of 650V (at T_j=150°C).

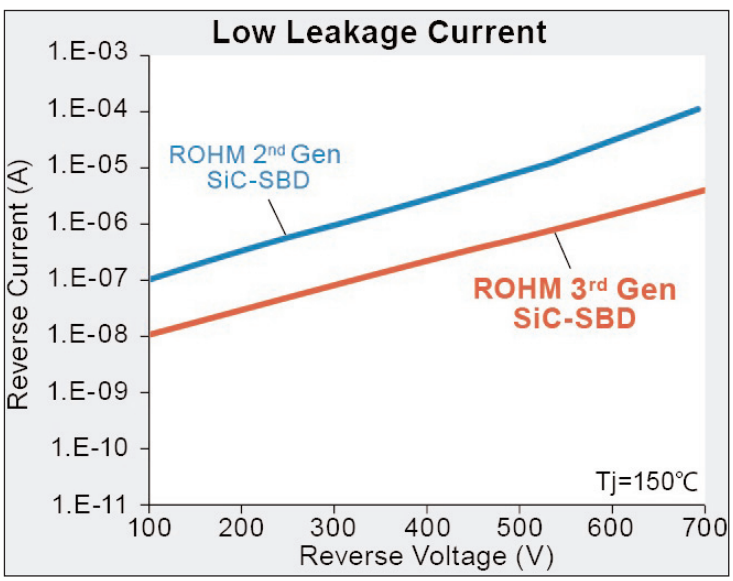
Also, together with what are claimed to be excellent leakage characteristics, there is a significant increase in surge-current resistance (from 40A to 82A). All this contributes to greater application efficiency, says the firm, enabling support for power supply PFC circuits.

Rohm's 3rd-generation SiC SBDs are currently available in the TO-220ACP package. Pricing starts from $2.28 each (in 1000-unit quantities). A surface-mount type (TO-263AB) is scheduled for future release based on market demands.

www.rohm.com





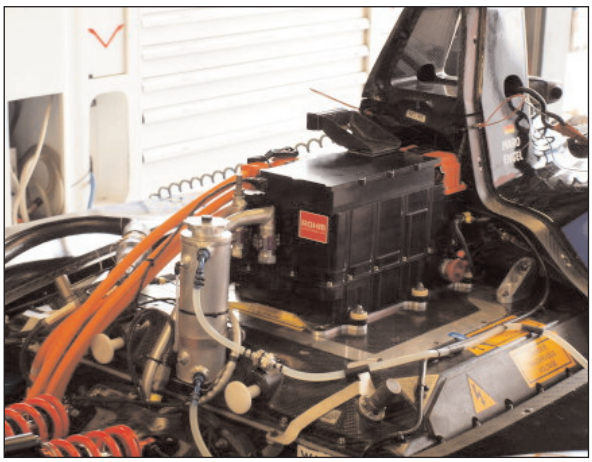


Rohm introduces SiC technology into Formula E

Rohm becomes sponsor & official technology partner of Venturi team

Japan's Rohm Semiconductor has introduced its silicon carbide (SiC) technology at the first race of the new 2016/2017 Formula E season in Hong Kong. With the start of season 3, Rohm is starting its official partnership with the Venturi Formula E team.

The collaboration between Rohm and Venturi in Formula E highlights power management as the key to the all-electric racing series. The challenge of Formula E is to find the most efficient way of using the energy provided by the battery and applying it on the road. Rohm hence developed new power device technology using silicon carbide, which can withstand much higher electric fields than conventional silicon, resulting in extremely low losses of power and higher temperature resistance. Rohm and Venturi thus hope to gain an edge over the competition while also pushing forward development of new technical solutions to increase power conversion efficiency.



Inverter for season 3 in Formula E car.

Venturi FE car on track.

SiC technology making power electronics smaller, stronger and faster

Using SiC technology in power devices, Rohm has achieved lower power consumption and more efficient operation. Compared with conventional silicon, benefits include the following:

- Smaller — System miniaturization means reduced size and weight, allowing improved weight distribution in motorsport and less power consumption in general.
- Stronger — SiC-based devices can work with higher voltages and currents, increasing power density and reducing switching losses even under high temperatures.
- Faster — Increased performance, maximizing speed.

"The silicon carbide technology that Rohm has introduced and which we will be using in our cars from the start of this season allows us to successfully manage the heat being produced, therefore enabling greater engine power," says Venturi Formula E team driver Maro Engel.

The partnership with Rohm "improves the overall electronics of our car, so we can reach higher performance with our electric motors," adds Venturi Formula E team chief technology officer Franck Baldet.

The inverter for season 3 features embedded SiC Schottky diodes, making it 2kg lighter than season 2's inverter. Electric efficiency has been increased by 1.7%, while the volume of heat extraction components has been reduced by 30%. In season 4, the SiC MOSFET integrated inverter will demonstrate drastic changes once again, says Rohm.

Sponsorship and technology partnership targets future development

As a developer of SiC products and power devices in particular, Rohm claims to be the first company to manufacture SiC MOSFETs (in 2010). In the automotive sector, an increasing number of electric vehicles (EVs) and inverters are adopting the use of SiC, and Rohm already has a large market share of on-board chargers for rapid charging.

Rohm is also an industry leader in system LSI, with a large lineup of AEC-Q-approved ASIC and ASSP products, including LED drivers, motor drivers and gate drivers optimized for engine control units (ECUs), as well as standard discrete components such as transistors, diodes, and general ICs.

For the first time, Rohm Semiconductor has become a global sponsor for the brand. The firm says that the partnership exemplifies its commitment to further the development of power and energy management systems, and that bringing SiC technology to Formula E and to e-mobility in general is a key step in changing drive technology. Also, Rohm reckons that, when the collaboration with Venturi shows how effectively the new technology works, SiC power devices will make their way into serial production.

"In the coming years, we should see SiC devices increasingly find their way into power electronics for hybrid and all-electric vehicles, creating simpler and more efficient power systems," says Dr Kazuhide Ino, general manager of Rohm's Power Device Division. "By making more economical technologies available for a wide array of industries and larger parts of society, we hope to take a prominent role in revolutionising energy policy."

http://rohm.com/fe

Wolfspeed launches first 1000V SiC MOSFET

65mΩ MOSFET available in through-hole 4L-TO247 package, with 120mΩ imminent; surface-mount versions later this year

Wolfspeed of Research Triangle Park, NC, USA — a Cree Company that makes silicon carbide (SiC) power products including MOSFETs, Schottky diodes, and modules — has introduced what it claims is the first 1000V MOSFET, which enables a reduction in overall system cost while improving system efficiency and decreasing system size. Specially optimized for fast charging and industrial power supplies, the new MOSFET enables a 30% reduction in component count while achieving more than a 3x increase in power density and a 33% increase in output power.

"Supporting the widespread implementation of off-board charging stations, Wolfspeed's technology enables smaller, more efficient charging systems that provide higher-power charging at lower overall cost," says chief technology officer John Palmour. "This market requires high efficiency and wide output voltage range to address the various electric vehicle (EV) battery voltages being introduced by automotive suppliers," he adds.

"Wolfspeed's new 1000V SiC MOSFET offers system designers ultra-fast switching speeds with a fraction of a silicon MOSFET's switching losses. The figure-of-merit delivered by this device is beyond the reach of any competing silicon-based MOSFET," Palmour reckons.

Designers can reduce component count by moving from silicon-based, three-level topologies to simpler two-level topologies made possible by the SiC MOSFET's 1000V_{ds} rating. The increase in output power in a reduced footprint is realized by the ultra-low output capacitance (as low as 60pF), which significantly lowers switching losses. The new device enables operations at higher switching frequencies, which shrinks the size of the resonant tank elements and decreases overall losses, reducing heat-sink requirements, says the firm. Wolfspeed has determined these proof-points by constructing a 20kW full-bridge resonant LLC converter and comparing it to a market-leading 15kW silicon system.

Wolfspeed offers a 20kW full-bridge resonant LLC converter reference design (part no. CRD-20DD09P-2). This fully assembled hardware set allows designers to quickly evaluate the new 1000V SiC MOSFET and demonstrate its faster switching capability, as well as the increased system power density that the device enables, says the firm.

The 1000V, 65mΩ MOSFET is available in a through-hole 4L-TO247 package (as part no. C3M0065100K) and is available for purchase at Digikey, Mouser and Richardson RFPD.

Wolfspeed plans to release another 1000V MOSFET in a 4L-TO247 package at 120mΩ (C3M0120100K) in the coming weeks. This package has a Kelvin-source connection that allows engineers to create designs that maximize the benefits of SiC's superior speed and efficiency.

Surface-mount versions of these devices (C3M0065100J and C3M0120100J) will be released later this year. Like the 4L-TO247, these will include a Kelvin-source pin to help minimize gate-ringing and reduce system losses.

www.wolfspeed.com/power/products

Qorvo launches compact GaN L- and S-band power amplifiers for advanced radar systems

Qorvo Inc of Greensboro, NC and Hillsboro, OR, USA has launched two new power amplifiers (PAs) including what is claimed to be the first 500W, L-band PA internally matched to 50Ω. The high-power devices are optimized for use in defense and civilian radar systems, with features designed to shorten and simplify system implementation.

Built on Qorvo's gallium nitride (GaN) technology, the new QPD1003 meets the performance needs of high-power phased arrays such as active electronic scanned array (AESA) radars, which operate in the 1.2–1.4GHz frequency range. These systems require PAs that operate at maximum efficiency, resulting in low heat generation in demanding environmental conditions. The QPD1003 addresses these requirements through the use of highly efficient GaN on silicon carbide (SiC) technology.

"This is the first and only compact, internally matched and high-powered L-band PA for AESA radar," claims Roger Hall, general manager of High Performance Solutions at Qorvo.

In addition, Qorvo has also introduced a 450W S-band PA, designed for 3.1–3.5GHz S-band radar systems. Both devices offer advantages in size and ease of implementation over conventional GaN transistors, it is claimed. They enable multiple frequency bands to be covered by a single matched design, reducing circuit footprint and overall complexity when used in multi-kilowatt arrays. Additionally, reducing the amount of power dissipation results in further system operational savings by reducing the need to cool the system.

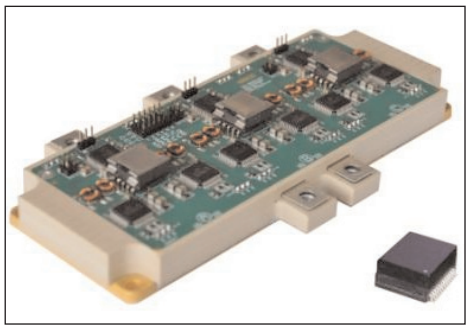
The new PAs support pulsed and linear operations, and are supplied in an air-cavity package suited to defense & civilian radar applications.

www.qorvo.com/defense

CISSOID and DDC cooperate on more compact and reliable SiC intelligent power modules

Fabless high-temperature and extended-lifetime semiconductor firm CISSOID of Mont-Saint-Guibert, Belgium is collaboratingwith Data Device Corp (DDC), which designs and manufactures data bus, motion control and solid-state power controller products for aerospace, defense and industrial applications, and with DDC subsidiary Beta Transformer Technology Corp (BTTC), which produces military, commercial and space-level magnetic components, for the development of more compact and reliable silicon carbide (SiC) MOSFET intelligent power modules (IPM) for aerospace power converters and motor control.

BTTC will develop high-reliability and high-temperature transformer modules, embedding both power and pulse transformers, optimized for CISSOID's HADES2 isolated gate driver. This solution will be used in the SiC MOSFET intelligent power modules developed by CISSOID, making them more compact and reliable. It will address SiC IPMs developed for high-power-density applications as well as IPMs in hermetically sealed packages currently in development for harsh environments (e.g. unpressurized locations and/or extreme temperatures).



An IPM and a TRFO module.

The first transformers modules are being developed, validated and qualified for temperature ranges from –55°C up to +225°C. Magnetic cores and other transformer materials have been selected to offer stable behaviour and reliable operation within this range. The transformers will provide isolation in excess of 2500V_{dc} and are optimized for very low parasitic capacitances in order to support high dV/dt, typically up to 50KV/µs (common with fast-switching SiC transistors). These transformers have been optimized to work with the HADES2 isolated gate driver chipset: the power transformer is used inside a flyback DC–DC converter supplying both low- and high-side isolated gate drivers while pulse transformers are transmitting PWM and Faults signals.

"With DDC and BTTC, we found the right partners to develop high-reliability and high-temperature transformer solutions for our SiC IPM and gate drivers. They bring to CISSOID their long experience in developing signal and power transformers for data transceivers and power converters as well as their high quality manufacturing facilities." says CISSOID's CEO Dave Hutton. "This partnership shows CISSOID's commitment to work with partners to offer to its customers a complete ecosystem for the development of high-temperature system solutions," he adds.

"This first partnership with CISSOID will trigger others as we see various collaboration opportunities between DDC and CISSOID, e.g. the development of high-temperature motor drive or power converter solutions for aerospace, defense and industrial applications," believes Frank Bloomfield, VP Power Systems at DDC.

www.cissoid.com

Qorvo launches new family of 0.15µm GaN-on-SiC die transistors, with new models available from Modelithics

Qorvo Inc, a provider of core technologies and RF solutions for mobile, infrastructure and aerospace/defense applications, has launched a family of gallium nitride (GaN) die transistors with the higher-frequency performance and low noise essential for advanced applications in communications, radar and defense RF systems.

The family includes six new GaN transistors manufactured using Qorvo's QGaN15 0.15µm GaN on silicon carbide (SiC) process and its associated models. The QGaN15 process enables these transistors to offer high-frequency operation of up to 25GHz, supporting die-level designs that deliver higher-frequency, cost-effective discrete technology up through K-band applications.

"The combination of higher-performance GaN products, complementary models and dedicated applications engineering support sets Qorvo apart," claims Roger Hall, general manager of High Performance Solutions at Qorvo.

Linear, non-linear and noise models, which enable rapid, accurate performance testing and speed production readiness, are available from partner Modelithics Inc of Tampa, FL, USA, which provides RF and microwave active and passive simulation models for electronic design automation (EDA). The models offer features such as scaling of operating voltage, ambient temperature and self-heating effects, as well as intrinsic voltage/current node access for waveform optimization.

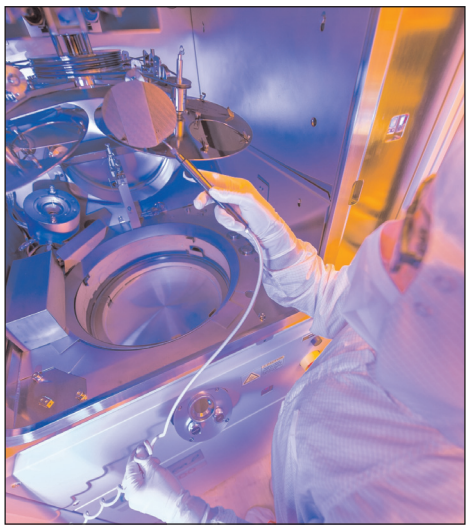
www.modelithics.com/mvpQorvo.asp
www.qorvo.com

AFRL and OSD award Raytheon $14.9m Title III contract to enhance GaN process technology

New contract to boost performance, yield and reliability of GaN-based, wideband MMICs

The US Air Force Research Laboratory (AFRL) and the Office of the Secretary of Defense (OSD) have awarded Raytheon Company of Waltham, MA, USA a $14.9m Title III contract to further enhance its process for producing gallium nitride (GaN)-based semiconductors. The new agreement follows a previous GaN Title III contract, completed in 2013, and aims to increase the performance, yield and reliability of Raytheon GaN-based, wideband, monolithic microwave integrated circuits (MMICs) and circulator components.

As GaN can efficiently amplify high-power radio frequency signals at microwave frequencies (enhancing a system's range and raid handling, while reducing size, weight, power and cost), it is used in a broad spectrum of military radars and defense systems, including the US Navy's Air and Missile Defense Radar (AMDR) and Next Generation Jammer (NGJ).



A GaN wafer undergoes fabrication process in Raytheon's foundry.

"We have only scratched the surface when it comes to harnessing the game-changing power that gallium nitride technology can bring to military applications," believes Colin Whelan, VP of advanced technology in Raytheon's Integrated Defense Systems (IDS) business unit. "This contract will build on the 17-year, $200m+ investment Raytheon has made in maturing GaN," he adds. "Over the next two years, we will further refine our GaN process to push the limits of radio frequency performance while maintaining or increasing yield and reliability."

The first demonstrator of this technology will be incorporated into Raytheon Space and Airborne Systems' Next Generation Jammer program, which is scheduled for low-rate initial production in 2018.

www.raytheon.com

Raytheon wins MDA contract modification to transition AN/TPY-2 radar production from GaAs to GaN

The US Missile Defense Agency has awarded Raytheon Company of Waltham, MA, USA a contract modification to develop a transition to production process to incorporate gallium nitride (GaN) components into existing and future AN/TPY-2 radars. This initial effort will support the transition from gallium arsenide (GaAs) to GaN technology, which would further modernize the ballistic missile defense radar and drive down system obsolescence.

As demonstrated in other Raytheon-developed military radar applications, GaN has the capability to enhance range, increase detection and discrimination performance and lower production costs.

Currently fielded AN/TPY-2 radars use GaAs-based transmit/receive modules to emit high-power radiation. Raytheon and the MDA are pursuing a retrofit approach to leverage GaN elements.

Raytheon's AN/TPY-2 radar.

"GaN components have significant, proven advantages when compared to the previous-generation GaAs technology," says Dave Gulla, VP of Raytheon's Integrated Defense Systems Mission Systems and Sensors business area. "Through this effort, Raytheon will develop a clear modernization upgrade path for the AN/TPY-2 radar, enabling the system to better defend people and critical assets against ballistic missile threats at home and abroad."

The AN/TPY-2 is a transportable X-band radar that protects civilians and infrastructure in the USA, deployed military personnel, and allied nations and security partners from ballistic missile threats. According to recent Congressional testimony by the director of the MDA, the threat is growing as potential adversaries acquire a greater number of ballistic missiles, increase their range, incorporate countermeasures and make them more complex, survivable, reliable and accurate.

www.raytheon.com/capabilities/products/antpy2

Fuji Electric
Innovating Energy Technology

Fuji Electric Lambda Series
New, Compact, Powerful

The New Generation of Low Voltage Earth Leakage Circuit Breakers

- Compact! Ground Fault Protection Built in One Unit for Space Saving Designs
- Same Footprint! MCCBs & ELCBs Interchangeable without Panel Modifications
- 18mm Per Pole Width(2P & 3P), IEC 35mm DIN Rail Mounting
- Higher Capacity SCCR ⇒ 18kA@ 240VAC UL489

Fuji Electric Corp. of America **Distribution & Control Department**

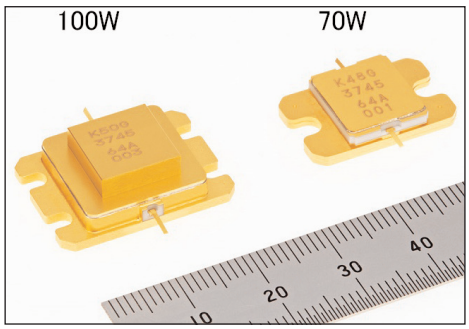
For sales, product & distributor information, please visit http://www.americas.fujielectric.com/componentsdistribution-control

or contact us: x-fea-fecoadc@fujielectric.com

Mitsubishi Electric expanding Ku-band GaN HEMT range to 70W and 100W to shrink satellite earth stations

Tokyo-based Mitsubishi Electric Corp is expanding its lineup of gallium nitride high-electron-mobility transistors (GaN HEMTs) to include models operating at frequencies of 13.75–14.5GHz with saturated output power of 100W (50.0dBm) and 70W (48.3dBm) for use in satellite earth stations utilizing the Ku-band (12–18GHz). Due to optimization of the transistor structure, the new 100W GaN HEMT offers output power that is reckoned to be among the highest available. Sample shipment will begin on 1 October (70W) 2016 and 1 January 2017 (100W).

Mitsubishi Electric says that demand for satellite communications is increasing, especially in the Ku-band, which enables high-speed communication even under adverse conditions such as natural disasters and in areas where construction of communication facilities is difficult. Deployment of transmitter equipment using higher-power GaN HEMTs has become more common in recent years, particularly in high-speed applications such as satellite news gathering.



Mitsubishi Electric's MGFK50G3745 (left) and MGFK48G3745 (right).

To meet this growing demand for higher output power levels, Mitsubishi Electric is hence expanding its Ku-band GaN-HEMT lineup with the 100W MGFK50G3745 model and 70W MGFK48G3745 model (which both have 10.0dB linear gain). Mitsubishi Electric notes that, due to the high output power, the need for fewer parts contributes to the miniaturization of transmitter equipment in satellite earth stations.

In addition, individual transmitter components can be configured independently during manufacture, eliminating the need for on-site configuration and shortening overall development time.

Finally, the existing MGFG5H1503 power amplifier can be used as a driver stage, leveraging the latter's linearizer device to help reduce distortion in power transmitters.

Development of the new devices was partially supported by Japan's New Energy and Industrial Technology Development Organization (NEDO).

www.MitsubishiElectric.com

GaN Systems presents GaN HEMT workshop at China Power Supply Society Conference

At the 24th China Power Supply Society Conference (CPSSC) in Shanghai, China, co-organized by the Power Institute of China and the Shanghai Maritime University, in a three-hour seminar on 31 October, GaN Systems Inc of Ottawa, Ontario, Canada — a fabless developer of gallium nitride (GaN)-based power switching semiconductors for power conversion and control applications — presented the advanced technology session 'GaN E-HEMT Devices, Principles and Applications' as part of a program that introduces the most current power semiconductor devices.

Global applications engineering manager Di Chen will present the seminar to an audience consisting of several hundred researchers and engineers. Topics covered include new wide-bandgap semiconductor technology, and an in-depth analysis of the structure, characteristic parameters, device selection and protection of high-frequency switching devices used for efficient power application problems. The agenda for Chen's workshop was as follows:

- A basic introduction to GaN E-HEMT power transistors;
- GaN E-HEMT principles and package design;
- GaN E-HEMT technology and reliability;
- Driver & component selection;
- PCB layout and thermal considerations; and
- GaN E-HEMT applications.

GaN Systems says that it continues to invest heavily in supporting its Asian customers by providing in-country staff, technical support and resources. This is extended by providing practical technology workshops. The firm says that it is bringing design knowledge to power system engineers, enabling them to rapidly develop the most efficient and competitive products that leverage the performance benefits of gallium nitride.

"More and more customers in China are developing leading-edge power electronics," notes Charles Bailley, director of GaN Systems' Asian operations. "Using GaN, they have been gaining a competitive edge across the industrial, consumer, transportation, and data-center server markets," Bailley adds. "This workshop gives engineers the tools to understand and use GaN transistors so they can meet their customers' power saving demands," he concludes.

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

Mentor Graphics joins Wide Band Gap integration power electronics consortium in Japan

Software provider to participate in thermal management and power cycling initiatives

Electronic hardware and software design and manufacturing solutions provider Mentor Graphics Corp of Wilsonville, OR, USA has joined the Wide Band Gap integration (WBGi) power electronics consortium to participate in thermal management and power cycling initiatives.

Established in 2013 by professors Katsuaki Suganuma and Tsuyoshi Fuaki of Osaka University in Japan, the WBGi Consortium assembles academics and industrialists worldwide to leverage the possibilities of wide-bandgap semiconductors materials such as silicon carbide (SiC) and gallium arsenide (GaN) — which enable devices to operate at much higher voltages, frequencies and temperatures than conventional silicon materials — and the associated challenges.

Mentor Graphics is already an active member of the US-based Center for Power Electronics Systems (CPES) and European Centre for Power Electronics Consortium (ECPE). WBGi is hence the third power electronics consortium that Mentor Graphics has joined, offering its expertise in the field and proven technologies to advance the power and performance of semiconductors, IGBTs, MOSFETs, and other devices.

"One of the key issues for SiC- and GaN-based power electronics is thermal dissipation," says Katsuaki Suganuma, professor at the Institute of Scientific and Industrial Research at Osaka University. "Mentor's T3Ster transient thermal tester hardware is the most advanced technology in its field and can contribute to understanding what is going on in WBG semiconductors," he comments. "There are standards for power LEDs already, and we believe that MicReD technology in the Mentor Graphics Power Tester can help in developing power cycling standards for WBG power electronics."

The WBGi Consortium is addressing all aspects of packaging and reliability in the next generation of power electronics, with 34 industrial company members plus several work groups, workshops and meetings in place. The WBGi is also involved with the ECPE in Europe, USA and Asian partner organizations to establish itself as a global consortium.

"Being a member of the WBGi Consortium in Japan is extremely valuable and important to us," says Roland Feldhinkel, general manager of Mentor Graphics' Mechanical Analysis Division. "Our proven technologies and our team of researchers, educators and scientists are eager to contribute to WBGi's initiatives and working groups," he adds. "Our collaboration with the WGBi and its members can help result in tremendous advancements for the power electronics systems industry worldwide."

www.mentor.com

AKHAN and Blue Wave partner to develop nanocrystalline diamond processes on HFCVD systems

AKHAN Semiconductor Inc of Gurnee, IL, USA, which specializes in the fabrication and application of nanocrystalline (NCD)-based materials & devices for semiconductor and electronic applications, has announced a partnership with Blue Wave Semiconductors Inc of Baltimore, MD, USA (which provides processing tools and thin-film technology components and materials to R&D customers, Federal Government, and industrial partners) that is reckoned to constitute a key step forward for the R&D of both companies, allowing both to expand the functionality and applications of their products and processes.

Blue Wave produces hot-filament chemical vapor deposition (HFCVD) equipment, representing an important differentiator as AKHAN is prepares to fabricate its Miraj diamond material from both microwave and hot-filament systems for a variety of thin-film substrates such as silicon, silicon carbide (SiC), and glass.

AKHAN is partnering with Blue Wave for nanocrystalline diamond process development on HFCVD systems. The partnership should allow AKHAN to optimize its diamond technologies for a variety of optical, mechanical & thermal/electronic product lines and is intended to also facilitate rapid and efficient commercial scaling.

"This partnership will greatly enhance our operational and commercial diamond capability, where our customers can benefit from an optimized lab-to-fab deployment schedule, while maintaining compliance with rigid electronics manufacturing standards," says AKHAN's president & chief operating officer Carl Shurboff.

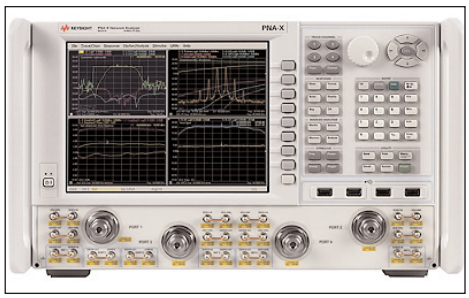
"This partnership strengthens our HFCVD product line for realizing diamond coatings applications to commercial opto-mechanical components," adds Blue Wave's CEO & CTO Dr R.D. Vispute.

www.akhantech.com
www.bluewavesemi.com

Chalmers chooses Keysight and Virginia Diodes to create first system for network & spectrum analysis up to 1.5THz

Capabilities enhance free-space, on-wafer & waveguide measurements of materials, devices and circuits at terahertz frequencies

Keysight Technologies Inc of Santa Rosa, CA, USA (which provides electronic measurement instruments, systems and related software used in the design, development, manufacture, installation, deployment and operation of electronic equipment) has collaborated with Virginia Diodes Inc (VDI, which makes test & measurement equipment for millimeter-wave and terahertz applications) to create a 1.5THz measurement solution for Chalmers University of Technology in Gothenburg, Sweden. Already up and running in Chalmers' national laboratory for terahertz characterization, the industry-first solution provides network and spectrum analysis capabilities for research on new materials, devices and circuits for applications at micro-, millimeter- and sub-millimeter-wave frequencies.



A Keysight PNA network analyzer

Chalmers' researchers are working in the terahertz gap between radio waves and infrared light. The measurement equipment from Keysight provides new capabilities that are enhancing their work with free-space, on-wafer and waveguide measurements in the terahertz gap.

The system is built around the Keysight's PNA-X microwave network analyzer, which covers 10MHz to 67GHz and reaches 1.5THz with external extension modules from VDI. Achieving an insightful understanding of device performance and behavior requires network and spectrum measurements, says Keysight, which claims that the PNA family is the first to provide integrated spectrum analysis capability that reaches into the terahertz range. The ability to access both capabilities in a single test setup — and make multiple measurements through one set of connections — saves time and enhances insight.

www.keysight.com/find/1.5THZ
www.chalmers.se/en
www.vadiodes.com

Tektronix launches Keithley S540 power semiconductor test system targeting SiC and GaN devices up to 3kV

Test, measurement and monitoring equipment supplier Tektronix Inc of Beaverton, OR, USA has introduced the Keithley S540 Power Semiconductor Test System, a fully automated, 48-pin parametric test system for wafer-level testing of power semiconductor devices and structures up to 3kV. Optimized for compound power semiconductor materials including silicon carbide (SiC) and gallium nitride (GaN), the S540 can perform all high-voltage, low-voltage and capacitance tests in a single probe touch-down.

As demand for power semiconductor devices continues to increase and as SiC and GaN become more commercialized, manufacturers are adopting wafer-level testing in their production processes to optimize yields and improve profitability, says Tektronix. For these applications, the S540 lowers cost of ownership by minimizing test time, test set-up time and floor space while achieving lab-grade high-voltage measurement performance, it adds.

"Many fabs are using custom-built, hybrid test systems for power semiconductor testing that require manually changing test setups when moving from low-voltage to high-voltage tests," says Keithley product line general manager Mike Flaherty. "As you might expect, this adds process steps and slows production," he adds. "In contrast, the S540 is a complete, fully integrated solution well suited for production environments where numerous devices must be tested quickly."

To deliver production-level performance, the S540 can perform parametric measurements on up to 48 pins without changing cables or probe card infrastructure. It can also perform transistor capacitance measurements such as Ciss, Coss, and Crss up to 3kV, again without manual reconfiguration of test pins. Further boosting test output, the S540 offers sub-pA measurement performance and can perform fully automated, high-voltage leakage current tests in <1s.

As a standard commercial product, the S540 offers fully traceable system specifications, safety compliance, diagnostics, and worldwide service and support, features that are often missing in home-built or custom systems. The S540 draws on Keithley's 30+ years of semiconductor parametric testing expertise, and safely and seamlessly integrates semiconductor test instrumentation with both low- and high-voltage switching matrices, cabling, probe card adapters, prober drivers and test software.

The Keithley S540 is available to order now, for delivery from March.

www.tek.com/keithley-s540-parametric-test-system

AXT's revenue grows 7% in third-quarter 2016, driven by stronger-than-expected demand for GaAs

InP inventory corrections in China suppress growth

For third-quarter 2016, AXT Inc of Fremont, CA, USA — which makes gallium arsenide (GaAs), indium phosphide (InP) and germanium (Ge) substrates and raw materials — has reported revenue of $21.9m (above the expected $20.5–21.5m). This is up 7% on $20.5m last quarter and up 19% on $18.4m a year ago, driven by stronger-than-expected demand for GaAs.

Of total revenue, 66% came from Asia Pacific, 23% from Europe, and 11% from North America. Only one customer generated over 10% of revenue, and the top five generated 38% (down from 42% last quarter), reflecting the ongoing diversification of both products and customers.

"The global build out of fiber-optical connections continue to be the leading driver of our InP sales," says CEO Morris Young. "Fiber-optic technology is helping to enable the fruition of applications such as cloud computing, the Internet-of-Things and video streaming. Worldwide fiber deployment has 100 million connections in 2015 and is expected to continue to grow for the long term." However, GPON and EPON markets in China are taking a pause to rebalance following two years of strong growth, notes Young. "This softness caused a modest decline in indium phosphide sales in Q3."

"Our raw material business remain under pricing pressure," says Young. Revenue from AXT's seven consolidated joint ventures was down $581,000. "But we are seeing price start to stabilize and in some cases improve," he notes. "Gallium price during the quarter seems to have stabilized and has ticked up a little bit, as has germanium pricing. This could lead to a more favorable pricing environment in quarters to come."

Gross margin has risen further, from 25.1% a year ago and 29.4% last quarter to 34.6% (the highest since Q1/2012), due to higher production volume, a favorable product mix (including InP substrate and other materials with high-end applications) and good progress in manufacturing efficiencies and yield improvements (especially in crystal growth).

Operating expenses have been cut further, from $5.3m a year ago and $5.1m last quarter to $4.9m. "Through the implementation of a number of programs, we are achieving improved deals for both ingots and wafer processing," says Young. "The benefit of these in-progress and other cost-reduction measures are becoming increasingly visible in our financial results."

Net income has recovered further, from breakeven a year ago and $1.2m ($0.03 per diluted share) last quarter to $2.2m ($0.07 per diluted share, above the expected $0.03-0.05 per diluted share).

Depreciation and amortization were steady at $1.2m. Capital expenditure (CapEx) was $0.5m (halved from $1m last quarter). After generating positive cash flow during Q3, cash, cash equivalents and investments rose by $2.4m from $45m to $47.3m.

For Q4/2016, revenue is expected to fall to $18.5–19.5m. InP revenue will rebound slightly, as increasing growth for fiber-to-the-home (FTTH) deployment and data-center connectivity will offset the continuing GPON- and EPON-related inventory adjustment in China. However, this will be outweighed by declines of $0.15m in germanium, $1m in GaAs (due mainly to temporary inventory adjustments by two major customers for semi-insulating GaAs following an unusually strong Q3, plus a slight $100,000–150,000 decline in semiconducting GaAs), and $1.5m in raw materials (following a strong Q3, which had included a sizable delivery to Japan of about 10 tons of gallium). Net income should be $0.02–0.04 per diluted share.

"In spite of these near-term factors that are expected in a down quarter in Q4, we do not see any fundamental changes in our key markets," notes chief financial officer Gary Fischer.

"Sales of semi-insulating GaAs has reached a relative stable level that provides a healthy base of profitable revenue," says Young. "Also, we are working with customers on certain investigations of new applications for the material that could provide future upside potential," he adds. "In the semiconducting GaAs market, we continue to participate selectively in high-end LED applications such as backlighting, signage and automotive," continues Young. "While the LED market remains highly competitive and fragmented, we are seeing relative stable demand that we expect to continue into 2017."

"Long term, we are closely watching the continued market development of VCSELs for 3D sensing applications, such as gaming, mobile phones, smart TVs, high-speed communications and high-power material processing. 3D sensing requires devices with relative high-precision functionality and consistent reliability," Young notes. This translates into the need for very low defect densities, i.e. very low etch-pit density (EPD). "Our VGF technology and proprietary processes allow us to offer industry-leading specifications that creates a significant competitive advantage for high-end VCSEL applications. This application could provide an attractive opportunity for our business if it is adopted into high-end smartphones, which could total 500–600 million units per year."

"We are focusing our resources on strategic product applications in InP, GaAs and Ge substrates that are showing promising market trends," Young says. "InP is a growth driver for our business in fiscal year 2017 and beyond, and we expect that GaAs will continue to provide a stable revenue base with upside potential from VCSELs and other investigational applications," adds Fischer.

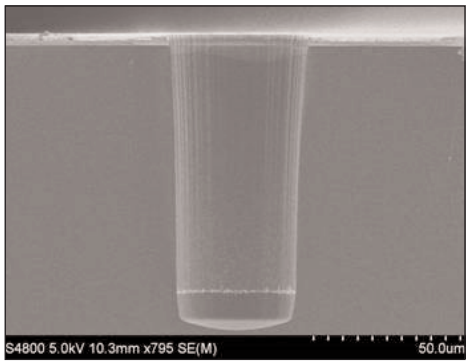
www.axt.com

Oxford Instruments develops SiC via etch for GaN-on-SiC RF device manufacture

UK-based process equipment maker Oxford Instruments has announced the development and launch of a silicon carbide (SiC) via plasma etch process using its PlasmaPro100 Polaris etch system.

SiC is becoming an increasingly important material, particularly for gallium nitride (GaN) RF devices using SiC as a substrate. A smooth via etch through the SiC is essential to enable these devices. Oxford Instruments says that it has developed a solution for etching high-quality SiC vias efficiently. Combined with a low-damage GaN etch within the same hardware, the PlasmaPro100 Polaris offers what is claimed to be a unique capability for GaN-based RF device plasma etch processing requirements.

The new technology offers several process capabilities suited to the SiC via application:



SEM showing smooth via etch through SiC.

- high SiC etch rate, enabling maximum throughput;
- smooth sidewalls for problem-free post-etch metallization;
- high selectivity to underlying GaN layers, giving a smooth, low-damage stop onto the GaN device layers;
- clamping of sapphire carriers using Oxford Instruments' patented Electrostatic Clamp technology, ensuring sample temperature control and maximum yield;
- capability of etching SiC and GaN in the same tool through advanced plasma source technology; and
- high utilization provided by long mean time between cleans (MTBC).

"Our applications specialists have spent significant time developing this SiC via etch process on the PlasmaPro100 Polaris etch system, enabling high selectivity and throughput, amongst other benefits," says Dr Mark Dineen, optoelectronics product manager at Oxford Instruments Plasma Technology (OIPT). "These benefits will enable our customers to etch both SiC and GaN in the same tool through advanced plasma source technology," he adds.

www.oxford-instruments.com/plasma

Veeco reducing investment in ALD technology after revenue realization delayed

Q3 revenue expected to be at high end of $70–85m guidance range

Deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has announced additional cost-reduction initiatives after deciding to significantly reduce future investments in its atomic layer deposition (ALD) technology development, reflecting its ongoing focus to balance technology investments with the potential for associated revenue realization.

ALD cost-reduction activities are expected to be completed by the end of 2016 and are in addition to the restructuring plans (announced on 1 August), which targeted $20m in annualized savings (starting in first-quarter 2017). In total, these initiatives are now expected to generate $30m in annualized savings.

"While we have continued to make progress with our ALD technology development for advanced semiconductor applications, the expected timing for revenue realization has been delayed," says chairman & CEO John R. Peeler. "Consequently, we have made the difficult decision to lower investments in our ALD program," he adds. "We plan to retain the intellectual property and technology capabilities and continue to assess future market opportunities."

In third-quarter 2016, Veeco expects to record total asset impairment and restructuring charges of $56–62m ($1.44–1.59 on a per-share basis). Of these charges, the vast majority are non-cash, relating to an intangible ALD asset impairment, while about $2m are cash restructuring charges.

Q3 revenue guidance update

Overall LED industry conditions and demand for Veeco's products have continued to improve, says the firm. As a result, revenue for third-quarter 2016 is expected to be at the high end of the guidance range of $70–85m (announced on 1 August). Veeco plans to issue third-quarter 2016 financial results on 1 November.

www.veeco.com

CNR-IMM Italy using SENTECH PEALD system for new high-k materials on wide-bandgap devices

SENTECH Instruments GmbH of Berlin, Germany says that the Institute for Microelectronics and Microsystems (CNR-IMM) in Catania — which is part of the Physics and Matter Technologies Department (DSFTM) of the National Research Council of Italy (CNR) — is using an SI PEALD LL plasma-enhanced atomic layer deposition tool with an 8-inch wafer configuration to investigate the integration of novel high-k gate dielectrics and passivating layers on devices based on gallium nitride (GaN) and other wide-bandgap semiconductors.

SENTECH says that its proprietary true remote CCP (capacitively coupled plasma) source is especially suited to such low-temperature and no-damage applications. The special design of the plasma source allows only radicals to reach the wafer surface, whereas high-energy photons and ions are completely blocked.

In conjunction, IMM and SENTECH have signed a joint development agreement (JDA) with the aim of the developing and characterizing laminated layers. The use of alternative high-k materials enables the shrinking of devices while maintaining their capacitance and reducing the leakage current density. In particular, the growth of Al_2O_3-HfO_2 laminated layers is among the most often used combinations for such applications.

"The SENTECH SI PEALD LL reactor is a high-performance and flexible system, allowing the production of several high-quality dielectric thin films, whose physical properties can be tailored upon changing their chemical composition," says Dr Raffaella Lo Nigro, who is the scientist in charge of the SI PEALD LL tool and of cooperation with SENTECH. Nigro has wide-ranging expertise in the synthesis of binary and complex thin films by chemical vapor deposition (CVD) methods for several microelectronic applications. "Possible applications of this activity are related not only to the integration of novel gate dielectrics and passivating layers on wide-bandgap semiconductors but also for RF devices based on graphene," he adds.

