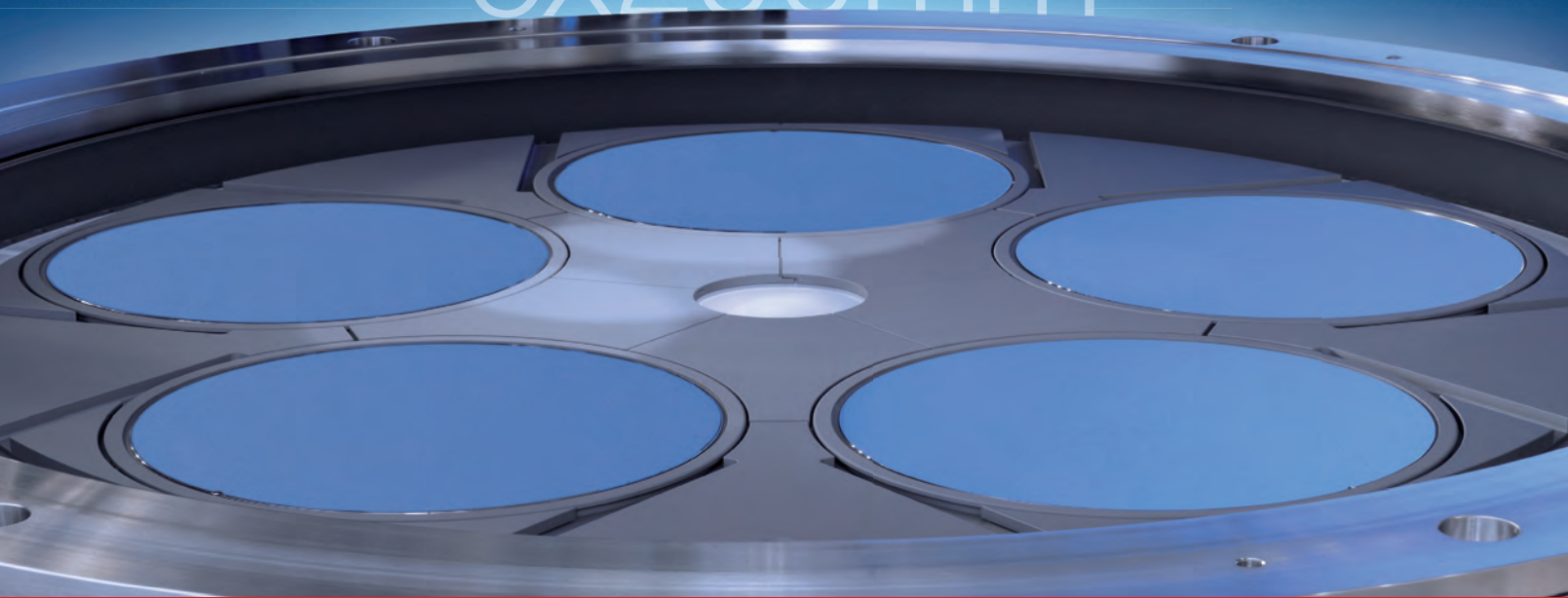


**AIXTRON**

# 200mm GaN-on-Si Batch Reactor

5x200mm



**AIX G5+**



## **AIX G5+ for GaN-on-Si**

- Dedicated technology package
- Compatible with the AIX G5 HT platform
- Enables Si-style mass manufacturing
- Builds on planetary technology:  
Excellent and symmetric uniformities,  
controlled bow behavior,  
using standard Si substrates.

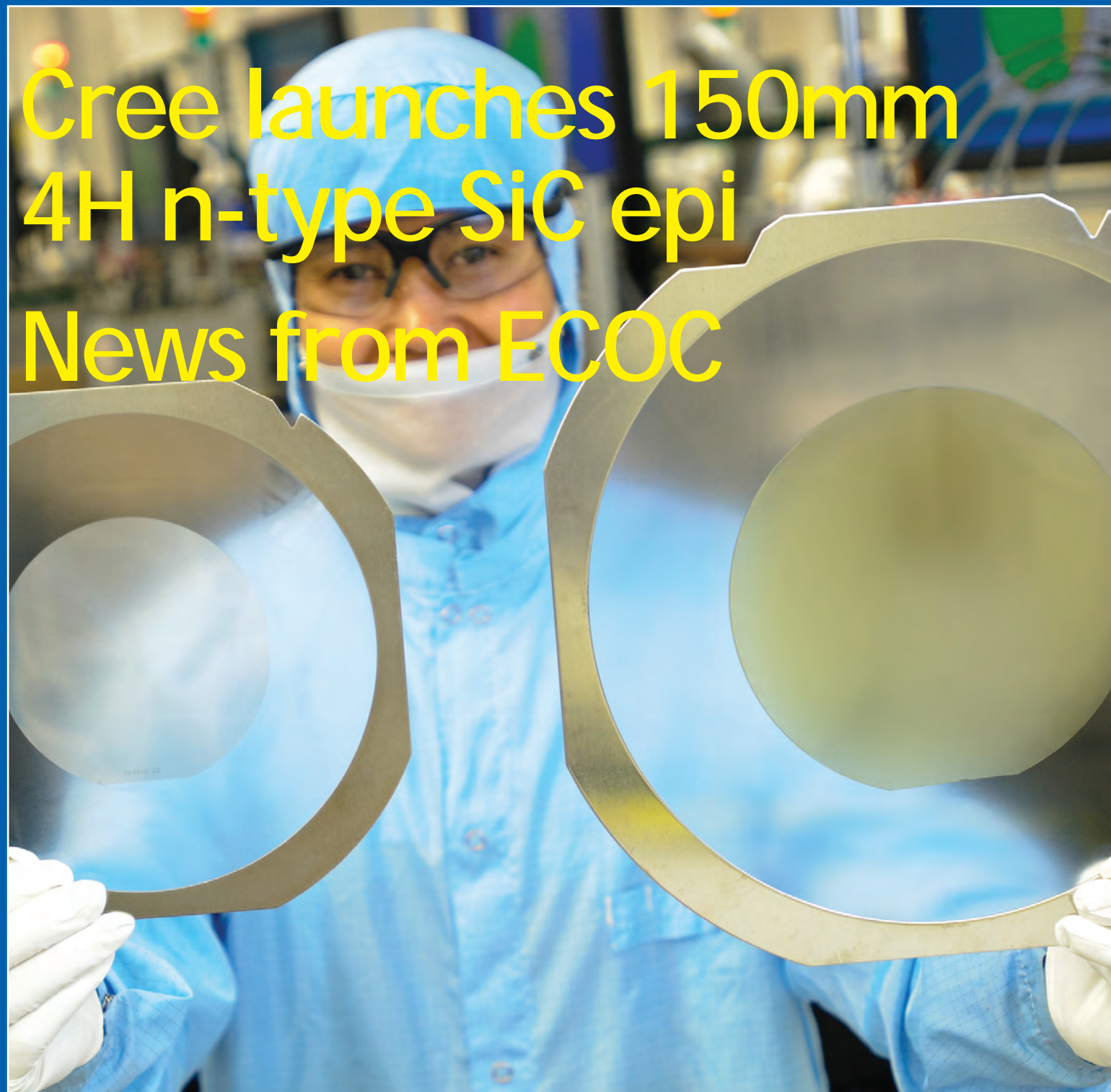


# semiconductor**TODAY**

*C O M P O U N D S   &   A D V A N C E D   S I L I C O N*

Vol. 7 • Issue 7 • September 2012

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**Cree launches 150mm  
4H n-type SiC epi  
News from ECOC**

Lextar absorbs Wellypower • Kyma launches HVPE tool  
IPG Photonics acquires JPSA • Semprius enters production



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Veeco's MaxBright MHP provides high productivity and excellent yield.

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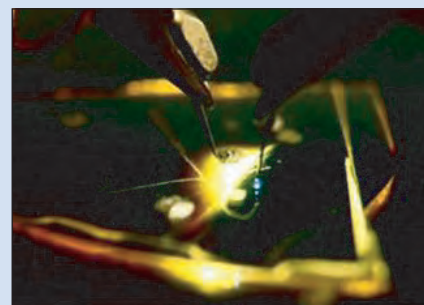
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## semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

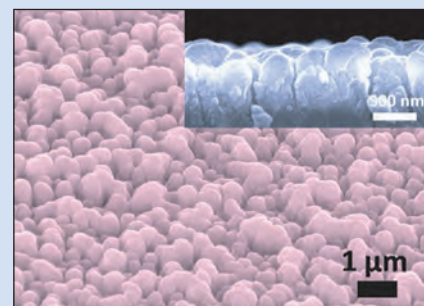
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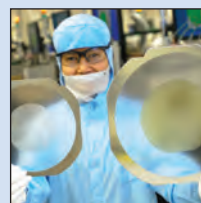
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## Energy efficiency driving growth

Between pages 50 and 63 of this issue we report news from September's European Conference on Optical Communications (ECOC) in Amsterdam, which once again debuted technical developments, such as the launches by both Oclaro and Finisar of 100km-reach 100Gb/s CFP2 transceiver modules. Unrelenting consumer demand for increased data transmission capacity is driving the development of such higher-data-rate components and coherent network technology.

However in the short term, due to "sluggish macro-economic conditions", the telecoms equipment market is still weak worldwide (particularly in Europe and increasingly in China). This is according to component maker Finisar, which has reported quarterly revenue down 8%, including telecom product sales down 13.6% (see page 57). Nevertheless, the firm stresses the importance of technology development for new products, with which it expects to win increased market share, driving a return to revenue growth (starting next quarter).

Despite the current slowdown, the overall compound semiconductor component market is still forecast by BCC to grow at a compound annual growth rate of 11.9% from \$27bn in 2012 to \$47.5bn in 2017 (see page 7).

One development with great potential is the growth of III-V materials on silicon substrates, for both microelectronic applications (e.g. GaAs- and GaN-based transistors on Si — see pages 76–85) and optoelectronic applications (e.g. GaN-on-Si LEDs for general lighting applications).

Meanwhile, the production of devices on silicon carbide (SiC) substrates is making further strides in economies of scale. North Carolina-based SiC substrate maker Cree has just announced the availability of 150mm-diameter 4H-SiC epiwafers (page 19), which the firm reckons will lower device cost and enable device makers to use existing 150mm-wafer processing equipment. In addition, China-based Dongguan Tianyu Semiconductor Technology is extending its SiC epiwafer business globally, while planning to expand its epi production from 2–4" wafers to 150mm wafers. Meanwhile, Japan's Showa Denko has recently added an Aixtron CVD system for not only extending its existing 100mm-diameter SiC epiwafer processing but also migrating its production to 150mm, as the larger-diameter substrates become available from suppliers (see page 26).

Developments in wafer supply correlate with expansions at micro-electronic device makers, such as Japan's Mitsubishi Electric. The firm is accelerating its development of new technologies and products (including those based on SiC) by adding a new building at its Power Device Works facility, boosted by its designation as a 'Green Asia Special Global Strategy Synthesis Area' company by Japan's Fukuoka Prefecture (see page 20).

Such energy-efficiency motives are also continuing to drive developments in LED manufacturing, particularly for general lighting applications, e.g. via the use of silicon substrates (which are not only cheaper than existing sapphire and SiC substrates but also allow the use of larger-diameter wafers and the economies of scale of existing silicon processing equipment and facilities). Most recently, China's Nantong Tongfang Semiconductor has received an MOCVD system from Veeco for researching GaN-on-Si HB-LEDs (page 31). Such developments can be expected to gather pace as the technology matures.

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COMPOUNDS & ADVANCED SILICON



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**Semiconductor Today covers the R&D and manufacturing of compound semiconductor and advanced silicon materials and devices**

(e.g. GaAs, InP and SiGe wafers, chips and modules for microelectronic and optoelectronic devices such as RFICs, lasers and LEDs in wireless and optical communications, etc).

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

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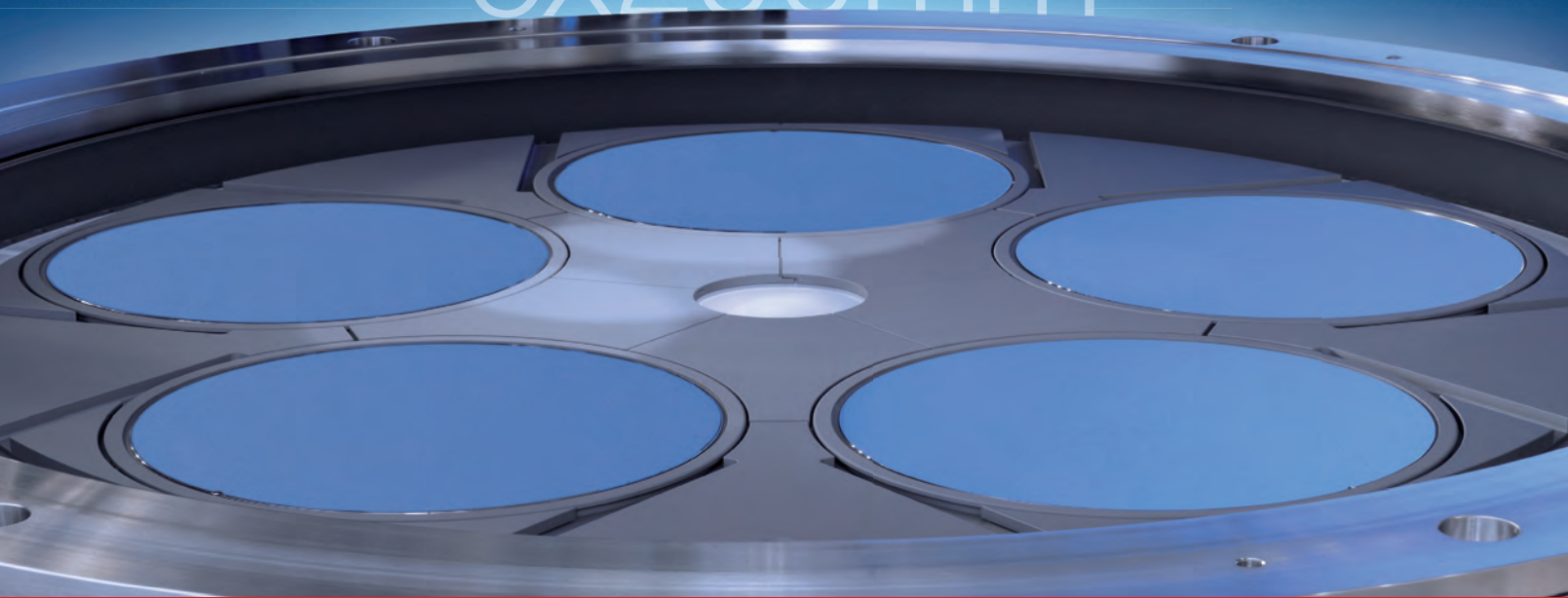
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## LED lamps to provide savings of \$100bn over 5 years

### LEDs to comprise 15% of lighting in 2016, cutting energy consumption by 20%, forecasts IMS Research

The widespread adoption of retrofit LED lamps will create global energy savings worth \$100bn over the next five years, according to the report 'Opportunities for Power Components in LED Lighting' from IMS Research. Although the use of LED lamps for general lighting is not currently widespread, the rapid uptake of retrofit LED lamps will result in a potential market of more than 4 billion units by 2016, reckons the market research firm. While adoption is currently driven largely by legislation, it is forecast to accelerate as consumers become more aware of the long-term savings that are attainable compared with competing lighting technologies.

"The environmental impact that global adoption of LED lighting will have is colossal," says report co-author and senior market analyst Ryan Sanderson. "Lighting accounts for approximately 19% of the world's energy use at present," he adds. "IMS predicts that in 2016 around 15% of all lighting will be accounted for by LED, which would reduce global energy consumption of lighting by around 20%."

Retrofit LED lamps use a fraction of the power of incandescent lamps to provide a similar luminance. The report forecasts that in 2012 alone the use of retrofit LED lamps in place of incandescent lamps will result in energy savings of more than 30 gigawatt hours. By 2016, with widespread adoption of retrofit LED lamps, these savings are forecast to reach more than 300GWe. It is calculated that the five-year cumulative total will be more than 800GWe, worth more than \$100bn.

"To generate the 800GWe of energy in 2016 years you would need to run more than 50 nuclear power stations at full capacity,"

**Comparison of lamp types, by cost in dollars (June 2012).**  
Source: IMS Research.

	Incandescent	CFL	LED
Base price	0.40	1.96	13.60
Expected lifetime (hrs)	1,000	8,000	30,000
Average cost per kWh	0.2	0.2	0.2
Average power (W)	60	13	7
Total kWh	1,800	390	213
<b>Cost for 30,000 hrs</b>	<b>389</b>	<b>84</b>	<b>46</b>
Lamps needed for 30,000 hrs	30	4	1
Total cost of lamps	12.00	7.84	13.60
<b>Total cost for 30,000 hrs</b>	<b>400.80</b>	<b>92.08</b>	<b>59.61</b>
Average number of lamps per house	15	15	15
Cost per house	6,012	1,381	894
<b>Saving by switching to LED lamps</b>	<b>5,118</b>	<b>487</b>	<b>N/A</b>

says report co-author and market analyst Jonathon Eykyn. "At a time when the world is struggling to balance the use of more sustainable power sources with the need to provide access to low-cost power sources to support economic growth, LED lighting could be a large part of the solution," he adds.

The benefits of using LED lamps to the general consumer are reductions in average household energy bills, says IMS. To buy and power a lamp for four hours a day for a year, it costs the average household \$20 for an incandescent lamp currently, but it would cost \$16 for an LED lamp (a saving of 20%). However, compact fluorescent lamps (CFLs) compete much better on efficiency with LED lamps and are becoming a popular lower-cost alternative to incandescent lighting. Despite a CFL lamp currently costing on average just \$6 to buy and power for a year (making it the most economical choice currently), LED lamps use, on average,

half the power of a CFL lamp. Therefore, the advantages of LED lamps become apparent in the longer term, helped by the dislike of CFLs due to their poor light quality, says IMS.

An LED lamp has an average life expectancy of 30,000 hours (i.e. 30 times longer than an incandescent lamp and 3.75 times longer than a CFL lamp). If the savings were calculated over the lifetime of the lamp, then LED lamps become the cheapest solution, notes IMS.

For example, a typical house with 15 lamps would save more than \$5100 over 20 years by switching from incandescent to retrofit LED lamps. A house with CFLs installed would save nearly \$500 over 20 years by moving to retrofit LED lamps. These savings will increase as the cost of LED lamps continues to fall significantly, especially over the next five years, forecasts the market research company.

[www.imsresearch.com](http://www.imsresearch.com)



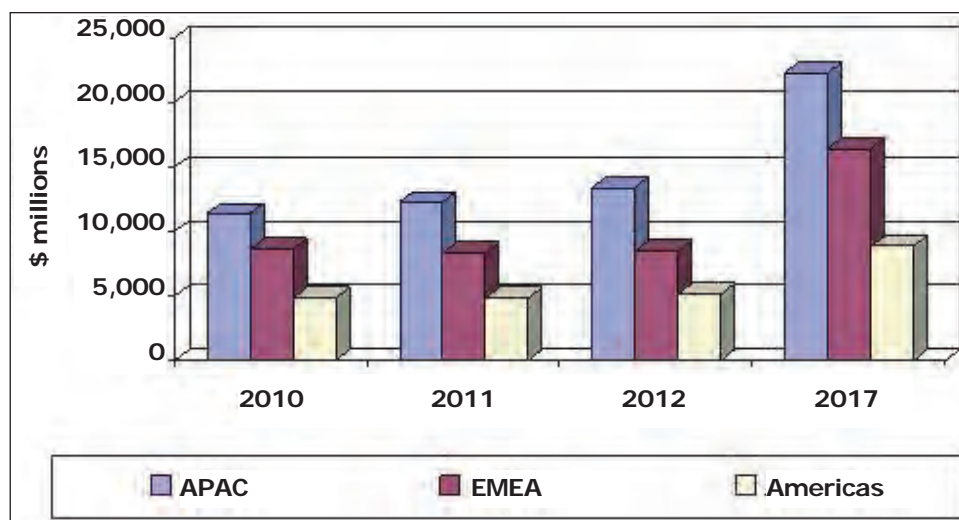
## Compound semiconductor component sales to grow at 11.9% from \$27bn in 2012 to \$47.5bn in 2017

Global sales of compound semiconductor-based components are expected to rise from nearly \$25.5bn in 2011 to more than \$27bn in 2012, then at a five-year compound annual growth rate (CAGR) of 11.9% to nearly \$47.5bn in 2017, according to the report 'Global Markets and Technologies for Compound Semiconductors' (SMC032D) by BCC Research.

Sales in the Americas are expected to grow at a CAGR of 11.4% to nearly \$5.2bn in 2012 and \$8.8bn in 2017. Sales in the EMEA are expected to grow at a CAGR of 14% to nearly \$8.5bn in 2012 and \$16.4bn in 2017.

According to the report, the greatest value of compound semiconductors is their variety and customization, comprising the prime ingredients of some of the most complex semiconductor components and playing a key role in manufacturing of lasers, optical components, LEDs, filters, mixers, power amplifiers, solar panels etc.

Compared with silicon, advantages include higher operating speed, lower power consumption, lower



Sales of compound semiconductor components, by region, 2010–2017 (in \$m).

noise, higher operating temperature, light emission/detection, and superior photovoltaic attributes. These attributes also change from compound to compound, offering considerable design flexibility.

However, the variety of compounds works unfavorably in terms of scale and consequently pricing, notes BCC. Considering that these materials are pitted against silicon (the most widely available material with the most refined and cost-efficient

fabrication process), there is a real danger of the competition being rendered lop-sided in favor of silicon.

However, it is not entirely accurate to compare and confine compound semiconductors to the benchmarks set by silicon, reckons the market research firm. With distinct characteristics of their own, compound semiconductors have spawned several applications that can be catered to only by them.

[www.bccresearch.com](http://www.bccresearch.com)

## GaAs device revenue to grow from record \$5.2bn in 2011 to \$6.1bn in 2016

### Growth suppressed to 6% in 2011 as smartphone market slows

According to the recently released Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) Forecast and Outlook 'GaAs Industry Forecast: 2011–2016', the overall gallium arsenide device market grew by 6% to a record \$5.2bn in 2011, despite a fast start to 2011 being followed by a slowdown toward the end of the year.

However, slowing growth in the smartphone handset market, plus the uncertain global economy, will limit future growth rates below

historical averages, and the market will reach slightly more than \$6.1bn in 2016, forecasts the report.

"The GaAs market began the year [2011] with strong growth," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "Toward the end of the year, slowing growth in the smartphone segment and uncertainty in the global economy became the overriding trends, and the overall GaAs device market slowed substantially. The underlying

trends in the GaAs market still support growth, but uncertainty in the economy is likely to limit this growth," he adds.

"We remain convinced that data consumption and GaAs content in handsets [e.g. for power amplifiers] will increase, but fluctuations in the global economy will put a damper on network and consumer spending," comments Asif Anwar, director in the Strategy Analytics Strategic Technologies Practice (STP).

[www.strategyanalytics.com](http://www.strategyanalytics.com)

## IN BRIEF

## RFMD launches 3.0–4.2V ISM-band Tx/Rx module with diversity transfer switch

Radio-frequency component designer and manufacturer RF Micro Devices Inc of Greensboro, NC, USA says that its new RFFM6904 is a single-chip RF front-end module (FEM) for applications in the 868/900MHz industrial, scientific & medical (ISM)-band.

Other applications include portable battery-powered equipment and wireless automatic metering.

The RFFM6904 addresses the need for aggressive size reduction for typical portable equipment RF front-end design and greatly reduces the number of components outside of the core chipset, minimizing the footprint and assembly cost of the overall solution, claims RFMD.

The FEM integrates a 2W power amplifier (PA), a high-isolation transmit/receive (Tx/Rx) transfer switch, a low-noise amplifier (LNA) with bypass mode, and matching components. Features include 50Ω inputs and outputs; low insertion loss; 33.5dBm of output power; and low harmonic content.

The RFFM6904 is packaged in a small-form-factor 32-pin, 8.0mm x 8.0mm x 1.2mm overmolded laminate package with backside ground which greatly minimizes next-level board space and allows for simplified integration, says RFMD.

This device is currently available in production quantities. Pricing begins at \$5.70 each in 100-unit quantities.

[www.rfmd.com](http://www.rfmd.com)

## SRC honors UC Berkeley's del Alamo for advancing chip technology

At its annual TECHCON technology conference in Austin, TX (at which the latest results of SRC-funded research are shared among university students, faculty and industry experts), university-research consortium Semiconductor Research Corp (SRC) of Research Triangle Park, NC, USA presented its awards for 2012 recognizing outstanding professors in SRC-supported, chip-related research and education.

Dr Jesús del Alamo, professor of Electrical Engineering at Massachusetts Institute of Technology (MIT), received the SRC Technical Excellence Award for his SRC-funded work advancing silicon and compound semiconductor transistor technologies for RF, microwave and millimeter-wave applications.

Selected by SRC's 12 member companies and the SRC staff, the award-winning faculty and research teams are honored for their exemplary impact on semiconductor productivity through cultivation of technology and talent.

"Advanced research has been instrumental in propelling the semiconduc-



Jesús del Alamo

tor industry forward, and we are recognizing these valuable researchers and their teams for the critical work they have performed in helping the industry achieve technological triumphs,"

said SRC president Larry Sumney.

del Alamo's research includes the fabrication of nanometer-scale transistors with record high-frequency operation, and investigating the use of III-V compound semiconductors to enable a new generation of deeply scaled transistors for future digital applications. "I am deeply honored by this recognition that comes from an institution that has done so much to foster progress in semiconductor science and technology," said del Alamo. "The partnerships between university and academia that the SRC creates and nurtures are critical elements of a healthy microelectronics ecosystem," he added.

<http://mtlweb.mit.edu/~alamo>  
[www.src.org](http://www.src.org)

## RFMD's PowerSmart MMMB PAs to power Samsung's GALAXY Note II

RF Micro Devices Inc of Greensboro, NC, USA, says that its PowerSmart Power Platforms — claimed to be the only converged multimode, multiband (MMMB) power amplifiers — are supporting Samsung's next-generation GALAXY Note II.

"With the ramp of the GALAXY Note II, RFMD extends our coverage of Samsung's product portfolio to include all tiers and segments," says president & CEO Bob Brugge-worth. "In the coming months, we look forward to the availability of additional devices and baseband architectures that expand our business with Samsung to include addi-

tional PAs, incremental switch-based content, and new high-performance WiFi front ends."

Samsung's GALAXY Note II features:

- a 5.5" HD Super AMOLED, 16:9-ratio screen;
- a 1.6GHz Quad-Core processor;
- HSPA Plus or 4G LTE connectivity; and
- a 8 megapixel rear-facing camera and a 1.9 megapixel front-facing camera with HD video recording capabilities.

GALAXY Note II is due to launch in October, starting in major European, Asian, and Middle East markets.

[www.rfmd.com](http://www.rfmd.com)



## TriQuint launches integrated multi-band, multi-mode PA for global 3G/4G smartphones

TriQuint has launched a new multi-band, multi-mode power amplifier (MMPA) that simplifies the increasingly complex RF front-end for next-generation global 3G/4G smartphones and other mobile devices. The compact, highly integrated TRIUMF MMPA achieves what is claimed to be best-in-class PAE (power-added efficiency), providing up to 15% more browsing time.

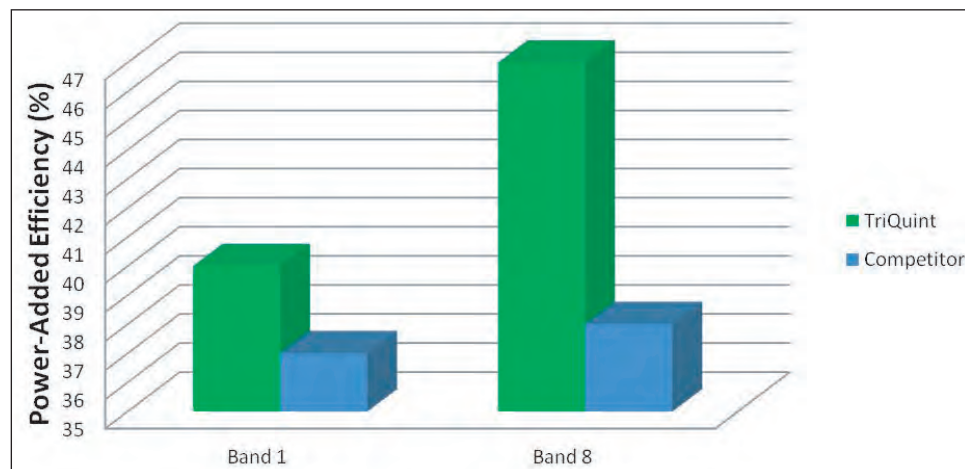
"As LTE networks roll out, next-generation smartphones have to incorporate a growing number of frequency bands. This means device manufacturers must support the rapidly growing RF content within very small form factors — without compromising performance," says Shane Smith, VP of global marketing for mobile devices. "Our customers confirm that our new TRIUMF TQM7M9053 MMPA is optimized for these demanding applications," he adds. "This integrated solution consumes 13% less PCB space than discrete components and simplifies routing to enhance system performance and time to market."

Increasing device complexity is driving demand for integrated RF solutions such as MMPAs. "Multi-mode, multi-band PAs mark the rise of a new high-growth segment that will alter the course of the RF

components industry," comments Christopher Taylor, an analyst with Strategy Analytics. The market for MMPAs will exceed \$700m in 2016, he predicts. "The biggest opportunity for MMPAs is mid- to high-end smartphones, which use the largest number of bands and modes to ensure availability of voice and data services when roaming."

TriQuint's new second-generation TRIUMF TQM7M9053 MMPA is drop-in, pin-compatible with the TQM7M9023 MMPA, which is found in some of the world's most sought-after smartphones and included on a leading chipset supplier's reference design, says the firm. The TQM7M9053 offers higher efficiency at a lower cost, which has already resulted in several smartphone design wins.

The versatile 5mm x 7.5mm TQM7M9053 is a fully matched MMPA that offers quad-band GSM/EDGE and WCDMA/LTE bands 1, 2, 5 and 8 to support the 3G/4G market in North America, Europe and Asia. The firm's family of TRIUMF MMPAs combines with its surface acoustic wave (SAW) and bulk acoustic wave (BAW) filters to deliver a complete RF front-end solution for smartphones and other mobile devices.



The TQM7M9053 TRIUMF MMPA achieves best-in-class PAE in bands 1 and 8. The 47% PAE in Band 8 translates to 15% more browsing time for users.

### IN BRIEF

#### Huawei honours TriQuint with supplier award

RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has been honored with the 2011 Supplier Award in the category of Technical Support by global information and communication (ICT) technologies solutions provider and long-time partner Huawei.

"For almost three decades we have developed and manufactured some of the highest-quality RF products in the world," says Brian Balut, TriQuint's VP for Networks Products. "We pride ourselves in providing top service and support that enable our partners to bring to market the best devices and technical solutions," he adds.

"TriQuint implemented the application-specific demands within a short time, and they delivered solutions just as quickly," says Huawei's PDT (Product Development Team) manager Libiao Wang. "We achieve our goals when our technical support team becomes an integral and dependable part of our partners' organizations."

Nominated by Huawei's team that builds Transport Products for the world's high-speed networks, TriQuint was recognized for superior performance in the following categories:

- Timely response to Huawei requests;
- Solutions to all of Huawei's technical questions within a requested cycle time; and
- Supplying continuous value-added training for Huawei employees.

Only three Huawei suppliers were presented with the award for Technical Support.

[www.huawei.com](http://www.huawei.com)  
[www.triquint.com](http://www.triquint.com)

## IN BRIEF

### Skyworks receives ZTE's Best Vendor and Outstanding Delivery awards

Skyworks Solutions Inc of Woburn, MA, USA has received the Best Vendor and Outstanding Delivery awards from wireless communication equipment manufacturer ZTE Corp of Shenzhen, China for supporting its RF business without a single part shortage in the last three years. This follows Skyworks last year receiving the 2011 Global Partnership Award from ZTE. Skyworks is now ZTE's leading front-end solution supplier and has supported several major product launches.

"Congratulations once again to the Skyworks team for their support and flexibility in meeting our needs in this demanding and dynamic mobile phone industry," says ZTE management. "With Skyworks support, we have been able to connect our customers in 140 countries via voice, data, multimedia and wireless networking solutions."

ZTE uses a variety of Skyworks' products, including WCDMA/LTE and EDGE front-end solutions for USB modems, data cards, TD-SCDMA and CDMA products for handsets, as well as antenna switch modules for several smartphone platforms. ZTE also leverages multiple custom analog solutions from Skyworks for wireless networking and infrastructure applications.

Skyworks is also supporting the launch of ZTE's Grand X LTE smartphone, with a multimode, multiband front-end solution. With this device, ZTE is the first mainland China vendor to introduce a 4G LTE mobile handset, says Skyworks.

[www.zte.com.cn](http://www.zte.com.cn)

[www.skyworksinc.com](http://www.skyworksinc.com)

## Revenue & earnings guidance raised

Skyworks Solutions Inc of Woburn, MA, USA (which manufactures analog and mixed-signal semiconductors) has updated its financial outlook for fiscal Q4/2012, based on strong program ramps across its high-performance analog and mobile internet businesses, as well as continued operating leverage within its business model.

Skyworks now expects revenue of \$420m (on the high end of its prior guidance range — given on 18 July — of \$415–420m). This is up 8% on last quarter's \$389m. The firm also expects to deliver non-GAAP diluted earnings per share of \$0.52 versus guidance of \$0.50–0.51. This is up 16% sequentially on last quarter's \$0.45 per diluted share.

### Skyworks launches 0.02–4GHz high-isolation SP4T absorptive switch with

Skyworks has launched a new 0.02–4.0GHz GaAs pHEMT-based high-isolation, symmetrical single-pole four-throw (SP4T) absorptive switch with integrated 50Ω RF port terminations in a small 3mm x 3mm x 0.75mm 16-pin QFN (quad flat no-lead plastic) surface-mount technology package (MSL1, 260°C per JEDEC J-STD-020).

The SKY13384-350LF suits designs

where low insertion loss (<1.0dB), high isolation (>40dB) and broadband return loss (15dB) are required, such as in critical filtering and band switching applications.

Markets for the wideband high-isolation switch include GSM/CDMA/WCDMA/TD-SCDMA/TD-LTE cellular infrastructure, military communications and test & measurement.

### Skyworks captures extra analog content in smartphones with LED camera flash drivers

Skyworks says it is capturing added content in smartphone platforms with its LED camera flash driver solutions.

The adoption of cameras in smartphones, along with consumers' expectations for high-quality photographs, is driving accelerated implementation of camera flash drivers in mobile devices, it says. "Our advanced suite of camera flash drivers demonstrates Skyworks' ability to expand content in the fastest-growing market segments, while also diversifying our broad analog product portfolio," says Liam K. Griffin, executive VP & general manager of high-performance analog at Skyworks.

According to market research firm Gartner Inc, mobile phone cameras will grow from about 1.6 billion units in 2011 to over 2.2 billion in 2015, representing 92% of mobile phones worldwide. An further 15% of them will have two cameras to take portrait photos or to enable video chat.

"A digital camera is found in almost all types of mobile electronic equipment devices ranging from mobile phones to notebook PCs, tablet computers and handheld video game consoles," says the report 'Market Trends: Digital Camera Functions in Mobile and Consumer Electronics'. "Mobile electronics equipment will have digital camera functions as well as wireless communication function as a standard feature."

Skyworks says its AAT1274 is a high-efficiency, 1.5A high-current boost converter for LED photo flash applications. It maintains output current regulation by switching the internal high-side and low-side switch transistors, pulse-width modulated at a fixed frequency of 2MHz. High switching frequency allows the use of a small external inductor and output capacitor, suiting all single-cell, Li-ion-powered applications.



## Anadigics launches dual-band ProEfficient 3G/4G PAs

GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has expanded its ProEfficient 3G/4G power amplifier (PA) product family (launched in June) with dual-band PAs for mobile devices such as smartphones and tablets.

Anadigics' ProEfficient PAs use the firm's exclusive InGaP-Plus technology and patented design architectures to provide greater talk time in low-power mode with longer data application use in high-power mode. This differentiated technology also enables higher levels of integration (including internal voltage regulation, DC blocks on RF ports, and RF matching optimized for output power, efficiency and linearity in a 50Ω system), reducing three-dimensional space requirements for dual-band 3G and 4G applications, says Anadigics.

"Modern 4G smart phones provide users with access to incredibly fast data speeds that rival many wired broadband connections," says Jerry Miller, VP of Wireless Mobile Products. "However, the increasing use of 4G data is driving greater current consumption, decreasing battery-life in both smartphones



**Anadigics' new dual-band ProEfficient 3G/4G power amplifiers.**

and tablets," he adds.

The CDMA-, WCDMA-, HSPA- and HSPA+ -compliant dual-band ProEfficient PAs feature two independent amplification chains (in a single package) to deliver what is claimed to be outstanding performance for each band. The PAs provide industry-leading efficiency across all power levels (46% in high-power mode; 40% in low-power mode) — as well as low quiescent current — to maximize 4G

battery-life without the use of a DC–DC converter, says Anadigics. They are also optimized for use with average power tracking (APT) to further increase efficiency and reduce current consumption at medium and low operating powers.

ProEfficient power amplifiers also deliver what is claimed to be best-in-class linearity (ACLR1) to ensure a stable connection for clear voice and high-speed data.

The frequency band combinations are: AWT6751 (bands 1 & 8); AWT6754 (bands 3 & 5); AWT6755 (bands 2 & 5); and AWT6756 (bands 1 & 5). By combining frequently used band combinations with an internal voltage regulator in compact low-profile 3mm x 4mm x 0.9mm packages, the battery-life-extending PAs also help to save valuable PCB space.

"By combining the industry's highest efficiency across all power levels with a highly integrated small-footprint package, Anadigics' new dual-band ProEfficient power amplifiers not only offer a smart path to greater battery-life, but also enable sleek designs," says Miller.

Samples are available now for qualified programs.

## Anadigics' MMPA powers Galaxy S Relay 4G smartphone

Anadigics is shipping production volumes of its ALT6181 multimode multiband power amplifier (MMPA) to Samsung Electronics for the new Galaxy S Relay 4G smartphone.

Anadigics says that the MMPAs leverage its InGaP-Plus technology and patented design architectures to provide a single-package solution for quad-band GSM/EDGE and dual-band WCDMA/LTE applications. It adds that its MMPAs combine integration and efficiency, helping to extend battery life in applications where minimizing printed circuit board (PCB) space is desired, such as handsets, smartphones, tablets, netbooks, and notebooks.

"By leveraging our innovative technologies, design techniques, and intellectual property, we are able to help manufacturers reduce RF PCB space requirements and extend battery life in sleek, power-hungry mobile devices," says senior VP of worldwide sales Michael Canonico.

The compact, low-profile 5mm by 7.5mm by 0.9mm ALT6181 MMPA has an integrated voltage regulator, separate single-ended RF chains, and high directivity RF couplers. WCDMA/LTE linearity specifications for bands 1, 5, 6, 18, 19, and 26 have been enhanced, while ensuring that critical harmonic, noise and intermodulation performance yields superior mobile device performance.

Anadigics says that, similar to its new ProEfficient family of products, the ALT6181 MMPA provides optimal WCDMA/LTE efficiency across all power levels (>40% in high-power mode and >20% in low-power mode), without the use of a DC–DC converter. The firm also claims best-in-class linearity at maximum output power, as well as a low quiescent current of 4mA.

The firm adds that the MMPA delivers high GSM/EDGE efficiency at all power levels and meets stringent modulation mask requirements under all conditions, while EDGE mode is optimized for the best combination of linearity and efficiency.

[www.anadigics.com](http://www.anadigics.com)

## IN BRIEF

### M/A-COM launches MMIC doubler with integrated gain, self-biased doubler and driver stages

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) has launched a gallium arsenide monolithic microwave integrated circuit (MMIC) doubler for VSAT applications.

The XX1010-QT is an active doubler in a RoHS-compliant 3mm x 3mm 16-lead plastic QFN package that delivers +20dBm output saturated power ( $P_{out}$ ) and 35dBc fundamental suppression. Using a GaAs pseudomorphic high-electron-mobility transistor (pHEMT) process, the XX1010-QT covers the 14.625–15.0GHz/29.25–30.0GHz frequency bands and integrates a gain stage, doubler and driver amplifier into a single device.

The doubler is suited to SatCom and millimeter-wave point-to-point radio applications, says the firm. The XX1010-QT integrates DC blocking and bypassing capacitors, eliminating the need for any external components. The device has a self-bias configuration, requiring only a positive 5V supply. The supply current is 200mA. Input return loss is 12dB and output return loss is 14dB.

"The high level of integration coupled with a standard 3mm x 3mm plastic QFN package offers our customers an optimal cost-effective solution by saving precious board area and reducing component count," claims product manager Amer Droubi. "The XX1010-QT is an ideal driver stage to the final output power amplifier in Ka-band VSAT terminals," he adds.

## GigOptix releases PAs delivering up to 26dBm for high-capacity E-band radio

GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical components enabling high-speed end-to-end information streaming over optical fiber and wireless networks) has released engineering samples of its new-generation power amplifiers (PAs) covering the 71–76GHz and 81–86GHz frequencies for high-capacity E-band radios.

The EXP7602 and EXP7603 GaAs pHEMT MMIC PAs provide gain of 16dB and 20dB, respectively, across the 71–76GHz band. The EXP7602 delivers a P1dB above 23dBm with saturated output power above 25dBm. The EXP7603 delivers a P1dB above 25dBm with saturated output power above 26dBm. The GaAs pHEMT MMIC PA EXP8602 provides gain of 18dB across the 81–86GHz band and delivers a P1dB above 20dBm with saturated output power above 23dBm.

All three PAs feature on-chip temperature-compensated output power detector to simplify system assembly and increase power efficiency, says the firm. The PAs feature RF inputs and outputs that are internally matched to 50Ω and

require no external matching components. The devices typically dissipate 2.2W during operation.

"The devices feature high gain and high output power levels with excellent return losses," says chief technology officer Andrea Betti-Berutto. "The availability of on-chip output power detector will enable customers to meet the challenging E-band radio specification whilst simplifying their integration," he adds. "The new devices enable E-band radios to transmit more data, more efficiently over a longer distance and at a more competitive price to what is currently available in the market. We expect our new power amplifier solutions to be a significant contributor to our future growth in the E-band market."

In a recent report on point-to-point radio links from ETL Wireless Research, E-band was forecast to be one of the fastest-growing segments in the wireless mobile backhaul market, with greater than 100% compounded annual growth rate (CAGR) to 2016.

Die of the EXP7602 and EXP7603 are available for sampling.

[www.gigoptix.com](http://www.gigoptix.com)

## M/A-COM launches 8W 2.5–3.5GHz power amplifier for S-band radar

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) has launched the MAAP-010171 2-stage pulsed power amplifier, fully matched to 50Ω on both the input and output and operating in the 2.5–3.5GHz frequency range, for S-band radar applications.

Fabricated using the firm's high-linearity GaAs pHEMT process, the MAAP-010171 is packaged in 5mm x 5mm 20-lead PQFN package,

allowing easy assembly.

Input and output return losses are both 10dB. Small-signal current ( $I_{DD}$ ) is 1A.

"This device is an integral part of our S-band radar product portfolio," says product manager Scott Vasquez. "With its 8W saturated output power [39dBm], 27dB gain, and 38% power-added efficiency, the MAAP-010171 is well positioned to be used as a power amplifier stage or as a driver stage in high-power pulsed radar applications," he adds.

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# Peregrine expands European operations

## UK facility for UltraCMOS products adds global design & sales support

Peregrine Semiconductor Corp of San Diego, CA, USA, a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-sapphire (SOS), has expanded its European operations with the opening of a design, manufacturing and sales facility in Reading, UK.

The new facility focuses on developing dedicated RFIC products of European content in order to better address European requirements, including those of the commercial, industrial, and high-reliability (hi-rel) markets, which have been a cornerstone for Peregrine's growth across Europe. The facility will also



**Peregrine Semiconductor Europe's Mark Moffat.**

provide design services for Peregrine's next-generation UltraCMOS RFIC portfolio, sold worldwide. Europe has been instrumental in the world-wide adoption of the firm's UltraCMOS technology, says Dave Shepard, VP of the High-Performance Solutions business unit. "Some of the world's most visionary designs originate in

the European region, and this expansion of our global design, sales support, and manufacturing operations further demonstrates our commitment to the European RF engineering community," he adds.

