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COMPOUNDS & ADVANCED SILICON

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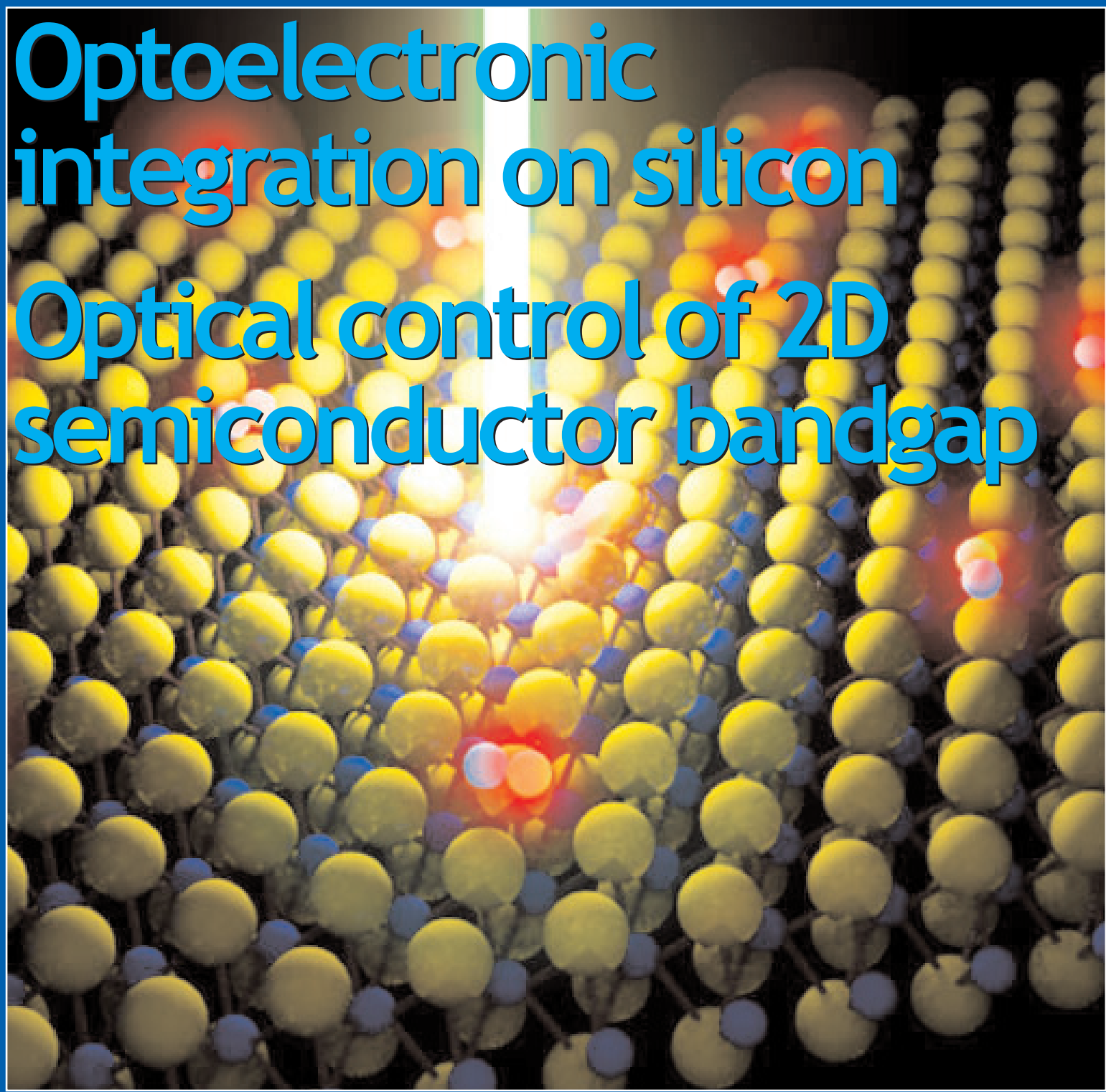
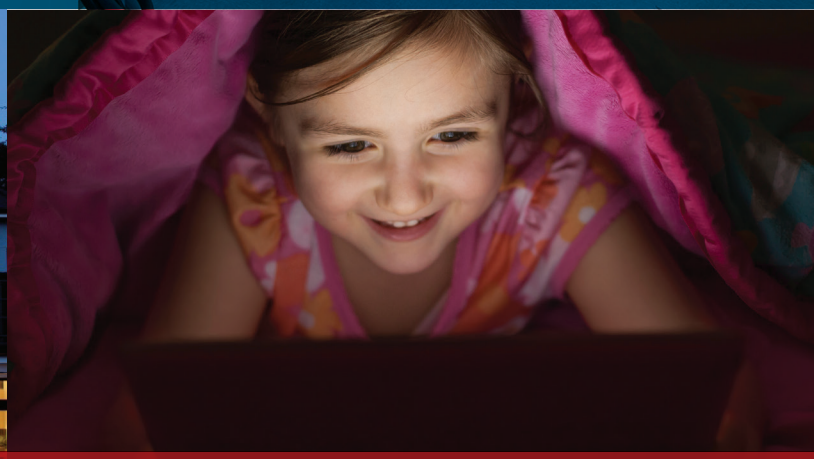


Optoelectronic integration on silicon

Optical control of 2D semiconductor bandgap

Infineon acquiring Wolfspeed • Hanergy launches solar vehicles
Kyma & Quora team on GaN substrates • imec Florida opens

Lower Cost LEDs



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Veeco's New TurboDisc EPIK700 GaN MOCVD System

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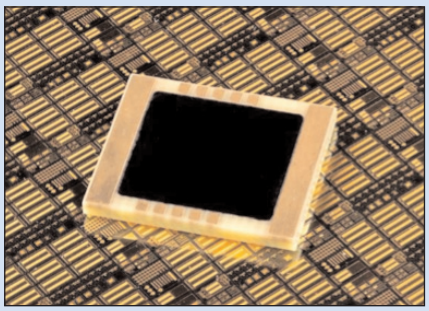
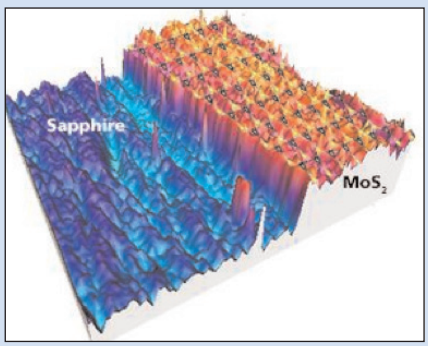
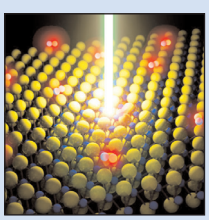


p24 GaN MISHEMT manufacturer VisIC has launched its new generation of ALL-Switch devices.



p41 Oxford Instruments has launched a molybdenum disulphide growth process development using its Nanofab nanoscale growth system.

p70 China-based thin-film solar power firm Hanergy has launched four full-solar-power vehicles.



Cover: An international collaboration working on Artemis — the ultrafast laser and XUV science capability of the UK Science and Technology Facilities Council's Central Laser Facility — has shown how the electronic properties of a 2D semiconductor can be controlled by light. **p60**

editorial

Opto integration on silicon, and consolidation in wide-bandgap power and RF

This issue's feature article focuses on the topic of integrating III-V materials directly on silicon to enable the integration of optoelectronic functionality on silicon substrates without the need for wafer bonding (see pages 80–85). Specifically, we focus on laser and photodiode devices incorporating indium arsenide (InAs)/gallium arsenide (GaAs) quantum dots (next issue we cover the integration of nitride-based optoelectronics on silicon).

In addition, on pages 78–79 we report research on integrating a 3.8μm mid-infrared antimonide-based ($InAs_{0.91}Sb_{0.09}$) photodiode array with a silicon-on-insulator (SOI)-based arrayed waveguide grating (AWG) using wafer bonding (facilitating the spectroscopic analysis of organic compounds). Also, on pages 86–87 we report what is claimed to be the first time that an epitaxially grown gallium indium arsenide phosphide/indium phosphide (GaInAsP/InP) double-heterostructure laser diode has been demonstrated on a wafer-bonded InP/Si substrate.

Regarding the increasing developments in two-dimensional materials for optoelectronic applications, Germany-based deposition equipment maker Aixtron is working with five partners in the EU-funded HEA2D project to investigate the production, qualities and applications of 2D nanomaterials, including a sub-project involving researching (MO)-CVD processes and systems technology for depositing optically active 2D semiconductors.

Also, the UK's Oxford Instruments has launched a molybdenum disulphide (MoS_2) growth process developed using its Nanofab nanoscale system, which is also capable of depositing other 2D transition-metal dichalcogenide (TMDC) materials such as WS_2, $MoSe_2$ etc (see page 41).

An international collaboration working on Artemis — the ultrafast laser and XUV science capability of the UK Science and Technology Facilities Council's Central Laser Facility — has shown how the electronic properties of a 2D semiconductor (including its energy bandgap) can be controlled (i.e. tuned) by light, specifically how a MoS_2-graphene heterostructure could open new applications for 2D optoelectronic devices (see page 60).

Regarding recent business developments in microelectronics, in mid-July Germany's Infineon Technologies agreed the $850m acquisition of the Wolfspeed Power & RF division of LED maker Cree Inc of Durham, NC, USA including its associated silicon carbide (SiC) wafer substrate business for power and RF power (see page 21). Wolfspeed's SiC-based power and GaN-on-SiC-based RF power product portfolio supplements Infineon's existing range of SiC-based power devices and complements its acquisition in January 2015 of US-based International Rectifier Corp, which focused on GaN-on-Si power semiconductor devices. "With Wolfspeed we will become number one in SiC-based power semiconductors. We also want to become number one in RF power," says Infineon's CEO Dr Reinhard Ploss.

The motivation for such consolidation is shown by a forecast that the wide-bandgap power semiconductor device market is rising at a compound annual growth rate (CAGR) of about 33% from $210m in 2015 to $3.7bn in 2025, with SiC comprising more than $3bn and GaN $600m, according to IHS Technology (see page 9).

Mark Telford, Editor

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

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

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HVM: High Volume Manufacturing

LED lamps and luminaires growing from 28.6% of lighting revenue in 2015 to over half by 2019

Longer lifespans of LEDs versus traditional technologies and need for fewer replacement lamps to reduce unit shipments and overall lighting revenues from 2019

Global revenue for lighting equipment grew by 4.6% in 2015, estimates IHS Inc through its Lighting Intelligence Service. This is a slightly lower growth rate than 2014's 4.8%. However, behind this overall growth rate are two separate, but interlinked, stories.

First, the lamp market revenue grew 4% in 2015, which was lower than 2014's 7.3% but higher than previous IHS revenue forecasts through 2023. As the lamp market continues to transition to LEDs, there are two effects combining to mute future revenue growth: an overall decline in lamp shipments, and price erosion of LED lamps. As users switch to LED technologies that have much longer lifespans than traditional technologies, fewer replacement lamps are required, resulting in lower shipment levels. As prices for LED lamps fall, manufacturer revenue will also begin declining in 2019.

Secondly, luminaire revenue grew 4.8%, which was higher than 2014's 3.9%. Unlike the lamp market, luminaire revenue growth is expected to continue over the forecast period. This growth comes from LED integrated and LED replacement luminaires, which will see continued growth in both revenue and shipments through 2023, forecasts IHS.

New global and regional market statistics, forecasts and market share estimates have been added to the IHS Lighting Intelligence Service. In addition to the above, other key findings include the following.

The supply base for both non-LED and LED lamps became more fragmented in 2015, with the top 10 vendors falling from 54.8% to 41.4% of the market for non-LED lamps and from 55.1% to 50.2% of the market for LED lamps.

LED lamps and luminaires comprised only 7.8% of unit shipments but 28.6% of revenue

Unlike the lamp market, the supply base for LED luminaires became more consolidated. The top 10 vendors accounted for 33.5% of the market in 2015, up from 29.6% in 2014.

China is estimated to have been the largest regional market for lighting equipment, accounting for almost 30% of the global market in 2015.

Although LED lamps and luminaires accounted for only 7.8% of unit shipments, they comprised 28.6% of revenue in 2015. Also, this is expected to rise to more than half of all lighting market revenue by 2019, concludes the report.

https://technology.ihs.com/Services/502759/lighting-intelligence-service
www.ihs.com

LED luminaire sales for horticultural applications to grow to $2.8bn by 2024

The global market for light-emitting diode (LED) luminaires for horticultural applications is expected to grow to $2.8bn by 2024, according to the report 'LED Lighting for Horticultural Applications' from Navigant Research.

The next five years are expected to bring great opportunity for lighting companies as new indoor growing facilities are built and as new horticultural market entrants make decisions on available brands. Despite being more expensive than other technologies, LEDs are now the preferred lighting technology in an increasing number of facilities, because of advantages that can increase energy efficiency and crop yields, notes the report.

"The United States and Canada are seeing some of the fastest adoption rates for LEDs in horticultural applications," says principal research analyst Benjamin Freas. "With high labor rates and land near population centers at a premium, even a small increase in crop yield can have a big impact on net revenue."

Indoor space used to grow food crops is expected to more than triple in the coming decade, forecasts the report. Of the other horticultural applications, indoor cannabis production, which is forecast to grow steadily worldwide and quickly in North America as legalization laws change, can particularly benefit from the dramatically lower costs associated with LED lighting.

www.navigantresearch.com/research/led-lighting-for-horticultural-applications

Emergence of COB technology to boost LED packaging equipment market to $656m in 2020

The global light-emitting diode (LED) packaging equipment market will rise at a compound annual growth rate (CAGR) of almost 2% to more than $656m in 2020, according to a report by Technavio.

The report considers the emergence of COB technology as one of the major trends that will gain traction in this market during the forecast period. "COB [chip-on-board] is a type of bare-chip technology used for LED lighting," says Navin Rajendra, one of Technavio's industry managers for sensors. "The lighting module for a COB LED is done by placing multiple LED chips in a small area. It is a comparatively new technology for LED packaging, and it involves multiple LED chips being mounted directly on the substrate to make an LED array in one lighting module," he adds.

Benefits such as the capability to spread light across a large area, effective thermal management, homogenous luminosity, energy efficiency and compactness will ensure that the increased adoption of COB LEDs will require the adoption of new and advanced LED packaging processes, which will demand the replacement of older packaging equipment.

By process, as a proportion of the LED packaging equipment market in 2015, LED testing comprised 59.69%, die singulation 18.99%, die attach 15.12%, substrate separation 3.88%, and permanent bonding 2.33%.

LED testing

LED testing is required throughout the LED packaging process, and testing equipment is used for the inspection and qualification of incoming materials, process monitoring and control, and testing end-of-line product. The expected increase in demand for LEDs will subsequently boost demand for this market segment in the coming years.

Die singulation

The die singulation (wafer dicing) segment (valued at $124.7m in 2015) is used to separate individual dies on the finished wafer for further packaging and assembly. The process is carried out on the basis of the LED's end-application (e.g. different types of dies are used in general lighting systems than in automotive applications).

The size of dies, type of structure, and nature and type of substrates determine the singulation technique to be used. Cost and performance parameters are also taken into consideration. The evolution of new laser technologies for dicing and scribing purposes will create demand for equipment and will also help die singulation maintain its market share in the LED packaging equipment market.

Die attach

The success of a finished product depends on many key processes that achieve their individual quality goals and targets. Die attach involves the attachment or bonding of a die (chip) to an LED package. Requirements for the die attach process include:

LED testing comprised 59.69%, die singulation 18.99% [of the LED packaging equipment market in 2015], die attach 15.12%, substrate separation 3.88%, and permanent bonding 2.33%

- thermal conductivity should dissipate the heat generated from the die;
- perfect contact should exist between the chip and substrate without any voids;
- the bond or attachment should be made carefully so that it does not destroy the chip; and
- the bond or attachment should be able to withstand extreme temperatures without any degradation.

The size of wafers used for LED chip production has increased from 2–4 inches to 6–8 inches. The large wafer size allows manufacturers to reduce the overall cost by producing more LED chips per wafer. Intensifying price wars have compelled manufacturers to emphasize cost reduction and a shift toward large-diameter wafers for LED production.

Substrate separation

The substrate separation segment was valued at $25.45m in 2015. To maintain manufacturing efficiency, LED makers typically attach or populate multiple LED boards, with the boards being tied together. After this, a punching tool or a manual breaking process is used to separate the LED boards. Care is needed during the process, as the printed-circuit board can easily bend or flex due to excessive stress on the ceramic substrate and the LEDs soldered onto the substrate. Excessive stress may also result in a crack, creating defective LEDs.

APAC to account for 88% of market by 2020, driven by LED display panels

The report estimates that the Asia-Pacific region (APAC) will dominate the market, accounting for about 88% of LED packaging equipment revenue by 2020. The exponential rise in demand for consumer electronics — coupled with the rollout of long-term evolution (LTE) bandwidths in APAC countries such as India and China — has led to the expansion of LTE base-station infrastructure. This will drive the market for display panels that use LEDs as the backlighting source of the screen. Also, the presence of major LED display lighting panel manufacturers in this region will contribute to market growth, reckons Technavio.

www.technavio.com/report/global-sensors-light-emitting-diode-packaging-equipment-market

GaAs device market to grow at 4.14% CAGR until 2020

The global gallium arsenide (GaAs) device market will rise at a compound annual growth rate (CAGR) of 4.14% over 2016–2020, forecasts a report by TechNavio (issued by the firm Research and Markets).

The GaAs device market largely comprises applications in mobile devices (smartphones and tablets) and wireless communications. These two segments collectively accounted for more than 80% of the market in 2015, according to the report 'Global Gallium Arsenide (GaAs) Devices Market 2016–2020'.

Smartphone shipments will grow significantly from about 1.4 billion units in 2015 to more than 2 billion units by 2020 due to the availability of low-cost smartphones in emerging markets such as China and India as well as increasing Internet penetration worldwide. The growth in smartphones shipments will drive demand for GaAs devices used in mobile handsets, particularly GaAs power amplifiers. Further, the report states that the availability of alternative devices is a major challenge faced by the market.

Vendors are expected to expand their business, improve their market share, and gain access to new technologies through strategic alliances, collaborations, mergers, and acquisitions, offering better solutions based on the latest technologies.

The report lists key vendors as: Skyworks Solutions, Qorvo (formed by the merger of RF Micro Devices and TriQuint Semiconductor in January 2015), Avago Technologies, Advanced Wireless Semiconductor, Anadigics, Hittite Microwave, M/A-COM Technology Solutions, and Murata Manufacturing.

www.researchandmarkets.com/research/kxxjlb/global_gallium

RF high-power semiconductor market for wireless infrastructure flattening out in 2016 after overall market exceeds $1.5bn, as GaN gains market share

Spending on RF high-power semiconductors for the wireless infrastructure markets has flattened out this year, despite the overall market hitting well over $1.5bn in 2015, according to ABI Research's report 'RF Power Semiconductors'. While certain market and sub-market segments show moderate growth, it is gallium nitride (GaN) that is capturing meaningful market share in RF high-power semiconductors, especially in wireless infrastructure.

"GaN is increasing its market share in 2016, and we believe it will be a significant force by 2021," says research director Lance Wilson. "This now mainstream technology bridges the gap between two older technologies, exhibiting the high-frequency performance of gallium arsenide and power handling capabilities of silicon LDMOS."

Outside of wireless infrastructure in the RF high-power semiconductor business, defense-oriented market segments show the strongest performance. Despite the poor press for defense-oriented electronic hardware, the actual performance in 2015 was better than originally thought for some sub-segments. In total, these defense-oriented segments will be a significant market and one to keep an eye in future, Wilson believes.

www.abiresearch.com/market-research/product/1022826-rf-power-semiconductors

VSAT shipments to nearly double by 2020

GaN revenue in commercial satcom to grow by 300%, at 30% CAGR

Spurred by new technology and architectures, very small aperture terminal (VSAT) applications are evolving from enterprise connectivity and video to competitive wireless broadband alternative, notes the Strategy Analytics Advanced Semiconductor Applications (ASA) service report 'Compound Semiconductor Content in Commercial Satellite Communications Networks: 2015–2020'.

Growth in data traffic requirements will nearly double the quantity of all elements of the commercial satellite communications network by 2020, forecasts Strategy Analytics. This growth, coupled with increasing market share, will fuel a compound annual growth rate (CAGR) of 30% for gallium nitride (GaN) revenue in this segment over the forecast period, concludes the report.

"The VSAT industry is moving to higher frequencies, more onboard processing and High Throughput Satellites (HTS) as a means of enhancing the data-rate capabilities of satcom networks," says ASA service director Eric Higham.

"GaN is enabling these new capabilities, so we expect strong growth from the technology as it makes fast inroads into applications previously served by traveling-wave tube amplifiers," he adds.

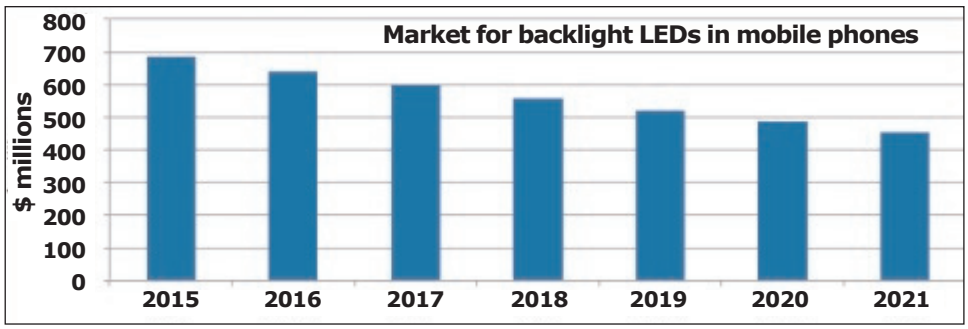
"While conventional applications are still the largest users, internet and mobility-related applications will be the fastest-growing segments of the commercial satellite communications industry," comments Asif Anwar, service director, Advanced Defense Systems service.

www.strategyanalytics.com

Mobile phone LED market to fall at CAGR of 2.6% from 2015 to 2021

The market for LEDs used in mobile phones — including backlighting behind the display, keypad illumination, and camera flash — will decline at a compound annual growth rate (CAGR) of 2.6% from 2015 to 2021, according to the latest information from IHS Markit Mobile Phones in Packaged LED Market Brief. A primary reason for this decline is increased penetration of organic LEDs (OLEDs), it notes.

For mobile phone displays the OLED panel penetration rate is forecast to grow from 13% in 2015 to 34% in 2021 due to strong demand from Chinese brands. LED revenue for backlighting in mobile phones was estimated to be $686m in 2015,



but will decline to $455m in 2021.

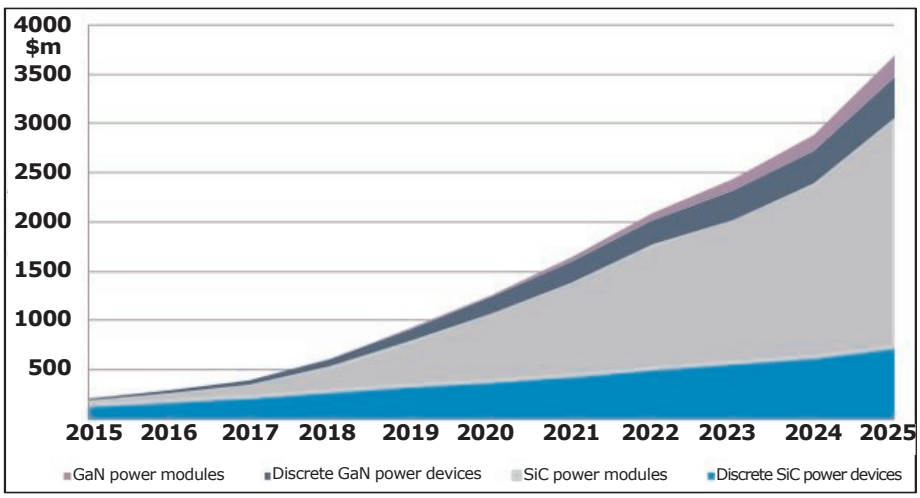
Nearly all mobile phones shipped in 2015 had at least one camera — and 86% also had a secondary camera — although not every camera was equipped with a flash. IHS expects the mobile phone flash LED market to fall slightly in 2016 due to a drop in mobile phone shipments. However, the market will begin to grow again from 2017 to 2020 due to increased penetration of color LEDs and secondary camera flash applications. LEDs used in mobile phone keypads will also fall, but they comprise only a very small part of the market, IHS notes.

https://technology.ihs.com

Wide-bandgap power semiconductor device market to grow at 33% annually to $3.7bn in 2025

SiC power market to exceed $3bn as GaN power market passes $600m

Due to falling prices and the commercial availability of wide-bandgap (WBG) semiconductor power devices from multiple sources, the adoption of silicon carbide (SiC) and gallium nitride (GaN) power devices in power supplies for computers, telecom equipment, photovoltaic inverters, electric vehicles, military devices and many other applications is on the rise. The global market for SiC and GaN power semiconductors is hence rising at a compound annual growth rate (CAGR) of around 33% from $210m in 2015 to about $1.265bn in 2020 then $3.7bn in 2025, forecasts analyst Richard Eden in IHS Technology's SiC & GaN Power Semiconductors Report.



While SiC-based Schottky diodes have been available for over ten years, SiC-based MOSFETs, junction-gate FETs (JFETs) and bipolar junction transistors (BJTs) have emerged commercially in the last few years, including 900V SiC MOSFETs with a price comparable to silicon. Also, the number of suppliers of discrete SiC power devices has increased in the last few years, pushing more power supply designers toward SiC power devices. Consequently, IEEE is expecting SiC MOSFETs alone to generate revenue of $300m by 2025, becoming the second-best-selling discrete power device type in the next 5–10 years.

Meanwhile GaN-on-silicon power transistors are ramping up in production and GaN power modules are beginning to emerge. As a result, it is expected that, by 2020, GaN-on-Si power devices will achieve price parity with silicon MOSFETs and IGBTs. However, the report suggests the first GaN Schottky diodes will not to commercially available before 2020. Accordingly, the GaN power market should generate $600m by 2025. while the SiC power market will exceed $3bn in revenue, the report concludes.

https://technology.ihs.com

II-VI Inc sells certain RF assets of Anadigics for $45m

GaAs wafer fab retained for VCSEL fabrication

In advance of the Citi Technology Conference on 9 June, engineered materials and optoelectronic component maker II-VI Inc of Saxonburg, PA, USA updated its investor presentation to note the sale of certain RF assets formerly owned by Anadigics (excluding the 6" GaAs wafer fab), as reported on a Form 8-K filed with the US Securities and Exchange Commission (SEC).

II-VI completed its acquisition of broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA in March for about $78.2m. Anadigics became a subsidiary of II-VI, with its common stock being delisted and ceasing trading on Nasdaq. This followed an auction (initiated last November) in which II-VI Inc outbid initial bidder GaAs Labs LLC and then subsequently an unnamed Chinese bidder.

Also, on 1 February, II-VI completed its acquisition of EpiWorks Inc of Champaign-Urbana, IL, USA (which manufactures epitaxial wafers for optical components, wireless devices and high-speed communication applications).

The Anadigics RF assets have been sold for $45m in cash plus a $5m earn-out over 18 months (conditional on certain performance levels), coupled with various support and multi-year wafer processing supply agreements with the purchaser. II-VI intends to use the retained Anadigics GaAs fab for fabricating optoelectronics components such as vertical-cavity surface-emitting lasers (VCSELs).

II-VI notes that, as the total addressable market (TAM) for VCSELs is forecasted to grow from $0.8bn in 2015 to $2bn by 2020, it is ramping up its optoelectronics manufacturing capacity, with significant volume expected in second-half 2017.

www.ii-vi-photonics.com
www.anadigics.com
www.sec.gov/Archives/edgar/data

Qorvo cuts production line interruptions by over 60% and scales apps for growth with AppDynamics' Application Intelligence Platform

AppDynamics Inc of San Francisco, CA, USA says that Qorvo Inc of Greensboro, NC and Hillsboro, OR (which provides core technologies and RF solutions for mobile, infrastructure and aerospace/defense applications) has chosen its Application Intelligence Platform to optimize performance of and address growth demands on its critical semiconductor design and production systems.

Qorvo's engineering and semiconductor wafer fabrication facilities in North America, Europe and Asia depend on business-critical .NET applications that tie engineering systems to the manufacturing environment that drives wafer fabrication on Qorvo's shop floors. "Performance hindrances to any one of our applications can cause a bottleneck in the fabrication plant or on the shop floor, resulting in late delivery, lots of overtime, and lost revenue," says Aparajit Saigal, manufacturing IT team lead. "As the company continued to grow, our applications simply couldn't scale."

After writing its own application monitoring code and performing manual analysis in an ongoing attempt to address application and database performance issues, Qorvo began looking at application performance monitoring solutions. The semiconductor manufacturer chose AppDynamics after comparing the capabilities of the AppDynamics Application Intelligence Platform and other application performance management (APM) competitors.

"The fact that AppDynamics offers solutions for monitoring distributed applications and provides an integrated view across applications, databases, and platforms was a huge advantage over competitive offerings," comments Saigal. "Our legacy application spans databases, storage, Active Directory, and a vast assortment of endpoints," he adds. "Other APM vendors couldn't figure out how to implement their solution or scale it in our complex environment."

Saigal estimates that AppDynamics' application performance management has helped his team to reduce interruptions to production by at least 60–70%. "The AppDynamics Application Intelligence Platform gives us true end-to-end visibility across application transactions," says Saigal. "We can determine the amount of time taken for each and every request, and drill down into each function and locate the exact line of code causing issues."

"Qorvo is in an exciting and critical technology sector, creating and manufacturing the semiconductors that make advanced communications possible," says AppDynamics' chief technology officer Bhaskar Sunkara. "We're pleased that they have chosen AppDynamics to give them the visibility, control, and insight into their application performance that they need to ensure efficient operations with little downtime. Our solution will scale effortlessly with them as their business continues to rapidly expand."

www.qorvo.com
www.appdynamics.com/solutions

Qorvo supports over twenty 5G field trials with leading infrastructure providers

Qorvo Inc of Greensboro, NC and Hillsboro, OR, USA (which provides core technologies and RF solutions for mobile, infrastructure and aerospace/defense applications) says that its infrastructure solutions have supported more than twenty 5G field trials with global infrastructure providers, representing a milestone in its strategy to support the evolving 5G ecosystem and to help accelerate the deployment of 5G.

In February, Qorvo announced that it had joined the 3GPP (3rd Generation Partnership Project) as a guest delegate. Qorvo is now a full voting member, advising the standards body on 5G RF solutions. The 5G standard is expected to be released in two phases. Phase 1 (due for completion in 2018) will focus on frequencies below 6GHz and define specifications for a prioritized subset of vertical markets. Phase 2 (due in 2019) will focus on frequencies above 6GHz and define specifications for an expanded list of vertical markets.

"As the leading RF supplier in more than twenty 5G field trials, Qorvo is both a primary enabler and a beneficiary of 5G deployments and the explosive growth in mobile data," says Qorvo's president & CEO Bob Bruggeworth. "With the development of the 5G standard and global allocation of frequency spectrum, we are well positioned to deliver a broad range of 5G connectivity solutions," he believes.

Similar to 4G, the USA is taking a leadership position in the definition and deployment of 5G, with the stated intent of enhancing the digital economy and greatly increasing economic opportunity. On 14 July, the US Federal Communications Commission (FCC) adopted rules for wireless broadband operations in frequencies above 24GHz. The proposed 5G frequency spectrum allocations cover licensed access in 28GHz, 37GHz and 39GHz; unlicensed access in 64–71GHz, and shared access in 37–37.6GHz, with all ranges expected to support multiple 5G use cases.

Qorvo's early start in 5G comes from our legacy of mmW work in the defense and aerospace markets

Higher-frequency millimetre-wave (mmW) bands are expected to expand both network capacity and wireless use cases, with theoretical 5G transfer speeds of up to 10Gb/s. These mmW bands operate over a significantly shorter range than lower-frequency bands, driving a significant increase in residential and commercial placements of short-range, smaller-cell sites.

Qorvo reckons that it is uniquely positioned to deliver an expanding RF portfolio for both infrastructure and smartphone applications including premium bulk acoustic wave (BAW) filters, gallium nitride (GaN) power amplifiers (PAs), phase shifters, amplifiers, switches, integrated modules and other high-performance RF solutions. "Qorvo's early start in 5G comes from our legacy of mmW work in the defense and aerospace markets and our field-proven mmW radio product line," notes Bruggeworth. "We are using this unique background to aid current 5G field trials, giving us multiple generations of product experience in the higher-frequency bands."

www.qorvo.com

Custom MMIC adds BroadRange distributed amplifiers with positive gain slope

Monolithic microwave integrated circuit developer Custom MMIC of Westford, MA, USA has added two new gallium arsenide (GaAs) MMIC BroadRange distributed amplifiers to its portfolio, for applications for including military/commercial communications and instrumentation.

The DC–22GHz CMD240 and 2–22GHz CMD241 both feature a unique positive gain slope, which is said to ease the design of broadband systems by eliminating equalizer circuits or added amplifiers to compensate for the typical negative gain slope of most amplifiers.

The CMD240 is an ultra-wideband distributed amplifier that operates with a low noise figure, low current consumption, and high linearity in a small die size. From DC to 22GHz, the amplifier delivers over 15dB of gain with a mid-band noise figure of 2.2dB, P1dB (output power at 1dB compression point) of 19dBm and output IP3 (third-order intercept point) of 28dBm at 10GHz with a 5V supply.

The CMD241 is a wideband distributed amplifier that operates with a low mid-band noise figure of 2.3dB, an output IP3 of +28dBm, and a low supply current of 74mA in a small die size. It offers over 13dB of gain with a maximum RF input power of +20dBm.

Both amplifiers are 50Ω matched designs (eliminating the need for RF port matching) and can operate off a 3–8V power supply. The CMD241 also has on-chip blocking capacitors. Both amplifiers will be offered in QFN packages later in the summer.

www.custommmic.com/cmd240distributedamplifier
www.custommmic.com/cmd241distributedamplifier

Huawei using ten Skyworks devices in flagship next-generation smartphones

Skyworks Solutions Inc of Woburn, MA, USA (which manufactures analog and mixed-signal semiconductors) says that Huawei's newest flagship P9 and P9 Plus smartphones are being enabled by a broad suite of its devices, ranging from highly integrated modules to analog control ICs. Specifically, Huawei's latest mobile platforms are utilizing the low-, mid- and high-band architectures of the SkyOne Ultra 2.0, featuring integrated filters and SkyBlue technology, antenna tuners, power management devices and multi-throw switches. Skyworks says that its products address LTE Advanced carrier aggregation standards and support up to nine global combinations, including the two most challenging mid-band/mid-band cases.

"Huawei's adoption of multiple solutions from our broad portfolio further solidifies Skyworks leadership position with the world's leading smartphone providers," says Carlos Bori, VP of sales & marketing. "Given our systems expertise and innovative designs, Skyworks is able to offer customers highly configurable and customized architectures that reduce complexity and deliver unparalleled performance. We are adeptly addressing carrier aggregation challenges and increasing frequency bands, while minimizing board size and optimizing battery life to provide competitive advantages and reduced time to market," he adds.

"Skyworks' advanced solutions are enabling unrivaled new features in the P9 and P9 Plus including a virtual triple-antenna architecture designed for consumers who need robust and seamless connectivity to cellular and Wi-Fi networks, allowing them to fully harness the power of the mobile Internet no matter where they are in the world," says Huawei.

According to a forecast by GfK, China smartphone demand in 2016 is stronger than expected and could reach 442 million units (up 7% on last year). In 2012, Huawei became the world's third largest smartphone manufacturer and in 2015 was the first Chinese company to sell more than 100 million mobile phones in one year.

The following solutions are powering Huawei's P9 and P9 Plus platforms:

- SkyOne Ultra 2.0 — a highly integrated single stock-keeping-unit (SKU) LTE platform (including the SKY78113 low-band, SKY78114 mid-band and SKY78117 high-band 3G/4G Tx-Rx SkyOne modules) with flexible antenna support and a baseband-agnostic interface that contains the firm's SkyBlue technology for what is claimed to be best-in-class power efficiencies and linear power capability:
- SKY77360-12 — 2G power amplifier module;
- SKY87020-11 — RF front-end power management IC;
- SKY19003 and SKY19225 — antenna tuners;
- SKY13351 — Wi-Fi single-pole double-throw (SPDT) switch;
- SKY13552 — double-pole 12-throw (DP12T) switch; and
- SKY13598 — high-isolation antenna swap switch.

http://consumer.huawei.com
www.skyworksinc.com

Skyworks expands antenna aperture tuning switches

Skyworks has expanded its antenna tuning product portfolio by adding several new high-performance solutions.

Skyworks' latest antenna tuning offerings address the design challenges that mobile device manufacturers face as smartphones become thinner, leverage revolutionary case materials and integrate more cellular bands. By optimizing radiated efficiency, Skyworks says that its antenna aperture tuners enable higher data throughput and smaller footprints, minimizing dropped calls.

"Cellular band proliferation in smartphones increases complexity and requires highly sophisticated RF solutions," notes David Stasey, general manager & VP of diversified analog solutions. "With our newest suite of antenna tuners, Skyworks is once again pushing the performance envelope and enabling breakthrough front-end performance as well as size reductions and cost savings."

The firm's new antenna tuning switches provide low R_{on} for higher efficiency, transfer more power to the antenna, offer low $C_{of}f$ to deliver accurate and consistent tuning results, enable high Vpeak for improved radiated spurious emission (RSE) performance and integrate GPIO-control for ease of use. To simplify the design process and accelerate time-to-market, Skyworks assists with antenna modeling, data simulation, design and layout optimization, and onsite support to help customers leverage these advanced antenna tuning products into their platforms.

The parts are shipped in compact 10-pin 1.1mm x 1.5mm x 0.5mm quad-flat no-lead (QFN) RoHS-compliant plastic packages. The common footprint of the devices allows one layout to be utilized across multiple designs.

The new devices are available in the following configurations: SP2T (SKY19243-686LF); SP3T (SKY19244-686LF); and SP4T (SKY19245-686LF).

The new antenna aperture tuners are available now for sampling and production.

Skyworks increases quarterly dividend and announces new $400m stock repurchase program

Skyworks Solutions Inc of Woburn, MA, USA (which manufactures analog and mixed-signal semiconductors) says that its board of directors has declared a quarterly cash dividend of $0.28 per share of common stock (an 8% increase from the prior quarterly dividend of $0.26 per share) payable on 25 August to stockholders of record as of the close of business on 4 August.

In addition, the board has authorized the repurchase of up to $400m of the firm's common stock from time to time prior to 19 July 2018, on the open market or in privately negotiated transactions, in compliance with applicable securities laws and other legal requirements. This newly authorized stock repurchase program replaces in its entirety the $400m stock repurchase program that was approved by the board on 10 November 2015 and had about $73m of repurchase authority remaining.

The timing and amount of any shares of common stock repurchased under the new repurchase program will be determined by management based on its evaluation of market conditions and other factors.

The repurchase program may be suspended or discontinued at any time. Any repurchased shares will be available for use in connection with the company's stock plans and for other corporate purposes.

Skyworks currently expects to fund the repurchase program using working capital. As of 1 July, the firm had cash and cash equivalents of about $974m.

www.skyworksinc.com

Three-year €33m European project REFERENCE to extend RF-SOI technology for above-1Gb/s 4G+ wireless communication front-end modules

Soitec leading 16-member consortium from five countries

The pan-European REFERENCE research project — created to leverage disruptive radio-frequency silicon-on-insulator (RF-SOI) technology in developing industrial solutions for the performance, cost and integration needs of RF front-end modules (FEMs) in wireless communications — was launched recently at the facilities in Bernin, near Grenoble, France of project director Soitec, which makes engineered substrates including silicon-on-insulator (SOI) wafers.

Selected as part of a call for proposals signed on 5 July by the Electronic Components and Systems for European Leadership (ECSEL) European Initiative, the project is supported by the European Community (EC) and several national governments. With an eligible budget of €33m, the project aims to extend RF-SOI technology for new cellular, Internet of Things (IoT), automotive and aeronautic applications.

Over the next three years, the REFERENCE project will focus on developing innovative means to address the unresolved requirements for 4G+ communications using RF FEMs with data rates above 1Gb/s and pave the way for next-generation 5G communications. The scope of work encompasses materials, engineered substrates, processes, design, metrology and system integration.

The REFERENCE project consortium involves 16 partners from five countries including six large industrial companies in the materials, foundry and aeronautics sectors, four semiconductor manufacturing equipment companies (SMEs) and a network of public research institutes and academic organizations:

The REFERENCE project will focus on developing innovative means to address the unresolved requirements for 4G+ communications using RF FEMs with data rates above 1Gb/s

France — Soitec, STMicroelectronics, TELIT, CEA-Leti, Université Claude Bernard Lyon 1/Laboratoire Multimateriaux et Interfaces (LMI);
Germany — GlobalFoundries, Siltronic, Airbus, AED, Sentronics, Fraunhofer Gesellschaft (FhG), Technische Universitat Dresden (TUD), Universitat der Bundeswehr (UBWM)
Belgium — IMEC;
Portugal — NANIUM; and
Ireland — Ferfics.

"We are very happy to lead this important European research project involving many key partners beyond our direct customers," says Soitec's partnership director Nelly Kernevez. "This initiative allows us to build the European Union's RF community, consolidate our vision of what the future can be and leverage proven material technology to create RF communication solutions for tomorrow," he adds.

www.soitec.com
www.ecsel-ju.eu

UTAC, Sarda and AT&S collaborate on small, fast GaAs-based voltage regulators to improve data-center energy efficiency

Sarda's Heterogeneous Integrated Power Stage to employ UTAC's 3D system-in-package based on AT&S' embedded component packaging

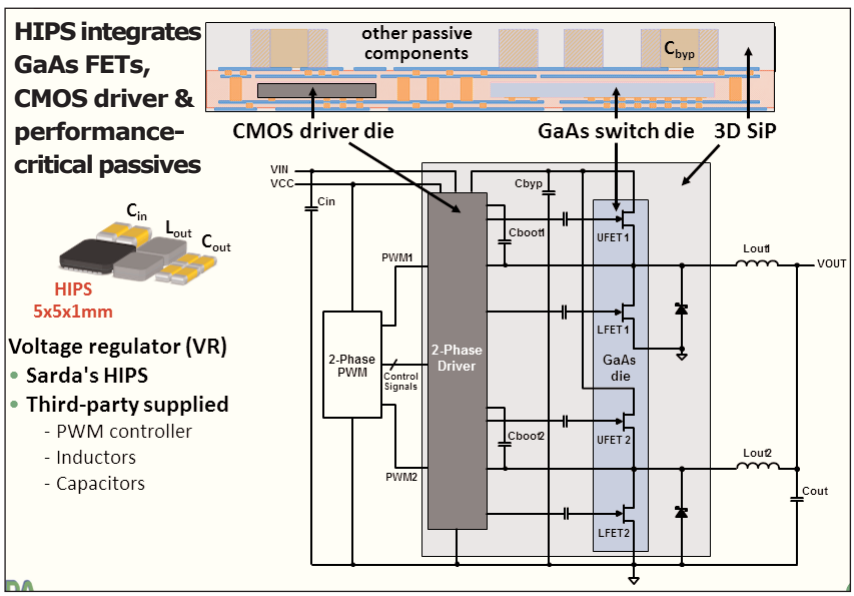
At the International Symposium on 3D Power Electronics, Integration and Manufacturing Symposium in Raleigh, NC, USA (13–15 June), power management component supplier Sarda Technologies of Durham, NC, USA announced a collaboration to implement its Heterogeneous Integrated Power Stage (HIPS) in the three-dimensional system-in-package (3D SiP) of Singapore-based semiconductor assembly & test services provider UTAC Holdings Ltd, based on Embedded Component Packaging (ECP) technology from printed-circuit board (PCB) maker Austria Technologie & Systemtechnik AG (AT&S) in order to improve data-center energy efficiency.

Designed to address the rapidly escalating power consumption in data centers, Sarda's HIPS replaces silicon switches with gallium arsenide (GaAs) in voltage regulators that are said to increase switching frequency by 10 times, improve transient response by five times and reduce size by 80%. With these fast, small voltage regulators, this enables granular power delivery to reduce data-center power consumption by 30%, it is reckoned.

"UTAC's 3D SiP enables Sarda to integrate GaAs switches, silicon driver and passive components in a compact, low-profile package that minimizes parasitics for efficient, high-speed operation," says Sarda's CEO & co-founder Bob Conner. "UTAC's collaboration with AT&S also provides a full turn-key supply chain assembly and test flow with much needed alignment of roadmaps as well as design rules for 3D SiP solutions with embedded chip in substrate technology," he adds.

"System manufacturers are moving from use of discrete components to highly integrated power management solutions to improve power density and energy efficiency," notes Lee Smith, UTAC's VP of Advanced Package Product Line. "UTAC is very excited in working closely with Sarda and AT&S to demonstrate the benefits of using 3D SiP to reduce footprint and improve electrical and thermal performance," he adds.

"Our collaboration with UTAC maximizes the benefits of utilizing AT&S' ECP technology for the Sarda HIPS Solution," says Michael Lang, CEO of Advanced Packaging at AT&S. "The major ECP advantages compared to standard IC packaging and PCB assembly include a significant form-factor reduction, higher reliability, improved thermal management, and a fast and easy system integration with high efficiency."



Reducing data-center cost-per-workload

Servers, routers and communications systems require new power management technology to keep up with the growth in data consumption and mobile connectivity, says Sarda. But power delivery and heat removal issues constrain system performance. Moreover, each system board uses dozens of voltage regulators which consume precious board space.

Designers can no longer rely solely on Moore's Law to deliver the required gains in energy efficiency, the firm adds. Leading-edge processors now operate at less than 1V, which prevents designers from reducing operating voltage enough to keep power consumption constant while increasing transistor density. Instead, developers are turning to 'More-than-Moore Scaling', which heterogeneously integrates different materials and components to improve system performance-per-watt.

Small, fast voltage regulators enable granular power, which reduces system power consumption through dynamic power management of each load, notes Sarda. Miniaturizing the voltage regulators also frees up board space for more processors and memory to increase system performance. Increasing system performance-per-watt decreases the system cost-per-workload.

www.sardatech.com
www.utacgroup.com
www.3D-PEIM.org

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Peregrine extends MPAC product family to 8–12GHz for X-band radar beam-forming

At the IEEE MTT-S International Microwave Symposium (IMS 2016) in San Francisco (24–26 May), 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 PE19601, a monolithic phase and amplitude controller (MPAC) solution for beam-forming. The new MPAC–Beamforming device spans a frequency range of 8–12GHz and has an extended frequency range of 6–14GHz, expanding Peregrine's MPAC product family into higher frequencies. The PE19601 is designed for X-band radar applications including active electronically scanned array (AESA) weather, air-traffic control and military radar.

"Peregrine has proved that RF SOI can deliver a high-performing, reliable and integrated solution at high frequencies," says director of marketing Kinana Hussain. "As the demand for high-frequency applications increases, Peregrine will continue to support the future of communications with intelligently integrated solutions, like the MPAC portfolio."

The MPAC product family showcases UltraCMOS technology's capabilities for intelligent integration (the seamless integration of RF, digital and analog components on a single chip). The PE19601 MPAC–beam-forming solution integrates a 6-bit digital step attenuator (DSA), a 6-bit or 10-bit digital phase shifter (DPS), RX/TX switching and a digital serial interface on a monolithic die. The DSA covers a 31.5dB attenuation range in a 0.5dB step with a low RMS amplitude error of 0.2dB. The phase shifter has a 360° phase range with a very fine resolution of 5° and RMS phase error of 2°. The PE19601 maintains high attenuation and phase accuracy over frequency and temperature. Through intelligent integration, the PE19601 combines RF and analog processing with digital programmability to deliver the flexibility to tune gain and phase at fine resolution.

The UltraCMOS technology platform also offers high reliability, repeatability and high linearity (critical to enabling high-dynamic-range, high-sensitivity radar). High dynamic range is the radar's ability to receive a wide range of signal strengths and levels, hence it can be more accurate because it can detect weaker return signals. High linearity improves the sensitivity of the radar and enables the radar to better detect small objects in cluttered environments. Offered as a 2.6mm x 4.65mm bare wirebond die, the PE19601 MPAC–beam-forming device has linearity of more than 40dBm IIP3 (third-order input intercept point) and high isolation of 50dB. It delivers high power handling of 17dBm P0.1dB and exhibits low power consumption of 0.001mA.

Suitable for high-density compact arrays, the PE19601 delivers the fine resolution and degree of control that is critical for radar applications, says Peregrine. Radar's intelligent arrays can be optimized through increased accuracy and resolution. This performance optimization can occur within the fundamental beam pattern or by reducing unwanted interferers. When the phase accuracy and resolution of the array is low, the directionality of the beam is also low. Increasing the phase accuracy and resolution improves the directionality and the ability to focus the signal. Further fine-tuning the phase relationships of all the elements in an array can create nulling effects, which can be leveraged to mitigate the effects of interferers and help to reduce the level of interference generated. The PE19601 allows for the precise and fine control of a beam's key characteristics.

www.psemi.com

Peregrine's discontinued products available via Arrow Electronics

Peregrine Semiconductor Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) — has announced the availability of its discontinued products through the Supply Assurance program of distributor Arrow Electronics, enabling customers to order obsolete Peregrine products beyond their end-of-life process and last-time-buy event.

"Arrow can support the customers' ongoing demand for parts after the component manufacturer has discontinued production," says Arrow's director of supply assurance Tyler Moore.

"By working with Arrow's supply assurance team, we are complementing the work currently undertaken with Richardson RFPD, an Arrow company and RF design-in specialist distributor," says Peregrine's VP of worldwide sales Colin Hunt. "The new collaboration will extend the availability of our devices to our mutual customers beyond the end-of-life date."

Arrow procures inventory through its Supply Assurance program to extend factory-direct support. The program supports customers' ongoing demand for 5–10 years after manufacturing has been discontinued. Parts purchased from Arrow are shipped with full certificates of compliance, which removes the risk of counterfeit parts entering supply chains.