The results of this work have already been published in scientific papers (Raffaella Lo Nigro, Emanuela Schilirò, Giuseppe Greco, Patrick Fiorenza and Fabrizio Roccaforte, Thin Solid Films, vol601, 2016, p68–72). Nanolaminated Al_2O_3-HfO_2 and Al_2O_3/HfO_2 bilayer thin films have been grown by PEALD on silicon substrates. Morphological, crystalline and electrical properties of the layer stacks were analyzed after low-temperature deposition and high thermal treatment.

The highly stable deposition of single films and multi-layer laminates using SENTECH PEALD together with very good uniformity of the deposition process over the whole wafer are essential prerequisites for applications such as designing new high-k dielectrics, says the firm.

www.sentech.de

Clearance withdrawn for sale of Aixtron to Grand Chip

Review proceedings to be reopened

On 21 October, deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany was told that Germany's Federal Ministry of Economics and Energy (Bundesministerium für Wirtschaft und Energie, or BMWi) had withdrawn the Clearance Certificate issued on 8 September to China's Fujian Grand Chip Investment Fund LP (an indirect shareholder of German subsidiary Grand Chip Investment GmbH) regarding its proposed offer to acquire Aixtron, and reopened review proceedings.

In May, Aixtron agreed to a takeover by Grand Chip Investment GmbH. Fujian Grand Chip Investment Fund LP is held 51% by Chinese businessman and private investor Zhendong Liu and 49% by Xiamen Bohao Investment Ltd (which is indirectly controlled by private investors Zhongyao Wang and Wanming Huang).

Fujian Grand Chip (FGC) hence announced a voluntary public takeover offer to acquire all of Aixtron SE's outstanding ordinary shares and American depository shares (ADS). Shareholders were offered €6 per ordinary share, valuing Aixtron's equity (including net cash) at about €670m and reflecting a 50.7% premium to the three-month volume weighted average share price prior to the announcement.

Aixtron and FGC said the transaction aimed to support Aixtron's long-term R&D activities to bring new products and technologies to market, support the execution of the firm's current strategy and technology roadmaps, and improve its ability to compete and grow in China. Specifically, R&D competency and Aixtron's existing technology were to be maintained at the existing technology centers. FGC also agreed that Aixtron would further strengthen its technology and IP portfolio, which would remain vested with Aixtron, including in Germany. In addition, Aixtron's existing global set up would be maintained and expanded at its three technology hubs in Herzogenrath (Germany), Cambridge (UK) and Sunnyvale, CA (USA), possibly supplemented by further international technology hubs. The legal domicile and headquarters would remain in Herzogenrath. Martin Goetzeler was to remain CEO of Aixtron and Dr Bernd Schulte chief operating officer, with FGC nominating four candidates to the six-member Supervisory Board.

However, according to the BMWi, information available to the German Federal Government indicated that Aixtron's know-how also comprises security-related technologies (in particular for the defense sector) that could be revealed through the acquisition.

According to the New York Times, concerns have arisen regarding possible links between Chinese state investment in both FGC and San'an Optoelectronics Co Ltd (China's largest LED maker). Berlin-based think-tank Mercator Institute says that Xiamen Bohao is a local government investment fund that has links to San'an. In early 2016, San'an failed to qualify Aixtron's new AIX R6 metal-organic chemical vapor deposition (MOCVD) system, leading to the truncation of a large multi-system order. This prompted a drop in Aixtron's share price, prior to the deal with FGC.

www.grandchip-aixtron.com
www.aixtron.com

Changelight adds capacity with Veeco K475i technology

Optoelectronics manufacturer Changelight Co Ltd of Xiamen, Fujian Province, China has ordered additional Veeco TurboDisc K475i arsenic phosphide (As/P) metal-organic chemical vapor deposition (MOCVD) system capability to boost production of red, orange, yellow (R/O/Y) LEDs. Changelight qualified and put into production Veeco's premiere K475i system in February.

"Our first K475i system has exceeded our expectations in terms of lowering manufacturing costs, driving exceptional uniformity and producing unmatched yield and brightness," says Shuangxiang Zhang, general manager of Yangzhou Changelight. "Adding this capability will enable us to meet existing demand for red, orange, yellow LEDs, as well as position ourselves to capitalize on the emerging As/P photonics market."

Introduced in February, the K475i system incorporates proprietary TurboDisc and Uniform FlowFlange MOCVD technologies and enables users to reduce LED cost per wafer by up to 20% compared with alternative systems, it is reckoned, via higher productivity, best-in-class yields and reduced operating expenses.

"Changelight's quick adoption of Veeco's K475i technology is a testament of its production-proven functionality," says Veeco's president William J. Miller Ph.D. "Changelight will benefit from superior uniformity and repeatability, lowering their cost of ownership."

Veeco says that its proprietary Uniform FlowFlange technology produces films with very high uniformity and improved within-wafer and wafer-to-wafer repeatability, resulting in what is reckoned to be the industry's lowest cost of ownership. The patented technology is said to provide ease-of-tuning for fast process optimization and fast tool recovery time after maintenance, enabling the highest productivity for applications such as lighting, display, solar, edge-emitter laser diodes, vertical-cavity surface-emitting lasers (VCSELs) and hetero-junction bipolar transistors (HBTs).

www.changelight.com.cn/en
www.veeco.com/products/turbodisc-k475i-asp-mocvd-system

Oxford Instruments' 2016 technical workshops return to IISc Bangalore

UK-based Oxford Instruments has announced its 2016 technical workshops in India (22–23 November). Now in their fifth year (following previous workshops in Bangalore, Mumbai, Chennai, Kolkata and Mohali), this year's event 'Bringing the Nanoworld Together 2016' returns to the Indian Institute of Science (IISc) Bangalore, the location of the first workshop.

Showcasing nanotechnology tools and their use in multiple applications, the two-day seminar will comprise over 24 talks from Indian and international speakers, as well as Oxford Instruments scientists. There will also be technical poster sessions, providing participants with the chance to discuss research in detail, as well as networking opportunities.

The event is organised in two parallel sessions:

- Sessions on Nanoscale Plasma Processing cover multiple areas including the latest advances in etch and deposition technologies, graphene and 2D materials and their applications, ion beam technologies, and emerging applications including atomic-scale processing, quantum and BioMEMS.
- Sessions on NanoScience Cryofree research tools comprise an introduction to nanotechnology, innovations in ultra-low-temperature research, sensing individual photons with atomic membranes, the latest developments in cryogen-free high-magnetic-field and low-temperature sample environments for neutron scattering, the application relevance of key Cryofree tool innovations, and more.

"We intend these educational seminars to improve participants' knowledge, and to keep them abreast of the latest technological advances in these research areas," says Frazer Anderson, strategic marketing & development director for Oxford Instruments Plasma Technology (OIPT). "The workshops provide ample opportunities for networking, debate and discussion around the rapidly evolving nanotechnology world."

The seminar is free to attend but prior booking is essential, as previous seminars have seen over 300 registrations.

www.oxford-instruments.com/btnt

SPTS wins two Best Factory Awards and two Insider Made in Wales Awards

SPTS Technologies Ltd of Newport, Wales, UK (an Orbotech company that manufactures etch, PVD and CVD wafer processing solutions for the MEMS, advanced packaging, LED, high-speed RF on GaAs, and power management device markets) has recently won four business awards.

At this year's Best Factory Awards organized by Cranfield School of Management, SPTS was presented with the Innovation Award and the Export Award. Having met the qualification criteria set by the judging panel as well as a comprehensive factory audit, the Innovation Award recognizes SPTS for its level of innovation throughout the company. The Export Award notes the firm's proportion of export sales of 95%. The judges noted the multi-dimensional aspects of innovation at SPTS, which enables the firm to remain at the forefront of technical advances in semiconductor process technologies and to bring industry-leading products to its global markets. The judges also pointed to SPTS' lean manufacturing processes and commitment to continuous improvement which provides improved operational efficiencies and annual cost savings to the business.

Also, at the ceremony for the Insider 2016 Made in Wales Awards at Cardiff City Hall (which celebrate the best in manufacturing, design and product development from across Wales), SPTS received the Apprenticeship Scheme of the Year Award and was crowned the Large Manufacturer of the Year. The Made in Wales Awards also recognized SPTS Technologies' export sales by short listing it in the Exporter of the Year Award category.

The Export Award notes the firm's proportion of export sales of 95%

"It's the commitment to continuous improvement across the entire organization that has allowed us to grow our business, both operationally and profitably, year on year," says Kevin Crofton, president of SPTS and corporate VP at Orbotech. "The Best Factory Awards judging process was on par with some of our most demanding customer audits, and we are extremely proud to be recognized for manufacturing excellence by the team of assessors from Cranfield School of Management, the IEE and other independent institutions," he adds.

The Insider Made in Wales Apprenticeship Scheme of the Year Award "recognizes our commitment to identifying and attracting young people to our industry and company," Crofton continues. "Our apprenticeship program is one element of many programs that helps SPTS ensure our future with a skilled talent pool."

www.spts.com

PRODUCE SUPERIOR SPECIMENS EVERY PROCESS WITH

THE NEW PM6: PRECISION LAPPING & POLISHING SYSTEM

LOGITECH
Materials Technologists & Engineers

- Process wafers up to 4"/100mm diameter
- Plate speeds of up to 100rpm - faster lapping rates & increased MRR
- Automatic Plate Flatness Control
- Real time data collection & feed back via Bluetooth
- Increased accuracy with polishing rates improved 30% - 50%*

The PM6 Precision Lapping & Polishing system delivers enhance process performance through a range of intuitibe operator controls, such as combined lapping & polishing options and Bluetooth enabled features. This bench-top solution allows for easy process repeatability, faster processes and high levels of user control.

E: ENQUIRIES@LOGITECH.UK.COM
T: +44(0)1389 875444
WWW.LOGITECH.UK.COM

*Compared to Logitech PM5 System

DISCOVER PROGRESS

RIT awarded NSF grant for ICP-RIE etch system for photonics and nanoelectronic device R&D

Jing Zhang, an engineering faculty member at Rochester Institute of Technology, has received a $305,000 grant from the US National Science Foundation (NSF) to acquire an inductively coupled plasma reactive-ion etching (ICP-RIE) system for photonic, electronic and bio-device fabrication. The system strengthens RIT's fabrication capability in its Semiconductor & Microsystems Fabrication Laboratory to support new and existing multi-disciplinary research in science and engineering, to enable educational curriculum development, and be used for workforce development and training activities led by RIT's engineering college.

"There is no equipment like this close by so there was a huge need, and it will help with collaborations we have with other university and corporate researchers," says Zhang, the Kate Gleason Endowed Assistant Professor in the electrical and microelectronic engineering department in RIT's Kate Gleason College of Engineering.

"The instrument is essential to enable research and education on III-nitride-based light-emitting diodes and lasers, and other semiconductor devices. We are studying every aspect of this material, from understanding the physics to the realization of novel devices. This equipment will help with that process," says Zhang, who has been at RIT since 2014 and is part of a growing group of semiconductor materials and photonics device researchers at the university. She has expertise in ultraviolet and visible LEDs, and in developing semiconductors for optoelectronic and electronic devices.

With the emphasis on workforce development in photonics, having the new equipment also provides a key educational opportunity for training. RIT's microelectronic engineering department provides short courses in semiconductor fabrication for area high school and community college teachers and for regional company employees looking to advance knowledge in this area.

The instrument is essential to enable research and education on III-nitride-based light-emitting diodes and lasers

In the past year, RIT also acquired a metal-organic vapor-phase epitaxy (MOVPE) system for the growth of III-V materials. The tool gives researchers the ability to fabricate optical and electronic devices and will be a key learning and training resource. This capability was once an outsourced to research laboratory partners such as NASA. Now, the in-house functionality provided by this equipment, combined with the ICP-RIE system, is available to RIT researchers as well as the regional Rochester photonics community, including partners in the consortium AIM Photonics (American Institute for Manufacturing Photonics), Zhang says.

www.smfl.rit.edu

CORIAL announces hard materials DRIE processes for MEMS manufacturing

Plasma etch and deposition equipment maker CORIAL S.A.S. of Bernin, France has announced the availability of hard materials deep etch processes using a new generation of 200mm ICP-RIE (inductively coupled plasma reactive-ion etch) equipment.

"With this new generation of 200mm ICP-RIE equipment, not only new customers will benefit from enlarged process capabilities towards deep etching of hard materials, but contracted customers would also be able to get access to this technology through system upgrades," notes marketing manager Elsa Bernard-Moulin.

Deep etching of silicon, achieved via Bosch or cryogenic microfabrication technologies, is routinely used for micro-electro-mechanical system (MEMS) manufacturing to create micro-structures with high depth and high aspect ratios.

Besides silicon, a number of hard materials — typically glass, quartz, silicon carbide (SiC) and lithium tantalate — have attracted interest in the MEMS and packaging industries, either due to their unique properties or to reduce manufacturing costs. One of the main challenges to the adoption of these hard materials is the ability to create deep structures using deep reactive-ion etching (DRIE) processes.

In recent months, CORIAL's R&D team has developed appropriate processes and equipment for hard materials DRIE. "We have upgraded our ICP-RIE equipment with features such as high-power (2kW) ICP source, high-power (1kW) RF bias supply, retractable quartz liner to protect the reactor walls, higher-capacity turbo pump, or optimized system for wafer cooling," says Bernard-Moulin. "These system upgrades, combined with the experience of our application specialists, have enabled us to develop hard materials DRIE processes with high etch rate, superior profile control, smooth surface, excellent selectivity and anisotropic profile for more than 100µm depth".

www.corial.net

SEMI GAS®

THE MARK OF

Purity.
Precision.
Performance.

When it comes to ultra high purity gas delivery systems, look for the mark of excellence.

For over 35 years, **SEMI-GAS® has been the semiconductor industry's go-to brand for premier, production-ready, ultra high purity gas delivery systems.** Today, Tier 1 leaders and high-tech innovators all over the world look to SEMI-GAS® for proven solutions that uphold their rigorous application demands.

Learn more at **www.semi-gas.com/mark**

SEMI-GAS® IS POWERED BY

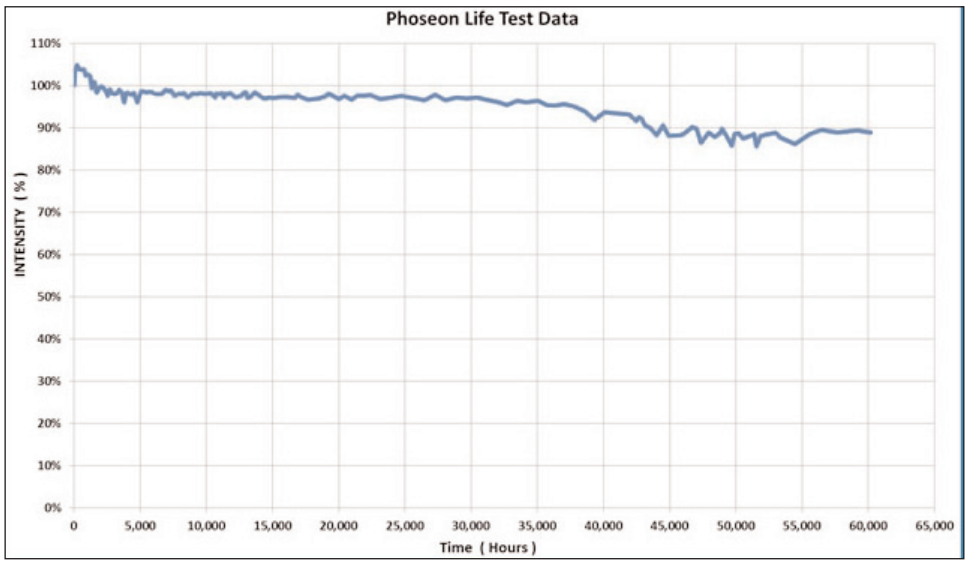
APPLIED ENERGY SYSTEMS

Phoseon surpasses 60,000 hours of LED lamp lifetime

UV LED curing firm Phoseon Technology of Hillsboro, OR, USA says that its air-cooled LED lamp has surpassed 60,000 hours of operational on-time with irradiance greater than 80% of its original output when the test first began seven years ago.

Phoseon's reliability testing includes highly accelerated life testing, temperature and vibration assessments. The light sources are stressed with decreased air flow, high temperatures and other parameters that mimic the harsh working conditions of industrial LED curing equipment.

"The lamp that has been running for 60,000 hours is the result of Phoseon's technology seven years ago; imagine how reliable the technology is today," notes president & CEO Bill Cortelyou. "Recent advances such as patented WhisperCool technology and TargetCure technology play a very important role in the quality and performance of the product," he adds. "With the development of more than 250 patents, Phoseon has worked tirelessly throughout the years to ensure products are rugged and reliable in even the harshest environments."



The firm reckons that, with more than 50,000 units installed worldwide, no other company has the depth of installations and run hours for commercial and industrial applications.

"With customers worldwide, Atlantic Zeiser relies on Phoseon products to provide process stability and a very long lifetime for their customers," comments Jens Walkerling (team leader Inkjet Development) of Atlantic Zeiser, which provides coding and marking for industrial customers. "Atlantic Zeiser started using Phoseon's LED curing products approximately ten years ago, and continues to be a strong supporter of the technology."

www.phoseon.com/technology/reliability-engineering

Phoseon launches FireEdge FE400 LED curing systems for both full-cure and pinning applications

UV LED curing firm Phoseon Technology of Hillsboro, OR, USA has launched FireEdge FE400 LED curing products which, with built-in intensity control options and by providing high UV power, can be used for both full-cure and pinning applications.

The new air-cooled products offer process stability via Phoseon's patented TargetCure technology, which provides precise and predictable UV output. The firm's unique scaling feature allows units to be stacked 'end to end' with contiguous, uniform UV output to fit any application size.

The FireEdge FE400 is also equipped with WhisperCool technology that provides a quieter solution with high UV output and small form factor. WhisperCool technology uses proprietary and patented Phoseon innovations that translate directly to higher productivity, the firm adds.

The FireEdge FE400 light source.

The FE400 light sources deliver 8W/cm^2 peak intensity and come in multiple curing lengths

"Customers will have the ability to control intensity to a wider range of power levels, and scale to any size for easy integration," says product marketing manager Joe Becker.

The FE400 light sources deliver 8W/cm^2 peak intensity and come in multiple curing lengths (80mm, 120mm, 160mm, 180mm and 240mm), all with a 10mm-wide curing window. Accessories include cables, power supply, hub unit, optics options, air inlet options, and extended warranty.

Products are available in fourth-quarter 2016.

www.phoseon.com/products/uv-curing-systems/fireedge

Excelitas adds higher-power UV LED curing system for fiber-optic coatings

Excelitas Technologies Corp of Waltham, MA, USA, which provides customized photonic solutions to OEMs, has expanded its OmniCure product line with a higher-power UV LED curing system for fiber-optic coatings.

The new OmniCure AC8225-F+ features a custom optical design that provides optical performance over longer working distances — a typical requirement for fiber coating processes. With high peak irradiance and efficiency, the system supports increased line speeds and allows significant cost savings from reduced electricity consumption.

The compact, air-cooled UV LED curing system can be integrated into existing or new production lines, and is suitable for optical fiber coating or marking applications, as well as applications such as display bonding. The AC8225-F+ provides peak irradiance of up to 16W/cm^2 at 10–15mm working distances, as well as superior uniformity for rapid, even curing with greatly reduced power consumption compared with either traditional lamp solutions or other LED products, it is claimed. It also includes an optional replaceable window for added protection, while supporting the ability to adjoin multiple UV LED systems without compromising on optical uniformity between each curing system.

"The new OmniCure AC8225-F+ delivers higher irradiance and performance parameters to enhance fiber-optic coating applications," says Oliver Scheuss, VP of Solid State Lighting and UV/Microscopy at Excelitas. "As a result, users can significantly lower electrical and equipment maintenance costs while increasing production speeds."

The AC8225-F+ UV LED curing system was showcased at the International Cable Connectivity Symposium (IWCS 2016) in Providence, RI, USA (3–5 October).

www.excelitas.com

AquiSense appoints director of business development

AquiSense Technologies LLC of Erlanger, KY, USA (which designs and manufactures water, air and surface disinfection systems based on UV-C LEDs) has appointed Jim Cosman as director of business development.

Cosman has a background developing new markets for UV disinfection globally, having spent most of his career in product and market management roles within the Trojan Technologies group of UV companies. He also has expertise in regulatory issues, having spent time in regulatory affairs. Combined, he has 18 years of experience in market development for the water treatment industry.

"His market and regulatory expertise, combined with our breakthrough UV-C LED system designs, will increase our pace of growth," reckons AquiSense's CEO Oliver Lawal.

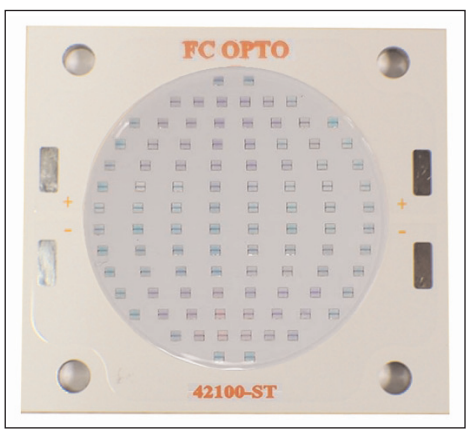
www.aquisense.com
www.NikkisoUVLED.com

Flip Chip Opto launches 100W & 200W UV-A COB LEDs

Flip Chip Opto Inc of Fremont, CA, USA has launched its Ares Series UV-A spectrum flip chip COB (chip-on-board) LED module as part of its standard product line up.

The Ares Series is based on patented DBR (distributed Bragg reflector) flip-chip LEDs and features unique proprietary low-temperature bonding technology that boosts lighting efficiency and decreases thermal resistance between the LED chip junction and the module's metal substrate.

The Ares Series features 100W and 200W COB modules with two different variants in the UV-A illumination spectrum at peak wavelengths of 375±5nm and 395±5nm.



The Ares 100 UV-A COB LED module.

The Ares 100A consumes maximum power of 185W (375nm peak) and 167W (395nm peak) and has a thermal resistance of 0.18°C/W.

The Ares 200A consumes maximum power of 360W (375nm peak) and 327W (395nm peak) and has a thermal resistance of 0.12°C/W. Both the 100W and 200W modules have dimensions of 42mm x 42mm x 3mm, with light-emitting surfaces of 30mm and 32mm, respectively.

Flip Chip Opto reckons that the new single-source UV LED module will open up new applications and solutions to a wide spectrum of industries including medical, sterilization, disinfection, horticulture and indoor gardening, food processing, phototherapy, security, sensors, and industrial curing applications.

www.fcopto.com

Advanced UV for Life exhibits custom-tailored UV LED developments at micro photonics fair

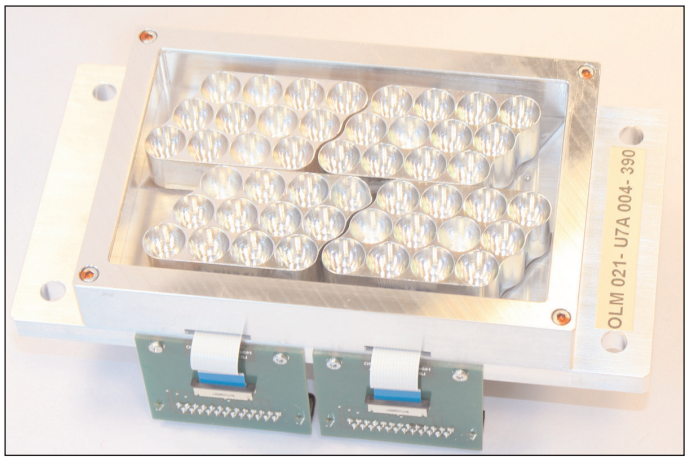
At the micro photonics 2016 International Congress & Expo in Berlin, Germany (11–13 October), the consortium Advanced UV for Life presented a selection of current developments.

In the interdisciplinary consortium, 37 scientific institutions and industrial companies with expertise along the entire value chain of ultraviolet light-emitting diode (UV LED) technology — from development to applications — have partnered to promote the technological development, availability and use of UV LEDs. Funded by Germany's Federal Ministry of Education and Science (BMBF) the program 'Twenty20 — Partnership for Innovation', Advanced UV for Life is managed by the Ferdinand-Braun-Institut (FBH) and addresses customized solutions in application fields including medicine, environment & life sciences, water treatment, and production.

At the micro photonics fair, Advanced UV for Life was represented by the following partners:

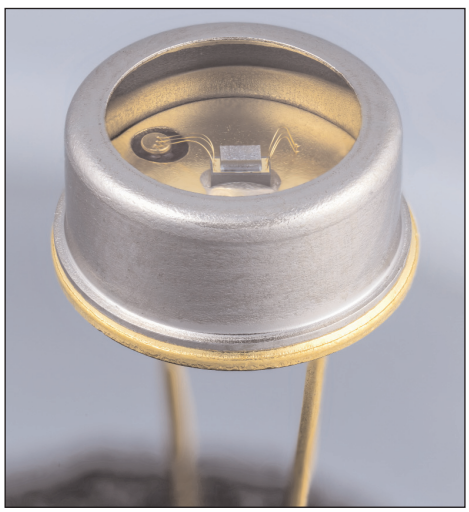
● Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH) develops UV LEDs for Advanced UV for Life consortium partners, focusing on the UVB and UVC wavelength ranges. The light sources offer tailored properties for various applications, from medical diagnostics and fluorescence spectroscopy to surface treatment and disinfection. At the micro photonics fair, FBH is presenting its competencies in UV LED development from the chip to the final radiation module. Exhibits include a UV LED-based demonstrator for water disinfection purposes.

● FBH spin-off UVphotonics NT GmbH develops highly efficient, reliable and customizable UV LEDs in the UVB (280–320nm) and UVC (< 280nm) wavelength ranges. The devices can be used for water purification and disinfection, phototherapy, sensing, and UV curing applications, among others. The LEDs are tailored to meet the customer-specific needs in terms of emission wavelengths, emission characteristics, power ranges, and chip layouts. UVphotonics also offers consultation on the integration of UV LEDs in application systems of industrial partners.



Water-cooled UV LED radiant source 4xOLM-021a. ©OSA Opto Light GmbH.

● sglux SolGel technologies GmbH targets the development of UV sensing technologies. The firm's portfolio includes a PTB (Physikalisch-Technische Bundesanstalt)-traceable calibration chain for the determination of optical power, irradiance, radiation characteristics and spectral distribution of UV LEDs developed by the consortium. Due to systematic monitoring of the degradation behavior under defined conditions, optical system components can be adapted to the requirements of different applications.



Encapsulated UVC LED for water disinfection. ©FBH/Schurian.co.

● OSA Opto Light GmbH develops UVB and UVC LED-based assemblies and modules for applications addressed by Advanced UV for Life, targeting the interface between device developers and end-users of UV LED-based technologies. At the fair, the firm is exhibiting its highly efficient LED radiation source OLM-021A-b, which is designed for photochemical processes in the 365–440nm wavelength range. The system has been tested successfully for the exposure of different materials, e.g. polystyrenes and polyacrylates up to 10mm thickness, printing inks and photoresists based on novolak, epoxy resin and acrylate.

● micro resist technology GmbH is applying and demonstrating the concept of UV LED-based microlithography by displaying patterned resist demonstrators. The ability to micro-pattern negative- and positive-tone photoresists with single-wavelength UV LED exposure at UV-vis, UVA and UVB aims to reduce equipment complexity and thus manufacturing costs. Photoresists with film thicknesses from 500nm to 50µm and the high-intensity UV LED modules need to be adapted to each other in order to achieve good pattern resolution featuring illumination homogeneity over the substrate and reduced exposure time.

www.micro-photonics.de/en
www.advanced-uv.de
www.fbh-berlin.com

FBH presents diode laser & UV LED developments

At micro photonics 2016, Berlin's FBH presented novel developments of its diode lasers and UV LEDs.

FBH develops diode lasers and LEDs from the chip through to the final module, and increasingly advances these devices up to the operational system. Customers and partners can hence test their developments in the respective application. FBH's customized diode lasers open up a variety of applications, from material analytics, sensors, and display technology to materials processing. Similarly, UV LEDs (focusing on the UV-B and UV-C spectral range) can be adjusted flexibly to the requirements. Applications cover medical diagnostics and fluorescence spectroscopy as well as surface treatment and disinfection.

FBH's exhibits included:

Industrial diode laser modules with optical fiber connection

FBH offers compact diode laser modules that allow customers to use high-brilliance laser radiation in their applications. Due to an integrated single-mode fiber (SMF) port, the matchbox-sized modules can be installed into different systems. Efficient laser light sources are hence available for the near-infrared spectral range, delivering diffraction-limited radiation with narrow bandwidth where it is needed.

So far, three different module types have been demonstrated. For modules with both high output power (>2W) and high spectral radiance, FBH has expanded the available wavelengths to the spectral range 804–1064nm. This setup can be transferred to wavelengths up to 1180nm and is thus suitable for pumping solid-state lasers as well as for frequency doubling. Additionally, seed-laser modules emitting at 633nm and 1180nm have been demonstrated that deliver output power of >20mW ex fiber, featuring an optical micro-isolator and polarization-maintaining SMF (PM-SMF) at the output. A polarization extinction ratio of more than 20dB was shown for modules with PM-SMF output in the spectral range 633–1180nm. As a third design, an amplifier module emitting at 1180nm with PM-SMF input and free-space output yielding >1W output power has been developed. By coupling light from a seed-laser source into the PM-SMF, this radiation can be easily amplified, says FBH. The principle is also transferable to other wavelengths.

Tailored, flexible picosecond light impulse source

With PLS 1030, FBH offers an efficient pulsed laser source that uses in-house-developed optical and electronic components. The laser system is currently being optimized so that all functionalities are integrated in just one compact device, instead of two separate components previously, offering improved capability. The all-in-one PLS 1030 delivers ultra-short light impulses at a wavelength of 1030nm within an adjustable time range of 5–15ps and provides freely selectable repetition frequencies, in a range of hertz to megahertz. Pulse peak performance is over 20W. Due to these properties, the laser source is suited to applications in materials processing, especially in connection to fiber amplifiers, for biomedical examinations based on fluorescence spectroscopy, and for mobile LIDAR systems. The device can be equipped with semiconductor components for 1030nm and 1064nm, but can be flexibly transferred to other wavelengths. It consists of a mode-locked laser with a repetition rate around 4GHz, a pulse picker element, and an optical amplifier. Electronic control has also been developed using FBH's gallium nitride (GaN) transistors. As a result, short impulses can be flexibly selected from single to multiple serial pulses (burst mode) and amplified. The PLS 1030 is computer-operated to enable it to be easily integrated into various laser systems, ensuring stable and user-friendly operation.

Higher brilliance and output power for diode lasers and bars

FBH develops high-brilliance diode lasers various designs and packages spanning 630–1180nm wavelengths. Single emitters with a stripe width of 90µm reach peak brilliance of 3.5W/mm-mrad. Smaller stripe widths deliver up to >6W/mm-mrad (for 20–30µm apertures) — again a record. For materials processing, FBH has developed custom arrays for spectral beam combining, consisting of five brilliant DFB lasers with 30µm apertures, each giving 5W output with 50% efficiency. The emitter-to-emitter wavelength spacing is 2.5nm. Future activities aim to improve efficiency, reliability and output power. Record results have recently been achieved from novel QCW bars that demonstrate 60% efficiency when operated with 1kW output at 15°C (rising to 70% at –70°C).

Module for water disinfection

Using in-house 262nm LEDs, FBH has designed a rod-shaped module for water disinfection that aims to replace conventional low-pressure mercury vapor lamps. UV LEDs have higher lifetimes, are maintenance-free and, since they do not require toxic chemicals like mercury, are environmentally friendly (mercury lamps need to be disposed of safely after a few thousand hours of operation). Wavelength and emission characteristics can also be adjusted specifically to the desired application. FBH's demonstrator (debuted at micro photonics) uses 40 LEDs, each delivering optical output of 1.7mW; the average irradiation intensity at a distance of 2cm is 2W/m^2. The geometry follows conventional flow-through water disinfection reactors for treatment of drinking or process water. The FBH setup is modularly expandable and adaptable to reactor size. Two LEDs form an assembly group with a constant-current supply (maximum 100mA per LED) and a temperature termination for security reasons. Heat is dissipated via a heat pipe with an attached fan.

www.fbh-berlin.com/business-areas/diode-lasers/

Plessey shortlisted as finalist in Lux Awards

UK-based LED maker Plessey's new Orion beam forming module has been shortlisted in two categories (Manufacturer of the Year and Enabling technology of the Year) in the 2016 Lux Awards, which celebrate and reward creativity and sustainability in lighting.

Plessey is showcasing the first standardized product using its Stellar Optic Technology at LuxLive in London, UK (23–24 November). As a slim-line module for directional light, the Orion is said to remove many of the restraints typically found in COB (chip-on-board)-type modules.

Awards winners will be announced at a ceremony on 24 November at The InterContinental London — The O2, following LuxLive. Plessey is exhibiting for its third year running and will demonstrate solutions based on its MaGIC (Manufactured on GaN-on-Si I/C) LED technology for the solid-state lighting market.

In booth M8 at LuxLive, Plessey's technical and design experts will present product demonstrations, providing an opportunity to gain an understanding of its latest solutions for commercial, industrial, consumer and wearable lighting markets.

www.plesseysemiconductors.com/

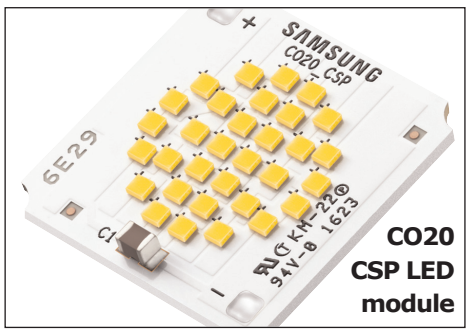
Samsung launches its first CSP-based LED modules

South Korea's Samsung Electronics Co Ltd has launched a line-up of chip-scale package (CSP) LED modules for spotlights and down-lights that features color tunability and increased design compatibility.

"Our new CSP LED modules provide an optimal solution for lighting manufacturers who seek highly compatible and reliable LED components," says Jacob Tarn, executive VP, LED business team.

The LED modules are Samsung's first to incorporate CSP technology, which brings a wide range of lighting benefits such as significantly reducing the size of a conventional LED package. The combination of flip-chip and phosphor coating technology eliminates metal wires and plastic molds to enable more compact designs when manufacturing LED modules and fixtures.

The CSP LED modules also deliver further characteristics that allow seamless tunable color. A color-tunable LED module requires twice the number of LED packages in cool and warm temperature, which work in combination on the same board to create a range of tunable colors. In contrast to conventional plastic-molded LED packages that inevitably increase the size of the modules, Samsung's ultra-compact chip-scale LED packages allow the module size to remain unchanged.



The new CSP LED modules are available in two form factors (19mm x 19mm or 28mm x 28mm) and are designed following Zhaga specifications, making assembly convenient. The modules are also said to provide high-quality lighting in diverse beam angle options (spot, medium, wide) for improved compatibility with optical solutions of Samsung's partners. The modules are based on CSP LED packages that have completed 9000 hours of LM-80 testing, reducing time to market for lighting manufacturers.

Samsung is sampling six models of the new CSP LED module in color rendering indexes (CRIs) of 80 and 90 with varying lumen output, size and correlated color temperature (CCT) specifications: i.e. (for 80CRI) the 19mm x 19mm CO10 and CO20 (with 9.4W and 18.3W power consumption and 1050lm and 2060lm output, respectively) and the 28mm x 28mm CO30 and CO40 (with 27.4W and 36.5W consumption and 3090lm and 4120lm output, respectively), all with CCT options of 2700/3000/3500/4000K, and the 28mm x 28mm TO10 and TO20 (with 9.2–9.8W and 17.7–18.4W consumption and 1060/1150lm and 1970/2190lm output, respectively), which are color tunable over CCTs of 2700–5000K.

www.samsung.com

Epistar to quadruple CSP LED chip capacity in early 2017

In view of fast-growing demand for chip-scale package (CSP) LED chips for TV backlighting, Epistar Corp of Hsinchu Science-based Industrial Park, Taiwan (the world's largest LED epiwafer and chip maker) will expand production capacity four-fold in early 2017, says Taiwan's Digitimes.

While CSP LED chips were adopted for direct-type LED-backlit LCD TVs, the adoption in edge-type backlit LCD TVs came much later due to technological problems, Epistar says. These problems have been solved, and demand for CSP LED chips has taken off, the firm adds. Monthly shipments of CSP LED chips have risen from 5 million units in early 2016 to 230 million, and Epistar claims a global market share of 30%.

Also, Epistar has been developing quantum dot (QD)-on-chip technology by combining CSP LED chips with QD technology. It expects QD-on-chip to be adopted for backlighting in 60–70" LCD TVs beginning 2017.

www.epistar.com.tw

Plessey launches single-chip high-power 7070 LEDs

UK-based lighting and sensing product and component maker Plessey has launched its 7070 high-power LED range (PLW7070GA.).

The PLW7070 products exploit Plessey's MaGIC (Manufactured on GaN-on-Si I/C) technology and provide a high-power LED component in an industry standard package footprint, complementing Plessey's existing family of i2LED high-power products. Using its proprietary gallium nitride on silicon (GaN-on-Si) high-voltage technology, Plessey says that it has been able to use a single LED die to improve thermal performance, improve far-field imaging and dramatically reduce cost over incumbent solutions.

Plessey provides components and solutions spanning the whole lighting value chain. Lighting system designers and specifiers can access its design, build and supply chain expertise from GaN-on-Si blue die all the way up to complete luminaires and fixtures. The PLW7070GA high-power LED with multiple junctions integrated in a single chip eliminates shadow effects and provides optimized far-field imaging, says the firm. Compatible with industry-standard secondary optics and operating at input currents from 350mA to 3A (1–15W power), Plessey's low-cost, high-power single chip LEDs are available in a full range of correlated color temperature (CCT) and color rendering index (CRI) options for demanding outdoor and commercial lighting applications.

"The PLW7070 range has been designed using our unique integrated multi-junction die architecture that provides us with a differentiated solution for a diverse range of high-power applications in high-bay, floodlighting, street lighting, spot lighting and down lighting, in addition to portable torches and lamps," says director of sales Giuliano Cassataro. "The move for designers to mid-power products because of low cost can now be reversed, as we can provide solutions where the overall fixture costs are up to 50% lower. GaN on silicon is really starting to come into his own," he adds.

"The key features and benefits we bring to customers and the LED lighting market with the Plessey 7070 range is a custom aluminium nitride ceramic lensed package with an industry-standard solder pattern and footprint," says chief technology officer Dr Keith Strickland. "Its low thermal resistance of less than 2°C/W, combined with a high maximum junction temperature of 135°C for good thermal management in demanding thermal environments, is critical in heat management," he adds. "Using a single GaN/Si multi-junction chip for 12V and 24V operation, Plessey is setting a new benchmark for far-field imaging and the use of secondary optics in narrow-beam-angle applications," he claims. "Superb maintenance of luminous flux is possible over a wide temperature range, and the in-built ESD protection provides stable yield through system manufacture and operation."

www.plesseysemiconductors.com/led-plessey-semiconductors.php

Beam-forming LED module using Stellar optical technology

Plessey has announced the first standard LED module based on its Stellar beam-forming technology. The new standard module is said to open up opportunities for creativity in industrial and architectural lighting design.

Plessey's Orion PLWS3000 series is an LED array module delivering more than 3000 lumens, integrating LED and optics into a module just 5.6mm thick and 82mm in diameter. Alternative solutions typically require optics that are usually 100mm deep and 111mm in diameter for a comparable light output and beam. Plessey says that it has achieved this size and performance by combining its Stellar beam-forming optics and gallium nitride on silicon (GaN-on-Si) LED technology. Plessey expects applications of the module to be in the design of track, retail, architectural, high-intensity, spot and directional lighting, and especially architectural applications.