Multiple product families will be developed at the new facility, including digital step attenuators, phase-locked loop (PLL) frequency synthesizers, and RF switches. Also, Peregrine is looking for employees to join its European team as part of its 2012 expansion plan, which so far has included a substantial increase in its global workforce.

## Peregrine unveils SPDT RF switch in SC-70 package for battery-powered and automotive-telematics applications

Peregrine Semiconductor has launched the SPDT PE42421 RF switch, available in a miniature, 6-lead SC-70 package. The firm claims that, with its small package size, strong ESD performance of 2kV on the RFC port, low-voltage support down to 1.8V  $V_{DD}$ , and low power consumption of 9 microamperes (typical), the new switch is suited to battery-powered portable applications, as well as automotive-telematics applications, such as vehicle entry systems and emergency calls.

The 50 Ohm, reflective UltraCMOS PE42421 switch features high linearity of 50dBm IIP3 and on-chip, low-voltage CMOS control logic. It can be controlled using either single-pin or complementary-control inputs. The switch also features low insertion loss of 0.35dB at 1.0GHz and 0.50dB at 2.0GHz, with high isolation of 30dB at 1GHz and 20dB at 2GHz. Using a nominal +3V power-supply voltage, a typical input 1dB compression point of +33.5dBm can be achieved.



**Peregrine Semiconductor's new PE42421 SPDT RF switch,**

"Customers continue to push for low-power and high-ESD performance in the smallest package size possible, in order to deliver optimal RF performance in their portable device and automotive-telematics designs," comments Mark Schrepferman, director of marketing for Peregrine's high-performance solutions business unit. "The PE42421 switch meets these needs, and also makes

customers' manufacturing processes more reliable," he claims.

The PE42421 switch is available for \$0.30 each, in 10,000-unit quantities. Peregrine has also announced the PE42421 Evaluation Kit (part number EK42421-01). The kit includes a USB interface board and cable, and is priced at \$95.

[www.psemi.com](http://www.psemi.com)



# RFMW appointed as global distributor of Peregrine Semiconductor's UltraCMOS RFICs

Peregrine Semiconductor Corp of San Diego, CA, USA, a fabless provider of radio-frequency (RF) integrated circuits (ICs) based on silicon-on-sapphire (SOS), and RF & microwave component distributor RFMW Ltd of San Jose, CA, USA have finalized a worldwide distribution agreement for Peregrine's UltraCMOS RFICs.

RFMW will stock, distribute and provide applications engineering support for Peregrine's broad product portfolio, including RF switches, digital step attenuators, pre-scalers, mixers, phase-locked loop (PLL) frequency synthesizers, and digitally tunable capacitors, for applications in the defense, broadband, industrial, mobile wireless device, test & measurement equipment, and wireless infrastructure markets.

"RFMW's focus on RF products, technology, and customers is a highly complementary solution to Peregrine's existing global sales network," says Dale Robinette, Peregrine's director of worldwide sales. "Our partnership with RFMW gives us visibility into the very early design stages of customer projects, where our unique UltraCMOS technology process and high performance provide the most benefit," he adds.

"Peregrine Semiconductor's UltraCMOS technology enables the development of highly integrated RFICs that combine RF, mixed-signal and digital functions on a single chip," says RFMW's president Joel Levine. "We've seen requirements

in certain market segments for this type of integration while, at the same time, many of our customers design with discrete devices such as switches, and digital attenuators. Peregrine's product portfolio satisfies the requirements of both," he adds. "Our immediate goal is to introduce customers to Peregrine's portfolio, in order to expand design-in opportunities."

"Our pan-European sales staff of focused RF specialists are eager to support customer design, prototype and manufacturing opportunities with Peregrine's devices, which provide much needed support for current design opportunities where we've previously been unable to offer solutions," notes Peter Saxby, managing director of RFMW in Europe.

[www.rfmw.com](http://www.rfmw.com)

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## IN BRIEF

### TowerJazz wins Raytheon NCS Supplier Excellence Award for second year running

Specialty foundry TowerJazz (which has fabrication plants at Tower Semiconductor Ltd in Migdal Haemek, Israel, and at its subsidiaries Jazz Semiconductor Inc in Newport Beach, CA, USA and TowerJazz Japan Ltd) says that its USA Aerospace and Defense Division has won a Supplier 3 Star Excellence Award from Raytheon Network Centric Systems (NCS) of McKinney, TX for the second year in a row. The NCS Supplier Excellence Program is designed to formally recognize Raytheon's suppliers for exemplary performance and commitment to excellence.

TowerJazz says that many aerospace and defense firms as well as branches of the US military use its specialty process platforms to manufacture a wide variety of solutions. Raytheon in particular uses the CMOS process in TowerJazz's Newport Beach fab for the manufacture of its read-out integrated circuit (ROIC) designs in support of their overall infrared detector products and systems. Raytheon also takes advantage of TowerJazz's manufacturing expertise, which helps to maintain high yields and quality for downstream detector manufacturing steps, the firm claims.

"It acknowledges that we have achieved our goal to continue supporting this partnership with the highest level of dedication and commitment," says Mike Scott, TowerJazz's director of sales & marketing – USA Aerospace and Defense Division, of the award.

[www.raytheon.com/businesses/ncs](http://www.raytheon.com/businesses/ncs)  
[www.towerjazz.com](http://www.towerjazz.com)

## RFaxis starting mass production of seven new CMOS RFeICs

Fabless semiconductor firm RFaxis Inc of Irvine, CA, USA, which designs RF semiconductors and embedded antenna solutions for the wireless connectivity and cellular mobility markets, says it will start volume production of its second-generation, pure CMOS-based RF front-end ICs (RFeICs) in fourth-quarter 2012. The new solutions will serve rapidly growing markets including smartphones and tablets, WLAN 11a/n/ac, ZigBee, wireless audio, smart energy and home automation.

Following the deployment of its RFX2401C and RFX2402C (claimed to be the first single-chip/single-die RFeICs in pure CMOS for ZigBee/ISM and 802.11b/g/n applications), RFaxis is now entering full-scale manufacturing and shipment of seven additional RFeICs, broadening its product range for the wireless/RF community.

The RFX5000 and RFX5000B deliver +18dBm output power with 3% EVM (error vector magnitude) for 64QAM/OFDM in the 5GHz 802.11a/n/ac frequency band, including all losses of the antenna switch and input/output impedance matching network. Combined with high gain (33dB), high efficiency (170mA at +17dBm in low-current mode), low EVM floor (<1.5%), excellent thermal stability and multiple mode controls with simple CMOS logic, they outperform all 5GHz front-end solutions on the market from any existing technology, including gallium arsenide (GaAs) or silicon germanium (SiGe), RFaxis claims. The RFX5000 and RFX5000B are also pin-to-pin compatible with existing incumbent 5GHz technologies.

The RFX8420 and RFX8421 are designed and optimized for dual-mode Wi-Fi/Bluetooth applications that are now standard features in mainstream smartphones. Housed in ultra-compact 2.5mm x 2.5mm x 0.45mm QFN packages and pin-

compatible with multiple GaAs-based front-end modules (FEM) on the market, they also deliver RF performance that includes what is claimed to be excellent EVM power and efficiency. In addition, the RFeICs have 0.8dB in total insertion loss for the SP3T switch with all DC-blocking capacitors integrated on-chip.

RFaxis also continues to expand its 2.4GHz and sub-GHz RFeIC portfolio for ZigBee, smart energy/smart home, wireless sensor network and generic ISM-band applications. The RFX1010 is an ultra-broadband half-watt RFeIC operating at 780–960MHz. The new RFX2411 and RFX2410 add antenna diversity capability to the firm's existing RFX2401C, without any compromise in output power/efficiency or increase in package size.

"RFaxis has broken all of the technical barriers that have prevented bulk CMOS to beat the performance of incumbent technologies, such as GaAs and SiGe," states chairman & CEO Mike Neshat. "We are not only starting full-scale deployment and production of these seven new RFeICs — ranging from sub-GHz ZigBee to 5GHz 11n/ac MIMO — but will also be sampling our RFX8825 RFeIC to support the upcoming migration to dual-band/dual-mode Wi-Fi designs in smartphones and tablets, as well as our RFX240 high-power linear power amplifier to capture the Wi-Fi AP/router and outdoor hotspot markets," he adds.

"By offering the best-in-class performance, lowest cost, highest level of integration, and pin-to-pin compatible solutions with our competitors, RFaxis is going to 'turn off the GaAs' and bring pure CMOS technology center stage for the RF front-end market," Neshat reckons. "Our goal is to be the world's preferred RF front-end solution provider and displace all competing solutions in 2013."

[www.rfaxis.com](http://www.rfaxis.com)



## Javelin supplies CMOS power amplifiers for Samsung's Galaxy S Duos smartphone

South Korea's Samsung Electronics Co Ltd has selected CMOS-based 3G power amplifiers (PAs) from Javelin Semiconductor Inc of Austin, TX, USA to support its new Galaxy S Duos Android-based smartphone which — along with dual SIM functionality — features a 4-inch touchscreen, 1GHz processor, 5 megapixel camera, Bluetooth, GPS and Wi-Fi.

"Javelin is a proven PA supplier capable of consistently exceeding our customer's stringent quality and reliability requirements," says Javelin's president & CEO Brad Fluke. "Our technology benefits have enabled our customers to quickly bring handsets to market using multiple Tier 1 baseband chipsets," he adds.

"Javelin's ongoing success with the world's largest mobile phone manufacturer is an impressive accomplishment," comments Brian



**CMOS-based PAs from Javelin support Samsung's Galaxy S Duos smartphone.**

Modoff, senior wireless equipment analyst at Deutsche Bank. "They continue to demonstrate the capability of monolithic standard CMOS to be a mainstream 3G PA technology."

Javelin's PA family is designed in a standard CMOS process and is shipping production volumes of the most popular 3G frequency bands.

With the introduction of the Galaxy S Duos, Javelin says that its CMOS PA technology is shipping worldwide into all major territories.

Javelin PAs feature a mixed-signal architecture with integrated bandpass filtering that allows the removal of transmit surface acoustic wave (SAW) filters and reduces duplexer isolation requirements.

This results in additional receive margin for ease of design implementation and improved handset manufacturing yield, it is claimed. With what is claimed to be the best noise performance on the market, Javelin says its PAs can improve receiver sensitivity and mitigate radio co-existence issues while reducing BOM cost in smartphones.

[www.javelinsemi.com](http://www.javelinsemi.com)

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# China's Tianyu expands SiC epi business globally, targeting power devices

## Expansion follows completion of three contracts in August

Dongguan Tianyu Semiconductor Technology Co Ltd, which claims to be the first manufacturer of silicon carbide (SiC) epitaxial wafers in China, has started to expand its SiC epiwafer business globally after the completion of three contracts in August.

Founded in January 2009 in Songshan Lake National High-tech Industrial Development Zone of Dongguan City, Guangdong province, Tianyu's facilities cover 20,000m<sup>2</sup> in plant area and 10,000m<sup>2</sup> in workshop area. Tianyu's technical team includes six researchers from the Chinese Academy of Sciences plus 30 engineers working on SiC epitaxial growth technology. Using two SiC chemical vapor deposition

(CVD) reactors, epiwafer sizes are 4", 3" and 2". Production capacity is 10,000 wafers per month (which can be increased if needed).

"SiC substrates are getting better, larger and cheaper; more attention is being paid to this market," says general manager Li Xiguang. "SiC devices will show more competitiveness in the global market," he believes, citing a forecast by market analyst firm Yole Developpement that SiC devices will net a billion dollars in revenue within a decade.

Tianyu notes that SiC epiwafers are used in producing Schottky diodes, MOSFETs (metal oxide semiconductor field-effect transistors), JFETs (junction field-effect transistors) and BJTs (bipolar junction transistors)

over a wide voltage range, while customized wafers are used for thyristors, GTOs (gate-turn-off devices) and IGBTs (insulated-gate bipolar transistors) over a wider voltage range for medium- to very-high-voltage power conversion systems. Such devices are used for energy-efficient power electronic devices for many applications, such as air-conditioning, solar and wind turbine inverters, hybrid and electric vehicles, high-speed trains, smart grids and high-voltage DC power transmission. SiC-based devices can reduce energy losses and system size, leading to overall reduced system costs and enhanced reliability, says Tianyu.

[www.sicty.com](http://www.sicty.com)

## Tianyu adds extra P+E hydrogen purifier for SiC epi expansion

Power+Energy Inc (P+E) of Ivyland, PA, USA, a manufacturer of micro-channel hydrogen gas purifiers, has provided a second hydrogen purifier to Dongguan Tianyu Semiconductor Technology Co Ltd, which claims to be the first manufacturer of silicon carbide (SiC) epitaxial wafers in China. The purifier is installed to support capacity expansion at Tianyu's facility in Dongguan City, Guangdong province, China.

Tianyu produces 4H-SiC epi-wafers with diameters of 2", 3" and 4" and (in the near future) 6".

"We have seen excellent results from the Power and Energy hydrogen purifier for our Aixtron silicon carbide reactors," says Tianyu researcher Sun Guosheng.

The compact 9000C Series purifier purifies hydrogen used in the Aixtron metal-organic chemical vapour deposition (MOCVD) epitaxial growth process for SiC wafers. Oxygen, moisture and nitrogen contamination must be



An Aixtron reactor, used for SiC epitaxy.

completely eliminated to parts-per-billion levels in SiC growth processes.

The 9000C purifier uses patented micro-channel palladium membrane technology to remove all impurities to parts-per-trillion levels. P+E says that it provides a durable, production-worthy hydrogen purifier that supports any flow rate and any inlet gas source quality. The compact design can be wall-mounted to provide ultra-high-

purity (UHP) hydrogen for MOCVD epitaxial processes.

"Tianyu has an impressive facility and they are poised for rapid growth as the first China-based supplier of SiC epi wafers," says P+E's Stuart Bestrom. "We are pleased to continue supporting this expansion," he adds. "P+E has been supporting customers in SiC processing for over 12 years, including many leading suppliers of SiC materials and epi-

wafers."

P+E says that hydrogen gas purifiers are critical to the rapidly expanding high-efficiency power devices industry, whether silicon carbide or gallium nitride. The firm says that its micro-channel Pd membrane technology allows users to continue to employ the same technology in high-volume production, regardless of source gas quality.

[www.powerandenergy.com](http://www.powerandenergy.com)



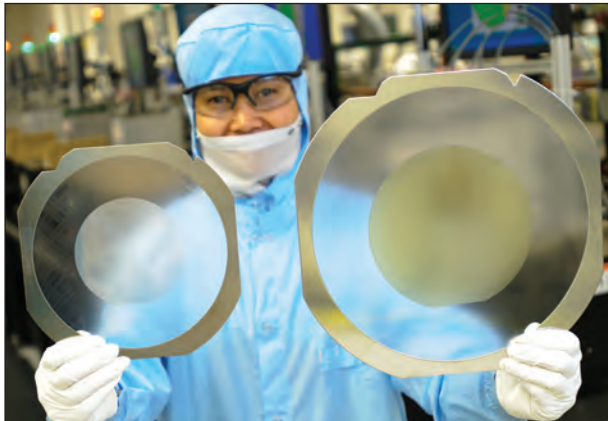
## Cree launches 150mm-diameter 4HN silicon carbide epiwafers

### n-type epilayers up to 100 $\mu$ m thick available immediately

Cree Inc of Durham, NC, USA has announced the availability of high-quality, low-micropipe 150mm 4H n-type silicon carbide (SiC) epitaxial wafers, with highly uniform epitaxial layers as thick as 100 $\mu$ m available for immediate purchase in limited quantities.

Cree reckons that this latest advance in driving the SiC materials market to larger diameters will help to lower device cost and enable adoption for customers with existing 150mm-diameter device processing lines.

SiC semiconductor material is used in the production of a broad range of lighting, power and communication components, including LEDs, power switching devices and RF power transistors for wireless communications. Cree says that 150mm-diameter single-crystal SiC substrates enable cost reductions and increased throughput, while bolstering the continued growth of the SiC industry.



Cree's 150mm-diameter 4HN substrates (right) in comparison with an existing 4" SiC substrate.

"Cree's ability to deliver high volumes of 100mm epitaxial wafers is unrivaled in the SiC industry, and our latest 150mm technology continues to raise the standards for SiC wafers," claims materials product manager Dr Vijay Balakrishna. "Our vertically integrated approach assures customers of a complete solution for high-quality 150mm SiC epitaxial wafers, providing industry leaders within the power electronics market the stable supply they demand," he adds.

[www.cree.com](http://www.cree.com)

## Cree launches low basal plane dislocation 4H SiC epiwafers

Cree Inc of Durham, NC, USA has introduced low basal plane dislocation (LBPD) 100mm-diameter 4H silicon carbide (SiC) epitaxial wafers.

The LBPD material exhibits a total BPD density of 1cm<sup>-2</sup> in the epitaxial drift layer, with BPDs capable of causing  $V_f$  drift as low as 0.1cm<sup>-2</sup>, says Cree.

"Bipolar devices in SiC have long been held back by forward voltage degradation caused by the presence of BPDs," says John Palmour, chief technology officer, Cree

Power & RF. "This low-BPD material enables very high-voltage bipolar devices such as IGBTs (insulated-gate bipolar transistors) and GTOs (gate turn-off thyristor) to have improved stability over time," he adds. "This recent development helps remove roadblocks to commercialization of these extremely high-power devices."

Low-BPD epitaxial wafers are available for purchase immediately.

[www.cree.com](http://www.cree.com)

## IN BRIEF

### M/A-COM Tech launches 40W 2.7–3.5GHz GaN HEMT pulsed power transistor

M/A-COM Technology Solutions Inc of Lowell, MA, USA has launched a highly efficient 40W pulsed power transistor optimized for civilian and military pulsed radar applications operating at 2.7–3.5GHz.

The MAGX-002735-040L00 is a gold-metalized, internally matched, depletion-mode gallium nitride on silicon carbide (GaN on SiC) RF power transistor with 40W peak output when operated at +50V, class AB operation, using a 300 $\mu$ s pulse and 10% duty-cycle pulsed signal.

Based on extensive HTOL (high-temperature operation lifetime) RF accelerated life testing, quantifiable test results demonstrate that the product is designed to provide a mean time to failure (MTTF) of 600 years or better.

"The 800MHz of instantaneous bandwidth and rugged performance makes this versatile device an excellent choice as a driver stage or output stage for any S-band radar power amplifier application," claims Gary Lopes, senior director for RF Power Technologies.

Manufactured in a thermally enhanced, Cu/Mo/Cu, flanged ceramic package, the MAGX-002735-040L00 has excellent thermal performance as well as high breakdown voltages that allow for reliable and stable operation in extreme mismatched load conditions. Operating at +50V, class AB, the pulsed power transistor provides 40W of peak power at 55% drain efficiency with minimum power gain of 10.5dB across the full 2.7–3.5GHz frequency band.

[www.macomtech.com](http://www.macomtech.com)

# Mitsubishi Electric receives Green Designation from Japan's Fukuoka Prefecture

## Power Device Works gaining new building for design and development

Tokyo-based Mitsubishi Electric Corp has been designated as a 'Green Asia Special Global Strategy Synthesis Area' company in Japan's Fukuoka Prefecture.

Kitakyushu and Fukuoka cities in Fukuoka Prefecture have been designated as Green Asia Special Global Strategy Synthesis Areas by the Japanese government on the basis of the Cabinet Office's 'Special Zone Measure' policy. Leveraging industries, technologies, human resources, networks and others resources accumulated in the region, projects are being carried out in line with the following four initiatives:

- exporting urban environmental infrastructure packages in Asia;
- developing environmentally conscious products along with their production facilities;
- establishing a resource recycling system; and
- realizing a borderless business environment in Asia.

A designated company receives special tax incentives for facility

construction and capital spending that meet certain criteria.

Under this designation, Mitsubishi Electric's Power Device Works in Fukuoka city, which is a base for the development and manufacture of power devices, will accelerate development of new technologies and products including silicon carbide (SiC) power devices.

Mitsubishi Electric develops and manufactures low-loss power devices. The new designation reflects the firm's development of environmentally conscious, highly functional and cost-effective products and production facilities, which is a main goal of the Green Asia Special Global Strategy Synthesis Area project.

The firm plans to strengthen its power device technologies and capabilities, and accelerate product development at its Power Device Works by building a new facility where related design and development divisions will be consolidated, while also making further investments. The new six-storey building

will cover 1800m<sup>2</sup>, with total floor space of 10,500m<sup>2</sup>. Completion is scheduled for February 2014, for use from that March. Total investment is about ¥2.5bn.

In addition to facilitating closer interaction between the divisions, the consolidation will free up space at the Works for new product sample evaluation, creating further operational efficiency. Efforts will focus particularly on accelerating the development of new technologies and power device products, for which demand is growing and becoming more diversified.

High-energy-performance power devices are used in products ranging from air conditioners, refrigerators and other consumer appliances to equipment for industry and railroads. The growing proliferation of hybrid and electric vehicles, solar and wind-power generation and similar developments are expected to raise the global demand for power devices further.

[www.MitsubishiElectric.com](http://www.MitsubishiElectric.com)

# Mitsubishi Electric develops 50W Ku-band GaN HEMT for satellite earth stations

Tokyo-based Mitsubishi Electric Corp has developed the MGFK47G3745 gallium nitride (GaN) high-electron-mobility transistor (HEMT) Ku-band (12–18GHz) amplifier for satellite earth stations.

Satellite-based communication, especially in the Ku-band, enables communication to be established under adverse conditions, such as during natural disasters, and in areas where communication facilities are hard to build. Mobile earth-based stations require in-vehicle portability and must be easy to install, so power-saving measures and downsized power transmitters are highly useful in helping to minimize the

size of earth stations.

Mitsubishi Electric says that in recent years the use of gallium arsenide (GaAs) amplifiers in microwave power transmitters has increasingly been replaced with gallium nitride (GaN) amplifiers due to their high breakdown voltage, power density and saturated electron speeds.

Under operating conditions of 24V drain-to-source voltage ( $V_{DS}$ ) and 1A quiescent drain current ( $I_{DQ}$ ) and at frequencies of 13.75–14.5GHz, the new MGFK47G3745 features high typical output power at  $P_{in}=42\text{dBm}$  of 50W (47dBm), typical linear gain at  $P_{in}=27\text{dBm}$  ( $G_{lp}$ )

of 9dB (achieved with a new high-voltage gate structure and optimized layout), and typical power-added efficiency (PAE) at  $P_{in}=42\text{dBm}$  of 30% (10 points greater than the preceding model MGFK44A4045).

The internally impedance-matched device is expected to reduce the number of high-frequency amplifiers by half and contribute to greater power saving and downsizing for power transmitter equipment.

Samples of the MGFK47G3745 will begin shipping on 1 October. Mitsubishi Electric adds that it expects to expand its lineup of Ku-band satellite earth stations in future.



## Microsemi launches GaN-on-SiC RF transistor for secondary surveillance radar aviation applications

Microsemi Corp of Aliso Viejo, CA, USA (which designs and makes high-reliability analog and RF devices, mixed-signal integrated circuits, FPGAs and customizable SoCs, and complete subsystems, based on silicon, gallium arsenide and silicon carbide) has launched the 1011GN-700ELM, the first in a family of radio-frequency transistors for high-power air traffic control (ATC) secondary surveillance radio (SSR) applications.

SSR is used to send a message to an aircraft equipped with a radar transponder and collect information that allows air traffic controllers to identify, track and measure the location of that particular airplane. Microsemi's new 700W-peak 1011GN-700ELM operates at 1030MHz and supports short- and long-pulsed extended length message (ELM). The new transistor is based on gallium nitride (GaN) on silicon carbide (SiC) technologies, which are particularly well suited for high-power electronics applications.

"We are aggressively driving the development of next-generation GaN-on-SiC power devices to address growing opportunities for higher-performance aerospace and military applications," says David Hall, VP of Microsemi's RF Integrated Systems product group. "We now offer highly reliable GaN-on-SiC

transistors at 250, 500 and 700W for secondary surveillance radar search and tracking applications," he adds. "We also have several additional GaN-on-SiC transistors in development that we will be rolling out later this year."

Microsemi's upcoming product lineup includes multiple high-pulsed-power GaN-on-SiC transistors for L-, S- and C-band radar systems. The firm also offers a suite of GaN microwave power devices, including the following S-band radar models: 2729GN-150, 2729GN-270, 2731GN-110M, 2731GN-200M, 3135GN-100M, 3135GN-170M, 2735GN-35M and 2735GN-100M. Also, products are being developed for L-band avionics at 960–1215MHz and radar at 1200–1400MHz; and S-band radar, higher-power devices at 2.7–2.9GHz.

The 1011GN-700ELM transistor delivers performance of 700W of peak power with 21dB of power gain and 70% drain efficiency at 1030MHz to improve overall drain current and heat dissipation.

Other key product features include: short- and long-pulse burst formats (ELM = 2.4ms, 64% and 6.4% LTD); output power of 700W; high power gain of >21dB (minimum); and a controlled dynamic range with 1.0dB increments (15dB total). The drain bias ( $V_{dd}$ ) is +65V.

Microsemi says that systems benefits that are achieved with GaN-on-SiC high-electron-mobility transistor (HEMT) include:

- single-ended design with simplified impedance matching, replacing lower-power devices that require additional levels of combining;
- highest peak power and power gain for reduced system power stages and final stage combining;
- single-stage pair provides 1.3kW with margin, four-way combined to provide full system 4kW;
- a high operating voltage at 65V reduces the power supply size and DC current demand;
- rugged performance improves system yields; and
- amplifier size is 50% smaller than devices built with Si BJT or LDMOS technology.

The 1011GN-700ELM is offered in a single-ended package and is built with 100% high-temperature gold (Au) metallization and wires in a hermetically solder-sealed package for long-term military reliability.

Microsemi offers demonstration units that are put on loan to the customer for a few weeks. Due to the cost of the product, free samples are not provided. Demo units are available now to qualified customers and technical datasheets are available on the Microsemi website.

[www.microsemi.com](http://www.microsemi.com)

## EPC releases safe operating area data for its eGaN FETs

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) used in power management applications, is releasing safe operating area (SOA) data for its entire product line of enhancement-mode gallium-nitride-on-silicon (eGaN) FETs.

EPC says that eGaN FETs offer superior device on-resistance, while their positive temperature

coefficients inhibit hot-spot generation within the die, resulting in superior safe operating area capabilities. In particular, the positive temperature coefficient across virtually their entire operating range (overcoming a performance limitation of silicon MOSFETs) allows a square SOA limited only by average device temperature, says the firm.

SOA is an indicator of the device's ability to transfer heat away from a resistive junction. The more effi-

cient a device is at getting rid of generated heat, the lower thermal resistance and the better the SOA performance.

An application note presenting the SOA for EPC eGaN FETs is available at: <http://epc-co.com/epc/documents/product-training/SafeOperatingArea.pdf>

EPC is also in the process of updating each of its product data sheets to include SOA performance curves.

[www.epc-co.com](http://www.epc-co.com)

# Hitachi Cable demonstrates first GaN vertical diode with 3000V breakdown and $1\text{m}\Omega\text{cm}^2$ on-resistance

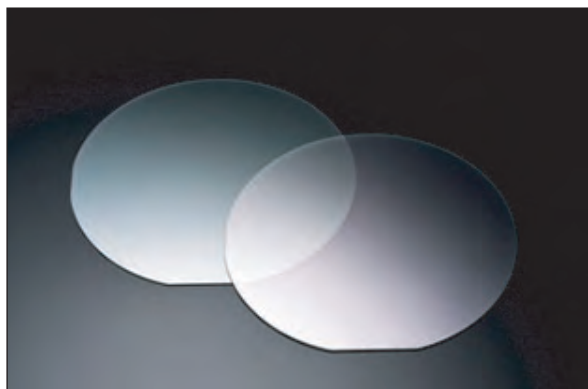
## Void-assisted separation free-standing gallium nitride yields defect dislocation density of $10^6\text{cm}^{-2}$

Hitachi Cable Ltd says that it has succeeded in the trial manufacture of what is claimed to be the first gallium nitride (GaN) vertical diode with a high reverse breakdown voltage of 3000V or higher and a low on-resistance of about  $1\text{m}\Omega\text{cm}^2$  in the forward direction. The development was achieved through joint research with Toru Nakamura Laboratory in the Research Center for Micro-Nano Technology of Hosei University and the Central Research Laboratory of Hitachi.

In recent years, public interest in power devices as a way to conserve energy has been increasing, notes Hitachi Cable. Conventional power semiconductor devices such as diodes and transistors with the ability to convert and control electricity (for applications including consumer electronics in houses, automobiles, railroad vehicles, and power plants) have mainly used silicon. But, to further reduce energy consumption, there has been active development of power devices using materials exceeding the performance limits of silicon.

The new device is a GaN vertical p-n diode with an electrode diameter of 400–800 $\mu\text{m}$  in which GaN epitaxial layers are deposited on Hitachi Cable's free-standing GaN substrate by metal-organic vapor phase epitaxy (MOVPE).

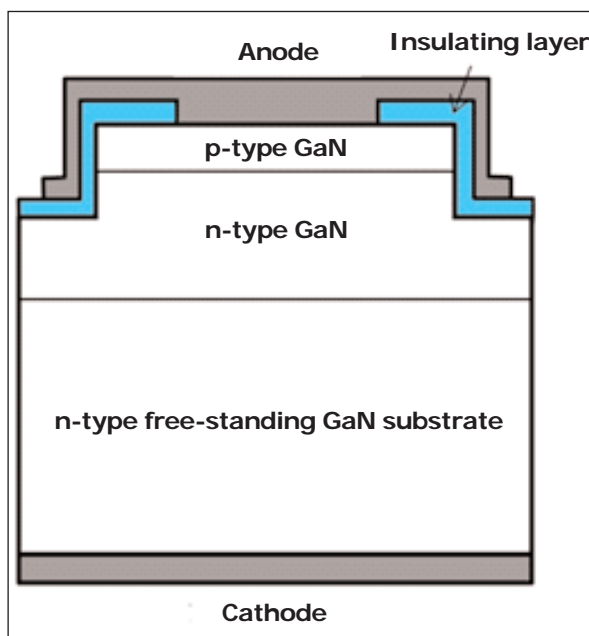
Due to the void-assisted separation (VAS) method developed by Hitachi Cable, the free-standing GaN substrate used in the sample diode yielded a stable, low-defect dislocation density of  $10^6\text{cm}^{-2}$ . The firm has also confirmed that the dislocation defects in the free-standing GaN substrate are only observed in edge dislocations and mixed dislocations, and that nowhere on the entire surface of the substrate is there a 'core' area



GaN substrates for power devices.

where dislocation defects are densely located.

The voltage resistance test using sample diodes confirmed a high reverse breakdown voltage of 3000V or higher, demonstrating that the dislocation defect in the free-standing GaN substrate is not a killer defect that significantly degrades performances of the power devices. The test also demonstrated that the epitaxial layers grown on the free-standing GaN substrate have a breakdown field that is close to the ideal GaN value (3.3–3.8MV/cm).



Schematic cross-section of sample diode.

The test also indicated that the on-resistance of the diode in the forward direction is about  $1\text{m}\Omega\text{cm}^2$ , which is smaller than the sum of the resistances at each layer of the diode. This means that conductivity modulation (which lowers the resistance) occurs when an electric current is injected. Conductivity modulation is an effect that can increase the performance

of a device beyond its material's inherent performance limits. While it is often used in silicon power devices, it has rarely been seen in compound semiconductors, which have short carrier life-times. In terms of this diode, Hitachi's theoretical analyses suggest that the light generated at a p-n junction is re-absorbed by a diode, and that conductivity modulation (which increases carriers) occurs due to the absorption. In the latest work, Hosei University has experimentally demonstrated the light-emitting properties of diodes.

Hitachi Cable says the findings demonstrate that the free-standing GaN substrate produced by the VAS method can yield power devices with a much higher performance index than with conventional materials such as Si and silicon carbide (SiC). High-efficiency power devices based on this development are expected to reduce the power consumed by equipment and facilities in the future.

Hosei University presented the research findings at the 73rd JSAP (Japan Society of Applied Physics) Autumn Meeting 2012 in September.

[www.hitachi-cable.com](http://www.hitachi-cable.com)



## Transphorm introduces JEDEC-qualified 600V GaN HEMT

Transphorm Inc of Goleta, near Santa Barbara, CA, USA (which designs and delivers power conversion devices and modules) has announced the JEDEC qualification of its TPH2006PS gallium nitride (GaN) HEMT on silicon carbide (SiC) substrate, claiming it as the first qualified 600V HEMT device.

Based on Transphorm's patented, high-performance EZ-GaN technology, TPH2006PS combines low switching and conduction losses, resulting in reduced energy loss of up to 50% compared with conventional silicon-based power conversion designs, says the firm. The TO-220-packaged device features  $R_{DS(on)}$  of 150m $\Omega$ ,  $Q_{rr}$  of 42nC and high-frequency switching capability that enables compact, lower cost systems.

"Our team has accomplished the first qualification of a 600V GaN

transistor product, allowing our customer-partners to now introduce energy saving products, Powered-by-Transphorm," says

**This development also lays to rest any doubts that high-voltage GaN transistors can indeed be successfully qualified**

president Primit Parikh. "This development also lays to rest any doubts that high-voltage GaN transistors can

indeed be successfully qualified."

Transphorm's technology can be used in a wide variety of electrical systems and devices, including motor drives, power supplies and inverters for solar panels and electric vehicles.

[www.transphormusa.com](http://www.transphormusa.com)

## Transphorm chosen by World Economic Forum as 2013 Technology Pioneer

Transphorm has been selected by the World Economic Forum as a 2013 Technology Pioneer, citing the firm's innovations in gallium nitride (GaN) design and process technologies, enabling the implementation of highly efficient power conversion systems.

The World Economic Forum says it selected its 2013 Technology Pioneers in the areas of information technology, telecoms and new media, energy and environment, and life sciences and health, based on a demonstrative vision and leadership in their fields, innovative ideas and approaches, and their impact on society and business.

Backed by \$38m in funding from Google Ventures, Kleiner Perkins Caufield & Byers, Foundation Capital and Lux Capital, Transphorm was co-founded in 2007 by CEO Umesh Mishra, a professor of

electrical & computer engineering at the University of California, Santa Barbara (UCSB). The firm only emerged from stealth mode in February 2011.

"By redefining power conversion using our proprietary GaN-based products, Transphorm is solving the immediate and urgent problem of unnecessary waste in power conversion — saving valuable resources and enabling new energy-efficient systems today," says Mishra.

Transphorm claims that its efficient, compact and easy-to-embed power conversion devices and modules can cut global energy waste by as much as 10% and simplify the design and manufacturing of a wide variety of electrical systems and devices, including motor drives, power supplies and inverters for solar panels and electric vehicles.

### IN BRIEF

## DARPA contract for TriQuint to triple performance of GaN RF power amplifiers

RF front-end component maker TriQuint Semiconductor Inc of Hillsboro, OR, USA has received a \$2.7m contract from the US Defense Advanced Research Projects Agency (DARPA) to triple GaN's power handling performance. The Near Junction Thermal Transport (NJTT) effort will build on TriQuint's GaN-on-SiC technology and reliability of its RF ICs.

"Like other programs we have supported, NJTT will set the stage for substantial MMIC performance enhancements including reduced size, weight and power consumption while increasing reliability and output power," says James L. Klein, TriQuint's VP & general manager for Infrastructure and Defense Products.

The NJTT initiative is the latest in DARPA's Thermal Management Technologies program. NJTT focuses on thermal resistance at the 'near junction' of the transistor die, as well as the device substrate. These areas can be responsible for over 50% of operational temperature increases, says TriQuint. By combining its GaN-on-SiC process technology with diamond substrates and new thermal handling processes, the firm aims to significantly reduce heat build-up to enable GaN devices that can generate much more power.

Program partners include the UK's University of Bristol (for its expertise in thermal testing, modeling and micro Raman thermography), Group4 Labs (a pioneer in diamond substrates that has worked with TriQuint to demonstrate their potential) and Lockheed Martin (which will evaluate results for the projected impact on future defense systems).

[www.triquint.com/defense](http://www.triquint.com/defense)

## MATHESON acquires majority stake in RASIRC

MATHESON of Basking Ridge, NJ, USA has acquired a majority share of steam purification company RASIRC Inc of San Diego, CA, USA.

RASIRC develops products that purify and deliver ultra-pure liquids and gases (with an initial focus on water vapour) for the semiconductor, pharmaceutical, medical, biological, fuel cell, and power industries. Products include steam purification equipment, high-temperature humidifiers, and vaporizers. Patented seal and product designs enable fluid delivery and control of temperature, flow rate, and purity. The technology is claimed to reduce cost, improve quality, and improve safety.

As the largest subsidiary of Japan's Taiyo Nippon Sanso Corporation Group (the world's fifth largest supplier of industrial, specialty, and electronics gases), MATHESON is a single source for industrial, medical, specialty and

electronic gases, gas handling equipment, purification systems, engineering and gas management services, and on-site gas generation.

The agreement provides RASIRC with access to MATHESON'S global reach, logistical expertise, and customer support network, while providing MATHESON with additional research and product development capabilities and new products and chemicals for the semiconductor, solar and related microelectronics industries.

RASIRC will continue to operate as an independent corporation under the leadership of current president Jeffrey Spiegelman, with all offices, employees, suppliers, and sales channels remaining unchanged.

"This acquisition is consistent with our electronics and solar strategies to enhance our purification technology and product line," says MATHESON's chairman & CEO William J. Kroll. "RASIRC's mem-

brane technology and purification techniques offer significant synergy, both to our purification products business and to our high-purity material business, as liquid chemicals become increasingly critical components in the advanced technologies employed in the semiconductor industry," he adds.

"RASIRC will continue to develop new and innovative products focused on in-situ chemical generation of ultra-high-purity (UHP) vapors from liquid chemical sources," says the firm's founder & president Jeffrey Spiegelman.

"Having global infrastructure, logistics and R&D, the MATHESON brand presence will assure customers that we have the size and stability to support them through a complete product adoption cycle — from bench-top testing, to pilot line, and high volume."

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## IQE appoints senior independent director

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has appointed David Grant CBE as a non-executive director and as senior independent director of the Group.

Grant gained a PhD in Engineering Science from Durham University in 1974. After designing power station control and instrumentation systems for Reyrolle Parsons Automation, he was made technical director of a European subsidiary of United Technologies Corp.

In 1984, Grant became managing director of Dowty Electronics Ltd and, in 1988, technical director of the Dowty Group. His last industrial appointment began in 1991, as technical director of GEC plc, responsible for engineering, research and technology development in an international firm spending £1.2bn per annum on product development and technology. He was appointed

vice-chancellor of Cardiff University in 2001, retiring in August this year.

Grant is also a non-executive director of Renishaw plc, and holds directorships with Welsh Networking Ltd and The Russell Group of Universities. He is involved in engineering professional development and has been a Council member and vice president of the Institution of Electrical Engineers (IEE, now IET). In 1997, he was elected as a Fellow of the Royal Academy of Engineering, and was made a CBE for contributing to the UK's Foresight Programme. He was a Council member of the Engineering and Physical Sciences Research Council (EPSRC) from 2000 until 2006. In 2007 he was made a governing board member of the Technology Strategy Board. In 2012, Grant was appointed a non-executive director of Dstl (the UK's Defence Science and Technol-

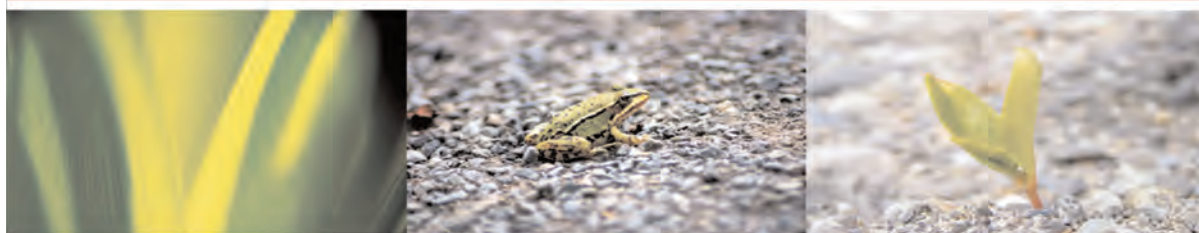
ogy Laboratory). He was a vice-president of the Royal Academy of Engineering from 2007 to 2012.

"David's appointment will bring both large company experience and a broad technology background, which can meld with an existing non-executive team that has considerable history and knowledge of IQE's business," says IQE's chairman Dr Godfrey Ainsworth.

"I can help them build on their existing achievements, at the same time as adding further weight to the non-executive responsibilities of the board," says Grant.

"The appointment of David to the IQE board as senior independent director will strengthen the non-executive team and our ability to comply with best corporate governance practice," says chief executive Dr Drew Nelson.

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## Voltaix to accelerate expansion with Samsung investment

Voltaix LLC of Branchburg, NJ, USA, which manufactures electronic chemicals and gases (including deposition precursors such as germane, diborane, trisilane, and trimethyl boron) used in the production of semiconductor chips, solar cells, and other electronic devices, has secured financing from Samsung Venture Investment Corporation (SVIC), the global investment arm of Seoul-based Samsung. The funding will be used to accelerate the firm's manufacturing capacity expansion to meet the emerging materials requirements of the micro-electronics industry.

Voltaix says that its current and emerging products are essential materials that enable continued scaling of semiconductor logic and memory devices. New Voltaix materials will enable next generation

flat panel display, LED, MEMS and power electronics advancements and cost reductions.

"The financing from SVIC will enable us to continue building our worldwide infrastructure and will further accelerate our new product pipeline development activities," says Voltaix's CEO Dr Peter Smith. "We believe our materials innovations will help drive new device architectures and manufacturing technologies to high volume manufacturing," he adds.

"The increasing demand for novel gases and materials in electronics fabrication has attracted our attention," says SVIC's senior investment director Dong-Su Kim. "Based on our analysis of the future demand and the players in the space, we found Voltaix to be the leader and are quite excited about our equity investment."

Voltaix materials enable logic chips to compute more quickly and solar cells to absorb a broader portion of the solar spectrum, and they improve manufacturability by minimizing defect formation and increasing machine throughput, says the firm.

Voltaix's products include: germane, diborane, trisilane, and trimethyl boron. The firm uses proprietary synthesis, purification, and packaging technology developed in-house. It also designs and builds its own equipment. The company, founded in 1986, employs more than 100 people at its sites in North Branch, NJ, High Springs, FL, Portland, PA and South Korea. Intel Capital, Novus Energy Partners, and Mission Point Capital Partners are investors in Voltaix.

[www.samsungventures.com](http://www.samsungventures.com)

[www.voltaix.com](http://www.voltaix.com)

## Showa Denko adds Aixtron CVD system for migration to 150mm silicon carbide substrates

Deposition equipment maker Aixtron SE of Herzogenrath, Germany says that Showa Denko of Chichibu, Japan has added a SiC CVD Warm-Wall Planetary Reactor system to its Aixtron equipment base, capable of handling either ten 100mm or six 150mm wafers. The chemical vapor deposition system will be used to produce homoepitaxial material on silicon carbide substrates for a range of power electronics applications and device types, such as inverter systems for solar power modules, AC-DC conversion and industrial motor control.

With the new system, Showa Denko will extend its existing 100mm-diameter wafer production and also migrate production to the larger-diameter 150mm SiC wafers that are now becoming available from material suppliers. Production on larger wafers should lead to cost reductions and wider market

acceptance, says Aixtron.

"Aixtron has designed its system to push these economies of scale even further by reducing the wafer edge exclusion zone, increasing chip yields per wafer of larger-diameter substrates," says Dr Frank Wischmeyer, VP & program manager Power Electronics at Aixtron. "The attraction of silicon carbide for such application derives from its unique material properties, such as high critical electrical field strength, allowing high device breakdown voltages and low turn-on resistance," he adds. "Further advantages for power applications arise from SiC's higher thermal conductivity and ruggedness at higher operation temperatures."

A special reactor chamber was developed for the most modern Aixtron Warm-Wall reactor for SiC, capable of handling the higher temperatures of up to 1650°C needed for epitaxial processing of SiC

wafers. The six 150mm wafers loaded per batch in Aixtron's system exhibit individual 'planetary' rotation during the epitaxial process, enhancing uniformity and reproducibility.