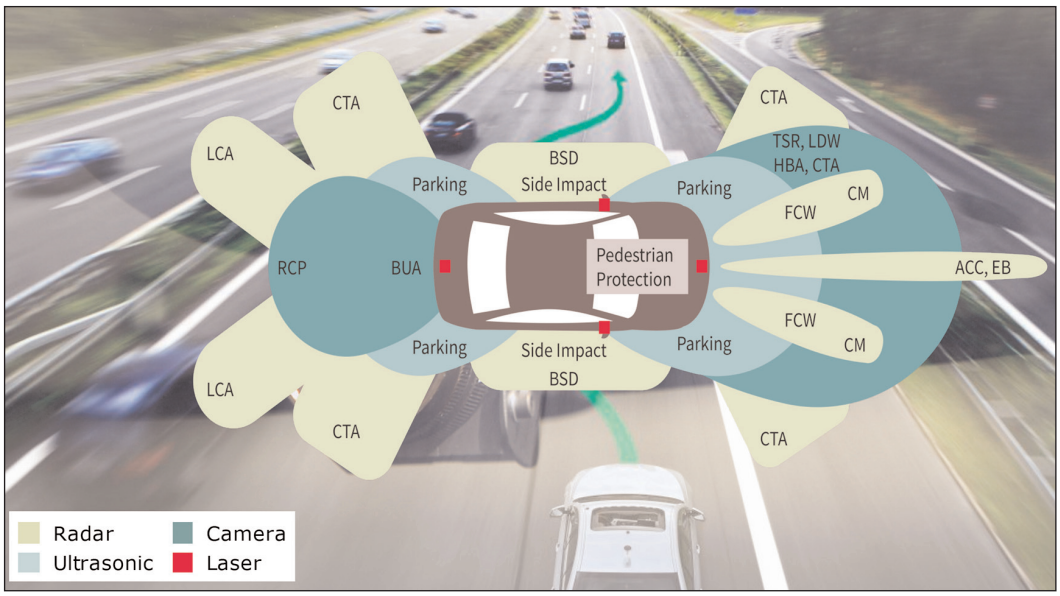
www.arrow.com/supplyassurance

One in 15 new cars to use Infineon SiGe 77GHz radar chips for driver assistance by end-2016

By the end of 2016, more than half of all new automotive 77GHz radar systems worldwide will be equipped with chips from Munich-based Infineon Technologies AG, meaning that about one in 15 new cars will use a driver assistance system using its 77GHz radar chips, says the firm.

Infineon's market leadership in the rapidly growing market for radar chips for driver assistance systems was recently confirmed by market research firm IHS Technology. While Infineon has sold a total of 20 million radar chips in the past few years, the firm aims to ship a further 30 million chips for driver assistance systems next year alone, hence doubling its radar chip sales annually for five years consecutively.

"Of the world's five largest manufacturers of radar systems, four already rely on 77GHz radar chips from Infineon," says Ralf Bornefeld, VP & general manager, Sense & Control at Infineon. "We make driving safety the standard in mid-sized and small vehicles," he adds. "Our sensor chips place the vehicle inside the kind of safety cocoon that is essential for autonomous driving."



In the autonomous vehicle (available from about 2020) at least ten radar systems may be installed. Together with camera, laser and ultrasonic systems, they form a safety cocoon around the vehicle and are the key technology for autonomous driving.

Sensors for the car of the future

Depending on a vehicle's category and how it's equipped, it will have between one and three radar systems. Soon up to five will be offered, together ensuring an 'all-around view' that makes new functions like the intersection assistant and parking assistant possible. In the autonomous vehicle (which the automobile industry expects to be available from around 2020) at least ten radar systems may be installed. Together with camera, laser and ultrasonic systems, they form a safety cocoon around the vehicle and comprise the key technology for autonomous driving.

"With Infineon as a partner, manufacturers of radar systems have an experienced technology leader at their side," says Bornefeld. "Whether they need a radar chip with silicon germanium [SiGe] technology or a highly integrated CMOS solution, our advantage is our product and system expertise at 77GHz and 24GHz, in silicon-germanium and CMOS."

www.infineon.com/rasic

TowerJazz extends partnership with JA Mitsui to drive San Antonio fab growth and ramp-up

Specialty foundry TowerJazz (which has fabrication plants at Tower Semiconductor Ltd in Migdal Haemek, Israel, and at its US subsidiaries Jazz Semiconductor Inc in Newport Beach, CA and TowerJazz Texas Inc in San Antonio, TX, and at TowerJazz Japan Ltd) has extended its long-term global business partnership with financial and banking institution JA Mitsui Leasing Ltd, with which TowerJazz has an established relationship in Japan through its affiliate TowerJazz Panasonic Semiconductor Co (TPSCo).

The agreement provides TowerJazz with up to $40m of an asset-based loan, which will carry annual interest of Libor+2.0%, mature between 2019 and 2022, and be used to support growth and ramp-up plans at the San Antonio fab (acquired in February from Maxim Integrated Products Inc of San Jose, CA, USA), including cross-qualification activities to address the firm's excess customer demand in its other fabs worldwide.

www.towerjazz.com
www.tpsemico.com
www.jamitsuilease.co.jp/en/profile.html

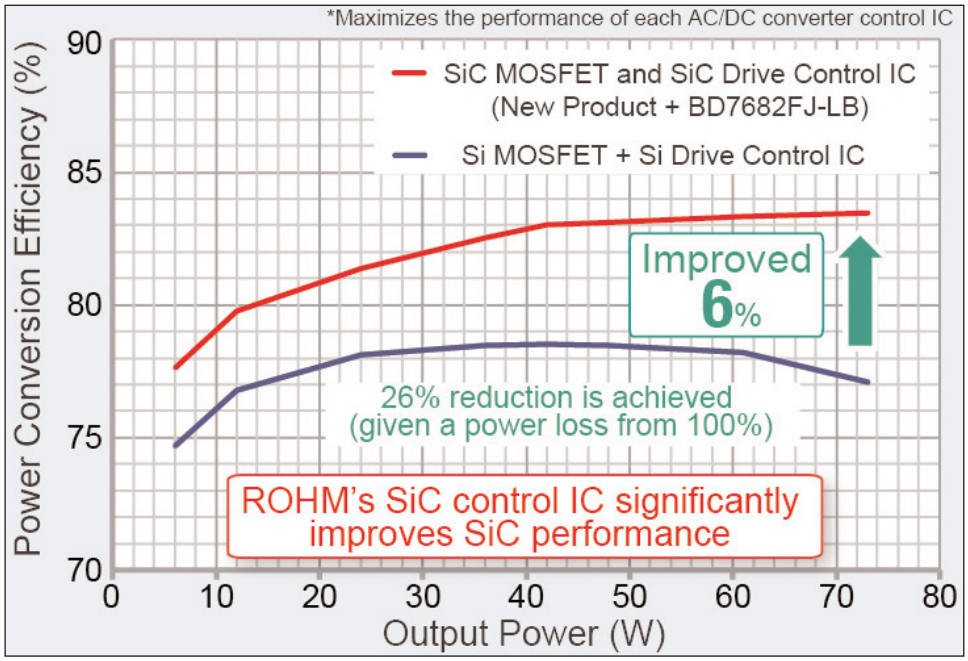
Rohm launches 1700V SiC MOSFET for industrial use

Prototyping & development aided by control IC and evaluation board

Japan's Rohm Semiconductor has announced the availability of a new 1700V silicon carbide (SiC) metal-oxide-semiconductor field-effect transistor (MOSFET) optimized for industrial applications, including manufacturing equipment and high-voltage general-purpose inverters.

In recent years, the growing trend to conserve energy in all areas has increased the demand for energy-saving power semiconductors, particularly for applications in the industrial sector such as general-purpose inverters and manufacturing equipment. In most auxiliary power supplies, which are used to provide drive voltages for power supply circuits, control ICs and various supplementary systems, high-breakdown (1000V+) silicon MOSFETs are normally utilized. However, these high-voltage MOSFETs suffer from large conduction loss (often leading to excessive heat generation) and problems related to mounting area and the number of external components, making it difficult to reduce system size. In response, Rohm developed low-loss SiC MOSFETs and control ICs that maximize performance while contributing to end-product miniaturization.

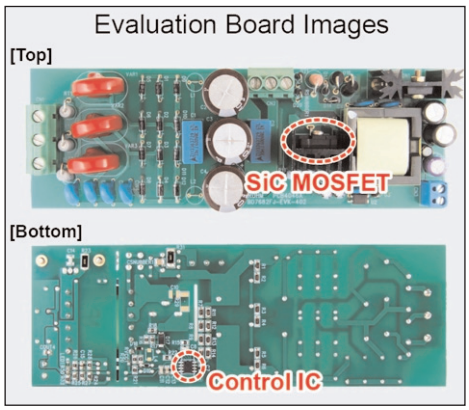
Compared with 1500V silicon MOSFETs used in auxiliary power supplies for industrial equipment, the SCT2H12NZ provides the higher breakdown voltage (1700V) required for auxiliary power supplies in industrial equipment. Also, compared with conventional silicon MOSFETs, conduction loss is reduced by 8x (a smaller on-resistance of 1.15Ω), contributing to greater energy efficiency, says Rohm.



AC/DC inverter efficiency comparison: silicon versus silicon carbide.

In addition, the compact TO-3PFM package maintains the creepage distance (distance measured along surface of the insulating material) required by industrial equipment.

Also, using the SCT2H12NZ together with Rohm's BD7682FJ-LB AC/DC converter control IC (designed specifically for SiC MOSFET drive) makes it possible to maximize performance and improve efficiency by up to 6%, reckons the firm. At the same time, heat generation is reduced, minimizing thermal countermeasures and enabling the use of smaller components.



Rohm is also launching evaluation boards and kits that make it possible to immediately begin evaluation and development. In addition to the BD7682FJ-LB-EVK-402, a gate drive board for evaluating Rohm's full SiC module along with a snubber module are offered.

The SCT2H12NZ is available at $3.38/unit (in 100-unit quantities). The Evaluation Board (BD7682FJ-LB-EVK-402) is available at $492.

Rohm is also developing the SCT2H12NY and SCT2750NY 1700V SiC MOSFETs (with 1.15Ω and 0.75Ω on-resistances, respectively) in a TO268-2L surface-mount-type package that also provides adequate creepage distance.

www.rohm.com/web/global/products/-/product/SCT2H12NZ

	Part No.	Package	Polarity	V_{DSS}	I_D	P_D (T_C=25°C)	$R_{DS(ON)}$ V_{GS}=18V	Q_g V_{GS}=18V
New	SCT2H12NZ	TO-3PFM	Nch	1700V	3.7A	35W	1.15Ω (typ.)	14nC (typ.)
Under Development	SCT2H12NY	TO-268-2L (Surface Mount)			4A	44W		
Under Development	SCT2750NY				5.9A	57W	0.75Ω (typ.)	17nC (typ.)

SDK expands capacity of high-grade SiC epi for mass production to 3000 wafers per month

Sub-0.1/cm² defect density targets MOSFETs, while thick-film epiwafers targets IGBTs

Tokyo-based Showa Denko K.K. (SDK) has expanded its capacity for producing high-quality-grade silicon carbide (SiC) epitaxial wafers for power devices, and begun mass production of the High-Grade Epi (HGE) wafers. The expanded HGE production facility has a capacity of 3000 wafers per month (equivalent, for power devices with a breakdown voltage of 1200V).

HGE is a grade of SiC epiwafer with very low crystal defect density, developed and commercialized by SDK in October 2015. SDK has since been working on sample shipments to device makers. SDK says that HGE can contribute to improving the reliability of SiC metal-oxide-semiconductor field-effect transistor (MOSFETs) by controlling the number of basal plane dislocation (the typical crystal defect) to under 0.1/cm^2.

Moreover, the establishment of technology to lower the number of defects has enabled SDK to mass produce thick-film epiwafers (with a thickness of 100μm or more) and p-type epiwafers (both for potential use in bipolar power devices), which are said to be difficult to produce with conventional technologies. SDK expects its thick-film HGE to contribute significantly to the development of SiC insulated-gate bipolar transistors (IGBT), which can be used as ultra-high-voltage devices for power generation/transmission systems.

The market for SiC epiwafers for power devices is expected to reach ¥100bn in 2025 as the early use of SiC power devices in vehicles is under consideration. SDK says that it will continue to meet market demand for high-quality SiC epiwafers, aiming to contribute to the improvement in energy efficiency of power devices.

www.sdk.co.jp

IXYS launches 1200V SiC power MOSFETs in SOT227 MiniBLOC packages for higher-power applications

IXYS Corp of Milpitas, CA, USA and Leiden, The Netherlands, which provides power semiconductors and mixed-signal ICs for power conversion and motor control applications, has announced availability of its IXFN50N120SK and IXFN70N120SK 1200V silicon carbide (SiC) MOSFETs in SOT-227 packages.

IXYS says that the additions to its SiC MOSFET portfolio enable higher-power applications for SiC-based products in switching and control for high-efficiency DC–DC solar inverters, uninterruptible power supplies (UPS) systems and rapid-charger solutions. "One key aspect of the devices is using our matching assembly technology to harvest the full advantage of the IXYS' SiC power MOSFET," says Dr Elmar Wisotzki, director of technology for IXYS Germany. "IXYS also offers the best driver ICs for such high-power MOSFETs; thus we offer the total solution to our customers, to improve efficiency at best performance-over-cost ratio," he claims.

The IXFN50N120SK and IXFN70N120SK SiC MOSFETs have on-resistance of 40mΩ and 25mΩ (typical), respectively, with a 1200V blocking voltage in a MiniBLOC (SOT-227) package featuring 3kV isolation to heat-sink and what is claimed to be an outstanding low thermal impedance. The 'cool' solution is based on heat-spreading technology before isolation and the usage of AlN substrate as isolator to further enhance thermal performance and allow optimized cooling of SiC dies operated at high power densities. Both new products provide a real Kelvin gate connection for optimized gate control.

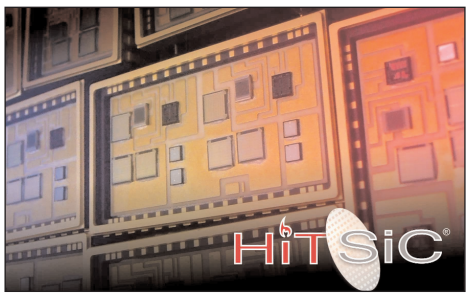
Additional features of the new 1200V SiC MOSFETs include very low gate charge for easy drive, a fast body diode, low input and output capacities, and a positive temperature coefficient supporting paralleling options for higher-power applications.

www.ixys.com

Raytheon UK develops SiC-based high-temperature small-form-factor power module for electrical switching in harsh environments

Raytheon UK's Integrated Power Solutions (IPS) business unit in Glenrothes, Scotland, has developed a high-temperature, small-form-factor bridge leg power module. Aimed at high-speed switching applications, the module has potential uses in the aerospace sector as it requires minimal external cooling and presents considerable weight-saving opportunities within the More Electric Aircraft power system. Also, by supporting applications in harsh environments and in meeting high operating temperature demands, the module can also be used in the geothermal power and oil and gas sectors.

A prototype module that includes two 1200V silicon carbide (SiC) bipolar junction transistors (BJTs) has currently amassed more than 1000 hours of stable operation at 300ºC (a temperature at which traditional silicon-based semiconductors cannot operate). Tests on the module have been performed switching 500V at room temperature and switching 200V at 300ºC. The BJTs are controlled by integrated base driver circuitry, fabricated using Raytheon's propriety High Temperature Silicon Carbide (HiTSiC) process.



"The co-location of BJT base driver circuitry and power transistors into a single high-temperature module is a major industry breakthrough," claims David Gordon, technical lead with Raytheon's IPS. "For example, in many instances it is necessary to switch power-stage transistors at tens of kHz, and that requires getting the base driver circuitry as close as possible to the power transistors. However, in a high-temperature environment, that presents a problem," he notes. "While silicon carbide transistors can switch high voltage and handle high temperatures, traditional silicon-based gate driver circuitry cannot cope with the heat. Silicon-on-insulator (SOI) raises the bar to about 220ºC, but that's still not high enough for some existing and emerging applications for power electronics. Raytheon's HiTSiC CMOS circuitry on the other hand was designed to operate at 300ºC, and has been tested at considerably higher temperatures."

The under-test switching speeds of Raytheon's prototype high-temperature bridge leg power module are exceeding expectations. When switching 200V, the turn-on time at room temperature is 20ns. This increases linearly to 40ns at 300ºC. "This performance has remained consistent throughout the 1000+ hours of testing," notes Gordon.

The module is packaged in a 32-pin hermetic dual in-line (DIL) ceramic package of 40mm x 23mm.

"Performance stability at extreme temperatures is one of the semiconductor industry's biggest challenges," says Gordon. "Our prototype and the hours it has amassed therefore represents an extremely encouraging demonstration of Raytheon's device capability," he claims. "Ageing tests continue, along with further testing at higher power levels."

Raytheon's development of this high-temperature module draws on experience gained during an Innovate UK project LAMPS (Lightweight, Affordable Motors and Power electronics Systems) in collaboration with other UK partners and led by UTC Aerospace Systems.

www.raytheon.co.uk

Plextek unveils phased-array GaN MMIC reference design

Plextek RFI Ltd of Cambridge, UK, which designs and develops RFICs, MMICs and microwave/millimeter-wave modules, has unveiled a new reference design for a gallium nitride (GaN) power amplifier (PA) monolithic microwave integrated circuit (MMIC) for X-band active phased-array radar applications.

"Active phased arrays require numerous PAs, which need to have high efficiency, and to have a small size and relatively low cost," notes CEO Liam Devlin. "Our new design has a die size of only 1.5mm x 2mm, which means around 2300 PAs can be fabricated on a single 4" (100mm)-diameter wafer. This makes the cost very competitive compared with other commercially available MMICs offering this level of RF output power."

The X-band GaN PA MMIC covers frequencies of 9.0–11.5GHz and delivers 7W (+38.5dBm) of RF output power from a +29dBm input, with a power-added efficiency (PAE) of 42%. This means that it can be driven by readily available GaAs parts when used as the output PA stage.

Plextek RFI designed the MMIC using Keysight ADS 2015 electronic design automation (EDA) software, and it was manufactured by United Monolithic Semiconductors (UMS) using its GH25 0.25µm-gate-length GaN-on-SiC foundry process.

"As the IC is designed and manufactured in Europe, it will have the added advantage of not being subject to US export control," notes Devlin.

www.plextekrfi.com

Infineon to acquire Wolfspeed for $850m by end 2016

Infineon compound semiconductor power solutions range boosted by SiC, GaN-on-Si and GaN-on-SiC

Infineon Technologies AG of Munich, Germany has entered into a definitive agreement to acquire the Wolfspeed Power & RF division of Cree Inc of Durham, NC, USA for $850m in cash (about €740m). The deal also includes the related silicon carbide (SiC) wafer substrate business for power and RF power.

The business to be acquired has generated pro-forma revenue of $173m in the 12 months ending 27 March. The acquisition will be immediately accretive to Infineon's adjusted earnings-per-share and margin. Infineon will fund the transaction with bank financing of $720m and $130m of cash-on-hand. The firm's capital structure should stay well within the previously communicated targets of €1bn gross cash plus 10–20% of revenue, and no more than two times the gross debt-to-EBITDA. Cree's board of directors and Infineon's supervisory board have approved the acquisition, which is expected to close by the end of calendar 2016 (subject to regulatory approvals including HSR and CFIUS clearance).

Infineon says that the acquisition will enable it to provide the broadest offering in compound semiconductors and further strengthen it as a supplier of power and RF power solutions in high-growth markets such as electro-mobility, renewables and next-generation cellular infrastructure relevant for the Internet of Things (IoT).

Based in Research Triangle Park, NC, USA and part of Cree for almost three decades, Wolfspeed is a provider of SiC-based power and GaN-on-SiC-based RF power solutions. This also includes the related core competencies in wafer substrate manufacturing for SiC, as well as for SiC with a monocrystalline GaN layer for RF power applications. With over 550 staff and an IP portfolio of about 2000 patents and patent applications, the deal complements Infineon's prior acquisition of International Rectifier in early 2015. Wolfspeed's SiC-based product portfolio adds to Infineon's existing offering.

"Joining forces with Wolfspeed represents a unique growth opportunity," believes Infineon's CEO Dr Reinhard Ploss. "Wolfspeed's and Infineon's businesses and expertise are highly complementary, bringing together industry-leading experts for compound semiconductors. This will enable us to create additional value for our customers with the broadest and deepest portfolio of innovative technologies and products in compound semiconductors available in the market," he reckons. "With Wolfspeed we will become number one in SiC-based power semiconductors. We also want to become number one in RF power. This will accelerate the market introduction of these innovative technologies, addressing the needs of modern society — such as energy efficiency, connectivity and mobility," Ploss adds.

"After much consideration and due diligence over the past year, we concluded that selling Wolfspeed to Infineon was the best decision for our shareholders, employees and customers," comments Cree's chairman & CEO Chuck Swoboda. "Wolfspeed will now be able to more aggressively commercialize its unique silicon carbide and gallium nitride technology as part of Infineon," he believes.

"Wolfspeed will now have all the advantages of a global company in our sector, including the ability to leverage Infineon's market reach and infrastructure," says Wolfspeed's CEO Frank Plastina. "With Infineon's complementary culture and additional investment, we'll be better positioned to unlock the potential of our portfolio and our people."

Infineon stresses that power management solutions based on compound semiconductors have advantages enabling its customers to develop systems with higher energy efficiency, smaller footprints and lower system costs. By combining their technology portfolios, products and manufacturing capabilities, Infineon and Wolfspeed aim to speed component development, enabling customers to develop differentiating systems. Major areas where applications will profit from SiC are renewables and especially automotive. Both benefit from the increased power density and improved efficiency. In automotive it fits well with the recent increased commitment of the industry to plug-in hybrid and all-electric vehicles (xEV), says Infineon. Combining both portfolios and competencies should accelerate time-to-market for new products based on compound semiconductors, the firm reckons.

Next-generation cellular infrastructure standards such as 5G and beyond will use frequencies up to 80GHz. Only compound semiconductors can deliver the required efficiencies at these high frequencies, notes Infineon. GaN-on-Si allows higher levels of integration and offers advantages at operating frequencies of up to 10GHz. GaN-on-SiC enables maximum efficiency at frequencies of up to 80GHz. Both technologies are crucial for next-generation cellular infrastructure standards, says the firm. Together with its Si-based LDMOS products, Infineon claims to be the industry's most complete provider for RF power components.

Infineon says the combined portfolio advances its strategic 'Product to System' approach. Additionally, it will benefit from accelerating the adoption of SiC- and GaN-based components in early-adopter markets, e.g. electro-mobility, high-end photovoltaic inverter, xEV charging infrastructure, and RF power components in cellular infrastructure.

www.infineon.com
www.wolfspeed.com

NRL explains radiation tolerance of AlGaN/GaN HEMTs versus AlGaAs/GaAs HEMTs

Piezoelectric field at AlGaN/GaN interface causes scattered carriers to be reinjected into 2DEG channel, mitigating harmful radiation effects

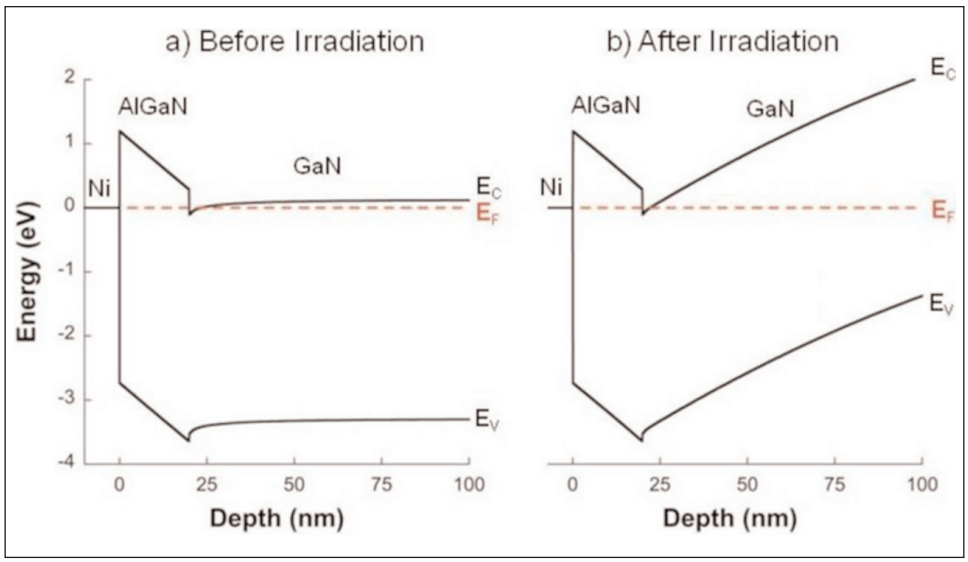
When it comes to putting technology into space, size and mass are prime considerations. High-power gallium nitride (GaN)-based high-electron-mobility transistors (HEMTs) are appealing in this regard because they have the potential to replace bulkier, less efficient transistors, and are also more tolerant of the harsh radiation environment of space. Compared to similar aluminum gallium arsenide/gallium arsenide (AlGaAs/GaAs) HEMTs, the GaN-based HEMTs are ten times more tolerant of radiation-induced displacement damage.

Until recently, the cause for this phenomenon could only be guessed. Was the gallium nitride material system itself so inherently disordered that adding more defects had scant effect? Or did the strong binding of gallium and nitrogen atoms to their lattice sites render the atoms more difficult to displace? The answer, according to scientists at the US Naval Research Laboratory (NRL) in Washington DC, is none of the above.

Examining radiation response

In a recent article 'On the Radiation Tolerance of AlGaN/GaN HEMTs' (in the open-access ECS Journal of Solid State Science and Technology (2016) vol5, issue7, pQ208), the NRL team states that, by studying the effect of proton irradiation on GaN-based HEMTs with a wide range of initial threading dislocation defectiveness, they found that the pre-irradiation material quality had no effect on radiation response.

Additionally, the team discovered that the order-of-magnitude difference in radiation tolerance between GaAs- and GaN-based HEMTs is much too large to be explained by differences in binding energy. Instead, they noticed that radiation-induced disorder causes the carrier mobility to decrease and the scattering rate to increase as expected, but the carrier concentration remains significantly less affected than it should be.



Schematic band diagram of GaN/AlGaN HEMT before and after irradiation by a fluence of $6x10^{14}$ 2MeV H^+/cm^2, as calculated using BANDENG. The values of ($N_d - N_a$) were (a) $2x10^{16}$cm_3 and (b) _$2.55x10^{16}$cm_3, and were chosen to reproduce the experimentally determined sheet carrier density.

Applications in space exploration

Because of their relative radiation hardness, GaAs- and GaN-based HEMTs are desirable for space application, such as the Juno Spacecraft, which on 4 July entered orbit around Jupiter (a planet that scientists still know very little about), which generates extreme levels of radiation. Without the appropriate technology, Jupiter's radiation levels could destroy the sensitive electronics in the satellite upon approaching the planet. Better understanding of why GaAs- and GaN-based HEMTs are more tolerant of radiation could ultimately accelerate innovation and bolster projects where radiation levels prove to be barriers.

Unexpected answers

The explanation for this novel discovery turns out to be rather elegant. In GaN-based HEMTs, a piezoelectric field forms at the AlGaN/GaN interface due to lattice strain. The field gives rise to a two-dimensional electron gas (2DEG) by which carriers travel across the transistor from source to drain. It also provides an electrically attractive environment that causes carriers that are scattered out of the 2DEG by radiation-induced defects to be reinjected. In this way, the scattering rate can increase and the mobility can decrease without greatly affecting the 2DEG carrier density. In other words, it is the internal structure itself that renders AlGaN/GaN HEMTs rad-hard.

"Gallium nitride is such a complicated system — not like gallium arsenide at all," says Bradley Weaver, co-author of the study. "We struggled for four years to figure out why it's so rad-hard, expecting a complicated solution. But the answer turned out to be really simple."

http://jss.ecsdl.org/content/5/7/Q208.full?sid=f0826ce1-0261-4799-863f-cc3468ee56db

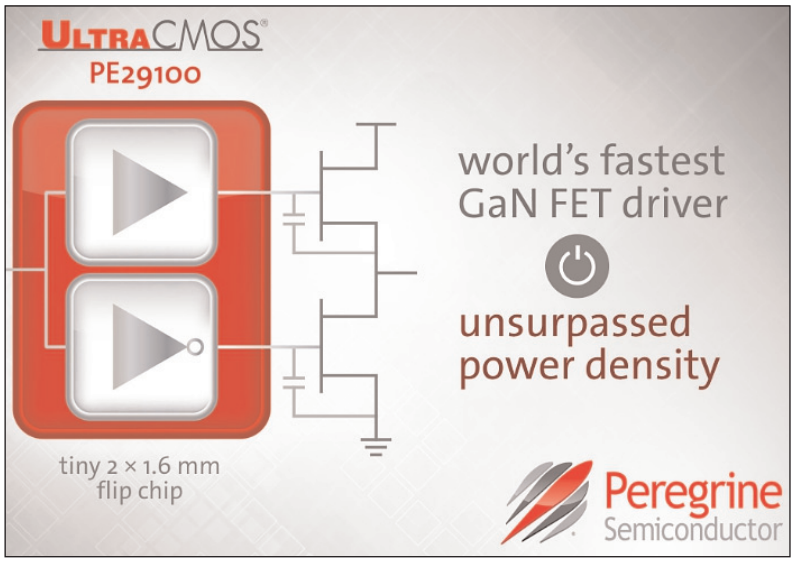
Peregrine unveils fastest GaN FET driver

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 what it claims is the fastest gallium nitride (GaN) field-effect transistor (FET) driver.

Built on Peregrine's UltraCMOS technology, the PE29100 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.

Peregrine notes that, in the power conversion market, GaN-based FETs are displacing silicon-based metal–oxide–semiconductor field-effect transistors (MOSFETs), as they operate much faster and have higher switching speeds in the smallest possible volume. GaN promises to dramatically reduce the size and weight of any power supply. To reach their performance potential, GaN transistors need an optimized FET driver that must charge and discharge gate capacitance as fast as possible and must have very low propagation delay to allow fast signals. It also must avoid 'shoot through' by not turning on high-side and low-side FETs at the same time. The PE29100 is designed specifically for this purpose.

"Our enhancement-mode GaN (eGaN) transistors deliver a whole new spectrum of performance compared to MOSFETs," claims Alex Lidow Ph.D., CEO & co-founder of Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes eGaN power FETs for power management applications. "GaN FET drivers like Peregrine's UltraCMOS PE29100 enable design engineers to unlock the true potential of eGaN FET technology," he adds. "The availability of the PE29100 further enhances our ability to deliver the best possible solution into the power conversion market where size, efficiency and simple design are critical."



Built on Peregrine's UltraCMOS technology, the PE29100 GaN FET driver empowers design engineers to extract the full performance and speed advantages from GaN transistors.

As the driving force behind the PE29100's speed, Peregrine's UltraCMOS technology platform enables integrated circuits to operate at much faster speeds than conventional CMOS technologies.

The speed of Peregrine's new GaN FET driver results in much smaller power converters, offering the design engineer increased power density.

"Design engineers are increasingly using GaN transistors for applications where higher switching frequency and high power is required," says Mark Moffat, director of Peregrine's power management product line. "However, the currently available gate drivers and controllers do not support the full potential of GaN," he adds. "With the enabling power of UltraCMOS technology, the PE29100 achieves the industry's fastest switching speeds at frequencies higher than competing products."

Engineers are increasingly using GaN transistors for applications where higher switching frequency and high power is required... The currently available gate drivers and controllers do not support the full potential of GaN

Manufactured on a truly insulating substrate, UltraCMOS technology has no bulk or well junctions, and therefore it has low parasitics. It also has low on-resistance for improved efficiency and low off-capacitance at higher operating frequency.

The PE29100 is a half-bridge GaN FET driver with internal dead-time control. The high-speed driver operates at switching frequencies up to 33MHz and handles voltages up to 80V. It delivers a short propagation delay of 8ns, and has a rise time of 2.5ns and fall time of 1.8ns when driving a 1000pF load and 1ns rise and fall times with 100pF load. The PE29100 has a one-pin, single-phase input mode, and an output source current of 2A and an output sink current of 4A.

Volume-production parts, samples and evaluation kits for the PE29100 are available now. Offered as a 2mm x 1.6mm flip-chip die, pricing for the PE29100 is $1.80 each for 1000-unit orders.

www.epc-co.com
www.psemi.com

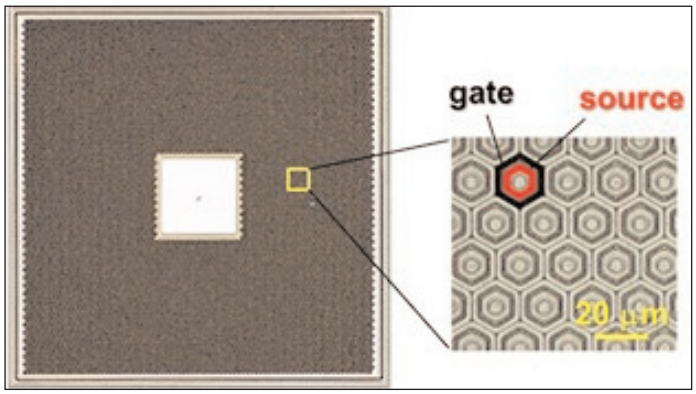
Toyoda Gosei develops high-voltage GaN power semiconductor device for large-current operation

Operating current of ≥20A demoed with 1.2kV-class vertical transistor

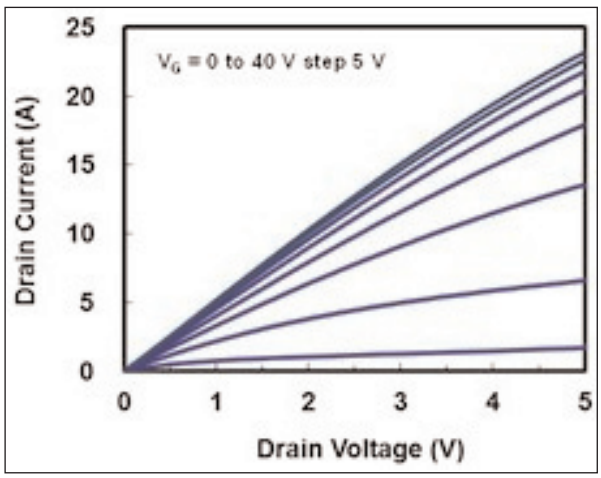
Toyoda Gosei Co Ltd of Kiyosu, Aichi Prefecture, Japan has developed what is claimed to be the first 1.2kV-class power semiconductor device chip capable of large-current operation exceeding 20A.

Using gallium nitride (GaN) crystal growth technology developed since 1986 for the production of blue LEDs, Toyoda Gosei began research on GaN-based power semiconductor devices in 2010. Previously, low-loss 1.2kV-class MOSFETs were fabricated on GaN substrates and then empirically tested (achieving 1.8mΩcm^2, when current is passed via a structure in which current flow is perpendicular to the substrate and gate trenches). Toyoda Gosei says that it has now established wiring technology for parallel operation of elements, passing a current exceeding 20A in a vertical GaN transistor with a 1.5mm x 1.5mm chip size (the first time that this has been achieved, reckons the firm).

The technology can be applied to circuits for power controllers in hybrid vehicles that handle large amounts of power, and to power converters such as those in solar power generation, promising to contribute significantly to making these devices more compact and efficient.



Photomicrograph of Toyoda Gosei's new MOSFET chip.



Forward current–voltage characteristics.

Toyoda Gosei says that it will continue research to increase the current-handling capacity and test reliability, with the aim of developing commercial applications by 2018–2020 in collaboration with semiconductor and electronics manufacturers.

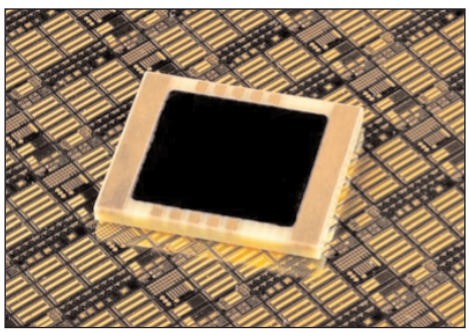
A report on this technology was given as a 'late news' paper at the 28th IEEE International Symposium on Power Semiconductor Devices and ICs (ISPSD) in Prague, Czech Republic (12–16 June).

www.toyoda-gosei.com

VisIC launches new generation of low-R_{dson} ALL-Switch 650V GaN devices usable with standard drivers

VisIC Technologies Ltd of Nes Ziona, Israel, a fabless developer of power conversion devices based on gallium nitride (GaN) metal-insulator-semiconductor high-electron-mobility transistors (MISHEMTs) founded in 2010, has announced the availability of its new generation of ALL-Switch (Advanced Low Loss Switch) devices, comprising V22S65A (with an internal SiC diode) and V22N65A (without internal SiC diode).

The new version of VisIC's ALL-Switch is said to significantly reduce the Miller effect, enabling readily available, standard drivers to be used in VisIC-based designs.



The new devices also reduce the bill of materials required for specific applications.

Effective in hard-switching topologies, the V22 series can be used for zero voltage switching or zero current switching topologies. It is claimed to have the lowest R_{dson} among either 650V GaN- or SiC-based MOSFET transistors, and can achieve extremely efficient power conversion with a slew rate exceeding 100V/nS. In addition, since the threshold voltage exceeds 5V, the devices work well in harsh EMI environments, adds the firm.

VisIC has demonstrated what it claims is record with performance of its half-bridge demonstration board, achieving better than 99.3% peak efficiency at 200kHz in a hard-switched topology, providing 2.5kW output.

www.visic-tech.com

Qorvo expands DOCSIS 3.1 CATV family with three new power doubler MCM amplifiers

At the ANGA COM 2016 Exposition & Congress for Broadband, Cable and Satellite in Cologne, Germany (7–9 June), Qorvo Inc of Greensboro, NC and Hillsboro, OR, USA (which provides core technologies and RF solutions for mobile, infrastructure and aerospace/defense applications) unveiled three new DOCSIS 3.1-ready power doubler multi-chip module (MCM) amplifiers that, the firm says, provide cable broadband service providers an easy upgrade path to DOCSIS 3.1 with maximum design flexibility and functionality while conserving power and reducing board space.

"Our latest power doubler MCMs give our customers additional tools to reach more subscribers with greater bandwidth and higher output power," says Kellie Chong, director, CATV and Broadband Access products. "Additionally, the compact MCM packaging provides a cost-effective solution, saving up to 70% board space compared to traditional hybrid packages."

The MCMs feature temperature-sensing pins to ease assembly, reduce power consumption and provide added confidence during printed circuit board (PCB) reflow. A combination of DC power-adjust and current-adjust capability allows operators to manage networks intelligently and reduce power consumption without sacrificing performance, Qorvo says.

Featuring Qorvo's gallium nitride on silicon carbide (GaN-on-SiC) process to deliver superior thermal conductivity, the RFCM3327 offers 23dB gain while the RFCM3328 offers 25dB gain. Both power doublers are capable of +63dBmV power output, the highest performance of their class it is claimed, and both include an external current-control feature that allows overall power consumption to be reduced by up to 20% while meeting required linearity specifications.

The QPB8808 has a compact footprint, which saves up to 70% PCB space over competing solutions, it is reckoned. Operating at 45–1218MHz, the 12V amplifier offers 20.5dB gain and +58dBmv power output, and includes a variable current bias adjust feature to conserve power while maintaining high output.

Qorvo leads the CATV GaN RF market with more that 50% market share, according to Yole Développement, and offers more than 60 DOCSIS 3.1-ready components (including attenuators, switches, power doubler amplifiers, pre-driver gain blocks, push-pull amplifiers and reverse-path amplifiers). Qorvo notes that it uses internally developed process technologies, including GaN high-electron-mobility transistors (HEMTs), to deliver superior linearity, output power and reliability. The firm's reverse-path amplifiers operate up to 300MHz — well beyond the current requirement of 204MHz for existing return-path amplifiers.

www.angacom.de
www.qorvo.com

Diamond Microwave launches GaN X-band SSPAs with integrated monitoring and protection

Diamond Microwave Devices Ltd of Leeds, UK (which specializes in high-performance microwave power amplifiers) has launched a range of X-band gallium nitride (GaN)-based pulsed solid-state power amplifiers (SSPA) offering integrated monitoring and protection.

The new product range features output power levels up to 300W, and an ultra-compact footprint of only 220mm x 150mm x 41mm (excluding heat-sink). Despite their small size, the amplifiers include key parameter monitoring with self-protect functions which are activated if the SSPA detects that the VSWR (voltage standing wave ratio) threshold, duty cycle or current limits have been exceeded. The SSPA will also alert the host system when a low-output-power condition is detected, or when temperature limits have been exceeded. An interface to the host system is provided by Ethernet connectivity.

With variants covering the 8.4–9.6GHz band, the amplifiers are suitable for use as a solid-state alternative to travelling-wave tube amplifier (TWTA) or magnetron technology in many radar applications.

"Like all our GaN SSPAs, these amplifiers are extremely compact," notes business development manager Ian Davis. "Our new product range combines state-of-the-art RF performance with practical system health and usage monitoring functions," he adds. "Similar designs can be tailored to alternative frequencies in the 1-18GHz range."

Diamond Microwave says that its amplifier range features designs that are flexible in layout and architecture, and are fully customizable to meet individual specifications for electrical, mechanical and environmental parameters. All amplifiers are suitable for use in demanding defence, aerospace and communications applications.

Diamond Microwave exhibited at the IEEE MTT-S International Microwave Symposium (IMS 2016) in San Francisco (24–26 May).

www.diamondmw.com

US Army grants Raytheon $1.1m to develop GaN-based front-ends for Next Generation Radar program

The US Army Research Laboratory (ARL) has entered into a collaborative alliance via a $1.1m grant with Raytheon Company of Waltham, MA, USA to develop Scalable, Agile, Multimode, Front End Technology (SAMFET) for the Army's Next Generation Radar (NGR) program.

As part of a 24-month cooperative research agreement within ARL's Advanced RF Technologies Program, Raytheon will help to create and demonstrate modular building blocks that can easily integrate with next-generation radar systems.

NGR will enhance radar-reliant Air Defense and Counter Rocket and Mortar system performance, particularly in portable configurations such as hand-held, vehicle-mounted and airborne deployments. Raytheon will work with ARL to explore new approaches for designing and fabricating modular components that will fit into NGR's open architecture, offering processing flexibility, agility and efficiency across radar bands.

"Raytheon's storied track record of innovation in applied radar technologies uniquely positions us to play a critical role in the development of the US Army's Next Generation Radar system," reckons Colin Whelan, Raytheon's VP of Advanced Technology. "With the Army Research Lab, our team will leverage Raytheon's deep investment and unmatched expertise as a pioneer in gallium nitride technology to dramatically improve radar capabilities."

Raytheon's efforts to mature GaN for military production earned it the highest OSD (Office of the Secretary of Defense)-rated manufacturing readiness level of any organization in the defense industry. As it can efficiently amplify high-power signals at microwave frequencies, GaN enables radars to operate up to five times more powerfully than with older semiconductor technology, it is reckoned, and without overheating. Raytheon's GaN components generate RF at a third of the cost per watt compared to gallium arsenide alternatives, deliver higher power density and efficiency, and have demonstrated mean time between failures (MTBF) of 100 million hours.

www.raytheon.com

Airbus wins third contract for GaN satellite amplifiers

Airbus Defence and Space, which is reckoned to be the world's second largest space company (and a division of Airbus Group, Europe's top defence and space enterprise), has won its third contract in 18 months for its latest gallium nitride (GaN)-based solid-state power amplifiers (SSPAs), bringing the total ordered to more than 350.

In satellites, SSPAs are used to amplify the signals from the ground ready to be broadcast down to Earth. Satellites must take a signal, clean it, and amplify it more than a billion times before re-broadcasting for pick up by small satellite dishes on Earth.

Investment leading Airbus' latest GaN SSPA was carried out as part of the European Space Agency's Advanced Research in Telecommunications Systems program, which is supported by the UK Space Agency.

Designed for use in both communications and navigation satellites, the GaN-based SSPAs are claimed to have superior performance and 50% less mass per Watt of RF output compared with previous generations of SSPA technology. In particular, the flight L-band SSPAs deliver RF power of 50–100W and are 15% more efficient than previous models. In laboratory demonstrations, the latest GaN SSPAs have produced RF power in excess of 200W in L-, S- and C-bands.

"These significant orders prove that the R&D investments we have made over the last few years are paying off," says Charlie Bloomfield, Airbus Defence and Space's head of Communication Products UK. "Our experts are now looking at how we can further improve our design to give customers more power for less mass."

https://airbusdefenceandspace.com

Comtech wins $11.8m order for in-flight connectivity PAs

Comtech Xicom Technology Inc of Santa Clara, CA, USA — a part of Comtech Telecommunications Corp's Commercial Solutions segment that makes tube-based and solid-state power amplifiers (SSPAs) for military and commercial SatCom uplink applications — has won a $11.8m follow-on production order for SSPAs for airborne in-flight connectivity.

"These [GaN-based] products will enable high-speed satellite connectivity for airlines based in the Americas, Europe, and Asia," says Comtech Telecommunications Corp's president & CEO Dr Stanton Sloane. "Comtech continues to increase its presence in this market and we look forward to a long period of growth as we transition to higher-volume production to meet the worldwide demand for continuous connectivity."

Comtech Xicom Technology's SSPA range spans power levels from 8W to 3kW and frequencies in sub-bands within the 2–45GHz spectrum. Amplifiers are available for fixed and ground-based, ship-board and airborne mobile applications.

www.xicomtech.com

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- Higher Capacity SCCR ⇒ 18kA@ 240VAC UL489

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

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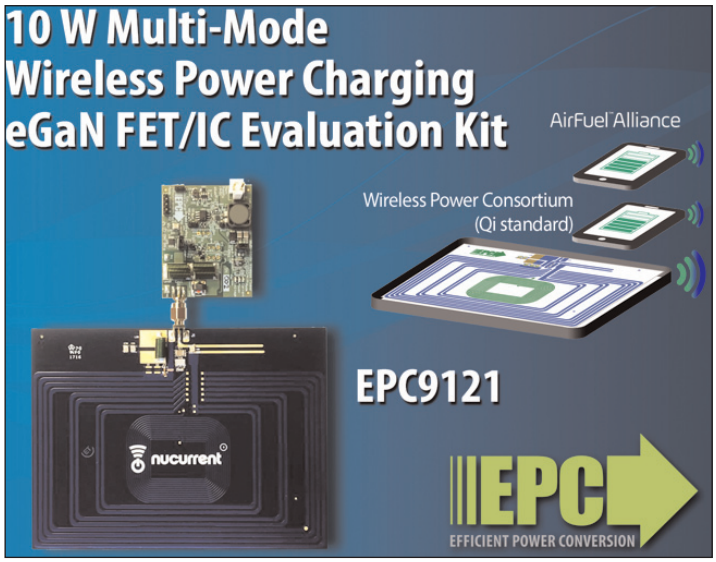
EPC launches wireless multi-mode demo system compatible with all wireless power charging standards

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) for power management applications, has announced the availability of a complete demonstration multi-mode wireless power charging kit.

EPC says that the superior characteristics of eGaN FETs and ICs enable a lower-cost single transmit amplifier solution that can wirelessly charge devices regardless of the standard used in the receiving device. The purpose of the EPC9121 demonstration system is hence to simplify the evaluation process of using eGaN FETs and ICs for highly efficient multi-mode wireless power charging systems that can cut across any standard used in the receiving units.

Wireless power has arrived, but along with its emergence are two industry standards to which end-products are being built — the Wireless Power Consortium (Qi) standard and the AirFuel Alliance standard — based on two different technologies for accomplishing wireless power charging. The Qi standard, based on inductive coupling technology, uses a low-frequency (<300kHz) approach,



whereas the AirFuel standard uses a magnetic resonant technology and has both low-frequency (100kHz through 315kHz) and high-frequency (6.78MHz) requirements.

There is therefore a need for a multi-mode solution, with a single transmitter that can power a receiver built using either standard. The EPC9121 is claimed to be the first implementation of a single-amplifier multi-mode solution. GaN enables high efficiency for both low- and high-frequency modes, plus the solution also saves space and lowers cost, adds the firm.

The 10W EPC9121 demonstration system has four components:

- A multi-mode-capable EPC9511 source (transmitter or power amplifier) board specifically designed to be compatible with all the wireless standards. It can operate at either high or low frequency.
- A multi-mode source coil (transmit coil) compatible with both the AirFuel Class 2 standard and Qi (A6)/PMA standards.
- An AirFuel-compatible Category 3 AirFuel device coil (receive coil) with rectifier and DC output.
- A Qi- and Power Matters Alliance (now AirFuel)-compatible device coil (receive coil) with rectifier and DC output.

The EPC9121 demonstration kit hence contains all the components needed to demonstrate and evaluate multi-standard wireless power charging.

The EPC9121 wireless power charging demonstration system is priced at $907.20 and is available via distributor Digi-Key.

www.epc-co.com

Ismosys made European sales, marketing & technical support partner

To support its accelerating growth throughout Europe, EPC has appointed Ismosys (the principal trading division of the Spectrum Electronics Group) as its sales, marketing and technical support representative, assisting customers in adopting eGaN FETs and ICs for power conversion systems using gallium nitride.

Founded in 1994, Ismosys provides support to design houses, designers and engineers across Europe. This is achieved through 10 regional offices covering the entire EMEA (Europe, Middle East and Africa) region and a centralized resource, fostering sales, driving marketing and enabling technical support.

"Ismosys has extensive reach and experience throughout Europe in making leading-edge electronics available to designers and engineers," comments EPC's VP of sales & marketing Nick Cataldo. "Their technical knowledge, along with their ability to provide local support, will provide the personal touch for taking our products to markets throughout Europe," he adds.

"Our new partnership with EPC is an exciting addition to our portfolio and will allow us to bring leading-edge power solutions to Europe," says Ismosys' managing director Nigel Watts. "Gallium nitride technologies are an exciting innovation and will enable the design houses we are partnered with and the wider European design community to embrace GaN."

www.ismosys.com
www.epc-co.com

EPC and ASD partner to speed customer designs from conception to manufacturing for eGaN-based wireless power charging applications

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA — which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) for power management applications — has joined forces with Hong-Kong-based ASD Technology Ltd, which delivers solutions for applications using eGaN technology.

EPC develops technology for displacing incumbent MOSFETs with eGaN FET and ICs that offer significant advantages in end-applications such as DC–DC converters, wireless power transfer, envelope tracking, RF transmission, power inverters, remote sensing technology and Class-D audio amplifiers.