The reduced form factor of the Orion eliminates design constraints and allows more design freedom for lighting designers, says chief technology officer Dr Keith Strickland. "Typically, using COB [chip-on-board]-type LEDs or modules makes it difficult to control color over angle, forcing designers to make fixtures much larger in size. The Orion, with Stellar beam-forming technology, represents the next phase in LED lighting with low cost, high efficiency and greater control of light. Greater control over the direction and quality of light is a crucial element in retail, industrial, hospitality and outdoor lighting; this, combined with the slim-line design and impressive thermal characteristics, means we provide lighting designers and architects far more design freedom," he adds.

"The Orion focuses on replacing design limitations with opportunities, thus providing lighting designers with a new level of design freedom," says Paul Drosihn, Plessey's head of Modular Products. "The size/performance envelope we have achieved allows industrial high-bay and architectural luminaires used in high-end offices, homes and retail outlets to be created in a new way," he adds. "With a particular emphasis on improving the thermal characteristics, the heat-sink can also be reduced in size, allowing the end fixture to be less obtrusive."

Nichia files white LED patent infringement lawsuit against HTC Nippon and its distributor Kanematsu

On 18 October, Nichia Corp of Tokushima, Japan filed a patent infringement lawsuit with the Tokyo District Court against Taiwan-based smartphone vendor HTC's Japanese subsidiary HTC Nippon Corp and its distributor Kanematsu Communications Ltd alleging that the white LEDs in the HTC Desire 626 smartphone sold in Japan incorporate white LED that infringe on Nichia's patents JP5177317 and JP5610056.

Nichia is seeking an injunction to indemnify the patent infringement as well as compensation for damages. Neither HTC nor HTC Nippon have yet responded to the accusation.

www.nichia.co.jp

Tokyo District Court rules that Tachibana Eletech infringed Nichia's patent by selling Everlight LED products

Following a lawsuit filed by Nichia, the Tokyo District Court has ruled that the importation/sale in Japan by Tachibana Eletech Co Ltd and E&E Japan Co Ltd of the 1254 series and 7344 series blue LEDs made by Taiwan's Everlight Electronics Co Ltd constituted infringement of Nichia's Japanese patent no. 2780618. The court has ordered Tachibana and E&E to pay Nichia monetary damages caused by their infringement.

Court grants preliminary injunction against Mouser regarding Everlight product based on Nichia YAG patent

On 29 September, Nichia filed a request in the Düsseldorf District Court for a preliminary injunction against Mouser Electronics Inc, alleging that the white LED product 334-15/X1C5-1QSA made by Everlight and distributed by Mouser in Germany infringes Nichia's YAG patent EP 936 682 (DE 697 02 929).

The court has now admitted Nichia's arguments that the product infringes claim 1 of Nichia's YAG patent, and has hence granted the preliminary injunction.

Due to the particular urgency, the preliminary injunction was granted ex parte (without the prior hearing of Mouser) and served to Mouser on 7 October. Nichia notes that this is a preliminary measure that can still be remedied by Mouser.

Epistar licenses LED filament patents to Super Trend

Epistar Corp of Hsinchu Science-based Industrial Park, Taiwan (the world's largest manufacturer of LED epiwafers and chips) has signed a license agreement for its filament patents to be used in the products of Super Trend Lighting (Group) Ltd.

Epistar holds key intellectual property regarding LED filament technology used in making LED filament bulbs. The patents relate to, among other things, LED filament structures, and light-emitting products using LED filaments. The patent portfolio covers Taiwan, China, USA, Europe and other territories.

Super Trend is the existing licensee with the right to manufacture products covered by Epistar's LED filament patents. Epistar says that it will continue to update its licensee list.

www.stll.com
www.epistar.com.tw

Epistar settles US patent infringement lawsuit against Adamax

Epistar has agreed to settle its patent litigation against Adamax Inc (trading as Newhouse Lighting) filed on 30 August in the US District Court for the Northern District of California alleging infringement of Epistar's light-emitting diode filament patents (US Patent Nos. 6,346,771, 7,489,068, 7,560,738, 8,240,881, 8,344,353, 8,791,467, 9,065,022).

The patents relate to, among other things, LED filament structures and light-emitting products using LED filaments. The complaint asserted that Newhouse Lighting products and technology infringed Epistar patents and sought injunctive relief to halt further sales.

Under the terms of the settlement, Epistar will release Adamax for the past sales of its LED filament products under the patents-in-suit. In addition, Adamax will pay ongoing royalties based on its sales of products for Epistar patents-in-suit.

Epistar says that the settlement protects its investment in R&D on advanced LED technologies at the core of its business.

www.newhouselighting.com
www.epistar.com.tw


umicore
Precious Metals Chemistry
We're playing your song:
"Green is the new Black."
Take trimethylgallium for instance, key to making the light-emitting semiconductor material found in an LED. Umicore produces it at low waste, high efficiency.
Our high purity metalorganics are taking sustainability a step further; we think out of the box and beyond electronics. Thinking greener isn't just a state of mind, it's part of our culture. Check out our product list for more hits.
Go for efficiency. Go for Umicore
www.chemistry.umicore.com

BluGlass and Lumileds move to Phase II of evaluation agreement after completing Phase I

Lumileds to further investigate integration of BluGlass' RPCVD technology into LED applications

BluGlass Ltd of Silverwater, Australia — which was spun off from the III-nitride department of Macquarie University in 2005 to develop a low-temperature process using remote plasma chemical vapor deposition (RPCVD) to grow materials including gallium nitride (GaN) and indium gallium nitride (InGaN) on glass substrates — has completed the technology demonstration outlined in Phase I of the exclusive evaluation agreement (unveiled in March) with LED maker Lumileds.

The Phase I demonstration of BluGlass' unique low-temperature RPCVD technology involved delivering technical milestones previously unachieved by RPCVD. "The successful demonstration of these milestones has broken exciting new ground for the RPCVD technology development," says chief technology officer Dr Ian Mann. "These initial demonstrations indicate that the novel implementation of RPCVD we are working on with Lumileds has certain advantages over the standard MOCVD process."

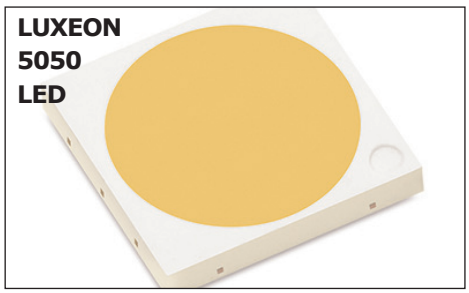
BluGlass is commercializing RPCVD for the LED and power electronics industries. The firm has developed patented hardware and processes targeting the production of more efficient semiconductor devices at lower cost. BluGlass entered into its Phase I Evaluation with industry leader, Lumileds this year.

www.bluglass.com.au

Lumileds launches multi-die LED, cutting cost-per-lumen

LED maker Lumileds of San Jose, CA, USA has launched the LUXEON 5050, a multi-die high-power package that provides high flux at high efficacy, enabling system designers to reduce LED count and cost in outdoor and indoor fixtures.

"The LUXEON 5050 is the superior choice for outdoor and directional lamp applications that demand high efficiency and cost-effective design together with precise beam control," reckons product manager Ivan Tsoi. For example, in outdoor applications, the source delivers luminous efficacy of >155lm/W at typical drive current



of 160mA (4000K, 70CRI) and >180lm/W at 80mA. For indoor spotlights and downlights, the LUXEON 5050 can achieve >130lm/W at 160mA (3000K, 80CRI).

The LUXEON 5050 is offered in a range of color temperatures (2700–5700K) at 70, 80 and 90CRI (color rendering index). The source is driven at a voltage of 24V, enabling the use of low-cost and high-efficiency drivers for all solid-state lighting applications.

The surface-mount device package has a thermal resistance of 1.9K/W, which greatly reduces thermal management needs. Finally, the LUXEON 5050 utilizes a small round light-emitting surface (4.6mm), simplifying optical design and making it easier to achieve high center-beam candle power.

www.lumileds.com/LUXEON5050

US DOE announces 2017 solid-state lighting R&D funding opportunity

The US Department of Energy (DOE) has announced the funding opportunity DE-FOA-0001613, 'Solid-State Lighting Advanced Technology R&D—2017'), in which a total of up to $10m is directed toward all three existing DOE SSL R&D program areas:

- Core Technology Research — applied research aiming to demonstrate scientific principles, technical application, and application benefits, and encompassing scientific efforts that focus on new knowledge or understanding of the subject under study, with specific application to SSL;
- Product Development — the development of commercially viable, state-of-the-art SSL materials, devices or luminaires using concepts from basic and applied research;
- US Manufacturing — research to develop advanced manufacturing approaches to reduce the cost of SSL sources and luminaires and improve product consistency and quality, with the additional benefit of supporting the development of US-based manufacturing.

The DOE will select up to 10 projects. Concept papers are due by 14 November, and full applications are due by 10 January 2017.

https://eere-exchange.energy.gov/#FoaId68693dde-c993-459d-8763-d3020ab40f6e

KEEPING AN EYE ON THE FUTURE

evatec process systems

Evatec brings you advanced thin film production solutions for Advanced Functionality Materials

From new high piezoelectric coefficient materials like AlScN to highly aligned NiFe soft magnetic layers or complex optical interference coatings, Evatec sputter platforms and processes help you keep an eye on the future. Advanced Process Control (APC) technologies bring precision and throughput to the deposition of new **Advanced Functionality Materials** in **Wireless**, **MEMS** and **LED** technologies. To find out more about Evatec processes and platforms visit **www.evatecnet.com**

RADIANCE SPUTTER CLUSTER

MSP 1232

LLS EVO II LOAD-LOCK SPUTTER

CLUSTERLINE® 300 II SPUTTER

SOLARIS S380 SPUTTER

MORE INFO

ADVANCED PACKAGING • HP OPTICS • MEMS • OPTOELECTRONICS • POWER DEVICES • WIRELESS • THE THIN FILM POWERHOUSE

www.evatecnet.com

Cree's gross margin aided by improvements in Lighting

Commercial lighting order momentum continues to rebuild

For its fiscal first-quarter 2017 (to 25 September 2016), Cree Inc of Durham, NC, USA has reported revenue of $371m, down 4% on $388.4m last quarter and down 13% on $425m a year ago, but in the upper half of the $356–378m target range.

Of this, discontinued operations contributed $49.9m (up on $30.9m last quarter and $43.9m a year ago, and above the targeted $46–48m). In July, Cree agreed for Germany's Infineon Technologies AG to buy its Wolfspeed business (which includes the Power & RF product lines that had historically been reported as a separate operating segment, plus the non-LED materials product line previously reported within the LED segment).

Continuing operations contributed $321.3m (down 10% on $357.5m last quarter and 16% on $381.5m a year ago, but in line with the expected $310-330m). Specifically, Lighting Product revenue (mainly LED lighting systems and bulbs) was $183.8m (57% of total revenue), down 7.4% on $198.4m last quarter and 26% on $248m a year ago. LED Product revenue was $137.5m (43% of total revenue), down 13.6% on $159.1m last quarter but up 3% on $133.5m a year ago.

On a non-GAAP basis, gross margin was 28.8%, down from 30.8% last quarter. Gross margin from continuing operations fell from 28.2% to 27.7%. Specifically, LED Product margin was 30.4%, down from 35.1% last quarter, but at the upper end of the targeted range. However, Lighting Product margin was 26.8%, up from 25.8% last quarter (with gross margins for commercial lighting and consumer lighting both improving).

"We delivered solid results in fiscal Q1, as Lighting, LED Products and Wolfspeed all achieved revenue and gross margins that were in line with our targets," says chairman & CEO Chuck Swoboda. "We made progress improving lighting margins in both our commercial and consumer product lines in the quarter."

Operating expenses (OpEx) for continuing operations were $80m (at the low end of the target range, primarily due to lower variable sales cost and the timing of IT litigation cost, some of which is expected to shift to Q2).

Net income has fallen further, from $21.3m ($0.21 per diluted share) a year ago and $18.9m ($0.19 per diluted share) last quarter to $15.2m ($0.15 per diluted share). However, this is towards the upper end of the $10-16m ($0.10-0.16 per diluted share) guidance range.

Net income from continuing operations was $9.5m ($0.09 per diluted share), down from $14.7m ($0.14 per diluted share) a year ago, but in the upper half of the targeted range of $6–11m ($0.06–0.11 per diluted share). Net income from discontinued operations was $5.7m ($0.06 per diluted share), down from $6.6m ($0.07 per diluted share) a year ago, but above the targeted range of $4–5m ($0.04–0.05 per diluted share).

Cash generated from operations has fallen from $64.6m last quarter to $18.1m. In addition to patent spending of $2.3m (down further, from $4.3m a year ago and $3.4m last quarter), spending on property, plant & equipment (PP&E) has been cut further, from $49.9m a year ago a year ago and $20.3m last quarter to $19.3m. Total capital expenditure has hence been cut further, from $34.7m a year ago and $23.7m last quarter to $21m, including $10m for Wolfspeed. Free cash flow was hence –$3.5m (improving on –$7.4m a year ago). During the quarter, Cree spent $36m to re-purchase 1.5 million shares and about $3m for the year-one earn-out achieved from the acquisition of APEI. Overall, consolidated cash and investments fell by $16m to $589m or, net of line of credit borrowings, by $43m to $402m. At the end of the quarter, Cree had $187m outstanding on its line of credit.

During fiscal Q1/2017, Cree launched the following new LED products: the next-generation higher-power XLamp XP-L2 LED (with twice the lumens-per-area); the XLamp XQ-E and XP-E High Efficiency (HE) Photo Red LEDs; the QLS6A and QLSB6 LEDs; and brighter MHB LEDs (for commercial outdoor lighting applications).

Cree also launched lighting products including the HXB LED Industrial High Bay fixture (which uses SC5 LED technology); a new 130lm/W ZR troffer product; the Essentia by Cree LED Surface Wrap; a high-performance version of the CPY canopy fixture; and the new GEN4 family of next generation LED bulbs.

For fiscal second-quarter 2017 (ending 25 December 2016), Cree targets revenue of $360–380m and net income of $13–19m ($0.13–0.19 per diluted share).

For continuing operations, revenue is targeted to be level at $310–330m, with both Lighting and LED roughly level as Cree continues to rebuild commercial lighting order momentum and operate in a very competitive LED market. Gross margin should also be similar to fiscal Q1, with improvement for Lighting offset slightly by LED Products due to lower targeted production volumes in Cree's LED factory (to help rebalance its commercial lighting inventory). Operating expenses should rise by $2m due to promotional spending related to Cree's GEN4 bulb launch and incremental IP litigations spending, as well as $1.5m of shared service costs supporting Wolfspeed operations (which will be mostly reimbursed for a period of time after closing, under a transition services agreement with Infineon). Net income is targeted to be $4–10m ($0.04–0.10 per diluted share).

For discontinued operations, Cree expects revenue to be steady at $50m, and net income to be $9m ($0.09 per diluted share), including

a $4m benefit net of tax ($0.04 per diluted share) from the full impact of not including depreciation or amortization expense from long-lived assets.

"The business fundamentals are improving in Lighting as we see improved customer service levels, increased channel coating activity and better gross margins," notes chief financial officer Mike McDevitt. "But it will take several quarters to see the full benefit in our financial results."

"We're still working to earn back share with our lighting agent and distribution channel partners and translate that effort to new projects and increased orders," says Swoboda. "The leading indicators are encouraging, and we're making investments in people and systems to further improve commercial lighting performance," he adds.

Accordingly, Cree has appointed Danny Castillo as president, Lighting (effective 7 November), responsible for both commercial and consumer lighting business. In addition, David Elien (a lighting industry veteran who has led the commercial lighting business for the last two quarters) will continue to run this business as part of the new lighting organization reporting to Castillo. "We're expanding our team, bringing in experienced leaders who understand the unique aspects of the traditional lighting industry and sales channels and complement our strength and innovation," says Swoboda.

"While we forecast the short-term increase in Q2 OpEx, in general we target company operating expenses to grow slower than our revenue over the next year, which should drive some incremental margin leverage," says Swoboda. "To enable our revenue and profit goals, we must continue to innovate in all business segments to differentiate our products in the market and improve the customer experience and service levels across the company."

For fiscal 2017, Cree targets Lighting and LED capital spending of $55m to support continuing operations. Until the sale of Wolfspeed is completed, Cree will continue to invest capital to support the business, including capital spending of $10m for fiscal Q2/2017 (in line with previous guidance).

Cree continues to target fiscal 2017 free cash flow of $100m, which may change depending on the timing of the Wolfspeed sale.

Cree and Infineon are continuing to work together to obtain the customarily required regulatory approvals in various jurisdictions, including foreign and domestic anti-trust approvals, as well as CFIUS approval. In late September, the parties received a second request for additional information from the US Federal Trade Commission (FTC). Cree and Infineon still aim to close the transaction around the end of 2016. "This will further strengthen our balance sheet to fund share repurchases in the near-term and pursue inorganic lighting growth in the medium to longer term," says Swoboda.

"Our second priority is driving top-line growth for our LED lighting business. Over the next year, we target growing core commercial lighting revenue from current levels and in line with the market, while potentially adding to that growth through product line expansion," says Swoboda. "Our corporate development team is working to evaluate lighting growth opportunities through potential M&A. But we don't target any deals in the next few quarters, as we give the new lighting leadership team time to build momentum for the core business."

"Customer service fundamentals in commercial lighting have clearly improved over the last two quarters, which is the first step to rebuilding order momentum," continues Swoboda. "The new products we released in [fiscal] Q4 are starting to gain initial project wins. But it typically takes nine-months to actually gauge market traction for new products," he adds.

"The consumer product transition to GEN4 is proceeding as expected with the initial loading orders combined with demand for our previously generation a little higher than forecast. Our new GEN4 LED bulb continues to provide the premium light and quality that consumers expect from the Cree brand, but at a lower price point and better value than our previous generation. The new bulb is targeted to provide some incremental margin improvement for the consumer product line, which we are using in the near-term to fund an expanded marketing program to support the new product launch," Swoboda says. The new bulbs have been shipped to stores, but are still in the process of being fully merchandised.

"The LED business has performed well over the last year," notes Swoboda. "The market remains very competitive and we continue to focus our efforts on the applications where our technology can add the most value to the customer. We're also working on some mid-to-longer term programs that could expand the LED business in future years for both existing and new applications."

www.cree.com

Cree appoints president of Lighting business

Cree has appointed Daniel Castillo as president, Lighting, reporting to chairman & CEO Chuck Swoboda.

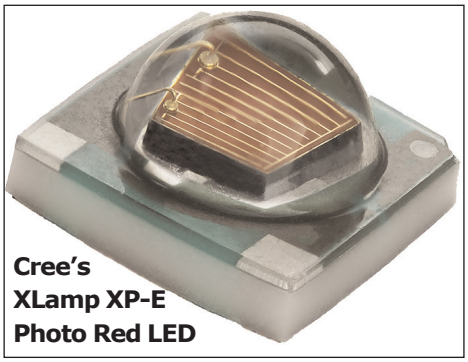
Castillo joins from Eaton Corp, where he was senior VP, Oil, Gas and IEC Assemblies. Previously, he held leadership roles in lighting and other electrical product areas at both Cooper Industries and General Electric.

"We have made tremendous progress over the past several years building a successful LED lighting business," says Swoboda. Castillo brings "valuable industry expertise and proven business leadership to Cree as we scale the business to the next level," he adds.

Cree launches higher-efficiency Photo Red LEDs, boosting output by 21% for horticulture applications

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has launched the XLamp XQ-E and XP-E High Efficiency (HE) Photo Red LEDs. With up to 21% higher output than previous generations of XQ-E and XP-E Photo Red LEDs, they enable horticulture lighting manufacturers to deliver higher-performance products, reduce luminaire size and lower system cost, says the firm.

"The XQ-E family provides a unique combination of ultra-compact package, high output and wide range of horticulture-optimized colors," says Michael Naish, director at high-thermal-conductivity substrate firm Rusalox. "Using XQ-E LEDs with our unique AlumOxide technology, our customers can create luminaires that use half the power of conventional HPS luminaires, as well as being smaller and weighing less than incumbent technologies," he reckons. "The higher-performing XQ-E High Efficiency Photo Red LED will enable customers to quickly reduce the power consumption of their current design even further for faster payback periods."



Cree's XLamp XP-E Photo Red LED

The XQ-E High Efficiency Photo Red LED delivers PPF (photosynthetic photon flux) of up to 5.39μmol/s at 85°C from a package footprint of just 1.6mm x 1.6mm. Its ratio of output to size is more than double that of the closest competitor, it is claimed. The XP-E High Efficiency Photo Red LED delivers up to 6.08μmol/sec PPF output at 85°C and is said to be the first LED to break the 1W radiant flux barrier at 85°C.

The XQ-E family provides a unique combination of ultra-compact package, high output and wide range of horticulture-optimized colors

"The new XQ-E and XP-E High Efficiency Photo Red LEDs bring Cree's latest high-power performance breakthroughs to horticulture lighting, with twice the PPF density and higher output than all other available LEDs," claims Dave Emerson, VP & general manager for Cree LEDs. "Our technology enables customers to create high-performance, long-life luminaires that drive the adoption of LEDs in this emerging application," Emerson adds.

Cree's portfolio of LEDs optimized for horticulture also includes White, Royal Blue and Far Red color options.

Both XQ and XP LEDs for horticulture are based on Cree's ceramic high-power technology, which can deliver R90 lifetimes over 100,000 hours, even at the extreme temperature of 105°C. In addition, horticulture lighting manufacturers can immediately take advantage of the existing ecosystem of drivers and optics proven to work with the XQ and XP platforms to accelerate their time to market.

www.cree.com/xlamp/horticulture

Cree launches brighter side-view LEDs for gaming machines

Cree has launched the QLS6A and QLS6B LEDs, which are claimed to be the brightest side-view LEDs optimized for gaming applications, yielding up to 66% higher luminous intensity than other side-view LEDs. Expand the firm's range of high-brightness LEDs optimized for indoor and outdoor video screens, displays and signage applications, the new side-view packaged LEDs are said to enable clearer image displays and higher visual impact in pachinko, slot and other video gaming machines.

The new LEDs allow simplification of design and manufacturing processes, says Motoaki Masaki, Optoelectronic Communication Technology Development Division Head, Energy Business Office, at Japan's NAGASE & Co Ltd. "The LEDs deliver high brightness and excellent far-field pattern and color mixing in an innovative compact package that does not block the background image. Additionally, the pin configuration and size of the LEDs simplify design, providing greater control and simplifying the manufacturing process," he adds.

The QLS6A and QLS6B deliver a typical luminous intensity of 2060 and 2493 millicandela (mcd), respectively. Built on a patented package with a shallow cavity that maximizes light output and enables better color mixing, the RGB (red-green-blue) QLS6A and QLS6B LEDs feature anode and cathode pins for each color to simplify design and provide greater control.

"Everything about the new QLS6A and QLS6B LEDs, from the innovative package to the performance to the binning of the LEDs, enables our customers to more easily deliver a better product," says Dave Emerson, VP & general manager for Cree LEDs.

Both QLS6A and QLS6B LEDs are binned full white to simplify design. The QLS6A LED shares the same design as the QLS6B with the addition of a Zener diode for improved ESD protection.

www.cree.com/hb/sideview

Pick your size.

The Temescal UEFC-4900—ultimate lift-off metallization performance like the UEFC-5700, but optimized for smaller wafers and smaller production volumes.

Temescal
UEFC–4900

It's the elephant in the room. With our Auratus™ deposition enhancement methodology and the UEFC-5700, we brought you huge metallization process improvements including near perfect uniformity; but UEFC-5700 is a high-volume production tool. Now we've packed this performance into a mid-sized system, the UEFC-4900, because sometimes the elephant is just too big.

Harmonize your process to the vapor cloud and experience the huge performance benefits, even if you run smaller wafers and smaller production volumes.

A Temescal system can bring near perfect uniformity to your lift-off metallization coating process. To find out more, visit **www.temescal.net/auratus-elephant** or call **+1-925-371-4170**.

FerroTec

German project yields demonstration model of high-resolution LED headlights with adaptive forward lighting

A German research alliance has developed the basis for smart, high-resolution LED headlights involving adaptive forward lighting. The demonstration model was developed by overall project manager Osram of Munich, Germany in collaboration with project partners Daimler AG, Fraunhofer Gesellschaft, Hella and Infineon Technologies.

Both headlights contain three LED light sources, each with 1024 individually controllable light points (pixels). The headlight can therefore be adapted very precisely to suit the respective traffic situation to ensure optimum light conditions at all times without dazzling other drivers. The light can be adapted to take account of every bend in the road so that there are no dark peripheral areas. In addition, with the aid of sensors in the vehicle, the surroundings can be analyzed in order to illuminate oncoming traffic. This allows the driver to see these vehicles more clearly. At the same time, the light beam does not shine into the eyes of oncoming drivers, so they are not dazzled. As a result, such shifting headlights no longer have to be dimmed on country roads.

Funded by the German Federal Ministry of Education and Research (BMBF), the project has now been completed after three and a half years with the production and field test of headlight demonstrators. For the implementation, Osram Opto Semiconductors, Infineon and the Fraunhofer Institute for Reliability and Microintegration (IZM) in Berlin, Germany developed an LED chip with 1024 individually controllable pixels. In the current generation of adaptive headlights on the market, several LED components are installed in the headlights side by side and on top of each other. Additional electronic components are required to switch light segments on and off. The number of segments is limited due to the restricted space in the headlight. In the new approach, electronic activation of the LED is integrated in the chip, resulting in much higher resolution, while still meeting limited space requirements. For the high-resolution, smart automotive lighting, in a second step the Osram Specialty Lighting unit developed an LED module with an electrical and thermal interface that enables direct connection to the vehicle's electronics.

The project has now demonstrated the feasibility of the system. When a smart, high-resolution headlight is used, driving and weather conditions are continuously analyzed: what is the course of the road, how fast is the car driving, is there oncoming traffic, and what is the distance between the car and other vehicles? Based on these conditions, the variable, adaptive light distribution ensures tailor-made lighting in every situation, e.g. at high speeds, the light beam's range is increased automatically. In city traffic, on the other hand, wider light distribution improves safety as, in addition to the road, also the sidewalk and peripheral areas are illuminated better. These functions are implemented fully electronically with no mechanical actuators. With glare-free full beam the driver always has the best possible light at night — with no adverse effects for other drivers. For motorists this is a benefit in terms of awareness, helping to reduce the risk of accidents when driving at night.

"We now want to develop this new type of high-resolution LED light source so that it's ready for serial production and we see enormous potential for its use in headlights," says Osram Licht AG's chief technology officer Stefan Kampmann.

Infineon developed the intelligent driver circuitry in the LED chip. This allows each of the 1024 pixels to be controlled individually. The firm managed to design it so it can be connected directly with the light-emitting LED array above it. The technical challenge lay in reconciling the special requirements for this with the manufacturing technologies for LED drivers. With the intelligent driver circuitry and its broad automotive application expertise, Infineon is supporting the trend toward adaptive front-lighting systems (AFS).

Hella specified the main technical requirements for the light source based on the functional requirements from Daimler. The light and electronics firm developed the entire optical system for the light modules and its cooling concept as well as the prototype headlights. As well as being efficient, they generate a very homogeneous light pattern and, in addition, the individual pixels have good lighting quality. The different light patterns can thus be generated purely electronically with no mechanical actuators (representing a step towards digitization in the lighting industry).

In the research project, Daimler specified the functional requirements and the future vehicle properties for the complete headlight system. This was the basis for the components and module properties for the overall headlight system, which calculates the best light distribution with consideration of future sensors and vehicle architectures and passes this information on to the pixel headlights. Regarding future electric vehicles, energy efficiency is an important requirement for the newly developed LEDs. A vehicle from Daimler with the smart LED headlights was used for the field trials under real traffic conditions.

The existing Mercedes-Benz E-Class car contains MULTIBEAM LED headlights from Hella which each have 84 individually controllable Osram LEDs. Daimler is continuing to develop LED headlights with a greater number of increasingly finer pixels.

Fraunhofer contributed to the project its competence in connection technology (LED & ICs) and materials as well as in the detection and isolation of defects. The high reso- ►

lution was achieved through even finer structuring with miniaturized connection technology. For this purpose, at the Fraunhofer Institute for Reliability and Microintegration (IZM), LED arrays from Osram with 1024 pixels were assembled on an active driver circuit from Infineon that controls each pixel individually. Aided by effective cooling, the chips were assembled to enable micron-sized height differences to be balanced out.

Two assembly methods were investigated: thermos-compression bonding with porous gold nano-sponge and reflow soldering with highly reliable gold-tin. Both techniques proved to be successful with a high yield and a robust interface for the subsequent LED processes.

One of the technical challenges of the high-resolution LED headlight is the comparatively large chip with 1024 individually controllable pixels. This is because, as the LED chip size increases, it raises the risk of failure or decreased luminosity of the individual pixels in the pixel matrix during the production process. To overcome this problem, the Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg, Germany developed new technology to repair defects. It is based on ultraviolet laser micromachining and enables defects in LED chips to be repaired during the production process. The microscopic defects are identified and removed with a UV laser through careful material removal or are electrically isolated without the laser inadvertently causing new defects (leakage current paths). When they have been repaired, the pixels regain their full luminosity — the luminescence pattern is homogeneous again.

The economic benefits of laser micromachining from the Fraunhofer IAF are not only in reducing defects during production and thus lowering production discard and costs for large LED chips. The process can also increase the average life of the LEDs (an important competitive advantage).

Supported by the German Federal Ministry of Education and Research (BMBF) under funding ID 13N12510, the µAFS project ran from February 2013 to September 2016, and achieved the aim to develop a smart lighting solution as the technical basis for a new class of energy-efficient LED headlights with additional road safety functions. Adaptive front-lighting systems (AFS) can be developed from this, enhancing safety for drivers, passengers and other road users.

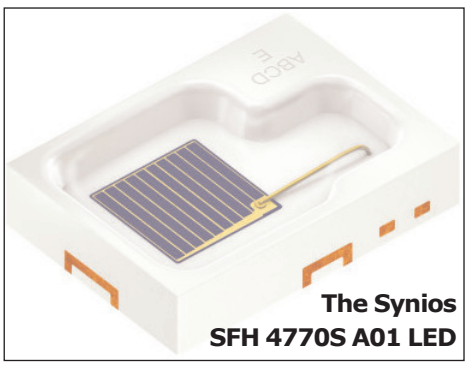
www.osram-os.com

Osram launches infrared LED for night-vision systems

Osram Opto Semiconductors GmbH of Regensburg, Germany is now offering a compact high-power Synios infrared light-emitting diode (IRED) for automotive applications

The IRED reduces the size of lighting units for camera-based assistance systems in cars. Compared with the Platinum Dragon previously used, the Synios SFH 4770S A01 offers 25% higher optical output with nearly a tenth of the footprint, making the IR light sources for night-vision assistance more cost-effective.

Osram presented its first Synios IRED for the consumer market (SFH 4770S) just last year. Now the component is also suitable as an IR lighting unit for camera systems that monitor the outside environment of the car. These systems include night-vision assistance and forward collision detection systems such as pedestrian protection solutions that work with camera images. Flooding the scene in front of the vehicle with infrared light enables the vehicle's environment to be reliably detected, even in the dark or in poor weather conditions. Unlike laser-based assistance systems that work with pulsed light, night-vision assistance and forward collision detection systems tend to use fixed light sources.



The Synios SFH 4770S A01 LED

The Synios SFH 4770S A01 will replace the established Dragon product family in these applications. The main requirement is high optical output in continuous operation (DC), and the new IRED delivers an optical output of nearly 1200mW from a current of 1A and is therefore roughly 25% brighter than the Platinum Dragon SFH 4235.

"SFH 4770S A01 offers the best efficiency and ratio between component size and optical output on the market for the automotive sector," claims Dr Walter Rothmund, head of marketing Infrared Automotive.

Like its predecessor, the 4770S A01 contains a highly efficient chip with nanostack technology featuring two light-emitting p–n junctions. The typical forward voltage is 3.2V.

Similar to the Dragon SFH 4235, the Synios is also a Lambertian radiator and is suitable for reflector-based systems. The Synios package is considerably smaller than the Dragon package, measuring 2.75mm x 2.0mm x 0.6mm. In particular, it requires nearly a tenth of the footprint and, given that its thermal conductivity has not changed, designers can create much smaller systems with the same thermal management. Also, due to the higher optical output, fewer components are needed to produce the same brightness levels, which in turn further reduces system costs.

"We have managed to create a compact product for the automotive sector with Synios, which we intend on expanding into a family of products including additional wavelengths in the future," says Rothmund.

www.osram.com

Osram laser achieves new lab record for brilliance

Osram Opto Semiconductors GmbH of Regensburg, Germany has produced a broad-area laser diode with a lateral brilliance of up to 4.8W/(mm-mrad) in the laboratory. The more brilliant the laser, the more efficiently it can inject its light into optical fibers, increasing the output power of modules for pumping fiber lasers used in material processing. This progress is a result of the project 'Integrated micro-optical and micro-thermal elements for diode lasers of high brilliance' (IMOTHEB) to increase laser system efficiency and reduce their production costs. Funded by Germany's Federal Ministry of Education and Research (BMBF) under the 'Integrated Microphotonics' initiative, the project has now ended (after starting in October 2012).

Since brilliance is a measure of the combination of optical output power and beam quality, brilliant laser sources generate a narrow beam of light with extremely small beam divergence and high power density. This property is crucial for the efficiency of fiber-coupled laser systems, says Osram Opto. The more brilliant the laser, the more light can be injected into an optical fiber.

Improved chip design

The lateral brilliance of up to 4.8W/(mm-mrad) in the lab is one of the highest values achieved for broad-area laser diodes, says Osram. Optimization of the chip design provided the basis for this, particularly the integration of micro-thermal and micro-optical elements for beam shaping on the chip.

The improvements were made in the course of the IMOTHEB project coordinated by Osram. An aim of the project was to further develop laser chips so that they deliver greater optical output power with constant beam quality. Project partner Max Born Institute supported chip development work in the form of extensive methodologies and analyses. The findings will now flow into product development.

Pump module output power boosted by 10%

An important application of fiber-coupled lasers is the pumping (injection of optical energy) of high-power lasers for material processing. Fiber lasers in particular are gaining in importance, for example for cutting and welding sheet metal in the automobile industry. At the same time, there is growing pressure on costs. The aim of IMOTHEB was therefore to reduce the system costs for such pump modules.

Project partner DILAS Diodenlaser researched concepts for the automated assembly of diode lasers. Another key factor was the brilliance of the laser sources. DILAS used a demonstration module to show that the improved Osram chips were capable of increasing the output power of the module by 10%. "Because the chip is more brilliant, more light goes into the fiber," says Dr Alexander Bachmann, project coordinator at Osram Opto. "The same module produces a higher output power than is possible with the laser diodes currently used in this application."

www.osram-os.com

VerLASE awarded US patent on 2D materials enabling downconversion of InGaN blue/violet emitters to any color

VerLASE Technologies LLC of Bridgewater, NJ, USA (a spin-off from technology development firm Versatilis LLC of Shelburne, VT, USA) says that the US Patent Office had awarded it US Patent No. 9,431,794 on the use of 2D materials to grow semiconductor structures that can downconvert InGaN-based blue/violet emitters into any color in the visible part of the spectrum, obviating the use of phosphors and quantum dots (QDs). The patent expands the firm's IP portfolio to six US patents now issued, with others pending, covering the use of quantum wells (QWs) and novel resonators to make color-converting chiplets principally for the emerging augmented reality (AR) market.

In AR architectures, optical or holographic waveguides can now superimpose a microdisplay image onto a user's field of view, or an image can even be scanned directly onto a user's retina, but forming such micro-images bright enough to see against a bright daylight background in full color and high resolution remains a significant challenge. The organic light-emitting diode (OLED) microdisplays used today principally in a self-contained virtual reality (VR) environment simply cannot meet requirements for such next-generation AR microdisplays; there are no good solutions to efficiently render such micro-images at high enough brightness, at high resolution and in full color.

The new patent builds on the firm's prior patents to show how II-VI and other semiconductor materials can be grown in the very difficult-to-achieve wurtzite crystal phase by using certain 2D materials as templates, a feat the firm had also shown experimentally, claiming to be the first group to have done so. Such II-VI films have hitherto been commonly grown in the less stable zincblende phase with high defect densities limiting their broader use.

Wurtzite phase makes possible robust, high-quality, near-defect-free QWs used in the firm's Chromover color down-conversion technology. Using a novel resonator design, Chromover can be designed to efficiently emit omnidirectional or directional spontaneous LED light, the latter in a narrow, low-étendue cone angle; or, if excited by a laser diode, to lase as an optically pumped vertical-cavity surface-emitting laser (VCSEL). Spectral properties can also be tailored to a degree, with some control of coherence to mitigate speckle (a significant problem in projecting images with lasers).

A single Chromover chiplet can be pixelated and support multiple colors (RGB), forming a color-converting layer for emerging InGaN-based microLED displays. Such microLED displays are suited to AR, being far brighter, more efficient and much longer lived than the OLED microdisplays used in VR. They require efficient color conversion, however, but the traditional phosphors and QDs used for color with LEDs are not practical. Moreover, the diffractive or holographic waveguide optics used in the leading AR architectures are highly sensitive to input angle and spectral width, making imperative some directional and spectral control of the input source light.

"This is a key step to realizing the vision of untethered, stylish glasses that can project high-resolution, full-color images onto your field of view with long battery life," says inventor & chief technology officer Ajay Jain. "All the manufacturing processes are readily available, commercially scalable, and can be outsourced," he adds. VerLASE has been working with leading players in the VR/AR space to better define market requirements.

www.verlase.com

Hamamatsu to add new building to expand production of IR detectors and emitters

Japan's Hamamatsu Photonics K.K. has announced the construction of the new building number 3 at its Miyakoda Factory in order to increase manufacturing capacity of compound semiconductor devices.

The expansion is being undertaken in anticipation of growing demand for detectors and emitters in various applications that utilize infrared light.

A groundbreaking ceremony is being held on the site of the new building on 12 October. Construction is scheduled to be completed in October 2017.

www.hamamatsu.com

Artist's rendition of the new building no. 3 at Hamamatsu Photonics' Miyakoda Factory.

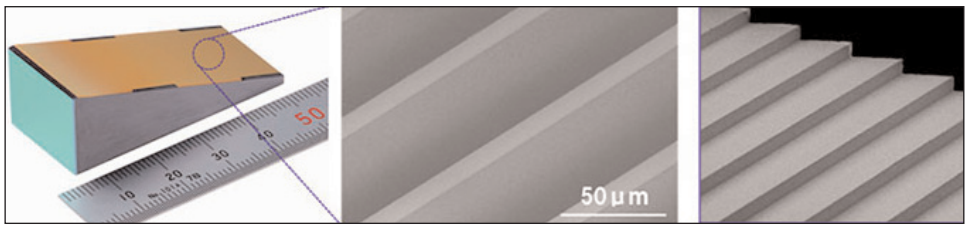
Canon develops first InP immersion grating

Addition of InP extends immersion grating range to span entire 1–20μm IR spectrum used in astronomy

Tokyo-based Canon Inc has developed what it claims is the first indium phosphide (InP) immersion grating (a spectrographic optical element capable of covering the InP transmissive frequency range of the infrared spectrum, i.e. spanning 1.5–8μm). Compared with conventional reflective diffractive gratings, the new immersion gratings enable higher dispersion relative to the refractive index (about 3.2 for InP).

Strengthening its lineup of immersion gratings, which includes gratings made from germanium (Ge) and cadmium zinc telluride (CdZnTe), Canon aims to contribute to greater progress in cosmological observation by expanding the range of observable infrared frequencies.

To retrieve information contained within light emitted from space, astronomical telescopes and man-made satellites are equipped with spectroscopes that incrementally divide light by its different frequencies and play a vital role in cosmological observation. Compared with typical reflective elements, immersion gratings enable spectrometers that are smaller in size and realize higher levels of performance. With the addition of an InP immersion grating to Canon's range, it is reckoned that spectrometers could be reduced to about 1/27th the volume of those equipped with typical reflective elements that cover the same frequencies. Overcoming restrictions on size and weight (which, until now, made it difficult to launch man-made satellites equipped with high-performance spectrometers) is expected to further expand the possibilities of cosmological observation. Also, application of this grating to next-generation large ground-based telescopes, which face the problem of ever-increasing sizes, could lead to reductions in size without sacrificing performance.