Showa Denko chose the Aixtron SiC CVD Planetary system in order to use its Planetary experience and know-how, as well as to expand its business scope with cost-efficient 150mm SiC wafers. The firm sees market opportunities for SiC-based products arising immediately in consumer electronics, and in the longer term in railroad power-handling and automotive markets. The epitaxial SiC business was acquired at the end of 2008 from Esicat-Japan LLP, a spin-off from Japan's National Institute of Advanced Industrial Science and Technology (AIST), Central Research Institute of Electric Power Industry (CRIEPI) and Showa Denko.

[www.sdk.co.jp](http://www.sdk.co.jp)



## 5N Plus announces changes to its management team

5N Plus Inc of Montreal, Quebec, Canada, a producer of specialty metal and chemical products, has made the following appointments to its management team:

- Jean Mayer as director, legal affairs & corporate secretary;
- Sean Fuller as VP, strategic supply; and
- Zhang Wen as VP, commercial activities China.

With 15 years of business and legal experience, Mayer has served as general counsel, has held senior executive positions, and has been director with various public companies in the mining and technology sectors.

Fuller has served at 5N Plus and MCP for the last 12 years. He initially acted as general manager in the UK for seven years and then as director in Hong Kong for the last five years. Fuller has a degree in Production Engineering from the

University of Aston, UK and more than 20 years of experience in metal sourcing and significant international experience.

Zhang Wen has served as 5N Plus' general manager, CIR since the acquisition of MCP and is based in Shenzhen (having been involved in metal sourcing and commercial activities in China over the last decade).

5N Plus has also announced that Laurent Raskin and Frank Fache have ceased to act as managers of the company. However, they will remain on its board of directors, continuing to provide insight and guidance.

"The new appointments and changes made to our senior management team are in line with our vision of sustainable growth aimed at maximizing long-term shareholder value," says president & CEO Jacques L'Écuyer.

### IN BRIEF

## 5N Plus seeks new board members to replace outgoing members

5N Plus has announced the resignation Laurent Raskin and Frank Fache from its board of directors.


The company says that it has already initiated the process of finding new board members and that it is currently meeting with high-profile potential candidates.

"We seek to add new board members whom will bring a wealth of technical expertise and business experience both domestically and internationally," says president & CEO Jacques L'Écuyer.

"We would like to thank Messrs. Raskin and Fache for their contribution to our company," L'Écuyer adds.

[www.5nplus.com](http://www.5nplus.com)

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# Riber's first-half profit halves year-on-year

## Product mix shifts from sources & cells to MBE systems

For first-half 2012, Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported gross profit (before changes in provisions for inventories) of €3m (gross margin of 32% of revenue), down from €5.6m a year ago, reflecting an unfavorable change in revenue and product mix. The provisions recorded for inventories show a net charge of €0.2m (compared with a €0.2m reversal a year ago), bringing gross profit to €2.8m, down from €5.9m a year ago. Compared with a net profit of €1.8m a year ago, consolidated net loss was €1m, reflecting the uncertain economic environment for the semiconductor industry, says the firm.

First-half 2012 revenue (reported previously in mid-July) was €9.4m, down 28% on €13m in first-half 2011 due to a change in product mix towards MBE system sales unmatched since 2002. Sales of MBE systems rose by 89% from

€3.4m to €6.4m, boosted by the consolidation of Riber's commercial position, particularly in the research sector.

Revenue for evaporation sources and cells is down by 89% from €7m last year (which included the delivery of a major investment order for organic LED production equipment in Asia) to just €0.8m.

Revenue for services and accessories is down by 15% from €2.6m to €2.2m, set against the slowdown in demand in Europe and the USA. Riber has made major efforts to build its order book back up again on this segment, with an upturn in business in third-quarter 2012.

In first-half 2012, cash reserves halved, falling by €6.1m since the end of December 2011 to €6m at the end of June, factoring in the half-year losses, the dividend paid out in June, and the increase in inventories in anticipation of the production plan for second-half 2012.

However, the order book at the end of August was €22.3m, up 13% year-on-year. Orders for MBE

systems are up 40%. Excluding an order placed in September (for a research system in India — see below), this includes one production system and 15 research systems, to be delivered between 2012 and 2013 (representing about one year's business for this segment).

For cells and sources, orders of just €1m are down 17% on €1.2m in first-half 2011 following the completion of investments in OLED production lines, as well as the difficulties faced by the photovoltaic sector as a result of the general economic environment. Nevertheless, Riber is currently preparing a range of new-generation cells with a view to the next waves of investments.

In view of the overall growth in the order book, full-year revenue for 2012 is expected to be €26–28m. Although down on 2011's €29m, this should yield an operating margin of 7–9% of revenue, including an OSEO refundable advance debt write-off with positive impact on second-half 2012 of €579,000.

## Shanghai Institute of Technical Physics orders Compact 21 system

Riber has received an order for a Compact 21 MBE machine from China's Shanghai Institute of Technical Physics (SITP).

SITP is a regular user of Riber MBE products specialized for the

growth of thin-film layers and quantum well structures.

The new system will be used by the laboratory to increase its fundamental research capabilities on new III-V-based structures.

Riber reckons that the order strengthens its key in the Chinese market, which is the semiconductor industry's fastest-growing region.

[www.riber.com](http://www.riber.com)

## Brolis win Young Entrepreneur of the Year award

Brolis Semiconductors Ltd of Vilnius, Lithuania has won the Young Entrepreneur of the Year category at the Swedish Business Awards 2012.

Established by brothers Augustinas Vizbaras, Kristijonas Vizbaras and Dominykas Vizbaras in 2011, the firm specializes in long-wavelength semiconductor lasers and molecular beam epitaxy (MBE) services.

The award ceremony was attended by Lithuanian President Dalia Grybauskaitė; former President Valdas Adamkus; Prime Minister Andrius Kubilius; Sweden's Ambassador to Lithuania Cecilia Ruthström-Ruin; Swedbank's president & CEO Michael Wolf; Ncell's president & CEO Pasi Ahti Yrjänä Koistinen, and other honourable guests.

Established in 2006 by the Embassy of Sweden and the Swedish Trade Council together with the founding partners Swedbank and TeliaSonera, the Swedish Business Awards aim to highlight and encourage entrepreneurship, outstanding business results and a continuous aim for sustainability.

[www.swedishbusinessawards.com](http://www.swedishbusinessawards.com)

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## IN BRIEF

### AZUR SPACE adds further Aixtron reactors for CPV cell production

Deposition equipment maker Aixtron SE of Herzogenrath, Germany has announced a repeat order from AZUR SPACE Solar Power GmbH of Heilbronn, Germany for two more metal-organic chemical vapor deposition (MOCVD) systems, to be dedicated to growing gallium arsenide (GaAs) materials for the production of concentrated photovoltaic (CPV) solar cells for terrestrial applications.

Aixtron Europe's service support team installed and commissioned the new reactors in second-half 2012.

AZUR SPACE Solar Power is a developer and manufacturer of high-efficiency solar cells for space and terrestrial applications; the latter based on CPV. With over four decades of experience in space solar cell technology, its product range covers several types of silicon and III-V solar cells, including those on germanium wafers.

"Our existing Aixtron MOCVD systems have more than proved themselves, so now it is time to further expand production with two new systems," says AZUR SPACE's managing director Juergen Heizmann. "Adding more equipment from Aixtron has many advantages in terms of start-up speed, continuity and process transfer," he adds. "It will also ensure a seamless and smooth transition to the next step in our strategic plans to move production to 6-inch wafers. This is a key step in the planned evolution towards high-performance materials, but with the economic advantages of larger diameters."

[www.azurspace.com](http://www.azurspace.com)

## Aixtron hosts LED production seminar in China

Deposition equipment maker Aixtron SE of Herzogenrath, Germany says that more than 200 participants, mostly manufacturing customers, attended its MOCVD seminar for LED production on 14 September at the Aixtron China Ltd Training Center & Lab in Suzhou, China. The seminar focused on LED and solid-state lighting (SSL) applications, from basic principles of metal-organic chemical vapor deposition (MOCVD) to break-through technologies and solutions.

Co-organized by the China Solid State Lighting Alliance (CSA), the seminar is the first in a series within the framework of Aixtron's cooperation with SINANO, the Suzhou Institute for Nanotechnology and Nanobionics. Along with presentations from Aixtron, SINANO reported its latest results.

"It is a real pleasure to welcome so many of our prestigious customers and business partners in Suzhou today and to continue the dialogue with China's leading LED manufacturers," said professor Michael Heuken, VP Corporate R&D at Aixtron. "Our common goal remains to intensify efforts, e.g. how to improve LED quality,

increase productivity and yield, and thus achieve more cost-efficient and brighter LEDs."

"The seminar was a further step in helping us to better meet the needs of China's rapidly expanding SSL industry," said Dr Nicolas Muesgens, director Demo & Training Center, Aixtron China Ltd. "We also received positive feedbacks on Aixtron's scientifically founded training concept and particularly on the fact that our Demo & Training Center in Suzhou can provide our customers with the experience of working on MOCVD systems under real process conditions."

Most of the presentations at the seminar were given in Chinese by Aixtron's Chinese trainers. Some were derived from Aixtron's training package for customers, so the seminar was a good opportunity to experience Aixtron's trainers and training methods.

At the Suzhou Industrial Park (SIP) in the Yangtze River Delta, future Chinese MOCVD experts are regularly trained in the latest semiconductor technology and manufacturing processes by Aixtron's engineers.

[www.aixtron.com](http://www.aixtron.com)

## Osaka University orders BM Pro system

In Q3/2012 Japan's Osaka University ordered an Aixtron BM Pro system, capable of handling 4" substrates.

Professor Matsumoto and assistant professor Maehashi and their team at the Department of Semiconductor Electronics, Institute of Scientific and Industrial Research (ISIR), will use the system to produce carbon nanotube (CNT) and graphene structures for bio-sensors, aiming to combine graphene FETs with organic chemicals, such as antibodies, antigens and aptamers, to allow electrical detection of specific proteins. It will also

be used to produce CNT for MEMS and energy storage devices.

"The ease of use, flexibility and proven recipes of the BM Pro system allows customers to reliably grow several types of nanotubes and graphene in a reproducible manner," says Dr Ken Teo, Aixtron's director of Nanoinstruments. "Our technology allows easy process transfer into large scale-production on 300mm wafers by using the BM 300T system."

The BM Pro is suited to meet the need for growing different types of graphene and carbon nanotubes with high consistent quality.



## Tongfang receives Veeco MOCVD system for GaN-on-Si HB-LED research

The new LED Technology Center of China's Nantong Tongfang Semiconductor Co Ltd (a subsidiary of publicly traded Tsingua Tongfang Co Ltd) has received shipment of a TurboDisc K465i MOCVD system from epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA for researching gallium nitride-on-silicon (GaN-on-Si) high-brightness light-emitting diodes (HB-LEDs).

"We successfully utilize Veeco's MOCVD systems in our current production of GaN-on-sapphire based LEDs. It was the logical choice to select Veeco for our new research into GaN-on-Si based LED devices," says Tongfang's general manager professor Liu Gang. "This is going to be a significant focus of our future R&D investment over the next few years," he adds.

The K465i features film quality and low defects, which are key

requirements for GaN-on-Si processing. It also incorporates Veeco's Uniform FlowFlange technology for superior uniformity and run-to-run repeatability. Low-maintenance TurboDisc technology enables high system availability, excellent particle performance and high throughput, says Veeco. The production-proven K465i also provides ease-of-tuning for fast process optimization on wafer sizes up to 8 inches and fast tool recovery time after maintenance.

"Many of our LED customers are developing GaN-on-Si technology, which offers the potential to accelerate the adoption of solid-state lighting by reducing the cost of making LEDs without compromising end-product quality," notes Jeff Hawthorne, Veeco's senior vice president, MOCVD.

[www.thtf.com.cn](http://www.thtf.com.cn)

[www.veeco.com](http://www.veeco.com)

## IPG expands laser production with Veeco GEN2000 MBE system

Veeco has completed installation of a GEN2000 Edge molecular beam epitaxy (MBE) system at IPG Photonics Corp of Oxford, MA.

Founded in 1990, IPG makes high-power fiber lasers and amplifiers. Following IPG's prior purchases of three GEN200 systems, the new GEN2000 system was ordered to expand its production of GaAs-based lasers.

"We have been very pleased with the cost of ownership advantages and the unsurpassed performance of our previously purchased GEN200 systems," comments Dr Alex Ovtchinnikov, VP-Components at IPG. "It made sense to scale-up to a higher-capacity GEN2000 system to accommodate our needs for increased throughput," he adds.

Repeat orders from IPG attest to

the performance of Veeco's cluster-based systems for production applications, as well as its continuing, comprehensive support, says Jim Northup, VP & general manager of Veeco's MBE Operations.

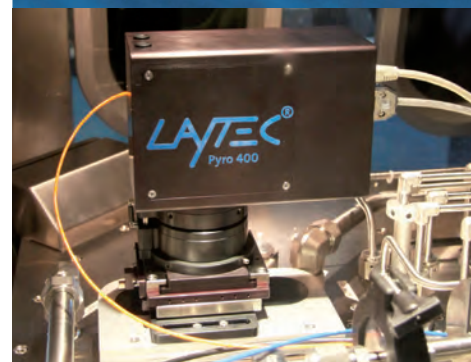
The GEN2000 Edge MBE system delivers exceptional wafer quality in high-capacity production applications, claims Veeco, adding that its cluster tool design provides cost-effective 7x6" epiwafer growth of devices such as pump lasers, vertical-cavity surface-emitting lasers (VCSELs) and heterojunction bipolar transistors (HBTs). The cluster tool architecture also minimizes cleanroom space and downtime due to maintenance, increases throughput, and allows growth of different materials in connected modules.

[www.ipgphotonics.com](http://www.ipgphotonics.com)

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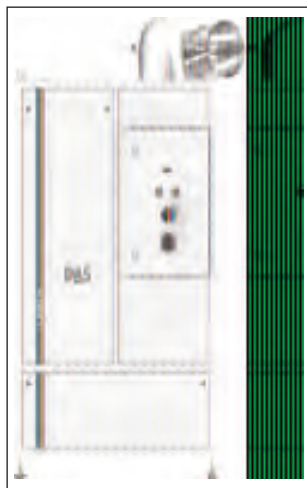
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## DAS launches system for cleaning LED waste gases

DAS Environmental Expert GmbH of Dresden, Germany has launched its LARCH system, developed for the disposal of reactive waste gases produced in LED manufacturing. With the introduction from 2013 of tighter statutory regulations for waste water and waste gas disposal in Taiwan, Taiwanese firms must soon seek new solutions such as the LARCH system, says DAS.

"With LARCH we are specifically reacting to requirements from LED makers," says Guy Davies, director of the Gas Treatment business unit. "In our discussions with customers we have become aware of the demands made on modern disposal technologies," he adds. "We have given a great deal of thought to this, and the LARCH system is the result. It has already generated a lot of



DAS' new LARCH system.

interest: enquiries from some potential customers have already come in." In manufacturing LED products, ammonia and hydrogen are used in large quantities as process gases. With the new LARCH system, the initial thermal dissociation of ammonia is achieved by reaction heat. Hydrogen is then ignited and burnt off by

electrical heating elements. The reaction heat is transferred to a downstream heat exchanger. This is a solution for disposing of the large quantities of process gases generated in LED production, says DAS.

Gases cleaned by LARCH can be safely released into the atmosphere, with sensors and redundant safety systems guaranteeing stable and safe operation.

"We developed LARCH especially for typical applications in the LED industry and adapted it to the industry's requirements," says Davies. "But we could also imagine the system finding application in other processes in which ammonia and hydrogen are generated. Therefore we are looking to continuously develop the technology."

[www.das-europe.com](http://www.das-europe.com)

## EVG launches next-gen automated resist processing platform for high-volume coating/developing

At SEMICON Taiwan 2012 (5–7 September), EV Group (EVG) of St Florian, Austria, a supplier of wafer bonding and lithography equipment, has launched its next-generation EVG150 automated resist processing system.

The high-volume coater/developer has been completely redesigned to provide a flexible, modular platform that integrates spin coating and developing with EVG's proprietary spray coating technology.

"Close collaboration with our customers made it clear that the next logical step for our coater/developer technology was to create a universal approach for high-volume processing of devices with more complicated structures and topographies," says Markus Wimpfinger, corporate technology development and IP director. "This latest incarnation of our EVG150 system addresses customers' production needs for back-end lithography, conformal coating and planarization — all in one modular,

fully automated platform," he adds. "Leveraging EVG's 15 years of experience in resist coating and developing, and particularly our spray coating, the EVG150 is ideally suited for high-volume coater/developer applications needing increased uniformity and process flexibility."

Part of EVG's resist processing equipment family, which addresses all wafer sizes up to 300mm, the EVG150 platform can accommodate wafers from 50mm to 200mm in diameter, and enables up to four wet process modules to be combined with two stacks of hot plates, chill plates and vapor prime modules. The system performs spin coating, developing, spray coating and lift-off, and its modular structure helps to minimize system downtime and improve serviceability, says the firm. Throughput is optimized via EVG's latest Computer Integrated Manufacturing (CIM) Framework software platform and unmatched process control.

EVG currently has more than 100 customers implementing its proprietary OmniSpray technology, which is also integrated into the new EVG150 resist processing platform. OmniSpray allows the conformal coating of high-topography surfaces via its proprietary ultrasonic nozzle. Spray coating technology is suited to ultra-thin, fragile or perforated wafers. Also, the implementation of OmniSpray coating can result in a greater-than-80% reduction in material consumption compared to traditional spin coating.

Another available option for the EVG150 platform is EVG's NanoSpray technology, which is a patented coating technique that can coat surfaces with vertical sidewall angles thus, for example, enabling conformal coating of through-silicon vias (TSVs) with polymer liners and photoresist.

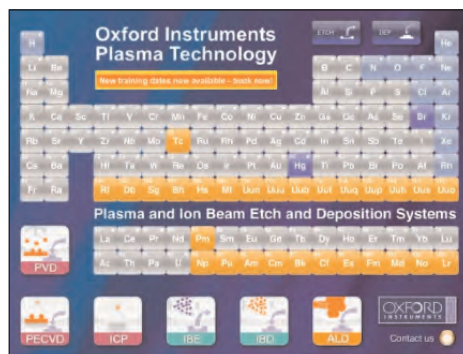
The modular EVG150 automated resist processing platform is available immediately for demonstration and evaluation.

[www.evgroup.com](http://www.evgroup.com)



## OIPT introduces iPad App for plasma etch & deposition

UK-based etch, deposition and growth system maker Oxford Instruments Plasma Technology (OIPT), part of Oxford Instruments plc, has introduced PT Elements, a free-to-download iPad App offering a clear and interactive periodic table of elements, with detailed plasma, ion beam and atomic layer deposition (ALD) processing information beneath. It allows the user to look up process chemistries in order to etch or deposit any material through an easy periodic table



interface, says the firm.

"It's not only an excellent educational reference tool, but also offers

a unique virtual process experience," says OIPT's CS, sales & marketing director Mark Vosloo about the App. "It was designed to benefit all levels of process experience and will also enhance the usability of our tools"

The App was demonstrated on Oxford Instruments' stand at the SEMICON West show in July.

PT Elements is available for download at:

<http://itunes.apple.com/app/pt-elements/id540019562?mt=8>

## Oxford Instruments sells 400th plasma tool for HB-LED production

September saw the 400th sale of an Oxford Instruments Plasma Technology processing tool for HB-LED production, with the receipt of a multi-tool order from China's largest HB-LED maker.

"Our systems play a vital role in manufacturing HB-LEDs, and we have served the industry as it has

developed from its R&D roots into the global industry it is today," says managing director Dan Ayres. "We have been able to offer systems for high performance every step of the way, developing our tools to match customer demands as the market has evolved," he adds. "Our PlasmaPro range of

systems offers both batch and single-wafer solutions."

Oxford Instruments produces plasma equipment for etching sapphire and gallium nitride, as well as PECVD tools for depositing the dielectric layers essential for the finished HB-LED devices.

[www.oxford-instruments.com](http://www.oxford-instruments.com)

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[www.oxford-instruments.com/plasma](http://www.oxford-instruments.com/plasma)



## Nanotronics to offer multi-functional defect inspection system handling both blank and patterned wafers

Nanotronics Imaging LLC of Cuyahoga Falls, OH, USA has introduced new capabilities for its nSPEC product, a fully automatic inspection system for analyzing transparent and semi-transparent wafers for defects.

nSPEC now detects and categorizes defects on semiconductor wafers after photolithographic patterning and other chip processing steps. Nanotronics adds that the system has already proven highly effective for inspection of blank wafers (substrates and epitaxial) across a full range of compound semiconductor materials: SiC, GaN, GaAs, InP etc. The patterned wafer inspection feature makes nSPEC a unique tool, with the capability to track wafer

quality through the whole chip manufacturing process from bare substrate to fully processed devices.

Software has been developed in collaboration with Microsemi Corp of Aliso Viejo, CA and supported by funding from the US Air Force. "We have been early adopters of nSPEC for SiC epitaxial wafer inspection, and our first Nanotronics tool has been producing highly informative data for over a year," says Bruce Odekirk, SiC Program director at the Microsemi manufacturing facility in Bend, OR. "Now we are delighted to extend its ability to monitor and improve our post-epi chip processing with equally great performance and cost-effectiveness," he adds.

"nSPEC's versatility in image acquisition and state-of-the-art data processing power allow us to deliver exceptionally broad range of testing capabilities by adding new software-driven features to existing tool platforms," says Nanotronics' VP Ivan Eliashevich. "Instead of bearing the expense of buying multiple tools, dealing with data compatibility issues etc., customers now can have multiple functions seamlessly combined in one affordable machine."

Currently available for evaluation as a beta version, commercial release of the patterned wafer inspection software for new and existing nSPEC systems is due Q1/2013.

[www.nanotronicsimaging.com](http://www.nanotronicsimaging.com)

## IPG Photonics acquires laser micro-machining firm JPSA

IPG Photonics Corp of Oxford, MA, USA has acquired privately held JP Sercel Associates Inc (JPSA) of Manchester, NH, USA, which makes laser-based materials processing workstations for wafer processing and micro-machining.

JPSA is anticipated to add about \$4m to IPG's revenues for the remainder of 2012. At current revenue levels, the acquisition is expected to be dilutive by \$0.01–0.02 per share in 2012, and to be accretive in 2013.

The acquired business will operate under the name IPG Microsystems LLC.

IPG says that the acquisition will expand its integrated laser systems product offerings for fine-processing, precision cutting, drilling and micromachining of non-metals, including glass, semiconductors and ceramics. JPSA's systems perform laser micro-machining, micro-cutting, scribing and laser lift-off for semiconductors, microfluidics, LEDs, thin-film solar panels, micro-electro-mechanical

systems (MEMS), biomedical technology and industrial automation applications.

"This acquisition broadens our customized laser-based systems offerings and provides significant sales synergies," says IPG's CEO Dr Valentin Gapontsev. "The combination of JPSA's specialized laser systems and the UV and short-pulse fiber lasers that IPG is developing now should allow us to deepen our penetration of the \$800m fine-processing market," he adds.

"At the same time, we plan to capitalize on opportunities to expand the global reach of JPSA's products

through IPG's extensive sales and service network. In addition, we expect that the development expertise of the very experienced JPSA team would benefit our capabilities in other micro-machining applications," Gapontsev continues.

"Strong demand exists for better-quality short-wavelength and short-pulse-width laser sources in applications addressed by JPSA's products," adds JPSA's CEO & chief technology officer Jeff Sercel. "While we will continue to sell our UV and excimer laser systems, as well as systems which use DPSS (diode-pumped solid-state) lasers, we strongly believe there are significant growth opportunities using advanced fiber lasers to displace traditional laser sources in high-growth applications," he adds. "Together, we will be able to sell into new applications, expand geographically, and accelerate into markets where there are needs for advanced fiber laser technology."

[www.jpsalaser.com](http://www.jpsalaser.com)

[www.ipgphotonics.com](http://www.ipgphotonics.com)

**IPG says that the acquisition will expand its integrated laser systems product offerings for fine-processing, precision cutting, drilling and micromachining of non-metals, including glass, semiconductors**



## CRAIC introduces spectral surface mapping capability

UV-visible-NIR microscope and microspectrometer manufacturer CRAIC Technologies of San Dimas, CA, USA has announced Spectral Surface Mapping (S2M) capabilities for its Perfect Vision microspectrophotometer line.

S2M gives microspectrometer users the ability to map the spectral variation in surfaces of samples with microscopic spatial resolution. Surface profiles can be created using UV-visible-NIR transmission, absorbance, emission, fluorescence and polarization microspectral data. S2M can also create maps from Raman microspectral data from CRAIC's Apollo Raman microspectrometer. The firm's microspectrometers can now create highly detailed spectral maps with micron-scale resolution rapidly and automatically. "CRAIC Technologies has worked to develop the Spectral Surface

Mapping package because of customer requests," says president Dr Paul Martin. "Our customers wanted the ability to automatically survey and characterize the entire surface of samples by their spectral characteristics. They also wanted a high spatial resolution" he adds.

"The S2M package allows you to collect spectral data from thousands of points with a user-defined mapping pattern," Martin continues. "Because our customers deal with so many different types of microspectroscopy, we gave S2M the ability to map UV-visible-NIR transmission, absorbance, reflectance, emission and even Raman microspectra all with the same tool."

Spectral Surface Mapping includes a software module to be used with CRAIC's MINERVA microspectrometer control software. When used

with CRAIC microspectrometers with programmable stages, S2M allows a user to automatically take spectral measurements with user-defined mapping patterns that reach to the limits of the stage. With the ability to measure up to a million points, high-definition maps of the spectral response of the surface of a sample can be generated.

The firm says that, because of the flexibility and power of the software, the maps may be from transmission, absorbance, reflectance, fluorescence, emission and even polarization data. Raman spectral responses can be collected and mapped when used with CRAIC's Apollo Raman microspectrometers. S2M hence gives more power to study the entire surface of samples by several different methods and in the highest level of detail, says the firm.

[www.microspectra.com](http://www.microspectra.com)

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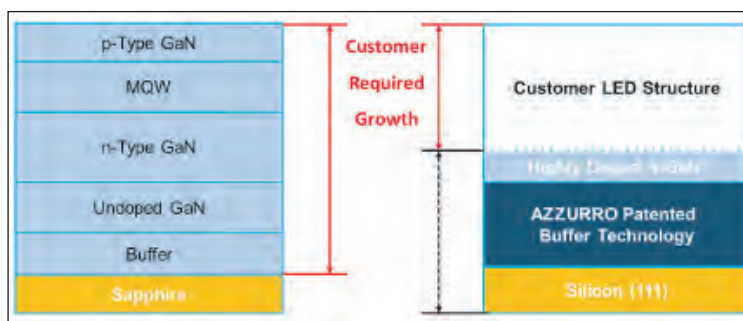
## AZZURRO issues white paper detailing migration to GaN-on-Si LEDs with 150mm templates

AZZURRO Semiconductors AG of Dresden, Germany, which makes gallium nitride (GaN) epitaxial wafers based on large-area silicon substrates, has released a white paper that describes the easy migration of LED manufacturing to GaN-on-Si. Using its 150mm templates, the advantages of GaN-on-Si can be exploited after very short design-in times, claims the firm.

The white paper outlines the technical hurdles to be overcome when migrating to GaN-on-Si, covers key achievements possible when using the right technology, details the advantages of moving to GaN-on-Si obtainable with templates, and shows development solutions to the LED epitaxy engineer.

Detailed data for GaN-on-Si products is revealed regarding its very high crystalline quality (with etch-pit density, EPD, of  $2 \times 10^8 \text{cm}^{-2}$ ), excellent homogeneity ( $< 4 \text{nm}$  wavelength distribution) and very low bow values ( $< 20 \mu\text{m}$ ).

Enabled by AZZURRO's thick GaN-buffer as well as its patented and



**Sapphire-based LED structure and silicon-based LED template-based growth structure.**

proprietary strain-engineering technology, these achievements permit the full utilization of the advantages of GaN-on-Si, says the firm. These include reduced binning due to superior homogeneities.

Also, the large wafer diameter and low bow values allow the use of standard silicon processing lines, offering cost breakthroughs for wafer processing and back-end manufacturing. Plus, the advantages of using templates for the move to GaN-on-Si are covered as contributors to cost reduction, including better utilization of epitaxy reactors.

"Our plug-and-play approach, supported by our application note and engineering support assures a smooth migration from the legacy materials towards GaN-on-Si with

easy to process, larger wafer sizes in standard silicon processing lines at much lower costs," says VP operations Dr Markus Sickmoeller.

As part of easing the move to GaN-on-Si, AZZURRO is delivering standard migration packages to customers that include dedicated engineering support from its team of experts.

The white paper aims to support the LED industry's move to GaN-on-Si and was presented at the Digitimes Tech Forum (DTF 2012) in Taipei, Taiwan on 13 September.

[www.azzurro-semiconductors.com](http://www.azzurro-semiconductors.com)

## Kyma enters GaN crystal growth equipment market with launch of HVPE system

Kyma Technologies Inc of Raleigh, NC, USA, which provides crystalline gallium nitride (GaN), aluminium nitride (AlN) and aluminium gallium nitride (AlGaIn) materials and related products and services, is entering the GaN crystal growth equipment market with the introduction of its Kyma100 HVPE system, in support of the growing demand for energy-efficient lighting and power electronics.

HVPE (hydride vapor phase epitaxy) is a proven high-growth-rate process for producing high-purity crystalline compound semiconductor materials, including GaN, GaAs, InP and CdS. It is the dominant process used currently for production of

free-standing GaN substrates and has recently been used by Kyma and others to produce high-quality GaN-on-sapphire templates and GaN-on-silicon templates. HVPE-grown GaN templates have major advantages over free-standing GaN in terms of cost per unit area and diameter scalability, says Kyma.

"Demand for our AlN and GaN template products is growing, yet many of our volume customers prefer to bring the template manufacturing process in-house," says president & CEO Keith Evans.

"Adding HVPE equipment to our product line is a natural step in Kyma's growth, and represents the first of several new equipment

product offerings we plan to announce in the coming weeks."

The Kyma100 HVPE system leverages over a decade of company experience in the design, construction and application of HVPE process equipment for manufacturing GaN materials. The firm says that its high-purity, vertical-flow, hot-wall design supports the production of n-type conductive GaN at growth rates up to  $500 \mu\text{m}$  per hour. Complete with a process for the production of high-quality GaN-on-sapphire templates, the system can grow up to three 2"-diameter wafers or one 4"-diameter wafer at a time.

[www.kymatech.com](http://www.kymatech.com)



## BluGlass granted US patent; buying out joint venture partner EpiBlu

BluGlass Ltd of Silverwater, Australia says that its patent US2008272463 'Method and apparatus for growing a group (III) metal nitride film' has been allowed in the USA. The patent brings BluGlass' total number of granted patents in the USA, Europe, Japan, Korea and China to 16.

The firm adds that its patents provide broad protection for its remote-plasma chemical vapor deposition (RPCVD) technology, and underpin the commercial opportunities for BluGlass in the production of high-efficiency semiconductor devices such as LEDs and solar cells.

"We have had another core patent accepted in the US, which will further help to protect BluGlass' technology assets, enabling the company to continue its move towards commercializing the RPCVD technology," says BluGlass' CEO Giles Bourne.

BluGlass has also recently lodged two additional patents through its

joint venture EpiBlu. In a separate statement regarding EpiBlu, BluGlass has proposed a capital restructure to its shareholders, which involves purchasing all the shares in EpiBlu held by its joint venture partner SPTS Technologies Ltd of Newport, Wales, UK. The proposal is for the issue of 15,973,678 fully paid ordinary shares (subscription shares) in the capital of BluGlass to SPTS, which equates to 5% of BluGlass' enlarged share capital.

After being appointed to BluGlass' board in November 2009, Dr Alan Li resigned as a non-executive director at the end of August due to personal reasons. "Alan has been an influential part of the BluGlass team, contributing great technical knowledge and direction, and we thank him for his significant contribution to the company over the last few years," said chairman George Venardos.

[www.bluglass.com.au](http://www.bluglass.com.au)

## Brewer Science discusses critical issues in high-brightness LED device manufacturing at SEMICON Taiwan

Brewer Science Inc of Rolla, MO, USA, which provides specialty materials, integrated processes, and laboratory-scale wafer processing equipment, exhibited and featured conference presentations at SEMICON Taiwan (5–7 September) in Taipei. In particular, Brewer Science highlighted product technologies for HB-LED manufacturing for wafer protection, thin wafer handling, epitaxial layer transfer, trench filling, and planarization.

"Brewer Science has been delivering advanced technology solutions for the HB-LED market for over seven years through close partnerships with leading LED manufacturers," said Ram Trichur, director of LED/Energy Devices Business.

Pathways to address critical issues in HB-LED device manufacturing through innovative material, process, and equipment technology were discussed by Brewer Science at the following conference presentations:

- 'Smart LED Fabrication Materials as an Extendable, Lower-Cost-of-Ownership Alternative to Equipment-Based Process Solutions', presented by chief technical officer Dr Tony Flaim at the LED Forum;
- 'High-Performance Materials for Improving Yield and Cost Efficiency of HB LED Chip Manufacturing', presented by Ram Trichur, director of LED/Energy Devices Business in the Innovative Technology Center.

[www.brewerscience.com](http://www.brewerscience.com)

### IN BRIEF

#### Ushio to sell Soraa's Superline LED series of GaN-on-GaN single-core halogen replacement lamps

Light source manufacturer Ushio Inc of Tokyo, Japan says that in November it will begin sales of Superline LEDs, a series of LED MR16 halogen replacement lamps from Soraa Inc of Fremont, CA, USA, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates. The products will be sold via Ushio's subsidiaries in countries including Japan, China, Taiwan, South Korea, Singapore and Germany.

GaN-on-GaN LEDs feature high luminous efficiency and light-extraction efficiency and also claim superior heat radiation performance. This enables both large currents and high levels of illumination to be achieved for a given area, in turn enabling miniaturization of the module (difficult to attain with conventional LED chips that use sapphire or silicon substrates). The single-core Superline LED (with just one LED module) hence enables the same or higher brightness than a standard, multi-core LED halogen replacement lamp (with multiple LED modules). It is also compatible with existing lighting fixtures for halogen lamps, since its size is equivalent to that of halogen lamps.

Ushio says that, as a series of next-generation LED halogen replacement lamps, Superline LED delivers not only the brightness of halogen lamps demanded by users, but also faithfully recreates the quality and properties of the light.

[www.soraa.com](http://www.soraa.com)

[www.ushio.co.jp](http://www.ushio.co.jp)

# HexaTech raises \$500,000 in debt financing

## Total funding surpasses \$17m since AlN substrate maker founded

According to a filing on 24 August with the US Securities & Exchange Commission (SEC), HexaTech Inc of Morrisville, NC, USA has raised \$500,000 in new debt financing involving six investors. A further \$54,496 remains still to be raised from the \$554,496 offering.

HexaTech was spun off from the Department of Materials Science of North Carolina State University in 2001 with a transfer of technology — developed by the firm's co-founders Dr Zlatko Sitar (president & chief technology officer) and Dr Raoul Schlessler (VP development) — to produce single-crystalline aluminium nitride (AlN) substrates for both electronic and optoelectronic devices. Subsequently, in late 2005, the firm raised \$8.9m in a Series A round of financing led by Intersouth Partners of Durham, NC and joined by H.I.G. Ventures, Sevin Rosen Funds and NC IDEA.

HexaTech says that its proprietary

technology combines the benefits of physical vapor transport (PVT) growth and of seeded growth for the reproducible production of single-crystal AlN boules. Seeded growth enables the fabrication of AlN boules of pre-defined crystallographic orientation. AlN wafers fabricated from the crystals are of well-defined orientation and of high, reproducible crystal quality, the firm says.

HexaTech also subsequently demonstrated a polarity-controlled device layer deposition process that is compatible with industry-standard MOCVD growth equipment. Control over the polarity opens up processing routes that allow the production of efficient deep-UV LEDs by growing aluminium gallium nitride (AlGaIn) layers on AlN substrates (targeting an emission wavelength of 254nm, which is known to interact with DNA in a way that stops water-borne organisms from reproducing).

Consequently, in 2007, HexaTech won a \$2m Advanced Technology Program (ATP) grant from the US Commerce Department's National Institute of Science and Technology (NIST) as part of a \$3.28m, three-year project (starting in November) to develop high-efficiency deep ultraviolet LEDs for use as a high-energy UV light source to kill micro-organisms in drinking and waste water.

Since then, HexaTech raised \$300,000 in debt financing in January 2010, followed by a further \$3.1m in a round that closed this July (with the aim of adding 10–15 staff to its current workforce of about 25 by the end of this year).

Including the latest \$500,000 in debt financing, HexaTech has now raised more than \$17m in total since the firm was founded.

[www.hexatechinc.com](http://www.hexatechinc.com)

[www.sec.gov/Archives/edgar/data/1346889/000134688912000001/](http://www.sec.gov/Archives/edgar/data/1346889/000134688912000001/)

## HexaTech launches high-transparency single-crystal aluminium nitride substrates for UV-C LEDs

HexaTech has announced the commercial availability of a new class of high-transparency single-crystal aluminium nitride (AlN) material. The firm reckons that this improved capability provides a significant reduction in optical absorption at UV-C wavelengths, resulting in improvements in the processing and performance of UV-C optoelectronic components.

The enhanced material promises improvements in lifetime and power output for UV-C LEDs. For the rapidly growing water purification market, the requirement for extended lifetime and improved efficiency are critical market-enabling parameters, says HexaTech. The firm adds that the new high-transparency bulk AlN substrate material has demonstrated improved output perform-



ance for UV-C LEDs, by increasing short-wavelength transparency, and limiting the amount of substrate thinning required for optimal UV-C emission.

"This new substrate will provide our customers with the bulk AlN material required to develop industry-leading UV-C LEDs which will enable improved EQE [external quantum efficiency], lifetime and reliability," says CEO Joe Grzyb.

**The new high-transparency bulk AlN substrate material has demonstrated improved output performance for UV-C LEDs, by increasing short-wavelength transparency, and limiting the amount of substrate thinning required for optimal UV-C emission**

crystal AlN, it is reckoned.

The improved material performance, after correction for reflection losses, exhibits absorption coefficient values of  $<100\text{cm}^{-1}$  ( $50\text{cm}^{-1}$  typical) @ 265nm, and is measurably superior to previous generations of single-



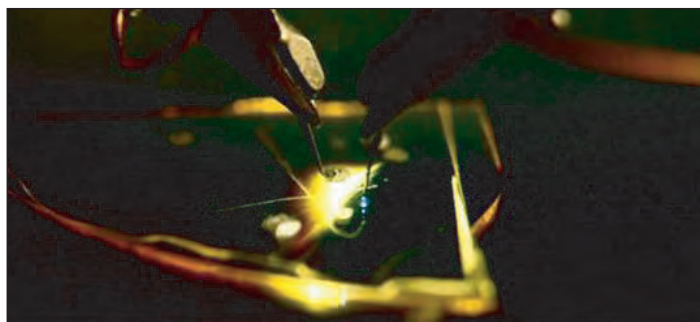
## Meaglow's thick InGaN epi yields strong yellow emission

### Firm seeks partners to co-develop devices targeting 'green gap'

Meaglow Ltd of Thunder Bay, Ontario, Canada — a privately held firm that produces a range of epitaxy equipment and MBE and MOCVD accessories, as well as providing specialized thin films to research institutes and industry — says that its low-temperature Migration Enhanced Afterglow film growth technique has been used to produce a thick indium gallium nitride (InGaN) layer with strong yellow emission. The firm reckons that this result bodes well to increase the efficiency and to lower the production costs of green LEDs and laser diodes.

The company is currently seeking collaboration opportunities to enhance the material properties required by industry for lighting, display, medical, and military applications, among other uses.

"It's the brightest p-n junction I've ever seen in my life, and it's right in the green gap," says Meaglow's chief scientist professor K. Scott Butcher. "The green gap (540–610nm) is a major unsolved



obstacle towards the development of high-efficiency solid-state lighting applications," he adds.

LEDs produced in the green region, between red and blue, have rapidly declining efficiency. Green and yellow in the middle of the color spectrum, known as the 'green gap', is a section of the light spectrum where devices made from either nitride or phosphide are inefficient and difficult to fabricate. Meaglow's reactor overcomes these difficulties by utilizing its patent pending hollow cathode and low-temperature growth process, which is capable of growing the volatile compound of indium required to make green and yellow diodes,

says Butcher.

Having a nitride device that emits strongly in the yellow is a big step forward for low-temperature InGaN growth and demonstrates the quality of InGaN

produced by the proprietary Meaglow technique, says the firm. Results for this test device were presented to the nitride semiconductor research community in May at the 9th International Symposium on Semiconductor Light Emitting Devices (ISSLED2012) at TU Berlin, Germany.

Meaglow is now focused on commercializing its InGaN technology, and is looking for partners interested in creating next-generation devices using the thick InGaN template layers. Interested parties should email [science@meaglow.com](mailto:science@meaglow.com).

[www.meaglow.com](http://www.meaglow.com)  
<http://issled2012.org>

## Plessey up for British Engineering Excellence Award

UK-based Plessey Semiconductors Ltd has been shortlisted as a finalist in the Electronics Product Category of the British Engineering Excellence Awards 2012 for its new MAGIC (MANufactured on Gan ICs) high-brightness LED (HB-LED) products. Winners will be announced on 25 October at an awards ceremony in London.

"Following on from a range of awards for our EPIC products, this is the first nomination for Plessey's new range of MAGIC HB-LEDs," notes Plessey Semiconductors' chief operating officer Barry Dennington. "The Plessey business model of bringing unique, disruptive technologies to the world market is working," he adds. "We have a British semiconductor manufac-

turing facility which gives us the ability to create bespoke production capabilities for our products. We can, therefore, optimise and fine tune process technologies and products to rapidly bring new solutions to market. Plessey has a long history of developing high margin, unique and innovative products and we are actively working to add yet more to our portfolio."

Plessey reckons that MAGIC technology will enable it to offer LEDs that are significantly less expensive than existing LEDs as they are made on standard silicon substrates in a high-volume, semiconductor production facility rather than existing, more expensive LEDs based on sapphire or silicon carbide (SiC).

The firm's technology uses gallium nitride (GaN) on 6" silicon substrates, to be manufactured at its Plymouth facility. It uses a much thinner GaN layer (just 2.5µm thick, compared to 6–8µm in other GaN-on-Si technologies). This requires less deposition time, so the firm can achieve multiple production cycles in 24 hours to achieve higher throughput and lower costs.

For its next-generation products, Plessey aims to integrate its MAGIC HB-LED products with its EPIC sensor technology to provide smart lighting solutions for even greater energy savings and carbon footprint reductions.

[www.plesseysemiconductors.com/products/magic](http://www.plesseysemiconductors.com/products/magic)

# Vertically integrated LED firm Lextar to absorb packager Wellypower

**Merged Taiwanese firm to operate as Lexstar from February 2013**

LED firms Lextar Electronics Corp and Wellypower Optronics Co Ltd, both of Hsinchu Science Park, Taiwan, have agreed to merge, targeting 1 February 2013 for Wellypower to be absorbed into Lextar. The merged entity will operate as Lexstar.

The share swap ratio for Wellypower and Lextar is planned to be 2:1, based on the stocks' market value, net worth, industry status and prospects, production capacity and profits, and subject to approval by the shareholders meeting of both firms.

Founded in May 2008, Lextar is a subsidiary of Taiwan's display panel maker AU Optronics (AUO) specializing in manufacturing high-brightness LED epiwafers, chips and packages, as well as energy-saving and smart lighting products. Applications includes LCD backlighting, professional lighting source, consumer lighting source and various lighting products. After acquiring LightHouse Technology Inc in March 2010, Lextar now has more than 2500 staff at manufacturing plants in Taiwan's Hsinchu Science Park, Hukou Industrial Park and Chunan Science Park, and an assembly plant in Suzhou, China. Revenue grew from US\$255m

in 2010 to US\$309m in 2011.

"Lextar is one of the top three LED companies in Taiwan and is the only one throughout the island to have a vertically integrated business model," says chairman Dr David Su.

With a factory in Zhunan, Mao-Li County, Taiwan as well as Hsinchu, Wellypower has experience in LED packaging as well as in lighting product manufacturing and sales.