Focused on imaging electronic components, ASD has over 14 years of experience in providing comprehensive customer solutions, from concept development to product manufacturing. The firm offers design and manufacturing services to those seeking products for shipments worldwide to customers in global markets including the USA, Europe and Greater China.

"Delivering innovative solutions while reducing time to market has been a challenge for many customers, especially when new technologies are involved," says ASD's CEO Patrick Lee. "The potential of the gallium nitride technology will lead the next uptake of the semiconductor industry, while customers also look for effective solutions from product conception to development and to manufacturing," he believes. "We are very excited to be able to partner with EPC by integrating its state-of-the-art eGaN technology with sophisticated designs for our customers who engage us to innovate hand-in-hand from conception to implementation," he adds.

"We have been looking for business partners who have extensive, proven system design experience from conception to implementation by supporting the ever-growing market demand for eGaN technology," says EPC's CEO & co-founder Alex Lidow. "In quarters ahead, we look forward to EPC and ASD's value-added partnership, which can support customers in their eGaN-based wireless charging designs and other applications while expanding our joint GaN business development worldwide," he adds. "We can see the markets for GaN-based products have been growing fast, and GaN-based applications are expected to displace MOSFET-based applications going forward."

www.asdtech.com
www.epc-co.com/epc/Applications

RF Energy Alliance paves way for next-generation solid-state RF energy applications at IMS

At the IEEE International Microwave Symposium (IMS 2016) in San Francisco (24–26 May), the current state of the RF Energy Alliance (RFEA) and the impact it has made in its first two years was showcased by its executive director Dr Klaus Werner.

The RF Energy Alliance was founded in September 2014 by Ampleon, E.G.O. Elektro-Gerätebau GmbH, Huber+Suhner, ITW, Rogers Corp and Whirlpool R&D (an affiliate company of Whirlpool Corp) as a non-profit technical association consisting of companies dedicated to realizing solid-state RF energy's potential as a clean, highly efficient and controllable heat and power source. Membership has since tripled. The Alliance aims to break down barriers to wide market adoption by collaborating on methods that reduce costs and complexities of solid-state RF energy (SSRFE) systems. Recent global industry leaders to become members include Panasonic, Miele, Cellencor and Passive Plus Inc. Research university Worcester Polytechnic Institute has also joined the Alliance.

Additionally, the RFEA recently announced the publication of its first specification, the 'RF Power Amplifier (PA) Roadmap: Residential Appliances', which sets more than 40 technical parameters for five PA module generations targeting consumer cooking applications.

Solid-state RF energy specifications and engineering roadmaps are essential to the advancement of the RF power and heating industry

"SSRFE specifications and engineering roadmaps are essential to the advancement of the RF power and heating industry," says Werner. "By addressing the necessary economical, technological and regulatory challenges, we believe that this technology will successfully penetrate high-volume, consumer-oriented markets in the very near future," he adds. Werner says that multiple companies have already announced SSRFE solutions leveraging the guidelines.

At IMS2016, the Alliance was hosted by Ampleon (a developer of SSRFE applications.

www.rfenergy.org

CoorsTek unveils enhanced GaN-on-Si epiwafers

At the 28th IEEE International Symposium on Power Semiconductor Devices and ICs (ISPSD 2016) in Prague, Czech Republic (12–16 June), engineered ceramics supplier CoorsTek Inc of Golden, CO, USA unveiled its enhanced gallium nitride on silicon (GaN-on-Si) epitaxial wafers.

For the first time at this event, CoorsTek displayed the integrated capabilities of CoorsTek and Covalent Materials (formerly Toshiba Ceramics, now CoorsTek KK) including:

- GaN-on-Si epiwafers for power devices and integrated circuits (ICs);
- aluminum nitride (AlN) substrates for hybrid circuits; and
- engineered ceramic components for semiconductor processing equipment made from PureSiC CVD silicon carbide, PlasmaPure high-purity alumina, and other technical ceramics.

"The latest CoorsTek GaN-on-silicon technology helps customers achieve higher device manufacturing yields and breakdown voltages based on lower defect densities and leakage current," says R&D manager Jun Komiyama PhD. "The shift from 150mm- to 200mm-diameter GaN-on-Si process is also improving the economics for power electronics in electric and hybrid automobiles, solar photovoltaic inverters, RF and microwave power, and more."

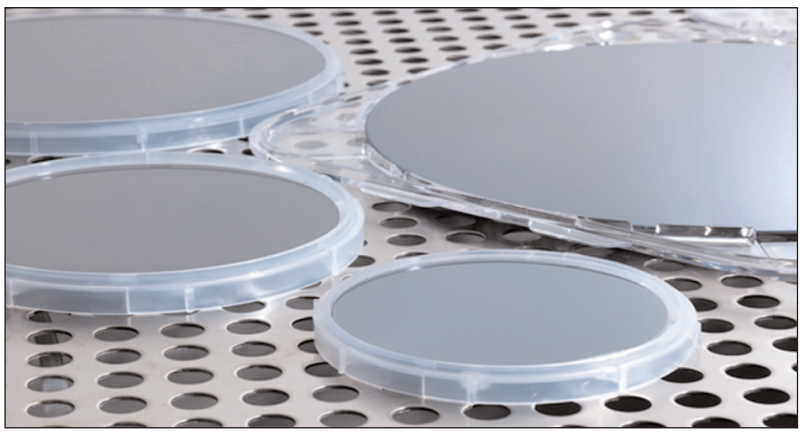
www.coorstek.com
www.ispsd2016.com

EpiGaN's production facility certified as compliant to ISO9001:2015 quality management standard

EpiGaN nv of Hasselt, near Antwerp, Belgium, which supplies commercial-grade 150mm- and 200mm-diameter gallium nitride on silicon (GaN-on-Si) epitaxial wafers, says that on 7 June it received official notification from the International Organization for Standardization that its production facility is now fully certified to the quality management system ISO9001:2015.

Incorporated in 2010, EpiGaN was founded by chief executive officer Dr Marianne Germain, chief technology officer Dr Joff Derluyn and chief operating officer Dr Stefan Degroote as a spin-off of nanoelectronics research center Imec of Leuven, Belgium. The founders jointly developed GaN-on-Si technology at Imec, part of which has been licensed to EpiGaN.

In 2011, EpiGaN was joined by start-up investment firms Robert Bosch Venture Capital, Capricorn CleanTech Fund and LRM to enable the installation of its wafer production facility. In June, Beijing/Brussels-based Euro-Asia private equity fund A Capital joined the initial investors to fund expansion of EpiGaN's sales and support base to Asian markets. EpiGaN is now undertaking volume production and wafer characterization at its Research Campus Hasselt in the Eindhoven-Leuven-Aachen high-tech triangle. In January, the firm signed a global representation agreement for its 150mm and 200mm GaN-on-Si power semiconductor product solutions with silicon substrate maker SunEdison Semiconductor of St. Peters, MO, USA.



EpiGaN now delivers GaN-on-Si and GaN-on-SiC epiwafers to device makers worldwide for power switching, RF millimeter-wave power and sensor applications, specifically shipping epitaxial (Al,Ga)N heterostructures grown on silicon substrates up to 200mm in diameter. In particular, EpiGaN is producing GaN structures on Si substrates up to 200mm diameter at the 600V node to enable its customers to position themselves in rapidly growing market segments.

ISO9001:2015 certification "reassures our commercial customers and institutional program partners on a global scale of our unwavering commitment to the professional quality management of our wafer deliveries," says Germain. "It proves that EpiGaN is a well-established entity in its field," she adds. "There are not many organizations that are certified to the new updated version of the standard."

The full range of quality management measures according to ISO9001 has been in place internally at EpiGaN's Hasselt campus since 2012. "The EpiGaN quality management system has grown up together with the company: all the prescribed standardization procedures had been installed, documented and maintained according to the ISO9001 requirements," notes Domenica Visalli Ph.D., GaN project engineer & quality manager. "The formal application procedure for ISO9001:2015 was launched in January 2016 and we received the final notification within the usual time frame on 7 June."

www.epigan.com

II-VI purchases Lasertec SICA88 inspection & analysis tool for SiC substrate manufacturing

II-VI Inc of Saxonburg, PA, USA says that the Advanced Materials Division of its Performance Products Segment in Pine Brook, NJ, has purchased a SICA88 SiC inspection & analysis tool made by the Lasertec Corp of Tokyo, Japan, for installation at II-VI's silicon carbide (SiC) substrate manufacturing facility in Starkville, MS, USA.

"This purchase enables II-VI to gather data to further its already state-of-the-art SiC substrate technology," says II-VI Advanced Materials' general manager Dr Gary Ruland. "The SICA88 provides advanced sensitivity and analysis capabilities that II-VI can utilize to improve the quality of our SiC substrates," he comments. "The addition of the SICA88 in our production line will allow II-VI to find and analyze substrate and surface defects more efficiently and effectively, in order to enhance our defect reduction efforts, provide customer support to enable higher device yields, and to continue advancing our ongoing efforts to make SiC-based devices more cost effective. In addition, the SICA88's new photoluminescence capability will enable us to detect other defects important to our epi and device customers such as substrate stacking faults," Ruland continues.

"SICA is designed to help fab engineers accelerate yield improvements by providing high-sensitivity, high-throughput defect inspection and highly accurate on-the-fly defect classification along with a fully automated defect review feature," says Hirokazu Seki, general manager of Lasertec's Technology Department. "SICA enables SiC substrate and device manufacturers to take corrective action sooner and improve their yields more quickly. The tool's user interface provides an intuitive graphical method for creating inspection recipes, further increasing its ease of use for automated reporting," he adds. "Lasertec will continue to pursue the development and advancement of defect inspection technologies in order to facilitate the further enhancement of power device quality and productivity."

The SICA88 provides advanced sensitivity and analysis capabilities that II-VI can utilize to improve the quality of our SiC substrates

www.iiviadvmat.com
www.lasertec.co.jp/en/products/environment/sic/sica88.html

3D-Micromac microDICE laser micromachining system adopted for volume production of high-power diodes

New North American HQ in San Jose adds applications lab and service/support facility

3D-Micromac AG of Chemnitz, Germany (which supplies laser micromachining systems and roll-to-roll laser systems for the photovoltaic, medical device and electronics markets) says that its microDICE laser micromachining system has been adopted by a major industrial manufacturer for volume production of high-power diodes.

Leveraging its proprietary thermal laser separation TLS-Dicing technology, the microDICE system is said to provide fast, clean and cost-effective dicing of wafers used for advanced semiconductor and power device applications. Its unique approach uses thermally induced mechanical stress to separate brittle materials such as silicon, silicon carbide (SiC), germanium (Ge) and gallium arsenide (GaAs).

TLS-Dicing is a contact- and residue-free process that is claimed to provide significantly higher throughput, higher yields and greater functionality compared with traditional die-separation technologies (e.g. throughput is up to 30 times greater compared with saw dicing). The technology also provides lower cost of ownership than other approaches, the firm adds. As a forceless and contactless machining process, TLS-Dicing eliminates tool wear and requires no expensive consumables for surface cleaning — resulting in cost savings of up to an order of magnitude or more, it is reckoned.

"While significant time and resources are invested in the front-end of semiconductor manufacturing to produce a completed product wafer, back-end wafer processing has historically been viewed as a necessary evil," says CEO Tino Petsch. "That is all changed with the adoption of new types of wafer substrates, thinner wafers and scaling to smaller dimensions, larger-size substrates, and new packaging technologies like 3D-stacking," he adds. "Back-end process steps such as wafer dicing are evolving as critical value-add process steps that not only ensure but also further enhance device yields. Using our TLS-Dicing technology, the microDICE system provides superior wafer dicing performance over other approaches while considerably reducing the dicing cost per wafer. Our technology has been proven in the photovoltaic and other industrial markets, and we are pleased to bring the benefits of it to the semiconductor and power device manufacturing industry."

3D-Micromac is also expanding its global infrastructure with the opening of its new 3D-Micromac America LLC headquarters in San Jose, CA, in the heart of Silicon Valley. Serving as both an applications lab and sales and support facility, the office marks the firm's first major presence in North America and will enable it to better meet rising customer demand for its laser micromachining products across all of its served markets, including solar, semiconductor, MEMS, display and smart glass.

http://tls-dicing.com
http://3d-micromac.com/int/

Innovate UK offering £4m funding for projects to speed development of compound semiconductors applications

Power electronics, RF/microwave, photonics and sensors targeted

UK Government agency Innovate UK (formerly the Technology Strategy Board) is inviting businesses to apply for a share of £4m in funding that it is investing to help speed the development of new applications for compound semiconductors.

Since 2000, the UK has invested nearly £750m in of compound semiconductor development. The global market is forecast to grow to about £125bn by 2025, and it is reckoned that the UK is well placed to exploit this market.

The aim of the funding competition is to ensure that UK businesses can respond to market opportunities in compound semiconductors. Innovate UK is therefore seeking proposals with large and scalable commercial potential in areas such as power electronics, RF/microwave, photonics and sensors.

Lasting between 6 months and 15 months, the total costs of a project are expected to range from £50,000 to £500,000. A project must be led by a business, but for costs of £100,000 or above it must also be collaborative. Projects may also lead to future collaboration with the £50m UK national Compound Semiconductor Applications Catapult scheme (launched in January).

The registration deadline is noon on 19 October, and the application deadline is noon on 26 October.

www.gov.uk/government/publications/funding-competition-compound-semiconductor-applications
www.catapult.org.uk/catapult-centres/compound-semiconductor-applications-catapult

Imec extends global R&D footprint with opening of imec Florida

Initial collaboration with University of Central Florida and International Consortium for Advanced Manufacturing Research to set up III-V-on-silicon fab

At its annual Imec Technology Forum (ITF) USA on 11 July, a half-day conference at the San Francisco Marriott Marquis hotel held in conjunction with the SEMICON West trade show and supported by industry association Semiconductor Equipment and Materials International (SEMI), nanoelectronics and photovoltaics research centre imec of Leuven, Belgium has announced the opening of imec Florida in Osceola, FL, USA, a new entity focusing on photonics and high-speed electronics IC design.

Imec Florida kicked off with the signing of a collaboration agreement with the University of Central Florida (UCF), Osceola County and the International Consortium for Advanced Manufacturing Research (ICAMR), that is setting up fab facilities for the development and production of III-V-on-silicon solutions for a range of applications including sensors, high-speed electronics and photonics.

Imec Florida will be established as a design center facilitating collaboration between imec's headquarters in Leuven and US-based semiconductor and system companies, universities, and research institutes. The initial focus will be R&D on high-speed electronics and photonics solutions, starting with IC design research for a broad set of semiconductor-based solutions such as terahertz (THz) and LIDAR (light detection and ranging) sensors, imagers, and a broad range of sensors. It will also provide IC design needs that will be driving the ICAMR manufacturing research. Through imec Florida, imec's design, prototyping and low-volume production service (imec IC-link) will provide the US market with low-cost access to advanced foundry services, helping entrepreneurs (in industry and academia) to design innovative products and get them to market.

Signing ceremony for imec Florida with ICAMR at Osceola County.

Funding for imec Florida will come from Osceola County and the University of Central Florida. Through future strategic partnerships, the new center aims to employ about 10 scientists and engineers by the end of 2016 and to increase this to 100 researchers in the next five years. Heading up the facility as general manager will be imec's vice president Bert Gyselinckx who previously served as general manager at imec in Eindhoven, The Netherlands, and helped to co-invent many technologies deployed by innovative semiconductor and consumer electronics companies.

"As the US semiconductor market continues to strengthen with semiconductor manufacturing, equipment, materials and system innovation, we are extremely pleased to collaborate with partner organizations in Florida, and see Osceola County in the Orlando region as an interesting location to drive the next phase of imec's growth and innovation," said imec's president & CEO Luc Van den hove. "Together with industrial and academic partners, we want to develop sustainable solutions and technology to accelerate innovation and stimulate economic growth within Osceola County and the State of Florida," he added.

"Imec's international prestige gives us the opportunity to leverage its standing in a field that is growing exponentially in order to recruit more partners and funding for our work at the new Design Center and the Florida Advanced Manufacturing Research Center (FAMRC)," commented Osceola County Commission chairwoman Viviana Janer. "The relationships and people that imec brings to our operation are tangible ways that Osceola County's 5-year, $15m investment will be more than re-paid… The new Design Center is going to capture the attention of everyone in this field, thereby ensuring maximum utilization and value of the FAMRC," she added.

"The imec Design Center is the funnel that will fill ICAMR with high-value manufacturing opportunities and we will work closely with them to make sure our capabilities tightly align with their technology direction," stated ICAMR's CEO Chester Kennedy.

www.imec.be
www.icamr.net

IQE's first-half growth of 15% year-on-year driven by diversification

Double-digit growth in photonics driven by a range of emerging end-markets

In a trading statement for first-half 2016, epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK says that it expects to deliver a significant increase in revenues and profits compared with first-half 2015 and continues to reduce its balance sheet leverage (deferred consideration plus net debt).

Sales are expected to be at least 15% higher than first-half 2015, with the business seeing increasing diversification of revenue.

"The group's continued diversification of revenues is improving its resilience to end-market fluctuations, and our Photonics business continues to deliver strong double-digit growth driven by a range of emerging end-markets which are primed for significant and sustainable growth," says chief executive Dr Drew Nelson. In particular, it is widely accepted that the photonics market will continue its rapid growth over the coming years as vertical-cavity surface-emitting lasers (VCSEL) and indium phosphide (InP) lasers are increasingly adopted for a wide range of end-market applications including consumer products, fiber-optic communications, data centres and industrial processes.

License income from joint ventures is expected to be about £3.5m for first-half 2016, with both joint ventures making good progress. "Our Wireless and InfraRed businesses were stable, delivering slight increases in revenues [year-on-year]," says Nelson.

The depreciation of Sterling against the US dollar due to Brexit occurred shortly before the end of the half year, and as a result the financial impact on first-half 2016 was limited (translated at average exchange rates). However, the balance sheet impact was more significant, with a presentational increase in both assets and liabilities (converted at spot rate). Despite this, IQE has continued to reduce its leverage in both Sterling and US dollar terms due to its strong cash generation. Deferred consideration for previous acquisitions will be completely eliminated by September. IQE says that, other than the impact of currency fluctuations, it does not see any material impact of the decision to exit the EU on its business or prospects.

"The growth in IQE's sales and profits reflect the increasing diversification of its revenues, the growing breadth of its end markets, and the strength of its IP portfolio," says Nelson. "As a result, the group's strong cash generation continues to de-leverage its balance sheet, with the deferred consideration from previous acquisitions on track to be completely eliminated by the end of September," he adds.

IQE says that during first-half 2016 it made good progress on new product development and qualifications, strengthening its IP position, and re-enforcing a positive outlook. The board hence remains confident that the firm is on track to achieve full-year expectations.

IQE will report its full results for first-half 2016 on 13 September.

www.iqep.com

IQE equips complete fab with LayTec tools for MOCVD process monitoring

In-situ metrology system maker LayTec AG of Berlin, Germany says that epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has purchased a large number of its latest metrology systems for fab-wide metal-organic chemical vapor deposition (MOCVD) process control.

In close collaboration with IQE, LayTec has implemented automated and highly precise new analysis algorithms into its Gen3 metrology tools, which utilize an updated x-ray diffraction (XRD) gauged high-temperature nk database of aluminium gallium arsenide (AlGaAs). This was the key to meeting the demands of the world's leading compound semiconductor wafer foundry, says LayTec. With its in-situ metrology, the fab's MOCVD systems can be tuned much more quickly to new and usually complex processes for best serving IQE's large customer base, it adds.

"As the global leader in wafer outsourcing, IQE is committed to deliver the highest product quality standards to its customers," says IQE's engineering & operations director Matthew Geen. "LayTec's new unrivalled growth process analysis offers a compelling alternative to expensive calibration runs by enabling us to extract material parameters in-situ during production," he adds.

"Our systems cover a complete range of thin-film applications, providing access to all significant thin-film growth parameters," says LayTec's chief technology officer Dr Kolja Haberland.

www.iqep.com
www.laytec.de/GaAs
www.laytec.de/gen3

HEA2D consortium to create basis for end-to-end processing chain for 2D nanomaterials

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany says that it is working with five partners in the HEA2D project to investigate the production, qualities and applications of two-dimensional nanomaterials.

When integrated into mass-production processes, 2D materials have the potential to create integrated and systematic product and production solutions that are sustainable in social, economic and ecological terms, says Aixtron. Using 2D materials can help to address topics such as climate change, an environmentally friendly and affordable energy supply or mobility, addressing the increasing scarcity of resources, adds the firm. These materials also enable innovative solutions to be explored. Even though the potential harbored by this new class of materials has been demonstrated for increasing numbers of applications in a laboratory environment, attempts at high-volume product manufacturing functionalized with 2D materials have failed due to the fragmented production chain, notes Aixtron. Innovations based on 2D materials have hence not yet led to any major product innovations in practice.

HEA2D is now researching an end-to-end processing chain consisting of various deposition processes for 2D materials, processes for transfer onto plastic foils, and mass integration into plastics components. Aixtron's partners for implementing systems technology and integrating materials into plastic molded parts are the Fraunhofer Institute for Production Technology (IPT), Coatema Coating Machinery GmbH, and Kunststoff-Institut für die mittelständische Wirtschaft NRW GmbH (K.I.M.W.) Lüdenscheid. The work is being supported in terms of nano-analytics and the development of prototype components by the Electronic Materials and Nanostructures workgroup in the Engineering Faculty of the University of Duisburg-Essen (Uni-DuE) and by the Graphene-based Nanotechnology workgroup in the Science and Technology Faculty of the University of Siegen.

Drawing on co-operations already in place at the project partners, the project results will be communicated to interested companies worldwide. The aim is to integrate suggestions from end users into the production chain at an early stage of development. The project will hence also use the platform operated by the Graphene and 2D Materials specialist group and the North Rhine Westphalia plastics cluster Kunststoffland NRW.

One focus of Aixtron's subproject involves researching (MO)-CVD (metal-organic) chemical vapor deposition processes and systems technology for depositing optically active 2D semiconductor materials, e.g. molybdenum tungsten (Mo, W), selenium sulfur (Se, S) and graphene. Also, together with its project partners, Aixtron will devise a roll-to-roll concept for use in the synthesis and transfer of graphene.

To ensure the efficient realization of a demonstration tool that is a core aspect of the HEA2D innovations, preliminary investigations will be performed, particularly to identify suitable source chemicals, on an existing system at Aixtron's applications laboratory. Based on the findings, the existing system technology will be enhanced. Together with project partners, demonstrators based on 2D semiconductor materials will be manufactured.

HEA2D is being supported by the European Fund for Regional Development (EFRE) 2014–2020.

www.aixtron.com

AKHAN joins US Council on Competitiveness

AKHAN Semiconductor Inc of Gurnee, IL, USA, which manufactures nanocrystalline (NCD)-based materials & devices, has joined the US Council on Competitiveness, a nonpartisan, leadership organization.

AKHAN Semiconductor Inc was formed in late 2012 as a subsidiary of AKHAN Technologies Inc, which was founded in 2007 by Adam Khan to commercialize Diamond Lattice Technology for diamond-based semiconductor devices. The firm's IP portfolio combines AKHAN's Miraj Diamond portfolio with low-temperature diamond deposition technology developed by Argonne National Laboratory's Center for Nanoscale Materials.

"The Council prides itself on its innovative membership, and AKHAN embodies the type of forward-looking, advanced companies that will keep the US competing at the highest level in the coming decades," comments Council president & CEO Deborah L. Wince-Smith.

Founder & CEO Adam Khan joins more than 140 industry CEOs, university presidents, national lab directors and labor leaders on the Council, which celebrates its 30th anniversary this winter. The group identifies policy solutions and creates public–private partnerships between its members and the federal government in order to ensure US prosperity in the global economy.

"Having pledged to increase the US economic competitiveness in the global marketplace through our leadership and growth in the diamond semiconductor market, AKHAN's work and goals are well aligned with the broader mission of the Council," says Khan.

www.akhantech.com
www.compete.org

Picosun and University of Helsinki develop photo-assisted ALD

Atomic layer deposition (ALD) thin-film technology firm Picosun Oy of Espoo, Finland, says that it is now providing equipment and solutions for the commercial utilization of photo-assisted ALD.

Photo-ALD is said to enable novel ALD processes, area-selective film deposition, low deposition temperatures, savings on precursor chemical consumption and costs, and lower environmental impact of the ALD processing.

Photo-assisted ALD uses light to enable ALD film growth. Whereas in regular ALD a film grows from two gaseous precursors that react on the coated surface one by one, in photo-ALD only one chemical is needed — light takes care of the rest.

In photo-assisted ALD, the coated surface is exposed to alternate pulses of precursor vapor and flashes of high-intensity light. The energy of light makes the precursor molecules on the surface chemically convert into the desired coating material. Alternatively, two precursors can be used but the other becomes reactive only when illuminated. When only one precursor is required, both costs and the environmental effect of the process are lower. In conventional ALD relying fully on gaseous precursors, area-selective film growth is particularly difficult to achieve and often requires additional processing steps for deposition and etching of passivation layers. Light, on the other hand, is easy to block from the areas that need to be left uncoated, and sharply defined patterns can be created without direct contact to the substrate or exposure to chemicals directing the film growth. Also, when the energy of light replaces the energy of heat (the driving force of conventional thermal ALD), processing can be performed at much lower temperatures than in regular ALD.

"The photo-ALD method has been investigated only marginally this far, mostly because of the lack of proper equipment," notes professor Mikko Ritala of Finland's University of Helsinki. "Now, using Picosun's photo-ALD tools we have been able to develop this technology and related chemistry for several key ALD processes. Potential applications can be found in MEMS (micro-electro-mechanical systems), sensors and other advanced microelectronics (for example, selective ALD to keep the chip contact areas clean), and solar cell manufacturing," he adds.

"Picosun's ambition is to take ALD where it has never gone before, to enable novel, disruptive industrial solutions and cutting-edge new products," says Picosun's managing director Juhana Kostamo. "Our photo-ALD system has enabled great results at our long-term collaboration partner University of Helsinki," he adds. "It is fascinating to introduce this technology to our industrial partners to help them find new ways to solve their manufacturing challenges."

www.picosun.com

Riber's first-half revenue rises 23% year-on-year, driven by MBE system sales

Orders rise 40%, as services & accessories orders almost double

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported a 23% rise in revenue from €5.7m in first-half 2015 to €7m in first-half 2016, comprising 56% from Asia (up from 43%), 24% from the USA (up from 6%) and 20% from Europe (down from 40%).

MBE systems sales were solid during first-half 2016. The number of systems sold has fallen from four research machines in first-half 2015 to two machines, but one of these was a production machine, so revenue rose by 29% from €2.8m to €3.6m.

Sales of services & accessories (€2.4m, up 14% from €2.1m) and cells & sources (€1m, up 25% from €0.8m) are up 17% collectively on first-half 2015. This growth reflects Riber's improved commercial performance in its long-standing markets, combined with the development of its position in the USA following its acquisition of the firm MBE Control Solutions of Santa Barbara, CA, USA in March 2015.

Order have risen by 40% from €6.3m in first-half 2015 to €8.8m in second-half 2016.

Specifically, MBE system orders (for delivery in 2016) have risen by 33% from €4.5m to €6m, comprising five machines (including one production machine).

Orders for services & accessories have grown strongly by 90% from €1.1m to €2.1m. Orders for cells & sources are level at €0.7m.

Riber says that, against a backdrop of moderate growth for the MBE market, the upturn in commercial business has been driven by the signing of several new contracts and supported by development of the range of services and accessories offered.

Based on these factors, Riber confirms its full-year 2016 revenue target of at least 30% growth on 2015.

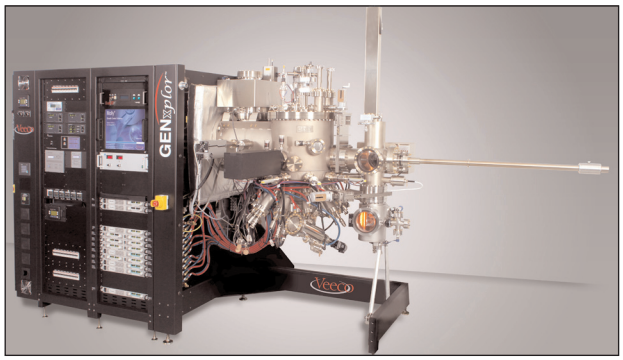
www.riber.com

Veeco wins first MBE R&D system order from Chinese university

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has received the first order from a Chinese customer for its GENxplor R&D molecular beam epitaxy (MBE) system. Nanjing University is scheduled to receive the system in second-quarter 2016. The GENxplor system is said to be the top-selling MBE system worldwide since its introduction in August 2013.

Nanjing University purchased the system as an addition to its Materials Science and Engineering research program, led by professor Dr Hong Lu. It will enable the epitaxial growth of III-V semiconductor materials for applications including optoelectronic devices and thermoelectric energy conversion.

"The open-architecture design and superior technology of the GENxplor



system is a welcome addition to the research facility of the National Laboratory of Solid State Microstructures and College of Engineering and Applied Sciences at Nanjing," says Lu.

The GENxplor system deposits epilayers on substrates up to 3" in diameter and is used for a wide variety of applications such as developing high-speed transistors, fiber lasers for material processing, and wireless technology. Veeco says that its efficient single-frame design combines all vacuum hardware with on-board electronics to make it up to 40% smaller than other MBE systems, saving lab space.

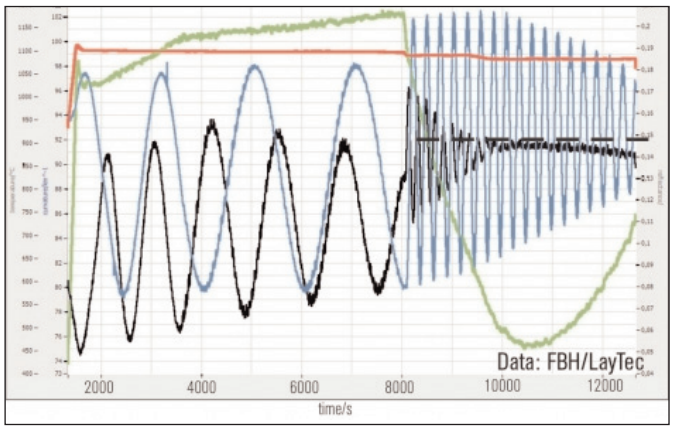
"Endorsement from Nanjing University and Dr Lu firmly reinforces GENxplor as the leading R&D MBE system in the industry," says Gerry Blumenstock, VP of Veeco's MBE Operations. "After launching the system at the 2013 China MBE Conference, we are excited that Nanjing University, a leading materials science and condensed matter physics research university, is the first customer to install a GENxplor in China."

www.veeco.com

LayTec offers EpiTT 280nm reflectance channel to sense AlGaN surface morphology in UV-C LED epi

Aluminium gallium nitride (AlGaN) buffer layers with high aluminium content are necessary for optimal UV-C LED performance. But their band-edge lies below 300nm, so established 405nm in-situ reflectance is insensitive to the surface morphology of such AlGaN layers. To monitor precisely both the AlGaN growth rate and surface morphology during UV-C LED epitaxy, in-situ metrology system maker LayTec AG of Berlin, Germany is hence offering an additional 280nm reflectance channel that employs a UV-C LED as a light source.

The Figure shows the results measured in-situ during growth of an AlGaN layer: The Fabry–Perot oscillations of the final AlGaN layer are damping out because the band edge of the material shifts toward longer wavelengths at the growth temperature. The small reflectance reduction at 12,000s indicates a small roughening of the AlGaN surface. The green line delivers the high-resolution wafer bow data.



Growth of AlN/AlGaN(60%Al) on a sapphire/AlN template in Aixtron CCS 6x2 reactor: black – 280nm reflectance; blue – 405nm reflectance; green – high-resolution wafer bow; red – true temperature.

This study is supported by Advanced UV for Life funding (grant number 03ZZ0105C) from the German Federal Ministry of Education and Science (BMBF).

www.advanced-uv.de
www.laytec.de/UVLED

High-resolution wafer bow measurements for CCS reactors

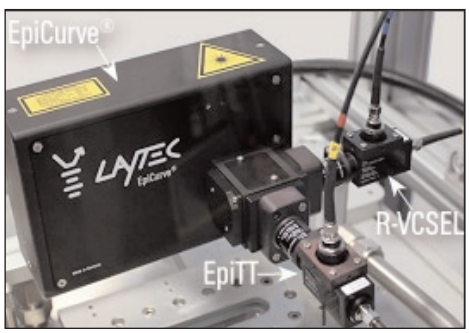
Detecting thin-film strain in-situ during epitaxial growth through the tiny openings of the showerhead view-ports of a metal-organic chemical vapor deposition (MOCVD) reactor is a challenge, notes LayTec. However, the firm says that, by using advanced software algorithms, it has improved the signal-to-noise ratio of its EpiCurveTT tool by a full order of magnitude.

The wafer bow data in the Figure (green line) shows that the wafer curvature noise in the Close Coupled Showerhead (CCS) reactor is now just 0.3km^{-1}. With this improvement, in-situ strain balancing or tuning the AlGaN lattice constant (strain changes from compressive to tensile during AlGaN growth at about 1000s) is now possible with accuracy levels formerly known only for ex-situ x-ray diffraction (XRD) methods, says the firm.

LayTec receives first order for EpiTT/VCSEL

LayTec says that, following the request of customers and utilizing the modular concept of its new Gen3 in-situ platform, it has customized and expanded the related in-situ metrology performance for vertical-cavity surface-emitting laser (VCSEL) epitaxy. VCSELs grown on gallium arsenide (GaAs) are currently emerging as a leading technology in rapidly expanding markets such as gesture recognition, 3D imaging, datacom and others. In May, one of LayTec's lead users in Europe placed the first order for such a system (the EpiTT/VCSEL), to be shipped by the start of 2017.

The EpiTT/VCSEL contains two fiber-optical heads: one for a standard EpiTT and one for spectral reflectance sensing (R-VCSEL). Both can also be mounted via an adapter flange on an EpiCurve head, making an EpiCurveTT/VCSEL system (pictured). This allows integration of full EpiCurveTT performance with the spectral monitoring of distributed Bragg reflector (DBR) stop-bands and cavity dip position. In the photo, this 4-in-1 metrology tool is mounted atop an Aixtron G3 Planetary metal-organic chemical vapor deposition (MOCVD) reactor.



EpiCurve TT/VCSEL – the four dimensions for VCSEL epi: measured feature #1 – wafer temperature (EpiTT head), #2 – growth rates (EpiTT head), #3 – wafer bow (EpiCurve head), #4 – spectral reflectance (R-VCSEL head) – all sensing via the purged view-port of an Aixtron G3 Planetary MOCVD reactor.

The EpiTT/VCSEL and EpiCurveTT/VCSEL are powered by new software modules that enable both single-pocket and multi-pocket operation.

www.laytec.de/VCSEL

Changelight qualifies Aixtron's AIX R6 and puts MOCVD system into LED mass production

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany says that opto-electronics manufacturer Xiamen Changelight Co Ltd of Xiamen, Fujian Province, China has finalized qualification of its AIX R6 Close Coupled Showerhead metal-organic chemical vapor deposition (MOCVD) system, which is designed particularly for LED mass production.

In the course of the qualification process, the AIX R6 not only demonstrated its production capabilities but also proved what is reckoned to be outstanding performances in terms of gas consumption, intrinsic yield and uniformity. Changelight has now put the AIX R6 system into production for LED high-volume manufacturing.

"By meeting Changelight's production standards, we have achieved another important customer qualification milestone for the AIX R6," says Aixtron's executive VP & chief operating officer Dr Bernd Schulte. "Based on our long-standing and great business relationship with Changelight, we are looking forward to further deepening our cooperation in the fields of gallium arsenide (GaAs)- and gallium nitride (GaN)-based applications," he adds.

Founded in 2006, Xiamen Changelight mainly produces full-color ultra-bright LED epitaxial wafers and chips, high-performance GaAs solar cells and LED lighting products. The firm also provides energy-saving lighting application solutions.

www.changelight.com.cn/en
www.aixtron.com

Aixtron qualifies LayTec's EpiNet 2016 software

In-situ metrology system maker LayTec AG of Berlin, Germany says deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany has qualified EpiNet 2016, its latest control and analysis software for LayTec's EpiTT and EpiCurve TT products.

The purpose of EpiNet 2016 is to turn a metrology system's in-situ data into high-level information. "With EpiNet 2016, our customers have access to key features of LayTec Gen3 metrology tools on our Aixtron's MOCVD platform," says Aixtron's director of technology Dr Christian Geng. "The improved performance and related customized upgrade packages of EpiNet 2016 will add further values to Aixtron-driven epitaxy processes."

www.laytec.de/epinet

SPTS receives Supplier Excellence Award from Qorvo for Outstanding Support and Commitment to Excellence

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 been presented with a Supplier Excellence Award by Qorvo Inc in appreciation of SPTS' hard work, support and commitment to excellence.

Formed from the merger of RF Micro Devices Inc of Greensboro, NC and TriQuint Semiconductor Inc of Hillsboro, OR, USA, Qorvo has more than 7000 staff globally and provides RF solutions for mobile, infrastructure and aerospace/defense applications. SPTS is a preferred supplier to Qorvo, and its Sigma fxP PVD solution is the process of record for depositing piezoelectric films.

"Qorvo needed to quickly and cost-efficiently increase production capacity of their Richardson, Texas line in order to meet customer demand," says Kevin Crofton, president of SPTS Technologies and corporate VP at Orbotech. "They set some challenging timescales, but by adapting our manufacturing and installation processes, we were able to meet their requirements on schedule and to specification. This Qorvo Supplier Excellence Award recognizes the results achieved through hard work and close collaboration between our teams," he adds.

"We have been impressed with the ability of SPTS to achieve the promised delivery deadlines to meet our planned ramp, with the flexibility to accommodate late changes, while also providing cost-savings associated with re-configuring existing toolsets and efficient hand-over of all the tools," comments Howard Witham, VP, Texas Operations, Qorvo. "Open and clear communication between us has been key at all stages from PO to process qualification."

www.qorvo.com
www.spts.com

Samco opens second production center

Semiconductor process equipment maker SAMCO Inc has held a completion ceremony for its second production center (a two-floor steel-framed building adjacent to the headquarters in Kyoto, Japan), which began construction in January and is expected to begin operation in the fall. The new center boosts Samco's original shipment capacity of ¥6–7bn per year to a total of ¥10–11bn per year).

Samco offers systems and services that revolve around three major technologies, namely thin-film plasma-enhanced chemical vapor deposition (PECVD), metal-organic chemical vapour deposition (MOCVD) and atomic layer deposition (ALD) systems; microfabrication with inductively coupled plasma (ICP) etching, reactive ion etching (RIE) and deep reactive ion etch (DRIE) systems; and surface treatment with plasma cleaning and ultraviolet (UV) ozone cleaning systems.

"We expect to see an increased demand for dry etching and CVD systems due to the Internet of Things' [IoT's] rapid expansion, as well as anticipated growth in the medical and robotics industries," says president, chairman & CEO Osamu Tsuji. "With the completion of our newest production center, Samco is prepared to meet those demands."

Containing a total land area of 1260m^2, the second production center's total floor space is 1130m^2 (including a 217.612m^2 cleanroom). It will mainly be used to assemble and modify processing equipment for mass production. The ¥600m investment also included renovation of the existing production technology building.

The new center's eco-friendly design utilizes LED lighting, as well as an energy-efficient air conditioner and large-scale solar panel that spans the roof and provides a portion of the building's electricity (up to 50kW/h). Also, the roof is coated with high-insulation paint.

www.samcointl.com

Riber receives order from Asia for research MBE reactor

Riber S.A. of Bezons, France, which makes molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has received an order for a Compact 21T MBE research system for delivery in 2016 to a laboratory in Asia, where it will help to expand capabilities for research on III-V structures.

The Compact 21T is derived from the Compact 21 thin-film deposition research system. The system was chosen for its high level of flexibility, its reliability and its capacity to produce extremely complex and high-quality materials on a reproducible basis, says Riber.

www.riber.com

Oxford Instruments launches molybdenum disulphide growth process

Nanofab capable of depositing other 2D transition-metal dichalcogenides

UK-based Oxford Instruments has launched a molybdenum disulphide (MoS_2) growth process developed using its Nanofab nanoscale growth system.

Single-layer MoS_2 is a direct-bandgap semiconductor that has wide-ranging applications in optoelectronics such as LEDs, photovoltaics, photodetectors, and bio-sensors, while multi-layer MoS_2 is an indirect-bandgap semiconductor that shows promise in future digital electronics.

Oxford Instruments says that it has undertaken extensive research and optimization of the chemical vapor deposition (CVD) process, developed on a Nanofab system equipped with precursor delivery modules capable of delivering a wide range of liquid/solid/metal-organic precursors suitable for two-dimensional (2D) materials growth. Offering growth on a range of substrates including sapphire and atomic-layer deposited (ALD) alumina (Al_2O_3 and SiO_2), the system is capable of depositing other 2D transition-metal dichalcogenides (TMDCs) such as WS_2, $MoSe_2$ etc.

"This process development and its proven results are extremely exciting, as we enter a new phase in our 2D materials processing capabilities with the Nanofab plasma processing system," comments Frazer Anderson, strategic marketing & business development director at Oxford Instruments Plasma Technology (OIPT). "Raman analysis has demonstrated a high-quality mono-layer, with AFM [atomic force microscopy] showing resultant smooth and uniform films," he adds. "We anticipate that this development in 2D materials growth will facilitate the next generation of nano-electronic devices."

www.oxinst.com/mos2

Nanjing University orders Oxford Instruments plasma systems

Oxford Instruments Plasma Technology (OIPT) has won an order from Nanjing University of Post and Telecommunications in Nanjiang, Jiangsu, China for multiple plasma etch systems to be used for silicon and III-V etching.

OIPT says the highly configurable PlasmaPro 100 systems offer a range of processes that make them suitable for the nanotechnology research being undertaken by Nanjing University. PlasmaPro 100 process modules are built on 200mm platforms, with both single-wafer and multi-wafer batch capability.

"We conducted a rigorous tender process and decided on Oxford Instruments for their state-of-the-art processing equipment that is key to our successful research," says Dr Huang Xiaoming of the Nanjing University of Post and Telecommunications. "The process modules offer excellent uniformity and high throughput processes which, together with a global customer support network and low cost of ownership, made this the system of choice for our university," he comments.

"Our PlasmaPro etch tools, installed in the Nanjing University cleanroom, will enable a wide range of research programs utilizing their capabilities in III-V and silicon etching," notes OIPT's strategic marketing & business development director Frazer Anderson.

New MD for Oxford Instruments Plasma Technology

UK-based plasma etch and deposition processing system manufacturer Oxford Instruments Plasma Technology (OIPT) has appointed Richard Pollard as managing director.

Most recently, Pollard was with spectrometer and light source provider Ocean Optics Inc (Halma plc), where he was president based in Florida, USA. He previously held several senior leadership roles at Halma, in operations, sales, marketing and product development in several of its instrumentation and components businesses based in the USA and UK. He hence has a proven track record of delivering

results in technology businesses, says OIPT.

"Richard brings his already extensive experience in the high-technology capital equipment sector to lead and develop Oxford Instruments Plasma Technology," comments Ian Barkshire, CEO of parent company Oxford Instruments Group, "As our markets expand, Richard will ensure the continued investment in new technology and applications," he adds.

"Having now spent some time in the factory, the field and in the rest of Oxford Instruments getting to know our people, processes, products, our markets and how the business works, I am confident that this new position will enable me to fully utilize my wide knowledge of leading a successful global business," says Pollard.

Pollard is a Chartered Engineer, with a BEng Manufacturing Engineering from Brunel University and an MBA from the Open University Business School, Cambridge.

www.oxford-instruments.com/plasma

Finetech's Lambda bonder enhances packaging capabilities at Lurie Nanofabrication Facility

Micro-assembly equipment maker Finetech of Berlin, Germany says that a Lambda bonding system has been installed in the Lurie Nanofabrication Facility (LNF) at the University of Michigan in Ann Arbor. The sub-micron accuracy bonder is designed to position and attach microelectronic or optoelectronic components on various substrates, including flex circuits, glass, silicon, ceramic, etc.

LNF selected the Lambda bonder to support packaging activities in its micro- and nanofabrication center. The 13,500ft^2 facility is used by hundreds of students and researchers at the University of Michigan, other academic institutions, national labs and industry. The lab has expertise in combining technologies and materials within a single device, for example optical or mechanical sensors with integrated processing circuitry and on-board power generation.

The Lambda is a semi-automated bonding platform suitable for product and process development of photonics devices, sensors, LED bonding, micro-electro-mechanical systems (MEMS), flip-chip and micro-optics assembly. Bonding technologies supported by the system include thermocompression, thermosonic, ultrasonic, adhesives, curing and soldering (AuSn, C4, indium, eutectic).

"We chose the Finetech Lambda based on the system's process flexibility, accuracy, ease of use, and reliability — important factors in an active multi-user environment," says LNF's user services director Pilar Herrera-Fierro. "The sub-micron placement capability is critical for our research being done in areas such as silicon integrated circuits, optoelectronics, MEMS, Bio-MEMS and microfluidics."

www.finetechusa.com/products/micro-assembly/fineplacerr-lambda.html
https://lnf.umich.edu

SUSS MicroTec launches fourth generation of semi-automated mask and bond aligners

Equipment and process solutions supplier SUSS MicroTec of Garching, Germany has launched the MA/BA Gen4 series, the new generation of its semi-automated mask and bond aligners which extends its capabilities with major improvements in alignment accuracy, ergonomic design and further reduced cost of ownership.

With this fourth generation, SUSS MicroTec is introducing a new platform system. The two platform types are configured differently and consist of the MA/BA Gen4 for standard processes and the MA/BA Gen4 Pro series for high-end processes. By moving to this new platform concept, SUSS MicroTec says that it is further optimizing its mask aligner product portfolio to better align with customer requirements.

The main application of the MA/BA Gen4 series is full-field lithography in academia, MEMS, 3D integration and the compound semiconductor market. Furthermore, it handles processes such as bond alignment, fusion bonding and SMILE imprint. In addition to standard wafer processing, the MA/BA Gen4 series can reliably process delicate substrates, such as fragile, warped or uneven surfaced wafers.

"With this new platform concept, we further align with different customer requirements — the MA/BA Gen4 for standard lithography processes or the leading-edge MA/BA Gen4 Pro for small-series production and more demanding solutions, e.g. our Soft Conformal Imprint Lithography (SCIL) solution," says CEO Dr Per-Ove Hansson.

www.suss.com

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OnChip offers thin-film wafer backside metallization of solderable die-attach metal stacks

Integrated passive device maker OnChip Devices Inc of Santa Clara, CA, USA says that its wafer fabrication facility is offering backside metallization (BSM) of thin films for applications such as military, medical and instrumentation.

Back-metal is required on a wide range of devices to form a solderable die-attach metal stack to ensure good electrical contact to the chip (ohmic contact) or proper bonding of the chips to their mounting cases. Specifically, power devices such as high-brightness light-emitting diodes (HB-LEDs) require backside metal for improved and reliable thermal conductivity. These metal layers are deposited using RF or DC sputtering and electron-beam evaporation.

In backside metallization of discrete devices, the typical layer stack consists of three to four metal layers. The most common stack consists of sputter-deposited titanium (500Å) then nickel (3000Å) and a flash of gold (200Å). The metals offered by OnChip are: layers for providing good ohmic contact (gold, aluminium and titanium); barrier and superior adhesion layers (copper, chromium, palladium and titanium); and solder layers (nickel, gold and silver).

OnChip says its systems deposit ultra-clean metal and dielectric films in a class-100 cleanroom. Generally, an in-situ RF etch is performed prior to sequential deposition of multi-layers to ensure good film adhesion and ohmic contact to underlying conductive layers or to the bare silicon. All sputter films are currently available on silicon wafers up to 150mm (6″) in diameter. Larger wafer sizes may be considered on a case-by-case basis.

BSM processing is available immediately worldwide. The lot charge ranges from $750 to $1450 (depending on metal stack, thickness of layers, wafer diameter, etc). Typical lot size is 11 for 100mm (4″) wafers, 9 for 125mm (5″) wafers, and 7 for 150mm (6″) wafers. Typical lead times are two weeks after receipt of order.

www.onchip.com

ClassOne reports ten-fold saving in gold usage using multi-chamber plating system

ClassOne Technology of Kalispell, MT, USA, which makes wet-chemical processing equipment including Solstice electroplating systems (especially for emerging markets and other cost-conscious users of ≤200mm substrates), is reporting significant savings in the plating of gold in ≤200mm applications using its Solstice systems. Savings come from eliminating gold waste, faster and simpler processing, and Solstice-enabled techniques that can substantially reduce gold usage.

"Many users have been spending millions of dollars on gold each year," says Byron Exarcos, president of ClassOne Group. "It's a major issue, especially in emerging markets such as lasers, LEDs, RF and MEMS which often require gold layers as thick as 3–35µm. That's why they are becoming keenly interested in Solstice to cut their gold spending," he adds.

"One fundamental advantage of Solstice electroplating is its elimination of gold waste," says ClassOne Technology president Kevin Witt. "Previously used CVD and PVD methods deposited gold not just on the wafer but also on the entire chamber interior. That 'over-sprayed' gold was difficult to remove and inefficient to reclaim — which led to a considerable net loss of gold," he adds. "By contrast, Solstice deposits only on the wafer, so there is no gold waste, and no need for cleaning or gold reclamation efforts."

Solstice economies also come from its higher gold deposition speed. Plating at 150–300nm/min, it is about ten times faster than CVD and PVD methods. In addition, Solstice starts processing immediately, not requiring an hour or more for pump-down (as vacuum-based tools do). All this translates to additional savings, via higher throughput and more cost-efficient production.

The unique eight-chamber design of the Solstice S8 enables it to readily replace a solid gold layer with a multi-metal stack — and reduce gold usage very substantially. For example, a feature that previously required a 5µm layer of solid gold can now be replaced with a 'sandwich' of 0.25µm Au, 1µm Ni, 2.5µm Cu, another 1µm Ni, topped with 0.25µm Au — to achieve equivalent functionality while reducing gold usage by a factor of ten. Also, Solstice's multi-chamber design enables it to deposit all five layers in a single cycle. So, no additional process steps or time are required to gain very significant cost savings.