(left) Indium phosphide immersion grating (about 50mm x 20mm x 15mm); (center) grating surface at 1000x magnification under electron microscope; and (right) immersion grating surface.

With the addition of an InP immersion grating, Canon's immersion grating lineup now covers light from near infrared to far infrared, enabling observation of almost the entire spectrum of infrared frequencies used in the field of astronomy (1–20μm). Infrared light can be captured from much greater distances than visible light, making detection of matter in space possible on a molecular, and even atomic, level. The new InP immersion grating could hence facilitate research into not only the origin of life and planets, but also the origin of the universe itself, contributing to even greater developments in space science.

While the benefits of fabricating immersion diffractive gratings were realized long ago, because the transmissive semiconductor materials suited to the 1–20μm infrared frequencies used in astronomy are particularly brittle, achieving a surface of virtually perfect regularity with grooves measuring only a few nanometers proved difficult. Canon applied its own ultra-precision processing technology, cultivated through the manufacture of precision components, using only machining processes to develop immersion gratings even with such brittle materials. The resulting InP immersion grating realizes an arrangement of 990 steps at 47μm intervals.

Diffractive elements for use with high-dispersion IR spectra ordinarily have an absolute diffraction efficiency (ratio of diffracted light intensity to incident light intensity at the precise point of strongest diffracted light intensity) of 50–60%. Canon's InP immersion grating, however, achieves an absolute diffraction efficiency of about 75% (compared with a theoretical limit of 85%). Canon reckons that, with its high-efficiency performance enabling superior light capture even amid low light intensity, it will enable small telescopes to achieve high-precision measurement, and large telescopes to measure infrared light from much greater distances in space.

Canon gave a presentation on its InP immersion grating at the International Conference on Space Optics 2016 in Biarritz, France (18–21 October).

Setting sights on medical and communication applications

Going forward, Canon intends to develop an immersion grating from materials suitable for frequencies close to visible light (0.8–1.2μm) and, with the development of its InP immersion grating, the firm is a step closer to achieving that goal. By developing a lineup of immersion gratings using a variety of different materials, users can choose the optimal grating based on the frequency range it will be used with to enable a wide range of applications in infrared spectroscopy. Canon anticipates applications in medicine and communication, as well as astronomy.

www.global.canon

Infinera joins AIM Photonics manufacturing consortium

Infinera to provide access to InP photonics technology and foundry

The New York State Photonics Board of Officers says that Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical transport networking systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has become the latest member of the Rochester-based consortium AIM Photonics (American Institute for Manufacturing Photonics). Infinera will provide access to its InP photonics technology and establish InP-based foundry wafer access for AIM.

"State funding is moving ahead on schedule as is the competitive process to identify a TAP [tuition assistance program] facility," says New York State Photonics Board of Officers chairman John Maggiore. "The reasons AIM Photonics and New York were chosen by the Department of Defense one year ago to lead the country's advanced research endeavors in integrated photonics are the same then as they are now. Only New York has the skill, industry partnerships, and expertise to manage and execute such a large and important project," he adds.

"Photonic integration has revolutionized the optical networking industry and Infinera has led the way, starting with delivering the industry's first large-scale photonic integrated circuit, which started to ship in networking systems in 2005," says Fred Kish, Infinera's senior VP of development & engineering. "We are happy to be working with AIM and SUNY Polytechnic Institute as a Tier 1 industry member," he adds. "Infinera continues to advance integrated photonics to enable service providers and data-center operators to deploy networks consuming less power and space while offering the capacity required to transport data over long distances."

AIM Photonics says that it is building a membership that includes some of the USA's most innovative technology companies that each provides critical elements to the success of the institute. Infinera leads the industry in photonic integration with large-scale PICs and packet-optical convergence, which both reduce space and power requirements while simplifying network operations, it adds. The PIC combines hundreds of discrete optical functions on a single microchip, drastically improving density, power consumption, heat dissipation and reliability.

"Our partnership with Infinera dramatically expands our access to cutting-edge photonics technologies that are crucial to the success of the institute," says Michael Liehr, CEO of AIM Photonics and executive VP of Innovation and Technology for SUNY Polytechnic Institute (which leads the consortium). "Infinera is a leader in photonics innovation, and the ability to tap into its resources, as well as those of our other nationwide members, further increases the already significant potential of this Rochester-based initiative," he adds.

Our partnership with Infinera dramatically expands our access to cutting-edge photonics technologies that are crucial to the success of the institute. Infinera is a leader in photonics innovation, and the ability to tap into its resources, as well as those of our other nationwide members, further increases the already significant potential of this Rochester-based initiative

"AIM continues to maintain independent and robust oversight through multiple boards and the federal government," says SUNY Provost, executive vice chancellor and SUNY Poly officer-in-charge Dr Alex Cartwright. "All partners, from academia to government to industry, are working in unison to ensure AIM's mission and potential are achieved."

AIM's Integrated Photonics Institute is designed to establish a technology, business and education framework for industry, government and academia to accelerate the transition of integrated photonics solutions from technology prototypes to manufacturing-ready deployment in systems spanning multiple commercial and defense applications. Each AIM Photonics partner brings unique expertise to address an end-to-end solution to the photonics ecosystem. Infinera brings unique differentiation because of its expertise in development of the most complex commercially available photonic integrated circuits.

The New York State Photonics Board of Officers coordinates New York State's financial investments in AIM. The board consists of seven members who represent a wide array of business, programmatic and technical expertise. The Governor of New York State appoints the chairman as well as two additional members; SUNY Poly Institute appoints two members; and the Rochester Institute of Technology (RIT) and University of Rochester (U of R) each appoint one member. The Photonics Institute board of officers consists of chair John Maggiore (Governor appointee), Anne Kress (Governor appointee), Alexander Cartwright (Governor appointee), Ronald Goldblatt (SUNY Poly appointee), Paul Tolley (SUNY Poly appointee), Ryne Raffaele (RIT appointee) and Rob Clark (U of R appointee).

www.infinera.com
www.aimphotonics.com/multiproject-wafer-mpw

POET and Luxmux enter into supply agreement and strategic partnership

DenseLight SLEDs to be integrated into photonic sensing products

POET Technologies Inc of San Jose, CA, USA — which has developed the proprietary planar optoelectronic technology (POET) platform for monolithic fabrication of integrated III-V-based electronic and optical devices on a single semiconductor wafer — has announced a long-term agreement to supply superluminescent diode (SLED) products to Luxmux Technology Corp of Calgary, AB, Canada, a developer of miniaturized photonics solutions that enable next-generation light sensing systems.

Through its Singapore-based subsidiary DenseLight Semiconductors — which designs and makes indium phosphide (InP)- and gallium arsenide (GaAs)-based optoelectronic devices and photonic integrated circuits (PICs) — POET will design and manufacture multiple-wavelength SLED sets for Luxmux to integrate into products for a number of photonic applications. POET says that these products will benefit from significant system-level advantages including compact size, accuracy and stability.

The agreement is structured as a strategic partnership to ensure the seamless integration of devices into Luxmux's Broad Spectrum Tunable Superluminescent Diode (BeST-SLED) butterfly package. The strategic partnership is expected to enable unique capabilities in the exacting and demanding fields of biomedical applications, energy, material characterization, metrology, optical device characterization and remote sensing.

Through its Singapore-based subsidiary DenseLight Semiconductors — which designs and makes InP- and GaAs-based optoelectronic devices and PICs — POET will design and manufacture multiple-wavelength SLED sets for Luxmux to integrate into products for a number of photonic applications

"This collaboration also provides both companies with expanded future opportunities to develop and commercialize additional integrated SLED optoelectronic technologies," says POET's CEO Suresh Venkatesan.

"Engaging with POET Technologies as a supplier and strategic partner is an important milestone for Luxmux, as it increases our capabilities in the photonics market," says Luxmux's president & CEO Yonathan Dattner. "We researched several suppliers and selected the Denselight SLED because of its unparalleled quality and performance," he adds.

www.luxmux.com

POET appoints chief financial officer

POET Technologies Inc of San Jose, CA, USA — which has developed the proprietary planar optoelectronic technology (POET) platform for monolithic fabrication of integrated III-V-based electronic and optical devices on a single semiconductor wafer — says that Thomas R. Mika has been appointed chief financial officer (effective 2 November). He replaces Kevin Barnes, who remains with the firm as corporate controller & treasurer.

"He is an accomplished executive with significant financial and operational expertise," comments CEO Suresh Venkatesan about Mika. "I would also like to thank Kevin for serving as CFO for the past several years and look forward to maintaining our strong working relationship in his new role."

Mika is currently chairman of the board of Rennova Health, the successor company to CollabRx and its predecessor Tegal Corp, a semiconductor capital equipment company. Since 2005, he has been president & CEO, and at times acting CFO of CollabRx and Tegal, retaining those positions following its merger with Rennova Health in November 2015. Previously, Mika co-founded IMTEC (a boutique investment and consulting firm serving clients in the USA, Europe and Japan over a period of 20 years), taking on the role of CEO in several ventures. Earlier in his career, he was a managing consultant with Cresap, McCormick & Paget and a policy analyst for the US National Science Foundation (NSF). Mika holds a Bachelor of Science in Microbiology from the University of Illinois at Urbana-Champaign and a Master of Business Administration from the Harvard Graduate School of Business.

"POET is a visionary company that is poised to disrupt optical data communications with its integrated optical solution," believes Mika. "With a powerful technology platform, first-mover advantage and experienced management team, I believe the company is well positioned for strong commercial success."

www.poet-technologies.com

POET to expand R&D operations with support from Singapore Economic Development Board

Integrated Photonics center to be established within existing Singapore operations

POET Technologies has entered into an agreement with the Singapore Economic Development Board (EDB) to expand its R&D operations in the country.

Through its acquisition in May of Singapore-based DenseLight Semiconductors Pte Ltd (a designer and manufacturer of photonic sensing and optical light source products for the communications, medical, instrumentations, industrial, defense and security industries), POET reaffirmed its strategic intent to expand its R&D and manufacturing operations in Singapore. The firm will establish an Integrated Photonics Center of Excellence within its current operations to further develop and commercialize differentiated photonics and optoelectronic products. This is expected to increase market penetration and enhance market acceptance of the POET portfolio as it is introduced. The firm says that the center signifies the growing importance of integration in photonics applications as a means to drive increased adoption and improve POET's competitive positioning. The Singapore operations will further the development and production of POET's key technologies, including those developed with the joint program that POET established with the Institute of Materials Research and Engineering (IMRE) in Singapore earlier this year. The planned initiatives are expected to gradually add up to 30 engineers and scientists to POET, as the R&D center is established.

"EDB's support will be instrumental in helping us drive the growth of intellectual property, talent and operations in Singapore, thus providing a foundation for compound semiconductor and photonics growth in the region," says chairman Ajit Manocha. "I have been engaged with Singapore for much of my career and value the nurturing and enduring partnerships with the EDB throughout. We chose Singapore because of EDB's initiative to grow the compound semiconductor and photonics ecosystem in the region," he adds. "The country's business-friendly climate and support from government agencies truly set it apart. We look forward to continuing to work with the EDB as we accelerate the commercialization of our highly differentiated technologies serving a variety of applications and markets," Manocha continues.

"This support from the EDB could potentially allow POET and its subsidiaries, DenseLight and BB Photonics, to accelerate product and revenue growth by leveraging Singapore's R&D efficiencies, infrastructure, learning institutions and human capital and its strong high-technology manufacturing base," says CEO Dr Suresh Venkatesan.

"Current projects in Singapore include the research and development of the POET Platform for Display applications, as well as the commercialization of POET, DenseLight and BB Photonics intellectual property in the fast-growing data communications and sensing markets," he adds.

"EDB is committed to developing the compound semiconductor industry through partnerships with companies to perform critical R&D and manufacturing in Singapore," says Pee Beng Kong, EDB's director for Electronics. "Innovations in compound semiconductor technology can enable the next generation of optical communication solutions needed for increasing requirements in data centers," he adds. "We are delighted to partner with POET Technologies to lead DenseLight, a company with a strong Singapore core of talent and activities, to greater heights."

POET is eligible to receive support up to a maximum of S$10.7m over five years pursuant to the EDB letter of offer, subject to headcount and expenditure thresholds. Should the terms of the support agreement with the EDB not be satisfied by POET, the EDB reserves the right to request repayment of any support advanced.

www.poet-technologies.com
www.denselight.com
www.sedb.com

POET confirms CDN$12.5m public offering

POET has entered into a placement agency agreement for a syndicate led by Rodman & Renshaw (a unit of H.C. Wainwright & Co LLC) as lead agent & book-running manager (and sole agent in the USA) and Cormark Securities Inc as lead manager in Canada to seek purchasers of up to 34,800,000 units (each comprising one common share and one purchase warrant) at CDN$0.36 per unit. Each warrant is exercisable to acquire one extra share for CDN$0.52 for 60 months after the offering closes (on or about 2 November). Gross proceeds are up to CDN$12,528,000m.

Net proceeds will be used for general corporate purposes (e.g. increasing working capital), R&D, further product and sales development, as well as potential business or intellectual property acquisitions in support of strategic growth.

Renesas launches first lasers achieving stable 28Gbps operation up to 85°C

4x25Gbps operation targets 100Gbps transceivers in data centers

Tokyo-based Renesas Electronics Corp has announced the availability of its new NX6375AA Series of direct modulation distributed feedback laser diodes (DFB LDs) supporting 25Gbps x four-wavelength operation as the light source in 100Gbps optical transceivers for communications between servers and routers installed in data centers.

The firm says that the NX6375AA Series enables the development of high-speed optical transceivers and optical modules that are highly reliable even in high-temperature environments, and the new series can be implemented in servers and routers used in data centers.

Recently, due to the popularity of cloud computing for the Internet of Things (IoT) era, the scale and processing capacity of data centers connected to the Internet and handling large amounts of data are expected to increase at 59% annual. In the optical transceivers used for communication between the servers and routers in the data centers in that environment, there is now demand for increased transmission rates, and it is expected that 100Gbps systems (which will replace the existing mainstream 40Gbps systems) will grow 75% annually.

However, there is concern that the increasing system heat generation (which is proportional to communication speed) could make the system operating state become unstable. So, the achievement of both stable operations in high-temperature environments and higher communications speeds have become a major issue for optical transceivers.

Renesas launched its first laser diodes for this application starting in 2004, when the communications data rate was 10Gbps. The new NX6375AA LD Series supports 100Gbps systems, which are expected to become the mainstream in communications systems in the future and, by resolving the issues involved, will contribute to higher speeds and increased reliability in optical transceivers, says the firm.

In addition, the NX6375AA Series of lasers uses Renesas' unique embedded structure and adopts aluminum gallium indium arsenic (AlGaInAs) material. Hence, by optimizing the DFB structure, the lasers are said to be the first to achieve stable operation at up to 28Gbps per wavelength over an operating temperature range of Tc = −5°C to +85°C. So, the lasers not only support 100Gbps with four wavelengths but are also capable of supporting systems operating at up to 112Gbps. Also, the four wavelengths in the laser diode series are 1271nm, 1291nm, 1311nm and 1331nm, which support coarse wavelength division multiplexing (CWDM) wavelength spacing.

To enable the lasers to be used safely in data-center environments, Renesas used narrow width selection growth technology for wafer crystal growth, controlled crystal defects in the active layer, and formed a protective aluminum oxide layer (using proprietary Renesas' technology). Since aluminum oxidation can be controlled during fabrication, the lasers achieve what is claimed to be an industry-leading mean time to failure (MTTF) of 100,000 hours.

Renesas intends to expand its range of laser diodes for 100Gbps high-speed communications. The firm is also working on expanding operation in the low-temperature range, which is required for applications such as communications base stations. Furthermore, Renesas can propose solutions with higher levels of added value by combining the lasers with the firm's high-speed optical receivers and its microcontrollers (MCUs).

Samples of the NX6375AA Series are available now, priced at $50 per wavelength. Mass production is expected to reach 100,000 units per month in April 2017 for four wavelengths.

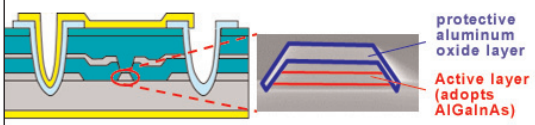
www.renesas.com

Feature 1

Industry's First to Achieve Stable Operation at up to 28 Gbps per Wavelength over an Operating Temperature Range of Tc = -5°C to 85°C

Technical method:

- adopts Renesas' unique embedded structure in the laser diode's light emitting point
- adopts aluminum gallium indium arsenic (AlGaInAs) as their materials



A side-view illustration of the laser diode

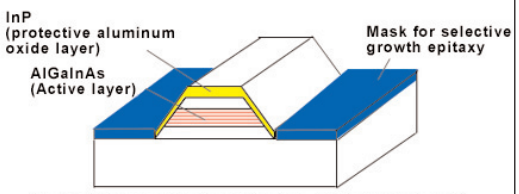
An up-close illustration of the laser diode's light emitting point

Feature 2

Industry-Leading Assuring High Reliability of an MTTF of 100,000 Hours

Technical method:

- To enable these LDs to be used safely in data center environments, Renesas used narrow width selection growth technology for the wafer crystal growth, controlled crystal defects in the active layer, and formed a protective aluminum oxide layer (Renesas' unique technology). Aluminum oxidation can be controlled during fabrication.



An illustration of the laser diode's light emitting point

Emcore expanding production of L-EML-based transmitters following qualification with cable MSOs

Emcore Corp of Alhambra, CA, USA — which provides indium phosphide (InP)-based optical chips, components, subsystems and systems for the broadband and specialty fiber-optics markets — is expanding production of DOCSIS 3.1, 1550nm CATV transmitters utilizing linear externally modulated laser (L-EML) technology. L-EML-based transmitters have achieved qualification with major cable multi-service operators (MSOs) and are in volume production. The new Medallion 8100 L-EML-based 1RU transmitter was on display for the first time publicly in the USA in at the 2016 Cable-Tec Expo in Philadelphia, PA (27–29 September).

Expanding on the firm's mixed-signal optics products, L-EML technology was invented, developed and is manufactured exclusively at Emcore. The L-EML device consists of a high-power, low-noise, narrow-linewidth laser combined with a proprietary highly linearized modulator in a monolithic assembly. It enables long-distance optical link performance approaching traditional lithium niobate-based externally modulated transmitters, but is more cost-effective for its targeted applications and far exceeds the performance of distributed feedback (DFB) laser-based systems, claims Emcore.

"With the rapid growth of next generation DOCSIS 3.1 deployments, Emcore developed a cost-effective solution that overcomes the technical limitations of linear DFBs, while pushing the boundaries of performance towards traditional, but higher-cost, lithium niobate-based solutions," says senior product line director Grant Olecko.

Emcore unveiled L-EML in June at the ANGACOM 2016 Exhibition & Congress for Broadband, Cable and Satellite in Cologne, Germany. "We continue to ramp production to meet demand following additional successful trials," says VP of marketing Gyo Shinozaki.

At the Cable-Tec Expo, Emcore is also showcased its full system-level portfolio for CATV including the new Medallion 6100 series transmitters, 7110 series of low-noise, high-power erbium-doped fiber amplifiers (EDFAs) and the 2100 optical A/B switch.

Emcore also exhibited its full line of DOCSIS 3.1 lasers, DFB CATV butter-fly and TO-56 lasers, low-noise optical receivers, broadband photodiodes, and components for wireless & distributed antenna systems (DAS).

www.emcore.com

Sol Voltaics appoints director of product marketing to speed commercialization of solar nanowire technology

Sol Voltaics AB of Lund, Sweden, which is developing nanomaterials technology for enhancing solar cell efficiency, has named solar technology leader Dr Arno Stassen as its new director of product marketing as it nears commercialization of its solar nanowire technology.

Stassen has more than 10 years of experience in the global solar energy industry, most recently as head of business development of German technology group Heraeus' solar energy division, where he was instrumental in growing its leadership in metallization of silicon and third-generation solar cells. Previously, he was project leader and part of the consultancy team at the Energy Research Centre of the Netherlands (ECN), where he led several large R&D programs in crystalline silicon solar cells. Stassen also contributed towards the 2014 and 2015 International Technology Roadmap for Photovoltaic (ITRPV), crafting the technology roadmap and driving future innovation in crystalline silicon PV.

"Having worked in advanced PV for the past 10 years, I fully understand the current limitations for the industry in achieving breakthrough efficiency technology at low costs," says Stassen. "Sol Voltaics' compelling tandem-layer technology and novel Aerotaxy nanowire manufacturing process show enormous potential to enable module efficiency improvements up to and above 30%," Stassen adds.

"His experience, reputation and technology expertise will add a new dynamism to our management team as we continue to improve our offering and fulfill our ambition of bringing this transformative technology to market," comments CEO Erik Smith.

Stassen's appointment follows Sol Voltaics' $17m series C funding round in May, the largest European solar technology funding round secured by a start-up in the past two years. Earlier this year, it also announced alignment of gallium arsenide (GaAs) nanowires in a thin film, showing measurable progress towards its aim to commercialize its solar technology for module manufacturers.

www.solvoltaics.com

First Solar commissions 52.5MW plant in Jordan

Cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA has commissioned the 52.5MW$_{AC}$ Shams Ma'an project in Jordan, on schedule.

The plant is owned by a consortium of investors consisting of Diamond Generating Europe Ltd, Nebras Power Q.S.C. and the Kawar Group. First Solar contributed to the development of the project before divesting its stake and being appointed the engineering, procurement & construction (EPC) contractor. Shams Ma'an has a 20-year power purchase agreement (PPA) with the the country's power generation and distribution authority National Electric Power Company (NEPCO).

"This power plant will deliver on its promises, reliably generating energy over its lifetime and forming the cornerstone of Jordan's energy security strategy," comments Karim Kawar, chairman of Kawar Energy.

The plant, which accounts for about 1% of Jordan's total energy generation capacity, produces electricity using more than 600,000 First Solar Series 4 thin-film modules, which deliver up to 5% more specific energy in Ma'an than conventional crystalline silicon panels, it is reckoned. The modules are mounted on single-axis trackers that allow the facility to generate up to 20% more energy.

The 52.5MW Shams Ma'an Solar Power Plant.

"Shams Ma'an has been engineered for performance and is further evidence of the fact that First Solar's high-performance modules can deliver more energy than conventional photovoltaic technologies in Jordan and across the Middle East," says Ahmed S. Nada, VP & region executive for First Solar in the Middle East.

The facility was constructed by a workforce that was almost entirely Jordanian, with First Solar spending over 40,000 man hours on training alone. "Our hope is that the skills acquired through this project will further enable Jordan's solar energy ambitions," says Dr Raed Bkayrat, First Solar's VP of business development for the Middle East.

The project takes First Solar's installed capacity in the Middle East to more than 70MW$_{AC}$, with a further 200MW$_{AC}$ to be added when the second phase of the Mohammed bin Rashid Al Maktoum Solar Park is completed in 2017.

www.firstsolar.com

Siva Power recruits former First Solar and Intel veteran Bruce Sohn as vice-chairman of the board

Copper indium gallium diselenide (CIGS) thin-film solar module developer Siva Power of San Clara, CA, USA has hired solar executive Bruce Sohn as vice-chairman of its board. Sohn was previously the key executive in the growth of cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA into an internationally recognized solar company, and he has also held leadership positions at Intel Corp.

Sohn started at First Solar in 2003, serving on its board and guiding the firm through its formative years of growth. In 2007 Sohn became First Solar's president, leading it from the pre-revenue stage to a multi-billion-dollar enterprise. Under Sohn's leadership, First Solar achieved three historic solar milestones: the first Company to manufacture at under $1/watt, the first company to ship more than 1 GW of production annually and the first company to develop and engineer, procure, and construct (EPC) over 1GW of utility-scale projects.

Previously, Sohn worked at Intel for 24 years, where he played a leadership role in developing, engineering and manufacturing semiconductor technologies. At Intel he was a crucial part of the start-up team at five fabs, managed two of its largest fabs, and was program manager for the firm's conversion to 300mm wafers.

Sohn graduated from Massachusetts Institute of Technology (MIT) with a degree in engineering, was a Clean Energy Ambassador to the World Wildlife Fund (WWF), and chaired the US Commerce Department's Manufacturing Council for the Obama Administration.

"It was under his leadership that First Solar, the only American thin-film PV success story, became what it is today," comments Siva Power's CEO Brad Mattson. "His guidance and leadership will be invaluable to Siva," he adds.

"Siva has made impressive progress on its advanced thin film technology," says Sohn. "While the solar industry has steadily improved its position as a leading generator of clean, renewable energy, we are still at the threshold of the upcoming growth phase," he adds. "Terrawatts of clean power are yet to be installed and there is opportunity to make thin-film solar the lowest-cost, most environmentally friendly solution."

Siva says that its roadmap will deliver lower electricity costs through advanced technology, scale, operational execution and an effective business strategy. Siva raised funds earlier this year to build a pilot line at its Silicon Valley headquarters, where it will produce CIGS modules based on its proprietary technology and manufacturing processes.

"Bruce's extensive experience in growing and managing large teams, and in global manufacturing capability, will prove to be a huge asset to Siva Power as we take our next step into giga-scale manufacturing," Mattson reckons.

www.sivapower.com

Oxford PV raises £8.7m in first close of Series C funding round, bringing total to £21m in 18 months

Further investment by end-2016 to speed commercialization of perovskite technology

As the first portion of a Series C funding round, UK-based Oxford Photovoltaics Ltd (founded in 2010 by professor Henry Snaith as a University of Oxford spin-off) has announced an equity investment of £8.7m, provided by a combination of new and existing shareholders. Total equity raised is now £21.3m ($27m) over the past 18 months. Further investment is expected before the end of 2016.

The funding will help to extend Oxford PV's position in the use of its perovskite technology to significantly enhance the performance and economic returns achievable from existing solar PV technologies. A portion of the funding has already been earmarked to develop a demonstration line to showcase the technology to manufacturers, bringing the firm one step closer to commercialization.

Applied as a thin-film layer in tandem with an active silicon cell, perovskite can boost cell output by about 30%, reckons the firm. "Energy consumption is set to double within the next 20–30 years. Perovskite has the potential to radically improve the efficiency of solar PV," says CEO Frank Averdung. "Our technology has already demonstrated the efficiency and stability necessary to engage commercially with major industry players and become a key part of enhancing solar energy supply in years to come," he adds. "This investment will support Oxford PV as we take large steps towards commercialization," he adds.

"We are gratified to have attracted not only reinvestment from many of our current shareholders but we have added some new and substantial ones with the promise of yet more funding later this year," notes chairman David Fyfe. "This is a tribute to the achievement of key strategic goals by the management and technical team."

www.oxfordpv.com

Solar Frontier surpasses 4GW of module shipments, reaching 11 more countries over last year

Kunitomi Plant starts manufacturing 175W panels as a main product

Tokyo-based Solar Frontier — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — says that total cumulative shipments of its CIS thin-film solar panels have surpassed 4GW, now reaching about 60 countries around the world. Some of the 11 new countries (accounting for about 1GW of modules shipped over the last year) include Norway, Somalia and Mongolia.

Solar Frontier attributes the landmark to its CIS solar panels' power generation capabilities as well as their economical and environmental advantages in real-working conditions — even in high temperatures or in partial shading.

Sustaining the shipments has been Solar Frontier's Kunitomi plant (with a nominal annual production capacity of 900MW) which has been fully operational since starting commercial production in 2011. Also, through Solar Frontier's efforts to boost the performance of its panels, this October the Kunitomi Plant began manufacturing solar panels with an output of 175W as a main product.

www.solar-frontier.com/eng

Midsummer receives repeat order for CIGS solar cell manufacturing system from Asian customer

Midsummer AB of Järfälla, near Stockholm, Sweden — a provider of turnkey production lines for making flexible, lightweight copper indium gallium diselenide (CIGS) thin-film photovoltaic (PV) solar cells — has won a repeat order for its compact DUO solar cell manufacturing system from an undisclosed Asian customer. The order was received in connection with Midsummer's first system at the customer going into production with a solar cell efficiency of over 15%, surpassing the acceptance criteria for cell efficiency by more than two percentage points at the customer's production site.

Midsummer says that, due to strong demand for lightweight, flexible modules, the customer has decided to buy another DUO manufacturing system, which will be delivered in mid 2017. The system will be used for manufacturing lightweight flexible panels to cater for the growing demand for portable panels and roof top installations.

The order was received in connection with Midsummer's first system at the customer going into production with a solar cell efficiency of over 15%

"The DUO system is now the most widely spread manufacturing tool for flexible CIGS solar cells," claims CEO Sven Lindström. The DUO is a compact, fully automatic deposition system for CIGS solar cell manufacturing, designed for operational stability and material utilization.

Midsummer says that it has developed a rapid process for the production of solar cells by using sputtering of all layers of the solar cell, allowing scalable and cost-effective manufacturing.

www.midsummer.se

Riber wins selenium evaporator order for Singulus CIGS PV systems

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has signed a contract worth more than a million Euros with Singulus Technologies AG of Kahl am Main, Germany, which makes production equipment for the Optical Disc and Solar sectors.

Riber will provide Singulus with its Jet 40K Selenium, which is a linear evaporator able to evaporate material alongside a surface. Selenium is a key element for making copper indium gallium diselenide (CIGS) thin-film solar cells. CIGS thin films are made using large roll-to-roll or in-line machines that deposit material onto glass or substrate film moving at high speed above the evaporators.

The Jet 40K Selenium evaporators will be installed on the several Singulus evaporation machines that will equip a new plant in China that is targeted to produce hundreds of MW of CIGS solar panel per year. Under the contract, Riber will deliver evaporators during first-half 2017.

The new contract follows Jet 40K Selenium evaporators being used for several years in Germany and the USA to produce CIGS thin-films, providing high quality and high thickness uniformity across large area of substrate film at high throughput.

www.riber.com

Dyesol wins £800,000 grant from UK's EPSRC

Dyesol Ltd of Sydney, Australia, which is industrializing perovskite solar cell (PSC) technology, and its collaboration partners have been awarded a grant of £800,000 from the UK's Engineering and Physical Sciences Research Council (EPSRC). The principal applicants for the grant 'Optimization of charge carrier mobility in nanoporous metal oxide films' are Dyesol (UK), Cristal and The University of York.

The background to this proposed research is the recent joint discovery by Dyesol and Cristal that halide-modified titania (TiO_2) surfaces in perovskite solar cells can provide a significant performance uplift. In early experiments, this translated into improved device performance of 2–3% (gross) in conversion efficiency and is, therefore, considered potentially important in industrialization of the technology, which Dyesol is leading globally.

Further internal investigation under this grant will now be undertaken to better understand the chemistry of the improved electron capture and transport. Translation into larger commercial photovoltaic devices is, of course, Dyesol's motivation for detailed scientific investigation. It is still too early to fully determine the full extent of the value of this discovery to Dyesol.

While not immediately necessary to progress Dyesol's industrialization plans, such as the Major Area Demo (MAD), it is expected that outputs from work such as this, and other R&D projects, will feed Dyesol's generational product improvement pipeline in the future. Dyesol says that it seeks to make optimal use of funding arrangements such as grants in the various jurisdictions in which it operates, in order to better leverage future opportunities without impacting cash flow in the present. Further, Dyesol is working with leading-edge researchers in areas important to advancement of the core technology upon which the firm relies, in order to harvest a strong base of innovation to build future value in commercialization endeavours.

Dyesol and Cristal, a subsidiary of Tasnee, recently filed a provisional patent to commence protection of intellectual property.

www.dyesol.com

Perovskite photovoltaic solar cells are based on applying low-cost materials in a series of ultrathin layers encapsulated by protective sealants. Dyesol's technology has lower embodied energy in manufacture, produces stable electrical current, and has an advantage in low light conditions relative to incumbent PV technologies. This technology can be directly integrated into the building envelope to achieve highly competitive building integrated photovoltaics (BIPV).

The key material layers include a hybrid organic–inorganic halide-based perovskite light absorber and nano-porous metal oxide of titanium oxide. Light striking the absorber promotes an electron into the excited state, followed by a rapid electron transfer and collection by the titania layer. Meanwhile, the remaining positive charge is transferred to the opposite electrode, generating electrical current.

5N Plus consolidating operations

Specialty metal and chemical products firm 5N Plus Inc of Montreal, Québec, Canada says that it intends to consolidate its operations at Wellingborough, UK with other sites within the group. In addition, in the USA, it will consolidate the operations of DeForest-Wisconsin and Fairfield-Connecticut in first-half 2017 into a newly updated and scaled facility in the state of Connecticut.

5N Plus provides purified metals such as bismuth, gallium, germanium, indium, selenium and tellurium, and also produces related II-VI semiconducting compounds such as cadmium telluride (CdTe), cadmium sulphide (CdS) and indium antimonide (InSb) as precursors for growing crystals for solar, LED and eco-friendly materials.

Earlier in September, aiming to improve profitability while reducing earnings volatility, 5N Plus unveiled its strategic plan '5N21', which is based on three main pillars:

(a) optimizing balance of contribution between upstream and downstream activities;

(b) extracting more value from core businesses, existing assets and capabilities; and

(c) delivering quality growth from existing growth initiatives including future M&A activities.

Over the next few quarters, the firm will transfer a number of product lines from Wellingborough to other manufacturing facilities within the group. The primary drivers in determining future locations of the affected product lines are operational synergy, cost competitiveness and client proximity, says 5N Plus.

The restructuring fees for the two initiatives are expected to be $3.5m, with payback of less than two years (with the positive impact reaching full potential starting in 2018).

"This specific decision is designed to extract more value from our existing assets as we optimize our core businesses," says president & CEO Arjang Roshan. "The culmination of these actions will result in a more agile operating structure while taking advantage of internal synergies as we increase utilization across other sites within the group."

www.5nplus.com

InGaN solar cells with positive temperature coefficient

Researchers develop attractive property for concentrator and high-temperature photovoltaic application using patterned sapphire substrate.

Researchers in China have developed indium gallium nitride (InGaN) photovoltaic devices that increase in efficiency with temperature up to 423K [Zhaoying Chen et al, Appl. Phys. Lett., vol109, p062104, 2016]. "The positive efficiency temperature coefficient is very attractive for concentrator and high-temperature photovoltaic application," the researchers comment.

Although the wide bandgap of III-N semiconductors should lead to smaller dark current and hence a positive temperature dependence of efficiency on temperature, the lower crystal quality compared with narrower-bandgap materials, such as silicon, germanium and gallium arsenide, tends to cancel this expected effect.

The team based at Peking University and Collaborative Innovation Center of Quantum Matter used patterned sapphire substrates (PSSs) to improve material quality. "The adoption of the PSS improved the crystal quality of the epilayer, making the positive temperature coefficient of efficiency kept to 393K," the researchers comment.

The researchers further worked to create an optimized solar cell on PSS by improving the fabrication process. As a result, a positive temperature coefficient for the efficiency was maintained up to 423K. The characteristic room-temperature (~300K) solar cell parameters were 2.06% efficiency, 1.69V open-circuit voltage (V_{OC}), 2.32mA/cm^2 short-circuit current density (J_{SC}), and 52.5% fill factor (FF).

Of course, 2.06% is nowhere near the values obtained for silicon (up to 27%) or multi-junction devices that use III-V compound semiconductors (46%). The maximum reported efficiency for III-nitride solar cells is still only 3.4%. The restricted efficiency is related to the wider bandgap cutting off the majority of the solar spectrum as simulated by the AM1.5G standard. However, high-indium-content InGaN has a narrower bandgap with a lower limit of 0.64eV (InN).

InGaN material quality is compromised by the tendency to phase separation of InN and GaN. This results in defects, dislocations and non-uniformity. This is the main reason that III-nitride light-emitting and -absorbing devices use thin 'quantum wells' of InGaN rather than bulk material.

Contact	p-GaN	150nm
MQW	30x(InGaN/GaN)	30x(1.2nm/4.5nm)
Contact	n-GaN	1μm
Buffer	GaN	4.5 μm
Substrate	Sapphire/PSS	

Figure 1. Epitaxial structure.

Even with the low reported efficiency, it is hoped that InGaN technology could find useful application as the top cell of multi-junction solar cells, particularly in concentrator/high-temperature conditions and with realization of a positive temperature coefficient for efficiency.

Multi-wafer metal-organic chemical vapor deposition (MOCVD) was used on (0001) sapphire with both normal and patterned substrates. The patterning consisted of a hexagonal array of conical protrusions.

The resulting epitaxial material (Figure 1) was formed into 1mmx1mm mesa-type solar cells with nickel/gold p- and titanium/aluminium/nickel/gold n-contacts

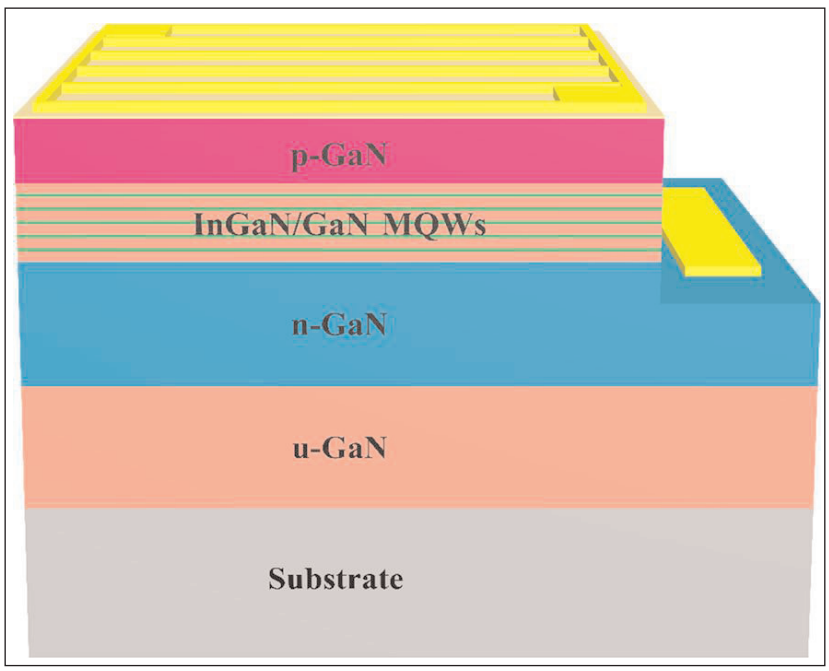


Figure 2. Schematic structure of InGaN/GaN MQW solar cell.

(Figure 2). The p-contact was patterned in a grid with 30nm/150nm layers and transparent conducting electrodes with 5nm/5nm layers.

Photoluminescence and x-ray analysis suggested that the InGaN quantum wells contained ~30% indium fraction and were ~1.2nm thick. The GaN barriers were around 4.5nm. Using patterned sapphire substrates reduced edge-type dislocation densities to $1.54x10^8/cm^2$, compared with $4.07x10^8/cm^2$ for plain sapphire. By contrast, screw-type dislocations increased slightly with patterning to $1.58x10^8/cm^2$, compared with $1.34x10^8/cm^2$ on plain sapphire.

Patterning improved the photovoltaic efficiency by 23.4% (Table 1). The researchers attribute this to the decrease in non-radiative recombination at dislocations, the resulting longer minority carrier lifetime increasing extraction into the photocurrent, and enhanced light absorption by the patterned sapphire texture.

The cells on patterned sapphire also showed increased efficiency with increased temperature up to 393K (Figure 3). By contrast, the device on plain sapphire showed a rapid decrease in efficiency.

Table 1. Summary of solar cell performance of samples on sapphire and PSS.