"To accommodate international energy-conservation trends, Wellypower believes it will obtain technological and management resources after the merger, which will be beneficial in quickening the company's transformation into an LED firm," says the firm's chairman Allen Huang. "The merger will also increase the company's competitiveness."

**Lextar reckons that the merger should reduce duplicate investment and enhance the economies of scale of production and procurement, while also expanding sales channels abroad**

Lextar reckons that merging with Wellypower will provide advantages in the sales and supply chain segments, providing a high degree of integrated operations. The merger should reduce duplicate investment and enhance the economies of scale of production and procurement, while also expanding sales channels abroad. Additionally, Wellypower is one of the largest T5 tube providers for China Electric MFG Corp, which has its own lighting brand TOA. So, Lextar reckons it should gain a more developed relationship with China Electric and be able to enhance mutual competitiveness in the LED lighting market.

"Lextar has resource management, production and supply chain experience together with company merging back in 2010, when it merged with the largest LED backlighting maker at the time, Lighthouse," says Su. "Lextar's merger with Wellypower this time around will provide the two sides more talent and resources, and will increase Lextar's advantages in the ever-quicken and evolving LED lighting market," he reckons.

[www.wellypower.com.tw](http://www.wellypower.com.tw)  
[www.lexstar.com](http://www.lexstar.com)

## Lextar's Photometric Lab receives LM-79 and LM-80 accreditation

Vertically integrated LED maker Lextar Electronics Corp of Hsinchu Science Park, Taiwan says that its Photometric Laboratory has received LM-79 and LM-80 accreditation, making it Taiwan's first LED corporation to be awarded both accreditations, it is claimed.

LM-80 is the Lumen Maintenance assurance for LED packaging. LED lumens (brightness) decay over time, producing light fades or colorcast. LM-80 tests LED packaging at multiple temperatures for 6000 hours to determine the quality and

life of a particular LED. Major international plants currently all use LM-80 as indicators for the quality and life of their LED packages, making it a common testing standard across the globe, says Lextar.

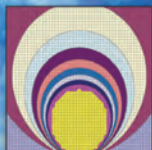
LM-79 is the industry standard procedure for photometric and electrical measurements for LED lighting products. LED lamp makers can test and report through LM-79 to provide an optical measurement value of credibility.

To receive the LM-80 accreditation, Lextar's 3014 and 5630 LED pack-

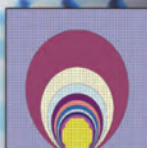
ages exceeded 6000 hours of testing over nearly 9 months, and maintained a high standard luminous output when subjected to temperatures of 55°C and 85°C. The 3014 and 5630 packages offer a high degree of stability and quality, and can be used in bulbs, tubes, down lights, panel lights, advertising light boxes and many other applications.

Lextar's CoB product series is also undergoing LM-80 testing, with accreditation expected next year.

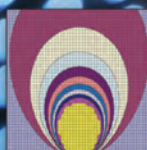




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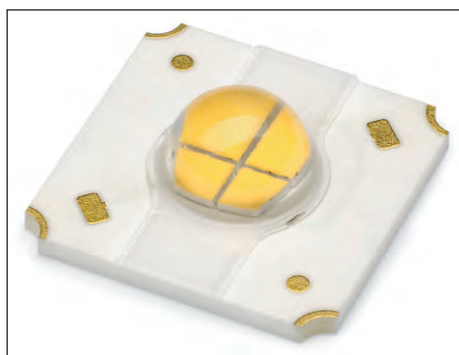
*Temescal*



## Philips Lumileds launches LUXEON H50-2 LEDs with luminous efficacy of 80lm/W

LED maker Philips Lumileds of San Jose, CA, USA has introduced its LUXEON H50-2 LED, with a typical efficacy of more than 80lm/W, rated at 40mA 2W (50V). The new LED improves on the efficacy of the existing LUXEON H50V LED by 27%, says the firm, and offers 10% more lumens per watt and 30% higher luminous flux than leading competitive products, as well as lumen maintenance exceeding Energy Star requirements.

"We continually work with our customers to help them address the challenges they are facing in their market through the introduction of innovative new LED packages such as the LUXEON H50-2," says product manager Viji Krishnamurthy. "This new LED package works with



Lumileds' LUXEON H LED.

simple, highly efficient drivers, enabling lighting designers to create unique form factors at lower costs, while still offering LUXEON performance and quality."

With a footprint of 3.7mm x 3.7mm, the H50-2 is designed for smaller envelopes in retrofit bulbs,

such as the A19, in space-constrained applications, as well as for under-cabinet and track lighting. With its small size and high-voltage architecture, the new LED enables more form factors and lowers costs through the use of cost-efficient drivers, adds the firm.

Each H50-2 LED is hot tested at 85°C to guarantee performance at operating conditions, and is color binned at 85°C and 40mA into three and five SDCM to ensure consistency among LED packages. In addition to A-line retrofits, the new LED can drive down the costs of other space-constrained lamps, such as candelabra and GU10.

LUXEON H50-2 LEDs are available from Future Lighting Solutions.

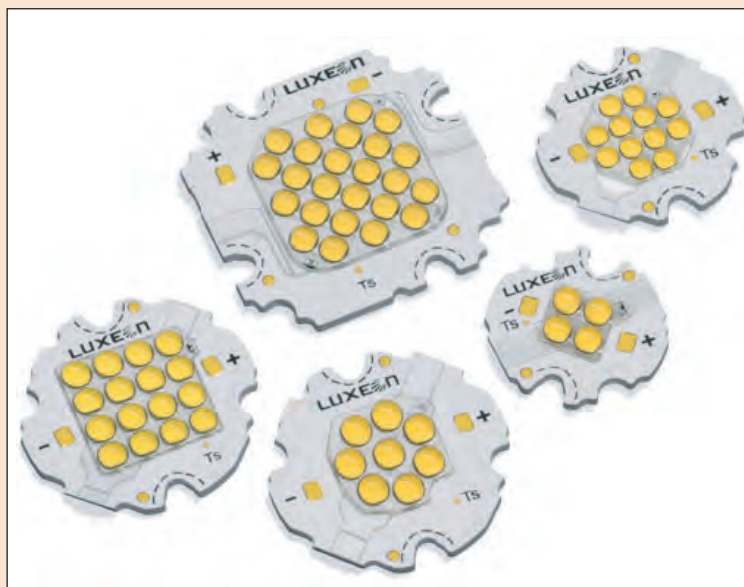
[www.futurelightingsolutions.com](http://www.futurelightingsolutions.com)

## LUXEON K LEDs deliver high brightness, lumen-per-watt consistency and precise white color

Lumileds has launched a white LED array that, it claims, will free LED system manufacturers from the LED binning process, reducing their costs, inventory requirements, and time to market.

Each new LUXEON K array falls within a single 3-step MacAdam ellipse and delivers improved consistency in lumen per watt due to tight forward voltage and flux ranges. The compact, high-efficacy arrays suit energy-efficient retrofit lamp and downlight applications requiring high light output within a thermally and space-constrained system.

Lumileds says that its Freedom From Binning policy means that every LUXEON K array is accurate to a single 3 SDCM (standard deviation of color matching), ensuring that each lamp and luminaire using LUXEON K arrays will deliver consistently precise color, brightness and lumens per watt. The firm adds that the result is a simplified system design and assem-



Lumileds' family of LUXEON K LEDs.

bly that increases time to market and reduces costs associated with binning, logistics and inventory management. LUXEON K also exceeds ENERGY STAR lumen-maintenance requirements.

The product line also provides LED system designers and manu-

facturers with a wide variety of lumen, color and size options. Modules are available in 400–4000lm outputs; 2700K, 3000K and 4000K CCTs; and 4-, 8-, 12-, 16- and 24-emitter arrays.

The arrays are mounted on an aluminium

metal-core printed circuit board that ensures good thermal path between the LEDs and the heat-sink on which the LEDs are mechanically mounted.

The LUXEON K arrays are available from Future Lighting Solutions.

[www.philipslumileds.com](http://www.philipslumileds.com)



## LUXEON mid-power 3535 launched

Lumileds has expanded its portfolio by launching the LUXEON Mid-Power 3535 LED, available in a high-density-lumen package and designed for non-directional light sources (such as LED troffers and tube lights) in commercial and residential applications.

"The LUXEON Mid-Power 3535 is the second product from our mid-power portfolio that we are introducing to the market," says Rahul Bammi, VP marketing. "It is a sign of our commitment to expanding our mid-power offering for the illumination market, meeting customers' expectations for high-performance mid-power LEDs that deliver quality of light."

With its compact, 3.5mm x 3.5mm form factor, efficacy of more than 110lm/W at 100mA and 80-plus color rendering index (CRI), the



Mid-Power 3535 gives designers the power to create cost-effective and energy-efficient luminaires, says the firm. It is offered in a range of correlated color temperature (CCT) options, from 2700K to 6500K.

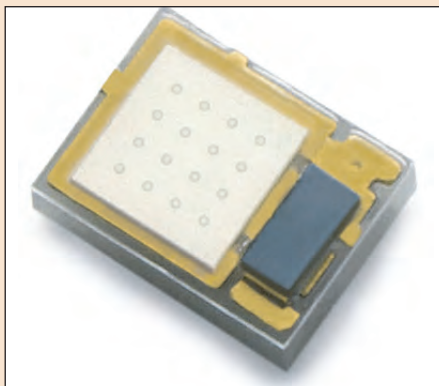
With the launch of the 3535, Lumileds is continuing to build its mid-power LED portfolio. The first for general illumination, the Mid-Power 5630, was launched in April.

## LUXEON Z LEDs claim highest lumen density

Lumileds has introduced what it claims is the smallest high-power LED package (75% smaller than most power LEDs, it is reckoned).

The LUXEON Z enables a level of customization in luminaire design that, until now, has been unattainable, claims the firm. Luminaire designers can use the ultra-compact 1.3mm x 1.7mm (2.2mm<sup>2</sup>) unencapsulated LEDs to create a large variety of packaging, optical configurations and lighting design form factors. The LUXEON Z is available in a full spectrum of colours of 440–670nm (including white). Testing and binning is at 500mA (1.5W for white), although the devices are rated for use up to 1A.

Unlike conventional products, according to the firm, the LUXEON Z can be used to create 2x2, 3x2, 6x1 and other mono-color or multi-color arrays for new and existing luminaires. "LUXEON Z fundamentally takes the building block approach and puts design flexibility back in the hands of engineers and specifiers," says Rahul Bammi, VP product man-



agement. Furthermore, it is possible to mount nearly 250 LUXEON Z LEDs within a square-inch, enabling what is claimed to be the industry's highest commercially available lumen density.

For products such as wall-washers, moving-head spotlights, tunable retrofits, and remote phosphor-based lamps, LUXEON Z LEDs offer design engineers a modular approach to developing entertainment, architectural and other specialty lighting. The unencapsulated chips can also accommodate custom optics, eliminating complex, inefficient secondary lenses.

[www.philipslumileds.com](http://www.philipslumileds.com)

## IN BRIEF

### Cree launches The Edge High Output LED luminaires

Cree Inc of Durham, NC, USA has launched The Edge High Output (H.O.) area and flood light LED luminaires, which can replace high-output sources (such as 1000W metal halide) and use 50% less energy in most applications. The luminaire has more than 20 optical configurations, including new FrontlineOptic technology designed for auto dealerships.

"Quality lighting has an immediate positive impact on the retail shopping experience," says Mike Lallier, president & owner of Reed Lallier Chevrolet. "The revolutionary solution provides superior color quality that allows us to effectively extend our selling window after dark."

Featuring patented NanoOptic technology, The Edge H.O. luminaire distributes light to where it is needed, so users only pay for the light required, says Cree. Also, thermal management enhances reliability and helps the system to provide more than a decade of near-maintenance-free service, eliminating expensive re-lamping cycles.

The new luminaire offers better color stability and reliability, plus a higher CRI and a much broader spectrum color source compared with high-wattage metal halide alternatives, adds Cree.

"The Edge H.O. offered significant energy and maintenance savings compared to 1000W metal halide without compromise," says Allen Trench, operations manager, Irvine Home Center, Irvine Company Retail Properties. "Improved illumination performance, better color quality and greater reliability allow us to provide a much more consistent and enhanced shopping experience for our customers," he adds.

[www.cree.com](http://www.cree.com)

# Osram Opto launches Oslon Black Flat LED for automotive front-lighting systems

Osram Opto Semiconductors GmbH of Regensburg, Germany has launched the Oslon Black Flat LED for automotive front-lighting systems.

Equipped with state-of-the-art chip and packaging technology and a ceramic converter, the latest LED in the Oslon Black series is a high-performance light source for automotive applications. According to the firm, it offers high light output even at high currents, uniform distribution of light, thermal stability and particularly good contrast for seeing and being seen. Oslon Black Flat had its premier as a prototype at the International Symposium on Automotive Lighting (ISAL 2011) at Technische Universität Darmstadt and is available now.

Light sources for front-lighting have to be multi-talented, says Osram Opto. Not only must they illuminate the road ahead reliably in rain and fog and at night, they must fulfill various functions such as low beam, cornering lights and fog lights. They must also withstand high temperatures in the headlights. Hence, more and more automobile manufacturers are opting for flexible, efficient and powerful LED technology. The Oslon Black Flat has been designed to meet all these requirements.

The new LED contains a UX:3 chip that delivers high light output even at high currents. Luminous efficacy is 87lm/W: with a power draw of 2.3W, typical luminous flux is 200lm at an operating current of 700mA



**Oslon Black Flat LED, which offers low thermal resistance, high currents and high light output at high temperatures.**

(with a junction temperature of 25°C) and 270lm at 1.2A (despite a junction temperature of 100°C).

Osram Opto says that thermal management is much simpler with the new LED due to the greater thermal stability of luminous flux even under 'hot' application conditions and due to a new temperature-optimized packaging process. Typical thermal resistance has hence been reduced to 4K/W. The thermal coefficient of expansion of the black QFN (quad flat no lead) package of the LED is matched to the coefficient of expansion of the metal core board. All these properties make the Oslon Black Flat particularly stable and extremely durable (giving a life-time of more than 100,000 hours at 700mA and a L70B50 solder point temperature,  $T_s$ , of 60°C, and 10,000 hours at 1.2A and 120°C).

The Oslon Black Flat was developed in Regensburg and has been

designed to function without a lens, so its light can be injected very close to light guides or lenses. At 70–100Mcd/m<sup>2</sup> (million candelas per square meter), the LED's luminance (i.e. what the human eye perceives as the brightness of a particular surface) is 2–5 times higher than comparable LEDs in its class, the firm claims. "This is particularly important in automotive front-lighting solutions based on projection systems," notes Peter Knittl, director Automotive LED at Osram Opto. "The greater the luminance of the LED, the smaller the external lens and the smaller the space needed," he adds. "Headlights can therefore be made much more compact, giving designers much more freedom."

Encapsulation of the chips directly in the package produces a defined light/dark boundary in the light pattern and — in conjunction with advanced package technology and the ceramic converter — a uniform distribution of light and a particularly good contrast ratio on the road, notes Osram Opto. The LED measures 3.75mm x 3.75mm.

The firm says that, before the end of 2012, we will be seeing automobiles and motorcycles on the roads in which the small black LEDs will be performing the most important front-lighting functions.

The Oslon Black Flat LED is being showcased at SIA-Vision 2012 in Versailles, France (9–10 October).

[www.osram-os.com](http://www.osram-os.com)

## Second consecutive year for Bridgelux on Inc.'s 5000 list

LED chip and lighting array maker Bridgelux Inc of Livermore, CA, USA has been included for the second consecutive year in Inc. Magazine's 5000 list, an annual ranking of the fastest-growing private firms in America.

Inc. ranks firms by the percentage revenue growth from 2008 through

2011. Companies on this year's list have created over 400,000 jobs in the past three years, and their aggregate revenue reached \$299bn.

"This serves as recognition of both the growth of the solid state lighting industry and the hard work of our employees in the success of our company," says CEO Bill Watkins.

"This also demonstrates the increasingly important role that clean technologies are playing in the rejuvenation of the American manufacturing sector," he believes.

Complete results of the Inc. 5000, including company profiles, can be found at [www.inc.com/5000](http://www.inc.com/5000).

[www.bridgelux.com](http://www.bridgelux.com)



## Cree's XP-E2 LEDs doubles lumens per dollar and boosts lumens per Watt by 20% over existing XP-E LED

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has launched the XLamp XP-E2 LED, delivering higher lumens per watt and lumens-per-dollar to lower system costs for existing XP-E and XP-G designs.

The new XP-E2 LEDs can increase the lumen output of XP-E designs for the same cost and power or lower system cost with fewer LEDs, enabling lighting manufacturers to deliver a better lighting system with minimal redesign, the firm claims.

"The price-to-performance ratio is an important consideration for our design process," says Erik Milz, VP of marketing of LED lighting product maker TerraLUX Inc of Longmont, CO, USA. "Since many of our products are based on Cree XP-E LEDs, the new XP-E2 LED is a significant upgrade in performance, helping to keep design costs down and speeding time-to-market for our solutions," he adds.

The XP-E2 LEDs use the same XP footprint (3.45mm x 3.45mm) and are optically compatible with all XP LED designs, including XP-E and XP-G LEDs. The new LEDs also enable a broad range of high-lumen applications, from indoor and outdoor lighting to portable and lamp retrofits.

As the latest products to be built on Cree's SC3 Technology next-generation LED platform, the XP-E2 LEDs deliver luminous efficacy of up to 128 lumens per watt at 350mA and 85°C, or 143 lumens per watt at 350mA and 25°C in cool white (6000K). The SC3 Technology platform is built with Cree's silicon carbide (SiC) technology, features advances in LED chip architecture and phosphor, and showcases a new package design tailored for lighting-class LED components.

Luminaire makers seeking ENERGY STAR qualification will have access to specification and performance data, including LM-80 reports, which can speed time-to-market, says Cree. XP-E2 LEDs are a 'successor' product to the original XP-E LED for LM-80 data, accelerating the qualification of luminaires using just 3000 hours of LM-80 data (instead of the normal 6000 hours).

Samples of XP-E2 LEDs are available now and production quantities are available with standard lead times. They are available in correlated color temperatures of 2700-7000K, with minimum color rendering index (CRI) options of 70, 80, 85 and 90.

[www.cree.com/accelerate](http://www.cree.com/accelerate)



Cree's new XLamp XP-E2 LED.



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# SemiLEDs' S35 LED passes LM-80 test with IST

In cooperation with Hsinchu-based lab services firm Integrated System Technology Inc (IST), LED chip and component maker SemiLEDs Corp of Hsinchu Science Park, Taiwan has announced that its S35 product line has completed the requirements of the stringent 6000 hour lumen maintenance test (LM-80) and that the results showed an extrapolated lifetime of up to 50,000 hours.

SemiLEDs claims that its S35 series is the first product to pass the third-party LM-80 test in Taiwan since IST received accreditation from the US Environmental Protection Agency (EPA). Results for further products, including the newly launched C35 family, will follow. SemiLEDs claims to be one of the few packaging firms in the Asian market to have passed the test on a certified third-party basis.

"LED components are sensitive to heat, and most failures in lighting fixtures involve thermal mistreatment," says Kevin Tsui, VP of IST's Reliability Engineering Department. "Therefore, verifying the degradation at various temperatures is very critical," he adds.

Tsui further explains that LM-80 is required by US Energy Star and involves the collection of data based on three different case temperatures for at least 6000 hours. The lumen maintenance requirement

is also defined. The test provides standardized quality assurance and quality certification for lighting fixture manufacturers and LED manufacturers, respectively.

SemiLEDs' CEO Trung Doan states that the S35 and P2 warm- and cool-white LEDs (with color temperatures of 5700K and 3000K, respectively) were the firm's first series to go through the 6000 hour tests at both 350 and 700mA currents. The test results from IST showed that lumen maintenance is 98.75% and 97.81% for 55°C and 85°C, respectively, for the 3000K emitter at 700mA drive current, far above the LM-80 requirements of 91.8% for domestic indoor applications and 94.1% for domestic outdoor and commercial usage.

SemiLEDs further explains that providing high-quality components to lighting fixture manufacturers is key to enabling quicker penetration of LEDs into the lighting market.

The S35 is SemiLEDs' first series of emitters with a 35mm x 35mm footprint using a silicon housing material. The firm launched the C35 — the second generation of its 35mm x 35mm emitters — in June. The C35 incorporates SemiLEDs EV LED chip and a ceramic base. The thermal resistance complements SemiLEDs' vertical chip on metal alloy substrate technology. Besides thermal management, SemiLEDs

has also implemented its latest innovation in phosphor technology ('Color Precision' binning) to its C35 product family, allowing customers to be in control of their CCT distribution. The firm says that, with the new technology, consistent color can be produced within a single 7-step, 4-step or 2-step MacAdam Ellipse centered in ANSI-defined standard color spaces.

"Being a certified test lab, IST showed its professionalism and provided all the necessary assistance for us to verify our performance," says Doan. "We look forward to further cooperation for new products in the pipeline."

IST's chief operating officer Jandel Lin notes that its LM-80 lab started up at the end of 2011 and has already been commissioned by more than 20 manufacturers to conduct the test. SemiLEDs' S35 is first to pass the test at IST's lab, and the results should significantly increase SemiLEDs' marketing competitiveness in terms of quality, he reckons.

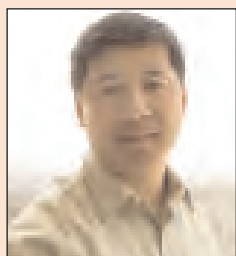
IST's chief financial officer Selina Lin says that, at the beginning of this month, IST signed a memorandum of understanding (MoU) with Intertek HK as the reporting body, and that it aims to continue strengthening its LED certification platform.

[www.isti.com.tw/index\\_en.php](http://www.isti.com.tw/index_en.php)

## Senior management team reshuffled at SemiLEDs

LED chip and component maker SemiLEDs Corp of Hsinchu Science Park, Taiwan has announced changes to its senior management team.

After serving as president, chief operating officer and director of SemiLEDs, Dr Anh Chuong Tran is to become the firm's chief scientist, dedicated to technology and product development. Trung T. Doan, currently chairman of the board and chief executive officer, will take on the additional role of



Trung T. Doan.

president. "Technology has always been SemiLEDs' foundation. This transition will allow Chuong to dedicate his time and focus on technology and product development," said Doan.

SemiLEDs has named Ilkan Cokgor as executive vice president

of sales & marketing. Cokgor has over 20 years of product development, marketing, sales, and business development experience. He joins SemiLEDs from Everlight Electronics, where he served as vice president of global marketing since 2010.

"Ilkan has an impressive track-record in establishing marketing and sales channels and strong expertise in the LED industry," says Doan.

[www.semileds.com](http://www.semileds.com)



## Seoul Semiconductor's Acrich2 achieves 100lm/W luminous efficacy in AC LED module

South Korean LED maker Seoul Semiconductor says that its latest Acrich2 AC LED module is now available for volume production orders with luminous efficacy of 100 lumens per Watt.

Acrich2 provides lighting designers a light source with not only high efficacy but also a power factor now up to 97% and improved total harmonic distortion (THD) performance (now less than 25%, to comply with the requirements of each country, including the US Department of Energy etc).

The firm claims that Acrich2 can save about \$2 over these traditional solid-state lighting solutions, where additional components and costs are required to provide an offline driver solution with acceptable dimming performance. As well as improving compatibility with Triac dimmers, the AC LED module also provides a DC dimming interface that allows designers to easily integrate new dimming functions such as Touch Sensor and WIFI control dimming.

Seoul Semiconductor says that the improvement in power factor, up to 0.99, can cut energy consumption by up to half, saving electricity costs. In contrast, conventional LED Lighting products have lower power factors (as little as 0.5, but mostly in the range 0.70-0.80). With a high power factor, the Acrich2 AC LED module hence aids the performance of the power grid, it is claimed.

The firm also says that Acrich operates effectively due to its integrated 'Integrated Multi-cell' technology, which it has developed over the last 10 years. As a result, Acrich can operate from both alternating current and direct current. In addition, it can tolerate a wide range of voltages.

Acrich2 AC modules with output powers of 4W to 16W are now available, and the production line is ready to produce large-quantity



orders. Customized versions are also available.

[www.acrich.com/en](http://www.acrich.com/en)

[/product/prd/acrich2.asp](http://product/prd/acrich2.asp)

[www.seoulsemicon.com/en](http://www.seoulsemicon.com/en)

Pictured (left): Seoul Semiconductor's Acrich2 AC LED module.

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## Chalmers' professor Anders Larsson wins HP Labs' Innovation Research Award for high-contrast-grating VCSELs for WDM computer interconnects

Professor Anders Larsson of Sweden's Chalmers University of Technology is one of 61 university professors in 46 institutions worldwide selected from more than 500 proposals for a 2012 HP Labs Innovation Research Award. He has been awarded for work on 'High Contrast Grating VCSELs for WDM Computer Interconnects' in collaboration with Dr Michael Tan and his group at the Intelligent Infrastructure Lab at HP Labs. The project also involves the Chalmers researchers Johan Gustafsson, Åsa Haglund, Jörgen Bengtsson and Erik Haglund.

HP Labs' Innovation Research Program (IRP) aims to create opportunities at colleges, universities and research institutes around the world for collaborative research with HP.

The vertical-cavity surface-emitting laser (VCSEL) is the primary light source for short-reach optical communication because of high efficiency, high-speed properties, efficient coupling to optical fibers, and low manufacturing cost.



**Researchers involved in the project:** Jörgen Bengtsson, Erik Haglund, Anders Larsson, Johan Gustafsson and Åsa Haglund.

VCSELs are produced in high volume for high-capacity optical interconnect cables in storage area networks (data-centers) and high-performance computing systems (computer clusters, supercomputers etc). In the near future, high-speed optical cables with VCSEL-based optical transmitters are also expected to make their debut in consumer electronics (Thunderbolt, USB, HDMI, etc).

For computing applications, the small footprint and high modulation speed of VCSELs enable very high-density and very high-capacity interconnects. To increase capacity beyond what can be provided by a single channel, space-division multiplexing (parallel fiber ribbons or multicore fibers) or wavelength-division multiplexing (WDM) can be used. WDM, which requires monolithic multi-wavelength VCSEL arrays, enables optical interconnect architectures that offer more complex interconnect topologies and routing schemes. It also enables the interconnect network to adapt to irregular and time varying traffic patterns.

The project aims to develop technology whereby the wavelength of individual VCSELs can be set in a post-growth fabrication process, enabling the realization of low-power-consumption, high-speed, multi-wavelength VCSEL arrays for WDM interconnects in computing systems.

[www.hpl.hp.com/open\\_innovation/irp/2012\\_results.html](http://www.hpl.hp.com/open_innovation/irp/2012_results.html)

[www.chalmers.se/mc2/force-en](http://www.chalmers.se/mc2/force-en)

## NSF awards Daylight phase II SBIR to commercialize QCL-based IR microscope platform

The US National Science Foundation (NSF) has awarded Daylight Solutions Inc of San Diego, CA, USA, which makes molecular detection, spectroscopic imaging and high-power illumination systems based on quantum cascade lasers (QCLs), a Phase II Small Business Innovation Research (SBIR) grant to advance and commercialize its infrared microscope platform.

Under NSF Phase I SBIR funding, Daylight developed a new approach to IR microscopy based on its system-level expertise in mid-IR imaging and its patented technology in broadly tunable, external-cavity QCLs.

The integration of a high-power, tunable IR laser illumination source enables full-frame spectroscopy and chemical imaging applications with data acquisition times up to 50 times faster than traditional IR approaches such as Fourier transform infrared (FTIR) microscopy, says the firm. The benchtop microscope allows users to generate full IR spectra at every pixel in an image, enabling chemical and molecular identification of samples in addition to traditional visual inspection. Its integrated software suite provides features that allow for flexible data acquisition, hyperspec-

tral imaging, data visualization and archiving, and spectral database matching for sample identification.

NSF Phase II SBIR funding will be used for the development of a commercial prototype and to prepare for production.

"Daylight's QCL-based infrared microscope is a true game-changer in the chemical imaging space," says president & chief operating officer Paul Larson. "This innovative approach will enable exciting new research and commercial capabilities in medical diagnostics, forensics, food safety, and many other market sectors."

[www.daylightsolutions.com](http://www.daylightsolutions.com)

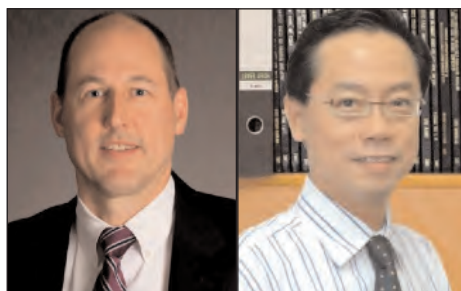


## LEES project aims to integrate optical and electronic components on chip using III-V-on-silicon technology

A meeting organized by the Singapore MIT Alliance for Research and Technology (SMART) Center has taken place to initiate the research project Low Energy Electronics Systems (LEES), which aims to develop technology to increase energy efficiency and advance high-tech industries that complement microelectronics.

SMART is a collaborative project between the Massachusetts Institute of Technology (MIT) and the National Research Foundation of Singapore (NRF). Its objective is to develop ways to integrate optical and electronic components on a chip, using III-V-on-silicon technology.

By 2016, the LEES team aims to have developed novel material compounds, process technologies, and integrated circuits on 200mm CMOS-compatible silicon wafers. Professor Eugene A. Fitzgerald of MIT's Department of Materials Science and Engineering (DMSE) is the lead principal investigator for the project, with Soon F. Yoon of



MIT's Eugene A. Fitzgerald (left) and NRF's Soon F. Yoon (right).

the Electrical and Electronic Engineering Department (EEE) at Nanyang Technological University (NTU) as co-lead.

Two CRIUS 1x200mm systems, ordered from Aixtron SE of Herzogenrath, Germany earlier this year, will form the technological basis for the LEES project work. Both systems will be available for use from Q4/2012.

"Given the increasing scarcity of energy resources, we are being challenged to provide integrated circuits that have more functionality and higher performance, and use less power," says Fitzgerald.



Aixtron VP of R&D Michael Heuken.

"LEES combines the advantages of expertise in III-V semiconductors with the already established silicon technology," says professor

Michael Heuken, Aixtron's VP of R&D, who has

been appointed as a member of the LEES scientific advisory board. "Our particular interest lies in the production of LEDs, lasers, and power semiconductors on large silicon wafers on an industrial scale."

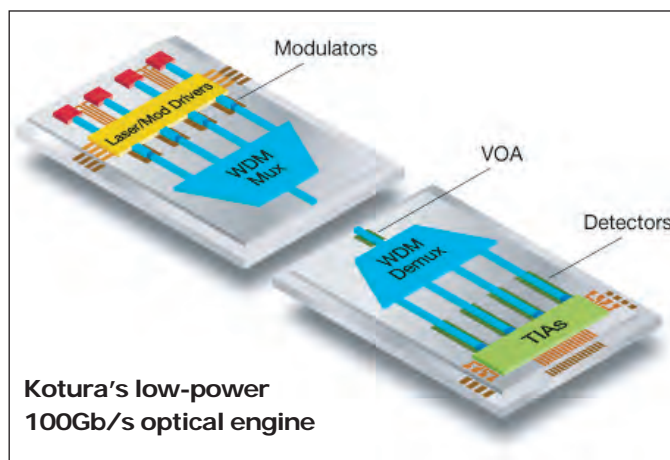
Integrating AlInGaN- and AlInGaAsP-based III-V semiconductors in silicon-based CMOS circuits should reduce energy use. New circuit designs will be used in multi-functional LED color displays of mobile phones, televisions, and computers, as well as in printing, power electronics, and LED lighting.

[www.nrf.gov.sg/nrf](http://www.nrf.gov.sg/nrf)  
[www.aixtron.com](http://www.aixtron.com)

## Silicon photonics firm Kotura named to Inc. 5000 list of America's fastest-growing private companies

Kotura Inc of Monterey Park, CA, USA, which designs and makes silicon photonics application-specific integrated circuits (ASICs) for the communications, computing, sensing and detection markets, has been named to Inc. magazine's sixth annual Inc. 500|5000 ranking of America's fastest-growing private firms.

Companies are ranked according to percentage revenue growth between 2008 and 2011. With a compound annual growth rate (CAGR) of 206%, Kotura has been ranked number 1452 on the overall list and number nine in the computer hardware industry category.



Kotura's low-power 100Gb/s optical engine

"As the field of silicon photonics continues to grow, Kotura is at the forefront of this industry and will continue to be a pioneer as the technology is expanded to new applications."

Complete results of the Inc. 5000 (including company profiles and an interactive database that

"To be included in the Inc. 5000 is a reflection of the dedication and hard work our team has displayed over the last few years," says Kotura's president & CEO Jean-Louis Malinge.

can be sorted by industry, region, and other criteria) can be found at the following web address:

[www.inc.com/5000](http://www.inc.com/5000)  
[www.kotura.com](http://www.kotura.com)

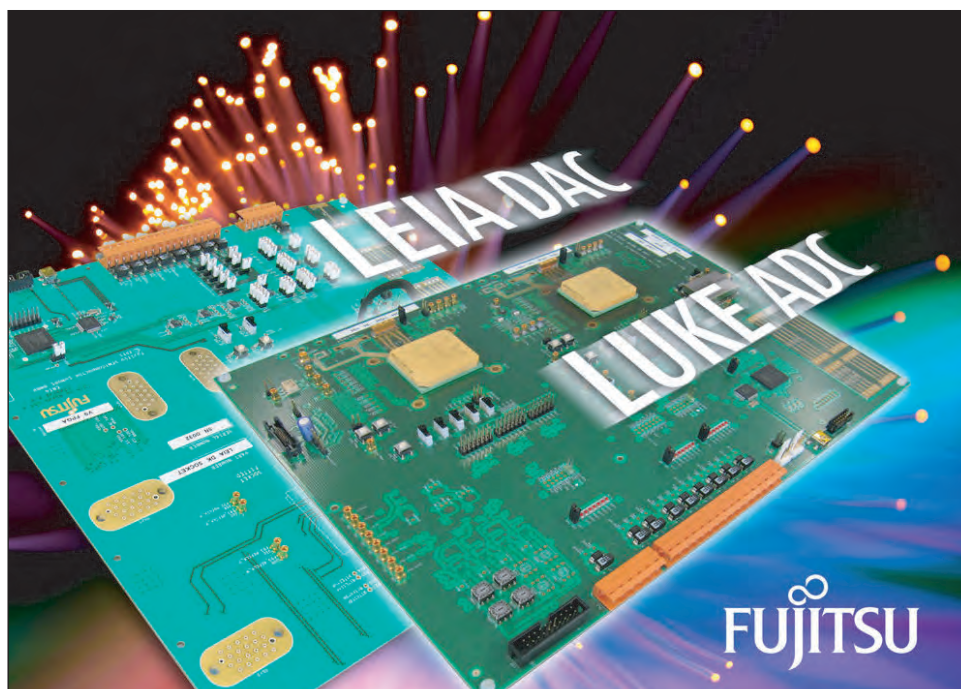
# Fujitsu quadruples data rate throughput over OIF CEI-28G-VSR interface based on multi-level signalling and advanced ADC/DAC technology

Fujitsu Semiconductor Europe (FSEU) in Langen, Germany has demonstrated the transmission of >100Gbps over a single CEI-28G-VSR channel, effectively quadrupling the data rate throughput defined by the Optical Internetworking Forum (OIF) for this chip-to-chip electrical interface.

The firm adds that the demonstration shows what can be achieved over short-reach electrical channels using the same field-proven CMOS converter technology deployed in long-haul optical transport systems today. Key to the study is a comparison of PAM (pulse-amplitude modulation) encoding versus DMT (discrete multi-tone) over this particular channel. FSEU's test and demonstration platform is based on the test chips and evaluation boards for the family of 40nm, 65GSps CMOS converters ('LEIA' DAC for transmit and 'LUKE' ADC for receive).

FSEU adds that the need for faster interconnects and higher port densities within data centres is driving the market for higher short-reach transmission rates across boards, through backplanes and between servers. However, there are fundamental challenges in designing short-range interconnects over 30Gbps across even short traces, where the limit of efficient signal propagation using standard materials is reached.

Equally, in optical transport networks, increased data traffic is pushing up the speeds required at the core of the network, driving the need for higher data rates in metro networks where cost, power and flexibility are major requirements. Over the last few years, the use of coherent detection in long-haul transport links enabled greater performance and flexibility of design by harnessing the capabilities of digital signal processing, enabled



FSEU quadruples data rate throughput over OIF CEI-28G-VSR interface.

by high-speed converters; all built in standard CMOS technologies. As the market moves forward, the expectation is that the same approach will be needed to transport 100Gbps (and higher) data rates over a few 10s of kilometres of fibre.

In both cases, the use of multi-level signalling or multi-carrier encoding will enable transmission of higher data rates, says the firm. For short-reach electrical interconnect, the aim will be to increase the data throughput over the

**In optical transport networks, increased data traffic is pushing up the speeds required at the core of the network, driving the need for higher data rates in metro networks where cost, power and flexibility are major requirements**

same link. For short-reach metro links, the aim will be to reduce cost and total system power by maintaining a low signalling frequency (e.g. 10GBaud) and using encoding to transmit more bits/symbol over less expensive optics.

The range of potential application spaces where multi-level signalling may apply is wide, from a few centimetres between chips and modules to several hundred meters across a data centre to a few kilometres. The common theme is that some form of non-binary signalling would allow for a much more scalable and flexible approach and is viable as long as the power/Gbps is low enough.

Fujitsu Research and Development Center and Fujitsu Laboratories presented results of related studies at the European Conference on Optical Communications (ECOC) in Amsterdam, The Netherlands (16–20 September).

[www.fujitsu.com/emea/services/microelectronics](http://www.fujitsu.com/emea/services/microelectronics)





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## IN BRIEF

### GigOptix appoints Victor Tu as VP of sales for Asia Pacific

GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical components enabling high-speed end-to-end information streaming over optical fiber and wireless networks) has appointed Victor Tu to the new position of VP of sales for the Asia Pacific region.

"The addition of Victor to the GigOptix family adds significant strength and experience to our international sales approach," says CEO & chairman Dr Avi Katz. "We have continuously grown our business in the Asia Pacific region to date, but this new role will enable us to take our customer engagements to the next level," he believes. "We are challenging Victor to help improve our market position in one of the fastest-growing regions for the communications market."

"This new appointment will prove beneficial to our customers and help garner additional new business," Katz believes. "I look forward to the new business developments that he will bring to GigOptix as he builds a solid sales team in the region."

Tu has nearly 20 years of semiconductor sales and engineering experience. Prior to joining GigOptix, he was VP of sales (APAC) at Gennum Corp (which was acquired by Semtech Corp in March). Tu was responsible for growing sales of analog and mixed-signal products, through direct sales and regional distribution channels. Previously, he worked for an array of startup optical component firms, where he managed and directed worldwide sales. Tu received his BS degree in Electrical Engineering Technology from Old Dominion University in Norfolk Virginia.

[www.gigoptix.com](http://www.gigoptix.com)

## GigOptix demos 40G chipset in AOC for QSFP+ applications

At September's China International Optoelectronic Expo (CIOE) in Shenzhen, GigOptix showcased its 40Gb/s VCSEL driver and receiver array chipset for QSFP+ applications.

The firm gave a demonstration of its HXT/R5104 chipset, which is used in both 40GBASE-SR4 QSFP transceivers and 40GBASE-LR4 receiver optical sub-assemblies (ROSAs).

The HXT/R5 chipsets are designed to be fully compliant with the IEEE 40GBASE-LR4 standard, meeting the exacting receiver sensitivity and stressed-eye specifications in addition to the 40G QSFP+ form factor requirements. The individual VCSEL driver & receiver arrays are ultralow power, consuming less than 75mW/channel while fully implementing the driver and receive function of a 10km 40G link. The firm says the design minimizes the number of components required to implement the 40G receiver resulting in a lower cost and smaller form factor.

GigOptix also showcased the following products:

- LX8220: 40Gb/s DQPSK TFPS optical modulator with low drive voltage and small form factor, designed for long-haul and ultra-long-haul optical transponders;
- LX8240: 100Gb/s DP-QPSK TFPS optical modulator with ultra-small form factor and low driving voltage;
- GX62255: low-power, integrated dual-channel 32Gb/s driver designed for 40G DQPSK and 100G DP-QPSK long-haul optical transmitters;
- GX62472: a 4x32Gb/s Mach-Zehnder quad linear driver designed with integrated GPPO outputs for 100G and 400G DWDM metro and long-haul optical transmitters; and
- GX3222: a dual-channel linear transimpedance amplifier (TIA) designed for use in 100Gb/s DWDM optical receivers.

[www.gigoptix.com](http://www.gigoptix.com)

### GigOptix signs Altima as Japan distributor

GigOptix has signed Yokohama-based Altima Corp, a subsidiary of Macnica Group, to be its distributor of optical and RF/MMIC products throughout Japan. GigOptix says that the products are suited for the telecom, datacom and consumer markets, and align well with Altima's current line-card offerings.

"Altima has excellent technical expertise and deep customer relationships with Japanese and global customers," comments GigOptix's chairman & CEO Dr Avi Katz. "Altima's reputation for providing dedicated customer service and superior technical support to their Japanese electronics and IT customers will greatly enhance the penetration of GigOptix's revolutionary solutions into and for the Japanese market," he adds.

"This partnership will enable us to provide our customers with an enhanced and cost-effective portfolio of optical and RF solutions for their varied applications," says Altima's

**Altima has a long history of offering innovative and quality solutions to major Japanese customers...** president Akinobu Miyoshi. "Altima has a long history of offering innovative and quality solutions to major Japanese customers,

**GigOptix's technology and market focus closely aligns with Altima's expertise** and we believe that GigOptix's technology and market focus closely aligns with Altima's expertise."

[www.altima.co.jp/en](http://www.altima.co.jp/en)



## Court denies GigOptix's renewed motion for preliminary injunction against M/A-COM Tech and Optomai

The Superior Court of Santa Clara County, California has denied a renewed motion for a preliminary injunction sought by GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical components for optical fiber and wireless networks) against M/A-COM Technology Solutions Inc of Lowell, MA, USA (a supplier analog semiconductor solutions for RF, microwave, and millimeter-wave applications), its subsidiary Optomai Inc, and two of its employees who were formerly engineers at GigOptix, in relation to a lawsuit alleging misappropriation of confidential information and trade secrets.

This is the second time that the court has denied such a motion by GigOptix, this time following forensic and documentary discovery by the parties and the presentation of related arguments and expert testimony in a hearing on 13 September.

GigOptix originally filed its lawsuit in April 2011, concurrently with M/A-COM Tech announcing its acquisition of Optomai. In July 2011, GigOptix sought a temporary restraining order and thereafter an injunction, both of which were denied by the court.

GigOptix says that It is not necessary that such motions be filed in trade secret misappropriation cases, claiming that the court's denial of the request for an injunction does not have any impact on the strength of its case, since the court did not address the merits of its claims against the defendants. While the court did not provide its reasoning for denial of the motion, the court did say that: "[a] party seeking a preliminary injunction 'ordinarily is required to present evidence of the irreparable injury or interim harm that it will suffer if an injunction is not issued pending an adjudication

of the merits," notes GigOptix.

GigOptix says that it remains confident that it has strong evidence supporting its claim for misappropriation of trade secrets, and looks forward to putting the evidence regarding the conduct and actions of the defendants before a jury and judge in "an adjudication of the merits" at trial. A date for the trial has not yet been set.

"GigOptix's suit is a thinly veiled attempt to derail our legitimate success in the Optoelectronics market," comments M/A-COM Tech's VP & chief strategy officer Jihye Whang. "While the suit remains pending, we are pleased at this latest victory, will continue to defend ourselves vigorously against GigOptix's allegations, and remain focused on ramping production and serving our customers," he adds.

[www.gigoptix.com](http://www.gigoptix.com)

[www.macomtech.com](http://www.macomtech.com)

## M/A-COM Tech launches 100G TIAs & modulator drivers

At the European Conference on Optical Communications (ECOC) in Amsterdam, The Netherlands (17–19 September), M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) launched two transimpedance amplifiers (TIAs) for 100GbE ROSA and 100G DP-QPSK applications.

The MATA-002902 is a 28Gbps dual-channel limiting TIA suiting 100G Ethernet ROSA (28Gbps x 4) receivers. It operates from a +3.3V power supply and has a typical bandwidth of 21GHz. Available as a die, it features automatic DC offset compensation while the input current ranges from 0.05mA<sub>pp</sub> to 2.5mA<sub>pp</sub>.