ClassOne notes that, over a year, total gold savings can grow quite large. In the above case, if the solid gold 5µm layer covers 50% of a 150mm wafer area, and if the fab is running 1500 wafers per week through a metal lift-off process and gold costs of $1200 per troy ounce — even if all over-sprayed gold were recovered — the annual gold expenditure would be $2,150,000. However, if the Solstice multi-metal layering technique were used, the total metal cost (for Au, Ni and Cu combined) would be cut to about $108,000, yielding annual savings of $2,042,000 (more than paying back the cost of a Solstice system).

www.classone.com/products

EVG launches automated metrology system for advanced packaging, MEMS & photonics manufacturing

EVG has launched the EVG50 automated metrology system.

Designed to support the increasingly stringent manufacturing requirements for advanced packaging, microelectromechanical systems (MEMS) and photonics applications, the EVG50 performs high-resolution non-destructive multi-layer thickness and topography measurement, as well as void detection, in bonded wafer stacks and in photoresists used in optical lithography. The system measures layers down to 2μm in thickness, can inspect up to 1 million points, and achieves throughputs of up to 55 300mm wafers per hour. This combination of extremely high resolution and high throughput provides cost-efficient full-wafer inspection that enables device makers to improve wafer bonding and lithography processes, as well as achieve higher yields, EVG claims.

"The semiconductor industry is witnessing a trend toward total control and monitoring of all production processes," notes corporate technology director Dr Thomas Glinsner. "Mid-end-of-line and back-end packaging processes face tighter process constraints at levels previously seen only in front-end-of-line wafer processing. This is creating an urgent need for highly accurate in-line metrology that can provide critical process data quickly and cost-effectively," he adds. "The EVG50 is an important addition to our suite of metrology solutions that achieves these goals at speeds and resolutions."

The standalone EVG50 system is based on the firm's existing in-line metrology module (IMM), which is available as an option in EVG's line of 300mm process equipment and has been widely implemented in high-volume manufacturing. The EVG50 complements the versatile EVG40NT measurement system (said to be the industry standard for bond overlay inspection) to meet increased demand for full-area layer thickness and topography measurement in critical applications. The new system's high throughput, accuracy and repeatability — even at ultra-high resolutions — enables cost-effective, 100% inspection of production wafers, resulting in improved process control, the firm claims.

The EVG50's versatility allows it to measure coating thickness for lithography as well as wafer bow and warp, and make void inspections for a bonded wafer stack on the same system, while its low-contact edge handling enables particle-free, full-area wafer inspection. Regarding flexibility, by leveraging a multi-sensor measurement mount, the system can be customized for different thickness ranges and substrates to address a wide variety of requirements. Its self-calibration capability also allows better system reproducibility and productive uptime, says the firm.

EVG's suite of metrology solutions, including the EVG50, was on display at the SEMICON West show in San Francisco (12–14 July).

www.evgroup.com/en/products/bonding/inspectionsystems/evg50

Fourth consecutive triple win in customer satisfaction survey

For a fourth consecutive year, EV Group of St Florian, Austria (a supplier of wafer bonding and lithography equipment for MEMS, nanotechnology and semiconductor applications) has earned all three awards resulting from VLSIresearch Inc's annual Customer Satisfaction Survey. For 2016, EVG was ranked as one of the '10 BEST Focused Chip Making Equipment Suppliers' (having steadily increased its overall ratings since 2013) and one of 'THE BEST Suppliers of Fab Equipment' (for the 14th consecutive year). EVG also won a 'RANKED 1st award' in the 'Specialty Fab Equipment' category.

According to VLSIresearch, EVG excelled in the supplier performance categories, which include trust in supplier, technical leadership, recommended supplier, partnering and commitment. Moreover, EVG scored well across the board, increasing its scores in eight of the 15 total categories. In particular, this is the fourth year in which EVG was the highest-ranked supplier of wafer bonding equipment.

"EVG continues to rank highly and grow its position on our annual survey, thanks to its strong, global customer-focused strategy," notes VLSIresearch's CEO & chairman G. Dan Hutcheson. "The company's approach integrates an emphasis on high-volume manufacturing with its long-running commitment to technology invention, innovation and implementation. The results of our annual survey exemplify EVG's continued success in delivering leading wafer bonding and lithography solutions."

For this year's survey, VLSIresearch received feedback from over 95% of the chip market and 80% of subsystems customers. Participants were asked to rate equipment suppliers among 15 categories based on three key factors: supplier performance, customer service, and product performance. A total of 3619 surveys were returned, resulting in 54,282 total responses.

A white paper detailing EVG's survey results is available from weSRCH.com.

www.wesrch.com/electronics/pdfEL1SE1CEEHTYN

Kyma and Quora partner on GaN substrate materials

Low-defect GaN-on-QST template to be scaled to 8", and 4" and 6" free-standing GaN substrates to be created

Kyma Technologies Inc of Raleigh, NC, USA (which provides crystalline nitride materials, crystal growth and fabrication equipment, and power switching electronics) and Quora Technology Inc have announced a strategic partnership to develop and commercialize GaN substrate materials.

Kyma is a developer of wide-bandgap semiconductor (WBGS) materials solutions, including gallium nitride (GaN), aluminium nitride (AlN), gallium oxide (Ga_2O_3) and diamond. GaN materials products include free-standing GaN substrates and GaN templates.

Established in March 2015 in California's Silicon Valley, Quora is a privately held fabless technology startup focusing on energy-efficient and high-performance WBGS materials and device solutions.

Quora is commercializing its QST substrate technology, which is fully diameter-scalable (6", 8", 12" and beyond) and engineered at a fundamental level to alleviate stress from epitaxial layers, allowing the deposition of tens of microns of high-quality and low-dislocation-density GaN on 6" or larger diameters. Quora reckons that, with validated performance results in LED, power and RF applications by major GaN device manufacturers, its QST substrate solution is poised for adoption in the WBGS industry.

Kyma and Quora have teamed to demonstrate that Kyma's high-growth-rate GaN processes can be used to realize a low-defect GaN-on-QST template that leverages the QST properties and provides a high-quality epi-ready surface for GaN epitaxial growth and device fabrication.

Kyma has confirmed that they can produce uncracked, low-defect-density ($<10^8 cm^{-2}$) 6"-diameter GaN-on-QST templates that have up to 40% narrower x-ray diffraction (XRD) linewidths, smoother surface morphology, and much lower bow than for similar structures grown on sapphire. Along with other wafer shape issues, low bow is important for achieving high-yielding and advanced device fabrication, says Kyma. Wafer shape control, including GaN cracking or entire wafer breakage, is a major problem with traditional approaches on large-diameter wafers and is one of the major obstacles for the WBGS industry, limiting achievable economies of scale.

The firms say that there is clear potential to extend the GaN-on-QST template approach to full GaN boule manufacturing. Accordingly, they have already won support on two separate federal research projects: (1) to develop processes for manufacturing cost-effective large-diameter high-growth-rate GaN-on-QST templates up to 8" diameter, and (2) to take that approach to the next level to create 4"- and 6"-diameter free-standing GaN substrates.

Kyma is developing an 8"-diameter GaN growth tool that is designed to produce uniform low-defect-density GaN-on-QST wafers in GaN thicknesses up to 100mm at a fast cycle time which will support low tool cost of ownership.

In the second project, Kyma will create low-defect-density GaN boules and fabricate 4" and 6" substrates from them

In the first project, Kyma is developing an 8"-diameter GaN growth tool that is designed to produce uniform low-defect-density GaN-on-QST wafers in GaN thicknesses up to 100μm at a fast cycle time which will support low tool cost of ownership (CoO). Kyma is already teamed with a leading OEM tool maker to support rapid market penetration of the technology once the team further advances the growth process and proves its ability to support high-performance device manufacturing. Kyma says that its device partners include leading US universities and multiple large device manufacturers.

In the second project, Kyma will create low-defect-density GaN boules and fabricate 4" and 6" substrates from them. The substrates will be made available to leading US device developers to prove the ability to support high-performance 1200V vertical power electronic device operation.

"We are very excited for Kyma to integrate its rapid GaN growth process on our high-performance substrate technology QST for delivering low-defect-density and large-diameter GaN wafers to the device manufacturers," says Quora's president & CEO Cem Basceri. "This special class of material will hopefully improve the existing device processes, designs, and performances, and also unlock new applications," he adds.

"We believe they have a game-changing baseline materials technology that will make a major impact on GaN-based LED, high-power-switching and RF device markets," comments Kyma's president & CEO Keith Evans. "By combining Kyma's advanced and high-growth-rate GaN technology with Quora's QST technology, we have the potential to help device manufacturers to accelerate their roadmaps for making higher performance devices at lower cost," he adds.

www.kymatech.com
www.quoratechnology.com

BluGlass progress in Lumileds and Veeco collaborations; first iteration of HC Semitek collaboration begun

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 reported progress in key areas critical to the completion of its evaluation agreements with three leading firms.

Lumileds evaluation

BluGlass' chief technology & operations officer Dr Ian Mann recently returned from visiting LED maker Lumileds of San Jose, CA, USA in the USA to review recent RPCVD data and plan the next iterations of experiments critical to the collaboration milestones.

Veeco evaluation

Samples were recently prepared by BluGlass and shipped to epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA. Veeco has compiled recent data for both the green LED and high-electron-mobility transistor (HEMT) projects, with both returning progressive results. Technical and commercial discussions with Veeco are ongoing.

HC SemiTek evaluation

Collaborative development work announced in April with LED epitaxy and chip maker HC SemiTek Corp of Wuhan, China (which supplies full-color ultra-high-brightness LED products throughout China) has now begun. The firms are exploring RPCVD's advantages for both green LEDs and aluminium nitride (AlN) to use in high-brightness LEDs.

A planned set of experiments has been agreed for both projects. The 4" sapphire wafers have now arrived in Silverwater, and deposition of the RPCVD AlN films has begun. These will be shipped to HC SemiTek to fabricate into LEDs for testing. BluGlass has also just received the LED wafers for the green LED development, and this RPCVD work is beginning this week.

Uniformity and scaling project

The RPCVD chamber upgrade to improve RPCVD deposition uniformity is well underway, with the first upgraded system expected to be operational in July. The upgrade of the second, larger RPCVD system will be determined by the progress on industry evaluations (to ensure minimal interruption to ongoing projects with partners).

Other applications and interest

BluGlass says it continues to receive interest from major industry participants looking at novel ways of exploiting RPCVD, and discussions are ongoing under confidentiality agreements.

www.bluglass.com.au

Monocrystal gains investment from Russian bank

During the St Petersburg International Economic Forum 2016, Monocrystal Inc of Stavropol, Russia (which manufactures large-diameter sapphire substrates and cores for LEDs, optical products and RFIC applications) has signed a memorandum of cooperation with Russian state corporation Bank for Development and Foreign Economic Affairs VEB (Vnesheconombank) involving investment in the firm's significant expansion of production capacity.

"It was extremely challenging to become a global leader in such a highly competitive industry as sapphire components for electronics," says Monocrystal's CEO Oleg Kachalov. "Our cooperation with VEB and other state business support programs will contribute to our success on global markets and help us enlarge market share," he believes.

During the Development Award Ceremony held by VEB during the St Petersburg International Economic Forum, Monocrystal was honored as 'The Best Export Project'. For the past 10 years, the firm has invested more than $220m in production capacity and technology development.

www.monocrystal.com

Rubicon's stockholders re-elect incumbent directors

Rubicon Technology Inc of Bensenville, IL, USA (which makes monocrystalline sapphire substrates and products for the LED, semiconductor and optical industries) says that, based on the preliminary vote count provided by the firm's proxy solicitor following its 2016 annual meeting, stockholders have voted overwhelmingly to re-elect Rubicon's director nominees Don N. Aquilano and Donald R. Caldwell.

"Rubicon is going through unprecedented difficult market conditions, and we are working hard to improve cash flow, launch new differentiated products and pursue new opportunities," says Rubicon's CEO Bill Weissman. "We will continue to do our utmost to strengthen performance and maximize stockholder value," he adds. "We look forward to continuing to engage productively with our stockholders."

Preliminary results also indicate that stockholders have voted to (1) ratify the appointment of the company's independent registered public accounting firm for 2016 and (2) approve the company's 2016 Stock Incentive Plan.

www.rubicon-es2.com

Seoul Viosys wins UV LED infringement lawsuit in USA

UV LED maker Seoul Viosys Co Ltd says the US Federal District Court for the Southern District of Florida has issued a judgment in which Salon Supply LLC (which sells UV LED curing device) acknowledges infringement of its asserted patents as well as their validity. Salon Supply has agreed to pay past damages, as well as a license fee, and to stop using unlicensed infringing products.

Seoul Viosys' asserted patents span a wide range of UV LED technologies including, but not limited to, LED packaging, LED chips and epitaxial layers, and UV curing device structure. Together, these technologies cover key components and features of UV LED curing devices.

Seoul Viosys was founded in 2002 as Seoul Optodevice (a subsidiary of South Korean LED maker Seoul Semiconductor Co Ltd) based on a technical cooperation with Japan's Nitride Semiconductor Co Ltd (the first firm to develop long-wavelength UV LEDs, emitting at 360–400nm, in 2001). It is said to be the first firm specializing in UV LEDs (spanning epitaxy, chip, package and module manufacturing) and the first to develop short-wavelength UV LEDs. Seoul Optodevice was renamed Seoul Viosys in 2013 to denote its expansion from a visible LED and UV LED chip maker to a UV LED system provider.

In 2005 the firm made an equity investment in Sensor Electronic Technology Inc (SETi) of Columbia, SC, USA, and subsequently produced its first 254–340nm UV-C and UV-B (deep UV) LEDs. Seoul Viosys has since maintained close technical cooperation with SETi for over 10 years to commercialize UV LED chips with wavelengths below 350nm.

Last August, with the approval of the US Committee on Foreign Investment in the US (CFIUS), Seoul Viosys acquired a majority stake in SETi, and has continued expanding and commercializing its UV LED business. In particular, Seoul Viosys' Violeds technology can be applied to biotechnology equipment and medical diagnosis equipment as well as skin and other medical treatment, including being used as part of the International Space Station (ISS) as well as MOSCLEAN (a mosquito trap).

"We have developed Violeds technology, not just for profit, but also to assist with critical health and environmental measures," says Yeojin Yoon, VP of the UV Development Center at Seoul Viosys. "With our ability to mass produce these life-saving devices at a low cost, we can supply Violeds technology and its products to people around the world," he adds. "We have invested tremendously to achieve this technology. We will strongly enforce our patents against infringers that do not respect our intellectual property, and we will initiate additional patent infringement lawsuit against such infringers within the next quarter."

www.seoulviosys.com

RayVio and Boston University expand UV LED research to combat vitamin D deficiency disorders

RayVio Corp of Haywood, CA, USA, which is commercializing deep-ultraviolet (UV) LEDs and consumer disinfection solutions, is expanding a research program with Boston University to develop new treatments for vitamin D deficiency (a disorder associated with osteoporosis, rickets and other metabolic bone diseases). The research will expose various skin samples to UV light generated by RayVio's LEDs to determine appropriate exposure times and intensity that can be effectively and safely used to treat vitamin D deficiency disorders.

"Vitamin D deficiency affects more than 100 million Americans and over a billion people worldwide," notes lead researcher Michael F. Holick Ph.D., M.D., professor of Medicine, Physiology and Biophysics at Boston's School of Medicine, an endocrinologist at Boston Medical Center. "Finding a solution will reduce the onset of catastrophic illnesses and potentially saves hundreds of thousands of lives," he adds.

"Our previous work with RayVio demonstrated that very low-intensity UV light from LEDs — the kind that might be incorporated into today's wearable technologies — will boost vitamin D production in skin and can improve peoples' health," continues Holick. "Our new program expands on that work to determine the best wavelength of light, appropriate duration and intensity that will optimize new and more effective treatments."

Vitamin D deficiency leads to debilitating diseases like osteoporosis, rickets and even increases the risk of developing common deadly cancers, diabetes, autoimmune diseases including multiple sclerosis and heart disease. Studies have also shown links between vitamin D deficiency and brain disorders including and Alzheimer's disease, depression and schizophrenia.

"At RayVio, we can produce LEDs targeted to specific wavelengths, and working with Dr Holick and his team will allow us to mass produce LEDs that provide the optimum UV light and intensity to address vitamin D deficiency," says RayVio's CEO Robert C. Walker Ph.D.

Further to the joint research project with Holick, RayVio's latest deep UV LEDs are being applied to disinfection and water purification applications with the potential to reduce hospital-acquired infections and illnesses resulting from drinking unsafe water.

www.rayvio.com
www.bu.edu

HexaTech demonstrates first-generation 263nm AlN-based UV-C LED

HexaTech Inc of Morrisville, NC, USA — which manufactures aluminium nitride (AlN) substrates and long-life UV-C LEDs for disinfection applications, as well as developing deep UV lasers for biological threat detection, and high-voltage power semiconductors devices for smart grid and efficient power conversion — has demonstrated its first-generation UVSure UV-C LED, based on HexaTech's proprietary aluminium nitride (AlN) substrate material.

The 263nm-wavelength device achieves output power of 6mW in a 0.15mm^2 active-area die. When scaled to the firm's second-generation larger footprint, the die is expected to produce about 24mW (twice the radiant flux of competing products, it is reckoned). Further, when driven in pulse mode at a current of 300mA, the same 0.15mm^2 active-area die can reach 19mW, or about 76mW in the large die format.

"This demonstration is a milestone in our business, and is the direct result of intense device R&D coupled with the use of our exclusive high-quality AlN substrate material," says CEO John Goehrke. "This capability allows us to engage the UV-C LED market at the right moment, linking together incredibly strong interest with cutting-edge performance. It also clearly demonstrates our continued assertion that the best substrate material yields the best device performance, and this first-generation result is just the beginning," he adds.

"With point-of-use (POU) sterilization applications alone representing a $400m+ opportunity in the coming years, we anticipate significant corporate expansion and strategic customer engagement," says Gregory Mills director of business development.

"HexaTech's world-leading, high-quality bulk AlN substrates are the essential foundation for attaining these results, enabling near perfect epitaxial growth quality throughout the active region of the device, essential to produce both high internal quantum efficiency (IQE) and long component lifetimes," says Dr Joseph Smart, director of LED development. "This is something that competing sapphire substrate technology simply cannot sustain at these wavelengths."

www.hexatechinc.com/uv–c–led

UV-C LED water disinfection system first to receive NSF lead-free certification

UV-C LED disinfection system maker AquiSense Technologies LLC of Erlanger, KY, USA has received certification from the Water Quality Association (WQA) for its PearlAqua water disinfection system.

WQA is an independent public health organization that tests and certifies a wide range of plumbing and drinking water treatment products. Specifically, the PearlAqua meets the stringent requirements of NSF/ANSI 372 (an accreditation for providing lead-free water) and NSF/ANSI 61 (which certifies the PearlAqua for safe drinking water).

PearlAqua was the first-to-market UV-C LED water disinfection system, it is claimed, and is the first UV-C LED system to receive NSF/ANSI certification, confirming that it provides clean water without the use of lead (which has contaminated water in a number of communities around the world). "This is a significant step in our overall commercialization strategy," says CEO Oliver Lawal. "It further validates that switching over to semiconductor-based technology is viable in providing equal or safer water quality," he adds.

www.aquisense.com

Plessey appoints head agronomist for PhytoLux

UK-based Plessey has appointed Maarten Klein as head agronomist for its horticultural lighting solutions. Klein brings specialist expertise in the use of LED lighting for growing commercial crops, developed while he was research director at Delphy in Wageningen, Holland.

In April, Plessey signed a global exclusive licence agreement with Phytolux for the manufacture, design and commercialization of its products, including the Attis set of horticultural lighting products.

"Having spent some time with the Plessey team and working with their Phytolux products, I am convinced they have the winning solution," says Klein. "I have been impressed with their commitment to understanding the problems being faced by individual commercial growers and working in collaboration with them to provide commercially viable, LED lighting solutions," he adds.

"Maarten's expertise will be invaluable in supporting our planned growth in the horticultural market, especially in the very challenging Dutch market," says Steve Edwards, head of horticultural LED fixtures at Plessey.

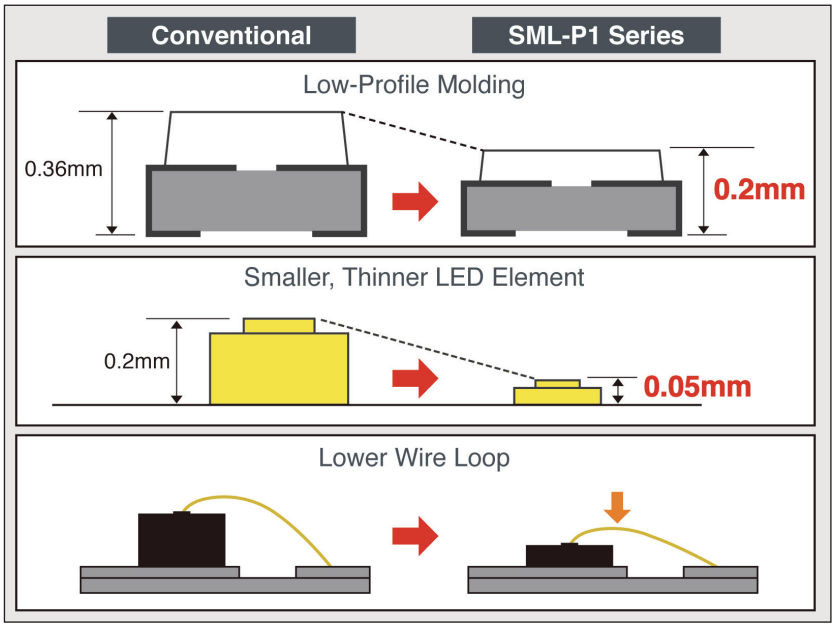
www.phytolux.com

Rohm expands lineup of low-profile, ultra-compact PicoLEDs from 8 to 15 colors

Rohm of Kyoto, Japan has added seven new colors to its PicoLED series of low-profile, ultra-compact chip LEDs optimized for wearable technology, portable devices, and drones, allowing for greater color expression and improved design freedom it is claimed.

In recent years the number of applications that have adopted LEDs for lighting (in conjunction with a notification function) has grown significantly, says Rohm, and greater miniaturization at the component level is increasingly demanded for compact portable equipment. For drones in particular, adoption in new applications is expected, such as utilizing multiple drones that integrate LEDs in visual performances. Also, due to significant expansion in these markets, companies have begun focusing on proprietary designs that require compact LEDs in a wider selection of colors, notes Rohm.

In response, Rohm developed the SML-P1 series of class-leading thin, compact chip LEDs, using an integrated production system and leveraging its strengths in element technology to eliminate wavelength variations that in the past have proven problematic. Rohm was hence able to increase the number of colors from 8 to what is claimed to be an industry-leading 15.



Combining a lower gold wire loop with a thinner light-emitting element (developed using proprietary production technology) makes it possible to achieve what is claimed to be the thinnest form factor on the market (just 0.2mm) in a class-leading small package size (1.0mm x 0.6mm). This contributes to the greater compactness, lower profile and light weight (0.2mg) required for portable devices and drones. Also, package miniaturization technology makes it possible to position the light-emitting element in a 0.6mmx0.6mm area, providing square emission characteristics ideal for dot matrix displays.

In addition, taking into consideration usage conditions during reflow allowed Rohm to prevent solder intrusion into the resin by implementing penetration countermeasures within the package itself. In particular, a type of stopper called a solder resist is implemented before the gold plating process to block the gold pattern (which features good wettability). This makes it possible to prevent solder from penetrating the resin, eliminating failures due to short-circuits and improving reliability considerably.

Going forward, Rohm will focus on strengthening its PicoLED lineup to include high-brightness types as well as expand its lineup of RGB LEDs capable of improved color mixing.

Pricing of the new LEDs is from $0.078 each (in 1000-unit quantities).

www.rohm.com

WPG Americas to distribute for Seoul Semiconductor

WPG Americas Inc (WPGA) of San Jose, CA, USA (a subsidiary of Asia's number-one electronics distributor WPG Holdings) has signed an agreement to distribute the complete product line-up of South Korean LED maker Seoul Semiconductor Co Ltd (said to be the world's fifth largest LED supplier).

The broad product portfolio includes a wide array of package and device choices such as AC-driven LEDs, high-brightness LEDs, mid-power LEDs, side-view LEDs, through-hole-type LED lamps, custom displays, UV LEDs and sensors.

"Seoul strengthens our total LED Lighting solutions for our customers with the addition of their highly competitive mid-power offering and Acrich products for direct AC applications," says WPGa's president Rich Davis.

"As the LED market continues to grow, we are glad to expand our distribution channel through WPGA to reach into the vast client base in the Americas," says Kyu Uhm, Seoul Semiconductor's executive VP of worldwide marketing. "WPGA's strength in demand creation, solution selling and operational excellence is a huge asset that Seoul can lean on for profitable growth."

www.wpgamericas.com

Vishay launches dual-color red and IR diode

Vishay Intertechnology Inc of Malvern, PA, USA has introduced a new dual-color red and IR emitting diode designed to save space in wearable devices and medical patient monitoring systems.

Offered in a compact 2mm x 2mm x 0.87mm package, the Vishay Semiconductors VSMD66694 has peak wavelengths of 660nm (red) and 940nm (IR), and is built on SurfLight technology, yielding radiant power of 9.5mW and 8.5mW, respectively.

For space-constrained devices like smart watches and fitness bands, the VSMD66694 can replace two leaded diodes with one component in a surface-mount package that can be combined with any custom-designed lens system. The device features a narrow spectral bandwidth of 20nm at 660nm and 40nm at 940nm, and its balanced radiant power at red and IR wavelengths provides balanced signal levels for SpO2 and pulse rate monitoring.

The new emitter provides fast switching times of 10ns and forward voltage down to 1.4V. Suitable for high-pulse-current operation to 1A at 100µs, the device features a ±60° angle of half intensity and operates over a temperatures from –25°C to +85°C. The VSMD66694 provides a moisture sensitivity level (MSL) of 3 in accordance with J-STD-020 for a floor life of 168 hours, supports lead (Pb)-free reflow soldering, and is RoHS-compliant, halogen-free, and Vishay Green.

Samples and production quantities are available now, with lead times of 10–12 weeks for large orders.

Vishay launches mid-power 365nm UV LED delivering long lifetime in compact 1.6mm package

Vishay has expanded its offering of mid-power UV LEDs in the 365nm wavelength range with a new device featuring a silicone lens in a compact 1.6mm by 1.6mm by 1.4mm surface-mount package. Designed to provide a reliable, energy-saving replacement for mercury lamps, the Vishay Semiconductors VLMU1610-365-135 delivers long lifetime for medical, industrial and printing applications.

The silicone lens enables extremely long lifetimes of up to 25,000hr compared with the typical mercury lamp lifetime of 10,000hr. The environmentally friendly UV LED is free of heavy metals and provides increased reliability through its shock resistance and immunity to degradation from frequent on/off switching. While mercury lamps require complex drive circuits and need 2-15 minutes to warm up, the VLMU1610-365-135 allows the use of simple low-voltage circuitry and requires no warm-up period.

Fabricated from indium gallium nitride (InGaN) technology, the new LED features typical radiant power of 18mW at 20mA and 50mW at 60mA in a wavelength range of 362.5–370nm. The VLMU1610-365-135 has an emission angle of 135°.

The LED's specifications make it suitable for UV curing in nail salon, dental, and poster printing applications; blood and counterfeit money detection; and photocatalytic purification.

RoHS-compliant, halogen-free and Vishay Green, the VLMU1610-365-135 is compatible with reflow soldering processes and features a Moisture Sensitivity Level of 3 in accordance with J-STD-020.

Samples and production quantities are available now, with lead times of 6–8 weeks.

www.vishay.com

Nichia settles patent lawsuit against Hirose's selling of Yadent lights using Everlight white LEDs

An agreement has been reached to settle the case pending between LED manufacturer Nichia Corp of Tokushima, Japan and Hirose Radio & Electronics (a Japanese corporation manufacturing and selling electronic appliances) in the Tokyo District Court.

In the case, Nichia claimed that its Japanese patents 5,177,317 and 5,610,056 (both related to white LEDs using YAG phosphors) were infringed by some of the LED lights imported and sold in Japan by Hirose, and sought a preliminary injunction against the importation and sale of infringing products.

While Hirose had been unaware of infringement at the time Nichia filed the case, it acknowledged during the proceedings that some of the LED lights that it purchased from Taiwan-based Yadent and imported into Japan used white LEDs made by Taiwan's Everlight Electronics, and that the Yadent LED light products using Everlight white LEDs fall under the claims of Nichia's YAG patents.

In light of these acknowledgement by Hirose, and for the purpose of amicable, quick resolution of the disputes, Nichia and Hirose agreed to resolve the case by a settlement before the court, on the condition that Hirose should stop importation and sale of the infringing products and pay settlement fees to Nichia.

www.nichia.com

US DOE investing over $10.5m in nine solid-state lighting research & development projects

Cost-share contributions raise public–private investment over $13.5m

Building on the new commitments to the Global Lighting Challenge announced in early June during the Clean Energy Ministerial, the US Department of Energy (DOE) is announcing funding for nine research and development projects that will support solid-state lighting (SSL) core technology research, product development, and manufacturing research and development. The 18–24-month projects aims to help to accelerate the development of high-quality light-emitting diode (LED) and organic light-emitting diode (OLED) lighting products.

"Solid-state lighting research and development has contributed to more than $2.8bn in US energy cost savings over the past 15 years, and further improvements in the technology will increase those savings even more in the years to come," says Energy Secretary Ernest Moniz. "By 2030, solid-state lighting could reduce national lighting electricity use by nearly half — which would equate to the total energy consumed by 24 million American homes today and could save American families and businesses $26bn annually," he adds.

Today's most advanced LED products are about 10 times more energy efficient than conventional incandescent lighting and last more than 25 times longer, notes the DOE.

Department-funded R&D aims to foster technology breakthroughs to unlock new levels of SSL performance and energy savings. For example, DOE targets aim to increase the efficiency of existing LEDs by an additional 66%. LED lighting also offers new potential for advanced lighting control, including color tuning and intelligent, adaptive lighting.

In total, the nine selected projects will receive more than $10.5m and will make a cost-share contribution for a total public-private investment of over $13.5m, as they help to further reduce the cost and improve the quality of SSL products:

- Cree Inc (Durham, NC) — Developing a high-efficacy LED lighting fixture that has good color rendering as well as advanced features such as the ability to tune the color of the light;
- Columbia University (New York, NY) — Developing improved quantum dots to increase the efficiency and lower the cost of LEDs;
- GE Global Research (Niskayuna, NY) — Developing an efficient LED fixture that features interchangeable modules and allows for simplified manufacturing and customized performance specifications;
- Iowa State University (Ames, IA) — Demonstrating a method to significantly increase the light output of white OLEDs by changing their internal features;
- Lumenari Inc (Lexington, KY) — Developing a narrow-bandwidth red phosphor to improve the efficacy of phosphor-converted LEDs; Lumileds (San Jose, CA) — Improving the design of an LED to make it more efficient by using a patterned sapphire substrate (PSS) flip-chip architecture;
- North Carolina State University (Raleigh, NC) — Developing a way to get more light out of OLEDs using low-cost corrugated substrates;
- Pennsylvania State University (State College, PA) — Developing a way to better understand and predict the occurrence of short circuits in OLED lighting panels in order to reduce failure rates; and
- University of Michigan (Ann Arbor, MI) — Developing three innovative methods to harness the light within OLEDs.

This is the eleventh round of DOE investments in solid-state lighting core technology research and product development. No manufacturing projects were selected in this round.

http://energy.gov/eere/ssl/doe-announces-selections-ssl-rd-funding-opportunity

Kingbright launches smallest SMD LED, using 0201 package

LED maker Kingbright Co LLC City of Industry, CA, USA has launched what it claims is the industry's smallest SMD LED, the HELI-UM series.

The 0.65mm x 0.35mm x 0.20mm (0201) footprint of the HELI-Ultra-Miniature allows it to fit into ultra-compact designs for wearable, portable consumer products and disposable medical device applications. Engineered with either aluminium gallium indium phosphide (AlGaInP) or indium gallium nitride (InGaN) chips, various colors are available.

Compatible with automatic placement equipment, the HELI-UltraMiniature can be easily utilized, similarly to 0201-packaged passive components, notes the company.

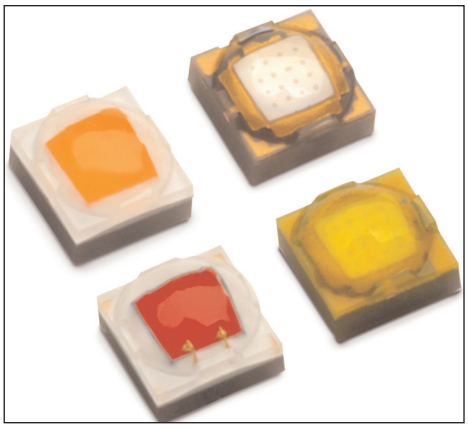
www.kingbrightusa.com/lobbyheli-UM.asp

Lumileds expands LUXEON C Color Line to Mint, Deep Red and Far Red, and boosts Red and Blue performance by 12%

LED maker Lumileds of San Jose, CA, USA has expanded its line of LUXEON C Color LEDs to a total of 12 colors (and 8 whites), making it the industry's broadest line of color LEDs available, it is claimed.

In the LUXEON C Color Line, the focal length of each LED is identical, enabling maximum optical efficiency in design. "Lumileds has filled out the spectrum on an LED color line that really sets the standard in color mixing," claims Jennifer Holland, product manager for the LUXEON C Color Line. "We're delivering seamless color mixing and the right colors for every application, including studio and stage lighting, architectural lighting, emergency vehicle lighting as well as color tunable lamps/fixtures," she adds.

The LUXEON C Color Line now includes Mint, Deep Red and Far Red colors, joining the existing range of



Lumileds' new LUXEON C Colors LEDs.

Red, Red-Orange, Amber, PC Amber, Green, Cyan, Blue and Royal Blue. In addition, the typical flux of LUXEON C Red and LUXEON C Blue have been boosted by 12%, delivering better output from two of the most commonly used colors.

The white portion of the LUXEON C Color Line has been expanded to include color temperature and color rendering index (CRI) combinations of 4000K, 5000K, 5700K and 6500K at 70 CRI; 2700K, 3000K and 4000K at 80 CRI; and 5700K at 90 CRI.

The LUXEON C Color is said to be the only line of color LEDs to be hot tested at 85°C to ensure performance at application conditions. With what is claimed to be the industry's lowest thermal resistance (2.8°C/W), users can save on heat-sink cost or drive the LEDs harder to attain higher output.

In addition to expanding the LUXEON C Color Line, Lumileds has also added a Far Red offering to its LUXEON Rebel Color Line (a portfolio defined by its light output, high efficacy and clear saturated colors). Additionally, the LUXEON Rebel Green, Cyan and Blue colors now feature 12% higher flux than the previous-generation emitters.

www.lumileds.com/LUXEONCColors

Lumileds introduces LUXEON Stylist Series of LEDs optimized for fashion retail, fresh food and restaurant industries

Lumileds has launched the LUXEON Stylist Series, which is claimed to be the first series of LEDs engineered to provide the optimum lighting environment to sell products in fashion retail stores, fresh food markets and restaurants.

The Stylist Series is based on four proprietary technologies: CrispWhite Technology, CrispColor Technology, FreshFocus Technology and AtmoSphere Technology. "We know that the right lighting has a profound impact on customer behavior, affecting the time spent in stores and net revenues," says Luis Aceña, senior manager, Stylist Series. "With the Stylist Series, lighting designers are now able to bring out the very best colors in the products and places it illuminates," he adds.

In fashion retail in particular, Lumileds' new CrispColor Technology highlights rich colors by achieving a higher color gamut. LUXEON LEDs with CrispColor Technology have color points below the blackbody line to target proposed ASSIST and ANSI requirements for Class A and TM30 specifications. CrispColor Technology can be used to achieve a more continuous spectrum, making it a suitable replacement for halogen and incandescent lighting. CrispWhite Technology, which has been implemented in a retail venues over the last two years, activates fluorescent whitening agents in retail items, making white fabrics and paints appear vivid and bright white. "What CrispWhite did for white, CrispColor will do for color," says Aceña.

In the fresh food market segment, Lumileds has invested in spectra development that presents food in its most appealing light. FreshFocus Technology under the LUXEON Stylist Series offers five different lighting approaches for fish, marbled meat, red meat, bread and pastries. "Customer loyalty in markets is largely built on the quality of the fresh food area," says Aceña.

For restaurants, bars and other gathering places, new AtmoSphere Technology is designed to help reinforce the image and brand. The Stylist Series can help create a warm ambiance, says Lumileds.

The LUXEON Stylist Series will be available in product families including CoB (chip-on-board), Mid Power and Matrix Platform.

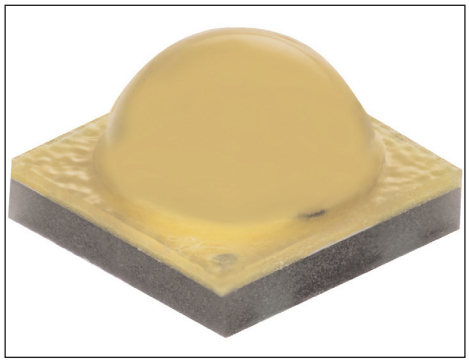
www.lumileds.com/StylistSeries

Cree's new High Efficacy option for XT-E LED delivers 25% higher lumens per watt

Leveraging key elements of its SC5 Technology Platform, LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has upgraded its XLamp XT-E LED family by adding a new High Efficacy (HE) option that delivers a 25% increase in luminous efficacy compared to the previous XT-E LED and provides a guaranteed minimum efficacy of 164 LPW at 85°C and 350mA.

These improvements make 130LPW (lumens per watt) or higher at the system level achievable under real operating conditions and enable existing customers to quickly upgrade system performance for applications such as outdoor and industrial lighting while still achieving the lowest total cost, the firm says.

"We are committed to building the most energy-efficient industrial lighting systems, and the newly improved High Efficacy XT-E LED enables us to do that without any additional investment or re-qualification," comments Colin Piepgras, VP of engineering at LED lighting system maker Digital Lumens. "With the new XT-E LED, we are able to leverage existing optical, mechanical and electrical design elements to quickly improve our portfolio of intelligent lighting solutions."



Cree's XLamp XT-E LED, now with a High Efficiency option.

Cree says that the enhanced XT-E LED improves the brightness, the voltage characteristics and the optical performance in the same proven 3.45mm x 3.45mm XT package. Demonstrating the long-term reliability of Cree's high-power ceramic LEDs, the XT-E LEDs now have more than 10,000 hours of LM-80 data available, delivering reported L90 lifetimes of greater than 60,000 hours (at 105°C, 1A). This reliability is suitable for applications such as outdoor and high-bay lighting, where long lifetimes at high ambient temperatures are important, says the firm. For example, XT-E's improved efficacy and reliability make it suited to the recently updated DesignLights Consortium (DLC) 4.0 requirements (which focus on higher efficacy for outdoor and high-bay luminaires).

Improvements make 130LPW or higher at the system level achievable under real operating conditions and enable existing customers to quickly upgrade system

"Cree's improved XT-E LED provides an immediate solution that eliminates the time and cost of re-design around other unproven alternatives," says Dave Emerson, VP & general manager for Cree LEDs.

Product samples are available at the end of the June, and production quantities are available with standard lead times.

www.cree.com/xlamp/xte

Cree expands LED components distribution network with Avnet

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has announced a strategic agreement with global technology distributor Avnet Inc that expands coverage in the Americas for the distribution of Cree's portfolio of LED components including high-power, chip-on-board (COB), high-brightness and LED modules.

"Adding Avnet to Cree's industry-leading distribution network demonstrates Cree's continued investment in and commitment to its LED business," says Dave Emerson, VP & general manager for Cree LEDs. "Combining Cree's LED technology with Avnet's dedicated team of LED-focused Illumineers and state-of-the-art LightLab [in Chandler, AZ, USA] will accelerate the adoption of the next generation of LED solutions that combines lighting with IoT [the Internet of Things]."

Cree has a broad portfolio of application-optimized, lighting-class LED components. With more than 4000 patents, Cree offers high-power LEDs for applications such as street, outdoor area, stadium, retail spot and high-bay lighting.

"Avnet and Cree share a commitment to not only facilitate the transition from conventional filament and fluorescent lamps to LED lighting, but to also help our customers bring true intelligence to lighting," comments Alex Iuorio, senior VP, supplier development, Avnet Electronics Marketing Americas. "With the support of Avnet's Illumineers and LightLab and Cree's portfolio of components and modules, we can provide designers who want to leverage the IoT to add more value to their products with easy-to-implement solutions that will reduce development time and cost, while fast-tracking time to market," Iuorio adds.

https://products.avnet.com/shop/en/ema/manufacturer/cree-inc
www.cree.com/LED-Components-and-Modules/Products

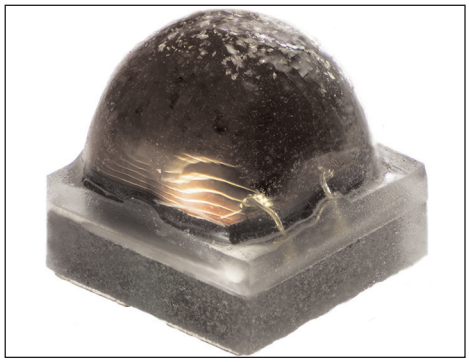
Cree expands portfolio of LEDs for horticulture lighting with XQ-E Photo Red LED

Cree Inc of Durham, NC, USA has expanded its portfolio of LEDs optimized for horticulture lighting with the introduction of the XLamp XQ-E Photo Red LED.

The new LED is capable of providing very high levels of growth-promoting light wavelengths from a footprint that is less than one-third the size of its closest competitor with similar output, it is reckoned. The new XQ-E extends the family of smallest LEDs optimized for horticulture and enables lighting manufacturers to reduce the size of luminaires and lower their system cost, adds Cree.

The new addition expands Cree's range of XQ and XP LEDs that deliver what is claimed to be the industry's highest photosynthetic photon flux (PPF), efficiency and reliability. Both LED families enable the replacement of incumbent lighting technologies at much lower power with similar spectral content. For example, a high-bay reference design using Cree white and photo red LEDs delivers higher average PPF density than a 1000W double-ended high-pressure sodium (HPS) fixture while drawing half the power, it is reckoned.

"Cree LEDs enable us to offer full-spectrum LED grow lights that truly mimic natural sunlight," comments Rami Vardi, CEO of LED grow-light manufacturer Spectrum King LED. "The high performance, high efficiency and high reliability of Cree LEDs allow us to match the intensity of traditional HPS lamps at a lower system cost, longer life and lower power."



The new XLamp XQ-E Photo Red LED.

The XQ-E Photo Red LED is capable of delivering more than 6.4μmol/s of the 660nm peak wavelength light that can be beneficial for plant growth from a 1.6mm x 1.6mm footprint. Cree says that its white and color LEDs deliver the full spectrum of light and mimic natural sunlight. The firm's color LEDs (including royal blue, green, red, photo red, and far red LEDs) deliver high PPF in the wavelengths best suited for the different stages of plant growth. The combination of consistent packages, footprints and drive currents allows easy tuning of spectral content and intensity at the luminaire level, Cree says. The new photo red LED leverages the XQ-E family's proven optical symmetry and consistency across all colors to improve color uniformity and simplify the production process for lighting manufacturers.

"Our mission at Local Roots is to improve global health by building a better food system, and that means growing food in a responsible way at a cost that increases access to fresh and delicious produce," says Matt Vail, chief operating officer of Los Angeles-based indoor vertical farming company Local Roots. "Cree's wide range of high-performing LEDs optimized for horticulture allows us to control spectrum and intensity and provide our crops precisely the light they need in order to maximize growth, nutrition and quality," he comments. "The high efficiency and long-term reliability of Cree LEDs enables us to lower the cost of the food we grow and feed more people better food."

Product samples of the new XQ-E Photo Red LED are available now and production quantities are available with standard lead times.

www.cree.com/xlamp/horticulture

Cree appoints experienced retail executive to board

Darren Jackson, most recently CEO of Advance Auto Parts Inc (AAP) from January 2008 to this January, has been appointed to Cree's board of directors.

"He has a proven track record leading large companies through industry transitions and we welcome the opportunity to work with Darren as we pursue our mission to build the most valuable lighting technology company," says chairman & CEO Chuck Swoboda.

Jackson originally joined AAP in July 2004 as a board member. He was also AAP president from January 2008 to January 2009 and from January 2012 to April 2013. Prior to becoming AAP's CEO, he held various executive positions with Best Buy Co Inc, a specialty retailer of consumer electronics, office products, appliances and software, ultimately serving from July 2007 to December 2007 as executive VP of customer operating groups. Jackson joined Best Buy in 2000 and was appointed as its executive VP-finance & chief financial officer in February 2001. Prior to 2000, he served as VP & chief financial officer of Nordstrom Inc, Full-line Stores (a fashion specialty retailer) and held various senior positions, including CFO of Carson Pirie Scott & Company (a regional department store company). Jackson has also served as a director of Fastenal Company (which sells industrial and construction supplies) since July 2012.

Jackson has a Bachelor's Degree in Accounting from Marquette University, where he also serves on the board of trustees.

Osram acquiring automotive LED module maker Novità

As part of its three-pillar strategy announced last November, Osram GmbH of Munich, Germany is further expanding the leading position of its Specialty Lighting (SP) business by agreeing to acquire Novità Technologies of Hendersonville, TN, USA, a manufacturer of automotive LED modules that are used particularly in tail lights, fog lights and daytime running lights.

With about 100 staff, Novità ships mainly to headlight and tail-light manufacturers in the USA, and has annual sales of over €40m. The transaction is planned to be completed by October, and should immediately be margin-accretive in Osram's Specialty Lighting segment.

"The purchase of Novità Technologies is an outstanding addition to our project and system business and at the same time strengthens our position on the important US market," believes Hans-Joachim Schwabe, CEO of Osram's Specialty Lighting business unit.

As technological changes continue to take place around LEDs, the requirements of manufacturers in the automotive industry are also changing with regard to the design and functionality of light, notes Osram. As a result, there is increasing demand for complete systems and modules rather than for the pure light sources. An example is the Ford F-150 pick-up truck, for which Osram has developed a complete LED-based front lighting system comprising low and high beam, turn indicators, parking light and control module. By purchasing Novità, Osram is complementing its LED module business with regard to the tail light and forward auxiliary lighting such as fog lights and daytime running lights (DRLs).

The global market for LED modules for front and rear lights is forecast to increase by an average of 20% per year by 2020. It is reckoned that Novità is well positioned in this sector, particularly in the USA, and therefore adds to Osram in terms of both the regional market and the LED automotive portfolio for project and system business. Founded in 2007 as an asset management buy-out, Novità has recorded rapid growth in the last three years and is said to have a high level of engineering and manufacturing expertise, specifically in the LED module business.

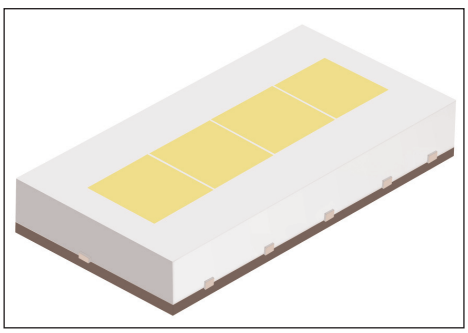
www.novitatech.com
www.osram-os.com

Samsung launches line-up of LED components for automotive lighting, featuring CSP

Samsung Electronics Co Ltd of Seoul, Korea has launched Fx-CSP — a line-up of LED packages featuring chip-scale packaging (CSP) and flexible circuit board technology — for use in automotive lighting applications.

"Our new Fx-CSP line-up will bring greater design flexibility and cost competitiveness to the automotive lighting industry," claims Jacob Tarn, executive VP, LED business team, at Samsung Electronics. "We will continue to introduce innovative LED products and technologies, such as multi-chip array technology, that can play a key role in the growth of the automotive LED lighting industry," he adds.

The combination of chip-scale packaging and flexible circuit board technology together enables more compact chip sizing and a higher degree of reliability, says the firm. The use of a flexible circuit board also enables greater heat dissipation, which leads to lower resistance and brings about a greater degree of lumen-per-watt efficiency than using a ceramic board.



Samsung's 14W (1x4) Fx-CSP4 LED.

In addition, the new automotive LED line-up allows car designers to use a variety of chip arrangements such as a single chip, a 1x4, or a 2x6 multi-chip arrangement to suit different lighting configurations, says Samsung. The Fx-CSP line-up can be used in automotive lighting applications that include position lamps and daytime running lamps (DRLs) as well as headlamps that require higher luminous flux and reliability than other automotive lamps.

The Fx-CSP line-up consists of the single packages Fx1M (1W, for DRLs and position lamps) and Fx1L (3W, for DRLs) plus the high-voltage array packages Fx4 (14W, for headlamps and light-guide-type DRLs) and Fx2x6 (40W, for multi-beam headlamps). The variation in wattage levels allows Samsung LED lighting packages to work with a wide range of exterior automotive lighting.

Samsung says that, by adding the new Fx-CSP line-up to its existing mid-power and high-power automotive LED component line-ups, it now provides a family of automotive lighting components. Also, the new Fx-CSP LED line-up was recently selected by a major global automotive manufacturer for a compact car headlamp project, notes Samsung.

The firm plans to introduce more CSP technology-based LED components for automotive lighting later this year.

www.samsung.com

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SemiLEDs' revenue falls 18% quarter-on-quarter

Cash reserves fall as margins and losses worsen

For fiscal third-quarter 2016 (to end-May), LED chip and component maker SemiLEDs Corp of Hsinchu, Taiwan has reported revenue of $2.38m (slightly below the expected $2.4–3m), down 18% on $2.92m last quarter and down 47% on $3.5m a year ago.

Gross margin was –61%, worsening from –27% last quarter (and –24% a year ago) and back to the –61% of two years ago.

Operating expenses have been cut from $1.98m last quarter to $1.69m, due mainly to R&D expenses falling from $0.62m to $0.39m and employee termination benefits falling from $0.15m to $0.06m. Operating margin has worsened further, from –88% a year ago and –95% last quarter to –132%.

On a non-GAAP basis, net loss has risen from $2.2m ($0.77 per diluted share) last quarter to $3.1m ($1.06 per diluted share), back above $2.8m ($0.10 per diluted share) a year ago.