Substrate	V_{OC}	J_{SC}	FF	Efficiency
PSS	2.01V	$0.97mA/cm^2$	59.4%	1.16%
Sapphire	2.06V	$0.71mA/cm^2$	64.4%	0.94%

The short-circuit current increased with temperature at almost the same rate in both devices. The team relates this to the narrowing of the InGaN bandgap with temperature, resulting in the cell being able to convert longer-wavelength photons. The narrower bandgap also reduces the open-circuit voltage, but on plain sapphire the voltage is further degraded by dark current from non-radiative recombination. ■

http://dx.doi.org/10.1063/1.4960765

Author: Mike Cooke

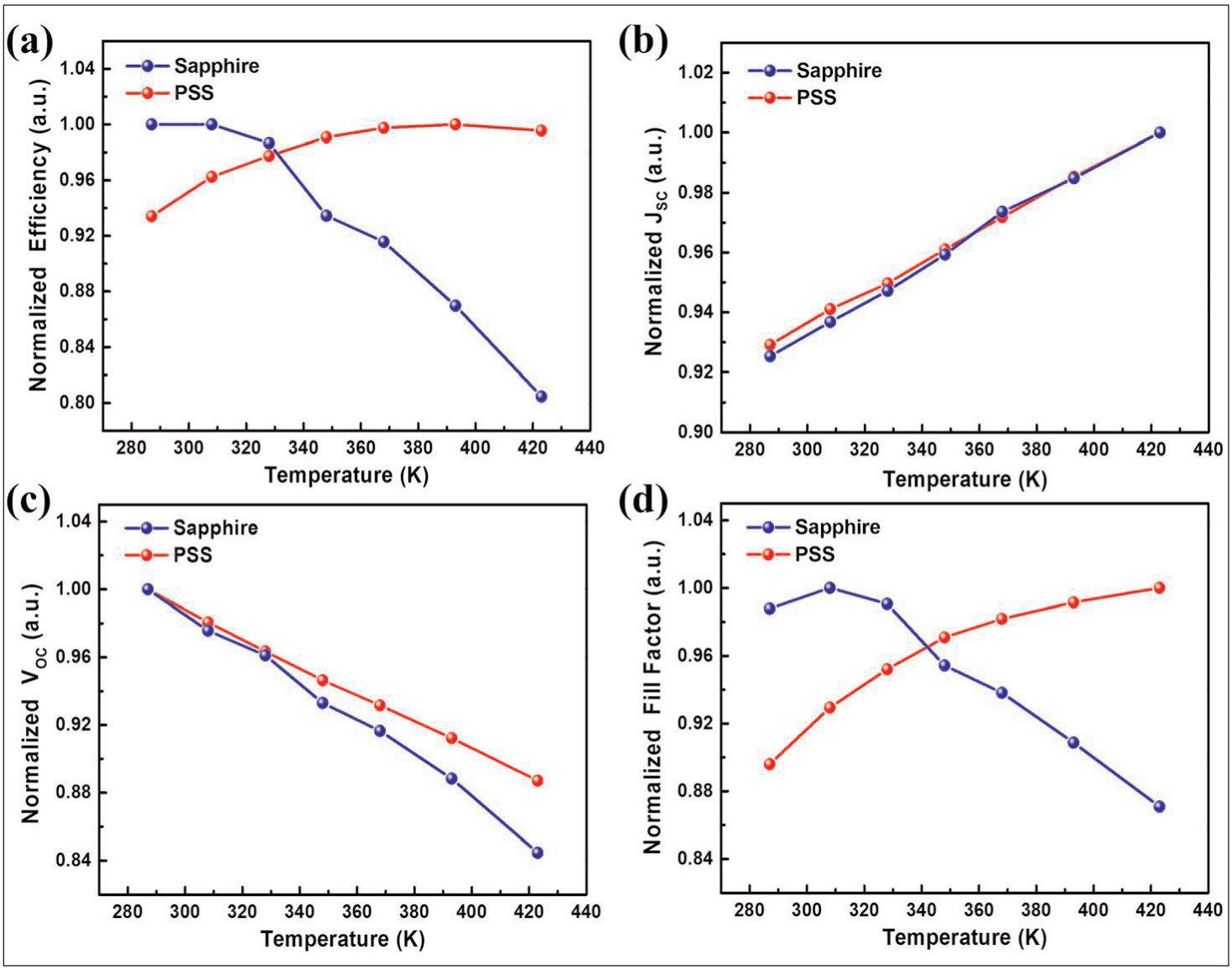


Figure 3. Normalized temperature-dependent conversion efficiency (a), short-circuit current density (b), open-circuit voltage (c) and fill factor (d) for solar cells on PSS and sapphire.

Two-dimensional GaN with graphene encapsulation

Researchers develop migration-enhanced encapsulated growth process.

Researchers in the USA have grown two-dimensional (2D) layers of gallium nitride (GaN) using a graphene encapsulation on silicon carbide (SiC) substrate [Zakaria Y. Al Balushi et al, Nature Materials, published online 29 August 2016]. The team from Pennsylvania State University, University of Notre Dame, US Naval Research Laboratory, University of Texas at Dallas, and Physical Electronics USA comments: "Graphene has proven to be a remarkable material over the past decade; and with the discovery that it can stabilize 2D forms of traditionally '3D' binary compounds, we have provided the foundation to realize many other classes of materials that are not traditionally 2D."

Such 2D GaN is expected to have a different vibrational/phonon structure with respect to bulk material that could modify polaritonic photon–phonon mixing behavior with possible nanophotonic application in the mid-infrared.

The researchers hope that the process could lead to new heterostructures of 2D layered materials, including those from the III-nitride group to which GaN belongs.

The researchers first sublimated silicon from the surface of the SiC (0001) substrate at ~1600°C in argon to give a layer of quasi free-standing epitaxial graphene (QFEG, Figure 1). The graphene layer was hydrogenated to passivate dangling bonds. The graphene on SiC structure was exposed to cycles of trimethyl-gallium at 550°C with Ga adatoms inserting themselves between the graphene and SiC. The intercalated Ga was transformed at 675°C into 2D GaN with the nitrogen supplied by ammonia decomposition.

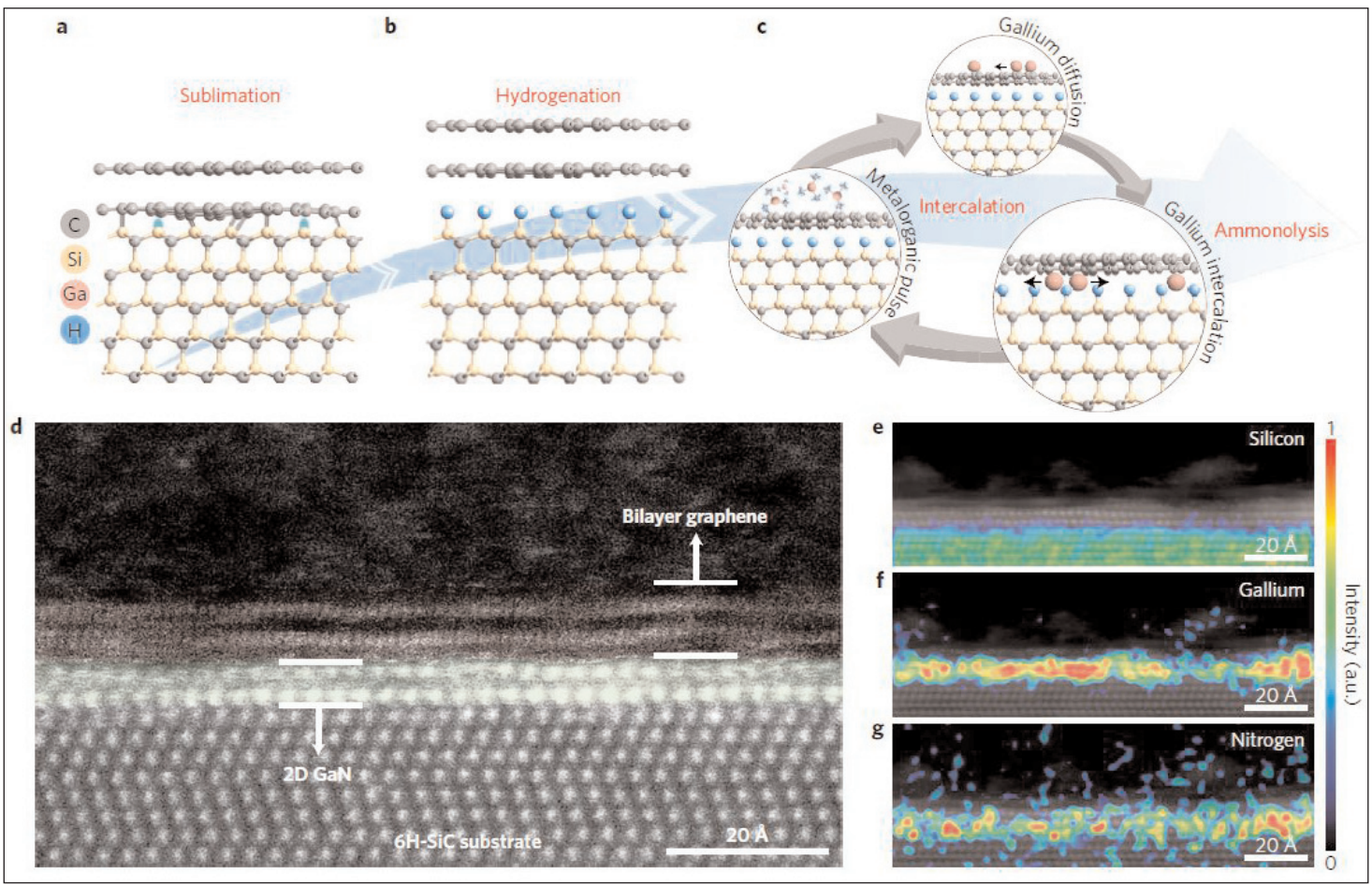


Figure 1. a–c, Schematic of MEEG process for 2D GaN (d). Green halos at SiC/graphene interface represents silicon dandling bonds. d, High-angle annular dark-field scanning transmission electron microscope cross-section of 2D GaN. e–g, Elemental energy dispersive x-ray mapping of silicon (e), gallium (f) and nitrogen (g) in 2D GaN.

It was found that the "migration-enhanced encapsulated growth" (MEEG) process resulted in two layers of GaN encapsulated by a bilayer of graphene. Examination of the sample showed that the intercalation was facilitated by defects of the graphene structure (point-, wrinkles, metal-graphene interactions). The MEEG process also causes increased defects in the graphene over regions of 2D GaN.

The researchers also used the MEEG process to produce thicker, more-than-5nm layers of 2D GaN. The surface termination of the 2D GaN was similar to that found with the two-layer GaN.

Ultraviolet–visible reflectance measurements found an inflection point at 4.90eV, not observed in samples without GaN (Figure 2). The researchers therefore believe that 4.90eV represents the region of the bandgap energy (E_g) of the 2D GaN. Density functional theory (DFT) calculations predict values of 4.79eV and 4.89eV, according to different approximations. Another approach using absorption coefficients in the ultraviolet–visible range gave a direct bandgap of 4.98±0.13eV. These values are much higher than the 3.42eV of normal bulk GaN.

The researchers also used low-loss electron energy-loss spectroscopy (EELS) measurements on material with the graphene encapsulation removed, resulting in a 5.53eV bandgap. The team comments: "The ~0.6eV deviation in the E_g measured from low-loss EELS arises from specular losses, such as Cerenkov loss, that are observed in EELS measurements of high-dielectric materials. Our results, however, provide direct evidence that the E_g is much larger than that found in bulk GaN, with theoretical and experimental values being in good agreement."

Vertical current flow was also measured using conductive atomic force microscopy (AFM). Forward bias flow is believed to be mainly electrons pulled from the accumulated n-type 6H-SiC over a ~1.7V conduction band offset between SiC and 2D GaN. The reverse flow is tentatively attributed to "electron injection from graphene over the Schottky barrier provided by 2D GaN, and into the depleted n-type 6H-SiC". Away from the regions of 2D GaN the conduction was ohmic (i.e. approximately linear).

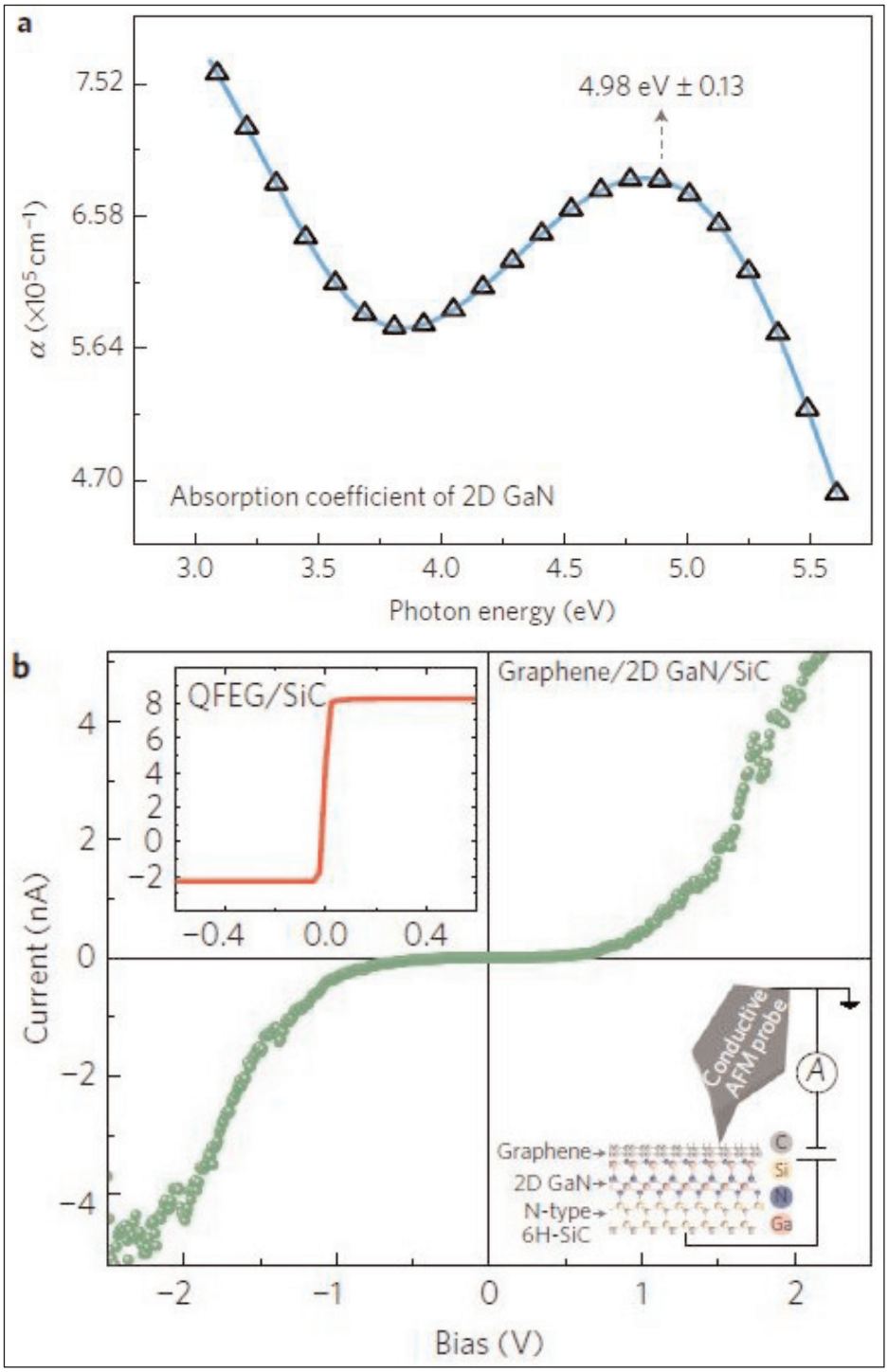


Figure 2. a, Absorption coefficient (α) of 2D GaN from ultraviolet–visible spectroscopic ellipsometry, revealing direct E_g of 4.98 eV. Connecting line is to guide eye. b, Vertical transport measurements with 2D GaN Schottky barrier. Current–voltage curve of heterostructure (green) and QFEG/6H-SiC (red curve in top-left inset) collected with conductive AFM (bottom-right schematic).

Analysis suggests the 2D GaN regions were in a buckled state and the stoichiometric composition was not 1:1. The layer was covalently bonded with the underlying SiC; the bonding with the graphene encapsulation was van der Waals. ■

http://dx.doi.org/10.1038/nmat4742

Author: Mike Cooke

Electrically driven single-photon emission from atomically thin diodes

Atomically thin layered transition-metal dichalcogenide material has been used as an active layer in a tunnel junction device.

The UK's University of Cambridge and Japan's National Institute for Materials Science have developed single-photon emission devices using layers of graphene, hexagonal boron nitride (hBN), and transition-metal dichalcogenides (TMDs) [Carmen Palacios-Berraquero et al, Nature Communications, vol7, p12978, 2016]. "These results present the transition-metal dichalcogenide family as a platform for hybrid, broadband, atomically precise quantum photonics devices," the researchers write.

The device consisted of thin layers that together constituted a tunnel junction (Figure 1). The substrate was silicon with a thermal silicon dioxide layer. The device heterostructure consisted of single-layer graphene (SLG), 2–6-layer hBN, and 1–2-layer tungsten diselenide (WSe_2) TMD. The layers were exfoliated from respective bulk materials. The TMD was naturally p-doped; it was also the active light-emitting layer. Electrons were injected from the single-layer graphene through the hBN tunnel barrier into the WSe_2 for recombination with holes, giving photons. The contacts were chromium/gold.

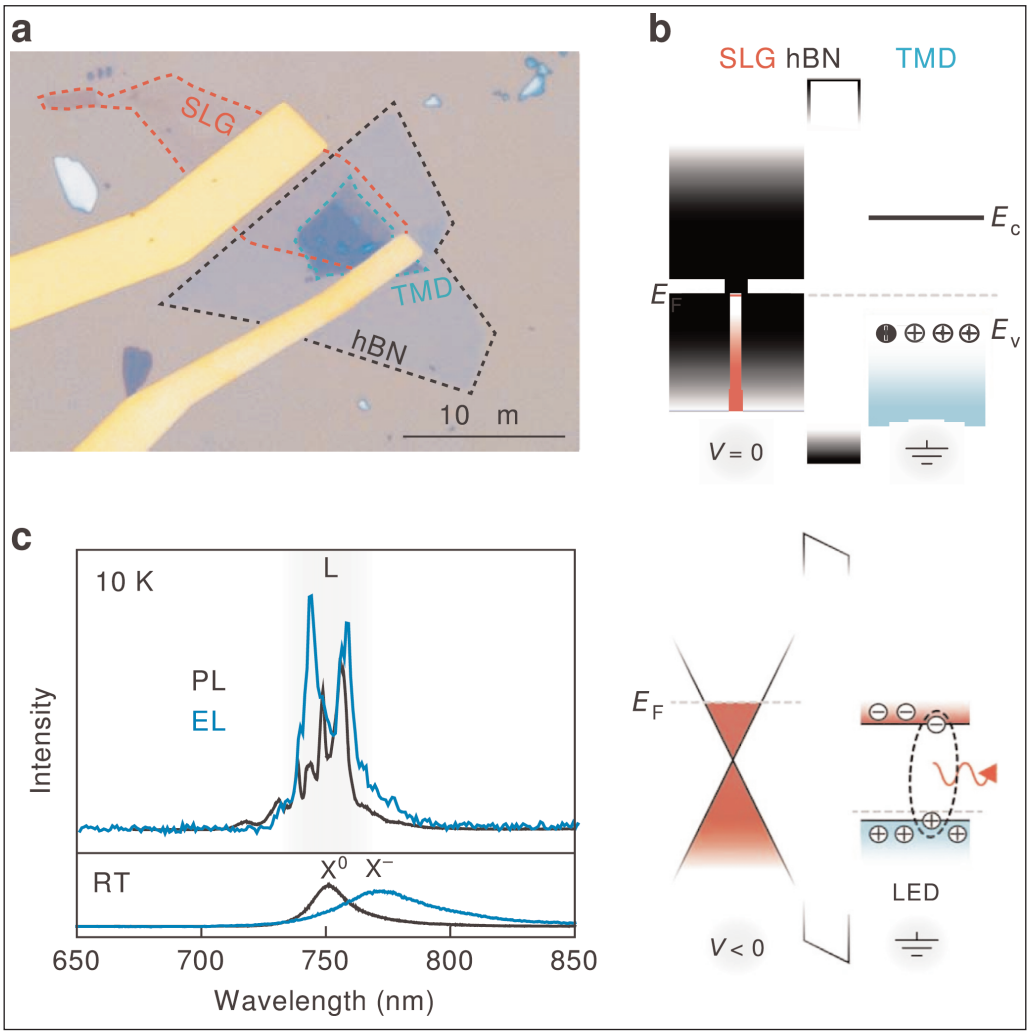


Figure 1. (a) Optical microscope image of typical device. Dotted lines highlight footprints of SLG, hBN and TMD layers. (b) Heterostructure band diagram. Top illustration shows zero-applied bias and bottom finite negative bias applied to the SLG. (c) Example of layered LED emission spectra for optically active layer of WSe_2 . Top (bottom) spectra correspond to 10K (room-temperature RT) operation temperature, where black and blue curves are obtained by optical and electrical excitation, respectively.

Photoluminescence (PL) from the structure at room temperature gave a broad peak at 750nm that the researchers associate with the unbound neutral exciton (X^0, electron–hole bound state) of WSe_2. The peak red-shifts by +20nm in wavelength under electroluminescence (EL). These wavelengths are just outside the visible spectrum (400–700nm) in the infrared (700nm+).

At very low temperature (10K), the spectra blue-shifted by about −30nm due to a slightly wider bandgap. Also, at 10K the spectra show structure,

even under EL. The team comments: "In the low-current regime (<1μA for this device) they dominate the EL spectrum, as shown in Fig. 1c, indicating that localized exciton states respond more efficiently to charge injection than the delocalized ones."

Emission from bilayer WSe_2 was brighter than the monolayer regions. There were also regions of localized emission bright spots that had a longer wavelength. "These localized states lie within the bandgap of WSe_2, and therefore emit at lower energies (longer wavelength) with respect to the bulk exciton emission," the researchers comment.

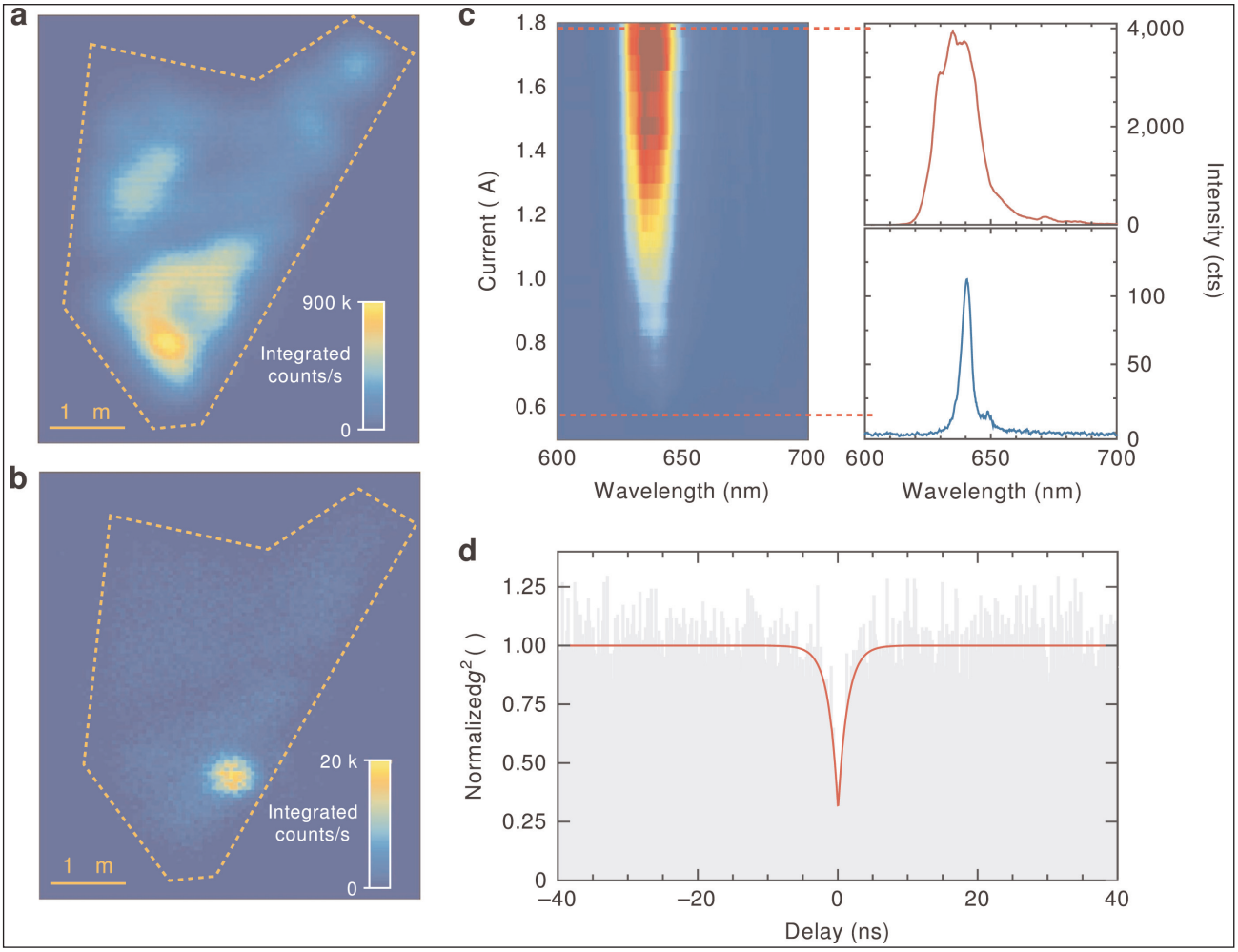


Figure 2. Raster-scan map of integrated EL intensity from monolayer WS_2 area: (a) at 0.665μA injection current (bias 2.08V), and (b) at 0.570μA (1.97V). (c) Map of EL spectrum as function of current. Spectrum at the top (bottom) of panel is line cut for injection current of 1.8μA (0.578μA). (d) Intensity-correlation function for localized quantum dot/bright spot in b.

The linewidths of the localized emitters were between 0.8nm and 3nm. Their distribution density was of the order of 1–2 emitters per 40μm^2 of active device area. The positions of the lines from the localized emitters wandered around 2nm over a timescale of seconds.

"Gating and encapsulation of the active layer should aid in reducing the broad linewidths observed here, which we attribute to charge noise in the device," the researchers suggest. "Slow spectral fluctuations can further be reduced through active feedback, for example via the direct current Stark shift."

The team reports that the devices could withstand up to five cooling/heating cycles and several hours of measurement under uninterrupted current.

Hanbury Brown and Twiss interferometer measurements give a low value of 0.29 for the intensity-correlation function ($g^{(2)}(0)$). Single-photon sources are expected to have values below 0.5. The non-zero value also contains contributions from background emission within a broad spectral window and from dark counts of the detector. The team expects improvements could be made by spectral filtering and optimized charge injection.

Replacing WSe_2 with another TMD, tungsten disulfide (WS_2), the researchers found localized red low-temperature (<10K) EL at 640nm with 4nm linewidth with 0.570μA injection. The emission was dominated by single photons, as demonstrated by a $g^{(2)}(0)$ of 0.31 (Figure 2).

The researchers believe that other TMDs could be used as active material. Further a back gate could allow some tuning of the Fermi energy and emission spectrum. They also suggest that couplings with dopant and vacancy levels in silicon or diamond could provide routes to quantum storage and coupling into photonic channels. ■

www.nature.com/ncomms/2016/160926/ncomms12978/full/ncomms12978.html

Author: Mike Cooke

Combatting droop with thick single quantum wells on semi-polar GaN

Researchers maintain ~40% external quantum efficiency up to 900mA injection current and almost 1W output power.

University of California Santa Barbara (UCSB) has used thicker single quantum wells (SQWs) of indium gallium nitride (InGaN) on free-standing semi-polar gallium nitride to create a light-emitting diode (LED) with 'negligible' external quantum efficiency (EQE) droop up to 900mA injection current and almost 1W output power [Sang Ho Oh et al, Appl. Phys. Express, vol9, p102102, 2016].

The researchers comment: "The adoption of a thick active region resulted in excellent optical and thermal performance characteristics that are suitable for high-power lighting applications."

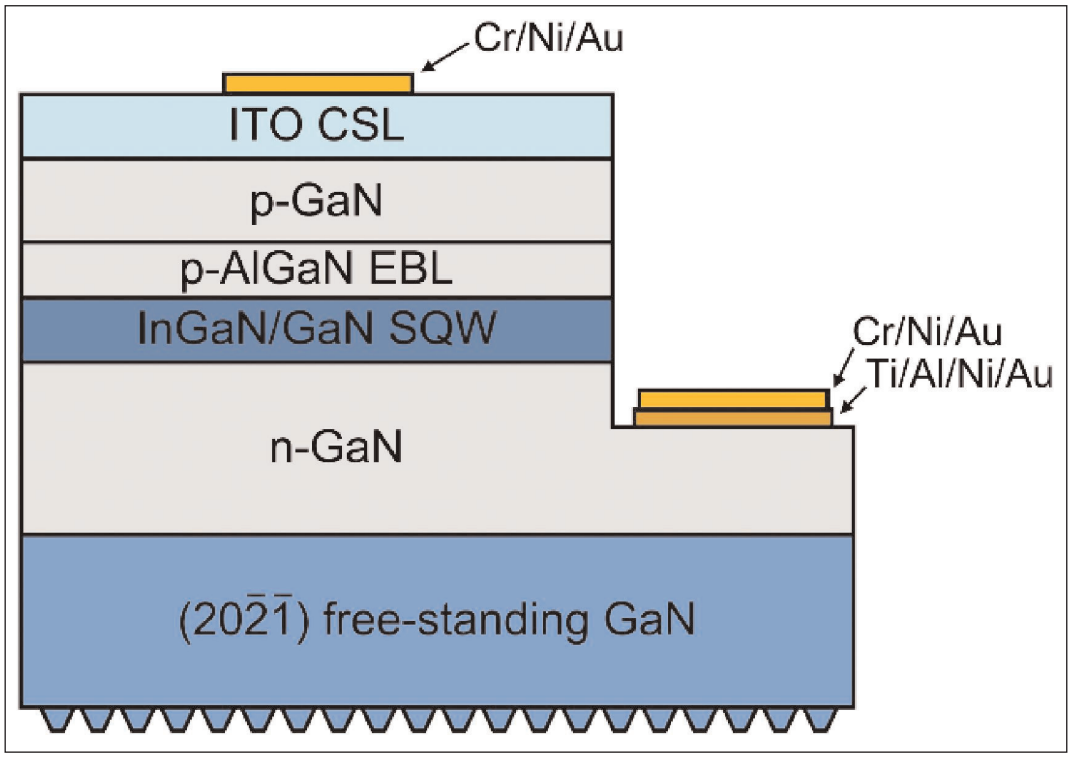


Figure 1. Schematic of 1mm^2 (20$\bar{2}\bar{1}$) LED with roughened back side.

Previous attempts to use thicker SQWs on c-plane templates have resulted in low performance due to poor overlap between the electrons and holes that should recombine into photons. The poor overlap is related to large electrical fields in the c-direction arising from charge polarization of the III-nitride bond. Net electric fields tend to pull the electrons and holes apart, reducing radiative recombination into photons.

Narrower wells on c-plane help confine the electron and hole wavefunctions, increasing overlap. Multiple quantum wells are often used in an attempt to increase brightness, but this is not terribly successful since holes tend to only be injected into the well nearest to the p-contact layers.

The use of semi-polar material increases radiative recombination by increasing the overlap without the need for confinement. The diode built-in electric field approximately cancels the reduced field arising from charge polarization effects in (20$\bar{2}\bar{1}$) semi-polar oriented material.

The UCSB LED material (Figure 1) was grown on 5mmx10mm pieces of (20$\bar{2}\bar{1}$) GaN by metal-organic chemical vapor deposition (MOCVD). The free-standing substrate was supplied by Mitsubishi Chemical.

The active SQW region consisted of a 9nm GaN barrier, 14nm or 12nm $In_{0.16}Ga_{0.84}N$, and a 16nm GaN barrier. The n-GaN contact layer was 1μm thick. The p-type layers included a 15nm aluminium gallium nitride (AlGaN) electron-blocking layer (EBL). The p-GaN contact layer was 115nm.

The material was fabricated into 1mm^2-mesa LEDs with 220nm indium tin oxide (ITO) current-spreading layer (CSL) on the p-contact, annealed titanium/aluminium/nickel/gold n-electrode, and chromium/nickel/gold n- and p-contact pads. The back-side of the device was plasma etched to improve light extraction.

The 14nm SQW device was package in a vertical transparent stand process. The submount was zinc oxide. The assembly was encapsulated in transparent

silicone with 1.41 refractive index. The 12nm SQW LED was mounted on a heating stage without encapsulation.

The output power and external quantum efficiency of the 14nm SQW LED showed much improved performance with respect to current (Table 1). The peak EQE of 42.3% occurred at 200mA. The peak EQE was only slightly lower than for a previous smaller-area ($0.1mm^2$) device. The difference is explained as being due to reduced light-extraction efficiency and current-crowding effects of larger-area LEDs. However, at 900mA current injection the device shows 'negligible' efficiency droop, which the researchers attribute to the lower carrier density allowed by the thick SQW.

While the EQE (photons/electron) is approximately flat above the peak, the wall-plug efficiency (WPE, output/input power) declines due to an increase in forward voltage. The researchers comment: "The forward voltage at 200mA ($20A/cm^2$) is 3.6V, which is relatively high compared with those of commercial LEDs, and results in a reduction in WPE at drive currents. Further optimization of the resistance of the p-contacts, n-contacts, ITO current-spreading layers, and n-GaN current-spreading layers should reduce the forward voltage and increase the WPE of the LEDs."

The 12nm SQW LED was used in temperature characterization. The demonstrated EQE was less than 15%. This was due to the horizontal orientation and absence of encapsulation, according to the team. Increasing the temperature reduced the EQE, but did not add any efficiency droop, which was small at all temperatures up to 100°C. The hot/cold factor of EQE at 100°C/20°C was constant at around 0.9 for currents between 100mA and 900mA (0.92 factor). The characteristic temperature for the output power droop was more than 800K (884K at 900mA).

Table 1. Output power and EQE at different current injection levels for (20$\bar{2}\bar{1}$) blue LED with 14nm SQW.

Current	Output power	EQE
100mA	112mW	40.1%
200mA	236mW	42.3%
500mA	574mW	41.1%
900mA	991mW	39.4%

The researchers maintain that these results indicate thermionic escape had an insignificant effect on droop. "This indicates that carrier leakage due to the thermionic escape is unlikely to be a cause of the efficiency droop," they add.

The researchers also found that the temperature dependence was similar to that of small-area $0.1mm^2$ devices. They conclude that the new devices are "well suited for high-power solid-state lighting applications that require thermal stability". ■

http://doi.org/10.7567/APEX.9.102102

Author: Mike Cooke

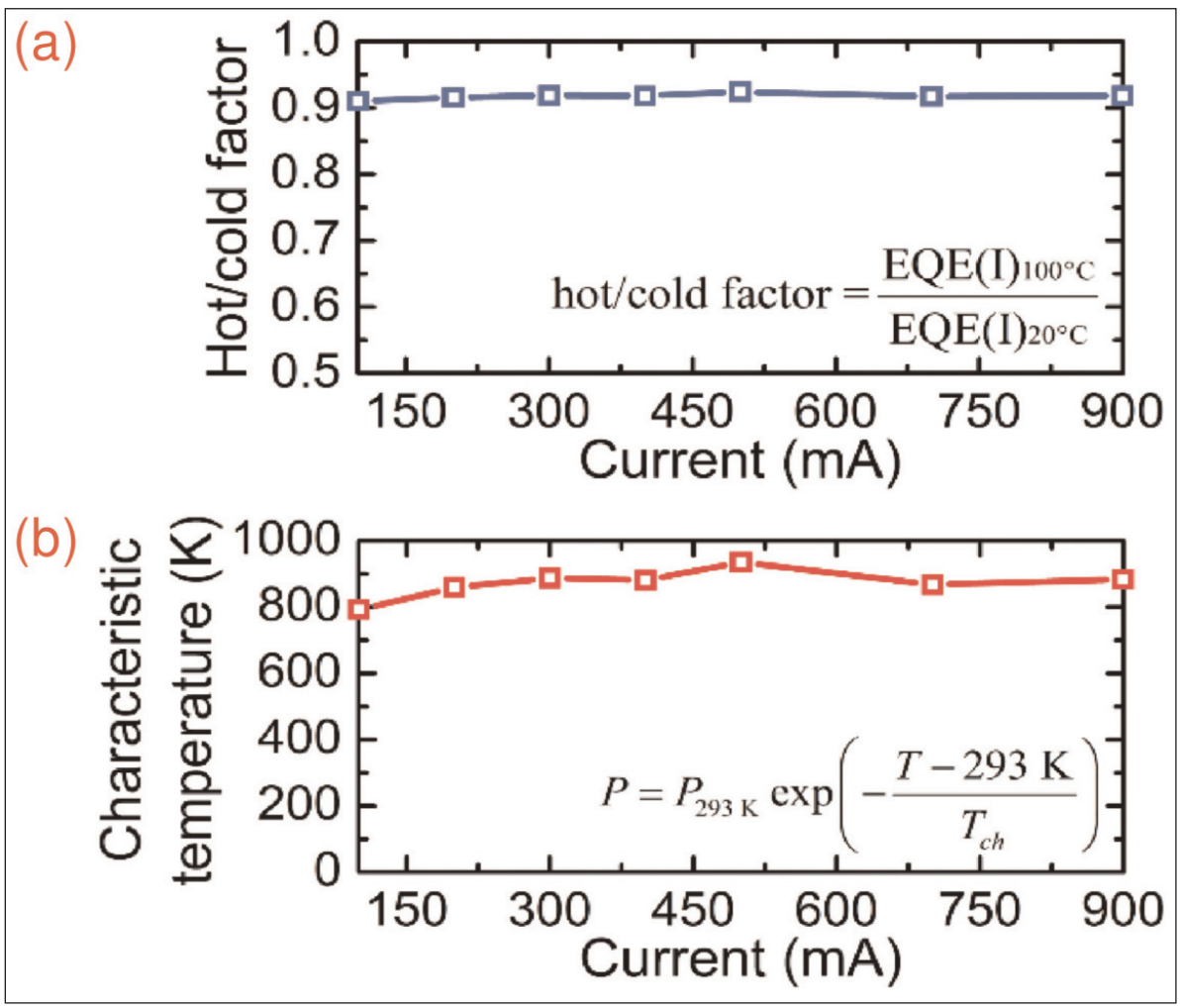


Figure 2. (a) Dependence of hot/cold factor on current for (20$\bar{2}\bar{1}$) blue LED with 12nm SQW. (b) Dependence of characteristic temperature on current for same LED (T = 100°C).

Reducing laser diode optical leakage with indium gallium nitride waveguides

Researchers in Poland show how layers with more than 5% indium content can be used to eliminate mode leakage with relatively thin cladding.

Institute of High Pressure Physics (IHPP) and TopGaN Ltd, both of Poland, have been jointly developing indium gallium nitride (InGaN) waveguide structures for use in blue laser diodes (LDs) [Grzegorz Muziol et al, Appl. Phys. Express, vol9, p092103, 2016)]. The aim is to improve beam quality for applications such as data storage and image projectors.

Beam quality in III-nitride semiconductor laser diodes suffers because of optical leakage to the substrate through the bottom aluminium gallium nitride (AlGaN) cladding. Thicker cladding layers reduce leakage, but the thickness of AlGaN layers is restricted for coherent straining to GaN and for avoiding the cracking of epitaxial layers.

The IHPP/TopGaN team proposes the use of InGaN waveguides with thickness and indium content sufficient to increase the effective refractive index to greater than that of GaN. This should not only reduce leakage, but fully suppress it, according to the researchers. They comment: "The most important advantage of this design is that a thick n-AlGaN cladding is not necessary to obtain high optical beam quality."