The MATA-038032A is a dual-channel differential linear TIA with automatic gain control (AGC) for 100G DP-QPSK (32Gbps x4) receivers.

Each channel has differential input and output. The device offers both manual and automatic gain control modes. In manual mode the gain can be controlled from 200Ω to 5kΩ differential via an external pin. In automatic mode, the gain is automatically adjusted to provide a constant output voltage. The TIA provides a linear amplification for current levels from 0.1mA<sub>pp</sub> to 2mA<sub>pp</sub> differential and has adjustable bandwidth between 17 and 25GHz.

"M/A-COM Tech's goal is to have market-leading products for all 100G receiver applications," says business development manager Ray Moroney.

Also at ECOC, M/A-COM Tech launched two modulator drivers for 100G Ethernet applications.

Available in a 4.7mm x 6.5mm SMD package, the MAOM-002108 is a Mach-Zehnder (MZ) modulator driver operating up to 28Gbps. The

IC has low power consumption of 1.3W at 6V<sub>pp</sub> output, low RMS jitter, and typical rise and fall time of 11ps.

The MAOM-002204 is a quad-channel electro-absorption modulator (EAM) driver IC for 100GigE (25Gbps x 4) applications. Available in a 14mm x 8mm package, each port is driven with differential input signal that can range from 250mV<sub>pp</sub> to 500mV<sub>pp</sub> to provide an output that can be controlled from 1.0V<sub>pp</sub> to 2.5V<sub>pp</sub> for each channel. The modulator driver exhibits very low power consumption of 0.75W per channel at 2.5V<sub>pp</sub>, low RMS jitter, and a typical rise and fall time of 12.5ps.

"These products demonstrate M/A-COM Tech's commitment to becoming the leading supplier of modulator drivers to serve all client- and line-side 100G applications," says Vivek Rajgarhia, general manager of M/A-COM Tech's Optoelectronics business unit.

## GigOptix & CPqD demo 100G/200G DP-16QAM system

At the European Conference & Exhibition on Optical Communications (ECOC) in September, GigOptix Inc of San Jose, CA, USA — in partnership with Brazil-based CPqD, an independent institution focusing on information & communication technologies (ICTs) — showcased a full 100G/200G DP-16QAM system using its GX62472 100G driver and the CR-100B (a second-generation 25G coherent receiver from Picometrix, an Advanced Photonics Company).

GX62472 is a surface-mounted technology (SMT) Mach–Zehnder modulator (MZM) quad linear driver designed with integrated GPPO outputs for 100G, 200G and 400G DWDM metro and long-haul optical transmitters. Features include:

- Data rates up to 32Gbaud for use in 200G/400G quadrature amplitude modulation (QAM) applications;
- Coplanar differential inputs compatible with industry surface-mounted digital signal processors (DSPs);
- GPPO-connectorized outputs compatible with market-leading 100G DP-QPSK MZMs;
- Low-RMS jitter degradation with what is claimed to be excellent linearity; and
- Single-ended linear output up to 6V<sub>pp</sub>.

“Our ultimate objective is to collaborate on high-speed optical transmission advances with leading-edge component companies, maintaining our R&D efforts in the state-of-art optical communications field; collaborating for the present and future of the Brazilian photonics ecosystem,” says Dr Júlio César R.F. de Oliveira, manager of Optical Systems at CPqD Foundation. “We have partnered with GigOptix for this QAM system, as their linear driver was developed in such a close partnership with their Tier 1 customer for 100G and 400G applications... We look forward to continuing to work closely on more advancement for the communications market,” he adds.

“As our business strategy is always to look towards the horizon, at what’s next, our GX62472 exemplifies this strategy as it was designed and released during the beginning stages of system design and qualification for the advanced speed applications that it supports,” says GigOptix’s chief technology officer Andrea Betti-Berutto.

● Picometrix’s CR-100B receiver houses GigOptix’s GX3222B, a dual-channel 32Gbaud linear trans-

impedance amplifier (TIA) designed for use in 100G DWDM optical receivers. This silicon germanium (SiGe) TIA has adjustable bandwidth control enabling use in receiver modules in a number of fiber-optic transmission systems, such as current-generation 100G DP-QPSK optical systems in addition to future 400Gb/s optical systems.

Features of the GX3222B include: adjustable frequency range supporting 28Gbaud up to 32Gbaud; differential gain up to 5000Ω; 660mW low power consumption; and linear gain with over 30dB of dynamic range.

“Working closely with GigOptix on implementing the GX3222B into our CR-100B receiver, and utilizing it in a 200Gb/s DP-16QAM demonstration, lets us successfully showcase the broad applicability of our leading-edge 100G coherent receivers,” says Picometrix’s general manager & president Rob Risser.

“With the proven technology that this demonstration presents to the market, it stabilizes a vision for future 400G applications,” says Dr Raluca Dinu, VP & general manager of the GigOptix Optical Product Line.

[www.gigoptix.com](http://www.gigoptix.com)

[www.advancedphotonix.com](http://www.advancedphotonix.com)

## Padtec’s Civcom and CPqD unveil 100G multi-rate DP-QPSK coherent tunable transponder

Brazil-based CPqD, Padtec S/A of Campinas–Sao Paulo, Brazil (Latin America’s largest manufacturer of optical transmission systems) and its subsidiary Civcom of Petach Tikva, Israel (which makes 1–100Gb/s widely tunable optical transponders and transceivers) are marking the conclusion of their joint R&D program for a soon-to-be-launched 100Gbps DP-QPSK (dual-polarity quad phase-shift keying) multi-rate coherent tunable transponder.

Provided by Civcom (founded in 2000 and acquired by Padtec in 2008), the 100Gbps DP-QPSK will initially be integrated into the equip-

ment of Padtec and then, by early 2013, by GA for the global market.

“Our research goal was to create a new generation of optical communication systems for broadband networks while providing short time-to-market,” says Padtec’s president Jorge Salomão Pereira.

In November 2011, CPqD and Civcom announced their joint cooperation on 100G coherent technology. Under a year later, Civcom showcased the product at ECOC 2012.

The new 100G DP-QPSK coherent tunable transponder module is equipped with an advanced digital signal processing (DSP) unit that

eliminates the need for optical compensation in chromatic dispersion, and has what is claimed to be the lowest power consumption in the optical market.

“Civcom has one of the most advanced commercial coherent tunable transponder solution in the market today, with strong research, development and commercial deployment capabilities, mainly due to the support and joint research established with CPqD,” comments Civcom’s VP R&D Efraim Roif.

[www.civcom.com](http://www.civcom.com)

[www.cpqd.com.br/en](http://www.cpqd.com.br/en)

[www.padtec.com.br](http://www.padtec.com.br)



## JDSU highlights fiber-optic and 100G technology at ECOC

At the European Conference on Optical Communications (ECOC) in Amsterdam, The Netherlands (17–19 September), optoelectronic chip and module maker JDSU of Milpitas, CA, USA highlighted key fiber-optic and 100G technology.

Optical communications solutions from JDSU that were demonstrated or displayed included:

- Live tunable SFP+ interoperability demonstration — Now shipping to network equipment manufacturers (NEMs), the tunable SFP+ transceiver provides flexible network management in enterprise and metro networks. The demonstration showed how the tunable SFP+ operates with JDSU's dense wavelength-division multiplexing (DWDM) SFP+ transceiver that is currently being sampled by customers.
- 40–100G transmission components and modules — On display were modulators and receivers that are being shipped in volume to NEMs for high-speed networks that

operate at 40G and 100G data rates. JDSU now also offers custom solutions for 40G and 100G modules. In addition, the firm showed its complete suite of client-side modules, including the next generation of high-speed 40G QSFP+ and 100G CFP2/CFP4 form-factor products.

- TrueFlex portfolio — JDSU exhibited its new optical product suite, which includes the industry's first twin 1x20 wavelength-selective switch (WSS). TrueFlex products are being sampled by customers and being incorporated into functionally integrated line-card products to enable the next generation of self-aware networks. Related developments are also under way for the next generation of super transport blades.

- SP Pump Platform — To date, JDSU has delivered to NEMs more than 150,000 pump lasers, which are used to power erbium-doped fiber amplifiers (EDFAs), a critical

optical component that regenerates weakened network signals traveling long distances over optical networks. This milestone represents more than 1 billion hours of field deployment and a field reliability rate of <10 FIT.

At ECOC, JDSU also participated in two speaking sessions:

- 'WS8: Beyond 100G — Technology Options', Brandon Collings, JDSU's chief technology officer for Optical Communications, presented on a panel that focused on evaluation of technology options for beyond 100G transport solutions including related system requirements, subsystems, components and interconnections.
- 'CDC and Gridless ROADM Architectures and Their Enabling Devices', Peter Roorda, optical technology expert at JDSU, discussed WSS technology and JDSU's TrueFlex portfolio and how it will impact self-aware networks of the future.

[www.jdsu.com](http://www.jdsu.com)

## GigOptix demonstrates 100G TFPS Mach–Zehnder modulator co-packaged in TOSA

At ECOC 2012 in Amsterdam, The Netherlands (17–19 September), GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical components enabling high-speed end-to-end information streaming over optical fiber and wireless networks) announced the experimental demonstration of the first integrated single-channel 100Gb/s NRZ-OOK (on-off-keying) transmit optical subassemblies (TOSA) based on its proprietary TFPS modulator and hybrid integration of an indium phosphide laser diode and InP electronics.

Operation of the TOSA was confirmed through BER (bit-error rate) measurements as well as through eye-diagrams at 80–100Gb/s, adds the company.

The work was conducted as part of the POLYSYS EU program, a collaboration between National Technical University of Athens; III-V Lab; Fraunhofer Institute for Telecommunications; Linkra Srl; and GigOptix. POLYSYS The aims is to produce a hybridly integrated laser and modulator TOSA that uses GigOptix's TFPS electro-optical polymer technology to integrate four lanes of 100Gbps OOK lanes to ultimately implement 400Gbps solutions. The 100G TOSA is the first stage of the project.

According to GigOptix, 100G NRZ-OOK streams have the potential to revolutionize 100G, 400G, and 1T technology, due to advantages in the number of components, footprint, simplicity, power consumption and cost. Also the underlying

technology can define a new base for operating symbol rates, and be further combined with higher-order modulation formats for 400G and 1T systems.

"The significant challenges of co-packaging several optical components together with a TFPS modulator have been overcome to obtain these results," says Eric Miller, general manager of GigOptix, Bothell, USA. "This successful demonstration proves the TFPS technologies ease of integration and superior data rate performance in yet another novel application," he adds. "Looking forward, the TFPS technology poses no fundamental barriers to higher data rates to achieve 400G and 1T links."

[www.gigoptix.com](http://www.gigoptix.com)  
[www.ict-polysys.eu](http://www.ict-polysys.eu)

# Finisar launches 10km 100 Gigabit Ethernet CFP2 module

At the European Conference on Optical Communications (ECOC) in Amsterdam, The Netherlands (17–19 September), fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA showcased its new 10km 100GE CFP2 module, which is based on the CFP2 MSA (multi-source agreement) form factor (equivalent to the CFP MSA with 2x CFP faceplate density).

The firm says the high-density, hot-pluggable optical transceiver offers much reduced size compared with the first-generation CFP and is optimally designed for standards-compliant 100GBASE-LR4 and OTU4 applications. The module has power dissipation of less than 8W, enabled by its transmitter package based on 4x28Gb/s distributed feedback (DFB) lasers. It is also optically interoperable with Finisar's existing 10km 100 Gigabit Ethernet (100GE) CFP modules. Lower power dissipation is critical for high-port-count line-cards that will use the CFP2 form factor.

Finisar also demonstrated its new

WaveShaper 2000S Polarization Processor and WaveShaper 4000S Fourier Processor, which it says are particularly beneficial to researchers and developers of optical communication systems. They enable more thorough system testing as well as reduced development time for optical components and systems.

The WaveShaper 2000S Polarization Processor allows users to emulate spectrally varying polarization-dependent loss (PDL) and differential group delay (DGD) by controlling the signal amplitude and phase, depending on the polarization of the optical input signal. High spectral resolution also allows controllable emulation of polarization-dependent frequency shift (PDFS) for narrow-band filtering components such as cascaded wavelength-selective switches.

The Fourier processing capability is an additional function of the WaveShaper 4000S Multiport Optical Processor. This allows users to split an optical channel into multiple outputs and process these outputs

independently. For example, multi-channel discrete Fourier transform (DFT) demodulators with arbitrary channel spacing can be created by programming the WaveShaper software. Development times can be greatly reduced, says the firm, as the parameters of such devices can be optimized simply by reprogramming the WaveShaper.

"With the introduction of the new WaveShaper 2000S and the Fourier Processing capability of the WaveShaper 4000S, we are significantly expanding the WaveShaper family, in particular for developing coherent, phase-modulated and polarization-multiplexed systems and components," says Dr Simon Poole, director of New Business Ventures, Finisar Australia. "These exciting additions have been developed for customers needing to extend the unique spectral shaping and phase control of the WaveShaper instrument in applications of next-generation communication systems using advanced modulation formats."

[www.finisar.com](http://www.finisar.com)

## First densely packaged 2-slot ROADM line-card demonstrated

At ECOC, Finisar demonstrated the first densely packaged 2x1xN two-slot reconfigurable optical add-drop multiplexer (ROADM) line-card with Flexgrid capabilities.

The highly integrated line-card, to be used primarily for route and select architectures in core or metro telecom networks in order to boost system performance, features a high-port-count Flexgrid wavelength-selective switch (WSS) and a high-speed parallel scanning Flexgrid optical channel monitor (OCM).

Finisar adds that the ROADM line-card's compact design improves system performance and reduces overall power consumption, while allowing carriers to increase transmission faceplate density. ROADM line-card features include hitless channel expansion and contraction to accommodate changes in traffic

patterns, which may be initiated by the carrier, such as switching from a 100Gb/s data stream to a super-channel data stream.

"Finisar is continuing to focus on innovating superior telecom products based on Flexgrid technology, which will enable carrier networks to meet next-generation performance requirements in the years to come," says Glenn Wellbrock, director of Optical Transport, Network Architecture, and Design at Verizon.

Finisar's Liquid Crystal on Silicon (LCoS)-based Flexgrid technology provides dynamic control of slot center frequency at 6.25GHz resolution and slot width at 12.5GHz resolution within a WSS, the key element in a ROADM. Once deployed, channel plans are configurable 'on-the-fly', meaning

that channel bandwidths can be tuned to most efficiently carry future demand when it arises, says the firm. Using Finisar's Flexgrid Multiport OCM, the user is able to determine channel power based on a flexibly designed channel spectrum, without being constrained by a fixed spectrum.

"This demonstration is a testament to our Linecard Design Team's ability to package next-generation ROADM technologies into condensed configurations," says Massimo Di Blasio, Product Line director at Finisar. "Our designs enable OEM customers to offer more compact line-cards requiring fewer chassis slots than traditional approaches," he adds. "This results in more open slots for revenue-generating transceiver and transponder cards."



## Xyratex and Finisar demonstrate 12G SAS embedded optical interconnect within data-center subsystem

At the European Conference on Optical Communications (ECOC) in Amsterdam, The Netherlands, Finisar Corp of Sunnyvale, CA, USA and UK-based data storage technology provider Xyratex Ltd — along with HUBER+SUHNER, vario-optics and LSI Corp — gave a joint technology demonstration of embedded optical connectivity within a 12Gb/s-enabled data-storage enclosure, showing how optical links carry 12G SAS traffic between internal controllers via polymer optical waveguides.

Embedded optical interconnect solutions are designed to meet the growing demand in data capacity, bandwidth and accessibility in future cloud and enterprise data centres, and are expected to overcome the projected performance bottleneck in data-storage subsystems.

The demonstration leverages Finisar's board-mounted optical

assemblies (BOA), a new optics technology that is mounted on a board much like an IC and provides the lowest power and highest bandwidth density available in the industry, says the firm. The BOA is protocol agnostic and supports up to 24 lanes of SAS, PCIe, InfiniBand and Ethernet as well as proprietary protocols enabling an entirely new ecosystem of backplane applications, as well as high-speed interconnects for supercomputers, servers and switches.

"Finisar is pleased to collaborate with these partners to showcase our board-mounted optics technology for up to 28Gb/s," says Finisar's VP of marketing Rafik Ward. "With the ever-increasing demands for bandwidth in optical communications networks, we believe that our BOA technology provides the most innovative and practical solution available today," he says.

Xyratex's joint demonstration of a prototype OneStor enclosure took place in Finisar's booth at ECOC. The prototype exhibit focuses on how optical interconnects are implemented in SAS architectures and will showcase Xyratex's next-generation 12G SAS controllers, Finisar's optical engines, vario-optic's polymer waveguides, HUBER+SUHNER's optical backplane connectors, and LSI's 12G expander technologies.

"Xyratex believes that preparing for the cloud and exascale eras requires new innovation in storage platforms," says Xyratex's director of Architecture Alex Worrall. "Through working with Finisar and our other partners, we are able to demonstrate real-world applications and start to move these new technologies out of the lab and into actual solutions."

[www.xyratex.com](http://www.xyratex.com)

[www.finisar.com](http://www.finisar.com)

## Finisar's revenue falls 8% on last quarter

For its fiscal first-quarter 2013 (ended 29 July 2012), fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has reported revenue of \$220.5m, down 8.1% on \$239.9m last quarter, due mainly to the sluggish macro-economic conditions, especially in Europe, as well as the slowing of economic growth in China.

"Generally, telecom spending throughout the world has been soft," says executive chairman Jerry Rawls. "In addition, we had two fewer shipping days in the first quarter than in the previous quarter."

Sale of datacom products fell by 4.5%. Sales of telecom products fell by 13.6%.

On a non-GAAP basis, gross margin was 30.3%, down from 31.4% last quarter. Operating income almost halved from \$20.9m (operating margin of 8.7% of revenue)

to \$12m (5.4% of revenue). Earnings before interest, taxes, depreciation, and amortization (EBITDA) fell from \$34.2m to \$24.9m.

During the quarter, overall cash and cash equivalents fell from \$234.5m to \$220.4m. Finisar repaid the remaining outstanding debt balance of \$3.2m at its Ignis subsidiary. It also completed its acquisition of RED-C Optical Networks Inc (for \$23.7m in initial cash consideration), broadening its product lines, primarily for telecom applications, by adding key amplification technologies.

"These technologies are considered critical for ROADM line-cards and are increasingly important in cost-effectively extending the reach of transceivers and transponders, especially for 100Gb/s and 40Gb/s coherent transmission, and low-latency networks," says CEO Eitan Gertel.

"We expect that the integration of

RED-C technology into Finisar products will enable us to offer our customers a much higher level of product integration with increased cost effectiveness," he adds.

"During the quarter, we continued to ramp a significant number of new products for both the datacom and telecom markets," continues Gertel. "We expect these new products to help drive our future revenue growth and market share expansion," he adds.

"We expect revenue growth to resume in the second quarter," says Rawls. Fiscal Q2 revenue should be \$225–240m. "We expect to hold operating expenses relatively flat, excluding the impact of a full quarter of the RED-C acquisition," he adds. "Thus, we expect operating income will grow." Correspondingly, operating margin should rise to 5.7–7.2%.

[www.finisar.com](http://www.finisar.com)

# Oclaro demos 100G products and technologies at ECOC

Optical communications and laser component, module and subsystem maker Oclaro Inc of San Jose, CA, USA debuted new 100G products and technologies and was represented on several industry panels at the European Conference on Optical Communications (ECOC 2012) in Amsterdam, The Netherlands (17–20 September).

As the world's number 2 provider of optical components, modules and subsystems, Oclaro claims that it maintains one of the industry's broadest and most vertically integrated product lines, helping to meet the bandwidth demands of new and fast-growing applications such as social networking, video streaming, and cloud computing.

"Oclaro has been able to leverage decades of optical expertise to deliver a complete portfolio of 100G solutions that provide the perform-

ance, reliability, small form factor and low power consumption that customers need to deploy and interface with today's high-speed coherent networks," says Jim Haynes, president, Global Business. "We look forward to providing these solutions to our customers so they can win the volume 100G deployments planned for 2013."

Oclaro's portfolio of high-speed networking products transmit, receive, switch, and amplify light signals over fiber-optic networks to deliver a new range of high-speed services for the core optical network and the enterprise and data-center markets. As the 100Gbps market continues to heat up, Oclaro says customers can benefit from working with and relying on one supplier for their key optical components, modules, and sub-systems — enabling them to save significant

cost and development time and focus on product differentiation.

Oclaro executives presented on several panels at ECOC, including:

- Market Focus: Challenges and Solutions for Optical Networks at 100Gbps and Beyond. Speaker: chief commercial officer Yves LeMaitre.

- Workshop: WS07 Low-Cost Open Access to Photonic Integration Technology, 4th European Photonic Integration Forum. Speaker: Mike Wale, director Active Products Research, 'The Generic Foundry Model in Europe'.

- Paper Th.2.A.3, 'Blind Chromatic Dispersion Estimation Using a Spectrum of a Modulus Squared of the Transmitted Signal' by Edem Ibragimov, senior optical design engineer.

[www.ecocexhibition.com](http://www.ecocexhibition.com)

[www.oclaro.com](http://www.oclaro.com)

## Oclaro launches first 8-port flexible-grid optical channel monitor

At ECOC, Oclaro launched what it says is the industry's first 8-port flexible grid optical channel monitor.

The new integrated 8-port OCM is a compact single module designed to deliver the flexibility, speed and accuracy needed for the next-generation ROADM (reconfigurable optical add/drop multiplexer) architectures being implemented to support 100Gbps and higher-data-rate channels, says the firm. It can measure the channel power and frequency of eight DWDM fiber input ports and incorporates features such as port or channel dwelling and prioritization through advanced embedded intelligence and signal processing capabilities to provide greater control and optimization of ROADM line interface and add/drop routing cards.

To meet demand for higher bandwidth at lower per-bit transmission costs, service providers are switching to highly meshed network topologies with multi-degree colorless, directionless, contentionless

and flexible-grid ROADMs and coherent high-bit-rate transceivers. OCMs with embedded intelligence features are critical for these optical networks, because they not only provide accurate channel power and frequency measurements for channel control and system optimization, but they also enable monitoring of add/drop routing fidelity, validation and correct control of alien channels, as well as provide early-warning diagnostics with features such as port and channel dwelling.

The OCM provides this functionality and allows users to meet the demanding space and power requirements in the central office by replacing switch/single-port OCM combinations or multiple 4-port modules with a single OCM. This frees up valuable space on the line-card and enables users to add more functionality and product differentiation while retaining a small form factor. The OCM hence enables efficient use of the card

real estate while providing cost-effective monitoring for agile operation and control of ROADM nodes.

"Oclaro's new OCM represents a significant milestone towards the development of more intelligent optical networks that are capable of managing advanced future signal formats at 100Gbps and above," claims Richard Smart, general manager of Oclaro's Optical Networks Solutions business unit.

Key features of the OCM include:

- data-rate- and modulation-format agnostic;
- flexible-grid channel power measurement with start-stop frequency commands;
- dynamic port and channel prioritization capability;
- channel dwelling capability and embedded data processing;
- cost-effective multi-port monitoring;
- high-speed operation; and
- small form-factor.

The 8-port OCM is being sampled by customers, prior to volume production in first-half 2013.



## Second-generation CFP cuts power consumption by 30%; first-generation CFP2 100G transceiver cuts size by 50%

Optical communications and laser component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has announced a second-generation 100G CFP (Centum Gbit/s form-factor pluggable) transceiver and first-generation CFP2 100G transceiver for 10km transmission over standard single-mode fiber, as demonstrated at the European Conference on Optical Communications (ECOC 2012) in Amsterdam, The Netherlands (17–19 September).

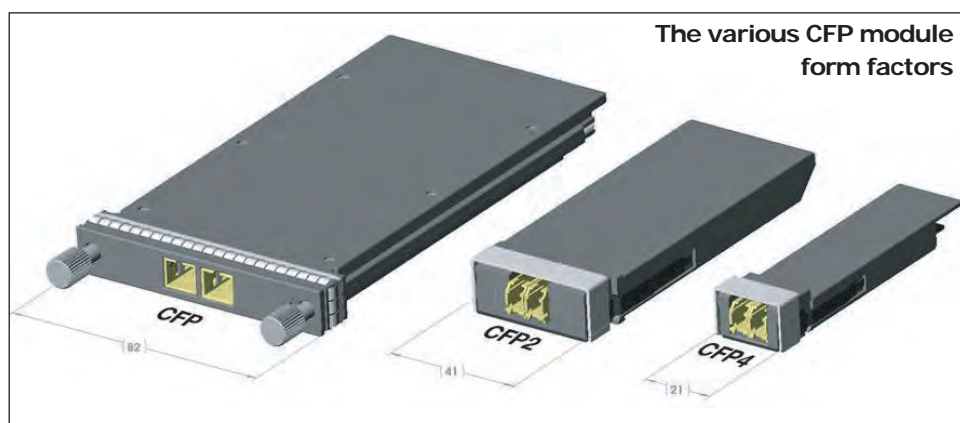
The new transceivers deliver significant reductions in power consumption and size and are the industry's first interoperable CFP and CFP2 solutions on the market, claims Oclaro.

They have also been designed specifically to meet the needs of higher-speed 100G networks for the core, metro, access, enterprise and data-center, where higher densities, lower power consumption and smaller size are key operator requirements for these next-generation network deployments.

Oclaro says that, leveraging its design, manufacturing and vertical integration strengths, the second-generation CFP delivers a 30% reduction in power consumption versus existing Oclaro CFP solutions and provides interoperability with the firm's earlier CFP products.

Likewise, the CFP2 (a new form factor recently specified by the CFP MSA) delivers a 50% reduction in size over all existing CFP solutions on the market and is the first CFP2 solution to be interoperable with a first-generation CFP product, the firm claims. Oclaro reckons that this interoperability is a major competitive advantage for users, as it allows a fast and cost effective transition to the smaller and lower-power designs without having to sacrifice their original investments in earlier CFP solutions.

"Customers can now deploy lower-cost CFP/CFP2 solutions that



pack backward-compatible interface and functionality onto lower-power consumption and smaller form factors," says Tadayuki Kanno, chief operating officer of Oclaro Japan Inc and general manager of Oclaro Inc's Modules & Devices business unit. "These solutions also offer the interoperability and standards-compliance that is required from the major telecom and datacom operators," he adds.

The explosive growth of the 100G optical transceiver market, which analyst firm Infonetics Research expects revenue to grow by 10x from 2010 to 2016, is being driven by a shift to coherent networking and data-center switching growth. However, while 100G networks deliver the bandwidth increases that consumers are demanding, they have posed challenges for customers and telecom operators who need to maintain competitive price/performance, low power consumption, interoperability with earlier solutions, and compatibility with the industry's newest standards. Oclaro says that, with its new CFP and CFP2 transceivers, it has leveraged its expertise in the core optical market with its history of delivering CFP products to achieve lower power and smaller size without sacrificing performance or interoperability.

● The second-generation CFP is fully compliant with IEEE 100G Ethernet 802.3ba 100GBASE-LR4 and ITU-T G.959.1 411-9D1F standards and

benefits from a CMOS gearbox IC that reduces power consumption and lowers cost relative to first-generation CFP designs. While first-generation CFP delivered 24W, the second-generation CFP delivers 16W. It utilizes more than 2 years of manufacturing experience of the first-generation CFP, and its in-house TOSA and ROSA technologies guarantee proven high quality and backward compatibility, says Oclaro.

● The CFP2 transceiver is Oclaro's first CFP2 design and is about 50% the size of all other CFP solutions on the market, increasing system front-panel port density from 4 to 8 ports. The smaller size is achieved by reducing the number of electrical lanes from 10 to 4 by applying a 25Gbps electrical interface per channel instead of 10Gbps and hence removing the GearBox from the module. More integrated in-house optical components are used, based on Oclaro's optical device technologies. Also, the CFP2 can optically interoperate with first- and second-generation CFP transceivers, allowing users to quickly and cost effectively transition to CFP2 designs as market requirements evolve. The CFP2 is also fully compliant with the MSA, IEEE and ITU-T specifications.

The second-generation CFP and CFP2 transceivers are currently sampling and are expected to be in volume production in early 2013.

[www.oclaro.com](http://www.oclaro.com)

# ClariPhy boosts 40G LightSpeed coherent SoC to 47Gbps to support FEC in Cortina's OTN processors for metro and regional networks

ClariPhy Communications Inc of Irvine, CA, a fabless developer of mixed-signal digital signal processing (MXSP) system-on-chip (SoC) ICs for coherent optical networks, has announced an optimized 40G coherent SoC for metro networks.

The advantages of dual-polarization QPSK (DP-QPSK) coherent technology — simplicity of deployment, dramatically increased fiber reach and capacity, and lower total cost of ownership — are well established in long-haul and submarine networks, and have been the key drivers for significant global deployment of ClariPhy's coherent solutions. Operators are now seeking to leverage these benefits in cost-efficient and scalable metro and regional networks, adds the firm. This requires a solution immune to cross phase modulation (XPM), which results from the interference of adjacent 10G channels onto 40G DP-QPSK wavelengths in a dense wavelength division multiplexing (DWDM) system and which limits the number of optical spans and reach achievable in metro coherent deployments.

ClariPhy has collaborated with optical transport network (OTN) solution provider Cortina Systems Inc of Sunnyvale, CA to solve the XPM problem and enable 40G coherent deployments in metro and regional networks. The solution comprises ClariPhy's CL4010 LightSpeed Coherent SoC, operating at an increased data rate of 47Gbps to support the advanced forward error correction (FEC) capabilities available in Cortina's CS604x and CS600x OTN processors. The combined solution improves optical signal-to-noise ratio (OSNR) sensitivity by up to 3dB. This, combined with the inherent capability of coherent transmission to deal with the polarization mode dispersion (PMD) present in legacy metro net-

works, increases the number of network spans and total reach by 50%. Carriers can now cost-effectively enable network links with up to 15 spans and at least 1200km reach, says ClariPhy. The solution also enables deployment of adjacent 40G and 10G wavelengths, without guard banding, allowing operators to maximize fiber capacity and reduce cost per bit.

The increased data rate of 47Gbps supports powerful FEC with a 13% overhead transporting four 10G Ethernet clients mapped into a standard ODU3e1 or ODU3e2 payload. If desired, even more powerful FEC schemes can be employed using Cortina's 20%- and 25%-overhead FEC codes. These codes can be used with ClariPhy's CL5018 LightSpeed Coherent SoC, which supports data rates of 47–50Gbps.

ClariPhy and Cortina says that they worked with a leading provider of metropolitan networking equipment to test the solution. The results are reported in the paper 'Use of High Gain FEC to Counteract XPM in Metro Networks Combining 40G Coherent DP-QPSK and 10G OOK Channels', presented at the IEEE Photonics Conference 2012 in Burlingame, CA, USA on 26 September.

ClariPhy's CL4010 LightSpeed Coherent SoC has been shipping since 2011 and is currently available in multi-source agreement (MSA) modules from partners such as Oclaro, NEC and JDSU. Cortina's 40G OTN processors have already been integrated into OEMs' metro platforms worldwide. Modules with ClariPhy's enhanced 47Gbps CL4010 will sample in September,

enabling OEMs and network operators to benefit from the synergies and economies of scale of a common coherent solution in long-haul, submarine and metro optical transport networks.

"Solving the cross-phase modulation was critical to adoption of coherent technology in metro networks," comments Cortina VP Arun Zarabi. "By working closely with ClariPhy to remove this significant barrier, we were able to fine tune the XPM-tolerant 47G coherent solution, thus enabling system manufacturers the ability to maximize fiber capacity and reduce cost per bit," he adds.

"The higher-bit-rate capability of the enhanced LightSpeed SoC from ClariPhy will help our customers to deploy 40G coherent line-cards more widely in metro networks, which are already carrying intensity-modulated wavelengths such as conventional 10G connections," says Richard Smart, Oclaro's senior VP & general manager of Optical Network Subsystems. "This feature enables network operators to introduce coherent technology more pervasively without having to build overlay networks," he adds.

"We are pleased to have removed the main obstacle facing operators in deploying 40G coherent over brownfield networks, where existing 10G traffic can interfere with 40G wavelengths," says ClariPhy's chief technology officer Norm Swenson. "Our strong ecosystem of module partners has allowed us to ship more coherent SoCs than all other merchant silicon suppliers combined," he claims. "We are now in a strong position to address the high-volume metro market with a cost-effective and smooth upgrade to 40G coherent technology."

[www.clariphy.com](http://www.clariphy.com)

[www.cortina-systems.com](http://www.cortina-systems.com)

[www.oclaro.com](http://www.oclaro.com)

**Solving the cross-phase modulation was critical to adoption of coherent technology**



## Oclaro and 3SPGroup establish MSA enabling smaller and more compact pump laser packaging

### 10-pin butterfly package to cut form factor by 70% over legacy 14-pin

Oclaro Inc of San Jose, CA, USA and 3SPGroup, which designs and manufactures optical components and modules for lasers, sensors and telecoms markets, have established a multi-source agreement (MSA) that defines a new industry-standard small form factor (SFF) pump laser package to enable the design of amplifiers in a compact 10-pin butterfly package about 30% the size of the legacy 14-pin format package.

The current standard for pump laser packaging is based on a 14-pin format that has changed little over the last 15 years. The new 10-pin package has the same pin-out, pin-pitch and front mounting hole centers, so it remains backwardly compatible with legacy applications. Electrical connections to laser, internal thermoelectric cooler (TEC), back facet monitor diode (BFM) and thermistor remain addressed to the same pin configuration. The MSA aims to provide assurance and

security of multi-vendor supply, aided by backward compatibility.

As firms driving the new MSA, Oclaro and 3SPGroup aim to enable their customers to develop compact amplifiers with lower costs and reduced space requirement in network equipment. Also, by offering compatibility with the MSA, Oclaro and 3SPGroup can ensure that next-generation pump lasers meet a defined and agreed mechanical outline, footprint and electrical pin-out (key to amplifier customers that must otherwise deal with many different formats and form factors from their pump vendors).

"Lower-cost and space-efficient optical amplification with potentially higher component density is critical to implementing complex network solutions," says Oclaro's director of product management Simon Loten. "Customers are looking for ways to reduce form factors and they also want to standardize on one format for all their needs —

whether that be cooled and uncooled pump products or multi chip devices," he adds. "We are pleased to deliver this innovative new format to our customers so that they can differentiate in the market with smaller and lower cost designs," Loten continues.

"We are excited to bring this new family of pump lasers (cooled or uncooled) that combine higher optical power into a small size into the market that will help our customers to evolve their next-generation network solutions," says 3SPGroup's chief technology officer Didier Sauvage. "This new product family complements our existing small size pump module offerings (MiniDIL)," he adds. "The industry is trending towards smaller form factors and, by establishing an MSA, customers now have a clear route and assurance that they will have multiple-vendor supply."

[www.oclaro.com/980PumpMSA](http://www.oclaro.com/980PumpMSA)  
<http://3spgroup.com/980PumpMSA>

## 100G PM-QPSK coherent MSA module to enter volume production

Oclaro's highly integrated 100Gbps PM-QPSK MSA transceiver module (OTM-100) entered volume production at the end of September.

The OTM-100 is an OIF-compliant 100Gbps PM-QPSK MSA transceiver module based on second-generation DSP coherent technology from NEL (part of NTT Electronics Corp). It enables network equipment vendors to cost-efficiently build high-performance 100Gbps metro, regional, long-haul, ultra-long-haul and submarine transport solutions. Using soft-decision forward error correction (SD-FEC) and advanced DSP algorithms, the module improves reach, minimizes or eliminates regeneration points, and simplifies network deployment rules, reducing infrastructure and operating costs, says the firm.

Recently, the OTM-100 demonstrated a record 3300km transmission distance on SURFnet's DWDM fiber infrastructure in Europe. Oclaro showcased the module at ECOC.

Highlighting growing momentum for volume deployment of 100G in optical networks, Oclaro has already shipped over 100 OTM-100 modules to customers worldwide for system integration and testing.

According to Infonetics Research, this market segment is projected to grow more than 10-fold in the next three years. High-bit-rate coherent solutions, such as the 100Gbps OTM-100 transceiver, offer capital as well as operational efficiencies through, for example, plug-and-play adaption to the fiber infrastructure characteristics and native transport of high-bit-rate signals.

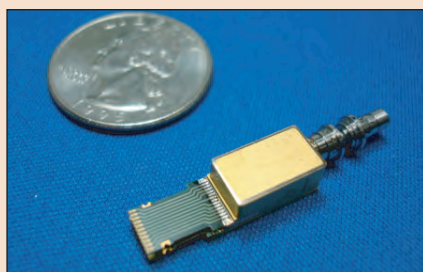
"The 100Gbps transceiver market has really heated up in 2012, with vendors delivering the price and performance that will enable 100Gbps networks to become a viable volume market opportunity," says Andrew Schmitt, directing analyst, Optical, at Infonetics. "We expect annual deployments of 100G wavelengths to at least double and possibly triple in 2013, and the component companies that are best positioned to drive this market are vertically integrated."

"The OTM-100 is a mature solution based on second-generation coherent DSP technology and delivers the performance, size and cost advantages needed for deploying 100Gbps wavelengths in volume," says Jim Haynes, president of Global Business at Oclaro.

## IN BRIEF

### Sumitomo Electric launches 4-channel ROSA with optical demultiplexer for 40Gb/s QSFP+ LR4

At ECOC 2012 in Amsterdam, The Netherlands, Tokyo-based Sumitomo Electric Industries Ltd (SEI) expanded its optical device portfolio by launching a 4-channel receiver optical sub-assembly (ROSA) with optical demultiplexer for 40Gb/s QSFP+ LR4.



QSFP+ is a compact transceiver emerging as the standard for 40GbE. Its technology for longer-reach single modes has many applications beyond 100m such as communication equipment used for data storage, networking devices for data centers, and enterprise networking where high-density power-saving systems are required.

The ROSA satisfies the IEEE 802.3ba requirements for the 40Gb/s optical receiver. The 40GbE performance is based on transmitting and receiving four different wavelengths at 10Gb/s. The compact ROSA includes four high-speed PIN photodiodes, four transimpedance amplifiers (TIAs), and an optical demultiplexer, which consists of specially designed low-insertion-loss filters and mirrors. The device supports extremely high receiver sensitivity of  $-16\text{dBm}$ , says SEI.

SEI says that, by applying this technology to higher-bit-rate devices, it will offer a 4-channel ROSA for 100GbE.

<http://global-sei.com>

## PIPE selects Infinera's DTN-X platform for 100G subsea network

Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), says that its DTN-X platform has been selected by TPG Telecom Ltd's subsidiary PIPE Networks Pty Ltd (one of Australia's premier telecoms carriers) for its submarine cable system PPC-1.

"Infinera's solution for the 100G market provides our network with unique benefits which led to our decision to select the DTN-X platform," says Lee Harper, head of Network Engineering for PIPE and the TPG Group. "The DTN-X platform's interoperability between our existing terrestrial and submarine networks, its ease of use when provisioning services along with the elimination of transponders at cable landing stations all led to our decision. We move a significant amount of data around the country, and deploying the DTN-X allows us to distribute reliable, high-capacity services with great simplicity and with industry-leading provisioning lead times."

PIPE is deploying FlexCoherent super-channels on PPC-1 with the Infinera DTN-X platform, offering international and Australian carriers increased speed and highly resilient services and marking the first deployment of optical super-channels in the Asia-Pacific region.

In addition to the submarine deployment, the DTN-X platform was also selected for the firm's terrestrial network, delivering 500Gb/s FlexCoherent super-channels to multiple, strategic data centers in Sydney. The platform supports 8T/b/s on a single fiber, which will significantly increase the capacity, scalability and resiliency of PIPE's metro fiber network in Sydney, says the firm.

The use of the DTN-X platform on PPC-1 opens PIPE up to significantly increased capacity on PPC-1,

delivering in excess of 3Tb/s. It will also allow PIPE to deploy Infinera's 100Gb/s coherent wavelengths using high-capacity super-channel transmission for the first time in the Asia-Pacific region.

FlexCoherent super-channels enable PIPE to optimize transmission performance across a range of applications using multiple software-programmable modulation formats, scaling network capacity for their customers without scaling operational expense.

PIPE is Infinera's first DTN-X super-channel deployment in the Asia-Pacific. "FlexCoherent super-channels simplify the deployment of 100G for both subsea and terrestrial applications while delivering scalability and efficiency," says CEO Tom Fallon.

One of the key factors in PIPE's selection of the Infinera DTN-X platform was the attraction of a solution based on PICs. Features of the DTN-X platform include:

- PICs that enable high-capacity wavelength-division multiplexing (WDM) to be integrated with 5Tb/s of optical transport network (OTN) switching without performance compromise;
- integrated non-blocking OTN switching that allows each wavelength to be efficiently utilized, resulting in fewer wavelengths for a set of service demands; and
- a reduction in capital and operating costs due to fewer fiber connections, less space and lower power consumption across the network, resulting in more cost-effective services for PIPE's customers.

Infinera adds that PIPE also benefits from a GMPLS control plane coupled with Bandwidth Virtualization, allowing its engineers to deploy its network in days and provision services across the submarine and terrestrial network within minutes to meet the rapidly changing demand of its customers.

[www.pipenetworks.com](http://www.pipenetworks.com)



## Source Photonics adds low-power 100GBASE-LR4 CFP transceiver to 40G and 100G portfolio

Optical communication component, module and subsystem maker Source Photonics Inc of Chatsworth, CA, USA has added a new low-power-consumption 100GBASE-LR4 CFP transceiver to its 40G and 100G transceiver product portfolio.

Targeting the growing bandwidth needs of telecom and data-center applications, the MSA-compliant CPL-A4-MR-LR-CLFB transceiver is designed to support 100 Gigabit Ethernet (100GbE) and OTU4 data traffic spanning distances of

up to 10km over single-mode fiber. The module integrates four EML lasers and PIN receivers. The maximum power consumption is compliant with CFP MSA power class 2, suiting low-power-consumption applications.

Source Photonics' 40G and 100G product portfolio includes a wide range of QSFP+ and CFP transceivers, including:

- the low-power SPQ-10E-LR-CDFx and SPQ-10E-SR-CDFx series 40G QSFP+ transceivers (which meet the growing bandwidth demands in

enterprise, data-center and access applications);

- the SPQ-10E-LR-CDFx and SPQ-10E-SR-CDFx series (which support transmission up to 10km over single-mode fiber and 300m over OM4 multi-mode fiber, respectively); and

- the CPC-44-MR-ER-CLFA 40G CFP transceiver (which extends the reach of 40GbE transmission to 40km, targeting metro and next-generation packet transport networks).

[www.sourcephotonics.com](http://www.sourcephotonics.com)

## Telefonica selects Infinera DTN-X platform for 100G SAM-1 submarine cable upgrade

Telefonica International Wholesale Services (TIWS, part of Telefonica Global Solutions) of Madrid, Spain and Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), have announced the international upgrade to TIWS' SAM-1 submarine Cable Network, connecting North and South America with Infinera's DTN-X platform.

TIWS has already been upgrading its submarine network throughout South America since 2009, using Infinera's DTN platform (which is based on 100Gb/s PICs and 40Gb/s coherent modulation).

The DTN-X can deliver 500Gb/s long-haul super-channels, enabling Telefonica to address growing bandwidth demands from millions of Internet users, mobile subscribers and business customers in South America.

TIWS designs and manages the international communications infrastructure of the Telefonica Group, offering an integrated voice, video and data network, with more than 100 points of presence distributed

across 60 cities and 40 countries. TIWS' network consists of more than 20,000km of diverse SAM-1 underwater cable. SAM-1 uses Infinera's family of products to carry traffic for more than 200 million customers, connecting South America with the USA, including landing stations in Brazil, Argentina, Chile, Peru, Ecuador, Guatemala, Colombia, Puerto Rico and Florida.

The DTN-X enables Telefonica to deploy 500Gb/s long-haul FlexCoherent super-channels integrated with 5Tb/s of optical transport network (OTN) switching per bay.

Infinera's FlexCoherent technology enables Telefonica to optimize transmission performance using multiple software-programmable modulation formats. By deploying FlexCoherent super-channels, Telefonica can scale network capacity without scaling operations. Integrated OTN switching, coupled with a GMPLS control plane, delivers a network with the highest wavelength flexibility and low cost of ownership, claims Infinera.