Capital expenditure has risen from $0.14m last quarter to $0.18m (still less than $0.28m a year ago). Also, net cash used in operating activities has risen from $1m last quarter to $1.3m (compared with cash inflow from operating activities of +$0.1m a year ago). Total free cash outflow has hence risen from $0.17m a year ago and $1.15m last quarter to $1.5m. During the quarter, cash and cash equivalents fell from $5.3m to $3.5m.

"The transition toward the fabless business model has taken longer than we anticipated," notes chairman, president & CEO Trung Doan. "However, we still believe it is the right model," he adds. "This should help us to lower our cash needs while evaluating other potential business opportunities."

For fiscal fourth-quarter (ending 31 August), SemiLEDs expects revenue of $2–2.5m.

SemiLEDs sells 20% stake to raise $2.885m

On 6 July, SemiLEDs entered into an agreement for Dr Peter Chiou to purchase 577,000 newly issued shares (about 19.6% of its outstanding common stock) at $5 per share (worth $2,885,000 in total).

Chiou has also agreed to purchase a $1,615,000 0%-interest convertible note with a maturity date of 29 September 2017. Subject to approval at the next shareholders meeting, the note will be convertible into a number of shares equal to $1,615,000 divided by the conversion price ($3.40, or the 5-trading-day volume-weighted average price on the NASDAQ Stock Market ending on the maturity date, whichever is less).

These investments are expected to be made in three instalments:

- $1,000,000 (already received);
- $1,885,000 (to be wired to the firm on or before 15 August) — upon completion of the share purchase, Chiou will be appointed a member of SemiLEDs' board of directors (Chiou has agreed to waive any compensation for his services on the board); and
- $1,615,000 (to be wired to the firm on or before 29 September).

SemiLEDs cautions that there is no assurance that it can successfully close the financing or if Dr Chiou is able to meet the remaining funding requirements of the purchase agreement.

www.semileds.com

Seoul Semiconductor wins revocation of Enplas' patent

Seoul Semiconductor says Japanese lens maker Enplas' LED lens patent has been revoked in Taiwan, adding to a series of legal victories against Enplas in the USA, Korea and Europe.

Since patent litigation between the two firms began, Seoul has pursued enforcement of its LED backlight lens and system patents against infringing products by Enplas.

On 24 March, a US jury ruled that Enplas had induced infringement of Seoul's patented technology with respect to all of the patent claims presented by Seoul. The jury found that Enplas' infringement was willful. It also unanimously agreed that Seoul's LED backlight lens patents were valid, rejecting all of Enplas' invalidity arguments. The jury awarded Seoul $4.07m in damages for induced infringement.

Previously, in the USA, Seoul filed inter partes review (IPR) petitions against three backlight lens patents owned by Enplas. All three were invalidated by the US Patent Trial and Appeal Board. In Korea, the Supreme Court affirmed the decision of the USPTO, invalidating all claims of Enplas' backlight lens patent. In Europe, the European Patent Office declined to register Enplas' backlight lens patent based on prior art references brought to its notice by Seoul.

On 26 January, Seoul filed an invalidation action against Enplas' backlight lens patent in Taiwan based on the same invalidity grounds. Enplas was unable to defend against these invalidation contentions and has had to cancel all of its patent claims, which has resulted in revocation of the patent.

"A series of patent litigations against Enplas has demonstrated that Seoul Semiconductor has pioneered patent portfolios regarding LED backlight technology," says Seung Ryeol Ryu, Seoul's IT application R&D officer.

www.SeoulSemicon.com

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UK's Artemis facility demonstrates optical control of 2D semiconductor bandgap

Tunability of MoS_2-graphene heterostructure could open new applications of 2D optoelectronic devices

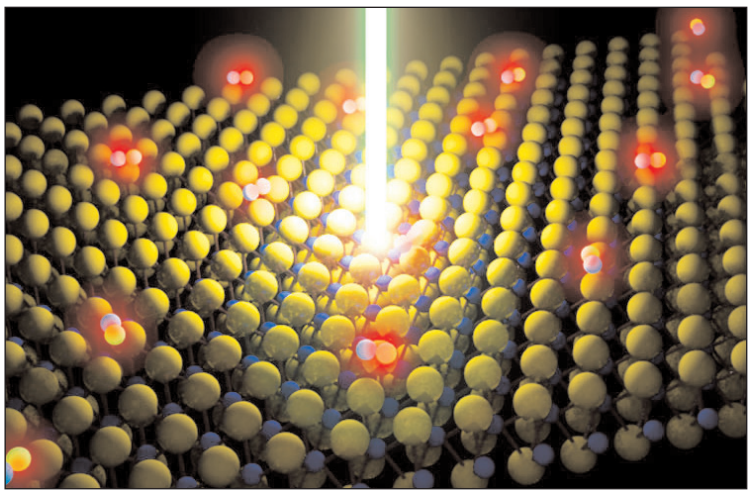
An international collaboration working on Artemis — the ultrafast laser and XUV (extreme ultraviolet) science capability of the UK Science and Technology Facilities Council's Central Laser Facility (CLF) — has shown how the electronic properties of a two-dimensional (2D) semiconductor can be controlled by light (Søren Ulstrup et al, ACS Nano vol10, p6315 (2016)).

The expanding toolbox of 2D materials has allowed researchers to assemble new materials that could have a disruptive impact on optoelectronic technologies. The all-carbon 2D material graphene is an excellent conductor when supported on a substrate and hence promises to be an ideal electrode material in a 2D device.

By placing a single-layer of the semiconductor molybdenum disulphide (MoS_2) on top of the graphene, one obtains a heterostructure with enhanced optical properties. MoS_2 plays an important role in such an assembly because it transforms from an indirect-bandgap semiconductor to a direct-bandgap semiconductor in the 2D limit. This greatly enhances the material's ability to absorb light and leads to new properties such as an ability to discriminate the polarization of an optical excitation.

In a recent experiment performed at the Artemis facility, a team of researchers used the time- and angle-resolved photoemission spectroscopy (TR-ARPES) technique to record ultrafast snapshots of how such a 2D MoS_2-graphene heterostructure responds to an optical excitation by a tunable laser pump pulse.

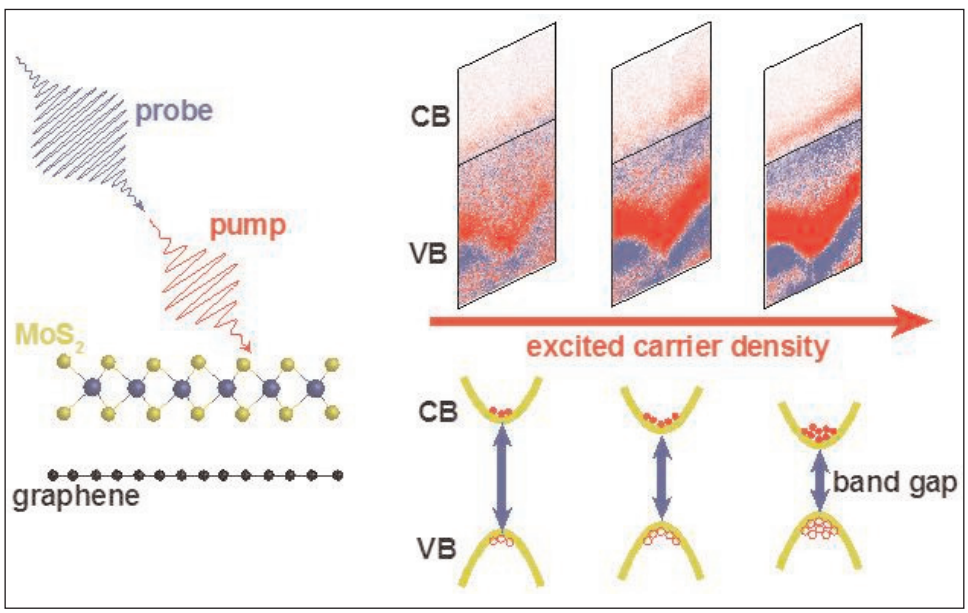
Surprisingly, the band structure of the MoS_2 layer changes dramatically once free carriers are excited in the valence and conduction bands of the material. The direct bandgap shrinks as the number of free carriers is increased due to the build-up of screening in the system. The number of free carriers and the following bandgap renormalization could be controlled by the power of the pump pulse in the experiment.



Schematic of a laser beam energizing a monolayer of molybdenum disulphide. (Credit: Der-Hsien Lien, Berkeley)

Since the size of the bandgap in a semiconductor determines its electronic and optical properties, the optical tunability discovered in the MoS_2-graphene heterostructure in the experiment could open new avenues for the application of 2D optoelectronic devices, it is reckoned.

www.clf.stfc.ac.uk/CLF/Facilities/Artemis/12270.aspx
http://pubs.acs.org/doi/abs/10.1021/acsnano.6b02622



(Left) Schematic of pump-probe experiment: The pump pulse excites a heterostructure consisting of a single-layer of MoS_2 on graphene. The excited state is probed via photoemission by an ultraviolet probe pulse. (Right) The upper panels present the excited signal measured in the MoS_2 valence band (VB) and conduction band (CB). Red indicates excited electrons in the CB and a shift in the VB towards the CB. The lower panel presents a schematic of the observation: the bandgap in MoS2 renormalizes depending on the number of excited carriers generated with the pump pulse. (Credit: Soren Ulstrup)

Ricoh develops 200W fiber-coupled 808nm VCSEL module

Assisted partly by the Program for Strategic Innovative Energy Saving Technology run by Japan's New Energy and Industrial Technology Development Organization (NEDO), Tokyo-based Ricoh has developed an 808nm-wavelength fiber-coupled high-power vertical-cavity surface-emitting laser (VCSEL) module that can be used as a light source for the firm's production printers currently on the market as well as in new applications such as engine ignition.

The power output of the VCSEL array is 310W standalone, and 200W with the fiber output module — under quasi-continuous-wave (QCW) drive conditions of 500μs pulse width and 20Hz repetition cycle — which is claimed to be unprecedented for a fiber-coupled VCSEL module.

The high-power VCSEL module is said to incorporate three technical advances: high output performance, compact size, and wavelength stability in variable temperatures.

Ricoh has increased the luminescence efficiency of the VCSELs. It has also achieved large-scale integration of the light-emitting channels. Specifically, the module uses a VCSEL array with a large number of light-emitting channels on its surface, along with a micro lens array (MLA) that integrates lenses corresponding to each light-emitting channel on a single chip. As it has fewer components compared with modules using conventional edge-emitting-type lasers, the VCSEL module is more compact. Altogether, the output power of the laser array is significantly boosted.

By improving the heat dissipation of the overall module, it can now deliver the high energy output needed by the laser crystal light source in a laser ignition plug head. This type of plug head has been attracting attention as a means of igniting gas engines for power generation used in cogeneration systems and other equipment.

Due to its structure, the VCSEL features what is claimed to be exceptional wavelength stability in variable temperatures, offering about ten times the thermal stability in wavelength compared with conventional edge-emitting-type lasers. In solid-state laser excitation used in applications such as the laser crystals of laser ignition plug heads, the wavelength stability of the excitation light is vital to achieving stable output. As a result, a precision temperature control unit is not required, allowing a significant reduction in size of the VCSEL module.

Ricoh is also looking to expand into applications such as laser processing machines, surface treatment processing such as laser patterning, non-thermal processing and sensing, as well as the development of other applications.

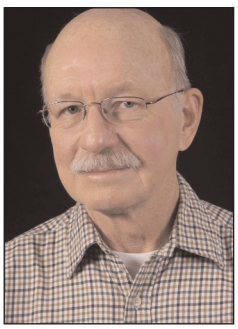
www.ricoh.com/technology/tech/038_vcsel.html

University of Utah's Stringfellow receives Frank Prize

In a ceremony in Nagoya, Japan on 8 August, Gerald Stringfellow, who is a Distinguished Professor in the University of Utah's departments of materials science & engineering and electrical & computer engineering (and dean of the College of Engineering from 1998 to 2003), will receive the International Organization for Crystal Growth's Frank Prize, in honor of his career-long work in developing processes for making light-emitting diodes.

The Frank Prize is an international award given once every three years to a researcher who has made "outstanding contributions to the field of crystal growth through technical achievements, publications and presentations and through their impact worldwide on science and technology."

Stringfellow was a group manager with HP Labs in Palo Alto, CA, in the 1970s when he began developing a new process to create LEDs with multiple colors that require much less power. He proposed organometallic vapor-phase epitaxy (OMVPE) for the deposition of semiconductor alloys incorporating aluminum, gallium, indium and phosphorous on a substrate to create red, orange, yellow and green LED crystals. This led to better HP handheld calculators that used red LEDs for the display.



Gerald Stringfellow.

Stringfellow took his research to the University of Utah, where he was hired as a professor in 1980. He made conceptual advances in the field and would later publish a book on the process that has since become the standard reference for the science of growing LED crystals.

With Stringfellow's work, along with the later development of blue LEDs by Japanese researchers, this technology led to the advancement of LED-backlit flat-screen LCD TVs, cell-phone screens, high-efficiency solar cells and LED light bulbs that are far more efficient than incandescent bulbs (as well as being used in automobile tail-lights as well as traffic and pedestrian lights).

"While professor Stringfellow's invention of organometallic vapor-phase epitaxy facilitated the commercialization of LEDs and improved the TV and computer displays we all use, its greatest benefit to society is in the energy savings that these devices brought about," comments Richard B. Brown, dean of the College of Engineering.

http://mse.utah.edu/faculty/gerald-stringfellow.php

University of Glasgow partners with Shanghai Lingang Science and Technology Innovation City to develop optoelectronics industry base

The University of Glasgow in Scotland, UK has signed a partnership agreement with a state-owned enterprise company in China to develop an international optoelectronics industry base in the Lingang area of Shanghai.

Earlier this year, a memorandum of understanding (MoU) was signed by the university and senior representatives of the Shanghai Lingang Science and Technology Innovation City Economic Development Co Ltd (a subsidiary of the Lingang Group which specializes in industrial park development) and the Shanghai Shunmao Information Technology Co (a private company established to manage and commercialize some of the technology that will be developed by the new initiative).

John Marsh, Professor of Optoelectronic Systems and Dean of the University of Glasgow-University of Electronic Science and Technology of China (UESTC) Partnership, attended an inaugural event at Lingang representing the University of Glasgow.

The agreement has led to the founding of the Shanghai Lingang International Photonic Integrated Circuit Joint Laboratory (PIC Lab), which will foster collaboration between the University of Glasgow and its partners in Lingang. PIC Lab aims to accelerate the development and commercialization of optoelectronic integrated chip technology — integrating multiple optical components on a single chip and packaging the chips with high-speed electronics — to address the demand for high-speed network connections for the next generation of the Internet.

"The University of Glasgow is delighted to be working with our new partners to strengthen international links relating to optoelectronic devices and the development and integration of an optoelectronic integration platform and industry incubation base in Lingang," says Marsh. "We shall also be working to create a Scottish platform. This is international recognition of Glasgow's long-term commitment to optical research."

A spokesman for the Shanghai Lingang Science and Technology Innovation City Economic Development Company said that the new PIC Lab would capitalize on the combination of domestic and foreign skills and resources to develop "an effective concentration of high-end technical and commercial talent in the field of photonics to deliver a world-leading, cutting-edge technology and industrial capital".

The partnership also aims to give clear leadership to the global PIC industry and offer a strong impetus to optoelectronic integrated chip technology R&D and to attract further domestic and foreign optoelectronic talent technology, adds the spokesman.

The Chinese partners in the agreement plan to visit the University of Glasgow later this year to promote and cement the new bilateral cooperation project.

www.shlingang.com
www.gla.ac.uk

Infinera's co-founder & president receives IEEE Ernst Weber Managerial Leadership Award for optical and cloud networking innovation

At the IEEE Honors Ceremony in New York City on 18 June, Dr David F. Welch — co-founder & president of 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) — received the 2016 IEEE Ernst Weber Managerial Leadership Award, recognizing exceptional managerial leadership in the fields of interests to the IEEE. Welch was specifically honored for his leadership in enabling the growth of cloud-based services and the Internet in optical transport networks.

The IEEE Awards Program has paid tribute to researchers, inventors, innovators and practitioners whose exceptional achievements and outstanding contributions have made a lasting impact on technology, society and the engineering profession. Each year, the IEEE Awards Board recommends a small number of outstanding individuals for IEEE's most prestigious honors.

Welch leads Infinera's engineering, business development and marketing groups. He has made numerous contributions to the field of optical communication systems (including more than 250 published articles and 169 patents).

Welch has received a number of honors and awards including the 2013 Institute of Engineering and Technology J J Thomson Medal for Electronics, 2011 Optical Society of America (OSA) John Tyndall Award, 1999 OSA Joseph Fraunhofer Award/Robert M. Burley Prize, 1998 IEEE LEOS Engineering Achievement Award and the 1992 OSA Adolph Lomb Medal. He serves on the board of directors for OSA and Infinera, and is a fellow of OSA and IEEE.

www.infinera.com

POET completes acquisition of BB Photonics

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 completed its stock-only acquisition of BB Photonics Inc, a designer of integrated photonic solutions for data communications (announced on 17 May), in exchange for issuing 1,996,090 common shares (for a total deemed purchase price of $1.55m, based on a price of the US equivalent of $1.00 per share). POET now owns 100% of BB Photonics and its assets, including intellectual property and technologies. BB Photonics had no liabilities at closing.

BB Photonics (a pre-revenue, New Jersey-based privately held firm) develops photonic integrated components for the data-center market utilizing embedded dielectric technology that is intended to enable on-chip athermal wavelength control and lower the total solution cost of data-center photonic integrated circuits (PICs).

The strategic acquisition is designed to provide POET with additional differentiated intellectual property and know-how for product development, to enable POET to better service its first identified commercialization market (the end-to-end data communications market), and to augment its sensing roadmap.

"The addition of BB Photonics significantly enhances our integrated photonic solution set and advances our commercialization initiative," says POET's CEO Dr Suresh Venkatesan. "By internal development and acquisition, we are accelerating our drive from technology leadership to market entry in differentiated photonics."

The POET platform and process technology continue to be the focal point of the firm's commercialization strategy. To this end, the POET team continues to make progress toward its previously announced goal of demonstrating an integrated product prototype by the end of 2016 using the POET platform. The firm's recent acquisitions (including DenseLight Semiconductors) and organic development are intended to serve as a logical continuum of the roadmap by enabling immediate market entrance into its first identified commercialization market (datacoms). The firm says that its acquisitions also allow it to engage prospective customers with an extensive suite of integrated photonics products, enabling multiple differentiated product sales and enhancing potential revenue.

www.poet-technologies.com

III-V Lab spin-off Almae takes over Marcoussis facilities

Start-up to industrialize InP-based epitaxy for photonic integration in telecoms applications

With the re-grouping of teams from III-V Lab (the joint Alcatel-Lucent, Thales and CEA-Leti industrial research laboratory), Almae Technologies SAS is taking over III-V Lab's facilities at Marcoussis, which is sited on the Plateau de Saclay (a long-established and growing high-tech center for materials and optics research in the Paris region).

Almae was spun-off by III-V Lab of Palaiseau, France in October 2015 at the initiative of one of the directors of III-V Lab and two managers of InPACT of Pomblière, France, which manufactures indium phosphide (InP) single-crystal wafers. In February, the firm received a capital input from "a major player in the photonic components industry". Almae will use the epitaxial reactors and nano-lithography equipment validated by III-V Lab to begin production of III-V semiconductor wafers for the telecoms market.

With over 2000m^2 of cleanrooms, Almae will have an annual full production capacity of several thousand wafers including for new-generation laser components supporting very high-speed access over optical fiber.

Along with acquiring the equipment, Almae will benefit from a technology transfer from III-V Lab, including operational support from its R&D teams in laser design, fabrication and characterization. The technology transfer should enable the start-up to rapidly achieve industrial scale and to develop products that meet the growing demand globally for III-V-based laser materials.

The deal with Almae "brings to market more than 10 years of research work on access photonics, strengthens our position as a technology leader in the field of laser applications for telecoms, and demonstrates the value of our model of an innovative, open industrial laboratory," comments III-V Lab's president François Luc.

Technical breakthrough in photonic integration moves out of the lab

Almae designs and produces InP epiwafers used to implement photonics circuits integrating semiconductor lasers, made possible by licensing a portfolio of patents from Nokia. This involves technology developed by III-V Lab for growing materials with atomic-scale control. This 'buried strip' laser technology consists of covering the semiconductor strip constituting the laser with an electrical insulator material with sub-micron precision, enabling good thermal exchange and optimum optical guidance of the beam. This technique enhances the implementation, stability and performance of integrated lasers. A range of products operating at data transmission rates up to 25Gb/s is in development.

"The photonic technologies developed by Nokia Bell Labs and III-V Lab will now be applied by Almae Technologies in the creation of semiconductor wafers for the telecommunications industry," says Jean-Luc Beylat, president of Nokia Bell Labs France. "Many of these optical technologies are at the core of next-generation networks, including 5G. They will provide the greater speed and processing required to meet the needs of a fully mobile and connected society while consuming less power. Almae Technologies will also provide a reliable industrial supply chain for our innovations going forward," he adds.

The agreement with III-V Lab "will enable Almae Technologies to develop its epitaxial wafer manufacturing business on an industrial scale, along with high-added-value services in collaboration with InPACT, a III-V Lab partner for 10 years, while positioning Almae as a major player in the field of photonic integrated circuits," reckons Almae's founder & CEO Jean-Louis Gentner. "This new R&D and industrial production activity will contribute to the dynamism of the ecosystem of the Saclay plateau technology region by creating value and highly skilled jobs in the growing sector of photonics applied to telecommunications."

www.3-5lab.fr

ICT-STREAMS EU project to develop transceiver and routing technologies for multi-terabit on-board chip-to-chip communications

III/V-on-Si in-plane lasers and silicon photonics target 1600% increase in throughput and 10-fold cut in energy consumption

ICT-STREAMS, a part of the European Union Horizon 2020 program, is a new three-year project launched on 1 February (followed by a kick-off meeting at the Aristotle University of Thessaloniki, Greece on 24–25 February) with the goal of developing the required set of transceiver and routing technologies to enable multi-terabit on-board chip-to-chip communications.

The ever-growing demands of mega data centers and high-performance computers for increased bandwidth at a fraction of real-estate and power consumption are pushing existing pluggable optics interconnection solutions to their limits. The research efforts of ICT-STREAMS are therefore aligned with the next generation of embedded optical transceivers, which are placed on-board and in close proximity to the electronic modules, as a way to drastically reduce the required physical space and power budget.

To this end, the project aims to develop a set of innovative technologies for the optical engines and board platform and combine them in a radically new approach for wavelength division multiplexing (WDM) routing architecture, aiming to increase server-board density by >400% and throughput by 1600% (with a 10-fold reduction in energy consumption).

ICT-STREAMS will exploit silicon photonics technology to develop ultra-powerful, compact, dense wavelength division multiplexing (DWDM), high-channel-count and dense embedded optical engines with the ability for aggregate throughputs beyond 1Tb/s.

The project will also develop a thermal drift compensation system employing a non-invasive wavelength monitoring and control technology to guarantee real-life applicability of the proposed multi-channel silicon photonics (Si-Pho) technology.

On the board level, a single-mode polymer-based electro-optical PCB (EOPCB) will be developed to serve as the host platform that will efficiently route both optical and high-frequency electrical data across the board.

As a way to relax manufacturing time and cost requirements associated with complex optical assembly processes, optical engines will rely on III/V-on-Si in-plane lasers for optical sourcing, while adiabatic coupling will be employed for I/O interfacing with the electro-optical PCB host platform.

Finally, ICT-STREAMS will assemble the new optical engines on the polymer EOPCB together with a 16x16 arrayed waveguide grating (AWG)-based routing component to leverage WDM technology from just a parallel transmission tool to a massive any-to-any, collision-less and low-latency routing platform with 25.6Tb/s aggregate throughput capability. Photonic-crystal-based III/V-on-Si nano-amplifiers will be introduced as a new amplification paradigm to enable optical power balanced links with advanced features and smart routing functionalities.

The project brings together three industrial partners, one small-to-medium enterprise and five academic and research institutes in the optical interconnects value chain. The partners are project coordinator Aristotle University of Thessaloniki in Greece, Centre National de la Recherche Nationale (CNRS) — Laboratoire de photonique et de nanostructures (LPN) in France, IBM Research Zurich GmbH in Switzerland, IMEC in Leuven, Belgium, Politecnico di Milano in Italy, STMicroelectronics in Italy, iMinds in Belgium, Vario Optics AG in Switzerland, and FCI Connectivity in Germany.

www.ict-streams.eu

ADVA joins EU-funded DIMENSION project for single-chip electro-optical integration in data centers

Consortium forms complete value chain for integrated optical circuits with active photonics

Communications network equipment maker ADVA Optical Networking SE of Martinsried/Munich, Germany is participating in the four-year project Directly Modulated Lasers on Silicon (DIMENSION), which aims to create a platform for single-chip electro-optical integration, taking electro-optical integration to a new level by producing silicon chips built with active laser components. The technology it produces will involve lasers built with active III-V materials embedded into silicon photonics chips, generating the versatile, cost-efficient components needed to optimize data-center interconnect (DCI) transport and creating the next generation of data centers.

Funded by the European Union's Horizon 2020 research and innovation program and running until the end of January 2020, DIMENSION brings together a consortium of research and industry partners from four European countries: Germany, Switzerland, Greece and the UK. Coordinated by Germany's Dresden University of Technology, the two research centers included are Germany's Innovations for High Performance Microelectronics (IHP GmbH) and Greece's AIT (Athens Information Technology) Center of Excellence for Research and Education. The large industry partners are ADVA Optical Networking, Optocap Ltd of Livingston, Scotland, UK and Switzerland-based IBM Research – Zurich. The consortium of partners also forms a complete value chain for the production of the new technology, from research through to innovative package design and assembly.

"DIMENSION unites specialists from different fields and enables us to address the complete value chain of directly modulated lasers, from materials research to application," says Bert Offrein, manager, photonics, IBM Research – Zurich. "What we're bringing to the table is a lot of experience with transformational data-center innovation," he adds. "We're focusing on incorporating highly efficient III-V materials into silicon chips. Our role is to design and produce the integrated active optical components," Offrein continues. ."This technology will bring the optics to where the data is generated, and that leads to improvements in every part of the data center. By enhancing interconnections at different reaches, from centimeters up to kilometers, we'll be able to reduce size, cost and power on links between boards, computers and facilities."

"Improving efficiency in the data-center interconnect (DCI) couldn't be more vital given the increasing demand for cloud computing and the growing scale of the Internet of Things," comments Michael Eiselt, director, advanced technology, ADVA Optical Networking. "Much of our recent innovation has centered on enhancing the DCI, such as our FSP 3000 CloudConnect solution," he adds. "By integrating the three distinct technologies of silicon photonics, electronics and active photonics, we're giving data centers what they need to meet tomorrow's demands."

http://cordis.europa.eu/project/rcn/199148_en.html
www.advaoptical.com

MACOM launches quad-channel linear driver for 28Gbaud PAM-4 applications to support 200G and 400G transceiver development

MACOM Technology Solutions Holdings Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for analog RF, microwave, millimeter-wave and photonic applications) has launched the MAOM-003419, a quad-channel linear electro-absorptive modulated laser (EML) driver for 28 Gbaud PAM-4 solutions for 200G and 400G. Samples are available now.

The MAOM-003419 is a low-power EML driver with high gain, high bandwidth and output voltage capability up to 2Vpp while it consumes less than 500mW of power. The device has differential inputs to provide common-mode rejection and single-ended output to drive industry-standard EMLs. The device is available in a small-form-factor surface-mount package while also integrating the high-frequency bias T for the electro-absorptive (EA) modulator.

"The MAOM-003419 is an ideal solution for customers developing EML-based PAM-4 transceivers," says Raymond Moroney, director of product marketing, High Performance Analog. "MACOM has achieved excellent performance with our PAM-4 chipset IP... This product is a great addition to enabling the next generation of 200G and 400G optical connectivity for enterprise and datacenter applications."

www.macom.com/opto-1

Emcore appoints new chief financial officer

The board of directors of 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 — has appointed Jikun Kim as chief financial officer, succeeding Mark Weinswig (who served as CFO since October 2010, and will be assisting through a transition period).

"We want to thank Mark for all of his contributions during his tenure and his support for the changes made at Emcore over the past few years," says president & CEO Jeffrey Rittichier.

"Kim brings broad operational and strategic experience to the organization and will play a critical role in leading the company through the execution of our business plan," comments Rittichier.

Kim has more than 20 years of experience in the high-technology industry. He has held senior financial management positions at several public and private high-growth companies. Most recently, he served as CFO of after-market aerospace support services firm Merex Group.

Prior to Merex, Kim was CFO of AeroVironment (a technology solutions provider with a portfolio of unmanned aircraft systems and electric transportation systems) and held senior finance positions with Raytheon Vision Systems. He holds a Masters of Business Administration in Finance from the Columbia Business School, a Masters of Science in Electrical Engineering from the University of California Los Angeles, and a Bachelors of Science from the University of California Berkeley.

Emcore to issue special dividend of $1.50 per share, completing return of $85m to shareholders

Emcore has completed its strategic review and will distribute $1.50 per share via a special dividend payable on 29 July to shareholders of record as of 18 July.

Emcore's board of directors will have hence returned about $85m of cash to its shareholders since June 2015, representing about 50% of the cash received from operations sold in the prior fiscal year.

"The return of cash to shareholders will strongly improve the return on assets of the business by reducing our overall capitalization, while maintaining flexibility to invest in new market opportunities to accelerate earnings growth," says president & CEO Jeffrey Rittichier. "We are encouraged by the performance of our CATV and Fiber Optic Gyro businesses and see strong growth opportunities in these and other areas to continue improving our financial performance," he adds.

"During my first year at Emcore, we grew revenues 47% and improved gross margins 13 points from fiscal-year 2014 to fiscal-year 2015, positioning the company for profitable growth. Building on this progress, we returned $45m to shareholders in June 2015 and began executing a strategic re-alignment of the manufacturing operations to drive margins higher," continues Rittichier. "With the core operations of the business on improved footing, in December 2015 the board and management began a comprehensive strategic review to strike the right balance between returning assets to shareholders and investing in growth opportunities," he adds. "During this review period, we actively worked to eliminate risks to our balance sheet posed by the Sumitomo arbitration and other lingering liabilities. Given the recent successful outcome of the Sumitomo arbitration and the completion of our strategic review, we are pleased to announce this return of capital to our shareholders."

As part of the strategic review process, the firm evaluated its growth opportunities in existing and adjacent markets, analyzed its products, technologies and production capabilities, and concluded that it could fully leverage its core competency in mixed-signal optics in both existing and new markets. As mixed-signal devices have both analog and digital circuits on multiple chips, or even a single chip, the value of these solutions is often far greater than traditional digital applications, and as a result they require specialized expertise that is unique in the optics industry, reckons the firm.

"Given Emcore's existing leadership in mixed-signal optic products such as DOCSIS 3.1 transmission devices, and emerging position in new products such as fiber-optic gyros and 5G distributed antenna system components for wireless applications, it became clear there is an opportunity to leverage our core mixed-signal competencies to penetrate new markets," says Rittichier. "Emcore is uniquely positioned as a supplier of advanced mixed-signal solutions given our design expertise and our captive wafer fabrication facility," he adds. "Mixed-signal technology is at the heart of all of our products, and is shared between fiber-optic gyros (sensor) and our CATV (transmission) products alike… If one were to open up one of our fiber gyros, one would see a miniature communication link that requires the same technologies, chip designs and production assets as our CATV products, giving us the ability to leverage our high-volume infrastructure against lower-volume, higher-value-added product."

www.emcore.com

Emcore appoints ex-AT&T/Lucent/CyOptics veteran Ed Coringrato to board

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 — has appointed Ed Coringrato to its board of directors.

Ettore (Ed) J. Coringrato Jr currently serves as a board member of Nanowave Technologies Inc, a manufacturer of microwave and millimeter-wave components and high-power solid-state transmit/receive subsystems for commercial aerospace, defense, medical, communications and industrial applications. He was a senior advisor to Nanowave from January 2014 to January 2016.

Previously, Coringrato served as president, CEO and board member of CyOptics Inc from January 2005 until its sale to Avago Technologies in June 2013, and he was VP of business development for CyOptics from February 2003 through December 2004. From 2000 until 2003, he was co-founder and chief financial officer of CENiX Inc, an optical start-up that developed high-speed optical modules using an automated manufacturing platform. Coringrato also worked for 18 years at AT&T and Lucent Technologies in its Microelectronics Group, where he held positions in engineering, marketing and sales, strategic planning, business development and product management.

Coringrato has a Bachelor of Science degree in Industrial Engineering and Systems Management, and an MBA from Pennsylvania State University.

"His extensive background in the telecommunications industry and expertise in wafer fabrication technology will be extremely valuable as Emcore continues to grow and expand into new markets," comments Emcore's chairman Dr Gerald Fine.

Emcore launches Medallion 8100 series DOCSIS 3.1 1550nm CATV transmitter and unveils linear externally modulated laser technology

At ANGACOM 2016 Exhibition & Congress for Broadband, Cable and Satellite in Cologne, Germany (7–9 June), Emcore launched the Medallion 8100 series DOCSIS 3.1, L-EML 1550nm externally modulated CATV transmitter.

The 8100 series leverages the L-EML (Linear Externally Modulated Laser), which was invented, developed and manufactured exclusively at Emcore. The L-EML 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)-based systems, claims Emcore.

To accommodate a broad range of network architectures, the Medallion 8100 series provides options, including P-type, C-type, T-type and R-type transmitters. The P-type transmitters offer a high-performance solution for applications where the simultaneous transport of CATV and satellite intermediate frequency (SAT-IF) signals are required. The SAT-IF signals can be applied anywhere in the 950–3500MHz band.

The C-type and T-type series transmitters are for use in node-splitting architectures requiring cost-effective dense wavelength division multiplexing (DWDM) transmission over medium-length fiber distances. They can be configured to meet most hybrid fiber coaxial (HFC) networks requiring link lengths from 0 to 65km with one erbium-doped fiber amplifier (EDFA) as well as links utilizing multiple EDFAs.

The R-type series transmitters are designed for fiber-to-the-premise (FTTP) and radio frequency over glass (RFoG) architectures requiring high-quality transmission over varying transmission lengths and EDFA output powers. The transmitters support very high optical launch powers while controlling the detrimental effects of stimulated Brillouin scattering (SBS), group velocity dispersion (GVD), and self-phase modulation (SPM).

"The Medallion 8100 series of rack-mount CATV transmitters ushers in a new era of transmission technology for the industry," says senior product line director Grant Olecko. "With the rapid adoption of next-generation DOCSIS 3.1 deployments throughout the world, Emcore recognized the need for 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," he adds.

At ANGACOM, Emcore showcased its full system-level portfolio for CATV, including the new Medallion 6100 series transmitters, the 8000 series of directly modulated transmitters, the new 7110 series of low-noise, high-power EDFAs, and the 2100 series of optical switches. Emcore also featured its full line of DFB butterfly lasers, DOCSIS 3.1 lasers, TO-56 lasers, low-noise optical receivers, broadband photodiodes and components for wireless and distributed antenna system (DAS) applications.

www.angacom.de
www.emcore.com

Hanergy launches full-solar-power vehicles with daily range of 80km

3.5–7.5m² of GaAs solar cells generate 8–10kW-hr

China-based thin-film solar power firm Hanergy Holding Group has launched four full-solar-power vehicles at a ceremony (attended by over 4000 guests) themed 'Disruptive Innovations Drive the Future' outside its headquarters in Beijing. R&D on the full-solar-power vehicles was undertaken independently by Hanergy, which owns more than 120 patents and proprietary intellectual property rights for them.

Beijing-based Hanergy launches full solar power vehicles.

Board chairman & CEO Li Hejun debuted the new sports car 'Hanergy Solar R' by driving it around the venue. The new series of vehicles also includes the Solar O, Solar L and Solar A, targeted at different groups of users.

In his speech, Li elaborated on the advantages of thin-film solar cells such as light weight and flexibility, enabling the cells to be integrated into products like cars, unmanned aerial vehicles, mobiles, backpacks and clothes. The new full-solar-power vehicles showcase the latest achievements of Hanergy's mobile energy strategy, he said.

With a solar energy conversion efficiency rate of 31.6%, Hanergy's gallium arsenide (GaAs) dual-junction solar cell was awarded with a World Record Certificate by the World Record Association at the launch event. Previously, on 5 January, the technology had been recognized by the US National Renewable Energy Laboratory (NREL) for its record efficiency.

The four new full-solar-power vehicles are integrated with flexible, highly efficient GaAs solar cells, maximizing the area covered (3.5–7.5m^2). Through a series of precise control and managing systems (including a photoelectric conversion system, an energy storage system and an intelligent control system), the zero-emission vehicles use solar energy as the main driving force. With 5–6 hours of sunlight, the thin-film solar cells can generate 8–10kW-hr of power per day, allowing the vehicle to travel about 80km (equivalent to over 20,000km annually), and hence satisfying the requirements for city driving under normal circumstances.

Users can manage different travelling and weather modes in a real-time, mobile, networked and smart way, selecting charging modes in accordance with varied weather conditions through Apps on their mobiles. In everyday-use mode, the vehicles can charge themselves with solar energy while traveling, making 'zero charging' possible for medium- and short-distance journeys. So, unlike traditional electric vehicles, the full-solar-power vehicles hence no longer need to rely on charging posts, eliminating the concept of 'distance per charge'. For weak sunlight or long-distance travel, the lithium batteries in the vehicle can get power from charging posts, enabling them to travel a maximum of 350km per charge.

Hanergy claims that the four new vehicles are the first full thin-film solar power vehicles that can be commercialized, breaking the bottleneck of poor practicality of previous solar-powered vehicles. The firm has also signed a framework agreement with Foton Motor to cooperate on developing clean energy buses.

www.hanergy.com

Fraunhofer ISE partners with NETRA on CPVIndia

Research project to determine requirements for using CPV in India

Fraunhofer Institute for Solar Energy Systems ISE of Freiburg, Germany, together with NETRA (the research facility of the largest Indian public utility NTPC), are working together on a cooperative research project to determine the specific requirements needed for the use of concentrator photovoltaics (CPV) in India.

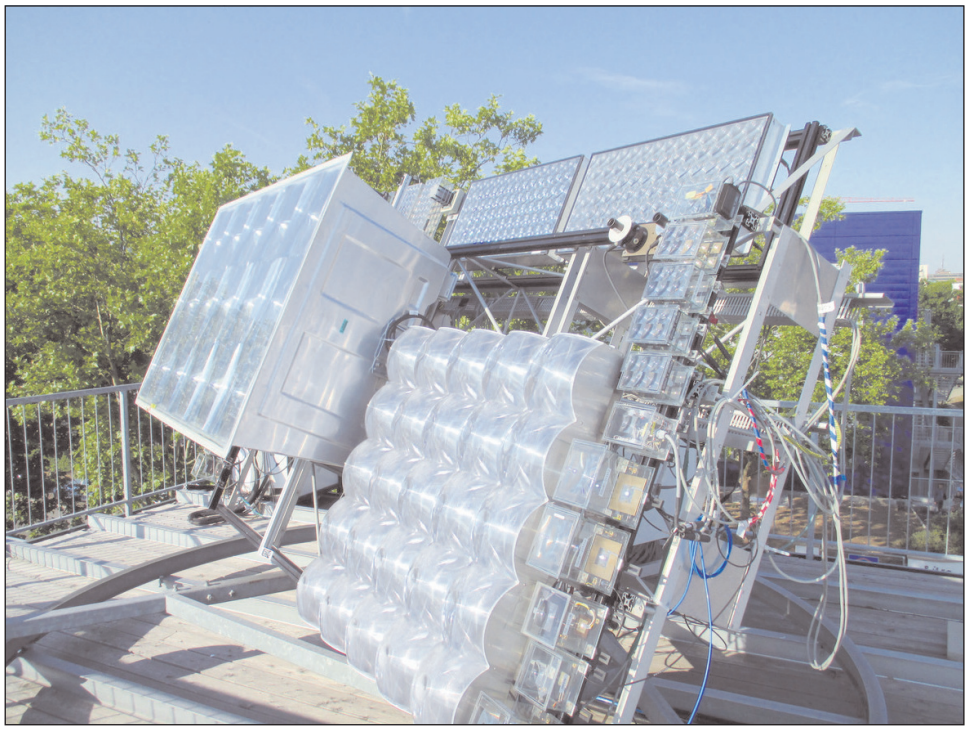
CPV is a cost-effective method for generating electricity in regions that have a large fraction of direct solar radiation. With the help of lenses, sunlight is concentrated onto small, highly efficient multi-junction solar cells with efficiencies above 40%. CPV modules are mounted on trackers that continually follow the sun's path in order to use direct sunlight.

The Indo-German research project CPVIndia is funded by the Kreditanstalt für Wiederaufbau KfW with resources from the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), as part of the international climate protection initiative.

Energy demand in India is large and growing rapidly. To meet this demand and at the same time develop the economy by climate-neutral means, the Indian government has declared the expansion of renewable energy in India as its goal. In this context, CPV is to be introduced as a research area in India and, in the medium term, established as a power plant technology.

"We want to achieve a transfer of knowledge especially in the area of CPV," says Dr Gerald Siefer, team leader of III-V Cell and Module Characterization at Fraunhofer ISE and head of the Indo-German CPV project. Numerous seminars are planned, given by researchers from Freiburg, together with their Indian colleagues.

"Another focus will be characterizing CPV technology in the context of the local climate conditions in India," says Siefer. For this purpose, four commercial CPV systems will be installed in India. These will be configured so that comparative tests can be performed, for example to determine the effects of soiling on the energy performance. On the test field of its Indian partner, Fraunhofer ISE will install a tracker that can be used flexibly for measuring either CPV or other types of PV modules. With this tracker, special measurements can be undertaken, for example to investigate how different CPV modules react to misalignments. The information gained is necessary for some of the evaluations carried out on the four CPV systems installed at the site.



CPV test tracker on the rooftop of Fraunhofer ISE — a similar system will be installed in India at NETRA's premises. ©Fraunhofer ISE.

The project will also provide the researchers with information on how to improve energy yield models for CPV. Relevant findings will be used as input for standards activities in the area of CPV, carried out by Working Group 7 of the Technical Committee 82 of the International Electrotechnical Commission (IEC TC82 WG7). The seminars and workshops are intended to have an impact that reaches beyond the project participants themselves and are open to external participants who are interested in the topics covered.

The project will also provide information on how to improve energy yield models for CPV

"The 'CPVIndia' project not only enables bringing CPV technology to India, but also opens up several new avenues for joint collaboration with Fraunhofer ISE in various new areas," says R K Srivastava, executive director, NETRA, NTPC Ltd during his visit to the Institute. The German Aerospace Center (Deutsches Zentrum für Luft und Raumfahrt; DLR) is also involved in a sister project on the topic of solar thermal power production (CSP). It is reckoned that a synergy could emerge, whereby the information gained about the required specifications for using concentrator technologies in India could benefit both types of power plants (CPV and CSP).

www.ise.fraunhofer.de

First Solar shifts Malaysian production capacity to Series 5 CdTe PV module assembly

TetraSun crystalline silicon solar panel product line discontinued to accommodate reallocation

First Solar Inc of Tempe, AZ, USA — which makes thin-film photovoltaic modules based on cadmium telluride as well as providing engineering, procurement & construction (EPC) services — is reallocating production capacity at its facility in Kulim, Malaysia to support a new assembly line dedicated to its recently announced Series 5 thin-film photovoltaic module.

As a result, First Solar will end production of its TetraSun crystalline silicon solar panel product currently manufactured there, and expects to incur impairment and related charges of $90–110m (substantially all of which is expected to be non-cash). These actions are expected to reduce First Solar's operating expenses by $2m to $4m this year and by $8m to $10m annually going forward.

The shift in production capacity is driven by First Solar's long-range business plan, which focuses on maximizing its core technology based on CdTe, according to chief operating officer Tymen de Jong.

"Over the past two years, execution of our CdTe technology roadmap has positioned the product as the industry leader for utility-scale solar, as well as established a promising path into the future," says de Jong. "The Series 5 module, and the Series 6 module still in concept development, are game-changing products that position us for exciting growth. They require the full attention of our manufacturing operations," he adds.

The Series 5 module, and the Series 6 module still in concept development, are game-changing products... They require the full attention of our manufacturing operations

"TetraSun is a sound technology for space-constrained rooftops, and served largely as a hedge against CdTe technology competitiveness that had challenged us in the past," de Jong continues. "With the success of our CdTe roadmap reflected in our record 22.1% cell efficiency, along with the proven higher energy yield and superior performance inherent in our thin-film technology, that hedge is no longer needed."

With this production transition, virtually all of the Kulim production associates previously assigned to the TetraSun line will move to the Series 5 assembly line, which will be in full operational mode by early 2017.

www.firstsolar.com

First Solar completes Atlas 25+ testing program for second time, on Series 4 PV module

Atlas Material Testing Technology LLC of Mt. Prospect, IL, USA, which provides weathering technology and services, says that, for a second time, cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA has completed the rigorous Atlas 25+ Comprehensive PV Durability Testing program and received test result certification from Atlas' inspection, verification, testing and certification partner SGS.

Testing was conducted on First Solar's original Series 4 thin-film photovoltaic module, which utilizes the core technology used in all of the firm's product offerings.

The Atlas 25+ protocol is a proprietary, multi-dimensional durability test program designed to subject photovoltaic modules to the environmental degradation stresses that can be expected over long-term service. The firm says that it provides manufacturers with the data needed to demonstrate long-term durability and to support warranty and performance claims, while reducing the costs associated with aftermarket product failure.

The Atlas 25+ program exposes solar panels to a series of stresses, including UV-A/UV-B exposure, salt spray corrosion, condensing humidity, solar/thermal humidity cycle, solar/thermal humidity freeze cycle, Arizona and Florida solar tracking — including peak summer — and initial, final and multiple interval measurements. In order to receive SGS certification, modules are required to have less than 8% degradation over the testing period.

"As part of the Atlas 25+ independent testing program, solar panels are exposed to harsh weather conditions similar to those faced during their lifetime," notes Richard Slomko, director of Atlas' Weathering Services Group.

"Only a handful of PV manufacturers — and no other thin-film manufacturer — have been certified," says Lou Trippel, First Solar's senior director of Product Management. "We are taking the world-class reliability documented here and building it into successive products," he adds. "We believe product evolution depends on fundamental reliability."

www.atlas-mts.com

PeroBOOST project to research efficient, stable lead-free perovskite solar cells

Germany-based consortium to develop both vacuum and wet-chemical roll-to-roll coating

Deposition equipment maker Aixtron SE of Herzogenrath, near Aachen, Germany says that it is pushing ahead with research on perovskite solar cells within the three-year project PeroBOOST (running from March 2016 to February 2019).

Aixtron will be collaborating with PeroBOOST consortium partners including the University of Cologne, PV system developer Enerthing GmbH, Herzogenrath-based laser machine system maker Lunovu GmbH, Cologne-based electrospray coating system maker Soluxx GmbH, the Center for Organic Electronics Cologne (ZOEK) GmbH, the Fraunhofer ISE Laboratory & Service Center (LSC) Gelsenkirchen, and Duisburg-Essen University (UDE). ZOEK will draw on the infrastructure available at the COPT.CENTRE for Organic Electronics at the University of Cologne (where ZOEK is the anchor tenant).

The basis for the project is the recent discovery of the properties of organo-perovskite materials for efficient solar cells. Aixtron says that this long-known of class of materials offers surprisingly great potential in terms of its energy conversion efficiency. The latest research results already report efficiency levels of more than 20%. The new type of solar cells is thus expected to achieve a similarly high level of energy efficiency as solar cells made of silicon. In addition to being expected to involve lower costs, the technology also opens up a variety of novel future applications due to its manufacturability on flexible substrates, notes Aixtron. Another attractive option involves using the technology in combination with silicon photovoltaics to further enhance efficiency.

Based on thin-film technology, the perovskite solar cell has many features in common with organic photovoltaics in terms of the materials used. The disadvantage of perovskite solar cells to date, however, has been that the highest efficiencies have only been achieved with lead-based materials. The development of perovskite solar cells that are stable on a long-term basis is also only in its infancy. Lead-free systems currently show lower levels of efficiency and long-term stability. The PeroBOOST project will therefore be focusing on two aspects and aiming to develop these further:

- efficient and stable lead-free perovskite solar cells;
- scaling up methods and techniques.

The project will hence investigate and develop two industrial production processes: vacuum coating and wet-chemical roll-to-roll coating.

The project also aims to investigate the stability of the solar cells and to develop processes and materials to enhance stability. For initial applications, a lifetime of 3–5 years is targeted.

PeroBOOST is being supported with funds from the European Regional Development Fund (ERDF) 2014–2020. LSC Gelsenkirchen will be responsible for developing new transparent conductors based on silver and copper nanowires. PeroBOOST is being supported by two institutes at UDE: the Institute of Materials Science and the Institute of Nanostructure Technology. The Institute for Materials Science develops and investigates functional materials for use in construction and electrical technology. Perovskites have been a key research field for more than 20 years now, although the types suitable for solar cell materials have only been investigated more recently. The focus here is on materials synthesis. The Institute for Nanostructure Technology develop tools and prototypes for use in electrical technology (with major topics being thermoelectric materials and solar cells). Existing research on organic solar cells is now being supplemented to include organic-inorganic systems. The institute's strengths also include device technology and optoelectronic and electrical characterization.

www.aixtron.com

ZSW regains thin-film solar cell efficiency record with 22.6% CIGS PV cell

Post-deposition treatment of surface with alkaline metal compounds boosts efficiency from 22%

ZSW (Zentrum für Sonnenenergie- und Wasserstoff-Forschung — or Center for Solar Energy and Hydrogen Research — Baden-Württemberg) in Stuttgart, Germany has set a world record for thin-film photovoltaic cell energy conversion efficiency for the fifth time, with 22.6% for its latest copper indium gallium diselenide (CIGS) PV cell, as confirmed by Fraunhofer Institute for Solar Energy Systems ISE. This surpasses ZSW's prior world record of 21.7% (set in September 2014), its European record of 22% (announced at the end of March), and the most recent world record of 22.3% set by a Japanese-made cell, as the pace of advances accelerates: the efficiency of CIGS-based thin-film solar cells has risen more in the last three years than in the previous 15 years.