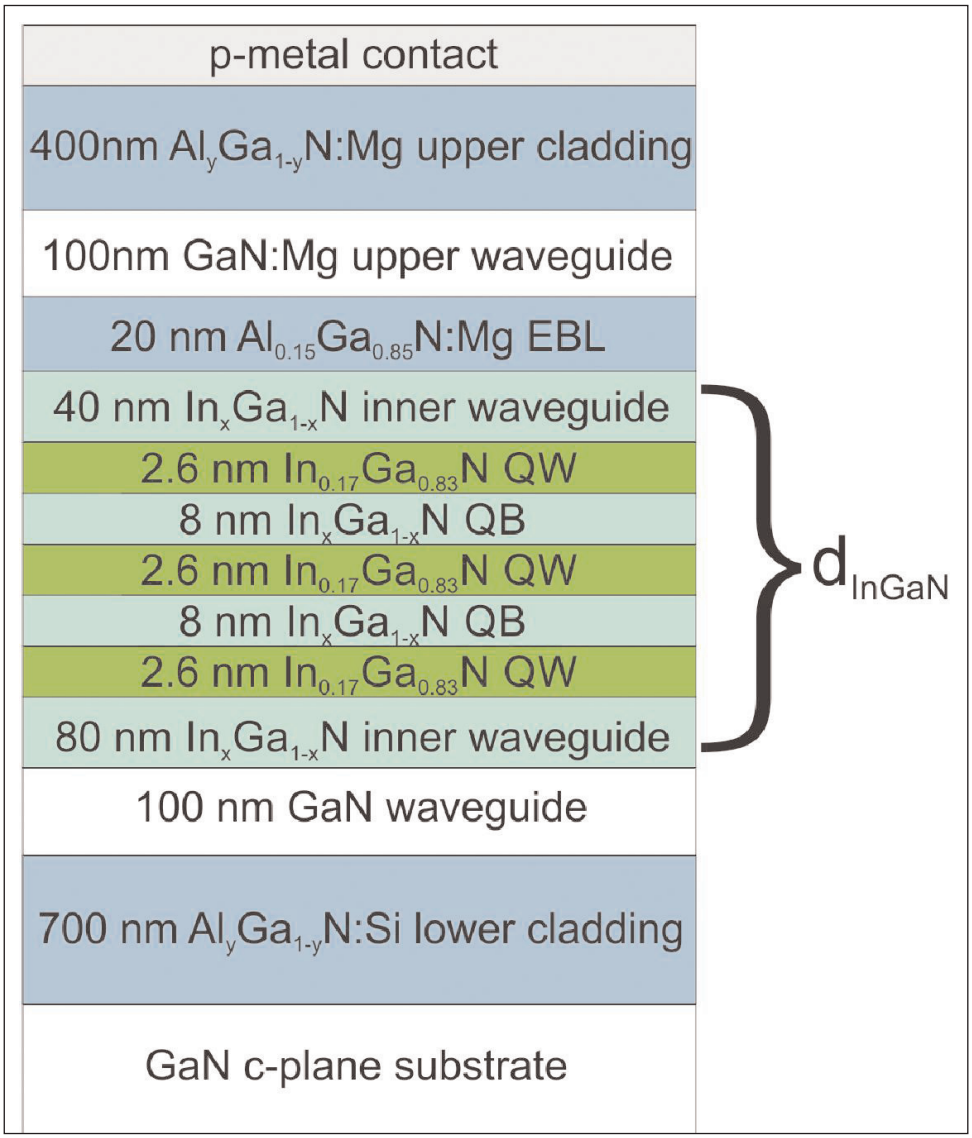


Figure 1. Schematic design of laser diode.

The researchers used plasma-assisted molecular beam epitaxy (PAMBE) to grow the material for blue laser diodes with InGaN waveguides (Figure 1). Eight different InGaN waveguide structures were grown, aiming to validate simulations previously developed by the team. The AlGaN cladding had fixed thicknesses of 700nm and 400nm and Al composition of 6% Al. The 700nm lower cladding thickness would allow significant optical leakage into the substrate without waveguide layers.

The far-field profiles were assessed using a CCD camera (Figure 2). The diodes with the lowest-indium-content waveguides showed the effects of leakage into the substrate in the form of an "enormous narrow peak" at 9.5° with 145nm $In_{0.04}Ga_{0.96}N$ waveguide layers. The intensity maximum was 7x that of the main Gaussian profile.

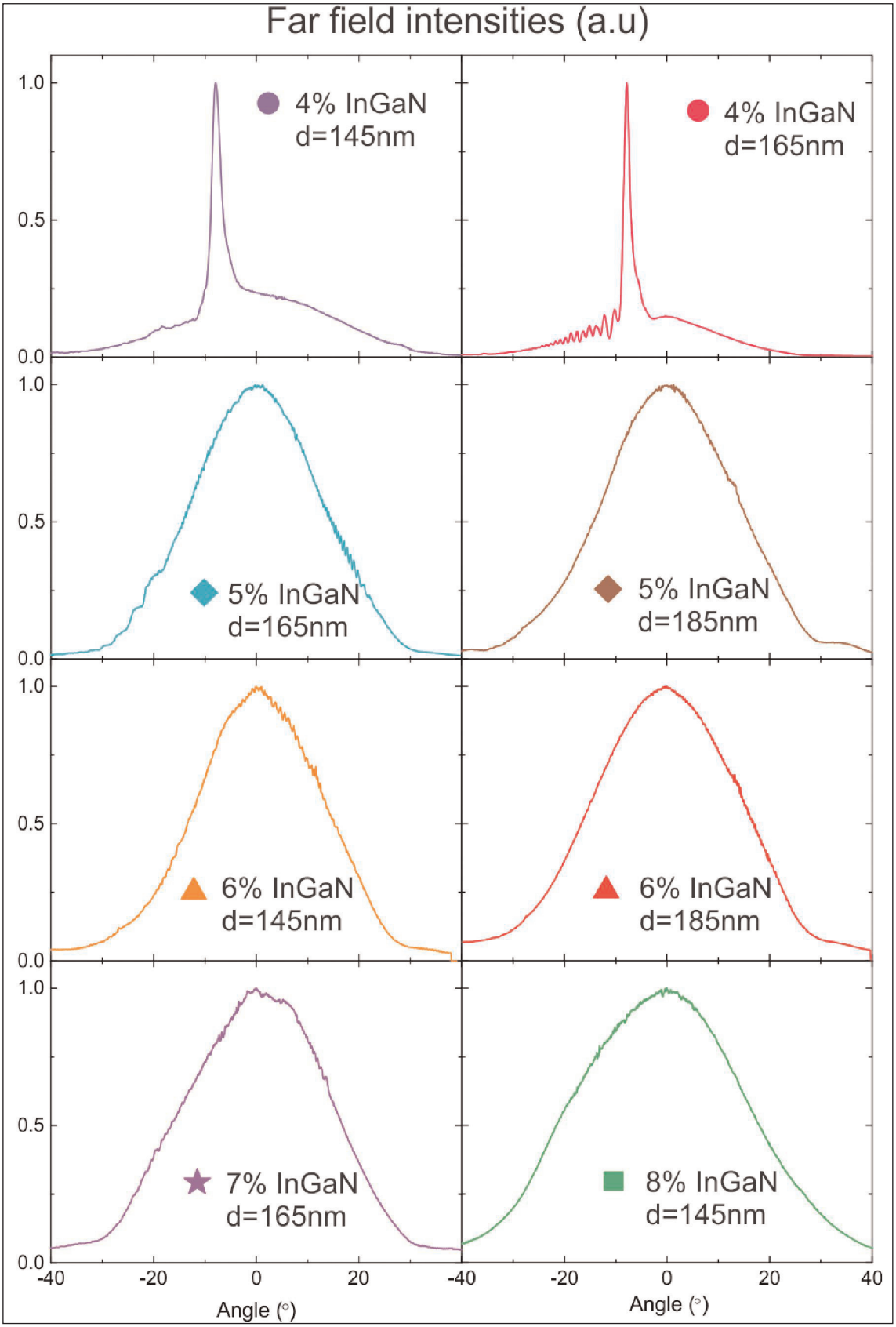


Figure 2. Experimentally measured fast axis of laser diode far-field patterns with various InGaN waveguide compositions and thicknesses.

The researchers comment: "This is a manifestation of a strong leakage to the GaN substrate. It is so strongly pronounced because the thickness of the n-AlGaN cladding layer is insufficient to reduce it. If the thickness would be higher, the leakage and thus the magnitude of the peak could be reduced. The amount of light in this peak is 25% of the overall far-field pattern and agrees well with the value of 21% predicted theoretically."

The width and height of the measured peak is broader and shorter than the simulations, however. The team suggests that this could be due to small inhomogeneities of electron concentration, affecting the refractive index.

The InGaN waveguides with indium content higher than 5% had no visible leakage peaks, in line with the modeling. ■

http://doi.org/10.7567/APEX.9.092103

Author: Mike Cooke

Flip-chip hybrid external-cavity laser array on silicon platform

Researchers claim first demonstration of an integrated surface-normal coupled laser array on a silicon-on-insulator photonics platform.

Oracle Networking Group in the USA believes that it has made the first demonstration of an integrated surface-normal coupled laser array on a silicon-on-insulator photonics platform [Shiyun Lin et al, Optics Express, vol24, p21455, 2016].

Passively aligned (i.e. laser off) high-accuracy flip-chip bonding was used to combine a III-V reflective semiconductor optical amplifier (RSOA) array with integrated total internal reflection mirrors onto CMOS silicon-on-insulator (SOI) containing silicon photonic circuits (Figure 1). The completed assembly formed a tunable hybrid external-cavity laser array.

The aim of the work is to fill the gap in silicon photonics for high-efficiency laser sources, giving a complete platform for next-generation optical interconnects that need large bandwidth, high density and high power efficiency.

The 2mmx2mm RSOA chip contained multiple quantum wells on indium phosphide (InP) with 600μm-long ridge waveguides in a 2x6 array. The pitch of the array was 1mm along the waveguide and 250μm perpendicular to this direction.

Chemically assisted ion-beam etch was used to create an angled mirror-facet. The light from the total-internal reflection mirror was angled to match the grating couplers (GCs) in the silicon photonics circuit. A further mirror on the back-facet of the RSOA was coated with material to give more than 95% reflectivity. The chip's top surface was coated with anti-reflective material to reduce back reflection.

The silicon photonic circuit was fabricated using a silicon-on-insulator substrate with 300nm of silicon on 0.8μm of buried oxide. A 130nm CMOS process was used to create a 2x6 array of ring reflector circuits that matched the RSOA chip (Figure 2). Silicon resistor micro-heaters were incorporated into the rings to provide laser wavelength tuning. Grating couplers were used to couple light into and out of the circuit. The light was output into a fiber array.

CMOS aluminium metalization provided bonding pads for the RSOA and metal traces to large probing pads. Under-bump metalization consisted of titanium-gold. Gold-tin (AuSn) bumps were sputtered onto the CMOS pads.

The one-step passive bonding process had a peak temperature of 320°C. The RSOA and SOI chips were bonded using a high-accuracy flip-chip bonder with an alignment tolerance of ±0.5μm. The alignment was achieved in a one-step passive process with matching patterns near the coupling region. The demonstration

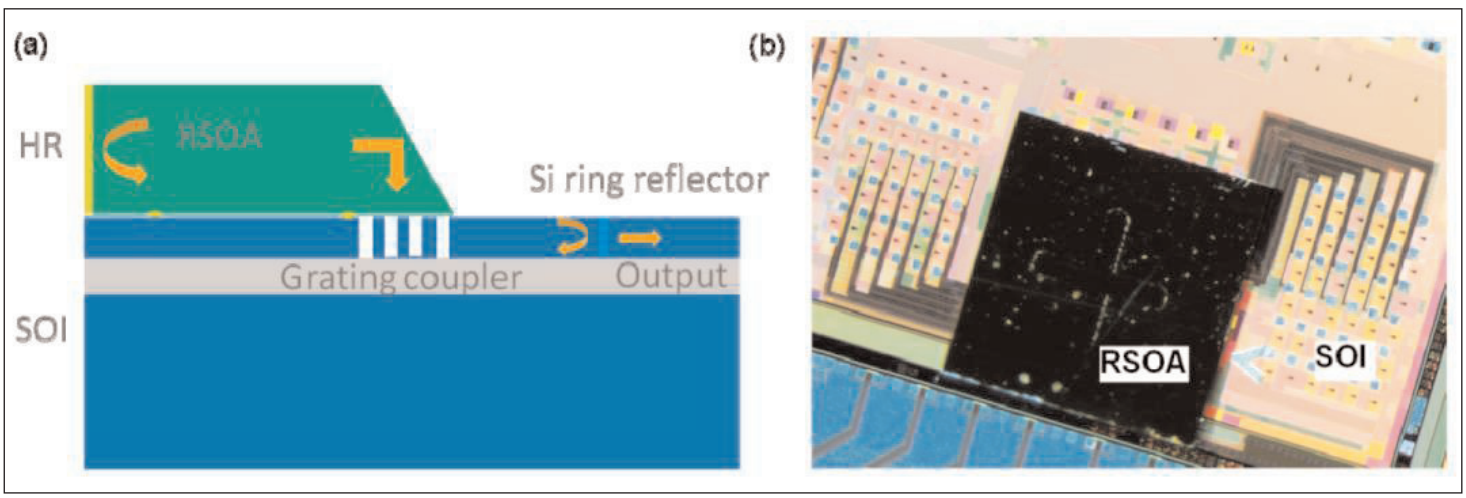


Figure 1. (a) Side-view schematic of surface-normal coupled hybrid laser, (b) microscope image of integrated 2x6 hybrid external-cavity laser array.

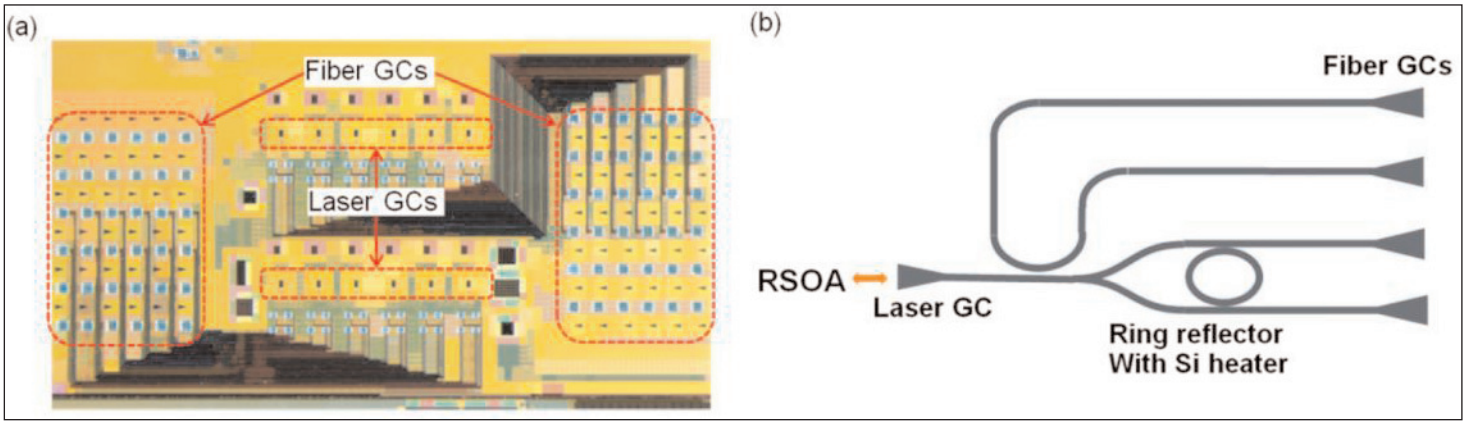


Figure 2. (a) Microscope image of CMOS SOI chip with 2x6 ring reflector circuit array, (b) schematic diagram of ring reflector design.

used chip-to-chip bonding, but the researchers believe that the technique could be expanded to a wafer-scale pick-and-place set up. Indeed the automated bonding machine is designed for wafer-scale operation.

The maximum waveguide-coupled wall-plug efficiency (wcWPE) was 2%. The maximum optical power was greater than 3mW. The researchers described the efficiency as "relatively low" due to a large coupling loss between the RSOA and SOI chips. The researchers attribute this to a ~3dB coupling loss from the mode size mismatch between the III-V and the GC. The mode-field diameter of the RSOA was 1.3μm in the vertical direction and 2.0μm in the horizontal direction. The GCs had a diameter of 4μm in both directions. Also, there is a 14μm gap between III-V waveguide and GC that increases the coupling loss to 7dB. Increasing the III-V mode-field diameter to 3μmx3μm would reduce the coupling loss by ~3dB.

With the laser drive current at 80mA, the tunability range by heating was 1544–1556nm. The device stopped lasing outside this window. Reducing the output power ratio increased the range from 12nm to 19nm. The cross-coupling ratio was designed to be 50% for the top row of lasers in the RSOA and 25% in the bottom row. The tuning efficiency of both rows was 0.2nm/mW. The researchers believe this can be improved by localized substrate removal.

The team comments: "In order to improve the wcWPE, a smaller gap between III-V waveguide and silicon GC is desirable, and can be achieved by bringing the top metal closer to the InP layer and removing the unnecessary metal/dielectric layer stacks on the SOI chip. Together with a larger mode size, we believe a coupling loss of less than 3dB is achievable."

The researchers attempted to work towards improved wcWPE by fabricating a 1x6 array SOI chip with only a single metal layer rather than the full metal/dielectric stacking to reduce the gap between the component devices. A 2x6 RSOA was bonded onto the new SOI chip. The coupling ratio of the directional couplers was 50%. Platinum heaters were used for tuning. These factors reduced the gap to 10μm. The researchers estimated that this improved the optical coupling by 2dB. "The gap can be further reduced by optimizing the contact design on the RSOA chip and reducing the thickness of the AuSn bumps," the team writes.

Unfortunately, two of the channels of the new assembly were damaged in post-processing, leaving a 1x4 array of working lasers. The output power was ~10mW at 120mA drive current. The wcWPE was calculated at 5%. The team believes that a high-efficiency laser array could be achieved by further reducing the coupling loss by using a mode size converter on the RSOA chip to give a larger mode size. ■

http://dx.doi.org/10.1364/OE.24.021454

Author: Mike Cooke

Germanium and silicon photonics

Mike Cooke reports on recent research using germanium to enable infrared light-emitting devices to be created on silicon platforms.

In the past year or so, new optical communications technologies for data communications and high-speed computer processing have become available based on silicon (Si) waveguides [See Mike Cooke, Semiconductor Today, p80, September 2016]. Silicon provides a versatile platform for both optics and electronics, but suffers from major limitations in terms of generating light, which must either be supplied externally or created internally using III-V compound semiconductor materials.

Combining III–V materials with silicon is tricky, and germanium (Ge) is often used as a bridge. As a group IV material, Ge shares many chemical properties with Si and is already used in mainstream electronics production. Here we look at some ways for how Ge could help to make possible more integrated optoelectronics on a silicon platform.

Silicon germanium LEDs

China's Xiamen and Nankai universities have jointly developed lateral p-i-n SiGe/Ge/SiGe light-emitting diodes (LEDs) with high luminous extraction compared with a vertical design [Guangyang Lin et al, Appl. Phys. Lett., vol109, p141104, 2016].

An efficient Ge-based light-emitting device is highly desired as part of the drive to silicon-based optoelectronic integrated circuits. Since Ge has a narrower bandgap than Si (Table 1), generated light could be used in silicon photonic structures that require wavelengths longer than 1.1μm.

The impediment to using Ge in this way is its indirect bandgap, which makes for very inefficient electron–hole recombination into photons. However, the difference between the indirect minimum and direct transitions between the conduction and valence bands is only about 140meV, giving a 'quasi-direct' gap. This difference can be further reduced by applying tensile strain.

On the processing side, Ge is already used in many mainstream electronics enhancements such as 'strained silicon' transistors and in SiGe bipolar transistors. This is in contrast to standard direct-bandgap light-emitting III–V compound semiconductors made of materials that poison the performance of standard Si components.

Table 1. Silicon versus germanium.

	Si	Ge
Bandgap	1.12eV	0.661eV
Wavelength	1.1μm	1.9μm
Separation at gamma point (k = 0, peak valence band)	3.4eV	0.8eV
Electron effective mass/vacuum mass	0.33	0.2
Hole effective mass/vacuum mass	0.5	0.3

Some vertical LEDs using various SiGe combinations have been developed. The Xiamen/Nankai researchers believe that lateral junctions could be a better choice in terms of reducing carrier loss in defect-rich Ge buffer layers at the Ge/Si interface, light absorption in metal contacts, and self-absorption in Ge. "So far, few works were reported on Ge lateral junction light emission diodes, especially with lateral heterojunctions," they write.

The Xiamen/Nankai epitaxial structure was grown on a Ge 'virtual substrate' (VS) on silicon on insulator (SOI). Six 9nm Ge quantum wells were separated by 15nm $Si_{0.13}Ge_{0.87}$ barriers. The structure was annealed at 800ºC for 60 seconds, intermixing the 6x(SiGe/Ge) structure to give a uniform SiGe layer. Raman analysis suggests the resulting 159nm layer consisted of 95% Ge with ~1% strain. The strain in the underlying Ge was ~0.3%.

The researchers comment that the high annealing temperature of 800ºC enhanced the tensile strain due to differences in thermal expansion coefficients between Si and Ge. "The tensile-strained SiGe overlayer can also act as an external strain source leading to larger tensile strain in the Ge VS, which is beneficial for achievement of direct band luminescence from Ge," they add.

Fabrication (Figure 1) included dry etching down to the buried oxide insulator layer to give 10μm-wide waveguides, dry etching the SiGe layer to form a lateral double heterojunction (SiGe/Ge/SiGe), ion implantation to form p- and n-type SiGe contacts, doping activation

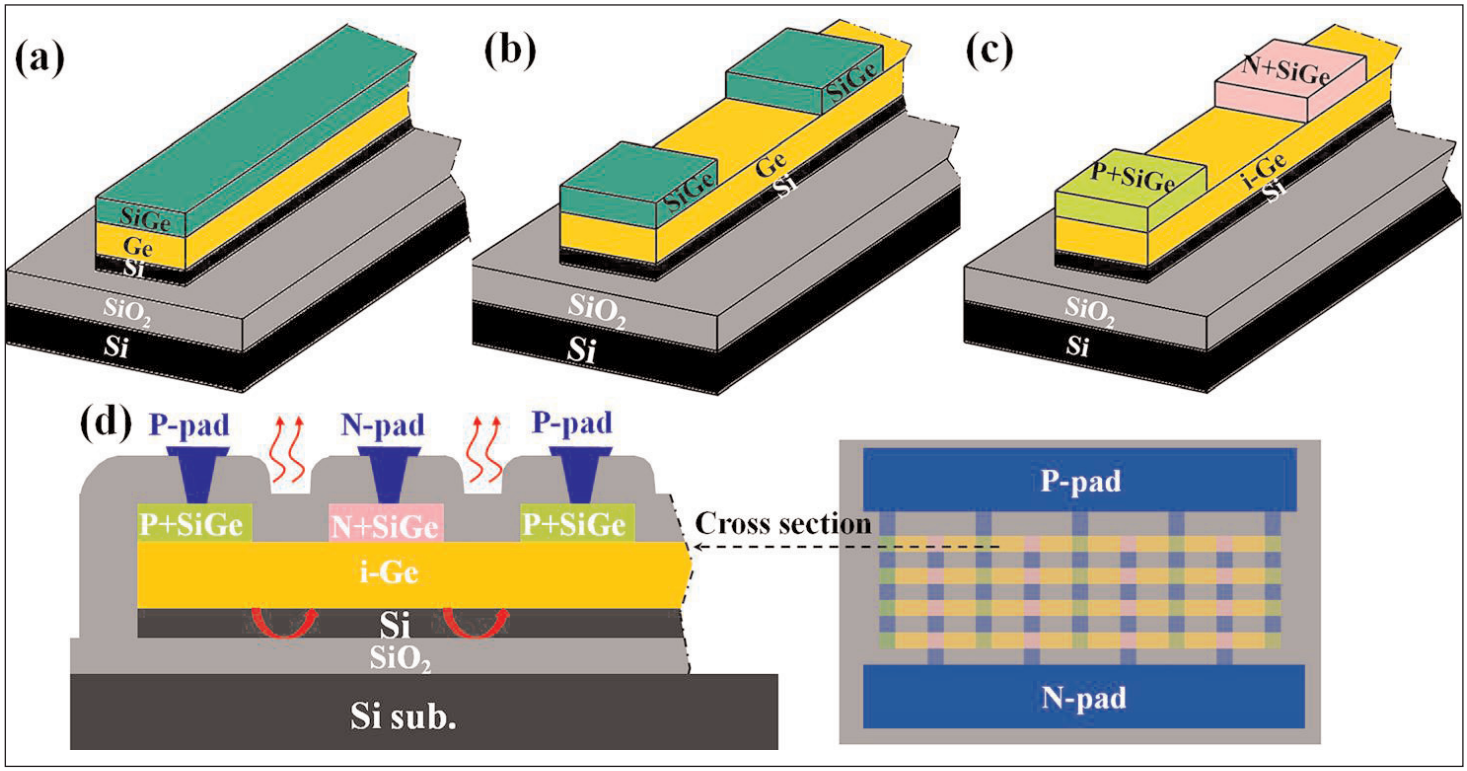


Figure 1. Fabrication flow of lateral p-SiGe/i-Ge/n-SiGe heterojunctions on SOI substrates: (a) SiGe/Ge/Si waveguides on SOI, (b) SiGe/Ge/SiGe lateral heterojunctions on waveguides, (c) selective ion implantation to form P^+ and N^+ SiGe regions, and (d) schematic of top view and cross sections.

at 650ºC for 15 seconds, encapsulation in silicon dioxide, formation of contact holes and deposition and patterning of aluminium electrodes and wiring. The team says that the fabrication process is CMOS-compatible, paving the way for integration with Ge MOSFETs.

Vertical p-i-n Ge homojunction devices were also fabricated on SOI with a similar area for comparison.

As current injection in the lateral device was increased, electroluminescence (EL) around 1600nm (1.6μm) wavelength was detected by an indium gallium arsenide (InGaAs) on indium phosphide (InP) photodetector (Figure 2). Red-shift was seen at higher currents due to Joule heating. At 2.5kA/cm^2 current injection, the peak intensity for the lateral heterostructure device was 4x that of the vertical homojunction structure. "In addition, the EL peak position of the lateral heterojunction locates at the higher energy side compared to the vertical homojunction, which might be attributed to modification of spectra by the cavity effect and/or weaker Joule heating effect," the researchers write.

The increase in intensity with current for 20μm- and 2μm-wide i-Ge region lateral devices is approximately quadratic (1.9 current-exponent for 20μm, 2.0 for 2μm), consistent with theoretical considerations of large carrier injection. The 20μm peak intensity is about 3x that of the 2μm device.

Light extraction from the device also benefits from reflection off of the silicon dioxide/silicon interface of the SOI substrate, giving enhancement from a cavity resonance effect.

First 1.3μm EL from MOCVD quantum dots

Japan's University of Tokyo claims "the first demonstration of EL at 1.3mm from InAs/GaAs quantum dots (QDs) monolithically grown on a Ge/Si substrate by metal organic chemical vapor deposition (MOCVD)" [Mohan Rajesh et al, Jpn. J. Appl. Phys., vol55, p100304, 2016].

The researchers see the room-temperature achievement as an important milestone towards the monolithic integration of QD lasers emitting at 1.3μm for silicon photonics application.

QD lasers can have improved characteristics such as low threshold current and high temperature stability compared with more traditional devices based on quantum wells. Producing electrically pumped lasers on silicon could plug the light generation gap in silicon photonics technologies. QD lasers have been produced through molecular beam epitaxy (MBE) on silicon, but MOCVD is often a preferred mass-production technology in terms of high throughput and low maintenance cost.

The Tokyo InAs in GaAs matrix QD structures were produced on a Ge interlayer on the Si substrate. III–V material such as GaAs tends to suffer from crystal imperfection when grown directly on silicon due to a large 4.1% lattice mismatch. Germanium has a smaller mismatch with GaAs of the order of 0.07%. Also, the thermal expansion coefficients of Ge and GaAs are similar, which is an important factor when high-temperature growth processes are used.

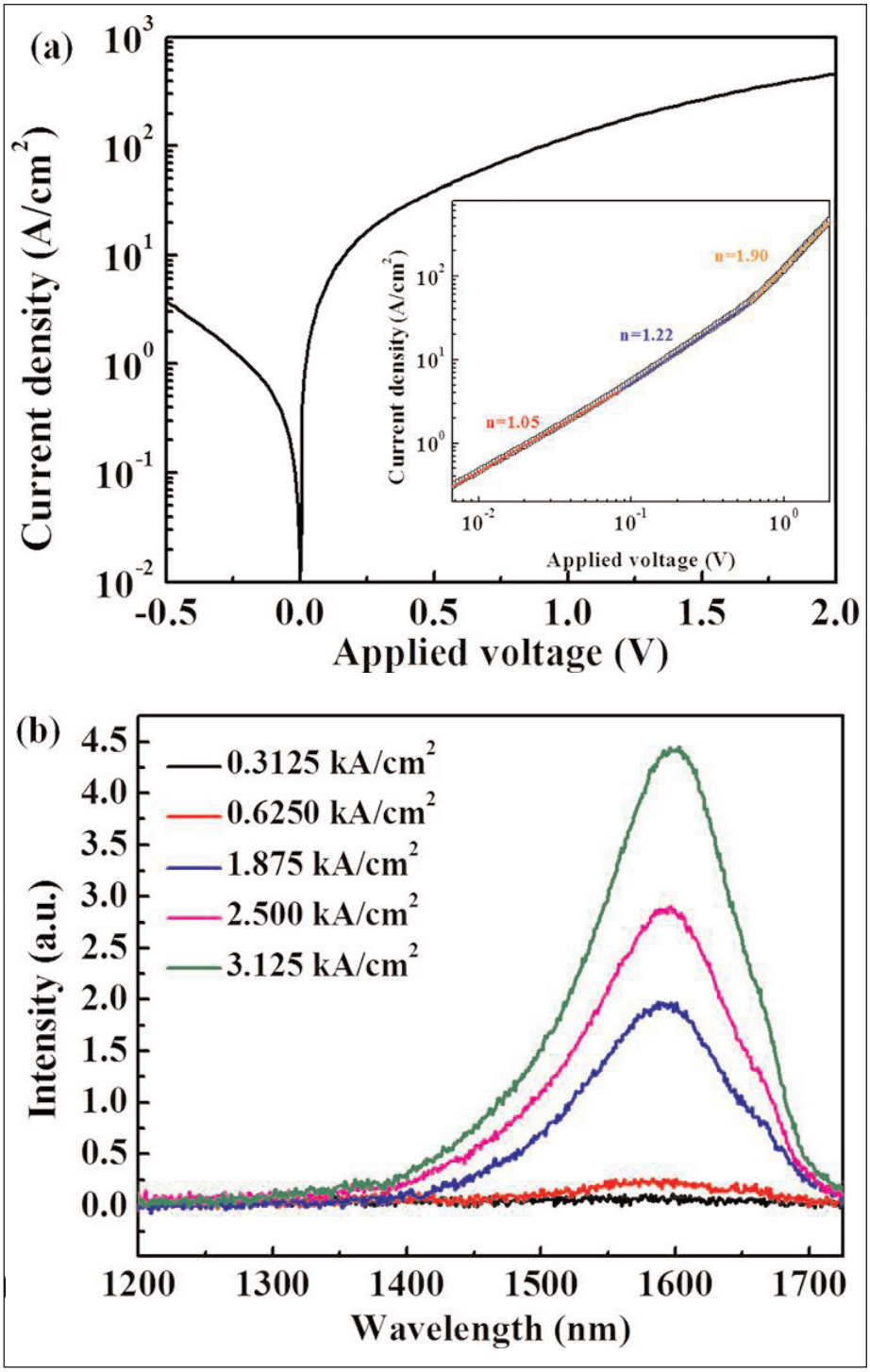


Figure 2. (a) Typical current density-voltage characteristic of heterojunction diode. Inset forward bias curve in log–log scale marked with extracted ideality factors; (b) EL spectra under various injection current densities.

The 2μm Ge interlayer was grown using ultra-high-vacuum CVD on a 6º-offcut silicon substrate. A further 100nm of Ge was grown after 5 minutes of cyclic annealing at 850ºC. The Ge/Si wafer was prepared for III–V MOCVD by a series of treatments to remove contaminants and native oxide.

When the Ge/Si wafer was loaded into the MOCVD reactor a further treatment of thermal annealing in tertiarybutylarsine at 650ºC for 10 minutes was used to desorb native oxide and create double atomic steps on the substrate surface, avoiding antiphase domains (APDs) in the subsequent growth.

The GaAs buffer layer consisted of 10nm nucleation on the As prelayer at 420ºC, 250nm low-temperature 500ºC material, and finally the main part at 650ºC to give 1.3μm or 3μm total thickness. The lower-temperature layers used triethylgallium precursor, while the high-temperature final part used trimethylgallium. Before QD deposition, the GaAs/Ge/Si wafer was annealed in tertiarybutylarsine.

The QDs were grown in a series of layers using antimony (Sb) as a surfactant. The Sb was irradiated onto the GaAs surface, after which the 3.8-monolayer InAs QD material was deposited at 495ºC. The growth was then interrupted for 80 seconds to allow the dots to form. The QD density was greater than $4.3x10^{10}/cm^2$. The base width and height were 36nm and 7nm, respectively. "The density of QDs grown on GaAs/Ge/Si substrate is almost comparable to that of QDs grown on a GaAs substrate, used for the fabrication of low-threshold-current lasers," the team writes.

The QD layer was capped with 500ºC 7nm $In_{0.05}Ga_{0.95}As$ and 5nm GaAs. The purpose of the $In_{0.05}Ga_{0.95}As$ layer was to reduce strain and to red-shift the InAs QD emission wavelength to 1.3μm and longer with a full-width at half-maximum (FWHM) of ~44meV. The QD layers were completed with 600ºC 30nm GaAs spacer for the next QD layer.

The antimony (Sb) surfactant-mediated growth increases dot density and suppresses coalescence. With certain growth conditions it can also increase photoluminescence (PL) intensity. Previous work on InAs/GaAs QD MOCVD on Ge substrates has resulted in low densities and coalescence of dots.

It was found that the GaAs buffer layer (BL) needed to be annealed at 600ºC to give PL intensity comparable with QDs grown on GaAs substrate.

The researchers comment: "The lower PL intensity in the case of QDs grown on a Ge/Si substrate may be attributed to the relaxation of charge carriers to non-radiative recombination centers, such as threading dislocations and APDs, formed at the GaAs/Ge interface and propagating into the GaAs BL and reaching the

QD active region, thereby quenching the QD emission efficiency. We have observed that the post-growth thermal annealing of the GaAs buffer layer prior to the growth of QDs can be a simple and effective tool for improving the luminescence efficiency of the QDs grown on Ge/Si sub-strates."

The researchers used these tech-niques to create light-emitting diodes with eight layers of QDs (Figure 3). The n- and p-cladding layers consisted of 1.4μm $Al_{0.4}Ga_{0.6}As$. These layers were grown at more than 600ºC, which can degrade underlying QDs in the case of the p-type cladding. In particular, the high temperature can diffuse gallium into and indium out of the dots, shortening the wavelength of emissions.

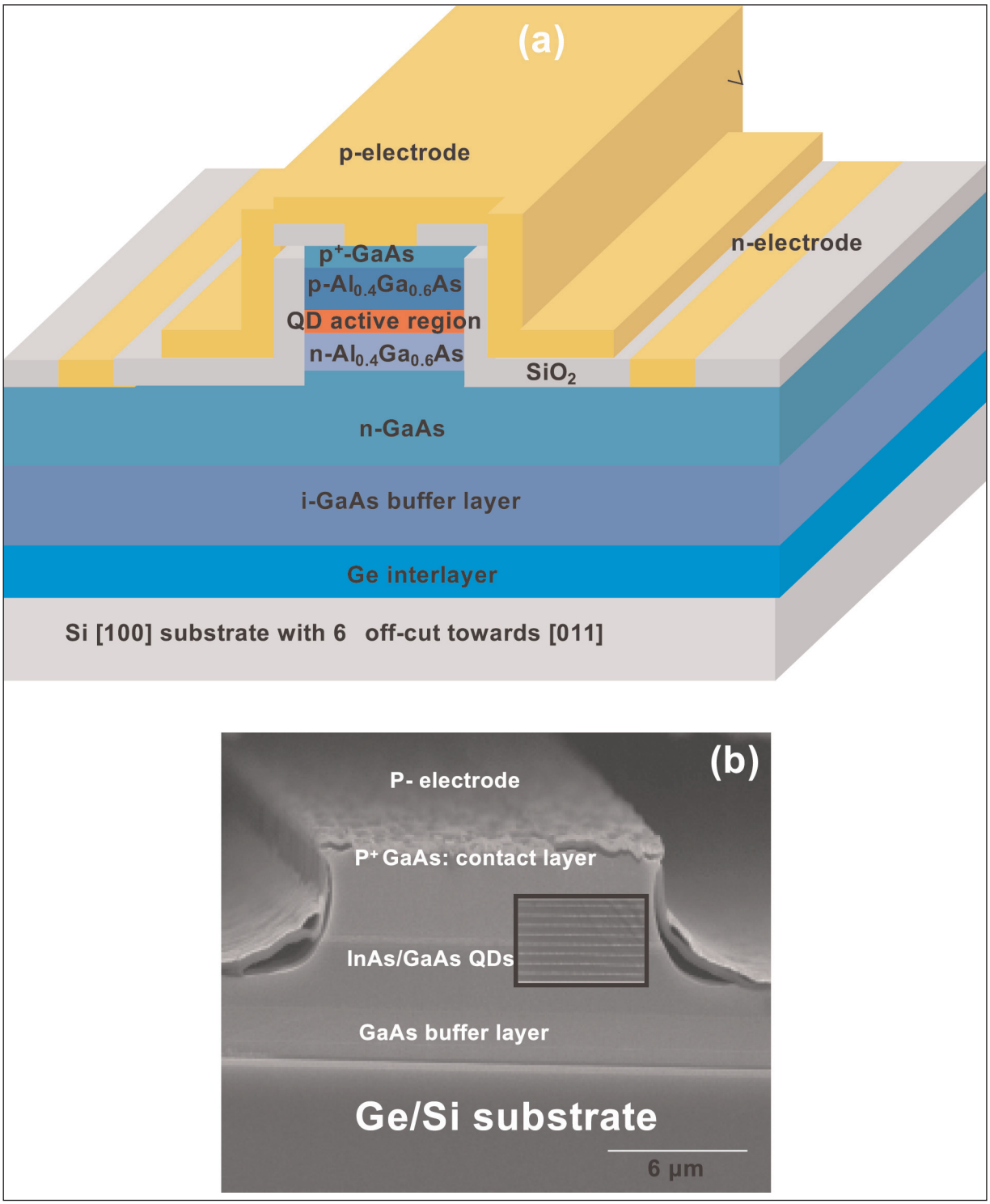


Figure 3. (a) Schematic layer structure of InAs/GaAs QD LED grown on Ge/Si substrate. (b) Cross-sectional high-resolution scanning electron microscope image of fabricated device.

The researchers comment: "The realization of electroluminescence at 1.3μm on Ge/Si, which is not blue-shifted, is attributed to our improved growth conditions of the InAs/Sb:GaAs QDs in the active layer, particularly the Sb irradiation time, before the deposition of InAs, as InAs/Sb:GaAs QDs do not show any blue-shift upon annealing at temperatures as high as 630ºC."

The structure was capped with 300nm p^+-GaAs contact. The contact metal electrodes were gold on gold-germanium-nickel alloy. The electron current injection was lateral from the top side of the device to avoid added series resistance from the high-defect-density GaAs/Ge/Si interfaces.

Under reverse bias the current was of the order 10^{-8}A, suggesting a good rectifying pn junction. Electroluminescence turned on around +0.8V forward bias (Figure 4). Series resistance was around 10Ω. The peak wavelength was 1.3μm with 54meV full-width half-maximum.