"Building our network with

Infinera's solutions has enabled us to seamlessly upgrade to higher data-rates and provision services quickly and easily," comments Telefonica Global Solutions' CEO Jose Ramon Vela. "Our investment in the DTN-X will enable us to scale into the future and continue to turn up services more quickly. Infinera's 500Gb/s long-haul super-channels allow us to continue delivering quality and reliability of service throughout our entire network, and allows us to extend the productive life of our submarine cable," he adds.

"The Infinera DTN-X platform gives Telefonica the flexibility to efficiently accommodate their network demands, allowing them to deploy 500G long-haul super-channels," says Infinera's CEO Tom Fallon.

"The DTN-X offers integrated DWDM transport and OTN switching without compromise, coupled with industry-leading 500G photonic integrated circuits, together enabling Telefonica to deploy services quickly to improve their competitive position in the marketplace," Fallon concludes.

[www.infinera.com](http://www.infinera.com)

# OPEL selling solar assets to Northern States Metals

OPEL Technologies Inc of Toronto, Ontario, Canada and its subsidiary OPEL Solar Inc, which makes high-concentration photovoltaic (HCPV) panels and solar tracker systems, have entered into an agreement involving the sale of most of its solar assets to Northern States Metals (NSM) of West Hartford, CT (which has manufacturing facilities in Youngstown, OH, USA and Toronto, Ontario, Canada).

In June OPEL appointed Peter Copetti as an executive board member and chair of a special committee established by the board of directors to diversify the firm out of the solar sector.

The deal is subject to NSM completing its due diligence review and execution of definitive legal documentation. Completion of a definitive agreement is conditional, among other things, upon the firm being able to enter into satisfactory repayment arrangements with its solar creditors. Completion is also conditional on OPEL being able to enter into satisfactory arrangements with certain of its employees and

consultants. Assuming that all conditions are satisfied, the transaction is expected to be completed in late September.

"It broadens our Solar FlexRack product line [a PV mounting system that came to market in 2009 and now has more than 350MW worth of systems installed in North America], and OPEL's Solar Tracker is perfect for the kind of utility-scale projects that we're now targeting," says NSM's president & CEO Tom Meola. "The OPEL Tracker technology is a proven system that is designed to increase the yield of a photovoltaic system by up to 30%. It eliminates inter-row shadowing, allowing for larger systems to be installed in a smaller area," he adds.

"Solar FlexRack has been successfully marketed as the mounting system with the fastest installation time, substantially lowering labor costs," Meola continues. "Likewise, the OPEL Solar Tracker is designed for efficient installation — a complete 10kW system can be assembled in less than four hours," he reckons.

"The OPEL Tracker acquisition fits well with the NSM mission to continually lower the balance of system costs for large solar projects," Meola comments.

"Completion of this sale will enable OPEL to achieve its objective, announced on 20 June, of divesting its Solar Division in order to focus on the POET platform technology of OPEL's ODIS [OPEL Defense Integrated Systems] Division [of Shelton, CT, USA]," says OPEL's president & CEO Leon Pierhal.

A core component of OPEL's strategy is to continue to develop the POET platform, which enables monolithic fabrication of gallium arsenide (GaAs) integrated circuits containing both electronic and optical elements on a single wafer. The technology has been developed over the past 18 years by chief scientist Dr Geoff Taylor and his team. The firm has 36 patents issued and 14 patents pending in both its PV systems and for its semiconductor POET process.

[www.extrusions.com](http://www.extrusions.com)

[www.opelsolar.com](http://www.opelsolar.com)

## Final \$1,44m tranche of \$3m financing completed, then \$1.2m added

OPEL has completed the final \$1,442,580 tranche of its \$3m financing via agent IBK Capital Corp.

Announced in mid-June, the private placement offering consisted of 13,043,479 units at \$0.23 each. Each unit consists of one common share and one common share pur-

chase warrant (allowing the holder to acquire one common share for a period of three years at an exercise price of \$0.35 per share). The securities issued are subject to a hold period that expires on 14 January.

Due to demand, OPEL has since completed a further financing, yield-

ing extra proceeds of \$1,234,870.

OPEL paid IBK a cash commission equal to 7% of the funds raised and 10% of the units sold in the form of broker warrants (each allowing the holder to acquire one common share at a price of \$0.23 for 48 months after the closing date).

## OPEL halves losses in Q2/2012, excluding solar business

For second-quarter 2012, OPEL Technologies Inc has reported a loss of \$4.4m (\$0.05 per share), more than doubling from \$2.1m (\$0.02 per share) a year ago.

However, this included a loss of \$3.5m (\$0.04 per share) due to the discontinued operations of OPEL's solar business. The firm identified \$1.5m in solar-related assets held for sale to a third party, as part of

its initiative to focus on the ODIS division and its POET process. Excluding this transaction, OPEL's loss on continuing operations, was halved year-on-year to \$1m (\$0.01 per share).

In Q2, the firm further reduced its R&D and G&A (general & administrative) expenses. Following a solar staff reduction in mid June, ODIS now makes up all of OPEL's R&D

expenses, since the US Government has cut back on funding to support to ODIS related projects.

"OPEL is implementing the core strategy to develop the POET platform," says president & CEO Leon M. Pierhal. "To achieve the POET focus as quickly as possible, OPEL will continue its aggressive expense reduction efforts," he adds.

[www.odisinc.com](http://www.odisinc.com)



## OPEL's AGM confirms strategy to focus on POET technology and divest solar division

OPEL Technologies Inc of Toronto, Ontario, Canada — which makes high-concentration photovoltaic (HCPV) panels and solar tracker systems through its subsidiary OPEL Solar Inc and develops III-V semiconductor devices and processes through US affiliate OPEL Defense Integrated Systems (ODIS Inc) of Shelton, CT — says that, at its annual general meeting (AGM), shareholders were updated on the firm's strategy (announced on 11 June) to focus on developing ODIS' Planar Optoelectronic Technology (POET) semiconductor platform.

POET enables monolithic fabrication of gallium arsenide integrated circuits containing both electronic and optical elements on a single wafer. The technology has been developed over the past 18 years by chief scientist Dr Geoff Taylor and his team.

In support of the strategic direction, two special committees were established by OPEL's board of directors. The first was to explore

the divestiture of OPEL's Solar Division to interested parties. The second committee's charter was to drive the monetization efforts of the POET platform technology. The AGM was held at the Nathan Hale Inn in Storrs, CT, USA so that a tour of the ODIS facility was available to reinforce the latter objective.

Also at the AGM, shareholders approved the election of the following nominees to OPEL's board of directors: Mark Benadiba, Peter Copetti, Chris Tsiofas, Dr Samuel Peralta, Leon M. Pierhal, and John F. O'Donnell. Shareholders also approved the re-appointment of Marcum LLP, Accountants & Advisors, of New Haven, CT, as auditors for the coming year.

A subsequent board meeting reappointed the following executive officers: executive chairman Mark Benadiba; president & CEO Leon M. Pierhal; treasurer & chief financial officer Michael McCoy; VP of engineering Dr Javier Berrios; VP of

administration, public & government relations Patricia Venneri Agudow; and corporate secretary Michel Lafrance.

Also following the AGM, directors granted incentive stock options to the newly elected director to purchase up to 500,000 common shares, representing 0.5% of the firm's outstanding voting shares. The stock options (which expire on 21 August 2017) are exercisable at a price per share of CA\$0.275 (the closing price on 20 August 2012).

There are 15,272,550 options outstanding and 100,461,813 voting shares outstanding. The options will vest and be exercisable on the basis of 25% on the date of grant and 25% every six months thereafter. They were granted subject to provisions of the stock option plan approved by shareholders at last year's AGM, and are subject to the TSX Venture Exchange policies and the applicable securities laws.

[www.opeltechinc.com](http://www.opeltechinc.com)

## Semprius begins commercial production as it opens its first solar module facility

### New facility to produce 33.9%-efficient modules

On 26 September, Semprius Inc of Durham, NC, USA, which designs and makes high-concentration photovoltaic (HCPV) solar modules, is officially opening its first production facility in Henderson, NC, USA. CEO Joe Carr, as well as North Carolina's Governor Bev Perdue and Representative James Crawford, will deliver remarks during the opening ceremony.

Using a proprietary manufacturing process, the new facility produces solar modules with what is claimed to be record efficiency of 33.9% efficiency, reckoned to be the first to convert more than one-third of the sun's energy into electricity. Developed with the support of the US Department of Energy's

National Renewable Energy Laboratory (NREL), Semprius' proprietary micro-transfer printing process enables the use of the world's smallest solar cell, about the size of a pencil point, to manufacture modules with performance and cost advantages. Compared with conventional silicon-based modules, the modules are twice as efficient, offer consistent energy output and superior energy yields while performing much better in hot climates, adds the firm.

"The highly anticipated opening of this new facility has significant implications for the future of renewable energy," says Carr. "We're very proud of our team and our public and private partners that

have helped us bring it in on time and on budget. With production ramped up, we will be able to effectively service our customers, including companies like Siemens and Pratt & Whitney Rocketdyne."

In the last 15 months, Semprius raised almost \$40m in funding from equity investors including ARCH Venture Partners, Illinois Ventures, Intersouth Partners, In-Q-Tel, Morgan Creek Capital Management and Siemens Venture Capital. In addition, the firm was awarded North Carolina and Vance County incentives totaling almost \$8m. Semprius says that it aims to hire more than 250 staff over the next few years.

[www.semprius.com](http://www.semprius.com)

## First Solar and PG&E sign contracts for 72MW of projects

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe) and provides engineering, procurement & construction (EPC) services, has signed power purchase agreements with Pacific Gas and Electric Company (PG&E) for 72MW<sub>AC</sub> of solar electricity, to be generated at two power plants that First Solar is developing in central California.

The 32MW Lost Hills project in Kern County and the 40MW Cuyama project in Santa Barbara County

are expected to create up to 600 jobs at peak construction. Project construction could start in 2013 as soon as the development process is complete, depending on plans of the project's eventual owners.

Together, Lost Hills and Cuyama will produce enough energy to power about 24,000 California homes, offsetting 45,000 metric tons of CO<sub>2</sub> annually (equivalent to taking 8900 cars off the road each year).

"We are very pleased to add these projects to PG&E's solar portfolio,

helping it and California reach their renewable energy goals," says Brian Kunz, First Solar's VP of project development. "Grid-friendly utility-scale power plants from First Solar are readily integrated into the electrical infrastructure."

The power purchase agreements — each with a delivery term beginning in 2019 — are subject to approval by the California Public Utilities Commission, whose decision is expected in first-half 2013.

[www.firstsolar.com](http://www.firstsolar.com)

## Constellation Energy and Maryland Governor dedicate 16.1MW grid-connected solar installation

As part of the state of Maryland's Generating Clean Horizons initiative, Baltimore-based Constellation Energy has announced completion of a 16.1MW<sub>DC</sub> grid-connected PV project (one of the state's largest solar installations) in Emmitsburg, MD.

"In just five years, we've put 530 times more solar on the grid, and we've put 2000 men and women to work in solar sector jobs," said Governor Martin O'Malley at a ribbon-cutting ceremony for the plant. "With partners like Constellation, we will continue to make investments in innovative technologies."

The ground-mounted solar power plant was constructed by First Solar using about 220,000 of its CdTe PV panels on 100 acres of land leased by Constellation from Mount St. Mary's University. Constellation financed, owns and operates the \$50m facility on behalf of its customer, the state of Maryland. Generated electricity is purchased by the state's Department of General Services and the University System of Maryland under 20-year solar power purchase agreements with Constellation. As well as the 16.1MW system, Constellation developed a 1.6MW system on the site to supply power directly to the university.

The grid-connected system is expected to produce more than



**Constellation Energy's 16.1MW grid-connected PV project in Emmitsburg.**

20 million kilowatt hours of electricity per year. Generating the same amount of electricity using non-renewable sources would result in the release of 17,981 metric tons of carbon dioxide annually, according to US Environmental Protection Agency (EPA) data.

"The solar farm presents an exciting learning and teaching opportunity for our students and for the local community, and places the Mount at the forefront in championing responsible land use and promoting renewable energy resources," says Mount St Mary's University president Thomas H. Powell.

In February 2009, the Maryland Energy Administration, in partnership with the University System of Maryland and the Department of General Services, approved the

award of four renewable energy projects under the Generating Clean Horizons program to spur the development of large-scale, commercial renewable energy projects. Under the initiative, the state issued requests for proposals for long-term power purchase agreements from renewable sources delivering clean power to the grid by 2014.

Constellation currently owns and operates more than 112MW of solar installations that have been completed or are under construction for commercial and government customers throughout the USA. In Maryland, Constellation has developed nearly 25MW of solar projects for customers, including Anne Arundel County, Coppin State University, General Motors, Maryland Science Center and McCormick & Company.

Constellation says that, by structuring its solar projects as power purchase agreements or solar services agreements, it offers solar installations that may require no upfront capital from customers and can provide fixed power costs that are less than projected market rates.

[www.constellation.com](http://www.constellation.com)

[www.exeloncorp.com](http://www.exeloncorp.com)

[www.firstsolar.com](http://www.firstsolar.com)



## Largest operational PV project achieves 250MW of grid-connected PV power

First Solar Inc of Tempe, AZ, USA says that the Agua Caliente solar project has achieved a peak generating capacity of 250MW<sub>AC</sub> connected to the electrical grid. The project, under construction in Yuma County, AZ, is currently the world's largest operating PV power plant, says the firm. When completed, it will have a generating capacity of 290MW<sub>AC</sub>.

Financed with support from a loan guarantee from the US Department of Energy's Loan Programs Office, construction began at the Agua Caliente site in the fall of 2010, and installation of First Solar's PV modules began in June 2011. First Solar is constructing the project using its thin-film PV modules, and will operate and maintain the facility for owners NRG Energy and MidAmerican Solar. Pacific Gas and Electric Company has a 25-year power pur-

chase agreement for the project's electrical output, which is projected to displace about 5.5 million metric tons of CO<sub>2</sub> over 25 years (equivalent to taking more than 40,000 cars off the road annually).

The project became commercially operational in January, generating 30MW of electricity for the grid. It surpassed 100MW of grid-connected power this spring and 200MW this summer. Construction (which is employing 400–450 workers daily) is expected to be completed on schedule in 2014.

The project has met all of its contractual milestones to date and exceeded targets for the speed, quality and safety of the construction process. As a result, First Solar says it has slowed the construction schedule in line with future contractual milestones and the scheduled

completion date. These adjustments have provided First Solar with increased flexibility to allocate its solar module supply to better serve increased demand in second-half 2012 across its portfolio of projects.

"The Agua Caliente project exemplifies how utility-grade solar PV power can be rapidly deployed in a phased approach and seamlessly integrated into the electrical grid," says Jim Tyler, VP of development engineering in First Solar's Engineering, Procurement and Construction Group. "We are extremely proud to set a new benchmark for the industry with Agua Caliente, which incorporates the knowledge gained over years of experience designing, building and operating utility-scale solar projects for leading utilities and energy providers."

[www.firstsolar.com](http://www.firstsolar.com)

## First Solar to supply modules for 25MW Rajasthan project

First Solar has concluded an agreement to supply its CdTe thin-film photovoltaic modules for a 25MW<sub>AC</sub> project in Rajasthan state developed by India's Green Infra Ltd. Green Infra has awarded the contract for engineering, procurement & construction (EPC) services to Germany-based renewable energy project developer juwi.

The project is part of the second batch of utility-scale solar projects concluded under India's Jawaharlal Nehru National Solar Mission, which aims to install 20,000MW of new solar electricity generating capacity by 2022.

"India is on the path of becoming one of the leading nations in the solar energy sector," says Sujoy Ghosh, First Solar's India country head. "Our latest project with Green Infra is a significant project under the National Solar Mission that will help India meet its energy security needs," he adds. "Large-scale solar photovoltaic power plants

are the key to achieving economies of scale and reducing the cost of solar electricity for everyone."

The project is expected to produce 46 million kilowatt hour units of electricity per year (equivalent to

the annual electricity needs of more than 19,000 average Indian households) and to displace more than 44,000 metric tons of CO<sub>2</sub> per year (based on national averages).

[www.firstsolar.com](http://www.firstsolar.com)

### First Solar installs 3.2kW PV demo system at Indian Solar Energy Center

Installation of a 3.2kW PV system has been completed at the Indian Ministry of New and Renewable Energy's Solar Energy Center (SEC) in Gwal Pahari, about 30 minutes outside New Delhi. Donated by First Solar, it will help the SEC to achieve its goal of 100% renewable energy consumption while demonstrating First Solar's technology.

The PV array will provide electricity to the SEC's offices, testing equipment and laboratories. The system also includes monitoring equipment to capture irradiance, climate and system performance data that can

be studied by experts at the SEC.

"We welcome the opportunity to demonstrate the performance characteristics and potential of First Solar's thin-film PV technology in India's climatic conditions," says Sujoy Ghosh, First Solar's India country head.

The PV array includes 40 of First Solar modules, the monitoring station designed by BEC Engineering, and an inverter by SMA. It is connected to a 440V mini-grid at the SEC.

[www.mnre.gov.in/centers/about-sec-2](http://www.mnre.gov.in/centers/about-sec-2)

# Ascent Solar raises \$10.1m in public offering

Ascent Solar Technologies Inc of Thornton, CO, USA, which manufactures lightweight thin-film photovoltaic modules based on copper indium gallium diselenide (CIGS) using flexible substrate materials, says that the under-written public offering of 9,166,700 shares of its common stock

(announced on 19 September) has been closed at a price of \$1.20 per share.

After deducting the underwriting discount and estimated offering expenses, Ascent received net proceeds of about \$10.1m. The firm has also granted the underwriters a 45-day option to purchase up to an

additional 1,375,005 shares to cover over-allotments, if any. Aegis Capital Corp acted as the sole book-running manager for the offering.

Ascent intends to use the net proceeds from the offering for working capital and for general corporate purposes.

[www.ascentsolar.com](http://www.ascentsolar.com)

# Manz's CIGS solar panels achieve record 14.6% efficiency

Manz AG of Reutlingen, Germany, which supplies integrated production lines for crystalline silicon solar cells and thin-film solar modules (as well as lines flat-panel displays), says that its CIGSfab integrated production line can manufacture copper indium gallium diselenide (CIGS) thin-film solar panels that supply power costing between 4 euro cents (Spain) and 8 euro cents (Germany) per kilowatt hour, depending on the location. According to Manz, this brings the cost of solar power in line with electricity produced from fossil power plants, and is less expensive than electricity from offshore wind parks.

Manufactured on a mass production line, Manz's CIGS solar panel achieve a total panel efficiency of 14.6% and an aperture efficiency of 15.9% (a record for thin-film solar panels, it is claimed). Previously, the record for total panel efficiency was held by First Solar, while the record for aperture efficiency was held by MiaSolé.

In addition, Manz says that its new record for thin-film solar panel efficiency now equals that of polycrystalline solar panels.

With its fully automated production line, Manz was able to cut the investment costs for a production line by about 40% during the previous two years. This was primarily made possible thanks to new developments related to the systems in the process, such as the CIGS co-evaporator, a significant increase in throughput, and the standardization of the equipment used.

**The thin-film panels manufactured on our systems are competitive everywhere in the world, and as a result, the solar market's growth will no longer be dependent on national subsidy conditions**

"The thin-film panels manufactured on our systems are competitive everywhere in the world, and as a result, the solar market's growth will no longer be dependent on national subsidy conditions," says founder & CEO Dieter Manz.

The manufacturing costs possible using a CIGSfab production line with an annual capacity of 200MW equal only \$0.55/Wp, and these costs fall to below \$0.40/Wp in factories producing in the gigawatts. In comparison, Chinese crystalline solar cell manufacturers' production costs are close to \$1/Wp on average.

Also, Manz says, CIGS technology is nowhere near its limit. Manz's exclusive development partner, the Baden-Württemberg Center for Solar Energy and Hydrogen Research (ZSW), has already achieved an efficiency of 20.3% in a laboratory. Out of all thin-film technologies, CIGS hence has the greatest potential for increased efficiency rates and lower costs, concludes the firm.

[www.manz.com](http://www.manz.com)

# TSMC's CIGS-based solar modules hit 14.2% efficiency

TSMC Solar Ltd, which was founded in May 2009 as a subsidiary of the world's biggest silicon wafer foundry Taiwan Semiconductor Manufacturing Co Inc (TSMC), says that it has manufactured 14.2%-efficient modules using its R&D and pilot production line at TSMC's highly automated manufacturing facility in Taichung, Taiwan. The panels have entered the

UL and IEC certification process, and should be available early in 2013.

TSMC adds that its production modules currently and consistently achieve 13% module efficiency, and that its TS CIGS Series product lineup has been upgraded to span 130–140W panels.

"These significant improvements achieved since entering pilot pro-

duction in March of this year demonstrate our ability to make rapid technology advancements," says TSMC Solar's president Ying-Chen Chao. "We are confident that our focus on technology improvement will enable us to continue driving efficiencies significantly higher for the next few years," he adds.

[www.tsmc-solar.com](http://www.tsmc-solar.com)



# Ascent's EnerPlex case available in North America and Korea now for iPhone, and soon for Samsung Galaxy S III

Ascent Solar Technologies Inc of Thornton, CO, USA, which makes CIGS-based photovoltaic modules using flexible substrate materials, has announced the retail debut of its EnerPlex solar-assisted battery case for Apple's iPhone 4 & 4S in North America via distributor CommXPerts at [www.iPhoneSolarCharger.com](http://www.iPhoneSolarCharger.com), and soon also via [www.amazon.com](http://www.amazon.com).

Ascent also announced its Korean debut via distributor H3P Co Ltd at [www.h3p.co.kr](http://www.h3p.co.kr), and several online retail stores such as Naver's 'Shop N' and E-Bay Korea's 'G-Market'.

Ascent is shipping EnerPlex chargers to customers and partners in Asia (beginning in third-quarter 2012) via strategic partners, including China-based TFG Radiant Investment Group Ltd.

Launched at June's Intersolar Europe 2012 trade show in Munich, Germany, the EnerPlex case takes advantage of Ascent's ultra-light, thin and flexible solar panels to enable iPhone 4 & 4S users to provide supplementary charging of



**Enerplex solar charger for iPhone.**

their iPhones with sunlight to extend the usage time.

Ascent says the EnerPlex case is uniquely enabled by the lightweight, thin and highly customizable form factor of its CIGS PV cells, allowing solar technology to be integrated into what is claimed to be the thinnest and lightest solar-enabled iPhone case on the market.

"Moving forward, we are eager to introduce a wide range of EnerPlex solutions for a variety of consumer products, including Apple's iPhone 5," says president & CEO Victor Lee.

In August, Ascent also launched an EnerPlex charger incorporated into

a case for the Samsung Galaxy S III smartphone. It is debuting in South Korea in October, with an expected launch in the USA in time for the 2012 holiday shopping season.

"With the launch of this second product in the EnerPlex line, Ascent now has a solar charger for two of the most popular smartphones on the market, the Apple iPhone and the Samsung Galaxy S III," says Lee.

Samsung continues to launch new products in a competitive market where the number of smartphones in use globally is expected to reach 1 billion in the next four years. Up to 144 million smartphones were sold globally in first-quarter 2012.

"Ascent's solar-powered case designs target the top two market share leaders, Apple Inc and Samsung, who together account for over 70% of the smartphone market," says Lee. "The growth of the smartphone market has been tremendous and is expected to continue for several years to come."

[www.ascentsolar.com/enerplex](http://www.ascentsolar.com/enerplex)

## Ascent partners with Silent Falcon and Bye Aerospace on drones

Ascent Solar is collaborating with Silent Falcon UAS Technologies of Albuquerque, NM, USA and Bye Aerospace, by providing lightweight CIGS photovoltaics for the Silent Falcon unmanned aerial system (UAS).

Founded in 2007 and based near Denver, Bye is applying clean energy to aircraft designs. Silent Falcon was founded in 2010 to introduce unmanned aerial vehicle (UAV) technology to global defense, intelligence and national security agencies, the domestic public safety agency market, and US-based private security contractors.

The Silent Falcon is a small tactical drone designed to be easily carried and used for longer-duration intelligence, surveillance and reconnaissance (ISR) missions. Unveiled at the Association for Unmanned

Vehicle Systems International (AUVERSI) conference in Las Vegas in August, the drone represents the synergy of several new technologies, including Ascent's flexible PV modules, to provide a near-silent, rapidly deployed platform. With three wing configurations for different mission profiles, each Silent Falcon system could represent up to 30 modules.

"There is a large and growing global military and public safety agency market for small or tactical unmanned aircraft systems," says Silent Falcon's CEO John W. Brown. "In these markets alone, sales exceeding several hundred units per year are possible. As their use in these markets proves their utility and functionality, and as the FAA [Federal Aviation Administration] rules for domestic commercial,

civilian use become more clear, we believe the market size and number of annual units sold could increase substantially," he adds.

"Our collaboration on Silent Falcon represents a key strength of our product, namely that its lightweight and flexible nature can address multiple markets, from consumer electronics to building integrated PV, and that our manufacturing process is sufficiently agile to support them simultaneously," says Ascent's president & CEO Victor Lee. "We see this emerging electric drone market expanding rapidly, with applications ranging from military to disaster relief with rapid deployment and recovery with little risk to human life."

[www.SilentFalconUAS.com](http://www.SilentFalconUAS.com)  
[www.ByeAerospace.com](http://www.ByeAerospace.com)

## PLANSEE presents molybdenum target with new inner-diameter coating

At the EU PVSEC trade event in Frankfurt, Germany (24–28 September), PLANSEE of Reutte, Austria (which makes refractory metals and composite materials including pressed-sintered crucibles made of tungsten and molybdenum) presented its upgraded rotary target.

Molybdenum sputtering targets are used to deposit the back contacts in copper indium gallium diselenide (CIGS) cells by magnetron sputtering. Monolithic rotary targets have no backing tube. They consist entirely of the thin-film material.

With these targets, CIGS manufacturers can increase sputtering performance and consequently achieve greater throughput, says the firm. The high level of material utilization also reduces the total cost of ownership in solar cell pro-



**Monolithic molybdenum target with inner-diameter coating.**

duction, it is claimed.

When monolithic targets are used, the molybdenum is in direct contact with the cooling water inside the sputtering equipment. Additional particular additives (inhibitors) must be used to condition the cool-

ing water for operation with monolithic targets, stabilizing the pH-value of the cooling water.

PLANSEE has developed a protective coating for the inner diameter (ID) wall of the target, making it easier to use monolithic targets. This polymer-based layer ensures that the molybdenum is no longer exposed directly to the cooling water, so

CIGS manufacturers do not need to use additional inhibitors and are therefore able to reduce costs. The ID coating does not noticeably impair the thermal conductivity of the rotary target, adds the firm.

[www.plansee.com](http://www.plansee.com)

## Smit Ovens surpasses 10 installations of in-line production systems for CIGS PV production

Smit Ovens of Eindhoven, The Netherlands has announced the installation of 10 in-line production systems for copper indium gallium diselenide (CIGS) applications at five customers worldwide. The systems cover selenium deposition and/or crystallization/annealing systems for the pilot and or mass production and development of thin-film CIGS photovoltaic cells that are produced using the two-step CIGS manufacturing process. Both roll-to-roll and sheet-to-sheet applications are served.

Smit Ovens claims that its in-line production system designs are proven to be more cost effective due to the output being double that of existing batch and in-line solutions. They also demonstrate high flexibility and repeatability in production, providing improved layer quality, high uptime and productivity, the firm adds.

Some systems are equipped with

active selenium reactors, linked to the crystallization/anneal reactor. The balance of the systems installed are configured for annealing of glass and flexible substrates. Control of the selenium pressure at different process steps is realized, offering overall process stability. For instance, output performance is less dependent on precursor parameters as the active selenium process is correcting for differences in pre-deposited selenium layer thicknesses.

"This milestone underscores the strong relationship we have with our customers, who aim to be leading players in the global CIGS cell market," says CEO Wiro Zijlmans. "Thermal processes are a key way to achieve competitiveness in this growing market. We are already seeing cell efficiencies of 15%. And, with advanced thermal processes, manufacturers can get close to production costs as low as €0.04 per

Watt for the selenization process, including the selenium contribution – a crucial threshold for creating a mass market for thin-film CIGS photovoltaics," he reckons.

"As a machine builder, Smit Ovens has extensive experience in high-precision thermal solutions for the solar energy industry, and we are eager to apply this know-how to new market areas such as CIGS," continues Zijlmans. "The Solliance Institute, which uses our R&D/pilot system, is a highly valuable technology partner with a vast knowledge of CIGS materials, processes and requirements," he adds. "The system at Solliance is available for Smit Ovens customers to use for verification and process development."

Smit Ovens exhibited at the 27th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC 2012) in Frankfurt, Germany (25–28 September).

[www.smitovens.nl](http://www.smitovens.nl)





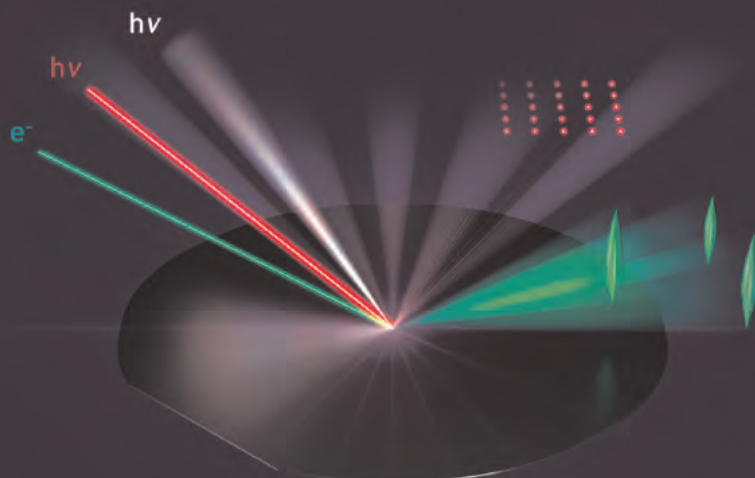
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## Control Your Process!

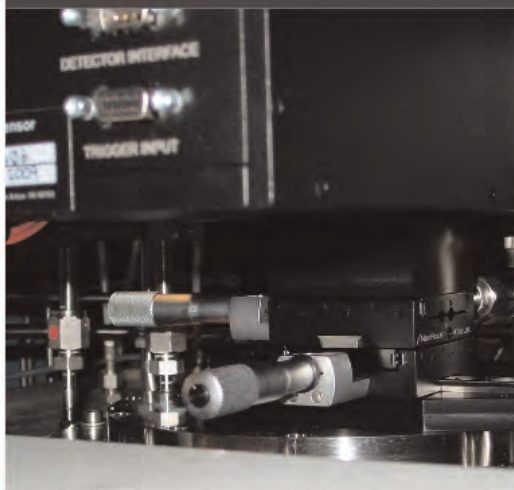
### Real-Time Process Monitoring for MOCVD, MBE, Sputtering, and Thin-Film PV Deposition



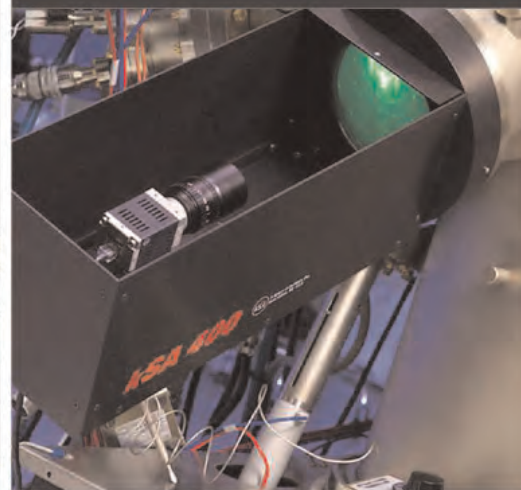
kSA BandiT Wafer Temperature



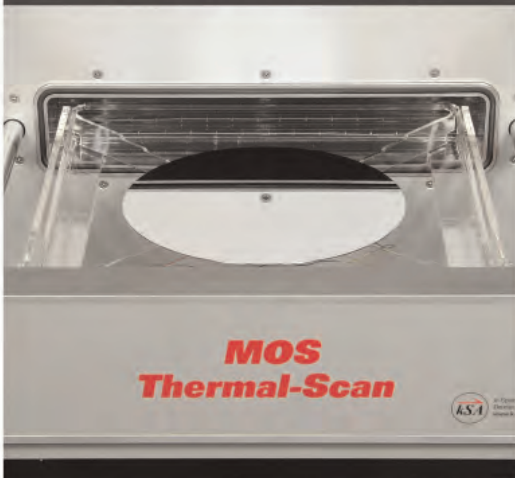
kSA MOS and kSA Mini-MOS Thin-Film Stress



kSA 400 Analytical RHEED



kSA MOS Ultra-Scan and Thermal-Scan Stress Mapping



kSA Rate Rat Pro Thickness & Deposition Rate



kSA BandiT PV Process Tuning





# Microdome p-GaN surface boosts nitride PV

**Taiwan team develops simple, mechanically robust process to create surface texturing.**

**T**aiwan-based researchers have boosted the energy conversion efficiency of nitride semiconductor solar cells (SCs) by 102% by texturing the p-type gallium nitride (p-GaN) contact layer with 'microdomes' [Cheng-Han Ho et al, Appl. Phys. Lett., vol101, p023902, 2012]. The collaborators were variously based at National Taiwan University, National Central University, and Ubilux Optoelectronics Corp.

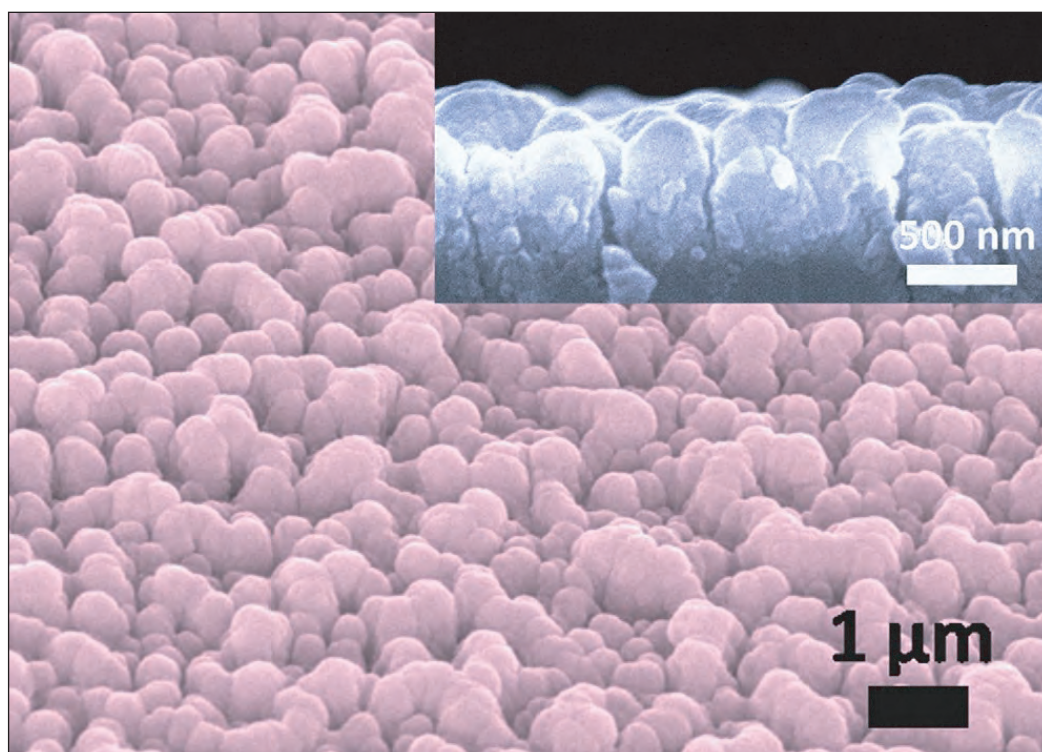
One effect of the microdomes is to reduce the amount of reflection at the surface of nitride semiconductor solar cells due to the large difference in refractive index ( $\sim 2.4$ ) with that of air (1). Such structures have previously been used by researchers at Lehigh University in the USA to improve extraction efficiency in light-emitting diodes.

The Taiwan researchers used a simple, mechanically robust process that textured the top surface of p-GaN on indium gallium nitride (InGaN) multi-quantum well (MQW) structures that convert light to electrons and holes.

The surface texture was controlled through the trimethyl-gallium flow rate and substrate temperature during epitaxial growth. A flat surface is achieved by a flow rate of 40–50  $\mu\text{mol/min}$  and temperature of 950–1100°C. Micro-roughened p-GaN (Figure 1) results from higher flow rates (more than 55  $\mu\text{mol/min}$ ) and lower temperature (less than 920°C).

The p-GaN microdomes were 530nm ( $\pm 250\text{nm}$ ) in height and 600nm ( $\pm 370\text{nm}$ ) in diameter. Specular reflection experiments on flat and microdome p-GaN showed a reduction in reflection of at least half in the 340–600nm wavelength range.

The surface texturing improves both short-circuit current ( $J_{sc}$ ) and fill-factor (FF, ratio of maximum



**Figure 1. 45°-tilted SEM image of MQW solar cells with p-GaN microdomes. Inset shows cross-sectional SEM image.**

obtainable power to product of short-circuit current and open-circuit voltage,  $V_{oc}$ ). These improvements (Table 1) give a conversion efficiency of 0.87%, which is a 102% increase compared with a conversion efficiency of 0.43% for a flat-surface device.

The low conversion efficiency is due to the cut-off wavelength for these devices ( $\sim 450\text{nm}$ ) being shorter than the peak of the incident solar spectrum ( $\sim 500\text{nm}$ ). The devices therefore miss out on the bulk of the energy contained in solar radiation. It is hoped that further development will lengthen the cut-off

**Table 1. PV characteristics of InGaN MQW solar cells with two kinds of surface structure.**

Surface structure	$J_{sc}$ ( $\text{mA/cm}^2$ )	$V_{oc}$ (V)	FF (%)	$\eta$ (%)
Flat	0.43	2.28	44.1	0.43
Microdomes	0.54	2.23	72.4	0.87



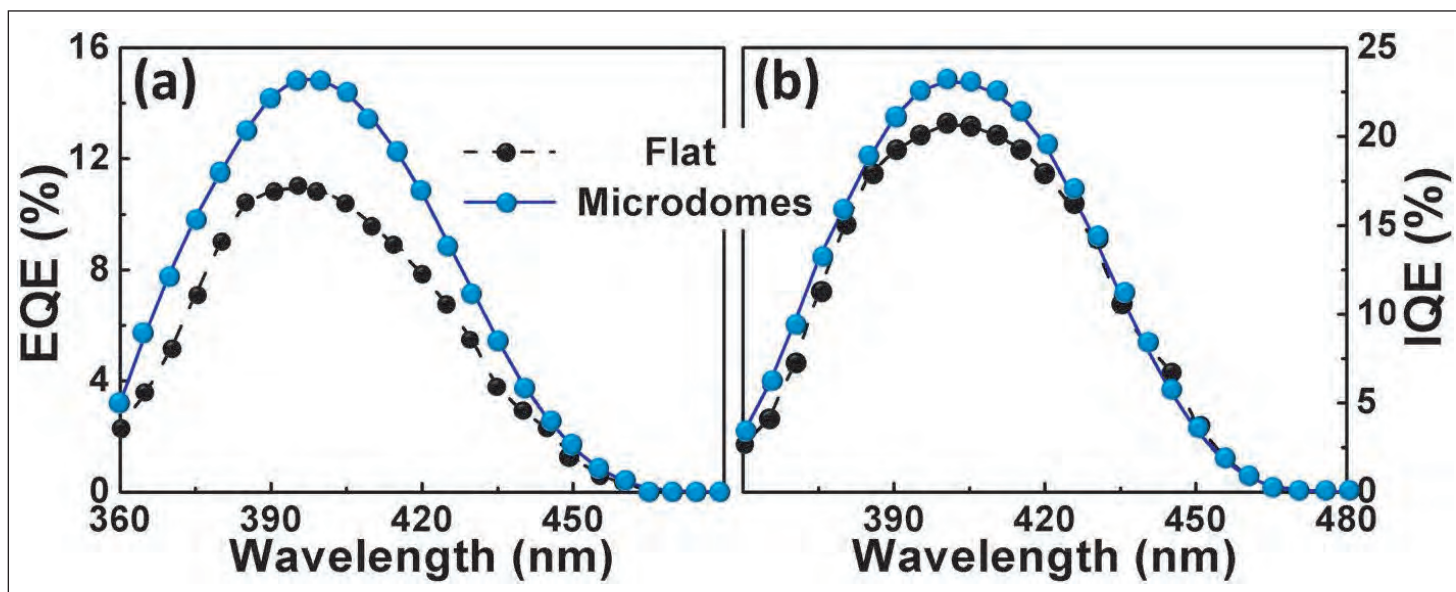


Figure 2. (a) EQE curves and (b) IQE curves for solar cells with two kinds of surface structure.

energy, enabling the use of such devices as part of multi-junction cells.

The fill-factor boost is thought to partly originate from strain reduction of the microdome layer leading to reduced piezoelectric fields in the device, alongside the suppressed reflection at the air/p-GaN interface. Reduced piezoelectric fields can improve photo-carrier separation/collection.

Spectral measurements of external (EQE) and internal (IQE) quantum efficiencies showed improvement from a microdome p-GaN layer falling in the range 360–450nm (Figure 2). The IQE improvement could originate in the lower piezoelectric field, but more detailed experiments are needed to correctly determine IQE, it is said. ■

<http://link.aip.org/link/doi/10.1063/1.4734380>

Author: Mike Cooke

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# Graphene-SiC transistor shows way to new ICs

**Prototype produces both normally-on and normally-off behavior with on/off ratio up to 12,000 at room temperature.**

**F**riedrich-Alexander University Erlangen-Nuremberg, Germany, and ACREO AB, Sweden, have developed a transistor technology combining graphene with silicon carbide (SiC) [S. Hertel et al, Nature Communications, published 17 July 2012].

Graphene is a remarkable material that scientists are keen to exploit, with properties such as extremely high mobility ( $\sim 10^6 \text{cm}^2/\text{V-s}$ ), high current stability ( $6 \text{mA}/\mu\text{m}$ ), and high temperature stability and thermal conductivity. While it has been fairly easy to induce metallic behavior in graphene, active switching/semiconductor properties have been more elusive.

The German/Swedish collaboration has rather used the semiconductor properties of the SiC substrate that they use to create graphene. The ohmic source-drain and Schottky contacts are formed from creating different interface properties between the SiC substrate and the graphene surface.

The process requires only a lithography step, allowing the creation of transistors, diodes, and resistors. Ultimately, the researchers hope to create a method for integrated circuits that contain only graphene interconnects.

"The material combination graphene on SiC thus combines two of the most robust materials for electronic applications we are aware of, and both materials are in intimate, epitaxially defined contact," the researchers say.

Transistors were created on 6H polytype SiC substrates ( $3.5^\circ$  off (0001) direction) with epitaxial  $3\mu\text{m}$  p-SiC and  $2.9\mu\text{m}$  n-SiC layers applied using CVD. The pn junction creates vertical confinement of the channel to the lightly n-doped top layer.

The ohmic contact monolayer graphene (MLG) was created using thermal decomposition of SiC at  $1650^\circ\text{C}$  in argon flux near room pressure. Device mesas were formed using reactive ion etch.