ZSW's latest record-setting cell has an area of about 0.5cm^2 (a standard size for test cells), and again was produced in a laboratory coating machine using the co-evaporation method. ZSW achieved the boost in performance by improving the manufacturing process at several points, including post-deposition treatment of the CIGS surface (with alkaline metal compounds being incorporated into this layer).

Momentum has been building in thin-film photovoltaics in recent years, notes ZSW. Records were few and far between from 1998 to 2013, with cells holding the best mark for as long as two or three years. Efficiency increased by just 0.1 percentage points per year on average. However, in the last three years the world record has been eclipsed every six months or so, with an average increase of 0.7 percentage points per year.

With these latest advances in R&D, thin-film cells could soon be a serious contender for the silicon-based solutions that have dominated the PV market for years, reckons ZSW. The lead of multi-crystalline silicon cells is now just 1.3 percentage points.

ZSW researchers still see plenty of untapped potential in the technology behind CIGS solar cells. "We can achieve up to 25% efficiency in the years ahead," expects professor Michael Powalla, ZSW board member and head of the Photovoltaics division.

We can achieve up to 25% efficiency in the years ahead

Thin-film cells are also making strides in other areas, as evidenced by key performance indicators: CIGS PV technology is catching up to multi-crystalline silicon regarding efficiency of the entire module (the larger module is always slightly less efficient than the smaller cell). The two technologies are not very apart these days, with efficiencies of 15% and 17% respectively. At US$0.40 per watt, the cost of manufacturing CIGS modules has also fallen to a level on a par with that of silicon technology. However, researchers are confident that module efficiency could reach 18% or more, with production costs dropping to about US$0.25 per watt. Also, whereas the price of silicon PV products depends largely on economies of scale, CIGS modules can be manufactured at low cost even on a relatively small scale, notes ZSW.

In the months ahead, ZSW will team up with its industry partner Manz AG of Reutlingen, Germany (a mechanical engineering firm that offers turnkey manufacturing lines for CIGS thin-film solar modules) to transition the latest advance from the lab into the factory.

www.manz.com
www.zsw-bw.de

XsunX launches Affiliate Sales Program

XsunX Inc of Aliso Viejo, CA, USA, which is developing hybrid copper indium gallium (di)selenide thin-film (CIGS) photovoltaic (TFPV) cell technologies and 'CIGSolar' manufacturing processes, has begun its entrance into an affiliate network marketing relationship to boost exposure and enhance the sales of its residential and commercial clean energy solutions.

Under the XsunX affiliate sales program, the parties will collaborate to generate interest among the affiliate company's current clients, giving both firms an opportunity to expand through a cross-marketing strategy designed to increase exposure and revenues through existing relationships.

"In consideration of the fact that we share a mutual target market, a plan was formed that will serve to benefit both entities, strengthening our presence in the solar market," says CEO Tom Djokovich. "At this stage of the game in our growing industry, we have found that when companies join forces to serve a common market, they are able to provide a diverse selection of solutions," he adds. "This is one of today's most successful marketing methods employed to expand a service provider's reach and, as evidence of the strategy's potential, we are already seeing deal flow and sales through the affiliate network."

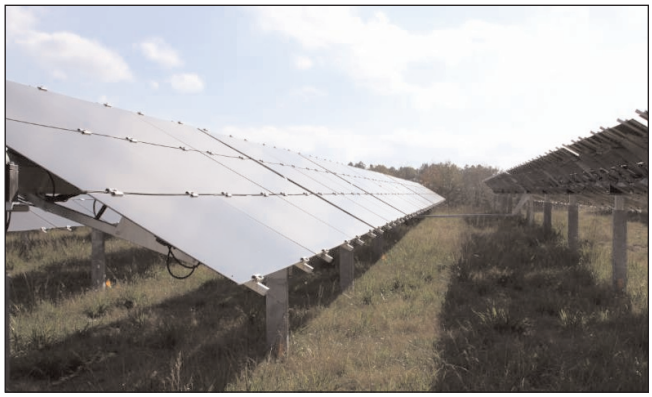
www.xsunx.com

Stion completes first direct utility projects in Mississippi

Stion Energy Services — the turn-key project development arm of Stion Corp of San Jose, CA, USA, which makes CIGS (copper indium gallium selenium) — recently completed the installation of the first utility projects in the State of Mississippi. A total of 1.5MW was installed at three different sites for Entergy Mississippi Inc.

One of the arrays — a 500kW system in Hinds County — is equipped with a single-axis tracking system that will generate 820,000kWh of power every year using Stion's solar modules. Two additional 500kW fixed-tilt arrays were installed in DeSoto County and in the City of Brookhaven. Collectively the three arrays will generate 2.2MW-hr of electricity on an annual basis for Entergy's customers in Mississippi.

Combining the benefits of a single-axis tracker with the increased performance benefits of the Stion module increases Entergy's return on investment, delivering better value as the solar modules produce more energy as they track the sun across the sky. "This maximizes the available light and increases power output of the system by 20% over the course of a Mississippi day," says Jim McGrath, VP of sales for Stion.



Stion Energy Services 500kW single-axis tracking array in Hinds, MS.

Entergy selected different locations throughout the state to test how panels perform in Mississippi's hot and humid climate. When the operating temperature of a solar panel increases, it starts to affect the module's energy production. In the hot Mississippi climate Stion systems are expected to produce 5% more per kW than silicon modules, primarily due to a low temperature coefficient of –0.26%/°C. Stion adds that its frameless modules provide additional value due to: no debris building up at the edge of the module (leading to better performance); and increased packaging density and a lighter-weight module (leading to lower transportation costs).

Entergy decided to work with Stion Energy Services, the only vertically integrated solar developer in the state. The modules were manufactured in Hattiesburg, MS, less than 100 miles from the installation sites, enabling Entergy to support the local economy as it tests the benefits of solar power.

"Solar energy will be an important part of the state's energy generation mix going forward, and we look forward to continuing to grow our manufacturing and project development efforts in Hattiesburg," says Frank Yang, Stion's VP of business development & marketing.

www.stion.com

Stion and Silicon Ranch complete Mississippi State's largest commercial solar facility

Stion and Silicon Ranch are celebrating the completion of Mississippi's largest commercial solar facility to date, sourced with modules made in Mississippi. The 3.9MW facility, which uses Stion's solar panels manufactured in Hattiesburg, MS, is located in Chickasaw County. Construction of the solar farm created about 75 jobs, with over half hired from the local labor pool.

Owned and operated by Silicon Ranch, the facility will provide enough electricity to help power more than 400 homes and businesses. Chickasaw County has the third-largest manufacturing capacity in the state of Mississippi, and such savings should help to keep local businesses competitive and help drive economic development in the region, it is reckoned.

Over the lifetime of Silicon Ranch's investment, the project will generate tax revenue from property taxes and generation for local governments. In addition, Silicon Ranch will provide funds to Mississippi State University and Houston High School to train students in engineering, manufacturing, installation, and operation of solar sites in Mississippi. "Houston, Mississippi has long been a solar-centered city with the great work at Houston High School," states commissioner Brandon Presley, who leads The Public Service Commission of the Northern District of Mississippi. The Houston Solar Car Team has won 14 of the last 15 challenges, beating all other high-school teams from across the USA at the annual event held in Austin, TX.

The panels use CIGS-technology, which are said to outperform other types of solar panels, particularly in hot climates due to an industry-leading temperature coefficient. The panel's design also has a unique cell structure that limits production losses due to shade, Stion adds.

By the end of 2016, Stion's factory will be able to produce 150MW of solar modules annually. The factory currently employs 110 people in Hattiesburg.

University of Tokyo tests 'solar sharing' using Solar Frontier's CIS solar panels above farm crops

Tokyo-based Solar Frontier — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — has provided its CIS solar panels for a 'solar sharing' experiment on Sado Island, Niigata Prefecture, Japan.

Solar sharing in Japan refers to the practice of using the same plot of land to simultaneously grow crops and generate solar power. Panels are installed high above the crops and spaced further apart than usual, enabling sufficient sunlight to pass through and farmers to work below. This business model has been gradually spreading across Japan, helping farmers to earn additional income by selling electricity.

Advancing this experiment is the University of Tokyo's IR3S (Integrated Research System for Sustainability Science), which aims to evaluate the potential economic impact of solar sharing on Sado Island, where the population is both declining and ageing. It is doing so as part of a broader project, which looks at using renewable energy and maximizing natural resources to achieve a low-carbon society and help to revitalize communities.

Solar Frontier's CIS solar panels installed over a small field of newly planted broccoli.

Solar Frontier has provided 10kW of its lightweight Solacis neo CIS solar panels for this experiment. In real-world conditions, CIS solar panels yield more electricity than crystalline silicon panels, including areas that receive lower levels of sunlight such as Sado Island, says the firm. This is currently being demonstrated by installations such as the Niigata Yukiguni Megasolar Power Plant (connected in 2010 in Niigata Prefecture) as well as smaller projects such as Gakko Gura ('school cellar'), a Japanese sake brewery that re-uses the building of a former elementary school on Sado Island.

Solar Frontier's panels have been installed facing south at a low inclination angle of 13.5°, and are expected to generate about 11,000kWh per year. The panels have also been installed 2m high, enabling the farmer to tend to his crop. In this particular case, it has started with a round of broccoli which will be followed by a range of seasonal vegetables as the year progresses. The test will hence provide data on light-shielding rates and crop yield for the Washizaki district (an area with relatively difficult farming conditions).

Solar Frontier says that it will continue to focus on collaborating with industry, academia and government, utilizing its CIS thin-film modules to promote distributed energy generation initiatives rooted in local regions.

http://en.ir3s.u-tokyo.ac.jp
www.solar-frontier.com/eng/casestudies/caselist/C002290.html

Solar Frontier announces completion of 14MW of projects installed with CIS PV modules in Indiana

San Jose-based Solar Frontier Americas, the US subsidiary of Tokyo-based Solar Frontier – the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules – says that two utility-scale solar projects installed with its CIS modules have been completed and are now in operation.

Located in Terra Haute and Brazil, Indiana, USA, both solar power generation plants are 7MW in size, and are the largest utility-scale projects in their respective counties. First announced in October 2015, the projects were developed and are owned and operated by Cypress Creek Renewables (CCR), which specializes in locally based development strategies and ownership of solar projects (with over 2.6GW of solar farms deployed or in development). The projects are delivering power to Duke Energy under a 20-year power purchase agreement (PPA).

"Cypress Creek Renewables is committed to the local communities they build in and they deliver high-quality, well-kept solar power generation plants," comments Solar Frontier Americas' chief operating officer Charles Pimentel.

According to the Solar Energy Industries Association (SEIA), the state of Indiana has 150MW of solar installed and is projected to install 345MW of capacity over the next five years. In addition to the federal tax credit and depreciation deductions, Indiana offers several renewable energy tax exemptions.

www.ccrenew.com
www.solar-frontier.com

Solar Frontier provides solar panels to help keep Bolivia's Uyuni salt flats clean

Tokyo-based Solar Frontier — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — has provided solar panels to Projecto YOSI, an organization working to keep Bolivia's Salar de Uyuni clean and promote sustainable tourism in the region.

Projecto YOSI will use the solar energy system (which consists of 40 solar panels) to power a device that changes plastic waste into petroleum, helping to address the growing problem of litter in the area. It is doing so with the help of the local community.

Representing the world's largest salt flats, the Salar de Uyuni is also among the flattest places in the world, with ground level differences no bigger than 50cm. So, when a thin film of water collects on top of the vast salt deposits during the rainy season, the flooded plains turn into what's described as a 'Sky Mirror', as the undisturbed surface of water reflects back the sun, sky and clouds.

The Uyuni Salt Flats are a popular sightseeing spot, attracting around 1.2 million visitors to Bolivia annually. But with few facilities to deal with waste, the salt flats are also accumulating litter, impacting the living standards of local communities, the quality of the salt collected from the salt flat, and the view of the landscape. To address this, a Japanese tour guide launched Projecto YOSI and, over time, gained the support of the local government and academic institutions.

Yoshihito Honma, representing the organization, has spent the last seven years leading tours across South America. He decided to raise awareness about this issue after witnessing the growing amount of litter lying across the region. As a first demonstrative step, he has introduced a small, solar-powered device that can break down plastic waste into petroleum. Some local people now even bring in plastic waste from their homes. Projecto YOSI has since gained wider recognition in Bolivia, including from the Ministry of Environment, municipal governments, universities and other organizations. In January, it featured in the Bolivian Ministry of Environment's booth at the Rallye Dakar.

Honma now also serves as a visiting lecturer on environmental issues at the University of San Andrés (IIAT: Applied Technology Investigation Institute) and as a supervisor for a joint project with the Ministry of Environment. Aiming to boost environmental awareness, he is undertaking activities in the hope of establishing Bolivia's first recycling facilities.

"I dream that the Uyuni Salt Flats will one day be recognized as a model for sustainable tourism and environmental protection… The first step is to set up activities that will protect the environment. To that end, it's important that we can establish a recycling system that is locally led," says Honma. "The solar panels that we have chosen are among the most environmentally friendly and, even in harsh environmental conditions, have demonstrated stable power generation," he adds.

"This kind of opportunity helps customers think about what solar energy can really achieve," says Yoshihiro Ishikawa, manager of Solar Frontier's Global Business Planning Division. "We're very grateful if projects such as these — using a device powered by clean, solar energy to turn waste into petroleum — will help raise public awareness."

www.yosip.org

Solar Frontier Americas begin constructions on two Californian PV projects totaling 107MWp

San Jose-based Solar Frontier Americas, the US subsidiary of Tokyo-based Solar Frontier — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — says that two utility-scale solar projects from its development pipeline are now in the construction phase in California's Imperial County. Midway I will generate 67MWp and has an executed power purchase agreement (PPA) with Pacific Gas & Electric. Midway II will generate 40MWp and has a PPA with the Imperial Irrigation District.

Managing both projects is Solar Frontier Americas' utility-scale project development division Solar Frontier Americas Development, which consists of a team offering development expertise, substantial financial resources and a network of industry relationships to ensure solar projects are executed on schedule. Blattner Energy is providing engineering, procurement & construction (EPC) services, Power Electronics will supply inverters, and NEXTracker will supply its NX Horizon single-axis trackers for increased energy yields.

"Solar Frontier has developed an extensive US project development pipeline of over 400MW and has rapidly established itself as a reliable and bankable player in the solar development industry," claims Solar Frontier Americas Development's CEO Charles Pimentel.

"Solar Frontier's solar projects will generate hundreds of direct jobs and employ local workers in Imperial County," comments Ryan Kelley, Imperial County supervisor, District 4.

www.solar-frontier.com

Integrating silicon photonics and III-V photodetectors in micro-spectrometer

Researchers claim longest wavelength for 3.8μm device that gives access to organic compound analysis.

Researchers based in Belgium, The Netherlands, the UK and France have realized heterogeneous integration of an indium arsenide antimonide ($InAs_{0.91}Sb_{0.09}$) photodiode array on a silicon-on-insulator (SOI) spectrometer for wavelengths as long as 3.8μm [M. Muneeb et al, Optics Express, vol24, p9465, 2016]. The team from Ghent University/imec, Eindhoven University of Technology, University of Southampton, and Université de Montpellier report: "To our knowledge this is the longest-wavelength integrated spectrometer operating in the important wavelength window for spectroscopy of organic compounds."

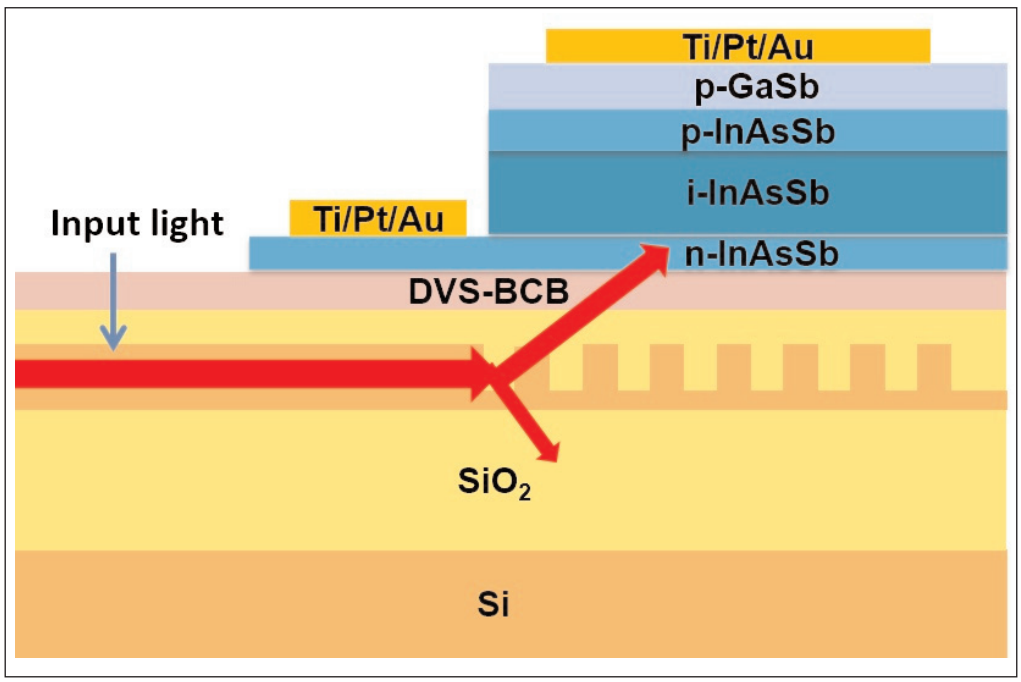


Figure 1. Schematic of grating-based coupling scheme.

The researchers believe that such heterogeneous integration could also be applied to broadband light sources on-chip for fully integrated spectroscopic sensing systems.

The 3.8μm-wavelength mid-infrared region is important for spectral analysis of carboxylic acids. Shorter wavelengths of 3.3–3.5μm could cover hydrocarbons. Integration of the components required for such analysis on a single chip could lead to reduced costs and size for spectroscopic systems.

The arrayed waveguide grating (AWG) structure was built using silicon-on-insulator technology. The SOI wafer structure had 380nm of silicon on 2μm of buried silicon dioxide. The silicon layer was 220nm crystalline and 160nm polycrystalline. The waveguides were produced by etching 160nm and cladding with silicon dioxide.

The waveguides were designed for transverse electric (TE)-mode light with a center wavelength of 3.8μm. The array consisted of six channels spaced 9.6nm apart. The input and output ports consisted of grating couplers created through etching down 230nm. The researchers comment: "For the integration of the photodiodes we chose a grating-based coupling scheme because it is more fabrication tolerant as compared to other schemes like butt coupling or evanescent coupling." Grating couplers were also used for the input from optical fibers.

The upward angle for the light into the integrated III-V photodiode (Figure 1) was optimized through simulations varying the thickness of the top cladding of silicon dioxide and DVS-BCB cyclobutene polymer used as bonding agent.

The researchers used imec's CMOS pilot line to create the AWG structures. The top cladding silicon dioxide was 800nm, achieved through deposition and planarization. The smooth top cladding improves the photodiode bonding uniformity; reduces overlap between the waveguide mode and the bonding material that absorbs ~3μm light; and protects the underlying waveguide structure during photodiode fabrication.

The epitaxial material for the photodiode was grown on n-type gallium antimonide (GaSb) wafers using

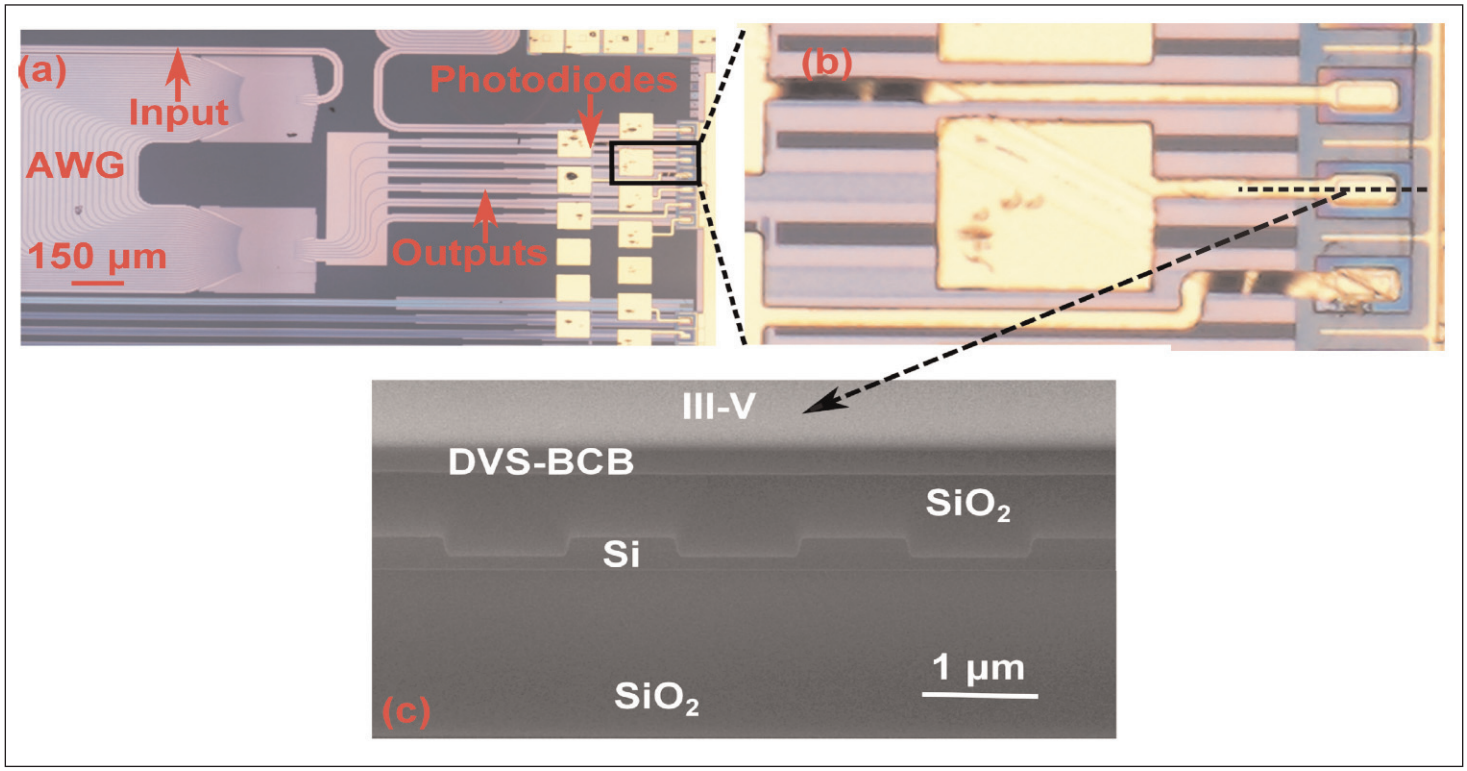


Figure 2. (a) Microscopic image of complete fabricated device, (b) close-up of single heterogeneously integrated photodiode and (c) scanning electron microscope (SEM) cross-section of photodiode.

molecular beam epitaxy (MBE). The growth sequence consisted of 550°C deoxidation, a 500°C GaSb buffer layer, a 450°C 0.5µm $InAs_{0.91}Sb_{0.09}$ etch-stop layer, a 50nm p-GaSb/50nm p-$InAs_{0.91}Sb_{0.09}$ contact layer, a 1µm unintentionally doped $InAs_{0.91}Sb_{0.09}$ absorber, and a 250nm n-$InAs_{0.91}Sb_{0.09}$ contact layer.

The III-V material was flipped and bonded to the AWG wafer using 300nm DVS-BCB. The 200µm GaSb growth substrate was lapped down to about 75µm before wet etching the remainder down to the etch-stop layer. The etch-stop layer was itself removed in another wet etch.

Further fabrication consisted of wet etching 30µm x 45µm mesas aligned with the grating couplers, deposition of metal contacts, and DVS-BCB passivation of the photodiodes. The AWG region covered an area of 1.1mm x 0.78mm. The total spectrometer area was 1.2mm^2 (Figure 2).

"To our knowledge this is the longest-wavelength integrated spectrometer operating in the important wavelength window for spectroscopy of organic compounds." The researchers believe that such heterogeneous integration could also be applied to broadband light sources on-chip for fully integrated spectroscopic sensing systems.

The DVS-BCB passivation was found to be needed to create rectifying behavior in the photodiode by suppressing sidewall leakage currents. Even with passivation, the dark current was rather high: 600µA at –50mV and 170µA at –10mV. The researchers attributed 136µA to the photodiode and 34µA to sidewall leakage for the –10mV reverse-bias dark current.

The researchers point out that a homogeneous $InAs_{0.91}Sb_{0.09}$ structure is used for the p-i-n diode. High-bandgap barriers could reduce the bulk leakage and better passivation could be used to further reduce sidewall leaking.

The six channels covered wavelengths separated by about 10nm between 3740 and 3800nm. The crosstalk suppression was 16dB, which was worse than the 20dB of a passive system developed and reported by the group in 2013. The researchers attributed this to increased phase noise in the arrayed waveguide grating due to processing of the photodetectors.

The system responsivity ratio of photocurrent/optical power in the fiber was 1.1mA/W. The fiber-to-chip coupling efficiency was estimated to be –20dB. The AWG insertion loss is given as 3dB and the waveguide losses as 5dB/cm. The researchers therefore estimate the on-chip photodiode response to be 0.3A/W, corresponding to a quantum efficiency of about 10%. The quantum efficiency matches expectations from the simulations. ■

http://dx.doi.org/10.1364/OE.24.009465

Author: Mike Cooke

Direct growth of InAs quantum dots on silicon

Mike Cooke reports on recent progress in producing III-V layers on silicon without using wafer bonding, showing potential for wider applications.

Direct growth of laser and photodiode structures on silicon could lead the way to lower-cost processing, and hence wider commercialization of compact photonic integrated circuits (PICs) on mainstream silicon platforms such as silicon-on-insulator (SOI) waveguides and CMOS electronics. Potential applications include communications, healthcare and energy systems.

Monolithic infrared photodetectors integrated with silicon-based readout electronics could also be used in high-performance, multi-spectral and large-format infrared focal plane arrays for hyperspectral imaging, infrared spectroscopy, and target identification. Other possible uses of such detectors include free-space communication, surveillance, tracking and missile interception, chemical sensing, and biomedical imaging.

Presently, combining laser diode and photodiode technology with silicon often involves tricky wafer bonding techniques. Direct growth of efficient III-V light-emitting semiconductor material on silicon has been hampered by reduced crystal quality due to lattice mismatches between the different crystal layers.

Gallium arsenide (GaAs) growth directly on silicon is hampered by lattice (~4%) and thermal expansion coefficient (TEC) mismatches, which generate dislocations. Better quality direct growth of some III-V materials can be achieved on germanium (Ge) either as a substrate or as an intermediate layer on silicon ('virtual substrate'). However, the presence of germanium can limit the range of accessible silicon electronic circuitry. Also, germanium absorbs the infrared light typically used in optical communications.

Microdisk lasers

Recently, there have been a number of reports on the direct growth of III-V material on silicon that contain indium arsenide (InAs) quantum dot (QD) light-emitting or light-detecting regions, including lasers. Some of the laser devices are not yet at the level of electrical pumping, but do point to future possibilities.

Researchers in Hong Kong and USA have been working on producing optically pumped micro-disk lasers on exact (001) silicon [Yating Wan et al, Appl. Phys. Lett., vol108, p221101, 2016]. The team, from Hong Kong University of Science and Technology (HKUST) and University of California Santa Barbara (UCSB), Sandia National Laboratories and Harvard University in the USA, writes: "We believe that the ultra-low threshold and small-footprint configurations provide significant insights and inspire future possibilities to incorporate efficient and compact laser sources on a CMOS-compatible platform."

The resulting devices had comparable performance to ones produced on GaAs substrates. The use of on-axis substrates is more compatible with mainstream CMOS silicon electronics compared with wafer bonding or epitaxy on offcut substrates with a germanium buffer or direct GaAs nucleation.

Laser emission at around 1.3μm was achieved in 'subwavelength' 1μm-diameter devices. The researchers claim that subwavelength lasing had not been reported in devices produced on silicon before, although it had been on GaAs substrates. In earlier work, almost the same team claimed the first 1.3μm room-temperature continuous-wave (cw) InAs QD microdisk lasers epitaxially grown on industry-compatible Si (001) substrates without offcut [Yating Wan et al, Optics Letters, vol41, p1664, 2016].

A GaAs template layer was produced first, consisting of a 1μm layer of coalesced GaAs on V-grooved silicon (GoVS) grown by metal-organic chemical vapor deposition (MOCVD) — see Figure 1. By growing GaAs first as nanowires in the grooves, followed by coalescence, the resulting template was of high quality and free of anti-phase domains. The lattice mismatch between the GaAs and silicon groove wall was 4.1%. The technique also avoids the use of thick buffer layers and dislocation filters, which are optically absorbing. The transition between the structures was accommodated with a few nanometers of stacking faults (SFs). The SFs were trapped in this region by 'diamond-shaped-pockets' near the top of the grooves.

The researchers see analogies with the aspect ratio trapping (ART) used to integrate III–V high-mobility channel fin field-effect transistors on silicon: "The GoVS templates can thus be envisaged as an extension of III–V fin arrays for optoelectronic devices requiring large active regions, suggesting the possibility of co-integration of silicon photonic and electronic circuits onto the same chip. More importantly, the highly scalable growth technique presented here is

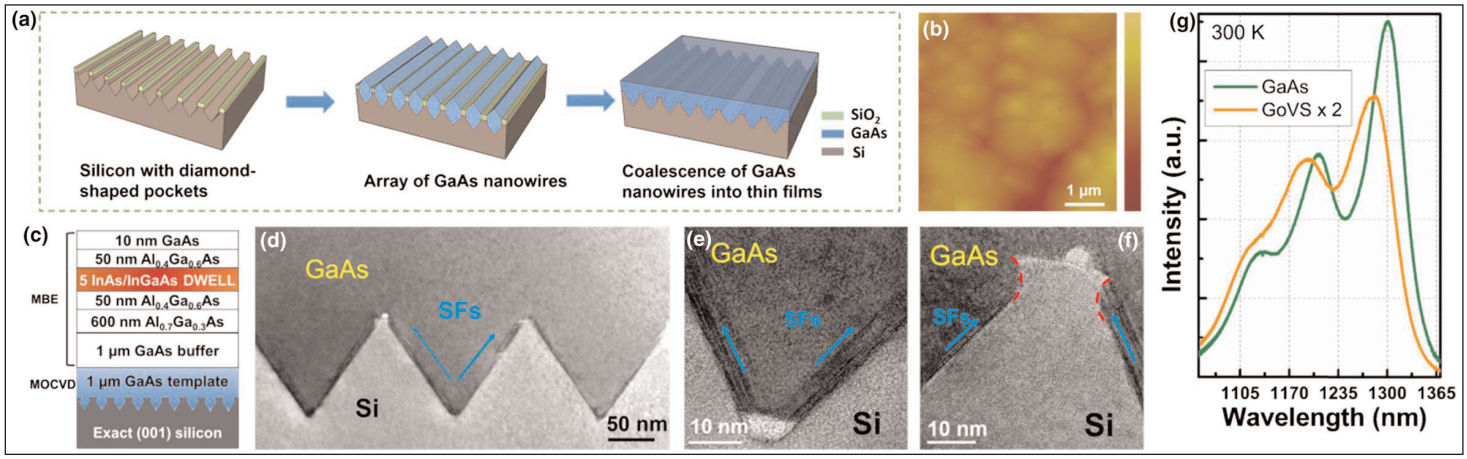


Figure 1. (a) Procedure for growing antiphase-domain-free GaAs thin films. (b) AFM image of coalesced GaAs thin-film grown on nanowire array. Vertical bar is 25nm. (c) Schematic of as-grown structure of microdisk lasers. (d)–(f) Cross-sectional transmission electron micrographs (TEM) of V-groove. (g) Room-temperature photoluminescence spectra of as-grown structures on GoVS template and GaAs substrate.

extendable to the [indium phosphide] InP material system, and can be potentially used for the growth of various heterostructures with ternary and quaternary materials, quantum wells, or QDs on silicon, as evidenced by a recent report of InP distributed feedback [DFB] laser arrays directly grown on silicon."

Since the surface of the GoVS template had low roughness of ~2nm root-mean-square over 5μm x 5μm atomic force microscope (AFM) scans, there was no need for chemical mechanical polishing (CMP). The researchers estimate the GaAs defect density at ~10^8/cm^2, commenting: "Both TEM and x-ray diffraction suggest a three- to four-fold reduction of defects, as compared to blanket heteroepitaxy of GaAs on offcut silicon wafers."

Further layers (Figure 2) were grown by molecular beam epitaxy (MBE) and included a 1μm GaAs buffer and 600nm of $Al_{0.7}Ga_{0.3}As$. The active region of the micro-disk laser consisted of five layers of InAs QDs in

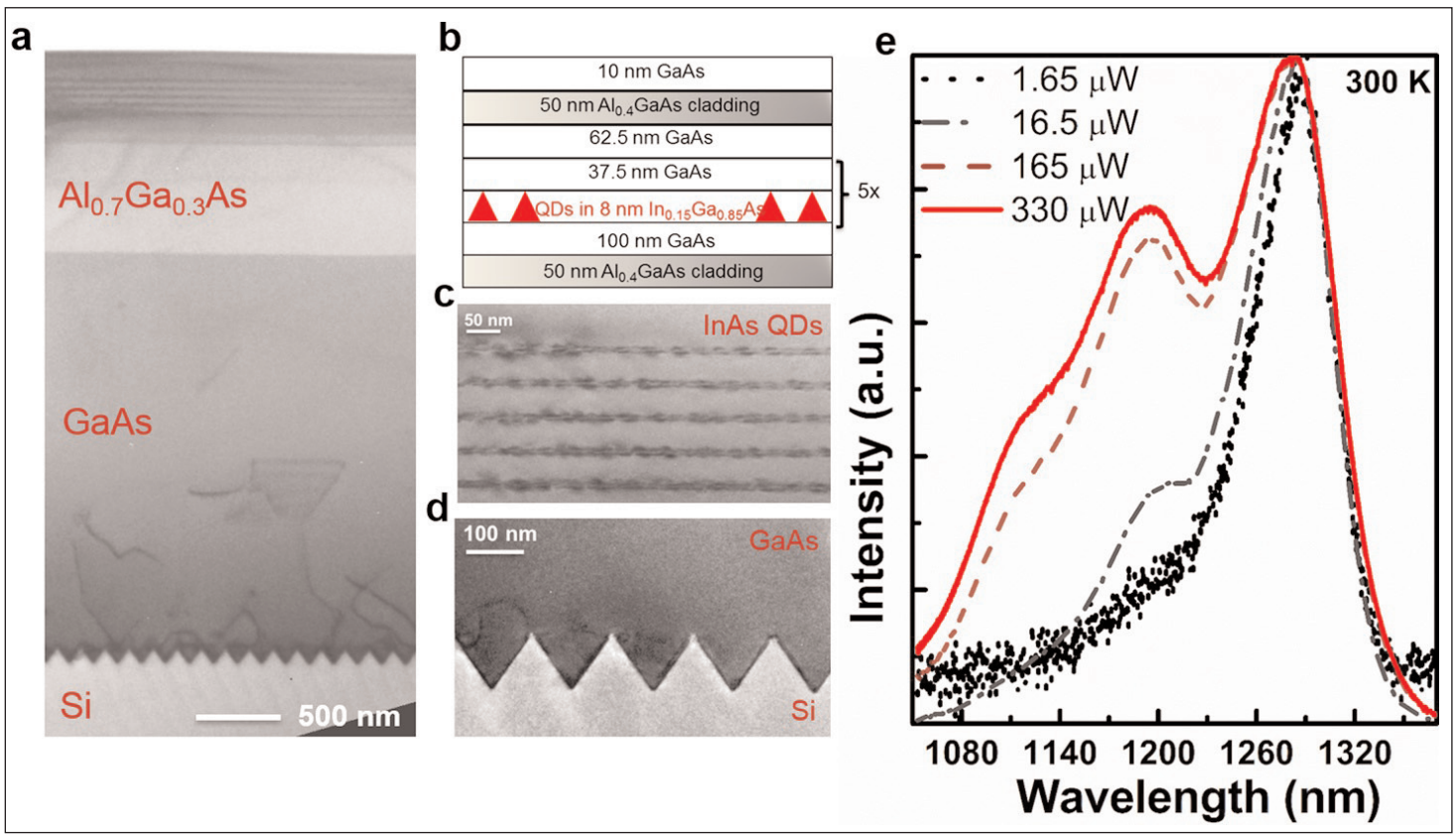


Figure 2. (a) Cross-sectional TEM of micro-disk structure grown on GoVS substrate; (b) schematic epitaxial structure of material in disk region; (c) high-resolution TEM of five-stack InAs QDs; (d) cross-sectional TEM of V-grooved structure, showing defect trapping and localization; (e) room-temperature photoluminescence spectrum of as-grown structure at progressively higher excitations.

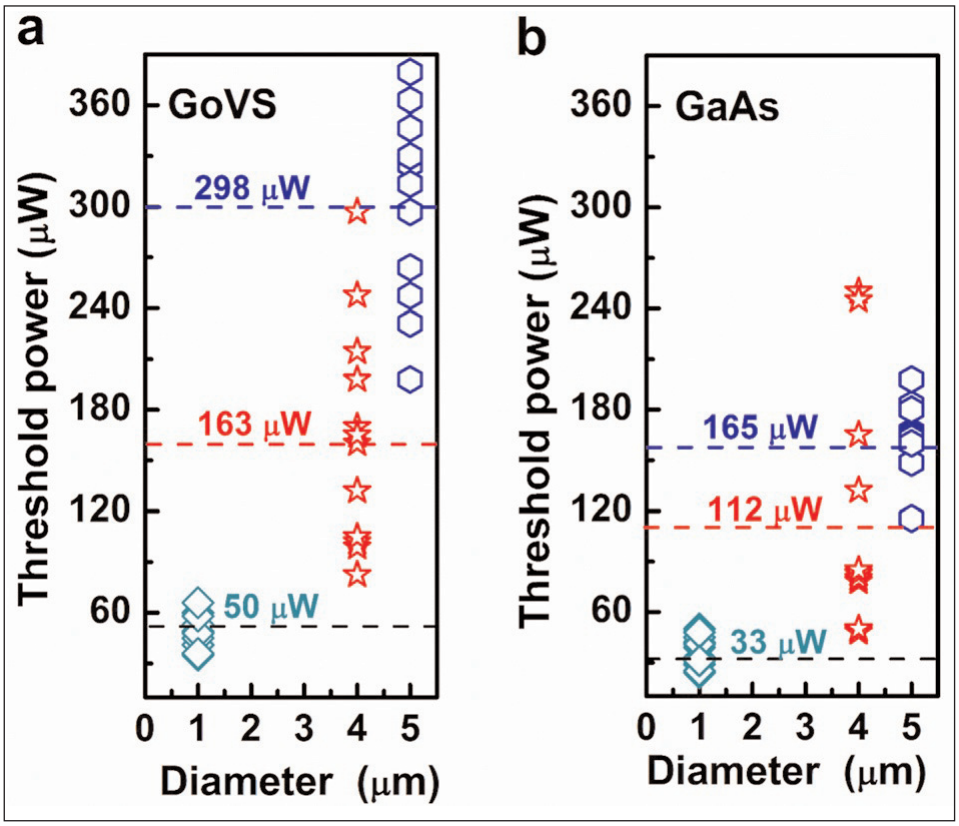


Figure 3. Threshold power as function of disk diameter on GoVS template (a) and GaAs substrate (b). Dashed lines represent average threshold.

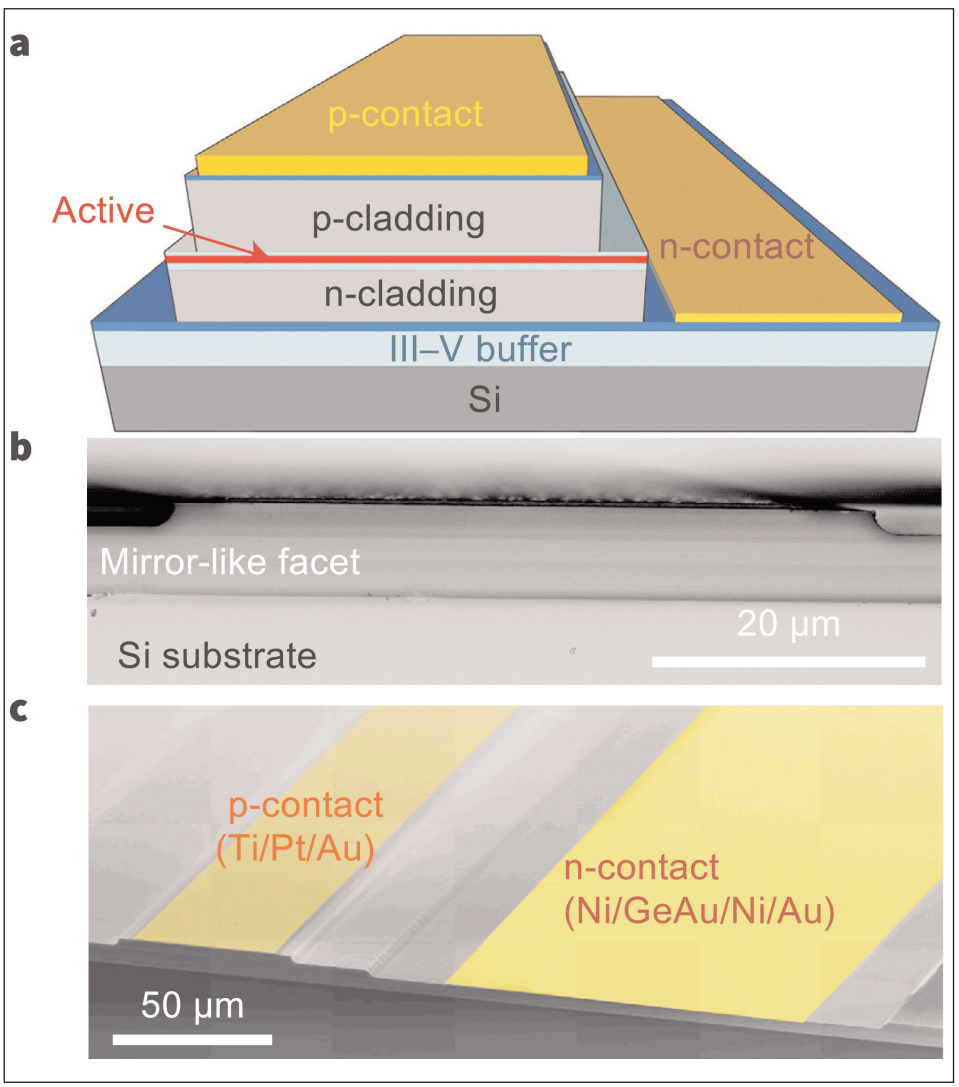


Figure 4. a, Schematic of layer structure of InAs/GaAs QD laser on silicon substrate. b, Cross-sectional SEM image of fabricated laser with as-cleaved facets, showing good facet quality. c, Scanning electron microscope overview of complete III–V laser on silicon.

InGaAs wells with GaAs barriers. The dot-in-well (DWELL) layers had a dot density of $4.3 \times 10^{10}/cm^2$.

In photoluminescence, the lowest excited-state to ground-state emission was found to be in the 1.3μm optical telecom band. Higher excited states appeared in a high-energy/shorter-wavelength shoulder with increased pumping. "The wide inhomogeneous linewidth (20meV) allows for easy coupling into the resonant modes from small-volume cavities with a large free spectral range (FSR)," the team adds.

The micro-disks were fabricated using lithography based on a colloidal suspension of 1μm-diameter silica beads, which were dispersed on the epitaxial material as a hard mask for inductively coupled plasma etch. The underlying $Al_{0.7}Ga_{0.3}As$ was under-etched with hydrofluoric acid to create pedestals for the micro-disk structures. The pedestal was designed to confine the optical modes to the disk and avoid evanescent coupling of electromagnetic energy into the underlying substrate.

Continuous-wave pumping with light from a 532nm diode laser at 10K showed evidence of lasing in the form of linewidth narrowing. The estimated thresholds came in the range 35–67μW. The average was around 50μW, about 1.5x that for micro-disk layers on GaAs substrate (33μW). "The somewhat larger lasing thresholds on silicon are presumably related to crystalline defects (on the order of $1 \times 10^8/cm^2$ by plan-view transmission electron microscopy) leading to reduced QD modal gain," the researchers comment.

Larger disk diameters required a higher pump power (Figure 3). The researchers attribute this to the smaller mode separation and thus mode competition. "Due to the mode competition, micro-disk lasers with multi-mode lasing generally show larger thresholds. In addition, the larger disks have larger volumes of material to pump; in particular, the central region of the micro-disk absorbs pump power but has no spatial overlap with the [whispering gallery modes]," the team writes.

Laser diodes

Researchers in UK claim the first demonstration of laser diodes grown directly on silicon that perform up to 75ºC and 120ºC under cw and pulsed operation, respectively [Siming Chen et al, Nature Photonics, vol10, p307 2016]. The team from University College London, University of Sheffield, and Cardiff University used a number of techniques to reduce the effect of defects on InAs QDs in GaAs barrier material used for light emission.

The InAs/GaAs materials were grown by MBE on phosphorus-doped n-Si (100). The off-cut angle was 4º to the [011] plane to avoid anti-phase domain formation. A thin 6nm aluminium arsenide (AlAs) nucleation layer was deposited in a 350ºC migration-enhanced process to suppress the three-dimensional growth mode.

Next, a GaAs buffer was grown in three steps: 30nm at 350ºC, 170nm at 450ºC, and 800nm at 590ºC. This confined most defects to the first 200nm of growth, but a significant fraction escaped to give a $1x10^9/cm^2$ threading dislocation (T_D) density.

To improve material quality, a strained-layer superlattice (SLS) was grown as a dislocation filter. The superlattice consisted of four repeats of five pairs of 10nm/10nm $In_{0.18}Ga_{0.82}As$/GaAs separated by300nm GaAs spacers.

The researchers comment: "The strain relaxation of the SLSs applies an in-plane force to the TDs, which enhances the lateral motion of TDs considerably, and hence increases the probability of annihilation."

In-situ thermal annealing in the MBE reactor was carried out on each of the four SLS sections by raising the temperature to 660ºC for six minutes. This encouraged the TDs to move and annihilate. The SLS dislocation filter was found to reduce TD density to the order of $10^5/cm^2$, "beyond the reliable measurement capability of cross-sectional TEM images," according to the researchers.

The ~20nm-diameter ~7nm-high QDs were grown in five dot-in-well (DWELL) layers with a density of about $3x10^{10}/cm^2$ and good uniformity. The well layers were 2nm and 6nm $In_{0.15}Ga_{0.85}As$ before and after the dots. The DWELLs were separated by 50nm GaAs spacers. Photoluminescence measurements gave a peak around

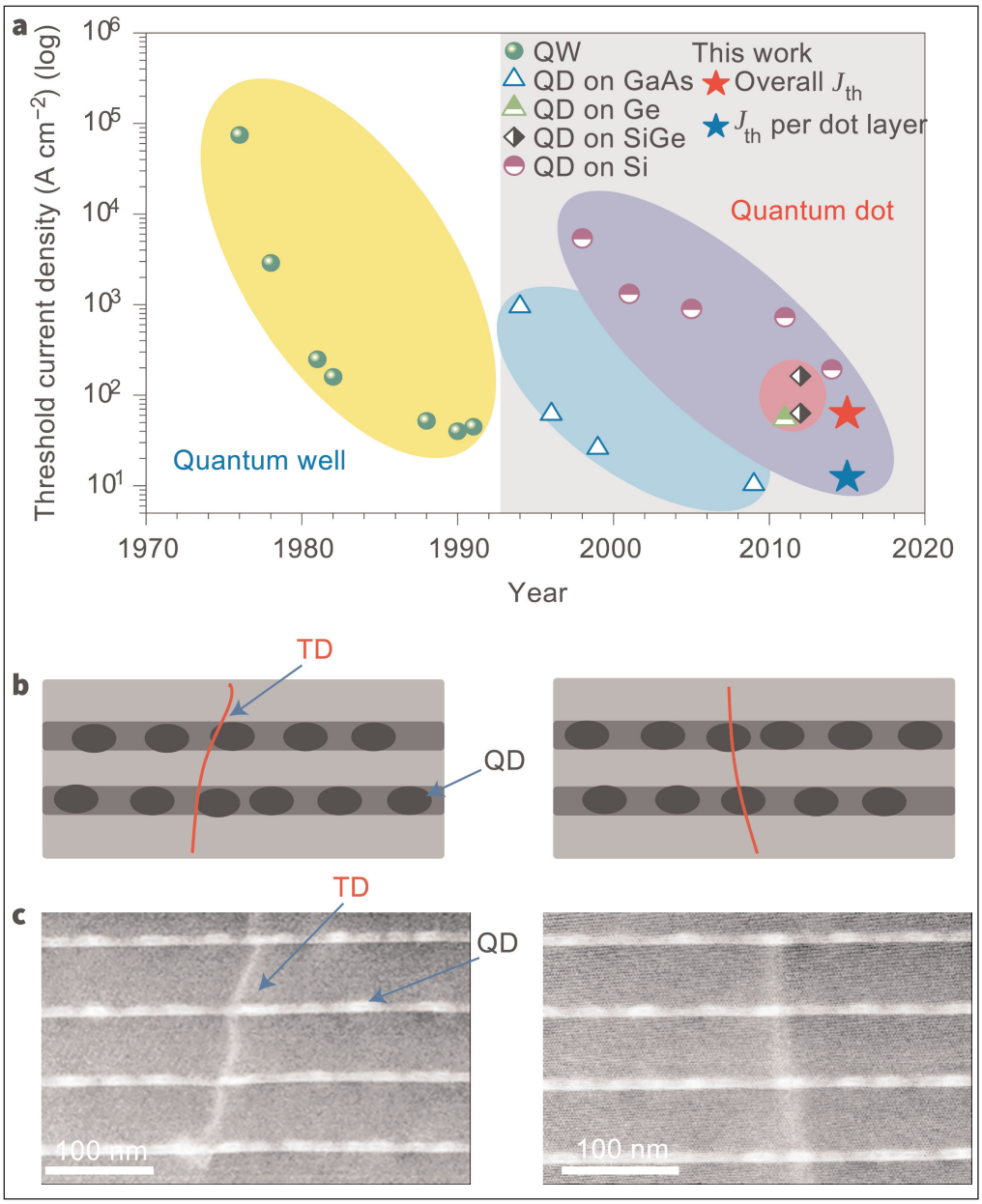


Figure 5. a, Development of low-dimensional heterostructure lasers, showing record threshold current densities. Red (upper) star indicates threshold value achieved. Blue (lower) star is value normalized to single QD layer. b, Schematic of interaction between QDs and threading dislocations. c, Bright-field scanning TEMs showing potential interactions between threading dislocations and QDs.