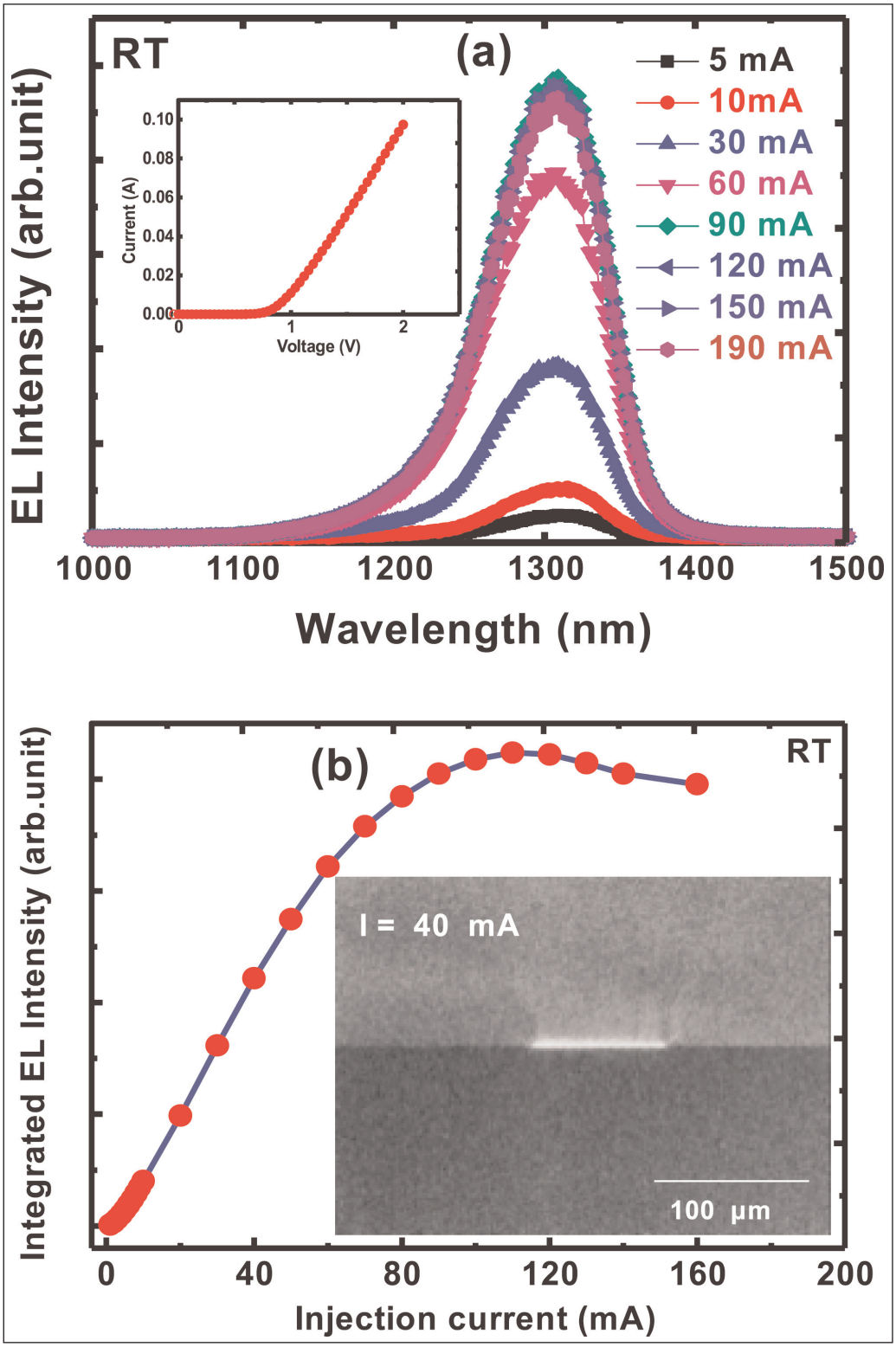


Figure 4. (a) EL spectra of device at room temperature at various injection currents. Inset: current–voltage characteristics of diode. (b) Integrated EL intensity as function of injection current. Inset: infrared camera near-field image of light emission from as-cleaved facet bar at 40mA.

The researchers comment: "To the best of our knowledge, this is the first demonstration of EL at 1.3μm from III–V QDs directly grown on a Ge/Si substrate by MOCVD."

Below 80mA, the increase in intensity with current is approximately linear. With further injection, the output saturates around 130mA and then falls back slightly due to thermal roll-over, non-radiative Auger processes, etc.

The output suffers from imperfect facets because of non-parallel/non-vertical cleavage along the [100] plane. "The combined effect of facet polishing and high-reflection coating on the facets, apart from further improving the uniformity of the QDs in the active region and reducing the defect density in the buffer layer, could potentially lead to the realization of a QD laser on silicon by MOCVD," the team believes.

InGaAs laser diode on exact Ge

Researchers in Russia have developed an InGaAs quantum well laser diode (LD) on (001) Ge-on-Si virtual substrate without offcut angle [V. Ya. Aleshkin et al, Appl. Phys. Lett., vol109, p061111, 2016]. Continuous wave lasing with emission wavelength of 941nm was possible at cryogenic temperatures of 77K. Room-temperature lasing at 992nm wavelength was restricted to pulsed mode.

The researchers hope that in future they will be able to extend the wavelength into the greater than 1.1μm (>1100nm) transparency range needed for use in conjunction with silicon waveguides. "It is assumed that the increase of the In content in the InGaAs QW with an appropriate correction of the QW width could be a possible solution," the team writes.

Normally III–V materials such as InGaAs on (001)-oriented silicon are grown with a significant offcut angle of 4–6º to avoid the formation of antiphase boundaries (APBs), which is a problem for polar materials deposited on non-polar substrates.

However, offcut angles complicate integration with silicon electronics and photonics. In addition, Ge buffers are often used to accommodate lattice mismatching of

III–V heterostructures with Si, but Ge on offcut Si is generally of low quality. Finally, offcut substrates lead to difficulty when cleaving the final devices into laser bars to give high-quality mirror facets.

The team from Institute for Physics of Microstructures of the Russian Academy of Sciences, Lobachevsky State University of Nizhny Novgorod, and FGUE 'Salut' produced their Ge/Si virtual substrate by solid-source molecular beam epitaxy. The n-Si substrate had a (001) crystal orientation with offcut angle less than 0.5º. A two-step process was used, involving deposition of 50nm Ge at 275ºC and then the remainder at 600ºC. The thin-layer growth allows strain relaxation through misfit dislocations. The higher-temperature growth gives better crystal quality material in the thicker layer. Further improvement was achieved with short-time cycle annealing. The annealing was found to reduce threading dislocation densities from 3–4x10^8/cm^2 to ~10^7/cm^2.

Table 1. Parameters of A_3B_5/Ge/Si(001) laser structure.

	Thickness (nm)	Doping (/cm^3)	Remark
Si(001) substrate (upper part)	. . .		Virtual substrate
Ge	~1000	. . .	
AlAs/GaAs/AlAs	10/50/10	. . .	Planarizing buffer
GaAs:Si	2500	2x10^{18}	Main buffer and n-contact
$Al_{0.3}Ga_{0.7}As$:Si	1000	5x10^{17}	Bottom waveguide layer
GaAs	340	. . .	Active region with multiple InGaAs QWs
$In_{0.17}Ga_{0.83}As$ QW	10	. . .	
GaAs	50	. . .	
$In_{0.17}Ga_{0.83}As$ QW	10	. . .	
GaAs	50	. . .	
$In_{0.17}Ga_{0.83}As$ QW	10	. . .	
GaAs	170	. . .	
GaAs:C	170	3x10^{16}	
$Al_{0.3}Ga_{0.7}As$:C	1000	5x10^{17}	Top waveguide layer
GaAs:C	500	2x10^{19}	p-contact

The III–V (A_3B_5) epitaxy involved metal-organic chemical vapor deposition (Table 2). In the initial planarizing buffer, two aluminium arsenide (AlAs) inserts were used to reduce GaAs–Ge interdiffusion and to filter out defects. The AlAs layer also reduced surface roughness by a factor of two.

There were some APBs present due to the use of a substrate with near-zero offcut angle. The APB density in the buffer layer was around 0.6/μm. After the whole structure was grown the density was 0.3/μm. The researchers comment: "These values of the APB density are significantly smaller than the typical ones obtained during growth of polar materials on the exactly oriented non-polar Si(001) substrates. We believe that the influence of the APBs is not the main critical factor affecting the optical properties of the grown A_3B_5/Ge/Si(001) structure."

Laser diodes (Figure 5) were fabricated with the active region 20μm wide, and 200μm-wide planar ohmic contacts of gold-germanium-nickel-gold (n-type) and chromium gold (p-type). The substrate was thinned to 80μm. The material was cleaved into 2.7mm-long bars with mirror facets.

Under electric current injection at 77K (Figure 6), the 941nm-wavelength emission peak narrowed from 30nm below threshold to less than 1nm above. Room-temperature (300K) 992nm emission was 95nm wide

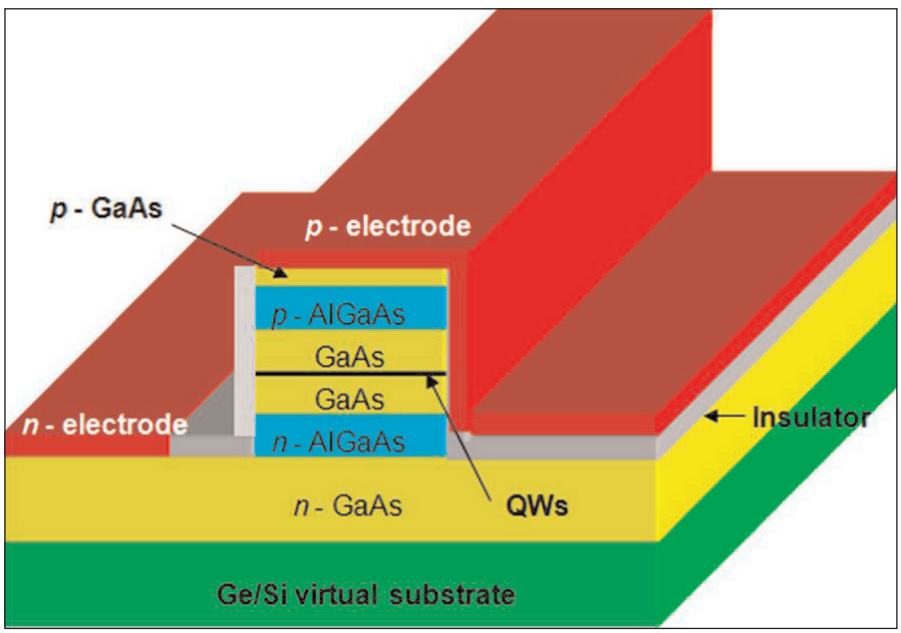


Figure 5. Schematic view of laser diode with planar ohmic contacts.

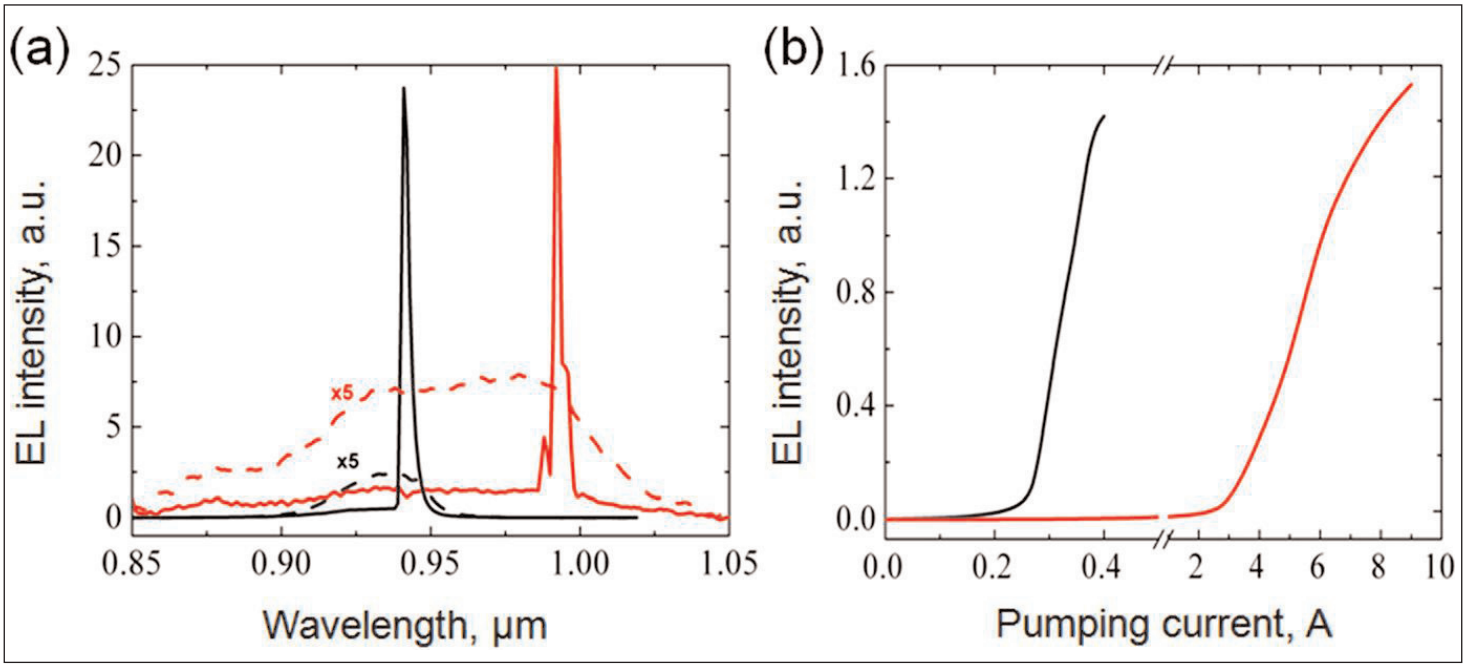


Figure 6. (a) EL spectra at sub-threshold (dashed lines) and above threshold (solid lines). Black lines correspond to 77K, red ones to room temperature. For 77K (300K), pumping current density for subthreshold spectra was approximately 370A/cm^2 (3.7kA/cm^2); and for above threshold spectra 550A/cm^2 (5.6kA/cm^2). (b) Power–current characteristics of the same laser diode.

below threshold and narrowed to less than 1nm above. The threshold for lasing at 77K was 463A/cm^2, low enough for continuous wave operation. At 300K, only pulsed operation was possible with ~5.5kA/cm^2 threshold. ■

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

Choose *Semiconductor Today* for . . .

MAGAZINE

Accurate and timely coverage of the compound semiconductor and advanced silicon industries

Targeted 41,000+ international circulation

Published 10 times a year and delivered by e-mail and RSS feeds

WEB SITE

Average of over 19,700 unique visitors to the site each month

Daily news updates and regular feature articles

Google-listed news source

E-BRIEF

Weekly round-up of key business and technical news

E-mail delivery to entire circulation

Banner and text marketing opportunities available

www.semiconductor-today.com

Join our LinkedIn group: Semiconductor Today

Follow us on Twitter: Semiconductor_T

Silicon monoxide passivation for gallium nitride transistors

Researchers in China and UK achieve improved subthreshold, Schottky and breakdown characteristics for GaN-based HEMT transistors.

Shandong University in China and University of Manchester in the UK have reported room-temperature thermal-evaporation silicon monoxide (SiO) passivation for aluminium gallium nitride (AlGaN) barrier high-electron-mobility transistors (HEMTs) [Gengchang Zhu et al, Appl. Phys. Lett., vol109, p113503, 2016].

The passivation reduced leakage currents and increased breakdown voltages compared with unpassivated and silicon nitride (SiN_x) passivated devices. The researchers comment: "Because of the good passivation effectiveness, no ion damage, simple preparation technology, and low cost, the thermally evaporated SiO is a promising candidate as a surface passivation for GaN-based HEMTs, especially for high-power and noise-sensitive applications."

The SiNx passivation reference was produced using 300°C plasma-enhanced chemical vapor deposition (PECVD), which can suffer from ion damage. "Compared with PECVD and other techniques, thermal evaporation has many advantages such as no ion damage, technical simplicity, and low cost," the researchers claim.

Although the team mentions avoiding current collapse under pulsed current operation as a motivation for passivation, the paper does not report any measurements that would be needed to assess that effect.

SiO has a higher dielectric constant of 5.0 compared with silicon dioxide's 3.9. The breakdown field of both these silicon oxides is around 10MV/cm. Although thermally evaporated SiO has been assessed for use with other technologies such as thin-film transistors, the researchers say that very little work has been carried out on its use in GaN HEMT passivation.

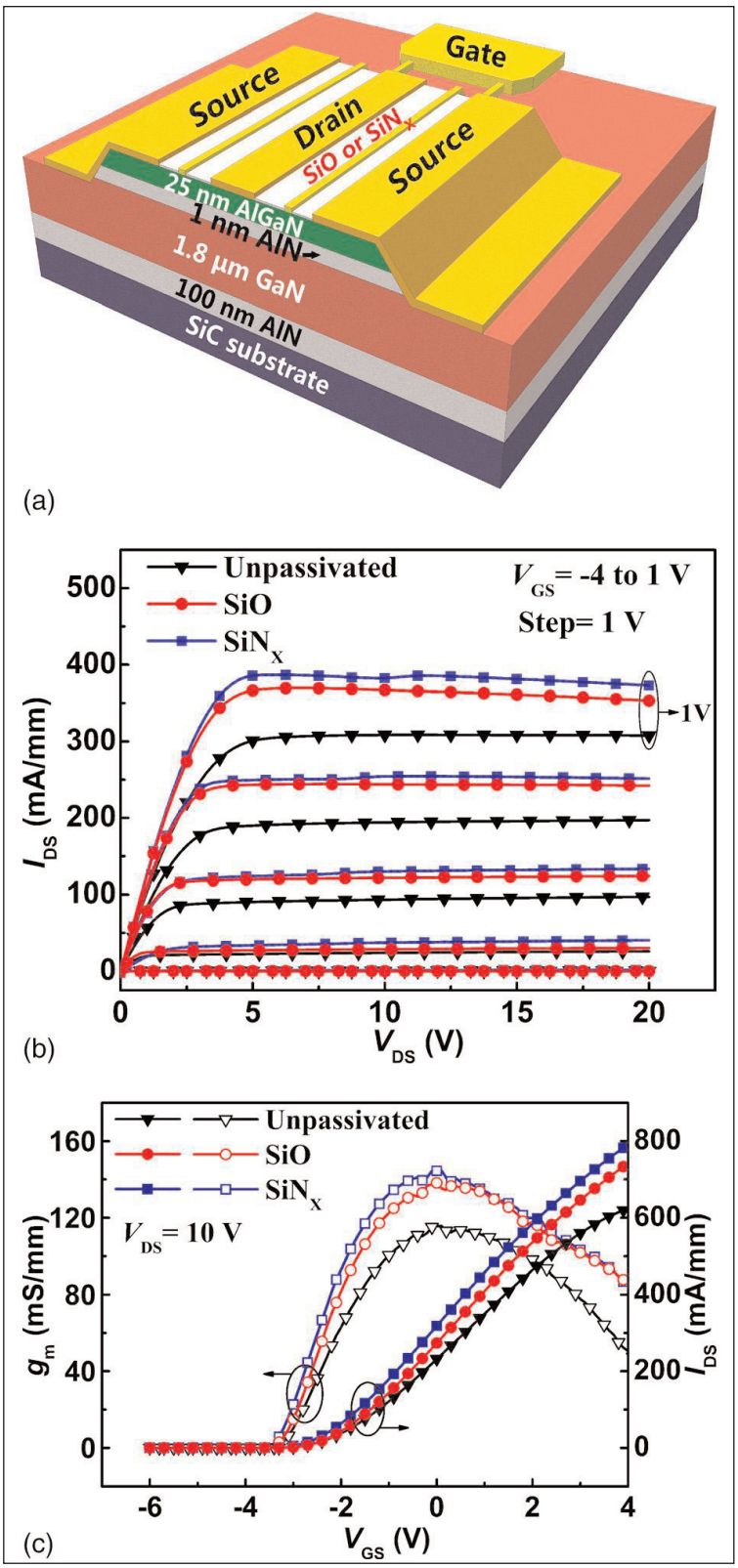


Figure 1. (a) Schematic cross-section of the AlGaN/AlN/GaN HEMTs. (b) Output and (c) transfer characteristics of the unpassivated, SiO-passivated, and SiN_x-passivated AlGaN/AlN/GaN HEMTs.

The device material was grown on 6H polytype silicon carbide (SiC), using metal-organic chemical vapor deposition (Figure 1). The conducting two-dimensional electron gas (2DEG) near the GaN/barrier interface had $1.05x10^{13}/cm^2$ sheet carrier density, 298Ω/square sheet resistance, and $18^{10}cm^2/V\text{-}s$ carrier mobility (μ_n), according to Hall measurements.

Table 1. Summary of measurements.

Sample	Unpassivated	SiO	SiN_x
n_s [$10^{13}/cm^2$]	1.05	1.25	369
μ_n [$cm^2/V\text{-}s$]	1810	1.32	385
I_{Dmax} [mA/mm]	309	1760	137
g_m [mS/mm] @ V_{DS} = 10V	116	1690	144
I_{off} [mA/mm] @ V_{GS} = −5V	$2.0x10^{-3}$	$2.1x10^{-4}$	$3.0x10^{-1}$
I_{on}/I_{off}	$1.5x10^5$	$1.8x10^6$	$1.3x10^3$
SS [mV/decade]	181	95	447
D_{it} [$10^{12}/cm^2$-eV]	3.76	1.16	11.30
I_g [mA/mm] @ V_{GS} = −5V	$3.3x10^{-3}$	$3.3x10^{-4}$	$4.1x10^{-2}$
n	1.77	1.75	1.83
Φ_B [eV]	0.79	0.85	0.73
V_b [V] @ V_{GS} = −5V	175	206	111
f_T [GHz] @ V_{DS} = 10V, V_{GS} = 0V	4.0	5.2	5.8

Device fabrication created plasma-etch mesa isolation, annealed/alloyed titanium/aluminium/nickel/gold source–drain ohmic contacts, nickel/gold gate, 100nm SiO passivation, and plasma-etch contact-pad opening.

The placing of the 2μm-long gate in the 13μm source–drain gap gave a gate–drain distance of 6μm. The gate width was 100μm.

Passivation with SiO, and the SiN_x reference, increased Hall sheet carrier density but reduced mobility (Table 1). The researchers suggest that the reduction in mobility could be related to increased Coulomb scattering due to the increased carrier density. The product of carrier density and mobility is higher for the passivated samples. The SiN_x has a marginally higher product than SiO passivation.

The performance in terms of maximum drain current (I_{Dmax}) and transconductance (g_m) at 10V drain bias (V_{DS}) on the HEMTs is again better for the passivated devices, with SiN_x passivation giving better results. The current and transconductance improvements were, respectively, 19% and 18% for SiO, and 25% and 24% for SiN_x. The researchers attribute the improvement to the increased carrier density-mobility product.

However, the SiO passivation has subthreshold and Schottky characteristics that significantly improve on both the unpassivated and SiN_x-passivated devices — that is, lower off-current (I_{off}), higher on/off current ratio (I_{on}/I_{off}), lower subthreshold swing (SS), lower gate leakage (I_g), and higher Schottky barrier height (Φ_B). The SiO passivation also gives the lowest ideality factor (n) for the Schottky diode gate.

The interface trap density (D_{it}) is also lower for SiO passivation. The researchers comment: "The increased density of interface traps for the SiN_x-passivated HEMTs is probably caused by the ion bombardment during the PECVD process, which can be avoided by applying the thermally evaporated SiO."

Another improvement of SiO passivation is for breakdown voltage (V_b) with −5V gate (V_{GS}), giving the 'off' state. Breakdown was defined at 10^{-4}A drain leakage. The breakdown current was set at a level that did not destroy the devices. The high V_b is claimed to be the result of lower gate leakage and off-current for the SiO passivation.

The SiN_x passivation gives a higher current-gain cut-off (f_T), while the performance of the SiO-passivated HEMT is better than the unpassivated device. In other studies, SiN_x passivation has variously improved and degraded f_T performance. The researchers comment: "The increase of f_T for the SiO-passivated and the SiN_x-passivated HEMTs is attributed to the increased g_m and decreased overall capacitance of C_{GD} and C_{GS}." ■

http://dx.doi.org/10.1063/1.4962894

Author: Mike Cooke

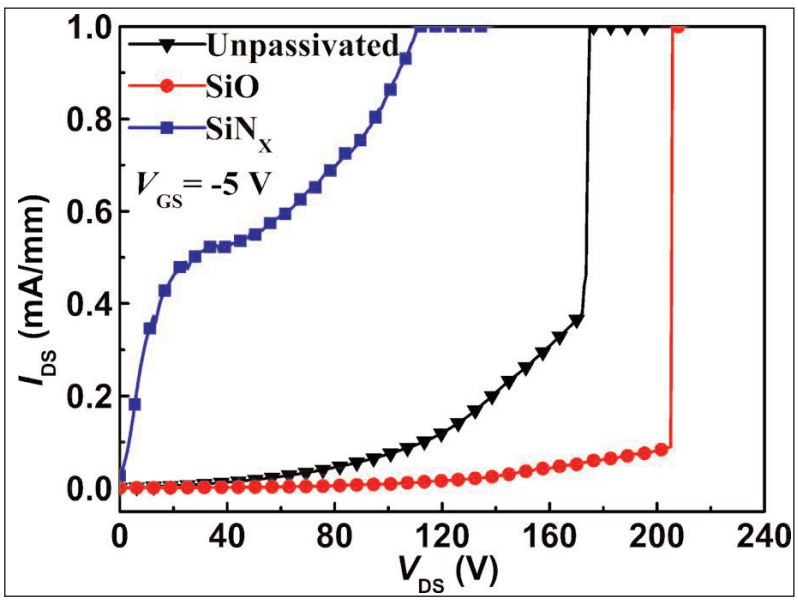


Figure 2. Off-state breakdown characteristics of unpassivated, SiO-passivated, and SiN_x-passivated AlGaN/AlN/GaN HEMTs.

GaN power devices market growing at 86% CAGR to $280m in 2021

Yole Développement expects 600V GaN HEMTs to take off.

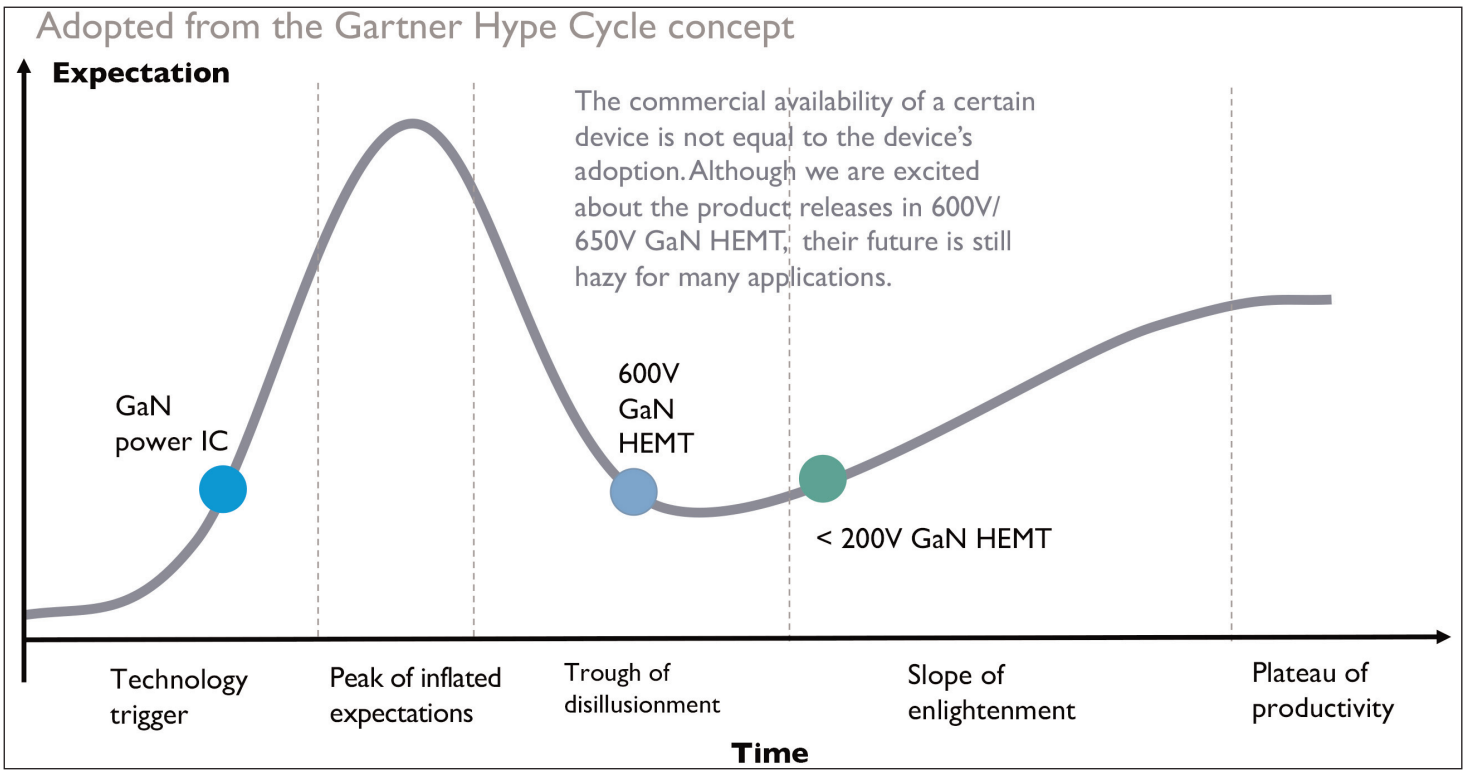
Driven by emerging applications including power supplies for data-centers and telecoms (AC fast charger, lidar, ET and wireless power), the GaN power device market is rising at a compound annual growth rate (CAGR) of 86% from 2016 to $280m in 2021, according to the report 'Power GaN 2016: Epitaxy and Devices, Applications and Technology Trends' from Yole Développement.

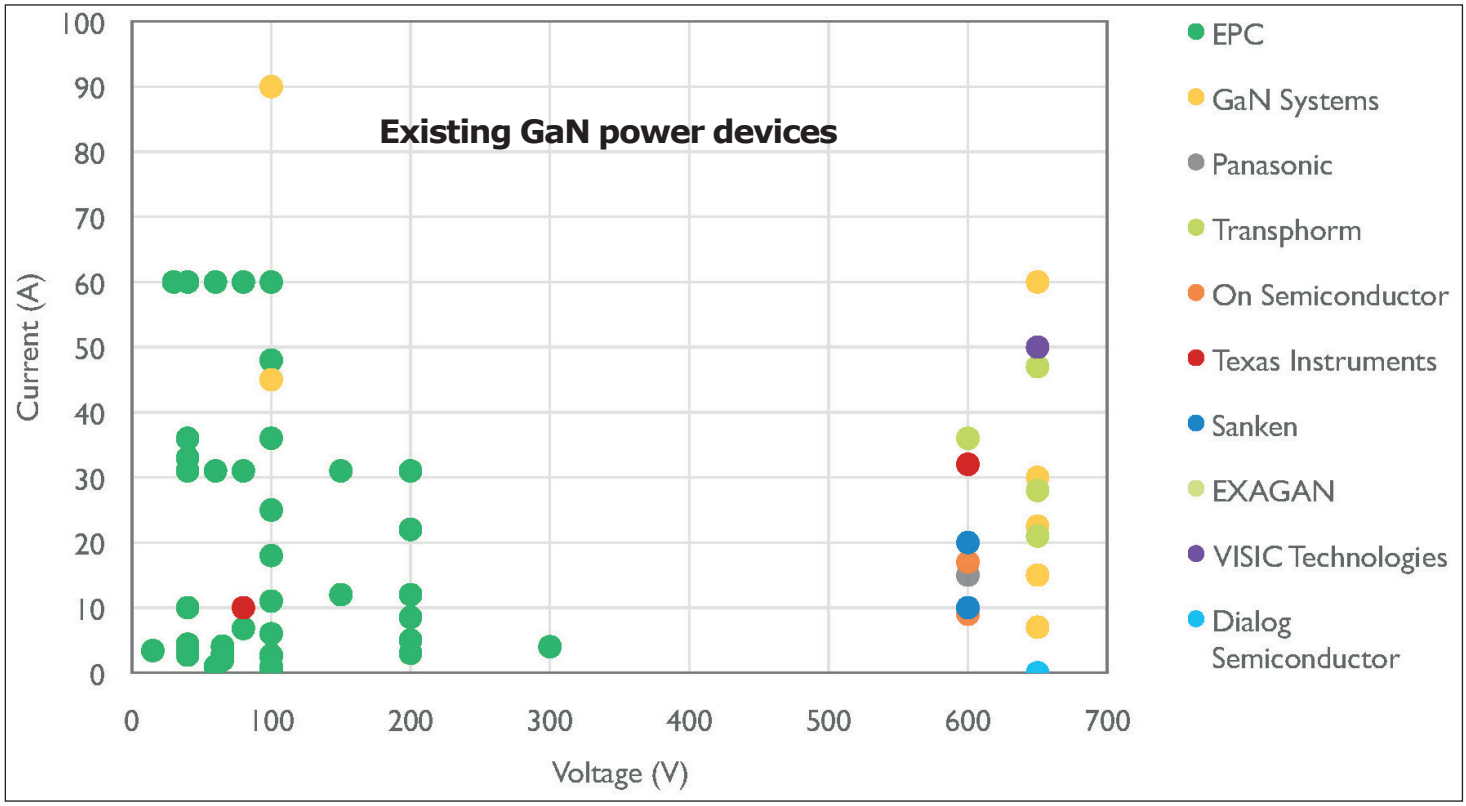
"Numerous powerful developments and key collaborations have been announced during this period and confirmed a promising and fast-growing industry," comments technology & market analyst Dr Hong Lin.

Integrated Device Technology (IDT) and Efficient Power Conversion (EPC); Infineon Technologies and Panasonic; Exagan and XFab; TSMC and GaN Systems for volume production and much more… all these collaborations took place in 2 years, between 2015 and 2016. In parallel, Texas Instruments launched a 80V power stage in 2015 and a 600V power stage in 2016. Also, VisIC announced its first GaN product in 2015. Since then, 2015–2016 have been exciting years for the GaN power business: after many ups and downs, 600V GaN is now commercially available.

Up until late 2014, the commercial availability of 600V/650V GaN HEMTs was still questionable, despite some announcements from various players. Fast forward to 2016, end users can now buy not only low-voltage GaN (<200V) devices from EPC Power but also high-voltage (600V/650V) components from several players including Transphorm, GaN Systems, and Panasonic.

In parallel the new start-up Navitas Semiconductor announced its GaN power IC this March, followed by Dialog Semiconductors unveiling its GaN power IC in August. The idea of bringing GaN from the power semiconductor market to the much bigger analog IC market is of interest to several other players too. For example, EPC Power and GaN Systems are both working on more integrated solutions, and the well-established analog IC player Texas Instruments has also been engaged in GaN activities, releasing an 80V power stage and 600V power stage in 2015 and 2016, respectively.

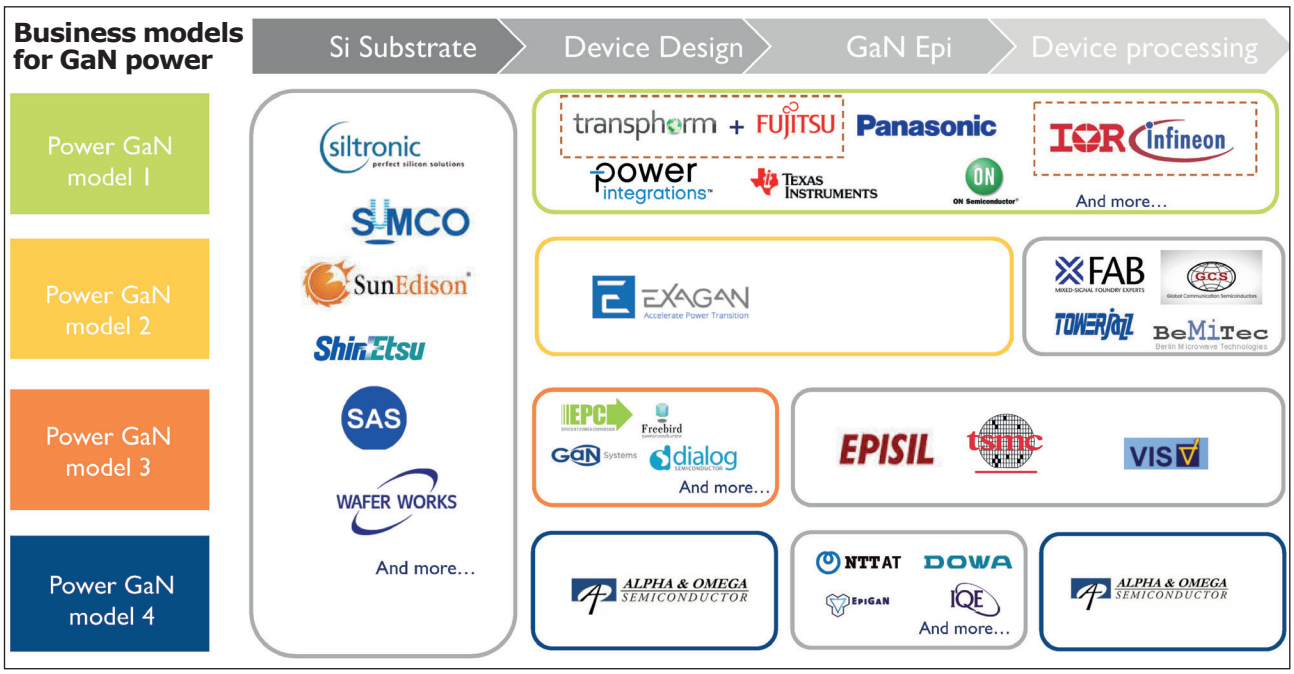




Despite these developments, the GaN power market remains small compared to the gigantic $335bn silicon semiconductor market. In fact, according to Yole, the GaN power market was less than $10m in 2015. "Remember that a small market size is not unusual for products just appearing on the market," notes Lin. Indeed, the first GaN devices were not commercially available until 2010. The most important factor is the potential of GaN power, notes Yole. "The current GaN power market is mainly dominated by low-voltage (<200V) devices in the forecasted period, but the 600V devices should take off," comments technology & market analyst Zhen Zong.

"More than 200 patent applicants are involved in the power GaN industry," reckoned KnowMade in its report 'GaN for Power Electronics: Patent Investigation' (KnowMade, August 2015). Such a figure shows the strong interest from power players in the GaN business. The take-off of patenting activity took place in the 2000s, with a first wave of patent publications over the 2005–2009 period due mainly to American and Japanese companies. A second wave started in 2010 while first commercial GaN products, collaborations and mergers and acquisitions emerged. "In today's power GaN market, it is crucial to understand the global patent landscape thorough in-depth analyses," states KnowMade's CEO & co-founder Nicolas Baron. "This approach helps the companies to anticipate the changes, identify and evaluate business opportunities, mitigate risks and make strategic choices."

www.yole.fr



Reducing subthreshold swing of gallium arsenide transistors

Researchers based in Korea claim a record low value of 68mV/decade.