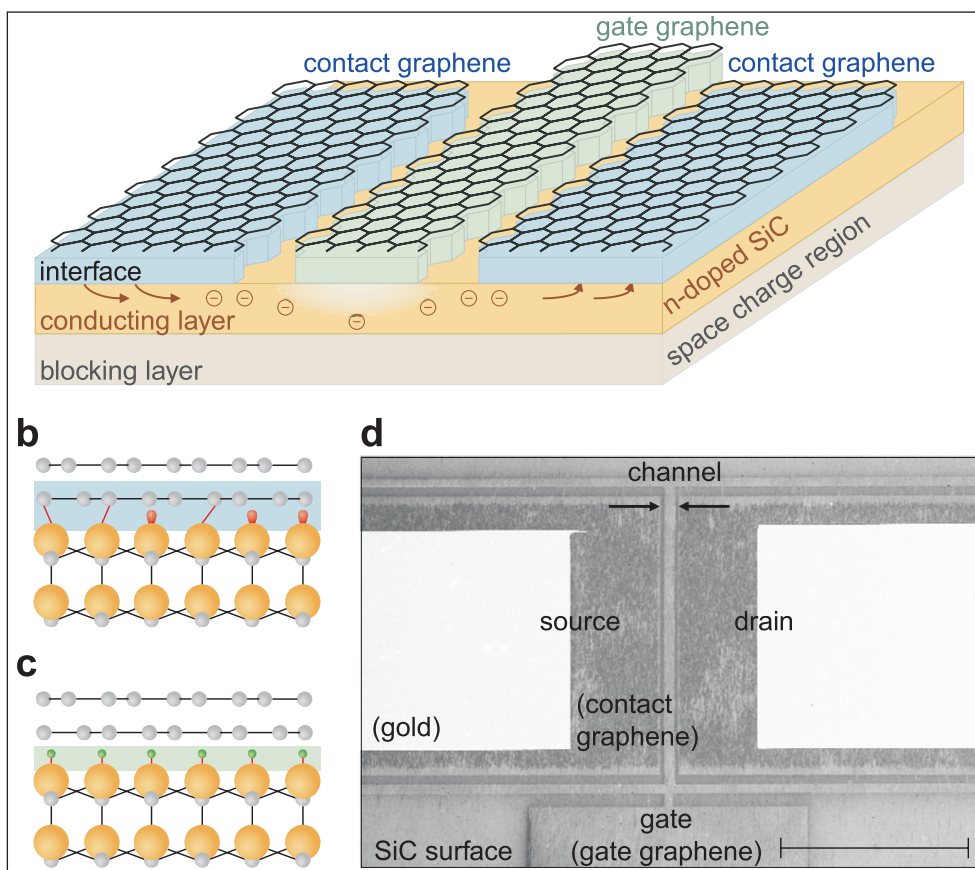
The gate structure is formed by converting the MLG to quasi-free-

standing bilayer graphene (QFBLG) by thermal annealing at  $540^\circ\text{C}$ , 880mbar for 90 minutes in hydrogen. Holes of 200nm diameter at  $0.5\mu\text{m}$  separation are created in the MLG beforehand to allow hydrogen into the regions where conversion is desired. The device structures were then patterned and etched.

Finally, the metal source-drain contacts of titanium/gold and Schottky gate contacts of nickel were applied. Also, a nickel contact was made to the p-SiC substrate layer to allow a back-gate control of the space-charge/channel thicknesses resulting from the pn junction.

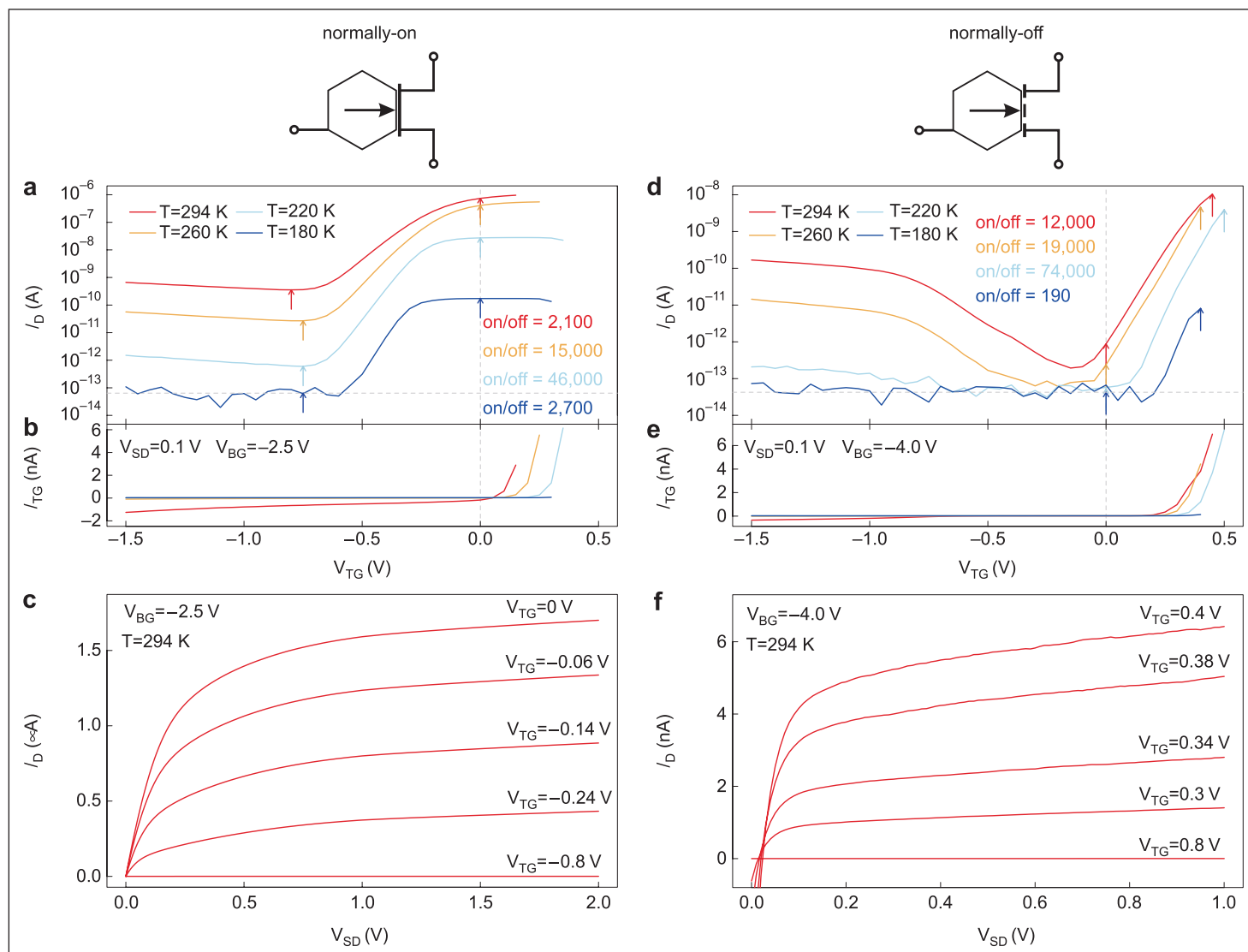
This is particularly useful for a prototype device, but would not be required in manufactured components when performance has been optimized in development.

Contact of MLG with n-SiC gives an electron density of  $10^{13}/\text{cm}^2$  and mobility of  $900 \text{cm}^2/\text{V-s}$ . The QFBLG



**Figure 1. Two different epitaxial graphene materials combined in a monolithic transistor: schematic (a); side views of ohmic contact graphene for source and drain (b), and Schottky-like gate graphene (c); electron micrograph showing the device geometry (d).**





**Figure 2. Electrical characterization of monolithic epitaxial graphene transistor. Transfer characteristics (a) and gate leakage currents (b) for various temperatures, and output characteristics (c) at room temperature in the normally-on operation mode. On/off ratios were determined between the current at 0V top-gate voltage and minimum drain current value (indicated by arrows). (d–f) Corresponding plots for normally-off operation.**

has a  $10^{13}/\text{cm}^2$  hole density and  $2000\text{cm}^2/\text{V}\cdot\text{s}$  mobility, giving a Schottky contact with the underlying n-SiC.

While the MLG contact gives ‘perfectly ohmic behavior’, unlike metal contacts on SiC, the QFBLG Schottky gate performance suffers from a spread of barrier heights and sample-to-sample fluctuations, indicating strong dependence on surface quality and therefore scope for improvements through better process control. Further, the contact resistance of the MLG can be improved from  $63\text{m}\Omega\cdot\text{cm}^2$  to  $6\mu\Omega\cdot\text{cm}^2$ , through  $10^{19}/\text{cm}^3$  nitrogen doping of the underlying lightly doped SiC (carrier density  $10^{15}/\text{cm}^3$ , mobility  $370\text{cm}^2/\text{V}\cdot\text{s}$ ).

The transistor could be put into normally-on or normally-off modes, depending on back-gate potential (Figure 2). Normally-on behavior was achieved for a back-gate bias of  $-2.5$  V. At room temperature (294 K), the on-off ratio was 2100 with a minimum drain current of  $0.36\text{nA}$  at a drain bias of  $0.1$  V. A back-gate bias of  $-4$  V gave normally-off behavior with the space-charge regions

of the unbiased graphene top-gate and of the pn junction back-gate meeting. Positive top-gate bias opened the channel, giving up to 12,000x on-current. A disadvantage was the forward-bias in the Schottky gate, leading to gate leakage. Better on/off performance in both modes could be achieved by lowering the temperature to 220 K.

The device’s large scale and the conductive substrate meant a modest frequency performance that showed no significant damping/phase shift or signal distortion up to 1 MHz, in line with theoretical expectations. A vanadium implant to give semi-insulating SiC in the transistor periphery could boost frequency cut-off by up to 30x. “The route for further speed improvements is obvious: optimization and shrinkage of the geometry, reduction of source, drain resistances, and so on,” the researchers add. ■

[www.nature.com/ncomms/journal/v3/n7/full/ncomms1955.html](http://www.nature.com/ncomms/journal/v3/n7/full/ncomms1955.html)

Author: Mike Cooke

# Enhancing compound semiconductor nanowire transistors on silicon

**Devices provide route to next-generation field-effect transistors.**

**R**esearchers at Hokkaido University and Japan Science and Technology Agency—PRESTO have reported surrounding-gate transistors (SGTs) using compound semiconductor core-multishell (CMS) nanowire (NW) channels on silicon that demonstrate greatly enhanced on-state current and transconductance while keeping good gate controllability [Katsuhiko Tomioka et al, *Nature*, published online 1 August 2012].

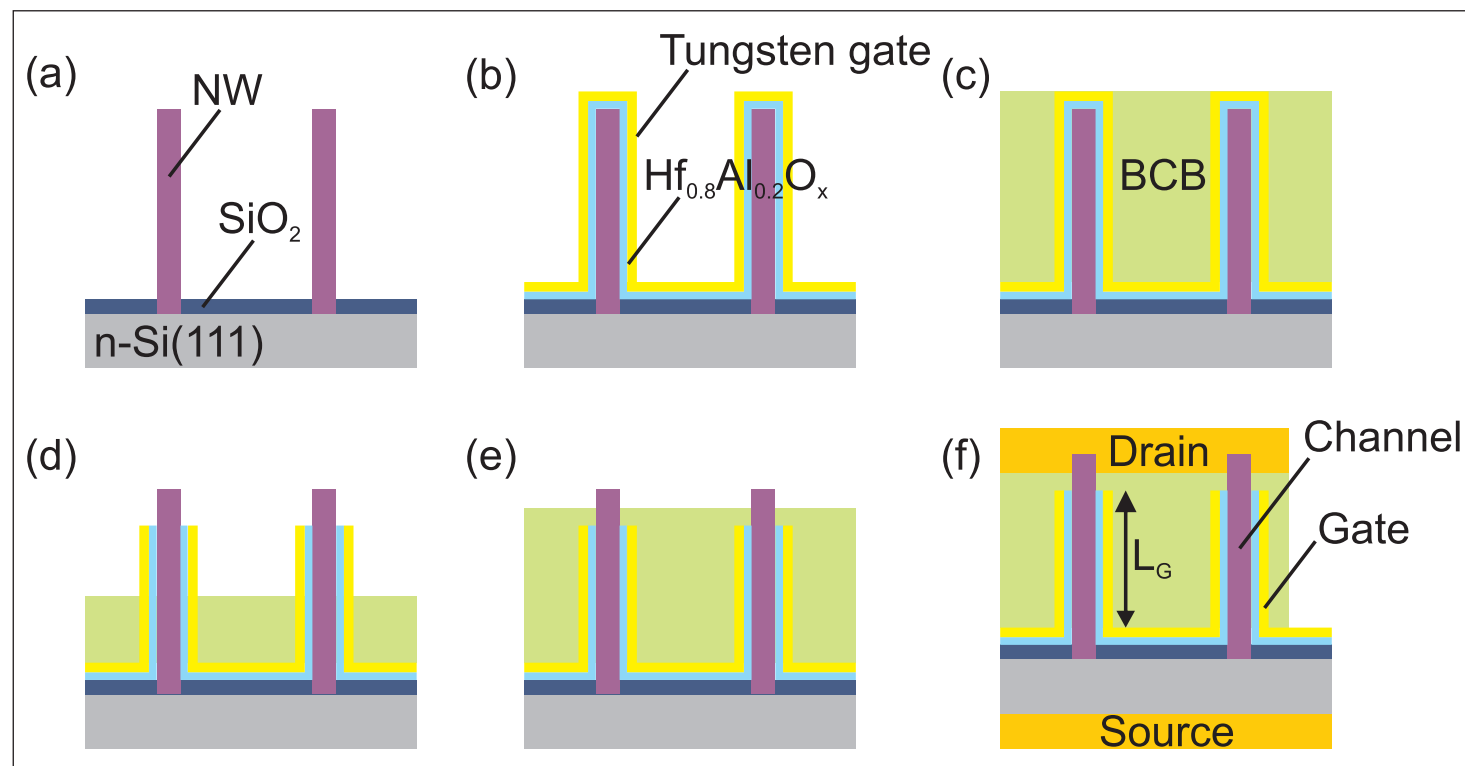
“These devices provide a route to making vertically oriented transistors for the next generation of field-effect transistors and may be useful as building blocks for wireless networks on silicon platforms,” they say.

The nanowires were grown vertically on Si(111) substrates using metal-organic chemical vapor deposition (MOCVD). The SGTs were constructed using atomic layer deposition (ALD) of hafnium aluminium oxide ( $\text{Hf}_{0.8}\text{Al}_{0.2}\text{O}_x$ ) dielectric, sputtering of tungsten gate metal, spin-coating

of benzocyclobutene (BCB), reactive ion etch-back (RIE) to define gate length, further spin-coating/RIE to isolate drain from gate metal. Further processing resulted in the deposition of source and drain contacts etc.

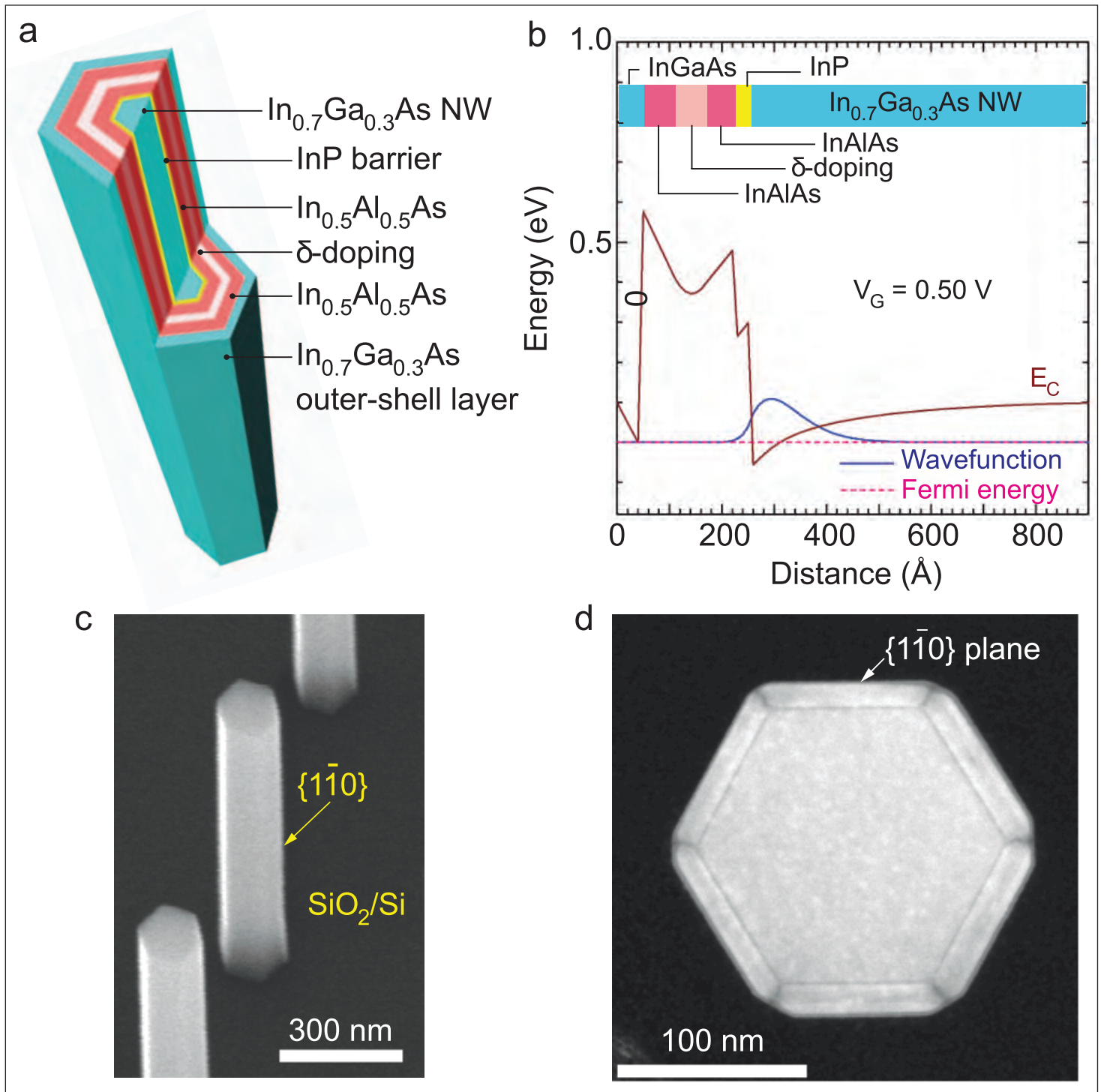
SGTs were formed from different types of nanowires. First, pure indium gallium arsenide (InGaAs) NW-SGTs were produced with an on/off current ratio of  $10^6$ , sub-threshold swing (SS) of 82mV/dec and drain-induced barrier lowering (DIBL) of 45mV/V.

Seeking improvement from this base, the researchers developed modulation-doped core-multishell (MD-CMS) nanowires consisting of layers of different compound semiconductor and doping applied to an InGaAs core using metal-organic sources (Figure 2). This raised the on/off ratio to  $10^8$ , lowered SS to 75mV/dec, and DIBL to 35mV/V (Figure 3). The maximum drain current was 0.45mA/ $\mu\text{m}$  and the peak transconductance was



**Figure 1. Device fabrication processes: (a) NW growth. (b) ALD of  $\text{HfAlO}_x$  and sputtering of W-gate metal. (c) Spin-coating of BCB polymer. (d) RIE of BCB, gate oxide and W metal. (e) Spin-coating of BCB and RIE etch-back for electrical separation layer formation. (f) Drain and source metal evaporation.**





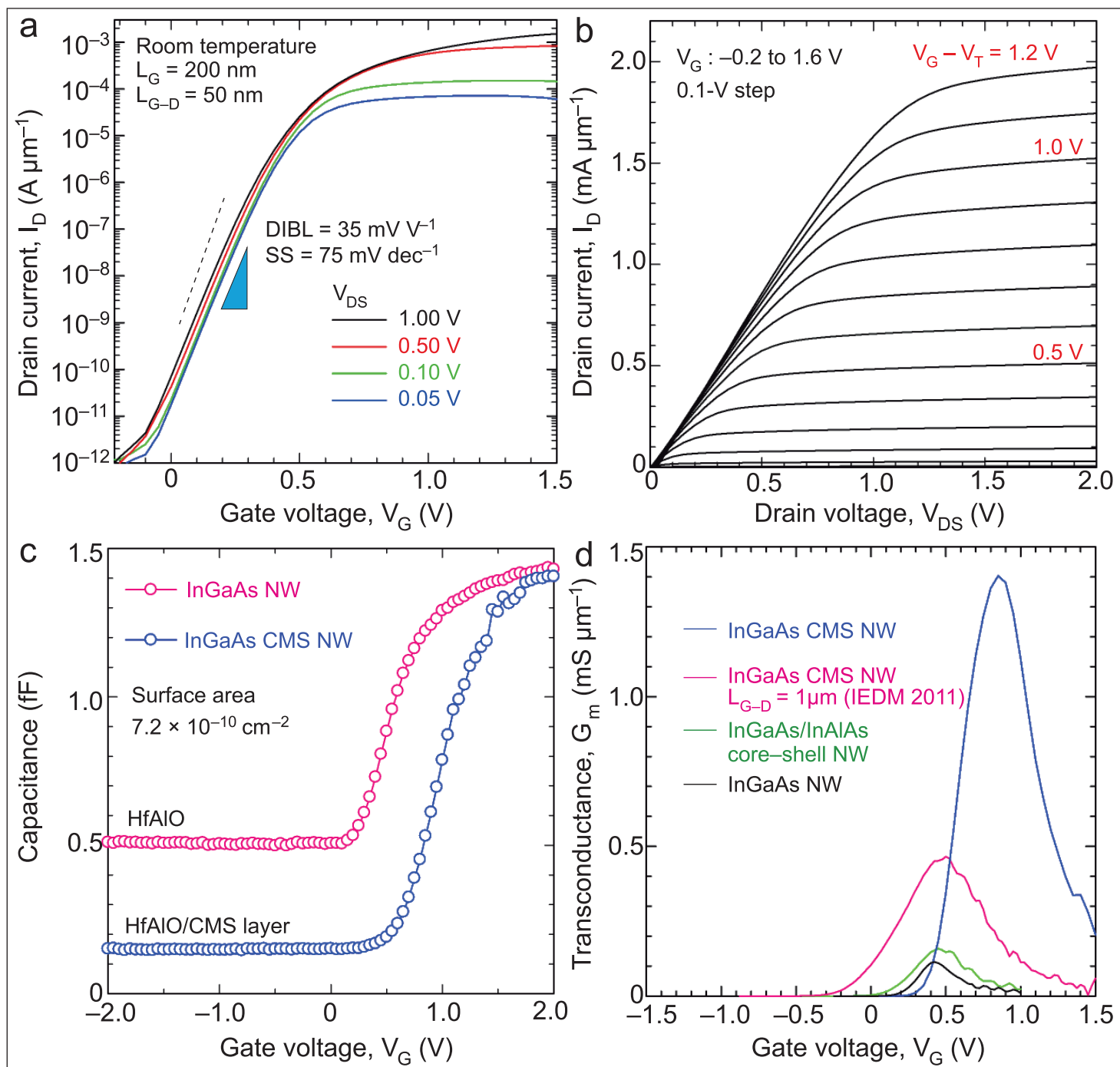
**Figure 2.** a, Schematic of indium gallium arsenide/indium phosphide/indium aluminum arsenide/indium gallium arsenide (InGaAs/InP/InAlAs/InGaAs) CMS nanowires on Si. The InAlAs layer is  $\delta$ -doped with Si. b, Simulated band diagram of the MD-CMS nanowire at 0.5V gate potential. Without gate bias, the carrier wavefunction is confined in the outer InGaAs shell layer. c, Typical SEM image showing vertical MD-CMS nanowires on Si. Average diameter and height of nanowires are 180nm and 1.2 $\mu$ m, respectively. d, Electron micrograph showing representative cross-section of a CMS nanowire with total diameter of 180nm.

1.42mS/ $\mu$ m with the gate 0.5V above threshold (0.38V) and the drain biased at 0.5V.

The researchers comment: "The very large increase in  $I_D$  and  $G_m$ , together with the steep SS, indicates that the CMS multilayers acted as a modulation-doped, high-electron-mobility structure while maintaining good controllability of the surrounding-gate structure.

These results are superior to those from devices made from similar materials and with similar dimensions."

In December 2011, the researchers presented InGaAs and multi-shell nanowire transistors with similar on/off ratios, but worse SS and DIBL values (97mV/dec, 160mV/V, respectively) at the International Electron Device Meeting last year (IEDM 2011,



**Figure 3.** Performance of SGT using InGaAs/InP/InAlAs/InGaAs CMS nanowire channels on Si. **a**, Transfer characteristics of SGT with gate length 200nm and gate-drain distance 50nm. SS is 75mV per decade; DIBL is 35mV/V. Dashed line: physical limit of SS (60mV per decade at room temperature). **b**, Output characteristics of InGaAs CMS nanowire SGT. **c**, Capacitance/gate voltage curve of InGaAs nanowire (pink circles) and InGaAs CMS nanowire (blue circles). Capacitances are measured values divided by number of nanowires (250 for InGaAs nanowires; 512 for InGaAs CMS nanowires). Measurement frequency is 1MHz. **d**, Transconductance of SGTs using InGaAs nanowires (black), InGaAs/InAlAs core-shell nanowires (green), MD-CMS nanowires with gate-drain distance of 1  $\mu m$  (pink; IEDM) and latest MD-CMS nanowires (blue). Drain bias 0.5V.

Semiconductor Today report, February 2012, p88). Also, the earlier devices had lower drain currents and transconductance.

More recently, the team presented tunneling field-effect transistors based on NWs at VLSI (Semiconductor Today report June/July 2012, p98). Due to the different device structure the SS values were as low as

21mV/dec with on/off ratios of  $10^6$ . The tunneling structure allows SS below the room-temperature theoretical minimum of 60mV/dec for more traditional structures, such as the SGTs presented here. ■

[www.nature.com/nature/journal/vaop/ncurrent/full/nature11293.html](http://www.nature.com/nature/journal/vaop/ncurrent/full/nature11293.html)

Author: Mike Cooke



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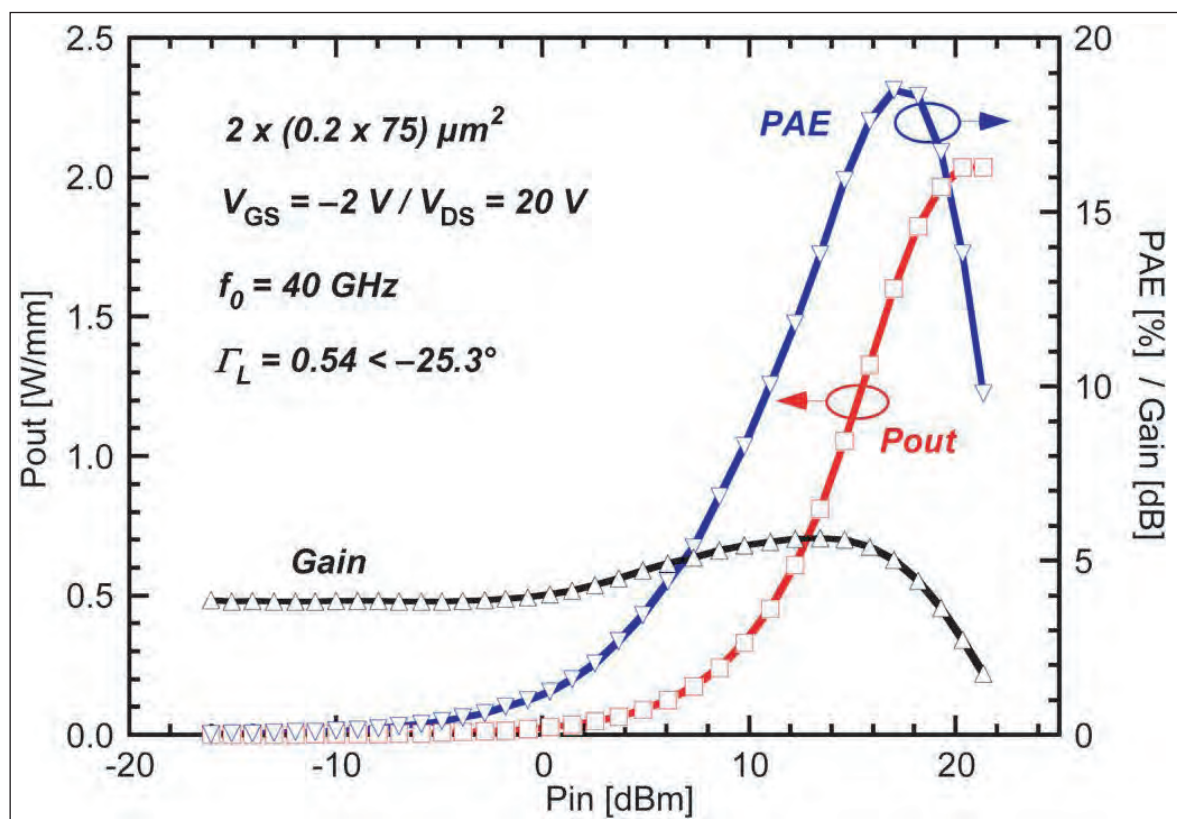
# GaN-on-Si large-signal performance beyond 40GHz

**Maximum output power density of 2W/mm with power-added efficiency up to 18.5%.**

**R**esearchers in Switzerland and the USA have reported the first large-signal performance for a gallium nitride on silicon (GaN-on-Si) high-electron-mobility transistors with output power density of 2W/mm and associated peak power-added efficiency (PAE) of 13.8% (peak 18.5%) at 40GHz without field plates [Diego Marti et al, IEEE Electron Device Letters, published online 9 August 2012]. The researchers also claim the highest cut-off frequencies to date for fully passivated AlGaIn/GaN HEMTs on silicon substrates.

Four of the researchers are with the Millimeter-Wave Electronics Group, ETH Zürich, and one other is with Nitronex Corp, the supplier of the nitride semiconductor on silicon layers. The substrate was 100mm float-zone refined Si (111) that had a high resistivity (10kΩ-cm). The layers consisted of: a nucleation/transition layer, a 1.7μm GaN buffer, a 1nm aluminium nitride (AlN) spacer, a 17.5nm AlGaIn barrier, and a 2nm GaN cap. This resulted in a material with improved mobility of 1500cm<sup>2</sup>/V-s and a crack-free surface.

The transistors were formed with 850°C annealed titanium/aluminium/molybdenum/gold ohmic source-drain contacts, mesa isolation, a recessed nickel/platinum/gold T-gate (200nm high, 500nm wide) in the center of the source-drain gap, 75nm silicon nitride passivation, and titanium/gold contact pads.



**Figure 1. Power sweep of 200nm-gate HEMT at 40GHz at bias conditions of -2V gate and 20V drain. The device showed a maximum output power of 2.05W/mm and a peak PAE of 18.5%.**

A range of HEMTs were produced (Table 1). For example, a HEMT with a 100nm gate length in a 1μm source-drain gap had a maximum drain current of 1.05A/mm at 2V gate potential and a maximum transconductance of 540mS/mm (for drain bias of 5V and gate potential of -0.5V). The Schottky gate diode leakage was 300μA/mm at -5V gate voltage. The gate-drain breakdown (1mA/mm) occurred at 29V.

Pulsed measurement to assess current-collapse/gate-lag effects showed little dispersion, indicating low-damage impact from the processing despite the deep recessing used. The researchers comment: "The drain lag is moderate and can be attributed to the surface SiN passivation as well as the improved channel confinement associated with the AlN spacer."

Small- and large-signal radio frequency measurements (0.2–40.2GHz) were carried out. The small-signal investigations of a 75nm gate-length device resulted



(1) MEASURED AT PEAK $f_T$ BIAS; (2) MEASURED AT $V_{DS} = 10$ V; (3) MEASURED AT $V_{DS} = 15$ V; (4) MEASURED AT $V_{DS} = 20$ V. UNDERLINING MARKS BEST OBTAINED VALUES IN EACH COLUMN					
$L_G$ (nm)	SD ( $\mu\text{m}$ )	$f_T/f_{MAX}$ (GHz) (1)	$f_T/f_{MAX}$ (GHz) (2)	Max( $P_{out}$ ):PAE (W/mm : %)	Max(PAE): $P_{out}$ (% : W/mm)
75	1	<u>152/148</u>	88/ <u>158</u>	1.00 : 5.3 (3)	14.3 : 0.70 (2)
75	2	137/132	75/117	1.30 : 8.0 (3)	14.6 : 0.85 (2)
100	1	121/146	95/145	1.56 : 12.9 (3)	<u>25.0</u> : 0.75 (2)
100	2	122/134	<u>96</u> /133	1.38 : 7.8 (2)	23.7 : 0.90 (2)
100	4	110/75	93/132	0.95 : 1.3 (4)	6.0 : 0.55 (4)
200	1	45/48	63/104	1.60 : 5.0 (4)	19.0 : 0.95 (2)
200	2	75/118	60/118	<u>2.05</u> : 13.8 (4)	18.5 : 1.80 (4)
200	4	70/110	57/109	1.55 : 6.5 (4)	22.8 : 0.85 (2)

Table 1. Large- and small-signal parameters.

in cut-off frequencies ( $f_T$ ) of 125GHz and maximum oscillation ( $f_{max}$ ) of 145GHz before de-embedding.

Making de-embedding corrections at a drain bias of 2.6V and gate bias of -0.5V, using extrapolations of Mason's unilateral gain parameter, gave  $f_T$  of 152GHz and  $f_{max(U)}$  of 149GHz. The researchers comment: "This  $f_T$  is the highest value ever reported for any GaN HEMT on silicon, exceeding the previous record established using AlInN/GaN HEMTs, providing a 42% improvement with respect to our previous 75nm AlGaN/GaN-on-Si devices."

The corresponding results for a gate length of 100nm were an  $f_T$  of 120GHz and  $f_{max(U)}$  of 140GHz (3V drain, -0.4V gate).

The frequency performance is also maintained at the drain biases needed for large-signal operation. The devices were tested at 40GHz in a set-up with a nonlinear vector network analyzer (Agilent PNA-X NVNA) source and load-pull. A 200nm gate-length device with 2 $\mu\text{m}$  source-drain gap had maximum power output density of 2.05W/mm and corresponding power-added

efficiency (PAE) of 13.8%. At a lower power output density of 1.8W/mm the PAE peaked at 18.5% (Figure 1). The gate leakage was 0.3mA/mm during operation.

In general, the longer gates give better large-signal performance (Table 1). "The results confirm GaN-on-Si technology as a promising contender for low-cost millimeter-wave power electronic applications," the researchers write.

Although better performance can be obtained on much more expensive silicon carbide substrates, there is much interest in GaN-on-Si for wider application in high-frequency high-power electronics. According to the researchers, there have been no reports of large signal for GaN-on-Si beyond 20GHz until now. However, low-noise performance has been reported in recent weeks (see [www.semiconductor-today.com/news\\_items/2012/AUG/1EMN\\_090812.html](http://www.semiconductor-today.com/news_items/2012/AUG/1EMN_090812.html)). ■

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6264085>  
[www.nitronex.com](http://www.nitronex.com)

Author: Mike Cooke

# Reducing noise at high frequency in nitride-on-silicon transistors

**France's IEMN reports transistors promising cost-effective ultra-robust low-noise amplifiers for next-generation communication networks.**

France's Institute of Electronic, Microelectronic and Nanotechnology (IEMN) has produced the first benchmark for low-noise gallium nitride on silicon transistors in the  $K_A$  band (26.5–40GHz) [F. Medjdoub et al, IEEE Electron Device Letters, published online 26 July 2012]. "To the best of our knowledge, this low noise performance is the best reported so far for any GaN-based transistors at such high frequency of operation," they say.

Possible applications of  $K_A$ -band millimeter-wave (mmW) technology include broadband radio links for cellular base-station networking, local multipoint distribution system (LMDS) data transmission, satellite communication and high-performance radar. Implementation of low-noise capability on low-cost

silicon is expected to drive such developments. Previous reports of low noise for nitride semiconductor transistors at frequencies greater than 20GHz have been restricted to those produced on more expensive silicon carbide (SiC) or sapphire substrates.

The transistor's aluminium gallium nitride (AlGaN) epitaxial double heterostructures (Figure 1 inset) were grown at EpiGaN in Belgium using metal-organic chemical vapor deposition (MOCVD) on highly resistive (111) silicon (4-inch diameter). The resulting material had an electron sheet concentration of  $2.1 \times 10^{13}/\text{cm}^2$ , mobility of  $1300 \text{ cm}^2/\text{V-s}$ , and resistivity of  $230 \Omega/\text{square}$ , as revealed in room-temperature Hall measurements. The ohmic source-drain electrodes consisted of titanium/aluminium/nickel/gold annealed at  $850^\circ\text{C}$  for

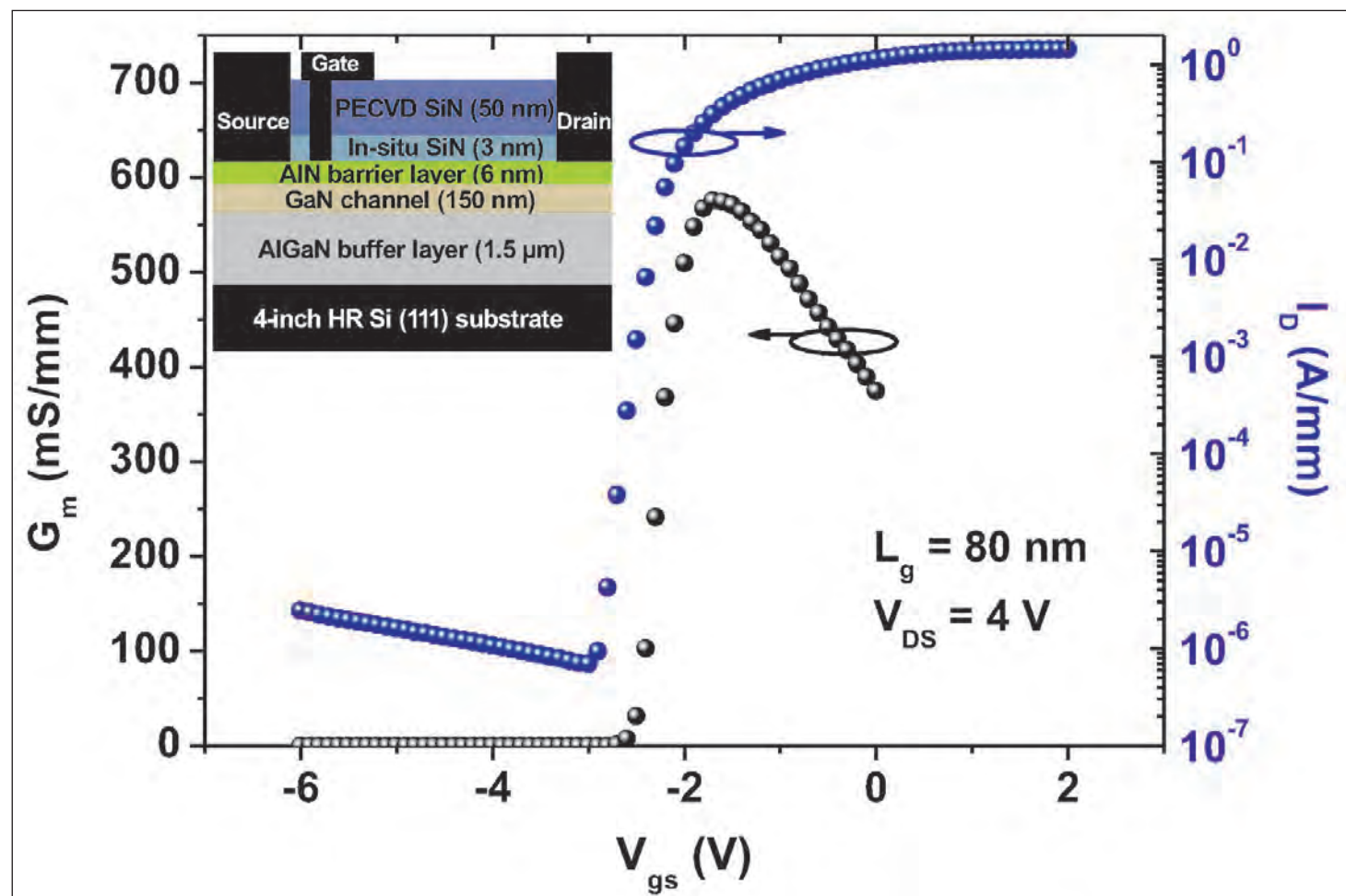


Figure 1. Transfer characteristic of a  $0.08 \mu\text{m} \times 50 \mu\text{m}$  AlN/GaN/AlGaN DHFET on silicon substrate at  $V_{DS} = 4 \text{ V}$ . Schematic cross section of device appears in inset.



30 seconds in nitrogen. The devices were isolated using nitrogen implants.

The Schottky gate structure consisted of 450nm of nickel/gold. The gate included a 0.2 $\mu$ m field-plate extension toward the drain to improve both breakdown voltage and gate resistance. The gate-source and gate-drain distances were 0.3 $\mu$ m and 1.2 $\mu$ m, respectively. The dual-gate width was 2x25 $\mu$ m (50 $\mu$ m total).

The maximum DC output current density of the device was 1.62A/mm at a gate potential of +2V (Figure 1).

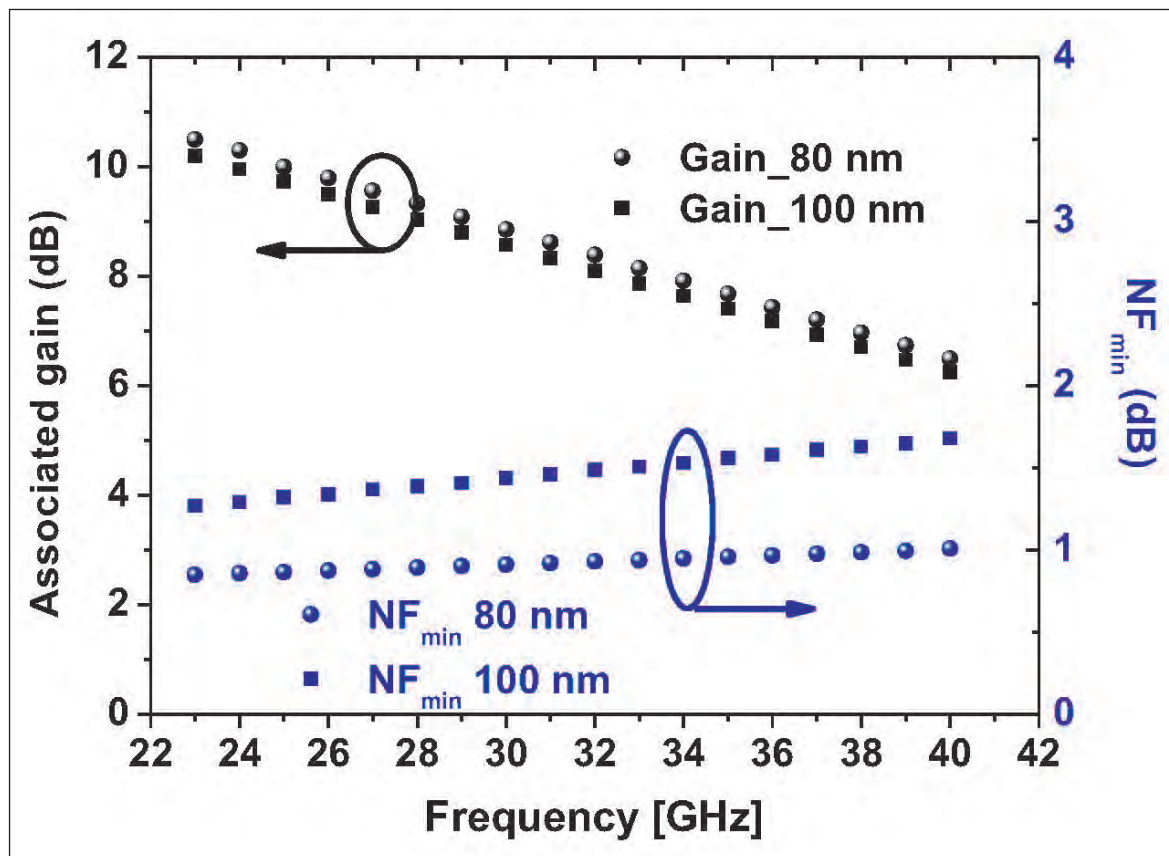
The extrinsic transconductance

was 600mS/mm. The high value was attributed to high carrier density in the conducting two-dimensional electron gas (2DEG) and the thinness of the AlN barrier. The gate current leakage was less than 1 $\mu$ A/mm. The drain leakage was microamps/mm. The off-state breakdown (1mA/mm) was at 80V.

Pulsed testing was used to quantify drain-lag and current-collapse effects. The absence of current collapse was attributed to the in-situ SiN cap layer that helps to neutralize surface charge effects by avoiding surface contamination and native oxide formation as well as enhanced electron confinement due to the AlGaIn back barrier.

Frequency performance (S-parameters) measurements were made over the range 1–50GHz. The extrinsic cut-off ( $f_T$ ) and maximum oscillation ( $f_{max}$ ) frequencies were 95GHz and 105GHz, respectively, for a 100nm gate-length device. These values were increased, respectively, to 118GHz and 145GHz for an 80nm gate-length transistor. The optimum bias conditions were –1.8V gate bias, and 4V drain bias.