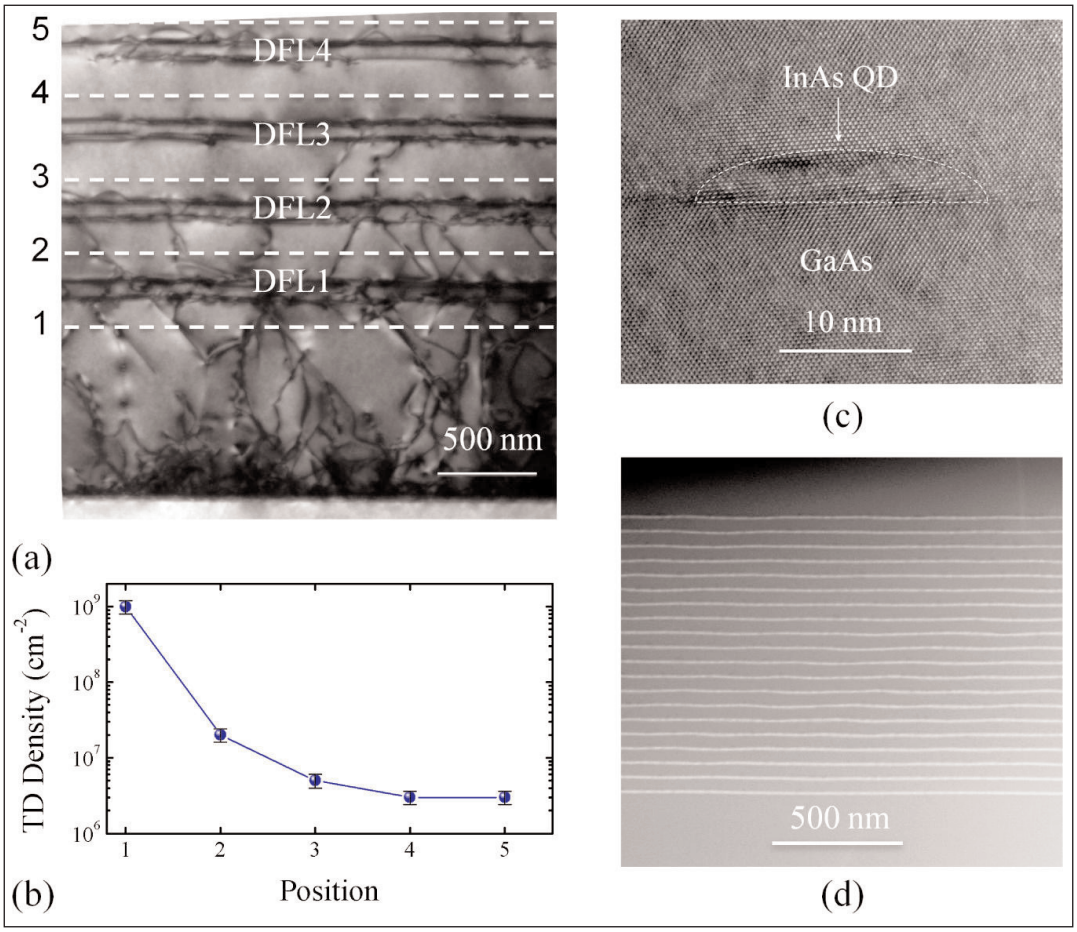


Figure 6. (a) Bright-field multi-beam TEM showing threading dislocation reduction induced by dislocation filter layers. (b) Estimated threading dislocations from TEM measurements at different positions in GaAs buffer as indicated in (a). (c) Representative high-resolution TEM image of single InAs/GaAs QD. (d) Low-magnification bright-field scanning TEM images of 20 layers of QDs.

1300nm wavelength (0.95eV) and 29meV full-width at half maximum (FWHM).

The waveguide was 140nm. Cladding layers were 1.4μm n- and p-type $Al_{0.4}Ga_{0.6}As$. The p-contact was 300nm GaAs.

Broad-area lasers (Figure 4) were fabricated with as-cleaved facets. The laser bars were mounted on gold-plated copper heat-sinks with low-melting-point indium-silver solder. Electrical connections were made with gold-wire bonding.

The threshold current density (J_{th}, Figure 5) was 62.5A/cm^2 (12.5A/cm^2 per QD layer) under cw operation. The researchers comment: "To the best of our knowledge, this value of J_{th} represents the lowest cw room-temperature J_{th} for any kind of laser on a silicon substrate to date and is comparable to the best-reported values for conventional QD lasers on a GaAs substrate."

The output power from both facets reached 105mW with 650A/cm^2 injection without evidence of saturation.

With a view to the high-temperature operation beyond 65ºC needed for many silicon-based electronic operations, the researchers tested the device under cw and pulsed conditions. The cw lasing was maintained up to 75ºC and pulsed lasing continued up to 120ºC. The 75ºC cw operation was limited by the current source. The researchers claim these as the first high-temperature performance figures for QD lasers grown directly on silicon.

A 3100-hour aging test was also performed at 26ºC and 210mA cw drive current (1.7x threshold). The output power degraded 29.7% over the test period, with the greatest fall in performance (26.4%) occurring in the first 500 hours. The threshold trend was similar. The researchers extrapolate a mean time to failure (MTTF) of 100,158 hours, based on the time needed for a doubling of threshold current.

The team comments: "These data represent the worst-case results, because (1) the laser was operated epitaxial side up, (2) the laser was not hard soldered to a high-thermal-conductivity heat-sink, and (3) no facet coatings were used. Nevertheless, the estimated lifetime is much longer than the best reported extrapolated MTTF of 4627 hours for a p-doped InAs/GaAs QD laser grown on a Ge-on-Si 'virtual' substrate."

Photodiodes

Researchers based in the UK, the USA and Germany have claimed the first direct growth of mid-infrared indium arsenide in gallium arsenide QD infrared photo-detectors (QDIPs) on silicon substrates by MBE [Jiang Wu et al, ACS Photonics, vol3, p749, 2016]. The team came from University College London in the UK, University of Arkansas in the USA, Humboldt University Berlin in Germany, and the United States Army Research Laboratory (ARL).

The team grew III-V material on silicon substrate by solid-source MBE. Anti-phase domains were avoided by growth on (100) substrates offcut 4º in the [011] direction. After a 5nm AlAs nucleation layer, the researchers grew a series of five GaAs buffer layers separated by four InGaAs/GaAs strained-layer superlattice threading dislocation filters (Figure 6). Without

a dislocation filter, 1μm GaAs buffers exhibited a dislocation density of 10^9/cm^2. This was reduced to 10^6/cm^3 with the superlattices.

The QDIP structure consisted of a 500nm n-GaAs contact, a 80nm GaAs spacer, a sequence of 20 QD layers separated by 50nm GaAs spacers, a 80nm GaAs spacer, and a 300nm top n-GaAs contact. The InAs dots were formed from a 2.1 monolayer of InAs that coalesced into discs of about 25nm diameter and 5nm height. Photoluminescence (PL) analysis suggested that the dots sizes were quite inhomogeneous.

Studying thermal quenching in the PL above 200K, the researchers estimate an activation energy of 226±27.3eV, which is roughly the difference in energy between the dots' ground state and the GaAs conduction band.

Measurements of the decay of the PL at 10K gave a long lifetime of ~1.3 nanoseconds, comparable to the performance of InAs QDs on GaAs substrate. The researchers comment: "The long decay time signals that the dominant PL decay for the QD states is radiative recombination. Therefore, the long-lived PL in the QDs suggests the GaAs buffer technique used here provides a high-quality QDIP with low defect density."

Mesa QDIPs were fabricated with annealed nickel/germanium-gold/nickel/gold top and bottom contacts. The 1V dark current was "rather low", according to the researchers: 8.9x10^{-4}A/cm^2 at 60K and 2.8x10^{-3}A/cm^2 at 80K (Figure 7). The mesa was 1mm in diameter. The researchers comment: "Despite the presence of threading dislocations (~10^6/cm^2) caused by the large lattice and TEC mismatch, the QDIP on silicon shows comparable dark current density to state-of-the-art devices grown on a native substrate."

The team also points out that its device does not use a current-blocking layer to reduce dark current. The dark current activation energy was 190±1.9meV, which is slightly lower than the photoluminescence thermal quenching value. The hole activation energy is therefore estimated to be ~36meV.

The main peak of the photoresponse was located at 6.5μm wavelength (190.7meV energy), agreeing with the dark current activation energy. The researchers say that this supports a mechanism of bound-to-continuum transitions. The peak was broad with a full-width at half maximum of 2.0μm. ■

Author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

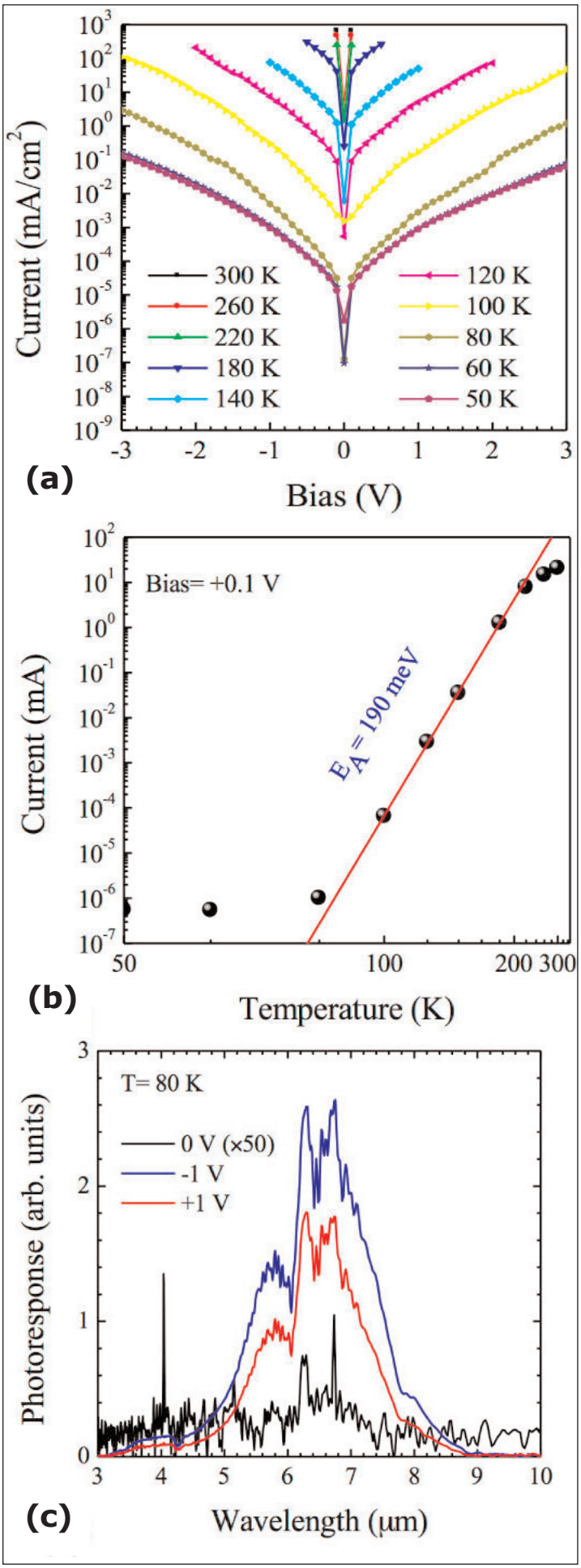


Figure 7. (a) Dark current-voltage characteristics at different temperatures for InAs/GaAs QDIP. (b) Dark current activation energy extracted from dark current measured under 0.1V bias. Fitting error is 1.9meV. (c) Photocurrent spectra measured with different bias voltages at 80K.

Epitaxial growth of laser diodes on wafer-bonded InP/Si substrates

Technique should allow alignment precision of monolithic integration without problems of lattice mismatching.

Sophia University in Japan has developed a technique for growing laser diodes on an indium phosphide (InP) layer bonded to silicon (Si) [Keiichi Matsumoto et al, Appl. Phys. Express, vol9, p062701, 2016]. The researchers claim that this is the first time that an epitaxially grown gallium indium arsenide phosphide/indium phosphide (GaInAsP/InP) double-heterostructure laser diode (LD) has been demonstrated on a wafer-bonded InP/Si substrate. Usually, wafer bonding is performed after the double heterostructure is created.

Although monolithic integration – direct growth of III-V materials on silicon – would be preferred, the technique suffers crystal degradation due to the large lattice mismatch between InP and Si (~8%). On the other hand, wafer bonding suffers from alignment difficulties, making precise high-density integration difficult at low cost.

The researchers comment: "Although the cost of the silicon circuits may be low, the alignment of a prefabricated laser diode chip to a planar optical circuit is time-consuming and expensive, which drives up the cost of the final assembly and packaged device. To solve these problems, we have proposed the monolithic integration of InP-based optical devices on a wafer-bonded InP/Si substrate by low-pressure metal-organic vapor phase epitaxy (MOVPE)."

The InP layer was prepared by growing a GaInAs/n-InP/GaInAs structure on (100) n-InP by MOVPE. The target thickness and carrier concentration of the sandwiched n-InP layer were 1μm and $3x10^{18}/cm^3$, respectively. The GaInAs layers functioned as etch-stop layers for the subsequent processing.

A layer of wax was applied to the structure as a mechanical support for the wafer bonding process (Figure 1). The n-InP growth substrate was removed

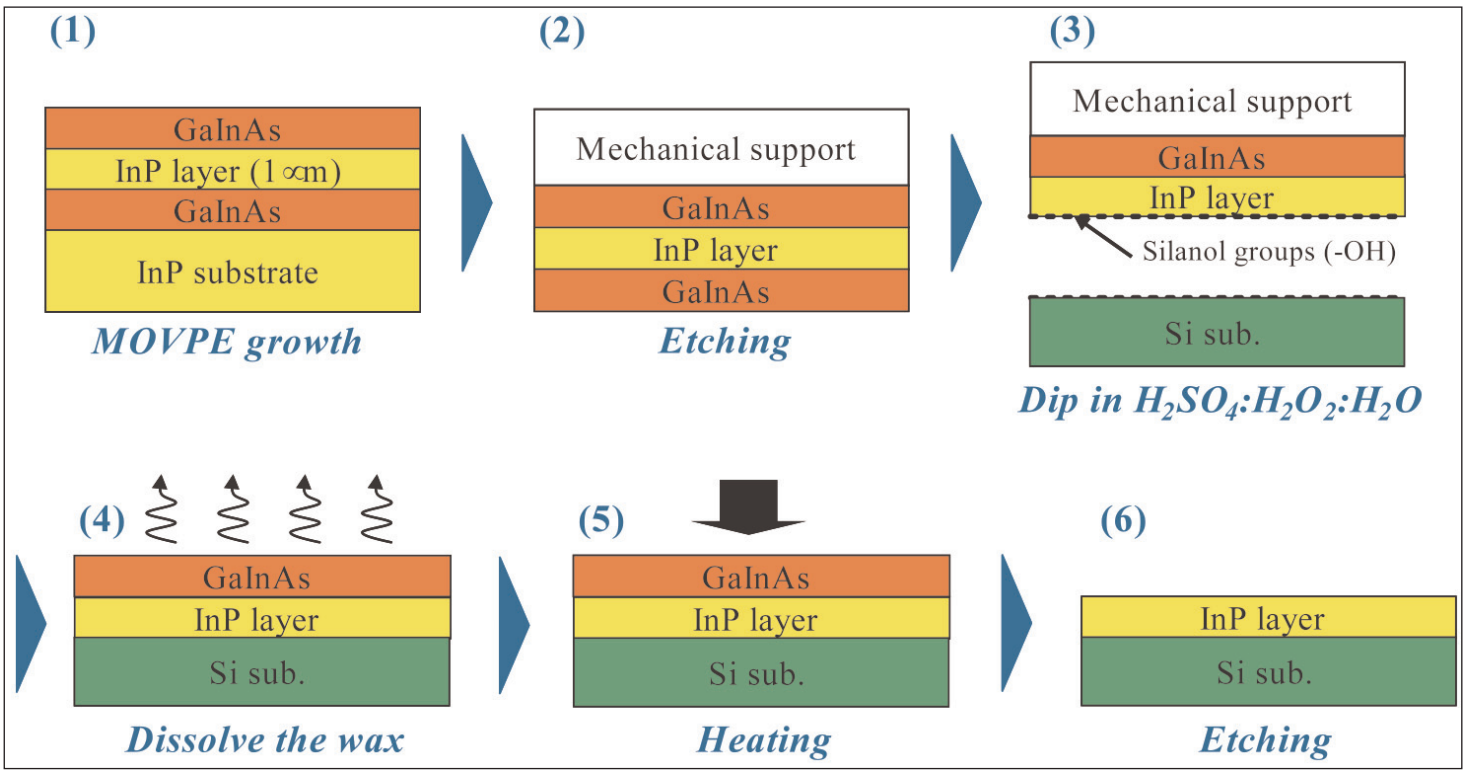


Figure 1. Schematic of InP/Si fabrication process.

by wet etching. The n-InP and silicon surfaces were cleaned and made hydrophillic before bonding. (It seems, from the paper, that by this stage the GaInAs surface away from the wax support has also been removed during this cleaning process.) The InP and Si surfaces are brought together in deionized water and then dried in a nitrogen gas flow.

The wax support was removed in a warm organic solvent. The n-InP/Si structure is then annealed under top pressure and the final GaInAs layer removed by wet etching.

The double heterostructure for the laser diode was then grown by more MOVPE (Figure 2). Photoluminescence from the structure compared well with that from a structure grown on InP substrate. The researchers say this indicates negligible degradation of crystal quality from the wafer bonding process.

Contact	p-GaInAs	50nm
Cladding	p-InP	1000nm
Active	$Ga_{0.25}In_{0.75}As_{0.45}P_{0.55}$	170nm
Buffer	n-InP	330nm
Bonded	n-InP	1μm
Substrate	Silicon	

Figure 2. Schematic of grown layer structure.

Laser diodes were fabricated by thinning the wafer to less than 100μm and applying electrodes: gold–zinc to the p-GaInAs top-side, and gold–aluminium to the n-Si under-side. Laser bars were manually cleaved: 200–300μm long and 50–100μm wide.

A 250μmx90μm device had a threshold current density of 7.5kA/cm^2 at room temperature under 10kHz, 100ns pulsed operation. This compares with 3.7kA/cm^2 for a device grown on an InP substrate. The researchers point to self-heating, reduced carrier injection due to instability of the heterointerface, and crystalline dark-line defects as leading possible causes of the degraded performance of the device on silicon. Dark-line defects arise from differences in the thermal expansion of InP and silicon.

The researchers suggest that high-reflection coatings could reduce the threshold current.

A kink in the laser output power around 9kA/cm^2 is tentatively attributed to lateral-mode lasing due to the slab structure of the device. Spectral analysis showed multiple modes being output as the current increased (Figure 3). "This problem will be overcome by the fabrication of a lateral single-mode waveguide," the team writes.

The researchers conclude: "These results are very promising for the high-density integration of InP-based LDs as light sources for optical interconnection and for overcoming the problems of the conventional hybrid integration approach." ■

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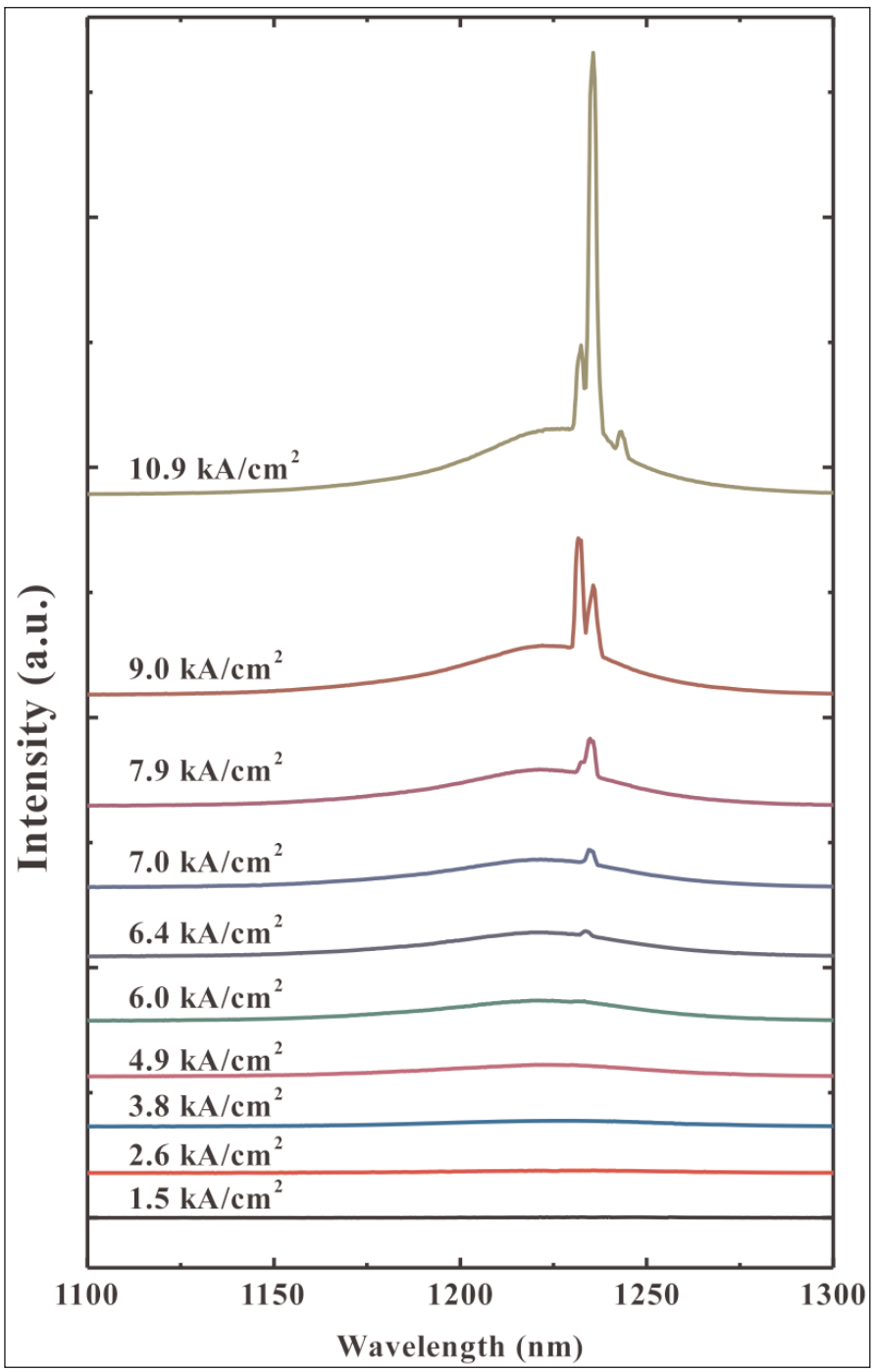

Figure 3. Spectrum at various currents.

Growing crystalline gallium nitride nanowires on flexible titanium foil

Resulting material has comparable quality to standard GaN nanowires grown on rigid silicon.

Paul-Drude-Institut für Festkörperelektronik in Germany has been studying self-assembled growth of gallium nitride (GaN) nanowires (NWs) on titanium (Ti) foil [Gabriele Calabrese et al, Appl. Phys. Lett., vol108, p202101, 2016].

Nanowire growth suffers from less problems due lattice mismatching, and the resulting material is generally more crystalline than for the usual epitaxial layers. Growth of GaN and related III-nitride materials on flexible substrates could open the way to low-cost roll-to-roll production methods for GaN optoelectronics. Metal foils also are attractive substrates in terms of enhanced thermal and electrical conductivity, along with optical reflectivity, compared with conventional substrates such as sapphire.

Ohio State University reported earlier this year on aluminium gallium nitride (AlGaN) ultraviolet light-emitting diodes on Ti and tantalum foils [reported at www.semiconductor-today.com/news_items/2016/apr/osu_290416.shtml].

The Paul-Drude-Institut GaN NWs were grown using solid source plasma-assisted molecular beam epitaxy (PA-MBE) on 25mmx25mm annealed polycrystalline Ti foil of 127μm thickness and ~50nm grain sizes. The foil was prepared by outgasing at 750°C and nitridation at 1000°C, giving a titanium nitride surface. The nitrogen source was plasma. The GaN NWs were grown at 730°C. The total growth took four hours.

The resulting NWs were vertically aligned (Figure 1). The regions between the wires were very rough: "The large surface roughness observed in between the NWs [see Fig. 1(c)] is tentatively attributed to inter-facial reactions between Ga and Ti at non-nitridated regions of the substrate surface," the researchers write. The density of misoriented (i.e. non-vertical) wires was between one and two orders of magnitude lower than the vertically aligned ones.

Statistical analysis of electron micrographs suggested that the NW lengths and diameters were 1.14±0.37μm and 70±40nm, respectively. The NW density was $8.2 \times 10^7/cm^2$, about an order of magnitude lower than that for GaN NWs on (111) silicon. Due to the lower density, the NWs do not suffer from the coalescence problems seen in growth on silicon or aluminium nitride. The researchers comment:

Growth of GaN and related III-nitride materials on flexible substrates could open the way to low-cost roll-to-roll production methods for GaN optoelectronics

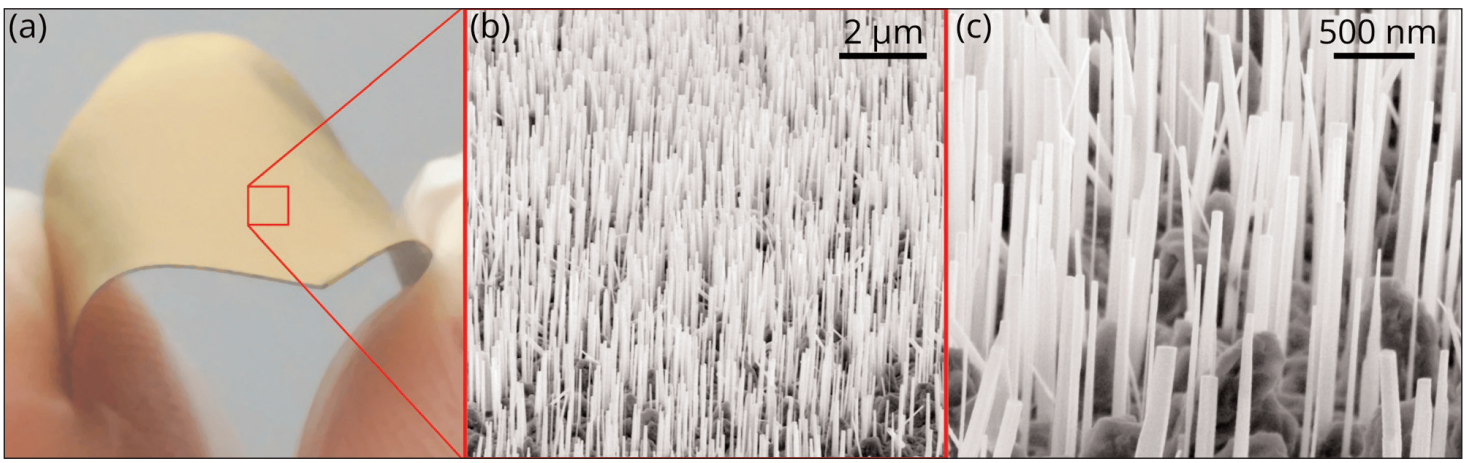

Figure 1. (a) Photograph of Ti foil after NW growth demonstrating high degree of flexibility. Also, bird's-eye view scanning electron micrographs of GaN NW ensemble grown on Ti foil with (b) low and (c) high magnification. Red square in (a) is not to scale.

"Since the coalescence of GaN NWs is a source of inhomogeneous strain and results in the formation of non-radiative defects at the coalescence joints, the possibility to fabricate NW ensembles free of coalescence on Ti foils represents a decisive advantage over other substrates."

Out of 20 NWs studied closely, only one was found to have a basal stacking fault. Potassium hydroxide wet etching analysis showed the wires to be N-polar, as is usual for such structures grown by PA-MBE.

The dominant peak for continuous-wave photoluminescence (PL) at 9K was at 3.471eV, corresponding to recombination of excitons bound to neutral oxygen donor atoms (D0 XA, Figure 2). This energy is the same as for bulk GaN, indicating the absence of homogeneous strain in the NWs. The full-width at half maximum (FWHM) value was 2.2meV. This is larger than the 1.5nm found for NWs grown on silicon. The researchers comment that FWHM values are determined by inhomogeneous strain and the energy distribution of donors as a result of varying distances from the NW sidewalls.

There was also a signal from the recombination of excitons bound to basal stacking faults between 3.40eV and 3.44eV. This was reduced by a factor of 50 compared with the 3.471eV peak. For NWs on silicon, the reduction factor is about 300, indicating a higher density of basal stacking faults in NWs on Ti foil. The researchers attribute the basal stacking faults to the significantly lower substrate temperature needed to promote NW nucleation on the titanium nitride surface.

A peak at 3.45eV is seen in the NWs on silicon, but is less pronounced on Ti foil. Such a peak has been associated with inversion domain boundaries (IDBs). "The absence of this transition suggests a reduced density of IDBs for growth on the Ti foil," the team writes.

The researchers also performed room-temperature photoluminescence measurements while bending the foil carrying the NWs. Little difference was seen in the spectrum before and after bending. The main peak at 3.41eV with 64meV FWHM was attributed to free A excitons. First- and second-order longitudinal optical (LO) phonon replicas were also seen. The researchers comment: "These observations demonstrate that the GaN NWs are well anchored to the substrate and do not detach upon bending." ■

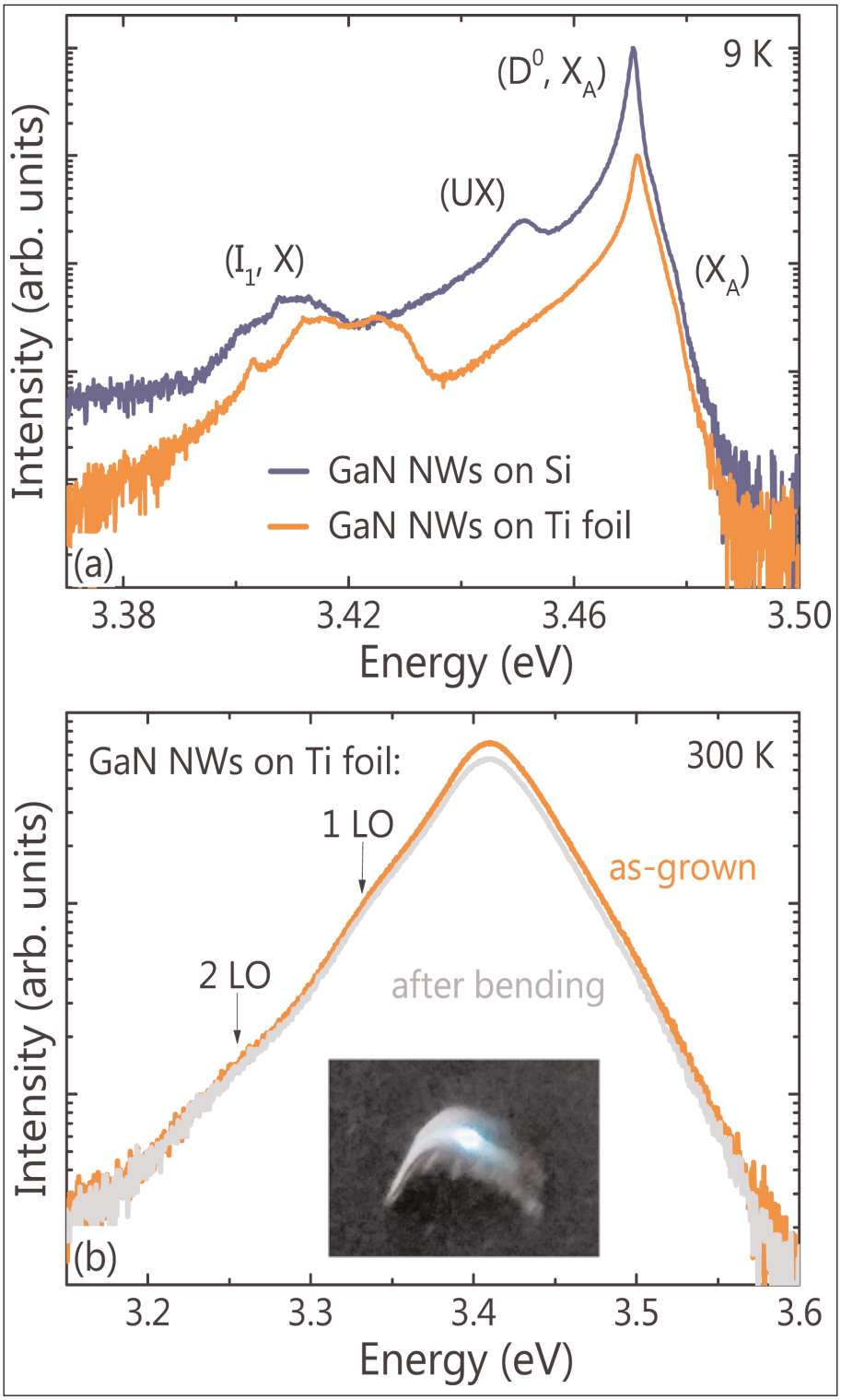

Figure 2. (a) Low-temperature (9K) PL spectrum of GaN NW ensemble grown on Ti foil. Corresponding spectrum of GaN NW ensemble on Si(111) is included for comparison. Spectra normalized and shifted vertically for clarity. (b) Room-temperature PL spectra of GaN NW ensemble grown on Ti foil for infinite and convex 4mm-radius curvature of substrate. Inset photograph of bent Ti foil taken during data acquisition.

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Author: Mike Cooke

Quaternary superlattice for electron-blocking layers

Researchers increase light output power and reduce efficiency droop.

Researchers in Taiwan have implemented a quaternary superlattice (QSL) indium aluminium gallium nitride (InAlGaN) electron-blocking layer (EBL) to improve light output power and external quantum efficiency (EQE) of green light-emitting diodes (LEDs) [An-Jye Tzou et al, Optics Express, Vol. 24, p11387, 2016].

Efficient high-brightness LEDs are difficult to achieve in the green wavelength range. Filling the 'green gap' is expected to improve color rendering for energy-efficient white light applications.

EBLs are used to confine electrons to the active multiple quantum well (MQW) light-emitting region rather than allowing them to enter into the p-GaN contact where electron-hole recombination is generally non-radiative. However, EBLs can also raise barriers for hole injection into the MQW, reducing efficiency.

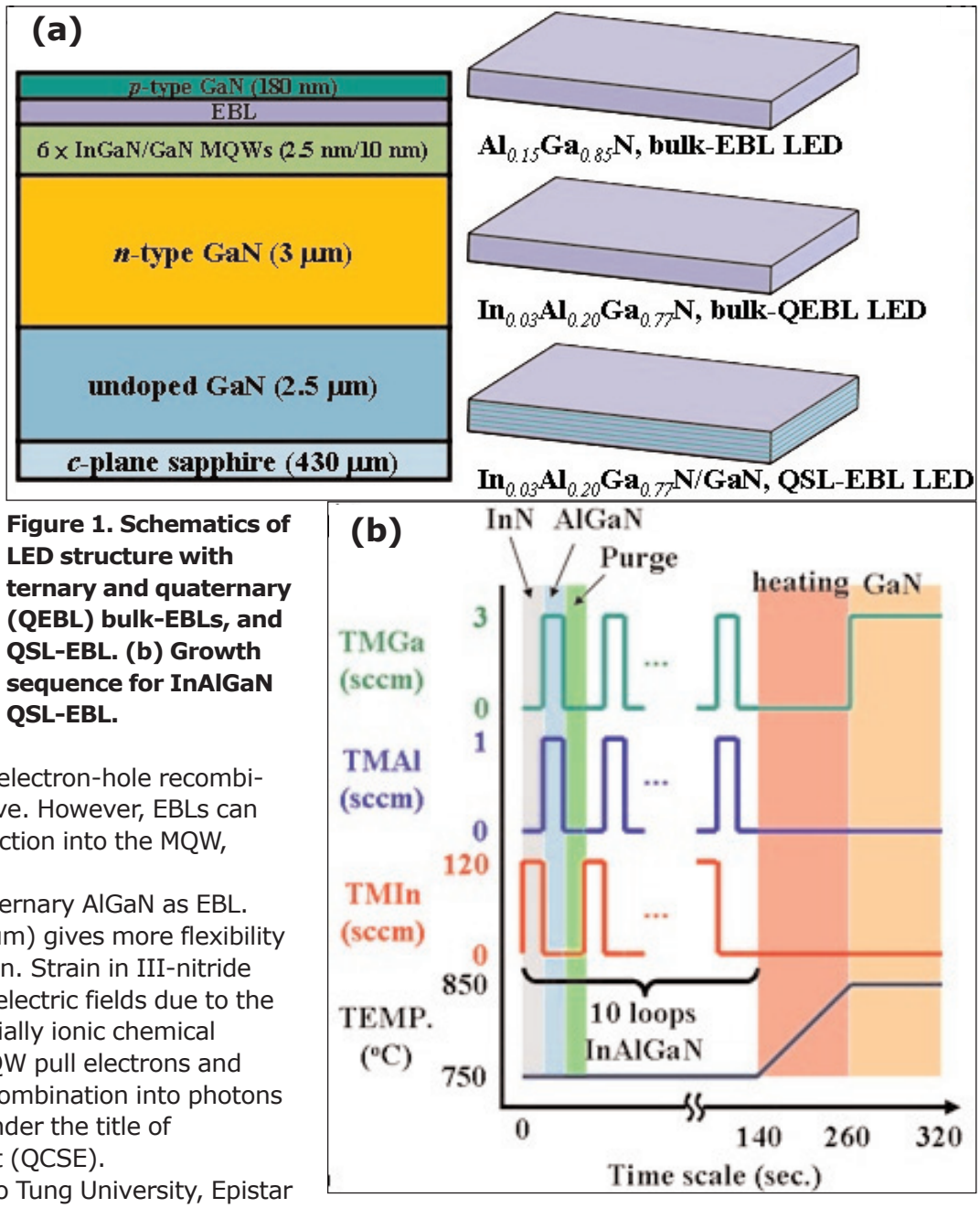

Figure 1. Schematics of LED structure with ternary and quaternary (QEBL) bulk-EBLs, and QSL-EBL. (b) Growth sequence for InAlGaN QSL-EBL.

Conventional LEDs use bulk ternary AlGaN as EBL. Adding a fourth element (indium) gives more flexibility in terms of strain compensation. Strain in III-nitride heterostructures gives rise to electric fields due to the charge polarization of the partially ionic chemical bonds. Electric fields in the MQW pull electrons and holes apart, reducing their recombination into photons — a phenomenon that goes under the title of quantum-confined Stark effect (QCSE).

The team from National Chiao Tung University, Epistar and Academia Sinica, explains: "The QSL-EBL structure can reduce the polarization-related electrostatic fields in the MQWs, leading to a smoother band diagram and a more uniform carrier distribution among the quantum wells under forward bias."

Low-pressure metal-organic chemical vapor deposition (MOCVD) in a vertical reactor was used to create the LED epitaxial material on sapphire (Figure 1). A layer of AlN was sputtered on the sapphire for nucleating the MOCVD growth. The MQWs consisted of $In_{0.27}Ga_{0.73}N$.

Two different EBL structures were produced: a conventional ternary 20nm bulk p-$Al_{0.15}Ga_{0.85}N$ layer, and a QSL consisting of five 2nm p-GaN wells and six 2nm p-$In_{0.03}Al_{0.20}Ga_{0.77}N$ barriers. The researchers also simulated a bulk quaternary EBL consisting of a 20nm p-$In_{0.03}Al_{0.20}Ga_{0.77}N$ layer.

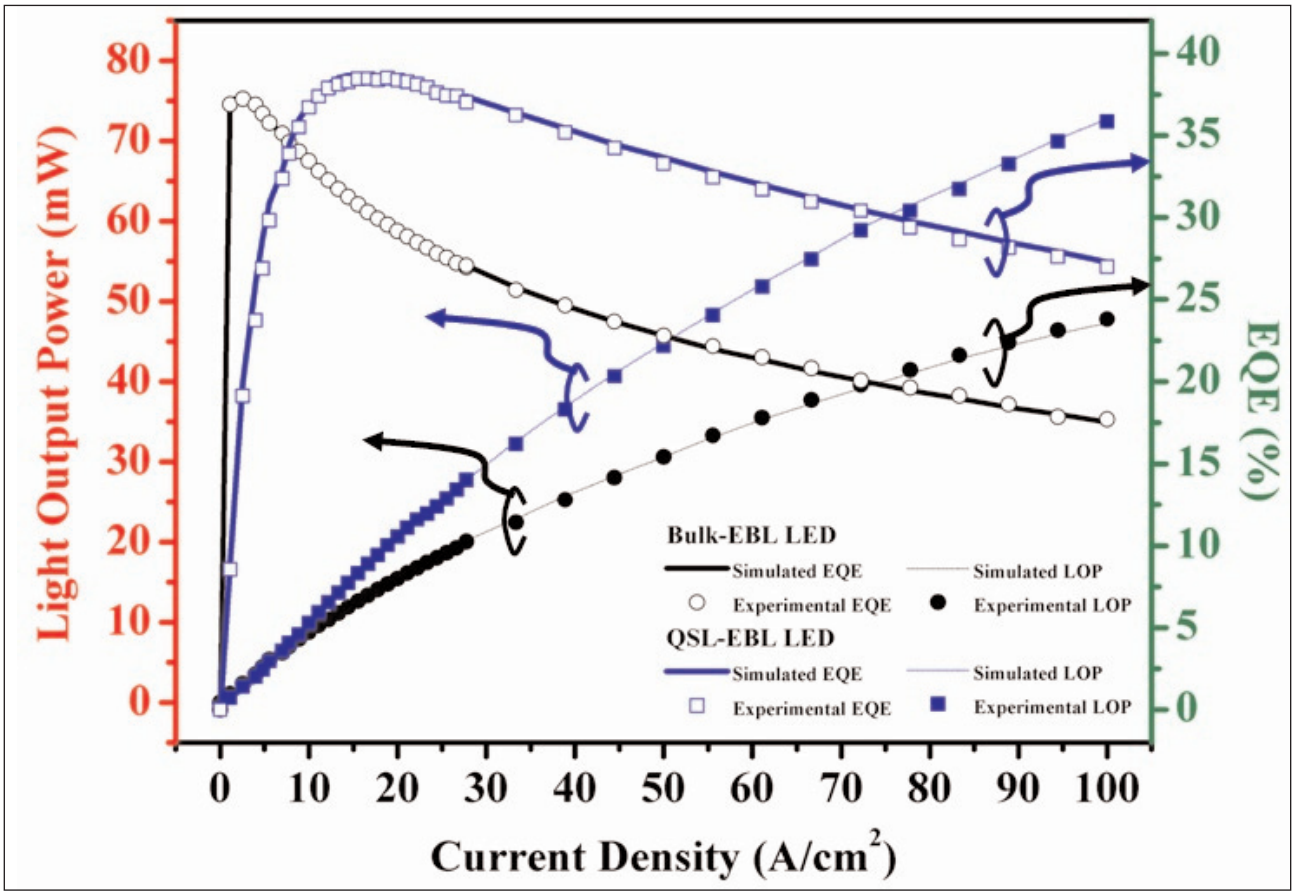

Figure 2. Measured light output power and EQE curves as function of injection current density for LEDs. Experimental EQE and power data plotted as symbols are well fitted to simulation lines.

One can speculate as to the reason for not attempting to grow such a bulk quaternary InAlGaN layer (e.g. strain/stability problems in thick layers?). In any case, the simulation suggests that it would perform worse than the QSL structure due to the generation of strong electrostatic fields in the last well of the MQW, leading to reduced radiative recombination from a smaller overlap of the electron and hole wavefunctions. A similar problem is seen in the structure with a bulk ternary AlGaN EBL.

The simulations also suggest that the QSL EBL has a higher barrier to electron overflow combined with a lower barrier to hole injection into the MQW than either bulk EBL. The QSL electron barrier is estimated at 306meV, compared with 231meV and 260meV for the ternary and quaternary bulk EBLs, respectively. The hole barriers were 210meV for the QSL, and 244meV/215meV for the respective ternary/quaternary bulk EBLs.

The researchers comment: "This result is attributed to polarization-matched QSL-EBL regarding the raised electrostatic field at the interface between the last barrier and EBL. This improvement suggests that the lower negative electrostatic field in InAlGaN of QSL-EBL than in bulk-QEBL and bulk-EBL. Therefore, the QSL-EBL not only suppressed the electron overflow but also improved the hole injection efficiency."

The quaternary material was grown by a digital method where 4 seconds of InN growth was alternated with 4 seconds of AlGaN. The 2nm layer took 10 cycles/loops of InN/AlGaN deposition. There was a six second hydrogen purge between AlGaN and InN depositions to enhance migration of the aluminium adatoms. The quaternary growth temperature was 750°C. The GaN barriers were grown at 850°C.

Mesa LEDs were fabricated with a 300μmx300μm indium tin oxide (ITO) transparent current-spreading layer on the p-GaN contact layer, and nickel/gold as electrodes for both contacts. The emission wavelength was around 550nm, at the long yellow end of the green range of 495–570nm.

The light output power and external quantum efficiency (EQE) were improved for the LED QSL EBL compared with the ternary AlGaN bulk EBL (Figure 2). The EQE at 100A/cm^2 injection was 53% better for the QSL EBL LED than for the AlGaN EBL. The peak efficiency for the QSL EBL device was at 17A/cm^2 and was higher than the AlGaN EBL peak, which occurred at a couple of A/cm^2. The droop at 100A/cm^2 from the peak was 30% for the QSL LED and 52% for the bulk AlGaN EBL. Often smaller droop is achieved at the expense of peak efficiency, unlike in this case.

The researchers comment that the droop was consistent with their simulations, attributing the improvement to enhanced hole injection and electron confinement, adding "polarization matched QSL-EBL is a good solution for high-efficiency InGaN-based green LEDs". ■

http://dx.doi.org/10.1364/OE.24.011387

Author: Mike Cooke

Thin-barrier quantum wells increase bandwidth of cyan light-emitting diode

Researchers claim 1GHz 3dB bandwidth record for visible-light LEDs.

Researchers based in Taiwan and USA have increased the modulation bandwidth of indium gallium nitride (InGaN) light-emitting diodes (LEDs) [Jin-Wei Shi, IEEE Electron Device Letters, published online 26 May 2016]. The enhanced bandwidth was achieved by reducing the barrier thickness in the multiple quantum well (MQW) active light-emitting region.

The team from National Central University (NCU) in Taiwan, University of California Santa Barbara (UCSB) in the USA, and National Cheng Kung University in Taiwan claims record 3dB electrical-to-optical (E–O) bandwidth values of nearly 1GHz, compared with other high-speed LEDs that only manage less than 0.5GHz.

One aim for the research was to boost data rates for visible-light communications and plastic optical fiber (POF) communications without significantly increasing light-source cost or energy consumption. Visible-light communication application could lead to ultra-broadband indoor wireless 'attocell' networks with large numbers of transmitter LEDs on the ceilings of rooms.

The researchers compared devices with standard 17nm and thin 5nm barriers (Figure 1). The LEDs were designed to be suitable for POF applications. The devices emitted around the cyan 480nm wavelength near the minimum loss window (less than 4dB/50m) of the poly(methyl methacrylate) (PMMA) thermoplastic that is commonly used for POF. The local minimum is actually around the 520nm green wavelength. A slightly deeper minimum is at 560nm (yellow). There is also a more lossy window around 650nm (red).

The researchers comment: "There are two major differences in the design of the active MQWs of these structures. One is the great reduction in thickness of the GaN barrier layer in the novel device structure from 17nm to 5nm. By thinning down the barrier layer, the total thickness of the active layer can also be reduced from 97nm to 37nm, which leads to an increase in the injected carrier density, radiative recombination rate, and modulation speed of the device. Furthermore, the thinness of the barrier layer should also improve the hole distribution among different wells and enhance the total output power."

With standard barriers, holes often find it difficult to

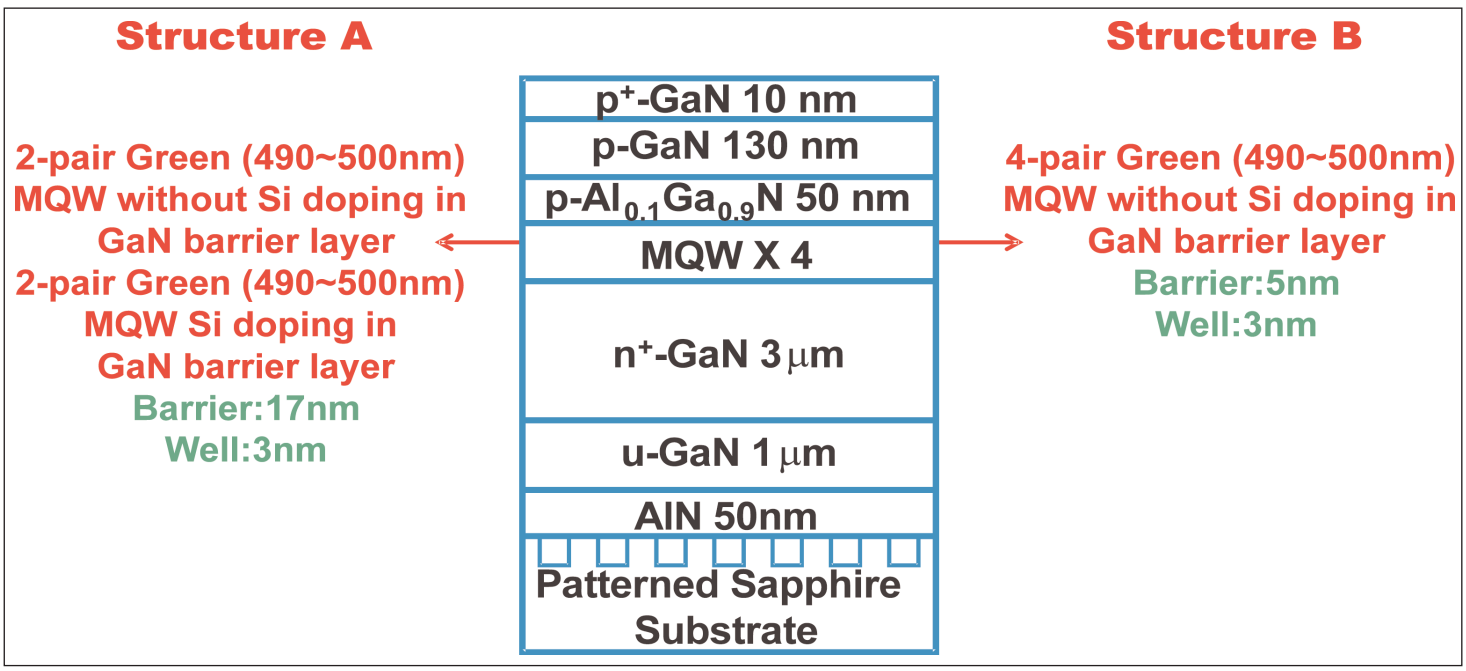

Figure 1. Conceptual cross-section of epitaxial layer standard (A) and thin-barrier (B) structures.