Korea Institute of Science and Technology (KIST) claims a record low subthreshold swing of 68mV/decade for a gallium arsenide (GaAs) field-effect transistor (FET) [SangHyeon Kim et al, IEEE Electron Device Letters, published online 24 August 2016]. In addition, the double-gate (DG)

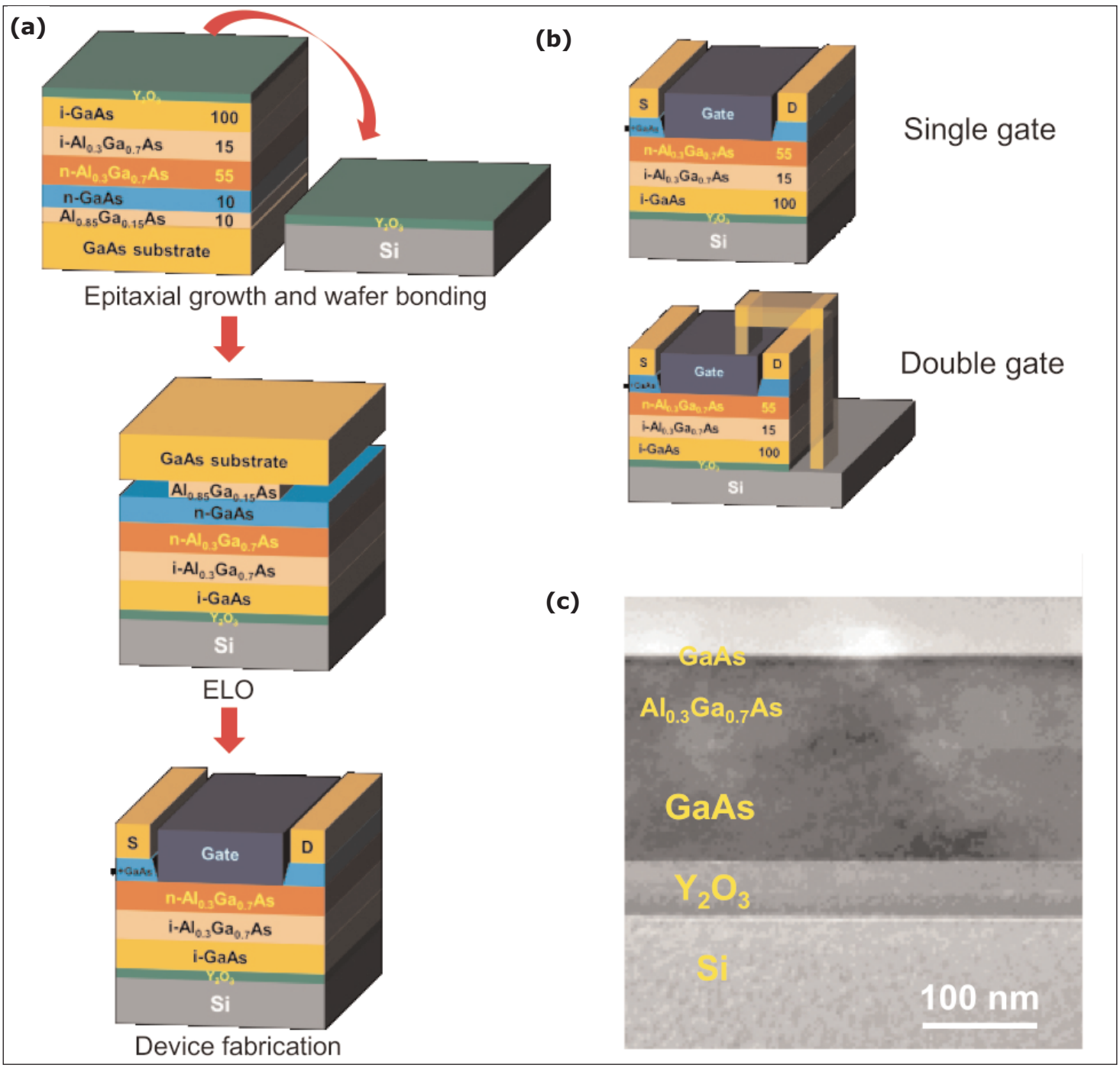


Figure 1. (a) Fabrication process flow of GaAs-OI FETs on Si via wafer bonding and ELO. Thicknesses of each layer are also shown (nm). (b) Schematic images of final device structures of SG and DG GaAs-OI FETs. (c) Cross-section transmission electron micrograph of fabricated GaAs-OI FETs on Si substrates.

device on insulator (OI) was fabricated on silicon through wafer bonding.

The team comments: "Combining other device technologies, DG GaAs-OI FETs will be a promising component technology in future III-V transistors on the silicon platform."

GaAs is a III-V semiconductor with higher mobility than silicon, and it is hoped that incorporating III-V materials on silicon could be a way forward to faster and/or lower-power-consuming electronics.

The KIST transistor structure (Figure 1) was grown on GaAs (100) substrates using molecular beam epitaxy (MBE). The III-V material was bonded to silicon using oxygen-plasma-activated yttrium oxide (Y_2O_3) layers deposited on the heterostructure and silicon substrate through electron-beam evaporation. The bonding was carried out at room temperature with 180kg force.

The Y_2O_3 forms a buried oxide layer in the final device with a relatively high dielectric constant (k) of 16. The high Young's modulus of 215GPa gives a strong bond between the materials. Trivalent oxides like Y_2O_3 also give good metal-oxide-semiconductor (MOS) interfaces with III-V semiconductors.

The transistor heterostructure was separated from the GaAs growth substrate by epitaxial lift-off (ELO) wet etch of an aluminium gallium arsenide (AlGaAs) sacrificial layer.

Single-gate (SG) and double-gate transistors were produced. The top gate consisted of recessed platinum/gold on an AlGaAs barrier/insulator layer. The source/drain electrodes were platinum/germanium/gold. The metals were annealed. Double-gate devices were formed by making a connection between the top gate and the silicon substrate acting as a back gate with Y_2O_3 insulator giving a MOS structure.

The researchers claim a record low subthreshold swing for GaAs FETs of 68mV/decade for the double-gate transistor. This beats a 2015 report of 70mV/decade for a GaAs–AlGaAs core–shell nanowire transistor. The SG swing was around 85mV/decade. The theoretical minimum is ~60mV/decade at room temperature. The on/off current ratio was also very high at around 10^8.

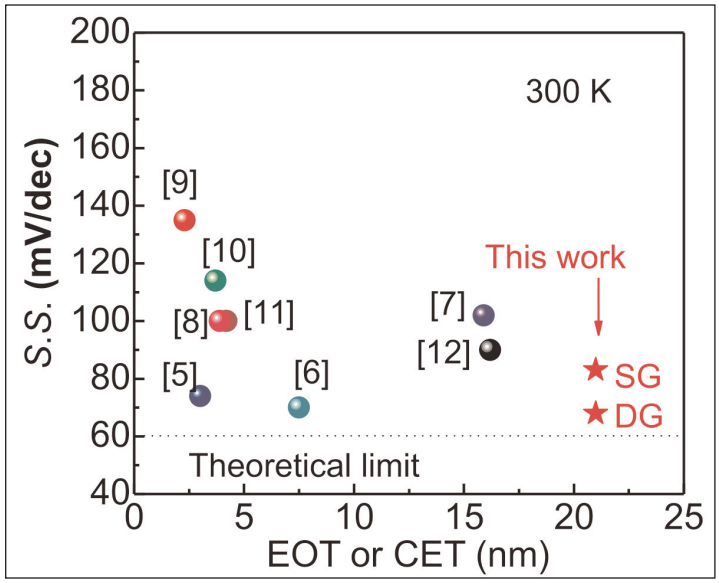


Figure 2. Subthreshold swing benchmarks for state-of-the-art GaAs FETs as function of equivalent oxide thickness or capacitance equivalent thickness.

"These good electrical properties were attributed to the DG device structure via the tight control of channel carriers," the team writes.

Thanks to a low subthreshold current, the threshold voltage of the DG transistor was higher than that of the SG device. The transconductance was also boosted by about 37% in the DG structure at 0.5V and 0.05V drain biases.

The equivalent oxide thickness/capacitance equivalent thickness (EOT/CET) was somewhat larger than previously reported devices (Figure 2). The KIST device was the only one on silicon — the other reported transistors were fabricated on GaAs substrates.

The researchers comment that device fabrication has not been optimized and there is a wide opportunity to scale down equivalent thickness. One optimization option could be to balance the top and bottom controllability of the gates. ■

http://ieeexplore.ieee.org/document/7549103

Author: Mike Cooke

Berkeley Lab-led team fabricates transistor with record 1nm-long gate

Proof of concept using MoS_2 channel with carbon nanotube gate points way to sub-5nm transistors

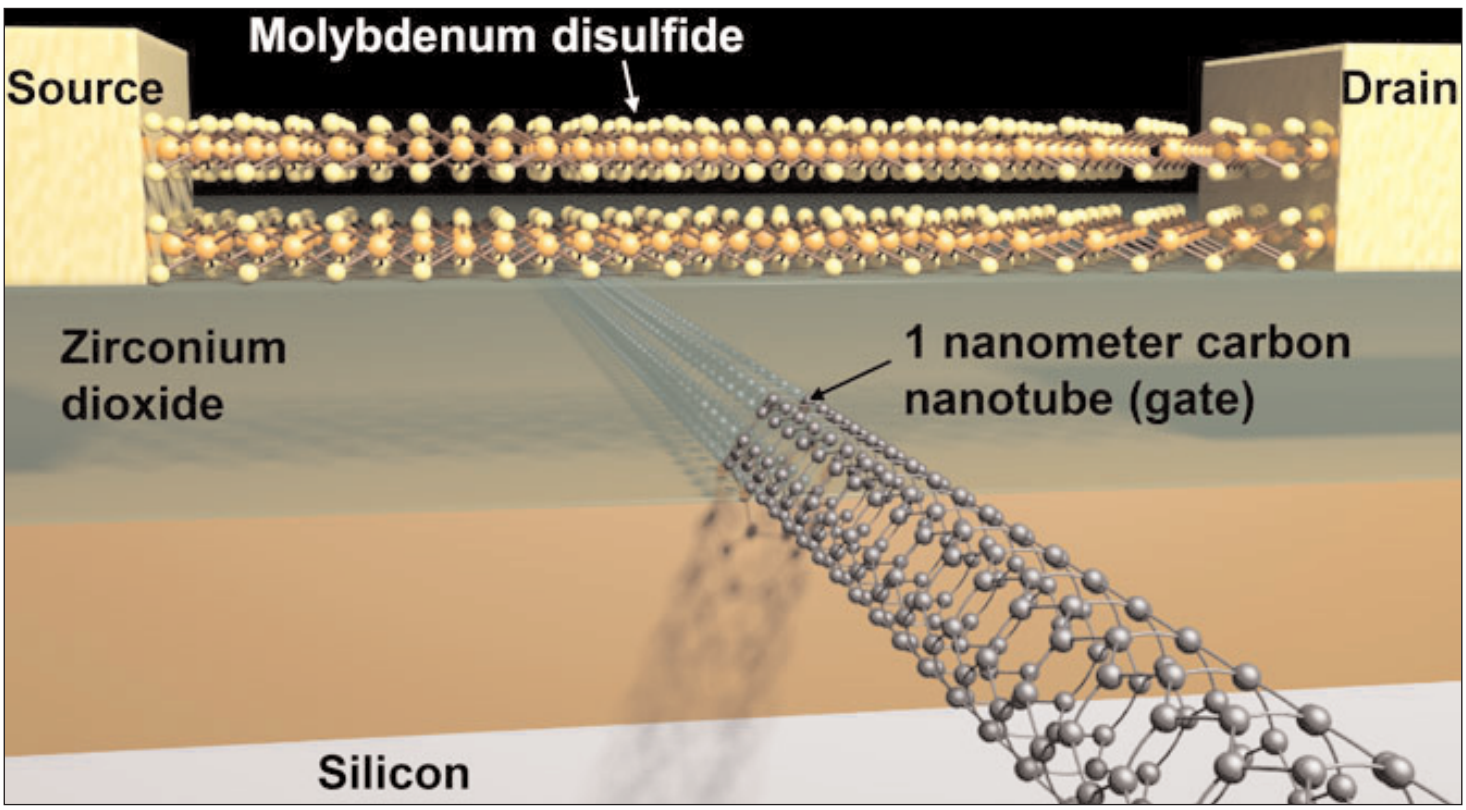
A research team led by faculty scientist Ali Javey at the US Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has created a working transistor with a gate length (the defining dimension of a transistor) just 1nm long, which is the smallest reported to date ('MoS_2 transistors with 1-nanometer gate lengths', Science Vol. 354, Issue 6308, p99–102).

For conventional semiconductors, the laws of physics set a 5nm threshold on the size of transistor gates (about a quarter the size of high-end 20nm-gate transistors currently on the market). However, the 1nm-gate transistor show that "with the choice of proper materials, there is a lot more room to shrink our electronics," says Javey, lead principal investigator of the Electronic Materials program in Berkeley Lab's Materials Science Division (and a University of California Berkeley professor of electrical engineering and computer sciences). The key was to use carbon nanotubes and molybdenum disulfide (MoS_2).

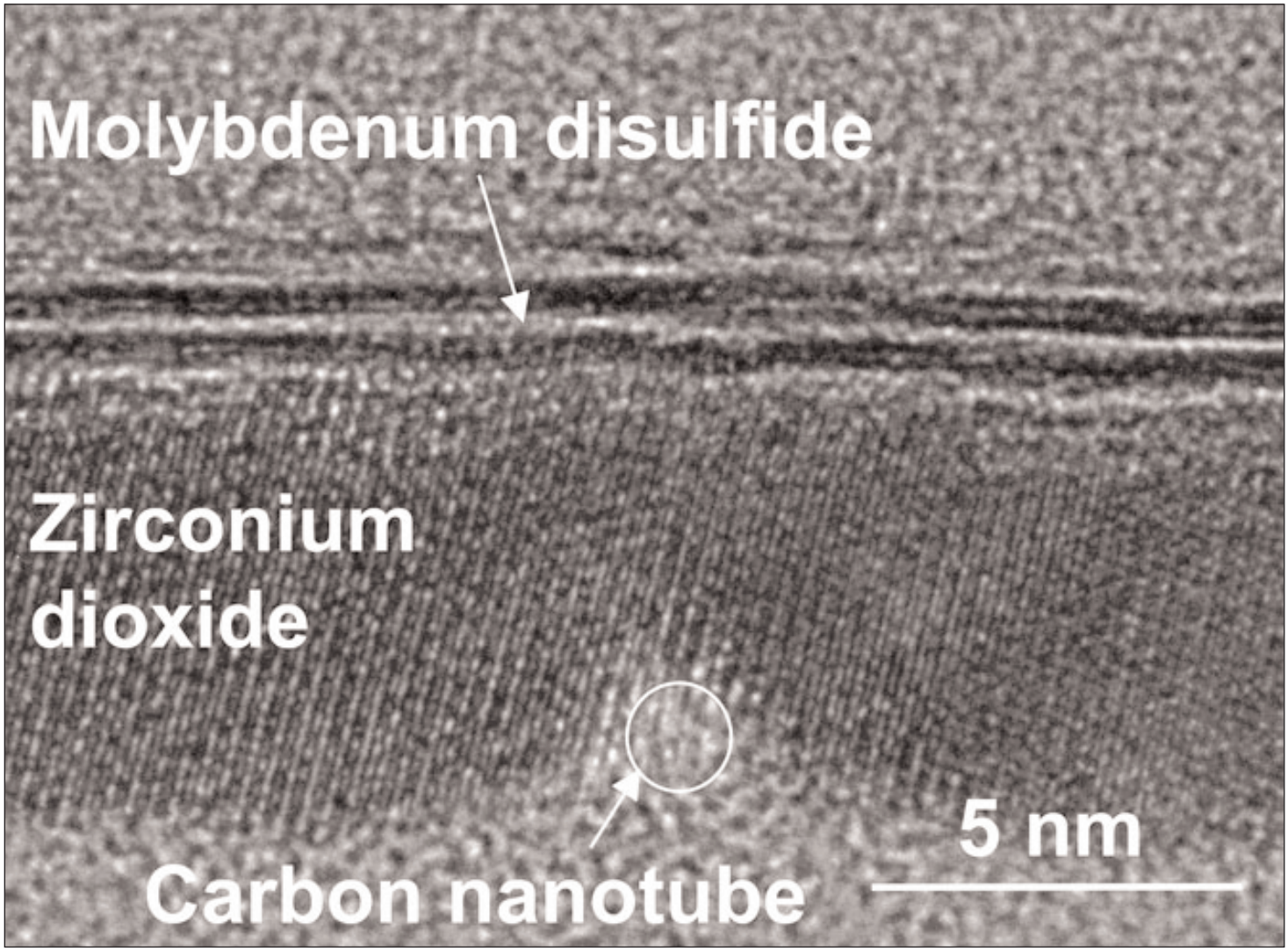
Other investigators on the paper include Jeff Bokor, a senior faculty scientist at Berkeley Lab and a professor at UC Berkeley; Chenming Hu, a professor at UC Berkeley; Moon Kim, a professor at the University of Texas at Dallas; and H.S. Philip Wong, a professor at Stanford University.

The new development could be key to keeping alive Intel co-founder Gordon Moore's prediction that the density of transistors on integrated circuits would double every two years.

"The semiconductor industry has long assumed that any gate below 5nm wouldn't work, so anything below that was not even considered," says study lead author Sujay Desai, a graduate student in Javey's lab. "This research shows that sub-5nm gates should not be discounted. Industry has been squeezing every last bit



Schematic of transistor with a MoS_2 channel and 1nm carbon nanotube gate. (Courtesy of Sujay Desai/Berkeley Lab.)



Transmission electron microscope image of transistor cross-section, showing 1nm carbon nanotube gate and MoS_2 semiconductor separated by the insulator zirconium dioxide. (Courtesy of Qingxiao Wang, UT Dallas.)

of capability out of silicon. By changing the material from silicon to MoS_2, we can make a transistor with a gate that is just 1nm in length, and operate it like a switch."

Both silicon and MoS2 have a crystalline lattice structure, but electrons flowing through silicon are lighter and encounter less resistance compared with MoS_2. That is a benefit when the gate is 5nm or more, but below that length the quantum mechanical phenomenon of tunneling kicks in and the gate barrier is no longer able to keep the electrons from barging through from the source to the drain terminals. "This means we can't turn off the transistors," says Desai. "The electrons are out of control."

Because electrons flowing through MoS_2 are heavier, their flow can be controlled with smaller gate lengths. MoS_2 can also be scaled down to atomically thin sheets (about 0.65nm thick) with a lower dielectric constant (reflecting the ability of the material to store energy in an electric field). Both of these properties, in addition to the mass of the electron, help to improve the control of current flow inside the transistor when the gate length is reduced to 1nm.

For constructing the transistor's gate, conventional lithography techniques do not work well at a scale of 1nm, so the researchers turned to hollow cylindrical carbon nanotubes with diameters as small as 1nm. They then measured the electrical properties of the devices to show that the MoS_2 transistor with the carbon nanotube gate effectively controlled the flow of electrons.

"However, it's a proof of concept. We have not yet packed these transistors onto a chip, and we haven't done this billions of times over," notes Javey. "We also have not developed self-aligned fabrication schemes for reducing parasitic resistances in the device. But this work is important to show that we are no longer limited to a 5nm gate for our transistors. Moore's Law can continue a while longer by proper engineering of the semiconductor material and device architecture."

The work at Berkeley Lab was funded primarily by the Department of Energy's Basic Energy Sciences program. ■

http://science.sciencemag.org/content/354/6308/99
http://emat.lbl.gov

suppliers' directory

Index

1 Bulk crystal source materials p92
2 Bulk crystal growth equipment p92
3 Substrates p92
4 Epiwafer foundry p93
5 Deposition materials p93
6 Deposition equipment p94
7 Wafer processing materials p94
8 Wafer processing equipment p95
9 Materials and metals p95
10 Gas & liquid handling equipment p95
11 Process monitoring and control p95
12 Inspection equipment p96
13 Characterization equipment p96
14 Chip test equipment p96
15 Assembly/packaging materials p96
16 Assembly/packaging equipment p96
17 Assembly/packaging foundry p96
18 Chip foundry p96
19 Facility equipment p96
20 Facility consumables p96
21 Computer hardware & software p96
22 Used equipment p97
23 Services p97
24 Consulting p97
25 Resources p97

To have your company listed in this directory, e-mail details (including categories) to mark@semiconductor-today.com
Note: advertisers receive a free listing. For all other companies, a charge is applicable.

1 Bulk crystal source materials

Mining & Chemical Products Ltd (part of 5N Plus, Inc)
1-4, Nielson Road,
Finedon Road Industrial Estate,
Wellingborough,
Northants NN8 4PE,
UK
Tel: +44 1933 220626
Fax: +44 1933 227814
www.MCP-group.com

Umicore Indium Products
50 Simms Avenue,
Providence, RI 02902,
USA
Tel: +1 401 456 0800
Fax: +1 401 421 2419
www.thinfilmproducts.umicore.com

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

2 Bulk crystal growth equipment

MR Semicon Inc
PO Box 91687,
Albuquerque,
NM 87199-1687,
USA
Tel: +1 505 899 8183
Fax: +1 505 899 8172
www.mrsemicon.com

3 Substrates

AXT Inc
4281 Technology Drive,
Fremont,
CA 94538,
USA
Tel: +1 510 438 4700
Fax: +1 510 683 5901
www.axt.com
Supplies GaAs, InP, and Ge wafers using VGF technology with manufacturing facilities in Beijing and five joint ventures in China producing raw materials, including Ga, As, Ge, pBN, B_2O_3.

CrystAl-N GmbH
Dr.-Mack-Straße 77,
D-90762
Fürth,
Germany
Tel: +49 (0)911 650 78 650 90
Fax: +49 (0)911 650 78 650 93
E-mail: info@crystal-n.com
www.crystal-n.com

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

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

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

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

MARUWA is a global supplier of ceramic substrates and wafers made of aluminium nitride (AlN), alumina (Al_2O_3), ZTA and silicon nitride (Si_3N_4). Products meet required properties such as high thermal conductivity and bending strength for power devices, especially wafers are suitable as a bonding wafer (GaN, SOI) for epi wafers.

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

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

III/V-Reclaim
Wald 10,
84568 Pleiskirchen, Germany
Tel: +49 8728 911 093
Fax: +49 8728 911 156
www.35reclaim.de
III/V-Reclaim offers reclaim (recycling) of GaAs and InP wafers, removing all kinds of layers and structures from customers' wafers. All formats and sizes can be handled. The firm offers single-side and double-side-polishing and ready-to-use surface treatment.

Umicore Electro-Optic Materials
Watertorenstraat 33,
B-2250 Olen, Belgium
Tel: +32-14 24 53 67
Fax: +32-14 24 58 00
www.substrates.umicore.com

Wafer World Inc
1100 Technology Place, Suite 104,
West Palm Beach, FL 33407,
USA
Tel: +1-561-842-4441
Fax: +1-561-842-2677
E-mail: sales@waferworld.com
www.waferworld.com

4 Epiwafer foundry

Spire Semiconductor LLC
25 Sagamore Park Drive,
Hudson, NH 03051,
USA
Tel: +1 603 595 8900
Fax: +1 603 595 0975
www.spirecorp.com

Albemarle Cambridge Chemical Ltd
Unit 5 Chesterton Mills,
French's Road, Cambridge CB4 3NP,
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.camchem.co.uk

Intelligent Epitaxy Technology Inc
1250 E Collins Blvd,
Richardson,
TX 75081-2401,
USA
Tel: +1 972 234 0068
Fax: +1 972 234 0069
www.intelliepi.com

IQE
Cypress Drive,
St Mellons, Cardiff
CF3 0EG,
UK
Tel: +44 29 2083 9400
Fax: +44 29 2083 9401
www.iqep.com
IQE is a leading global supplier of advanced epiwafers, with products covering a diverse range of applications within the wireless, optoelectronic, photovoltaic and electronic markets.

OMMIC
2, Chemin du Moulin B.P. 11,
Limeil-Brevannes, 94453,
France
Tel: +33 1 45 10 67 31
Fax: +33 1 45 10 69 53
www.ommic.fr

Soitec
Place Marcel Rebuffat, Parc de Villejust, 91971 Courtabouef, France
Tel: +33 (0)1 69 31 61 30
Fax: +33 (0)1 69 31 61 79
www.picogiga.com

5 Deposition materials

Akzo Nobel High Purity Metalorganics
www.akzonobel.com/hpmo
Asia Pacific:
Akzo Nobel (Asia) Co Ltd,
Shanghai,
China
Tel. +86 21 2216 3600
Fax: +86 21 3360 7739
metalorganicsAP@akzonobel.com
Americas:
AkzoNobel Functional Chemicals,
Chicago,
USA
Tel. +31 800 828 7929 (US only)
Tel: +1 312 544 7000
Fax: +1 312 544 7188
metalorganicsNA@akzonobel.com
Europe, Middle East and Africa:
AkzoNobel Functional Chemicals,
Amersfoort, The Netherlands
Tel. +31 33 467 6656
Fax: +31 33 467 6101
metalorganicsEU@akzonobel.com

Cambridge Chemical Company Ltd
Unit 5 Chesterton Mills,
French's Road,
Cambridge CB4 3NP,
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.camchem.co.uk

Dow Electronic Materials
60 Willow Street,
North Andover, MA 01845,
USA
Tel: +1 978 557 1700
Fax: +1 978 557 1701
www.metalorganics.com

Matheson Tri-Gas
6775 Central Avenue,
Newark, CA 94560,
USA

Tel: +1 510 793 2559
Fax: +1 510 790 6241
www.mathesontrigas.com

Mining & Chemical Products Ltd
(see section 1 for full contact details)

Praxair Electronics
542 Route 303, Orangeburg,
NY 10962,
USA
Tel: +1 845 398 8242
Fax: +1 845 398 8304
www.praxair.com/electronics

SAFC Hitech
Power Road, Bromborough,
Wirral, Merseyside CH62 3QF,
UK
Tel: +44 151 334 2774
Fax: +44 151 334 6422
www.safchitech.com

Materion Advanced Materials Group
2978 Main Street,
Buffalo, NY 14214,
USA
Tel: +1 716 837 1000
Fax: +1 716 833 2926
www.williams-adv.com

6 Deposition equipment

AIXTRON SE
Dornkaulstr. 2,
52134 Herzogenrath,
Germany
Tel: +49 2407 9030 0
Fax: +49 2407 9030 40
www.aixtron.com

AIXTRON is a leading provider of deposition equipment to the semiconductor industry. The company's technology solutions are used by a diverse range of customers worldwide to build advanced components for electronic and optoelectronic applications (photonic) based on compound, silicon, or organic semiconductor materials and, more recently, carbon nanotubes (CNT), graphene and other nanomaterials.

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

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

Temescal, the expert in metallization systems for the processing of compound semiconductor-based substrates, provides the finest evaporation systems available. Multi-layer coatings of materials such as Ti, Pt, Au, Pd, Ag, NiCr, Al, Cr, Cu, Mo, Nb, SiO_2, with high uniformity are guaranteed. Today the world's most sophisticated handsets, optical, wireless and telecom systems rely on millions of devices that are made using Temescal deposition systems and components.

Oxford Instruments Plasma Technology
North End, Yatton,
Bristol, Avon BS49 4AP, UK
Tel: +44 1934 837 000
Fax: +44 1934 837 001
www.oxford-instruments.co.uk

We provide flexible tools and processes for precise materials deposition, etching and controlled nanostructure growth. Core technologies include plasma and ion-beam deposition and etch and ALD.

Plasma-Therm LLC
10050 16th Street North,
St. Petersburg, FL 33716, USA
Tel: +1 727 577 4999
Fax: +1 727 577 7035
www.plasmatherm.com

Plasma-Therm, LLC is an established leading provider of advanced plasma processing equipment for the semiconductor industry and related specialty markets.

Riber
31 rue Casimir Périer, BP 70083,
95873 Bezons Cedex, France
Tel: +33 (0) 1 39 96 65 00
Fax: +33 (0) 1 39 47 45 62
www.riber.com

SVT Associates Inc
7620 Executive Drive,
Eden Prairie, MN 55344, USA
Tel: +1 952 934 2100
Fax: +1 952 934 2737
www.svta.com

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

Veeco is a world-leading supplier of compound semiconductor equipment, and the only company offering both MOCVD and MBE solutions. With complementary AFM technology and the industry's most advanced Process Integration Center, Veeco tools help grow and measure nanoscale devices in worldwide LED/wireless, data storage, semiconductor and scientific research markets—offering important choices, delivering ideal solutions.

7 Wafer processing materials

Air Products and Chemicals Inc
7201 Hamilton Blvd.,
Allentown, PA 18195, USA
Tel: +1 610 481 4911
www.airproducts.com/compound

MicroChem Corp
1254 Chestnut St. Newton,
MA 02464, USA
Tel: +1 617 965 5511
Fax: +1 617 965 5818
www.microchem.com

Praxair Electronics
(see section 5 for full contact details)

8 Wafer processing equipment

EV Group
DI Erich Thallner Strasse 1,
St. Florian/Inn, 4782,
Austria
Tel: +43 7712 5311 0
Fax: +43 7712 5311 4600
www.EVGroup.com
Technology and market leader for wafer processing equipment.
Worldwide industry standards for aligned wafer bonding, resist processing for the MEMS, nano and semiconductor industry.

Logitech Ltd
Erskine Ferry Road,
Old Kilpatrick,
near Glasgow G60 5EU,
Scotland, UK
Tel: +44 (0) 1389 875 444
Fax: +44 (0) 1389 879 042
www.logitech.uk.com

Oxford Instruments Plasma Technology
(see section 6 for full contact details)

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

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

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

SUSS MicroTec AG
Schleißheimer Strasse 90,
85748 Garching,
Germany
Tel: +49 89 32007 0
Fax: +49 89 32007 162
www.suss.com

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
Goodfellow supplies small quantities of metals and materials for research, development, prototyping and specialised manufacturing operations.

10 Gas and liquid handling equipment

Air Products and Chemicals Inc
(see section 7 for full contact details)

Cambridge Fluid Systems
12 Trafalgar Way, Bar Hill,
Cambridge CB3 8SQ,
UK
Tel: +44 (0)1954 786800
Fax: +44 (0)1954 786818
www.cambridge-fluid.com

CS CLEAN SYSTEMS AG
Fraunhoferstrasse 4,
Ismaning, 85737,
Germany
Tel: +49 89 96 24 00 0
Fax: +49 89 96 24 00 122
www.cscleansystems.com

SAES Pure Gas Inc
4175 Santa Fe Road,
San Luis Obispo,
CA 93401,
USA
Tel: +1 805 541 9299
Fax: +1 805 541 9399
www.saesgetters.com

11 Process monitoring and control

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
k-Space Associates Inc specializes in in-situ, real-time thin-film process monitoring tools for MBE, MOCVD, PVD, and thermal evaporation. Applications and materials include the research and production line monitoring of compound semiconductor-based electronic, optoelectronic, and photovoltaic devices.

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

LayTec AG
Seesener Str. 10–13,
10709 Berlin,
Germany
Tel: +49 30 89 00 55 0
Fax: +49 30 89 00 180
www.laytec.de
LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

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

12 Inspection equipment

Bruker AXS GmbH
Oestliche Rheinbrueckenstrasse 49,
Karlsruhe, 76187,
Germany
Tel: +49 (0)721 595 2888
Fax: +49 (0)721 595 4587
www.bruker-axs.de

13 Characterization equipment

J.A. Woollam Co. Inc.
645 M Street Suite 102,
Lincoln, NE 68508, USA
Tel: +1 402 477 7501
Fax: +1 402 477 8214
www.jawoollam.com

Lake Shore Cryotronics Inc
575 McCorkle Boulevard,
Westerville, OH 43082,
USA
Tel: +1 614 891 2244
Fax: +1 614 818 1600
www.lakeshore.com

14 Chip test equipment

Keithley Instruments Inc
28775 Aurora Road,
Cleveland, OH 44139,
USA
Tel: +1 440.248.0400
Fax: +1 440.248.6168
www.keithley.com

15 Assembly/packaging materials

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

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

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

Materion Advanced Materials Group
2978 Main Street,
Buffalo, NY 14214,
USA
Tel: +1 716 837 1000
Fax: +1 716 833 2926
www.williams-adv.com

16 Assembly/packaging equipment

Ismeca Europe Semiconductor SA
Helvetie 283, La Chaux-de-Fonds,
2301, Switzerland
Tel: +41 329257111
Fax: +41 329257115
www.ismeca.com

Kulicke & Soffa Industries
1005 Virginia Drive,
Fort Washington,
PA 19034,
USA
Tel: +1 215 784 6000
Fax: +1 215 784 6001
www.kns.com

Palomar Technologies Inc
2728 Loker Avenue West,
Carlsbad, CA 92010,
USA
Tel: +1 760 931 3600
Fax: +1 760 931 5191
www.PalomarTechnologies.com

TECDIA Inc
2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054,
USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

17 Assembly/packaging foundry

Quik-Pak
10987 Via Frontera,
San Diego, CA 92127, USA
Tel: +1 858 674 4676
Fax: +1 8586 74 4681
www.quikicpak.com

18 Chip foundry

Compound Semiconductor Technologies Ltd
Block 7, Kelvin Campus,
West of Scotland, Glasgow,
Scotland G20 0TH,
UK
Tel: +44 141 579 3000
Fax: +44 141 579 3040
www.compoundsemi.co.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

MEI, LLC
3474 18th Avenue SE,
Albany, OR 97322-7014,
USA
Tel: +1 541 917 3626
Fax: +1 541 917 3623
www.marlerenterprises.net

20 Facility consumables

W.L. Gore & Associates
401 Airport Rd, Elkton,
MD 21921-4236,
USA
Tel: +1 410 392 4440
Fax: +1 410 506 8749
www.gore.com

21 Computer hardware & software

Ansoft Corp
4 Station Square, Suite 200,
Pittsburgh, PA 15219, USA
Tel: +1 412 261 3200
Fax: +1 412 471 9427
www.ansoft.com

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

Semiconductor Technology Research Inc
10404 Patterson Ave., Suite 108,
Richmond, VA 23238,
USA
Tel: +1 804 740 8314
Fax: +1 804 740 3814
www.semitech.us

22 Used equipment

Class One Equipment Inc
5302 Snapfinger Woods Drive,
Decatur, GA 30035, USA
Tel: +1 770 808 8708
Fax: +1 770 808 8308
www.ClassOneEquipment.com

23 Services

Henry Butcher International
Brownlow House, 50–51
High Holborn, London WC1V 6EG,
UK
Tel: +44 (0)20 7405 8411
Fax: +44 (0)20 7405 9772
www.henrybutcher.com

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

24 Consulting

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

25 Resources

Al Shultz Advertising Marketing for Advanced Technology Companies
1346 The Alameda,
7140 San Jose, CA 95126, USA
Tel: +1 408 289 9555
www.alshuktz.com

SEMI Global Headquarters
3081 Zanker Road,
San Jose, CA 95134, USA
Tel: +1 408 943 6900
Fax: +1 408 428 9600
www.semi.org

Yole Développement
45 rue Sainte Geneviève,
69006 Lyon, France
Tel: +33 472 83 01 86
www.yole.fr

event calendar

If you would like your event listed in *Semiconductor Today*'s Event Calendar, then please e-mail all details to the Editor at mark@semiconductor-today.com

7 November 2016
Imec Technology Forum ITF2016 Japan
New Otani Hotel – Tokyo, Japan
E-mail: vanherck@imec.be
www.itf2016.be/page.aspx/2218

7–9 November 2016
4th IEEE Workshop on Wide Bandgap Power Devices and Applications (WiPDA 2016)
Fayetteville, AR USA
E-mail: mantooth@uark.edu
www.wipda2016.org

13–16 November 2016
11th International Conference on Advanced Semiconductor Devices & Microsystems (ASDAM '16)
Smolenice, Slovakia
E-mail: asdam@savba.sk
http://elu.sav.sk/asdam

3–7 December 2016
IEDM 2016: 62nd annual IEEE International Electron Devices Meeting
San Francisco Union Square Hilton Hotel, CA, USA
E-mail: info@ieee-iedm.org
www.ieee-iedm.org

7–10 December 2016
47th IEEE Semiconductor Interface Specialists Conference (SISC 2016)
Catamaran Hotel, San Diego, CA, USA
www.ieeesisc.org

13–14 December 2016
International MicroNanoConference 2016
Beurs van Berlage, Amsterdam, The Netherlands
E-mail: info@micronanoconference.org
www.micronanoconference.org

14–16 December 2016
SEMICON Japan 2016
Tokyo International Exhibition Center (Tokyo Big Sight), Japan
E-mail: jcustomer@semi.org
www.semiconjapan.org

27–30 December 2016
3rd International Conference on Emerging Electronics (ICEE 2016)
Indian Institute of Technology Bombay (IIT Bombay), Mumbai, India
E-mail: icee@ee.iitb.ac.in
www.iceeconf.org

28 January – 2 February 2017
SPIE Photonics West 2017
Moscone Center, San Francisco, CA, USA
E-mail: customerservice@spie.org
http://spie.org/SPIE-PHOTONICS-WEST-conference

5–9 February 2017
IEEE International Solid-State Circuits Conference (ISSCC 2017)
San Francisco, CA, USA
E-mail: m.figueroa@ieee.org
www.isscc.org

advertisers' index

Advertiser	Page no.	Advertiser	Page no.
Aixtron SE	5	SEMI-GAS	35
Evatec	45	Umicore	43
Ferrotec-Temescal	49	University Wafer	52
Fuji Electric	23	Veeco Instruments — MBE	9
IQE	25	Veeco Instruments — MOCVD	2
Logitech	33	Wafer World	29
RIFF Company	59		

28 February – 2 March 2017
IEEE Electron Devices Technology and Manufacturing Conference (EDTM 2017)
Toyama International Conference Center, Japan
E-mail: edtm@jtbcom.co.jp
http://ewh.ieee.org/conf/edtm/2017

14–16 March 2017
SEMICON China 2017
Shanghai New International Expo Centre, China
E-mail: semichina@semi.org
www.semiconchina.org

19–23 March 2017
Optical Fiber Communication Conference & Exhibition (OFC 2017)
Los Angeles Convention Center, CA, USA
E-mail: OFC@compusystems.com
www.ofcconference.org

3–5 April 2017
19th European Conference on Integrated Optics (ECIO 2017)
Technical University of Eindhoven, The Netherlands
E-mail: info@jakajima.eu
www.ecio-conference.org

3–5 April 2017
2017 Joint International EUROSOI Workshop and International Conference on Ultimate Integration on Silicon (ULIS)
Institute of Nanoscience & Nanotechnology of NCSR 'Demokritos', Athens, Greece
E-mail: a.nasiopoulou@inn.demokritos.gr
www.eurosoi-ulis2017.inn.demokritos.gr

9–13 April 2017
SPIE Defense + Commercial Sensing (DCS 2017)
Anaheim Convention Center, CA, USA
E-mail: customerservice@spie.org
http://spie.org/SPIE-DCS-conference

18–21 April 2017
SNEC's 11th International Photovoltaic Power Generation Conference & Exhibition (SNEC PV Power EXPO 2017)
Shanghai, China
E-mail: info@snec.org.cn
www.snec.org.cn

1–3 May 2017
13th International Conference on Concentrator Photovoltaics (CPV-13)
University of Ottawa, Canada
E-mail: info@cpv-13.org
www.cpv-13.org

22–25 May 2017
2017 CS ManTech (International Conference on Compound Semiconductor Manufacturing Technology)
Hyatt Regency Indian Wells Resort & Spa, Indian Wells, CA, USA
E-mail: lynn_fincher@msn.com
www.csmantech.org

28 May – 1 June 2017
29th International Symposium on Power Semiconductor Devices and ICs (ISPSD 2017)
Sapporo, Japan
E-mail: ispsd2017reg@ech.co.jp
http://eds.ieee.org/eds-meetings-calendars.html

4–6 June 2017
IEEE Radio Frequency Integrated Circuits Symposium (RFIC 2017)
Hawaii Convention Center, Honolulu, HI, USA
http://rfic-ieee.org

25–30 June 2017
44th IEEE Photovoltaic Specialists Conference (PVSC 2017)
Marriot Wardman Park Hotel, Washington DC, USA
E-mail: info@ieee-pvsc.org
www.ieee-pvsc.org/PVSC44

10–12 July 2017
IEEE Photonics Society's 2017 Summer Topicals Meeting Series
San Juan, Puerto Rico
E-mail: i.donnelly@ieee.org
www.sum-ieee.org

23–25 August 2017
IEEE 14th International Conference on Group IV Photonics (GFP 2017)
Berlin, Germany
E-mail: m.figueroa@ieee.org
www.gfp-ieee.org

22–25 October 2017
IEEE Compound Semiconductor Integrated Circuit Symposium (CSICS 2017)
Miami, FL USA
E-mail: l.lelong@ieee.org
https://csics.org

26–28 October 2017
International Conference on Advanced Materials and Nanotechnology
Osaka, Japan
http://advancedmaterials.conferenceseries.com/events-list/photonics-and-semiconductor-nanophysics

semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

Choose *Semiconductor Today* for . . .

MAGAZINE

Accurate and timely coverage of the compound semiconductor and advanced silicon industries

Targeted 41,000+ international circulation

Published 10 times a year and delivered by e-mail and RSS feeds

WEB SITE

Average of over 19,700 unique visitors to the site each month

Daily news updates and regular feature articles

Google-listed news source

E-BRIEF

Weekly round-up of key business and technical news

E-mail delivery to entire circulation

Banner and text marketing opportunities available

www.semiconductor-today.com

Join our LinkedIn group: Semiconductor Today

Follow us on Twitter: Semiconductor_T