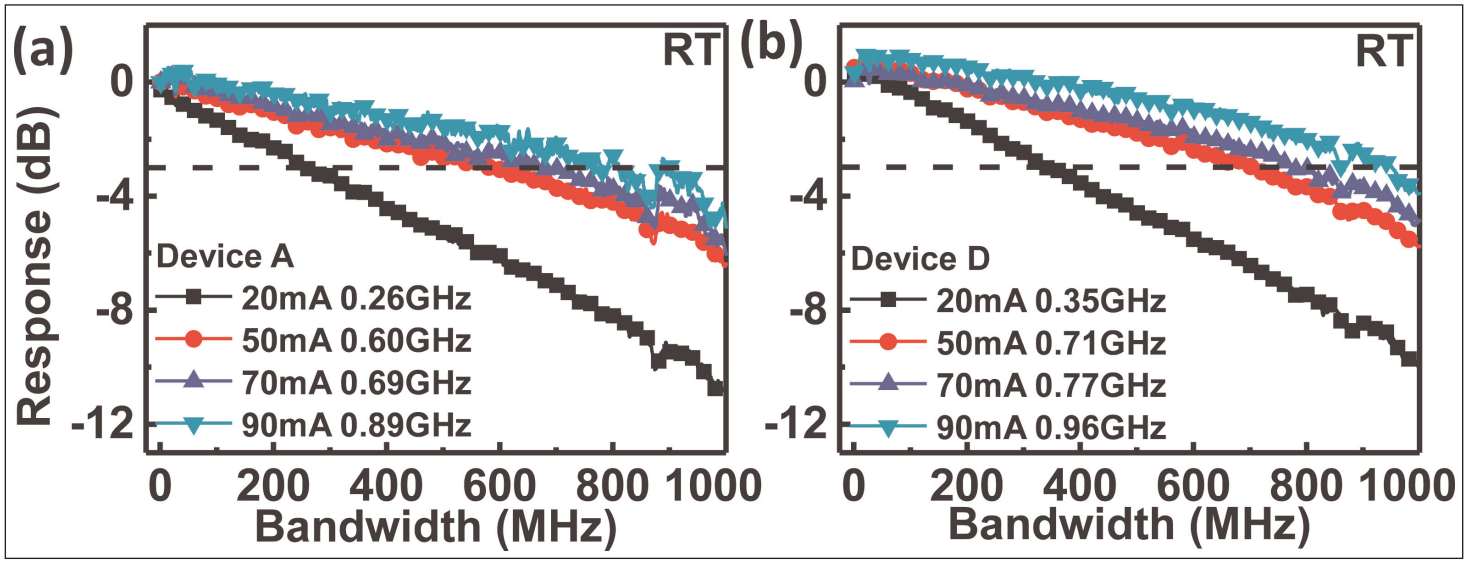

Figure 2. Bias-dependent E–O frequency responses for (a) standard device A and (b) thin-barrier device D at room temperatures.

distribute themselves effectively across MQW structures and tend to congregate in the well next to the p-type injection layers. Simulations suggested that the new thin barrier design could enhance hole transport across the MQW.

Another difference between the devices was that the standard LED had a partial n-type doping profile for the MQW in an effort to enhance modulation speeds and power output. Since the MQW region of the thin barrier device was much reduced, giving a greater applied electric field, the researchers believed that the new design did not need doping to achieve these effects.

The two device types were grown on patterned sapphire. Devices were fabricated on mesas etched down to the sapphire to avoid parasitic capacitance. The active area was around 50μm in diameter, while the device dimensions were 0.75mmx0.86mm (including contact pads on the sapphire substrate). By putting the metal pads on insulating sapphire, resistor–capacitor (RC) delays are minimized, enhancing bandwidth.

The performance of the two devices was similar, with the thin-barrier LED having a peak output power at room temperature of 1.7mW, compared with 1.5mW for the standard setup. The fall-off of peak power with raised temperature of 110°C was also similar: 20% for the standard LED and 19% with thin barriers. The researchers comment: "The comparable output power of these two structures under 110°C operation suggests that the thin barrier design does not significantly increase the probability of carriers escaping under high junction temperatures."

The large bandgap offset in the active layer and the activation of the p-type dopant (Mg) in our III-nitride LED under high ambient temperatures act to suppress electron leakage

The 3dB E–O bandwidth for the new thin-barrier structure reached 0.96GHz at room temperature and 90mA bias (Figure 2). The standard device achieved 0.89GHz bandwidth. Both these values are claimed as being faster in terms of modulation compared with the best reported visible LEDs. Also, green InGaN laser diodes (LDs) have only achieved 0.4GHz bandwidth.

The researchers comment: "The bandwidth performance of device D is over two times faster than that reported for the high-speed red [resonant-cavity] RCLEDs (0.35GHz) or GaN-based green (~500nm) LEDs and LDs (0.5GHz)."

While the LED performance is not as good as the recently reported 2.6GHz 3dB E–O bandwidth for a blue 450nm laser diode, the researchers point out that "the required driving current and fabrication cost of GaN laser diodes are both much higher than would be required for LED-based solutions." Also, PMMA POF becomes more lossy at 450nm.

At 110°C, the bandwidths at 60mA were 0.64GHz for the standard MQW LEDs and 0.71GHz for thin barriers. The relatively small degradations in power and bandwidth are seen as not serious.

The researchers write: "This is quite different from the behavior of the high-speed red RCLED, which shows bandwidth enhancement (110MHz to 130MHz) and serious degradation in the output power (~40%) when the temperature increases from 10°C to 70°C. The large bandgap offset in the active layer and the activation of the p-type dopant (Mg) in our III-nitride LED under high ambient temperatures act to suppress electron leakage and produce superior high-temperature performance over that of the GaAs-based high-speed red LED." ■

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7479469

Author: Mike Cooke

Speed up for indium gallium nitride two-dimensional electron gas

Researchers claim record mobility, with the potential for high-power and high-frequency applications.

Xidian University in China has used pulsed metal-organic chemical vapor deposition (MOCVD) to increase indium gallium nitride (InGaN) room-temperature channel mobility to 1681cm^2/V-s, which is claimed to be a record [Yachao Zhang et al, Appl. Phys. Express, vol9, p061003, 2016]. The team comments: "The results in this paper demonstrate the superiority of the InGaN channel heterostructure over the conventional GaN channel heterostructure, especially at elevated temperature, indicating its huge potential in high-power and high-frequency applications."

Xidian has used pulsed MOCVD for some time to achieve improved III-nitride quality for aluminium nitride (AlN) and InGaN [e.g. www.semiconductor-today.com/news_items/2015/aug/xidian_130815.shtml, http://dx.doi.org/10.1063/1.4937127]. In pulsed MOCVD, the precursor sources of the elements are supplied in particular sequences. InGaN growth proceeds by depositing a sequence of short-period GaN and InN layers as a superlattice. "This change in the growth mode increases the surface mobility of adatoms and enables them to find energetically favorable locations," the researchers explain.

The researchers see the applications for InGaN high-mobility channels as being higher-speed and higher-frequency microwave power devices. The narrower bandgap of InGaN should reduce the effective mass, increasing carrier speeds for a given electric field. The (slight?) penalty would be a somewhat reduced critical field, reducing breakdown voltages. In fact, mobilities higher than GaN channels have not been achieved as yet.

Until the latest Xidian work, the best reported figure the team points to was 1295cm^2/V-s. The problems seem to revolve around alloy disorder and interface roughness. Both these factors increase carrier scattering, which in turn reduce mobility and increase sheet resistance.

Another advantage of InGaN is increased confinement of the two-dimensional electron gas (2DEG) channel with a top and bottom barrier structure. The team comments: "Previous reports have shown that devices with an InGaN channel exhibit excellent performance by some measures, such as suppression of current collapse and the virtual gate effect."

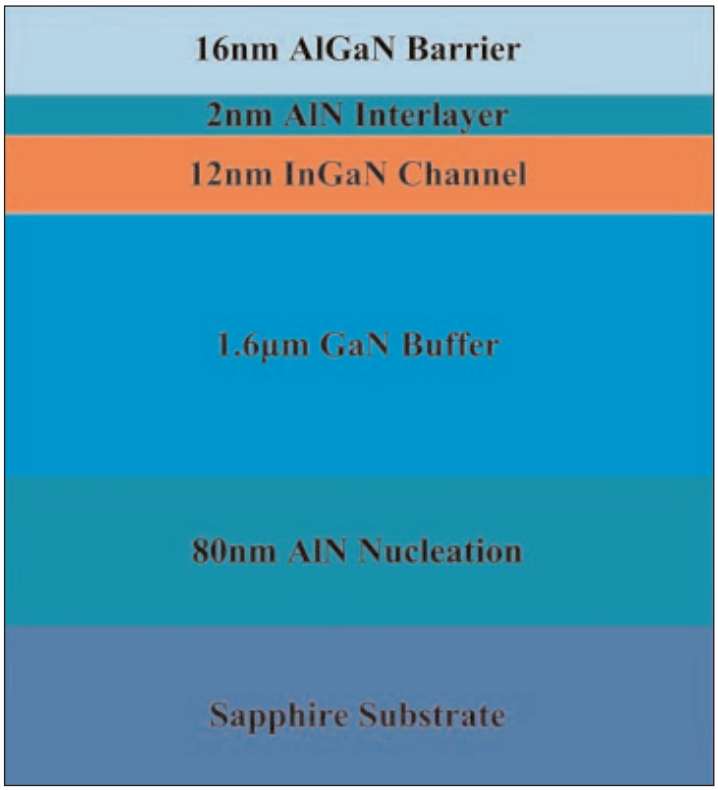

Figure 1. Schematic cross-section of AlGaN/InGaN heterostructure.

The heterostructure (Figure 1) was grown on (0001) sapphire using a home-made vertical low-pressure MOCVD system. The metal-organic sources were trimethyl-aluminium, -gallium, and -indium. The nitrogen source was ammonia. The GaN buffer and AlGaN barrier were grown at 940°C. The pulsed part of the process, creating the InGaN layer, was carried out at 740°C.

The 2nm AlN interlayer was formed by a two-step process. This interlayer was designed to improve interface morphology between the InGaN channel and barrier and to protect the high-quality InGaN channel from damage during the subsequent high-temperature growth.

X-ray analysis suggested that the AlGaN alloy barrier had a 35% AlN mole fraction, according to Vegard's law. The x-ray signal for the InGaN layer was much stronger than for previous work, indicating the high quality of the pulsed MOCVD process. The InN mole fraction was estimated at 5%. Photoluminescence experiments also gave 5% for the InN content of the InGaN layer.

Secondary-ion mass spectrometry (SIMS) on samples with and without an interlayer showed that the 2nm AlN effectively prevented indium atom losses during growth of the high-temperature AlGaN barrier.

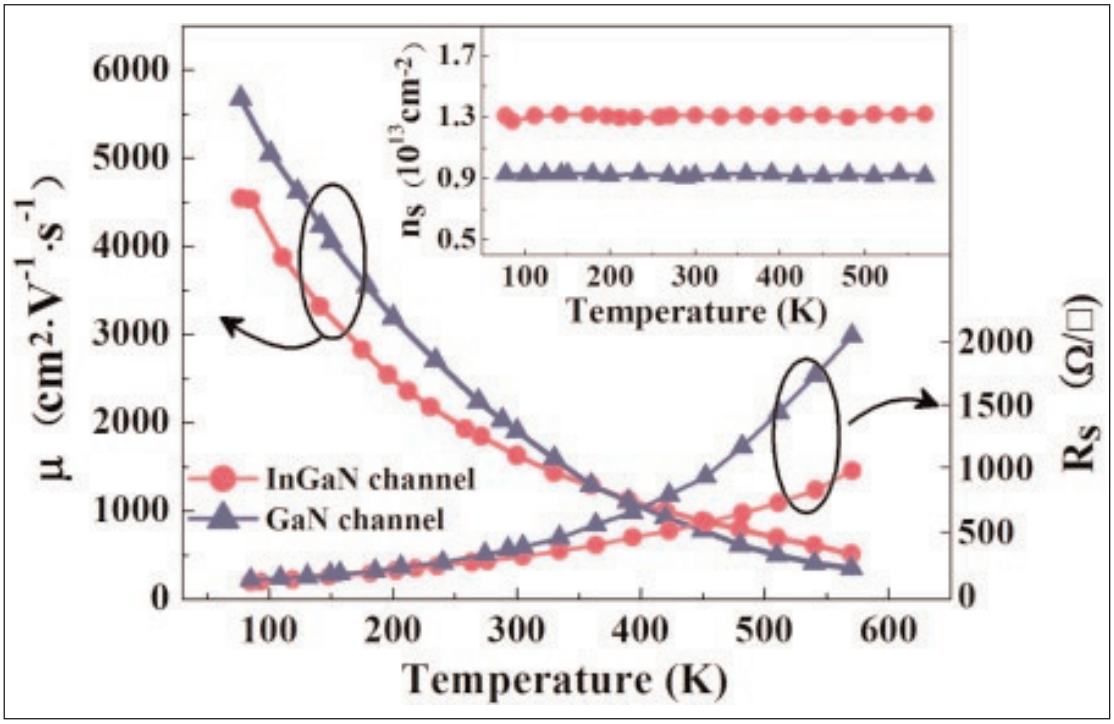

Figure 2. Temperature dependence of 2DEG mobility (μ) and sheet resistance (R_s) for InGaN-channel and GaN-channel heterostructures. Inset: carrier density (n_s) as a function of temperature.

Atomic force microscopy (AFM) on a sample without the AlGaN barrier layer gave a root-mean-square (rms) roughness of 0.19nm over a 2μmx2μm field. With the AlGaN barrier, the roughness was 0.15nm. The researchers comment: "The result is even better than that obtained for conventional AlGaN/GaN heterostructures, proving that there is negligible structural degradation in the AlGaN barrier when it is grown on the InGaN channel."

Temperature-dependent Hall measurements show the InGaN channel to have lower mobility than pure GaN up to 360K (Figure 2, room temperature ~300K). Beyond that, the InGaN channel has the edge. "These results demonstrate the superiority of the InGaN-channel heterostructure over the conventional GaN-channel heterostructure for fabricating high-power and high-frequency devices, which often operate at elevated temperature in practical applications," the researchers write.

At the same time, the carrier density in the InGaN two-dimensional electron gas (2DEG) channel is higher than for GaN — $1.3x10^{13}/cm^2$ versus $0.9x10^{13}/cm^2$, respectively — giving a lower overall sheet resistance. The researchers attribute the higher carrier density to improved 2DEG confinement. The team believes that the $1.3x10^{13}/cm^2$ density can be improved by increasing the AlGaN barrier thickness or the AlN mole fraction.

Comparing with previous work, the researchers comment: "A record highest room-temperature electron mobility of $1681cm^2/V$-s is obtained in our experiment, which is far superior to the other reported results."

The team attributes the performance to improved InGaN crystal quality from pulsed MOCVD growth and the use of the AlN interlayer to suppress alloy disorder and interface roughness. ■

http://dx.doi.org/10.7567/APEX.9.061003

Author: Mike Cooke

Hybrid III-nitride and silicon carbide high-voltage power transistors

Device simulations suggest proposal could combine high mobility with higher OFF-state voltages.

Researchers at Hong Kong University of Science and Technology (HKUST) are proposing using III-nitride and silicon carbide (SiC) hybrid technologies for high-voltage power devices [Jin Wei et al, IEEE Transactions on Electron Devices, vol63, p2469, 2016].

The researchers are looking to improve on the performance of silicon-based devices by using materials that can sustain higher electric fields before breakdown — a quality associated with wider bandgaps as seen in SiC and aluminium gallium nitride (AlGaN).

SiC metal-oxide-semiconductor field-effect transistors (MOSFETs) can sustain high OFF-state voltages but suffer from low channel mobility. By contrast, AlGaN/GaN high-electron-mobility transistors (HEMTs) have high mobility (as the device name suggests), but suffer from problems with current collapse on switching due to delays from charge trapping. Current collapse would seem to restrict the potential use of lateral AlGaN/GaN HEMTs to applications lower than 1000V. The problem

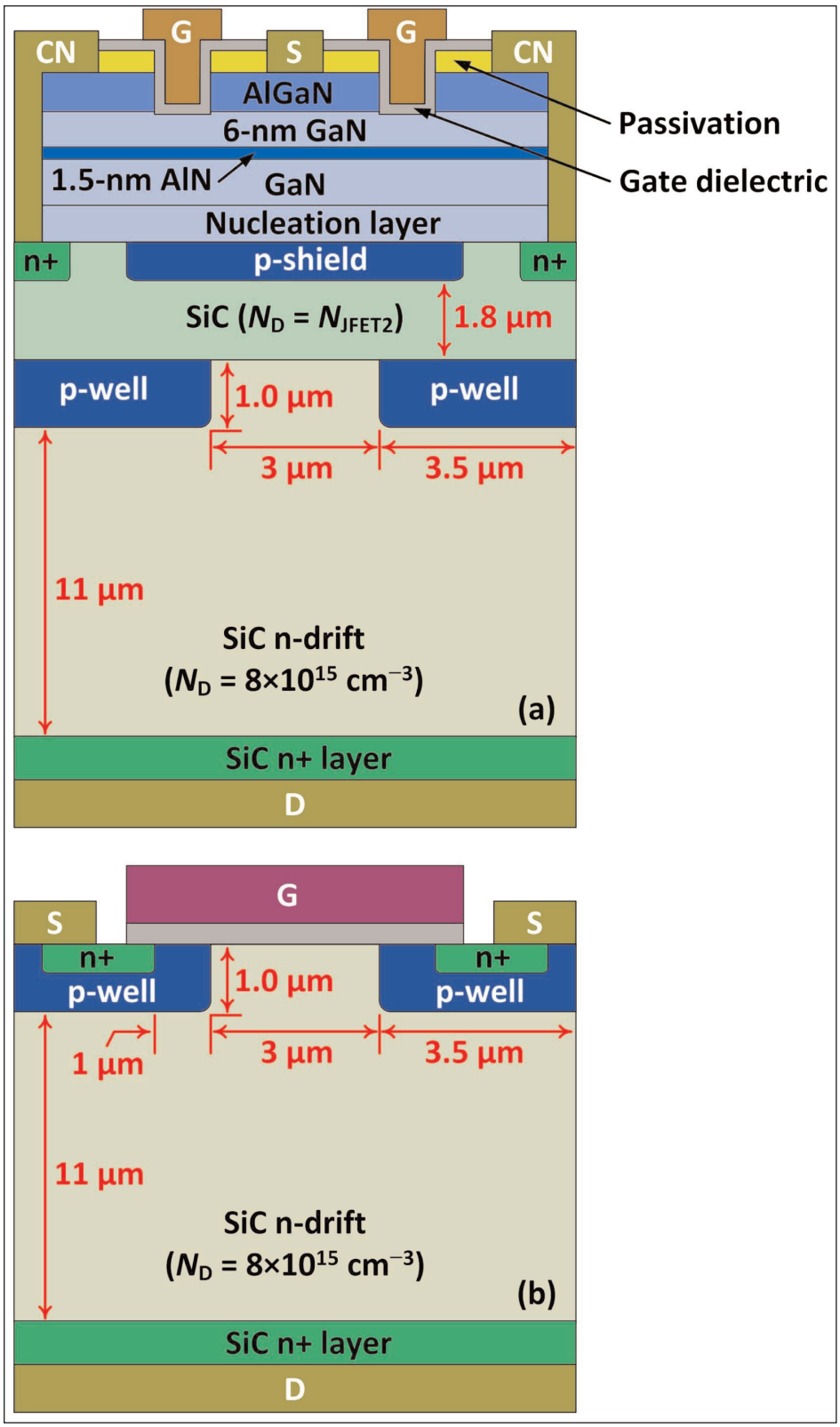

Figure 1. Schematics of (a) proposed GaN/SiC HyFET and (b) conventional SiC MOSFET. HyFET consists of AlGaN/GaN channel and SiC voltage-blocking portions, electrically connected by CN connection contact. Also, p-wells and p-shield in HyFET are connected to source terminal. JFET1 is the region between p-wells. JFET2 is the region between p-shield and p-wells.

could perhaps be solved by adopting a vertical structure, but this would need growth on very expensive GaN substrates. Some first steps have been taken, but an effective implantation technique has yet to be developed for creating p-type wells.

The HKUST research proposes combining III-nitride epitaxial layers on SiC to create hybrid FETs (HyFETs). The team comments: "Since epitaxial growth of GaN layers on SiC substrate is a rather mature technology, a superior power device is expected if the merits of SiC devices and GaN HEMTs are combined on a single platform."

HKUST simulated a device with AlGaN/GaN high-mobility channel and vertical SiC drift region for high OFF-state voltages. In addition to three HKUST researchers (Jin Wei, Qimeng Jiang, Kevin J. Chen), Huaping Jiang of both Dynex Semiconductor Ltd in the UK and Zhuzhou CRRC Times Electric Co Ltd in China contributed to the work.

Dynex develops and markets high-power bipolar discrete semiconductors, along with insulated-gate bipolar transistors (IGBTs), electronic assemblies and components. Zhuzhou CRRC Times Electric is concerned with propulsion and control systems for high-speed trains, electric multiple unit (EMUs), mass transit, and for electric and diesel locomotives.

The proposed structure (Figure 1) uses an AlGaN/GaN channel portion for gate control on a SiC substructure that is designed to maintain a good OFF-state.

The p-type regions of the SiC structure could be achieved using aluminium implantation and activation at 1650°C. The JFET2 region between the p-wells and p-shield would be achieved by epitaxial regrowth. The p-shield depth is 0.2μm.

The AlGaN/GaN region could be grown either by metal-organic chemical vapor deposition (MOCVD) or molecular beam epitaxy (MBE). Connections to the n^+ (CN) and p-type regions in the SiC substructure could be achieved by dry etch of via holes through the AlGaN/GaN layer.

One aspect that does not seem to be fully developed as yet is a high-temperature anneal for the GaN/SiC contacts. The researchers suggest that this might need a multi-step process.

Although there are a number of techniques in the literature for giving enhancement-mode (normally-off) operation in the AlGaN/GaN structure, the researchers decided to model a relatively new double-channel MOS gate structure that has been demonstrated by HKUST [Jin Wei et al, IEEE Electron Device Letters, vol36, p1287, 2015]. The second channel is created by a 1.5nm AlN insertion layer. The gate recess is terminated by the upper channel at the AlGaN/GaN interface. This maintains a high mobility in the lower AlN/GaN channel by avoiding etch degradation.

One variable in the model, the n-type doping in the JFET2 region (NJFET2), was subject to a delicate compromise between low ON-state resistance and the ability to deplete the region for the OFF-state. The CN voltage used to achieve the OFF-state is higher with high NJFET2, and this can reduce the reliability of the overlying AlGaN/GaN channel. The modeling

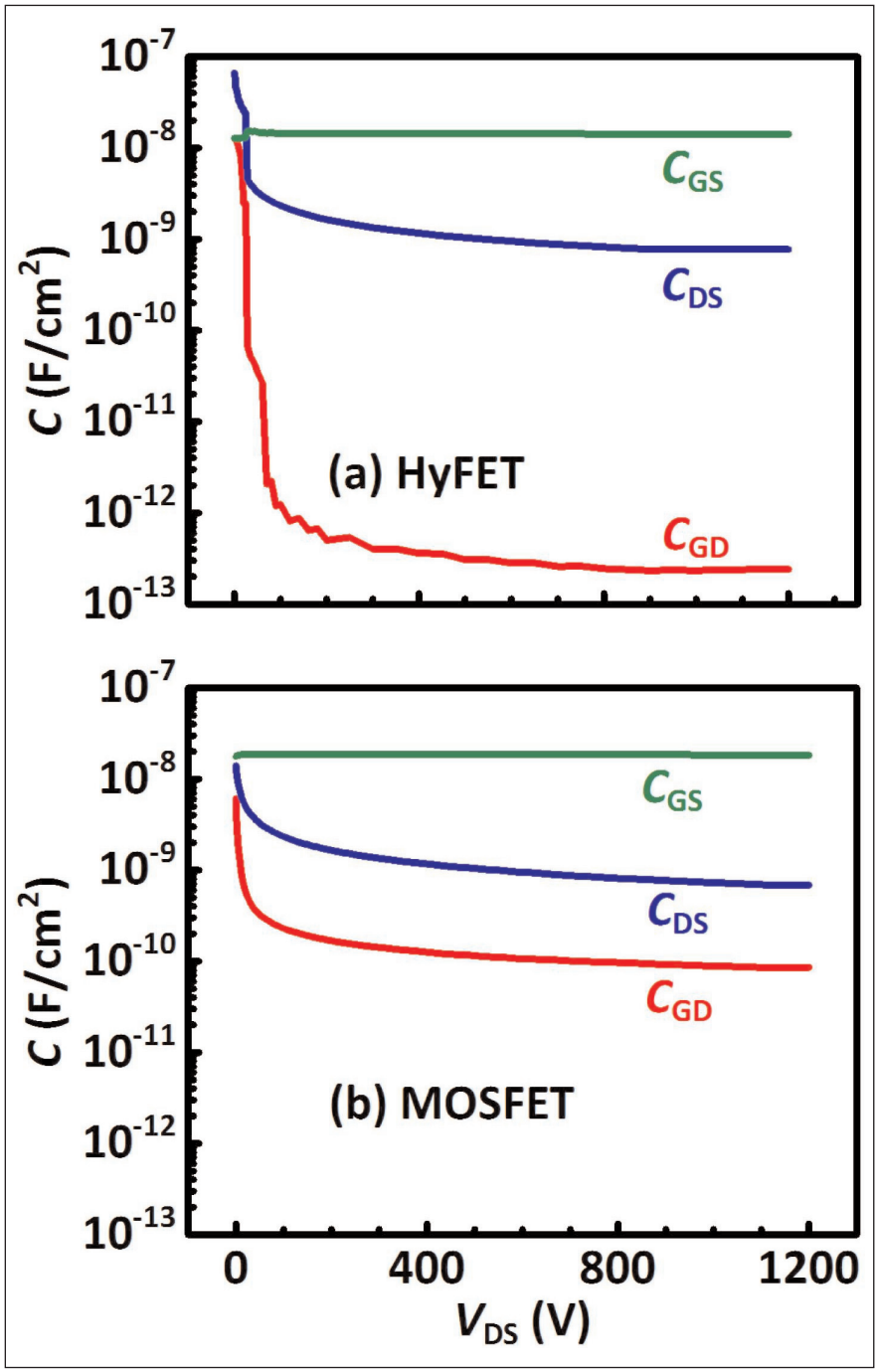

Figure 2. Terminal capacitances of (a) GaN/SiC HyFET and (b) SiC MOSFET.

suggested that NJFET2 of $5x10^{16}/cm^3$ gave a balance between low ON-resistance and a relatively low OFF CN voltage of ~50V.

The hybrid structure gives a sharper turn-on with gate voltage compared with the SiC MOSFET: at 5V HyFET gate potential the ON resistance was $26m\Omega\text{-}cm^2$, while the MOSFET at 20V gate had $4.6m\Omega\text{-}cm^2$. The main improvement arises due to reduced channel resistance — 52% of the overall value in the MOSFET, compared with 7% for the HyFET, excluding contact and substrate resistances.

The HyFET has a lower OFF-state breakdown voltage of 1581V, compared with 1716V for the MOSFET. This is blamed on "more severe electric field crowding at the corners of the p-wells".

On the other hand, the gate–drain capacitance (C_{GD}) of the HyFET is "dramatically reduced" — by almost three orders of magnitude compared with the MOSFET (Figure 2). "A low C_{GD} is of great importance in reducing the switching loss," the researchers write.

The HyFET setup also reduced gate charge in a simulated test circuit with supply voltage 600V and load current 100A. The circuit included a SiC Schottky barrier diode that provided a freewheeling path. The transistors were $1cm^2$ in area. For the HyFET, the gate charge (Q_G) was found to be $239nC/cm^2$ and the gate–drain charge (Q_{GD}) was $47nC/cm^2$. The corresponding figures for the SiC MOSFET were $885nC/cm^2$ and $223nC/cm^2$. The very low gate–drain charge is related to the improved C_{GD} for the HyFET.

The researchers comment: "Low values of Q_G and Q_{GD} are highly desired for power FETs, since a lower Q_G is beneficial for reducing the driving loss, while a lower Q_{GD} results in a smaller switching loss." ■

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Author: Mike Cooke

SiC power market growing at CAGR of 19% to 2021 as it spreads to more applications

SiC diodes hold 85% market share, but SiC transistors to reach 27% share in 2021, says Yole Développement.

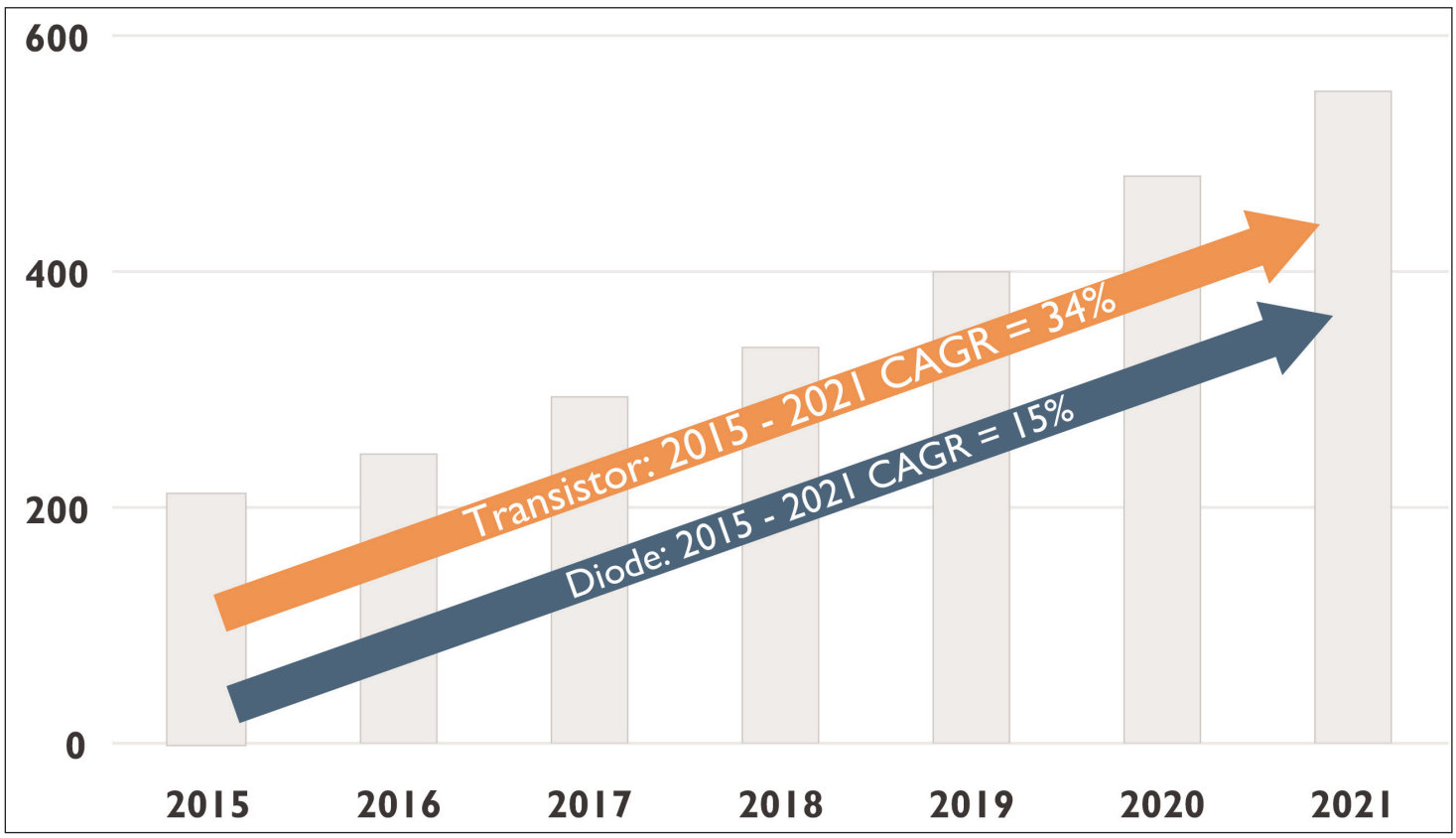
When the first SiC diode was launched in 2001, the industry questioned the future of the SiC power business: Will it grow? Is this a real business? But 15 years later, in 2016, people don't ask these questions anymore, since the SiC power business is concrete and real, with a promising outlook, notes the 'Power SiC 2016: Materials, Devices, Modules & Applications' Market & Technology report released in June by Yole Développement.

The SiC power market (including both diodes and transistors) is forecasted to rise at a compound annual growth rate (CAGR) of 19% from more than $200m in 2015 to over $550m in 2021.

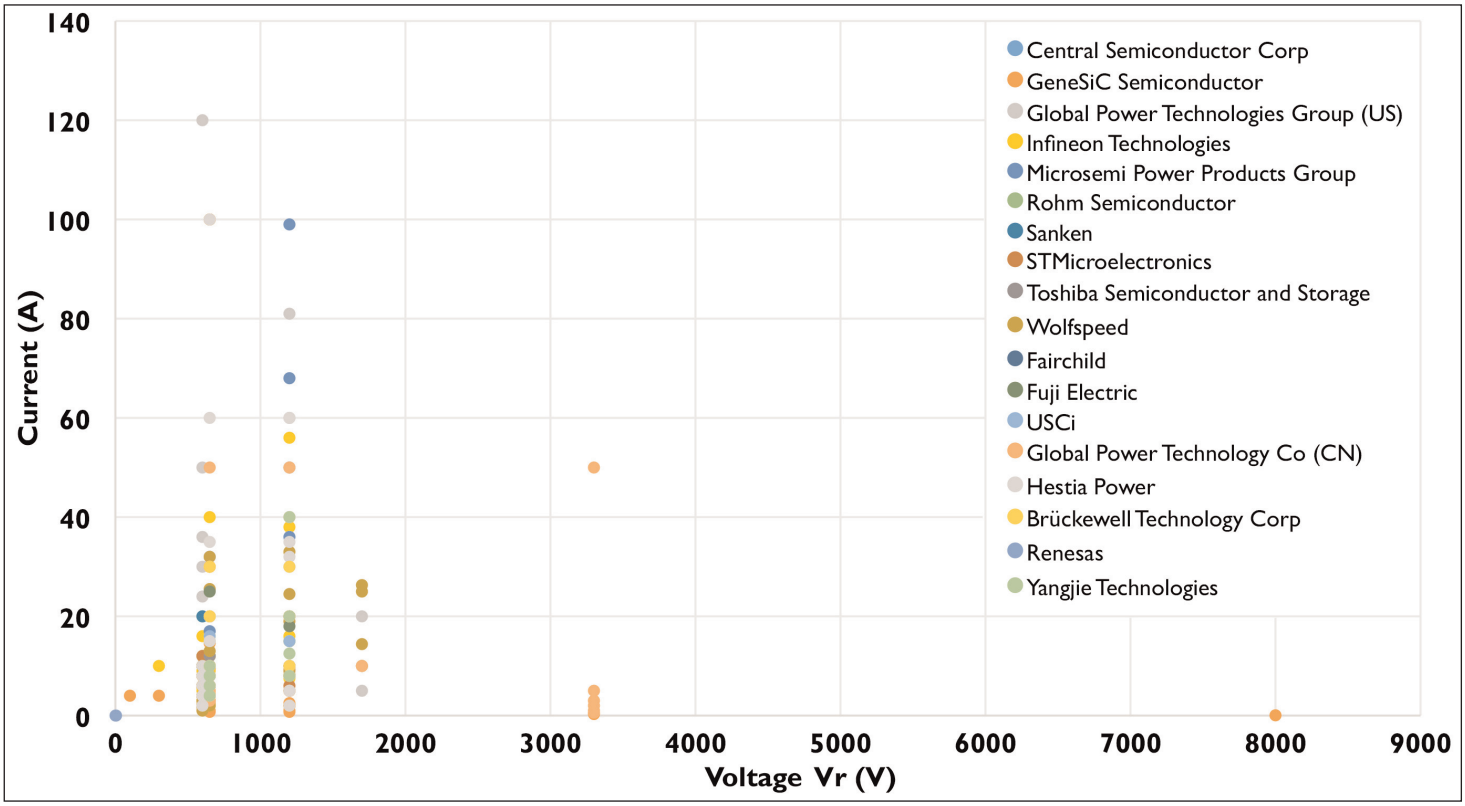
SiC diodes still dominate the overall SiC market, with 85% market share, and this leading position will not change for several years, reckons Yole. In parallel, SiC transistors are increasingly present and should reach 27% market share in 2021. SiC solutions are diffusing step by step into multiple application segments: "We are at the opening stage of the SiC industry for power electronics applications," believes Yole.

Unsurprisingly, the power factor correction (PFC) power supply market is still the leading application, with almost 50% market share (by revenue), consuming a large volume of diodes in 2015. However, this market share is expected to decline progressively after 2016.

Photovoltaics (PV) inverters are close behind, as SiC diodes and MOSFETs are now used by various PV inverter manufacturers in their products. It has been confirmed that SiC implementation provides several performance benefits, including increased efficiency, reduced size and weight. In addition, it allows low cost at the system level in a certain power range. Yole says



Silicon carbide device market revenue (in millions of US dollars).



Commercially available silicon carbide diodes.

that it has received increasingly positive feedback from the market, and it expects other manufacturers to follow in the footsteps of the early adopters, leading to a rapid expansion of the PV segment in the coming years.

The benefits enabled by SiC, the continuous performance improvement, and the cost erosion of SiC power devices will fuel the implementation of SiC in different applications, reckons Yole. The report hence conveys Yole's understanding of SiC implementation in different segments, and offers a summary of SiC power device market data (split by application), including PFC/power supply, PV, EV/HEV, uninterruptible power supplies (UPS), motor drives, wind, and rail.

SiC device makers must support system makers to facilitate adoption

Designers are well aware of SiC's advantages, but they also know the challenges they face: a new product incorporating SiC devices means R&D investment, higher device cost, differences between silicon devices that they're already familiar with, and a lack of field data. All of these factors present barriers to using SiC, notes Yole.

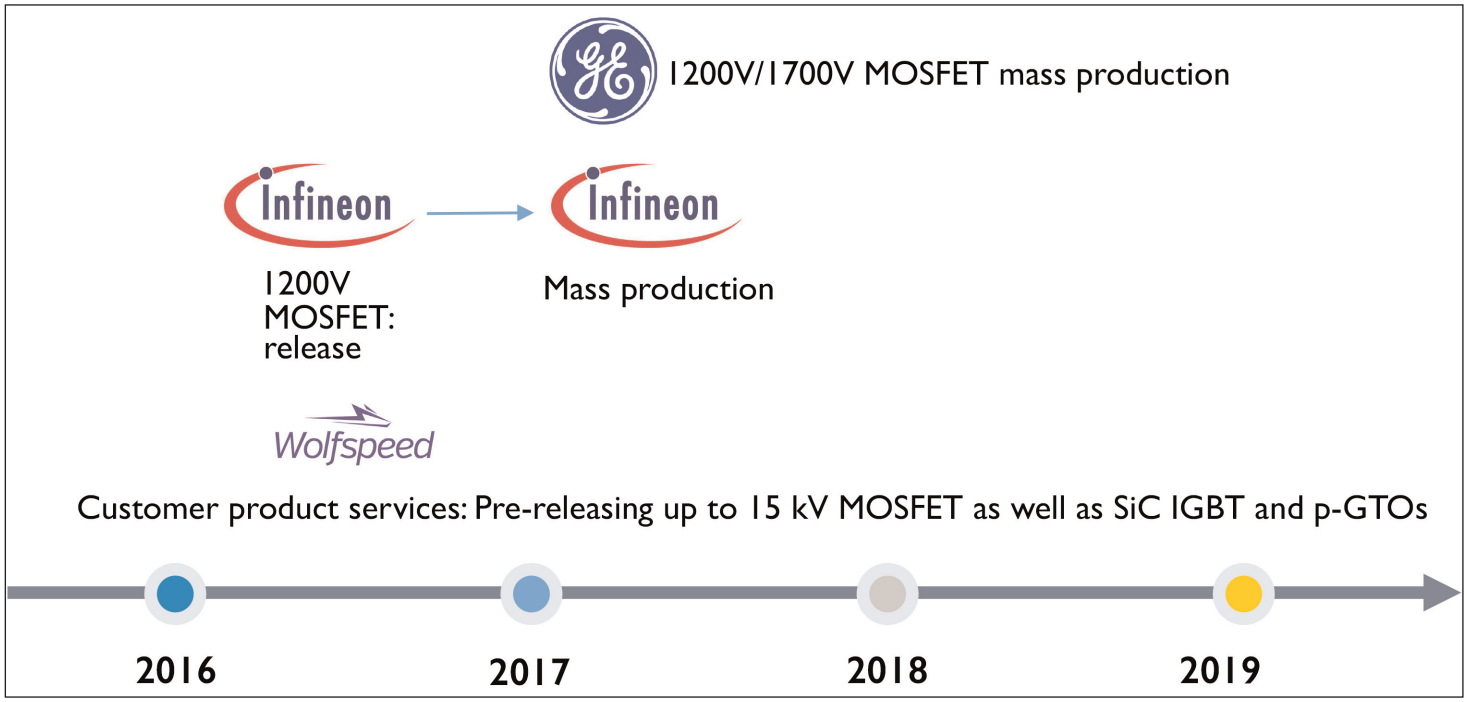
To accelerate SiC's adoption, it is necessary to continue to educate end-users about the benefits at the system level, and more importantly to support them in using these new devices. Yole sees that device makers have gradually learned from their experiences and are moving in a good direction. For example, facing questioning about reliability, SiC device suppliers are offering more and more reliability data, supported by internal and third-party testing. Understanding that the reliability standards for silicon do not completely suit SiC devices, a consortium to establish new standards has been formed by different SiC power device makers.

Also, the announcement of a new module is frequently associated with the release of a driving solution, assisting the designer in surmounting the difficulties linked to the driver. Similarly, Wolfspeed proposes a new SiC-dedicated online design simulation tool to simplify the designer's task. Moreover, additional integrated solutions such as power stack ('power assembly' or 'power block') are appearing on the market. For example, GE has proposed a power block designed to be a kind of 'plug-and-play' solution, with the objective of avoiding integration difficulties that designers may encounter.

SiC power creating many opportunities for different types of suppliers

Attracted by the market's potential, more and more players are entering at different levels of the value chain:

- at the module packaging level, Starpower unveiled its SiC module in May;
- at the device level, after investing in Monolith Semiconductors in 2015, Littlefuse released its SiC diode products this May, with the intention to develop a full product range;
- Yole has also identified other newcomers, including Brückewell, YangJie Technology, and Gengol, each with different backgrounds and different business models;



Coming examples of SiC products.

and

- on the materials side, SiC growth furnace supplier Aymont has started to supply SiC wafers.

Furthermore, existing players will expand their products, says Yole. For example, Infineon has just released its 1200V SiC MOSFET and plans to go into mass production in 2017. Also, Fuji's full SiC module will be available. As more and more products reach the market, Yole hence expects an acceleration in SiC, with the growing market generating plenty of opportunities for different types of suppliers, such as passive components, materials suppliers, test equipment suppliers, etc. ■

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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

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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
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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
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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
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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
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Tel: +49 2407 9030 0
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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.

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7 Wafer processing materials

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www.airproducts.com/compound

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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
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Fax: +43 7712 5311 4600
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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
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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
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www.cscleansystems.com

SAES Pure Gas Inc
4175 Santa Fe Road,
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Fax: +1 805 541 9399
www.saesgetters.com

11 Process monitoring and control

k-Space Associates Inc
2182 Bishop Circle
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MI 48130,
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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.

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Fax: +49 30 89 00 180
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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.

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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.
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Lincoln, NE 68508, USA
Tel: +1 402 477 7501
Fax: +1 402 477 8214
www.jawoollam.com

Lake Shore Cryotronics Inc
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USA
Tel: +1 614 891 2244
Fax: +1 614 818 1600
www.lakeshore.com

14 Chip test equipment

Keithley Instruments Inc
28775 Aurora Road,
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Fax: +1 440.248.6168
www.keithley.com

15 Assembly/packaging materials

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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,
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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
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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
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Fax: +49 711 8804 1950
www.mw-zander.com

24 Consulting

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25 Resources

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www.alshuktz.com

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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

3–5 August 2016
IEEE International Conference on Electron Devices and Solid-State Circuits (EDSSC 2016)
The University of Hong Kong
E-mail: laip@eee.hku.hk
www.eee.hku.hk/edssc2016

6–19 August 2016
14th National Conference on MOCVD
Yanji, Jilin, China
E-mail: lidb@ciomp.ac.cn
www.mocvd14.org

7–12 August 2016
18th International Conference on Crystal Growth and Epitaxy (ICCGE 2016)
Nagoya, Japan
E-mail: secretariat@iccge18.jp
www.iccge18.jp

24–26 August 2016
13th International Group IV Photonics Conference (GFP 2016)
Grand Kempinski Hotel Shanghai, China
E-mail: m.figueroa@ieee.org
www.gfp-ieee.org

28 August – 1 September 2016
SPIE Optics + Photonics 2016
San Diego Convention Center, CA, USA
E-mail: customerservice@spie.org
http://spie.org/optics-photonics1

5–9 September 2016
18th European Conference on Power Electronics and Applications (EPE 2016)
Karlsruhe, Germany
E-mail: info@epe2016.eu
www.epe2016.com

4–9 September 2016
19th International Conference on Molecular Beam Epitaxy (MBE 2016)
Montpellier, France
E-mail: contact@mbe2016.com
http://mbe2016.sciencesconf.org

6–7 September 2016
2nd International Forum on Sapphire Market & Technologies
Shenzhen Convention & Exhibition Center (SZCEC), China
E-mail: veyrier@yole.fr
www.i-micronews.com/events/yole-events/eventdetail/142/-/2nd-int-forum-on-sapphire-market-technologies.html
alongside:

6–9 September 2016
18th China International Optoelectronic Exposition (CIOE 2016)
Shenzhen Convention & Exhibition Center (SZCEC), China
E-mail: cioe@cioe.cn
www.cioe.cn/en

7–9 September 2016
SEMICON Taiwan 2016
Taipei Nangang Exhibition Center, Taiwan
E-mail: semicontaiwan@semi.org
www.semicontaiwan.org

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12–15 September 2016
25th International Semiconductor Laser Conference (ISLC 2016)
Kobe Meriken Park Oriental Hotel, Kobe, Japan
E-mail: islc2016@ics-inc.co.jp
www.islc2016.org

12–15 September 2016
46th European Solid-State Device Research Conference (ESSDERC 2016)
Swisstech Convention Centre, Lausanne, Switzerland
E-mail: essderc2016@epfl
http://esscirc-essderc2016.epfl.ch

19–22 September 2016
LED China 2016
Shanghai New International Expo Centre (SNIEC), China
E-mail: led-trust@ubm.com
www.LEDChina-sh.com

25–29 September 2016
ECSCRM 2016:
11th European Conference on Silicon Carbide and Related Materials
Halkidiki, Greece
E-mail: ECSCRM2016@symvoli.gr
www.ecscrm2016.org

2–6 October 2016
29th IEEE Photonics Conference (IPC 2016)
Waikoloa, Hawaii, USA
E-mail: c.c.scott@ieee.org
www.ipc-ieee.org

3–7 October 2016
European Microwave Week (EuMW 2016), incorporating:
46th European Microwave Conference (EuMC)
11th European Microwave Integrated Circuits Conference (EuMIC)
13th European Radar Conference (EuRAD)
ExCel London, UK
E-mail: eumw2016@manchester.ac.uk
www.eumweek.com

10–13 October 2016
2016 IEEE SOI-3D-Subthreshold Micro-electronics Technology Unified Conference (S3S SOI/3D/SubVt) — 'Energy Efficient Technology for the Internet of Things'
Hyatt Regency San Francisco Airport, Burlingham, CA, USA
E-mail: manager@s3sconference.org
http://s3sconference.org

23–26 October 2016
2016 IEEE Compound Semiconductor Integrated Circuit Symposium (CSICS)
Austin, TX USA
E-mail: hpmoyer@hrl.com
https://csics.org

25–27 October 2016
SEMICON Europa 2016
Grenoble, France
E-mail: eweller@semi.org
www.semiconeuropa.org

26–28 October 2016
6th Annual World Congress of Nano Science & Technology (Nano S&T-2016) — ' Theme: Small is All, The Future of Nanotechnology'
Singapore
E-mail: stella@bitconferences.com
www.bitcongress.com/nano2016

7 November 2016
ITF2016 Japan
New Otani Hotel – Tokyo, Japan
E-mail: Annouck.Vanrompay@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
62nd annual IEEE International Electron Devices Meeting (IEDM 2016)
San Francisco Union Square Hilton Hotel, CA, USA
E-mail: info@ieee-iedm.org
www.ieee-iedm.org

14–16 December 2016
SEMICON Japan 2016
Tokyo International Exhibition Center (Tokyo Big Sight), Japan
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