The researchers comment: “The frequency performance mainly results from the high transconductance and ultrashort gate lengths but are still limited by the RF loss at the buffer/Si interface that has been measured with standard transmission lines as high as 1.5dB/mm.”



**Figure 2. Associated gain and minimum-noise figure as a function of frequency biased at  $V_{GS} = -1.8V$  and  $V_{DS} = 4V$  at room temperature of 100nm and 80nm AlN/GaN/AlGaIn-on-Si DHFET.**

The researchers finally measured noise figures (NFs) and associated gain ( $G_A$ ) for the 100nm and 80nm gate-length devices. At 40GHz, the  $NF_{min}$  for the 80nm device was 1dB (1.68dB for the 100nm transistor), while  $G_A$  remained above 6dB. The optimum bias conditions were used. Record values of  $NF_{min}$  at 0.97dB and  $G_A$  of more than 7.5dB were obtained at the slightly lower frequency of 36GHz.

The researchers believe that, since the optimal NF systematically corresponds to maximal  $G_A$ , unique monolithic integrated circuit designs may be realized using the transistor.

The high performance is attributed to the high  $f_T$  and  $f_{max}$ , along with good resistance performance of the source-drain access and gate, low gate leakage, and low DC-to-RF dispersion.

The researchers conclude: “The reported  $K_A$ -band GaN-on-Si minimum noise performances are comparable to best-class GaAs devices with the significant advantage of having a ten times higher breakdown voltage. Consequently, such devices are a promising candidate for cost-effective ultra-robust low-noise amplifier applications in next-generation millimeter wave communication networks.” ■

<http://dx.doi.org/10.1109/LED.2012.2205215>

Author:

Mike Cooke

# Wafer-scale transfer of III-Vs to silicon preparing for low-cost manufacturing

**Potential for application to heat-assisted magnetic recording and optical interconnect technologies.**

**R**esearchers based in the Republic of Ireland, Northern Ireland and the USA have developed a wafer-scale method to integrate III-V devices with silicon and other substrates [John Justice et al, *Nature Photonics*, published online 19 August 2012]. The researchers were based at Ireland's Tyndall National Institute, University College Cork, Ireland, Semprius Inc of North Carolina, and Seagate Technology, Northern Ireland.

The team foresees applications arising within the hard-drive and more general electronics industries. For hard-drives, the new heat-assisted magnetic recording (HAMR) technology uses a laser light sources to increase storage densities. Seagate reported the achievement of 1 terabit/inch<sup>2</sup> density in March this year. This application requires III-V laser diodes integrated with alumina/titanium carbide (AlTiC) substrates. Another potential application is increased signal data rates for CMOS-based circuits on silicon.

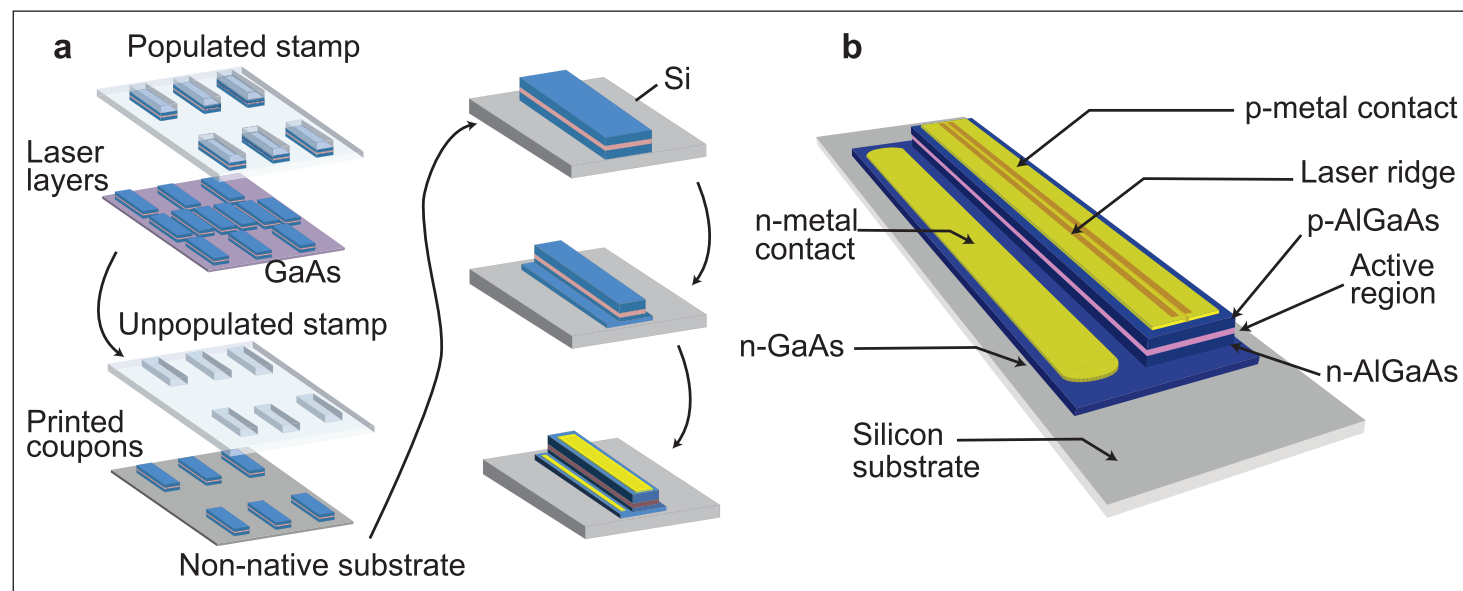
The researchers comment: "These and other forthcoming applications will require laser device volumes

that are multiples of those in use today. A prerequisite for any design is that the laser can be efficiently integrated with the low-cost manufacturing infrastructure and planar processes already established for AlTiC and silicon substrates."

The new wafer-scale method involved transferring epitaxial material 'coupons' from a III-V wafer to the new substrate in batches. The transferred material is then processed into III-V laser diodes.

The epitaxial material was supplied by IQE Ltd. The structure grown by metal-organic chemical vapor deposition (MOCVD) consisted of two compressively strained aluminium indium gallium arsenide (AlInGaAs) wells in aluminium gallium arsenide (AlGaAs). The AlGaAs sacrificial buffer layer before the laser structure was 1 µm thick with 95% Al-content.

Coupons were formed with photolithography and wet etch. The coupons were separated from the underlying sacrificial layer with hydrochloric acid before transfer printing. The coupons were kept in place on the substrate using photoresist resin.



**Figure 1. a, Schematic of transfer of unprocessed coupons of epitaxial material from a native III-V wafer (containing desired layer structure) to host substrate. Lasers are fabricated in parallel on host substrate using lithographically defined etched facets to align to underlying alignment marks. b, Laser on silicon substrate.**



► The transfer printing was performed using a microfabricated stamp consisting of elastomer and glass layers. The stamp mounted on a precision motion platform was designed to pick up coupons from alternate rows and columns. Four passes of the stamp removes all coupons from the original substrate. The stamp contained 16x23 coupons per print. The pitches of the 400 $\mu$ m x 100 $\mu$ m coupons were 420 $\mu$ m x 175 $\mu$ m on the III-V wafer and 840 $\mu$ m x 350 $\mu$ m on the stamp.

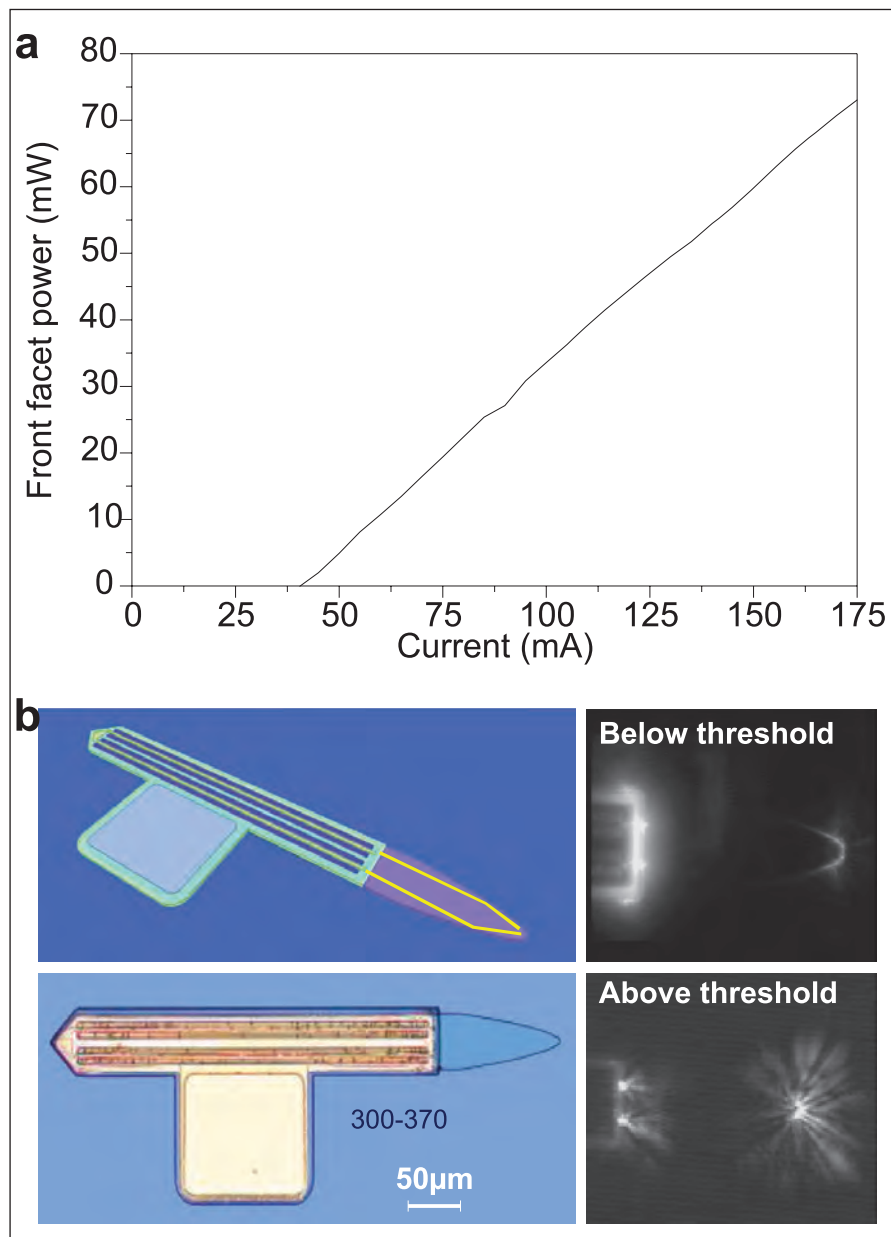
The printing step consisted of a shear-enhanced transfer process creating Van der Waals bonds between coupon and new substrate. The process has been performed on silicon and alumina/titanium carbide (AlTiC). A 1 $\mu$ m polymer layer of Dow Cyclotene (BCB) was coated onto the wafer before transfer printing to enhance transfer-printing yields.

The laser formation consisted of facet and waveguide formation. The facets were etched with a silicon tetrachloride/helium inductively couple plasma using a silicon dioxide mask. Waveguide ridges with widths of 3 $\mu$ m and 6 $\mu$ m were etched to a depth of 1.6 $\mu$ m, 50nm above the top of the core waveguide layers. The ridges did not extend to the edges to avoid facet damage. The p-contact consisted of titanium/platinum gold.

There was some degradation in laser performance from the process: the laser threshold was higher, at 17mA, compared with 14mA for a cleaved-facet device on GaAs substrate. Total slope efficiency was 0.62W/A on silicon and 0.8W/A on GaAs. The wavelength of the devices was 824nm (near-infrared). The small-signal modulation bandwidth was more than 3GHz.

The researchers comment: "The difference in characteristics can be explained by the experimental collection efficiency not being as high for the device on silicon, as well as by the different levels of current injection on the etched facet devices where the ridge waveguide and the p-type contact are recessed from the facet."

The researchers had been hoping for improved thermal performance due to the higher thermal conductivity of silicon compared with GaAs. However, the thermal resistivity of the device on silicon fell in the range 20–40K/W typical of GaAs-based devices. The team believes the disappointing result is due to the heat-generating region of the III-V device being too far from the silicon material. The present distance was 4 $\mu$ m, whereas simulations suggest that this needs to be



**Figure 2. a, Light/current characteristics of 6mm-wide ridge, 370mm-long retro-reflector laser fabricated on silicon substrate. b, Left: schematic (upper) and realized (lower) etched-facet retro-reflector laser and integrated polymeric focusing waveguide. Right: plan-view charge-coupled device images of emission from laser facet and from focusing waveguide below and above laser threshold.**

reduced to less than 3 $\mu$ m for the silicon to be effective in conducting heat away from the device.

The collaborators also produced external cavity laser diodes with output power of 60mW (Figure 2). External waveguides were formed using a silicon dioxide lower cladding applied with plasma-enhanced chemical vapor deposition (PECVD). The upper part of the waveguide consisted of spin-on PMGI SF11 photoresist, patterned with ultraviolet lithography. ■

[www.nature.com/nphoton/journal/vaop/ncurrent/full/nphoton.2012.204.html](http://www.nature.com/nphoton/journal/vaop/ncurrent/full/nphoton.2012.204.html)

Author: Mike Cooke

# Ballistic deflection with improved transconductance using aluminium oxide

**Ballistic deflection transistors integrate high-k dielectric for first time.**

University of Massachusetts Lowell, Universidad de Salamanca, and North Carolina State University have integrated aluminium oxide dielectric into III-V ballistic deflection transistors (BDTs) for the first time [Vikas Kaushal et al, IEEE Electron Device Letters, published online 3 July 2012]. The effect of the dielectric is to increase transconductance (by about 2x) and to shift the transconductance peaks to lower biases.

Room-temperature BDTs have positive and negative transconductance regions that enable the design of inverting or non-inverting circuits, depending only on the gate offset voltage. The non-linear transfer function of such devices could be used to perform frequency doubling up 400GHz at room temperature, according to simulations.

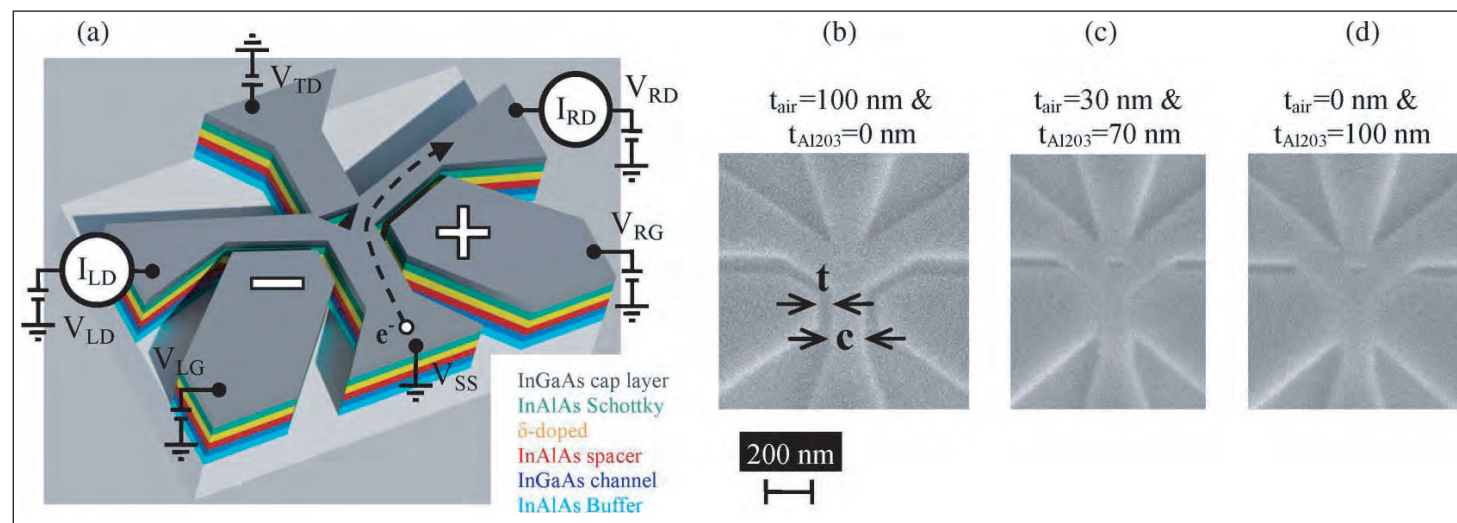
The researchers have incorporated high-k aluminium oxide ( $\text{Al}_2\text{O}_3$ ) dielectric with the aim of improving the electrostatic gate-channel coupling through the dielectric trenches.

Ballistic transport is achieved through reducing device dimensions to the order of the carrier mean free path,

i.e.  $\sim 200\text{nm}$  for two-dimensional electron gases (2DEGs) in indium gallium arsenide (InGaAs) at room temperature. Short mean-free paths (compared with device dimensions) give traditional ohmic/viscous resistivity. The long mean-free path of ballistic devices opens up new charge carrier behaviors that could lead to future high-performance logic and analog applications.

The BDT fabrication was performed at the Center for Nanoscale Systems at Harvard University. The epitaxial material consists of lattice-matched layers of InGaAs and InAlAs on indium phosphide (InP) substrate: 450nm InAlAs buffer, 50nm InGaAs channel, 20nm InAlAs spacer, silicon  $\delta$ -doped InAlAs, and 10nm InGaAs cap. The structure creates the conditions for a two-dimensional electron gas (2DEG) with sheet electron carrier density of  $10^{12}/\text{cm}^2$  and mobility of  $1.1 \times 10^4 \text{cm}^2/\text{V}\cdot\text{s}$ .

The six-terminal planar structure of the BDT (Figure 1) was formed with electron-beam lithography (EBL), inductively coupled plasma-reactive-ion etching (ICP-RIE) to make a mesa with 130nm step height,



**Figure 1.** (a) Three-dimensional 'artistic' topology and heterostructure of typical BDT. Top-left and top-right contacts are drain terminals; bottom-left and bottom-right terminals are gates; top contact is a bias terminal that controls gain, and the bottom terminal the source. (Inset) Schematic showing electron trajectory for positive right gate bias condition ( $V_{RG} = -V_{LG}$ ). SEM image (with scale indicator) of top view of BDT with a channel width of 140nm and a trench width (b) of 100nm air; (c) 70nm  $\text{Al}_2\text{O}_3$ , 30nm air; and, (d) 100nm  $\text{Al}_2\text{O}_3$ .



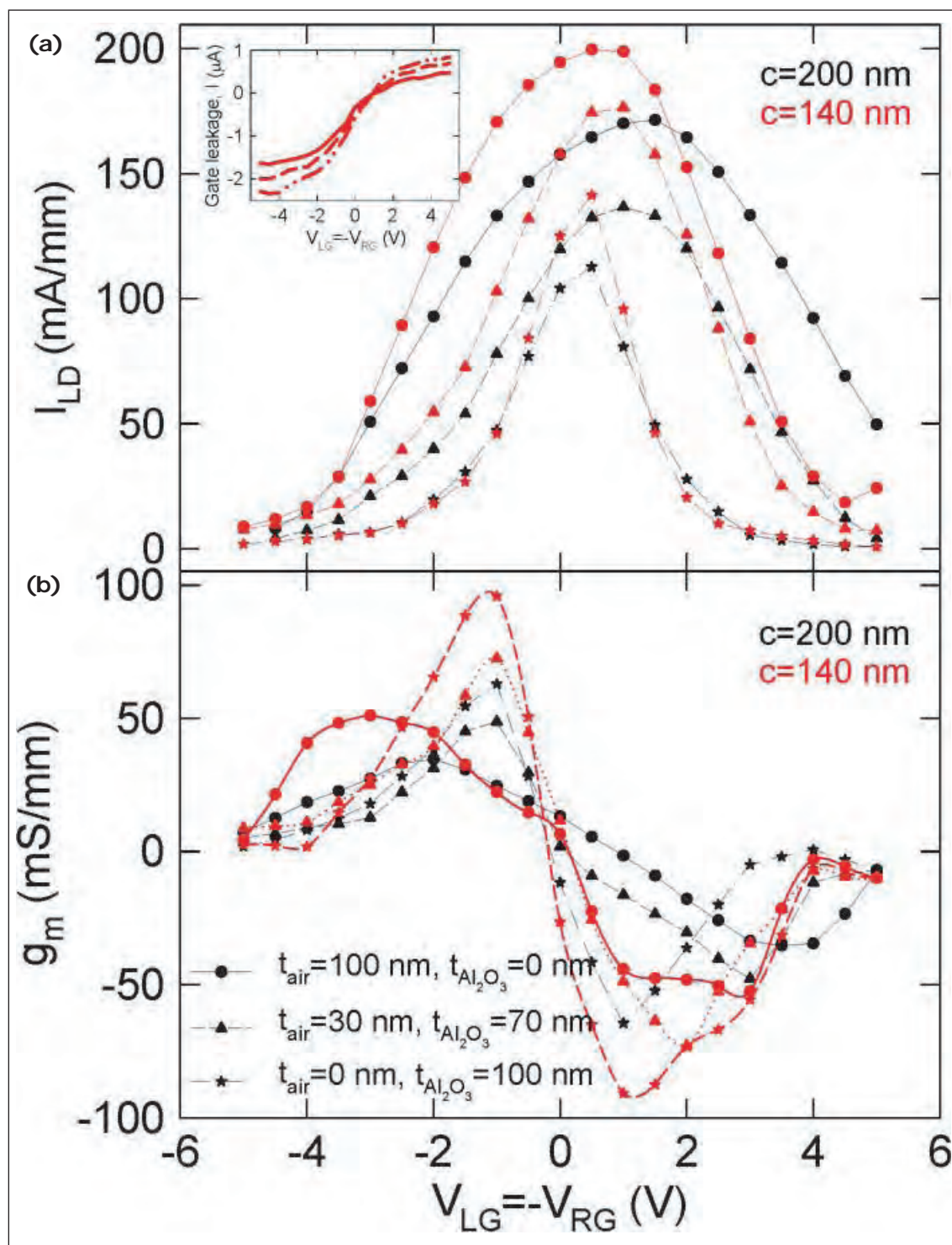
further EBL to allow selective deposition of nickel-germanium-gold contacts (annealed at 420°C for 30 seconds), and finally titanium-gold contact pads were applied in a lift-off process. Two basic BDT types were produced: one with a channel width of 140nm and the other with a channel width of 200nm.

The in-plane BDT terminals — grounded source, three drains (left, right and top), and left and right gates — provide control of carrier density and transport direction. Aluminium oxide dielectric was deposited using 200°C atomic-layer deposition (ALD), filling the gap between the gates and channel.

The effect of filling the trenches with aluminium oxide is to create surface states at the oxide-semiconductor interface and to increase gate-channel coupling.

Surface states degrade mobility and deplete the carrier density in the channel. Increased gate-channel coupling creates early pinch-off. Both these factors tend to reduce the channel current.

For example, in a 140nm-wide channel device the current is decreased by 29% by filling the trenches with 100nm of Al<sub>2</sub>O<sub>3</sub> (Figure 2). At the same time, the transconductance peaks (positive and negative) shift in from about ±3V to ±1V and also double in value. The 140nm device has higher current density, has earlier pinch-off, and a slight increase in transconductance, compared with the 200nm device. ■



**Figure 2. (a) Transfer characteristics and (b) transconductance of BDT normalized to channel widths of 200nm and 140nm. Depositing 35nm and 50nm of Al<sub>2</sub>O<sub>3</sub> along both walls of trench resulted in 70nm and 100nm of net effective Al<sub>2</sub>O<sub>3</sub> in trenches. The three drain terminals were biased at 1V. The inset in (a) shows gate leakage current for BDT 140nm channel width.**

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6230605>

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Mike Cooke is a freelance technology journalist who has worked in semiconductor and advanced technology sectors since 1997.

# Hamamatsu reports record-power-density VCSEL

**First demonstration of 10-watt-class VCSEL with implant isolation.**

**H**amamatsu Photonics K.K. has reported the first demonstration of 10-watt-class output power for a vertical-cavity surface-emitting laser (VCSEL) array with ion-implanted isolated current apertures [Hideyuki Naito et al, Appl. Phys. Express, vol5, p082104, 2012]. The power density was three times the record for short-pulse-operated oxide-confined VCSELs.

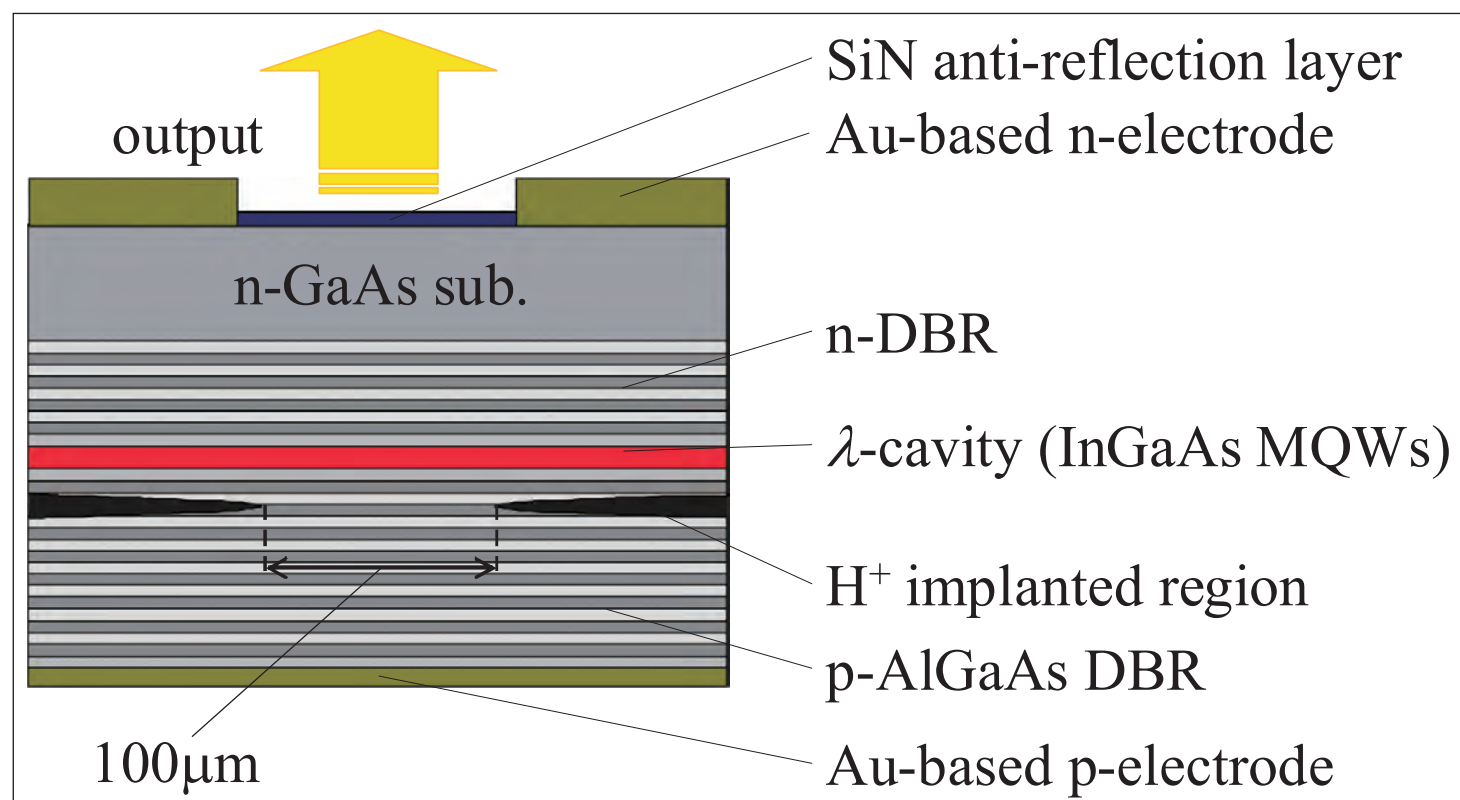
Selective oxidation and ion implantation are typical current-aperture technologies for VCSELs. For high efficiency these apertures must be of high quality. Although oxidation is the most common technique in production, ion implantation has the potential to be the better technique for large-aperture devices. Disadvantages of oxidation include the introduction of strain and defects that degrade performance. An advantage of oxidation is that it provides transverse optical confinement to reduce diffractive losses — a feature that is not as important at larger apertures.

The epitaxial structure for the VCSEL (Figure 1) was grown on n-type gallium arsenide (n-GaAs) substrate using metal-organic vapor phase epitaxy (MOVPE).

The distributed Bragg reflector (DBR) structures were constructed from layers of different aluminium gallium arsenide (AlGaAs) alloys. The multi-quantum well (MQW) light-emitting active region consisted of indium gallium arsenide (InGaAs) in a wavelength cavity ( $\lambda$ -cavity). The designed emission wavelength was 980nm. The 100 $\mu$ m-diameter current aperture was defined using proton ( $H^+$ ) implantation. The light-emitting aperture was covered with an anti-reflection coating. Seven devices were put in a hexagonal array with spacing of 150 $\mu$ m.

In pulse mode (100ns, 10kHz repetition) the peak output power was 40.6W (a density of 73.8kW/cm<sup>2</sup>) at an injection current of 50A (90.9kA/cm<sup>2</sup>). The pulse conditions are typical for sensing and ranging applications. The new device compares with the maximum power density of oxide-confined VCSELs of 24.6kW/cm<sup>2</sup> with a pulse width of 60ns and 100Hz repetition.

The researchers comment: "In spite of a harder drive condition in our study, the output power-density of our



**Figure 1. A schematic cross-sectional structure of a bottom-emitting proton-implanted VCSEL.**



device is three times greater than that of the device described in the previous report".

The spectral width of the output increases with current. It is thought that this is related to transient spectral shifting effects of the pulse-mode operation. In previous work, the researchers found the spectral width of a similar device operated in continuous-wave (CW) mode had a spectral width around 0.4nm. This compares with a width of the order of 10nm for a 40A pulsed current (Figure 2). It is estimated from the spectral broadening that the device temperature during a pulse increases around 70K, in line with the rise of 60–80K at which output power saturation occurs in a single device under CW operation.

"It is thought that the output power is suppressed at the last part of the pulse duration, although the peak output power is not saturated," the researchers comment.

Closer study of the power output with time around the pulse showed a faster fall of the transient peak at higher injection current. Therefore, although no significant output power saturation was seen in measurements up to 50A (the limit of the measuring equipment), the researchers expect deviations from linear behavior to occur above 50A.

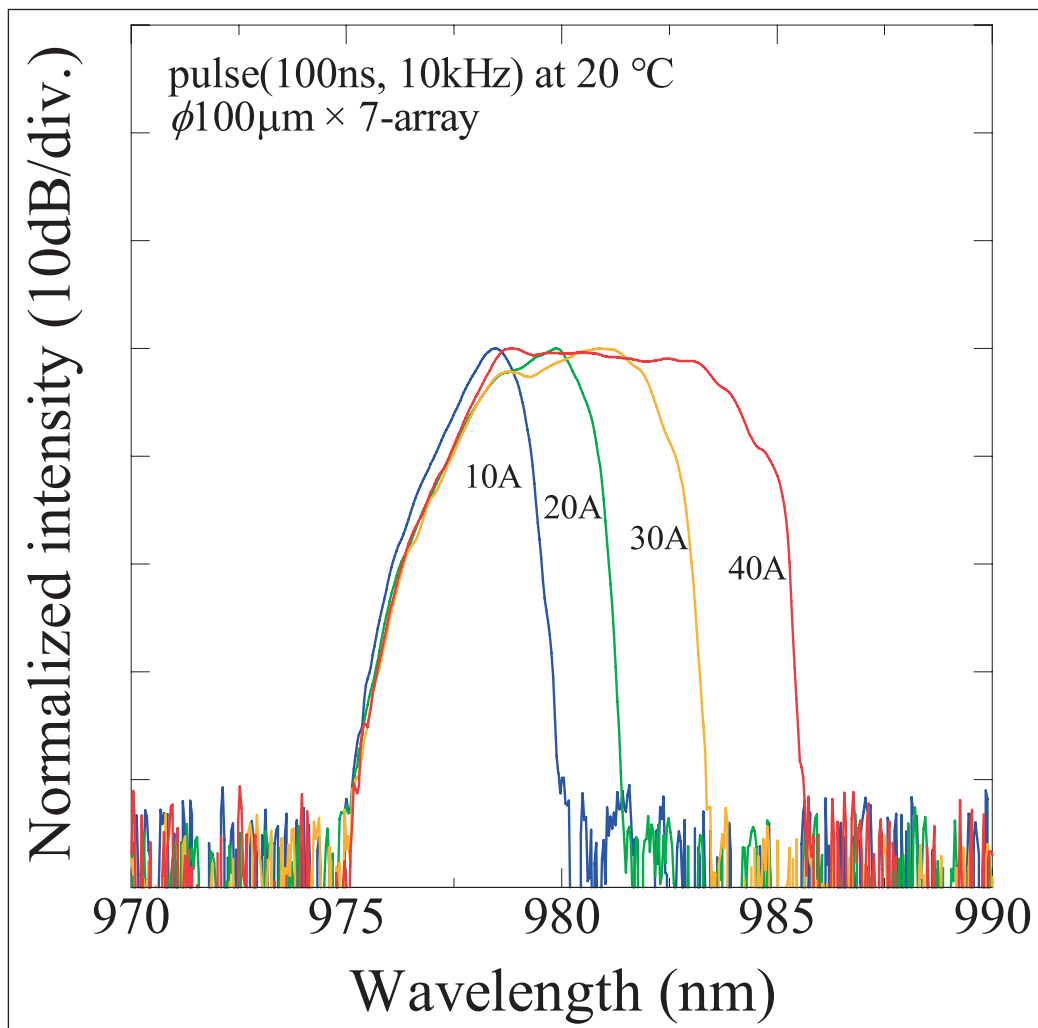


Figure 2. Time-averaged spectra of seven-array under 100ns-pulse operation.

"In order to achieve a higher output power, it is essential to apply effective thermal management and to reduce the electrical resistance in DBRs for less heat generation," the team comments. ■

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Author: Mike Cooke

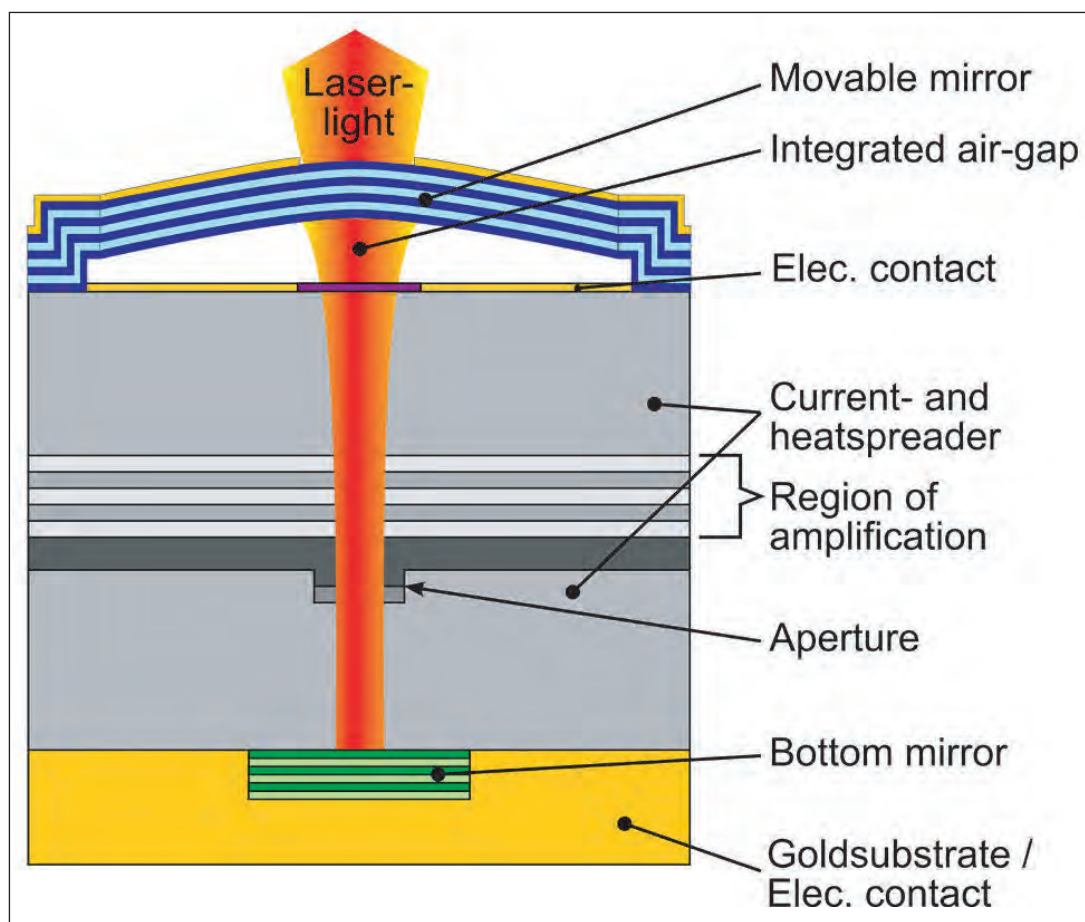
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# TU Darmstadt develops 1.5 $\mu\text{m}$ VCSEL with record 100nm bandwidth, plus first tunable 2 $\mu\text{m}$ laser

**Use of flexible membrane targets fiber-optic telecommunications and gas detection applications.**

In collaboration with partners in the EU project 'Subtune' (Widely Tuneable VCSEL using Sub-wavelength Gratings), researchers at Technische Universität Darmstadt have developed semiconductor lasers that emit light over a wavelength range of 100nm, which is claimed to be a record for a single semiconductor laser. Such lasers could allow more efficient, lower-cost operation of future fiber-optic telecoms networks and the development of high-responsivity gas sensors.

Since vertical-cavity surface-emitting lasers (VCSELs) emit light at a right angle to the plane of the substrate and require very little power for operation, they are used as light sources in, for example, computer mice and laser printers. Subtune's aim was to develop InP-based long-wavelength VCSELs emitting at 1.5–2.0 $\mu\text{m}$  and GaAs-based VCSELs with wavelengths down to 800nm, targeting the introduction of widely tunable VCSELs in a broad range of the optical spectrum. Physicist Christian Gierl and materials scientist Karolina Zogal of TU Darmstadt's Institute for Microwave Technology and Photonics have hence recently significantly extended the tunabilities of such lasers.



**Figure 1. Design of TU Darmstadt's semiconductor laser. (Picture: Institute for Microwave Technology and Photonics.)**

Their approach involves taking advantage of another benefit of surface-emitting semiconductor lasers, namely their very large resonator-length/emitting-area ratios, which greatly increases the spacings of their emitted wavelengths. Their broad free spectral range allows tuning of the wavelength of their strongest emission line over a broad range, i.e. converting them into transmitters whose output may be set to any wavelength falling within a certain, broad range. ►



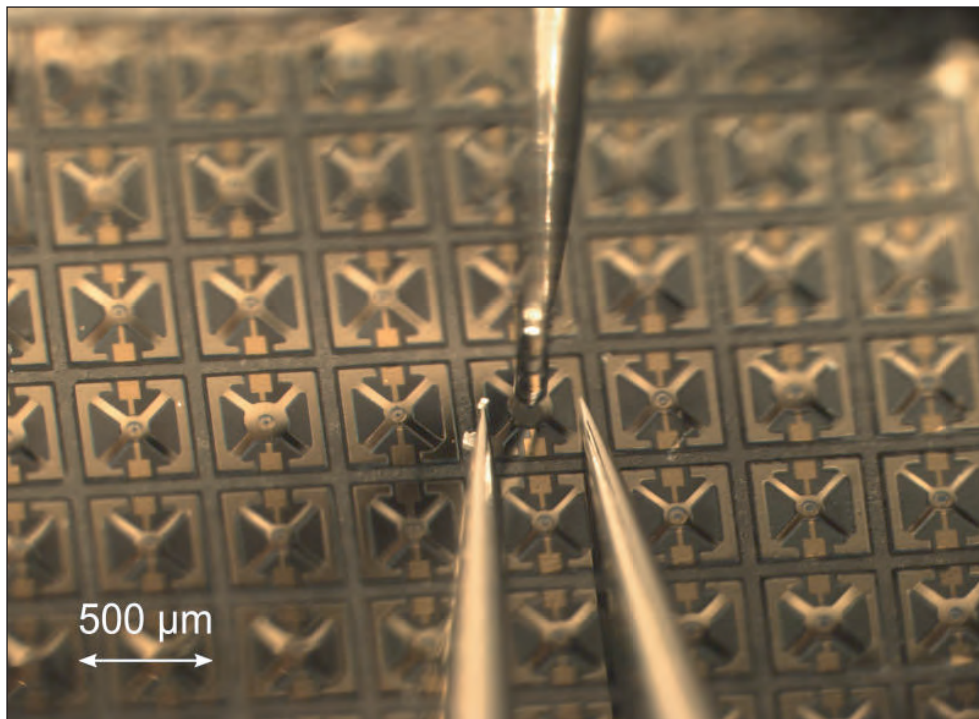
► Gierl and Zogal managed to tune the wavelength of the output beam of a semiconductor laser (provided by Subtune project partner Walter Schottky Institute at TU-München) over a range of more than 100nm (reckoned to be the broadest tuning range achieved by any semiconductor laser) while retaining other emission characteristics such as its high output power and high spectral purity.

To obtain that broad tunability, they applied to its emitting surface a flexible membrane (with a reflectance exceeding 99% at its lasing wavelengths) that served as its output mirror, and whose flexing could be externally controlled. Since every laser is equipped with a pair of facing mirrors (reflecting the light back and forth, for amplification by the laser's active medium on each pass), the spacing of the mirrors determines which wavelengths from the amplified range are emitted. In the new lasers, the active component (half-VCSEL) is combined in a hybrid two-chip assembly with a bulk-micromachined movable mirror membrane that can be actuated electro-thermally to expand the air-gap. This allows the spacing to be varied accurately and the laser output wavelength to be tuned smoothly over a broad range by shifting the cavity resonance towards longer wavelengths.

The lasers are tunable over a range centered on 1.5 $\mu$ m (the wavelength used by fiber-optic telecom systems). The researchers have also developed what is claimed to be the first tunable laser covering a range centered on 2.0 $\mu$ m.

"The telecommunications industry is extremely interested in this technology because in the future it will need to service households via fiber-optic networks operating at various wavelengths," says Gierl. "If there were no tunable lasers, a special type of semiconductor laser would have to be fabricated for each wavelength to be involved," he adds. "Tunable lasers obviate that necessity, since only a single type of laser will have to be fabricated."

The wavelength range centered on 2.0 $\mu$ m is of particular interest to sensors for detecting the presence of gases, since it falls within the range where the vibrational modes of molecules (such as carbon dioxide) are excited. Gases may be identified and their concentrations determined by means of precision measurements of the wavelengths at which they absorb radiation and the absorption coefficients occurring at those wavelengths. "Since that absorption is very strong, gas sen-



**Figure 2. Such lasers may allow more efficient, lower-cost operation of future fiber-optic telecoms networks and the development of high-responsivity gas sensors. (Picture: Institute for Microwave Technology and Photonics.)**

sors based on our technology have high responsivities, in addition to being extremely compact and highly energy-efficient," says Gierl. Again, due to their tunability, a single laser will be sufficient for detecting various gases.

According to the researchers, another benefit of the new lasers is that they are easy to fabricate. "Although the method we employ for applying the membrane directly to the laser is new, we utilized methods [microphotolithography] that have become well established in the semiconductor industry for that purpose," says Gierl. "We are able to fabricate chips having numerous, tunable, surface emitters that meet all of the requirements for the particular applications involved," he adds.

A follow-on project is intended to close the remaining gaps in readiness of such chips for practical applications. Closing one of those gaps involves enabling their output to be modulated at high frequencies so that data can be transmitted at high transfer rates. The researchers also plan to incorporate their chips into modules similar to USB sticks that may be readily integrated into telecoms systems. They are already collaborating with Lawrence Livermore National Laboratory in California and with Leister Technologies AG of Kaegiswil, Switzerland on improving their gas sensors. Furthermore, the new lasers have already been tested on a communications network at Subtune project partner Tyndall National Institute in Cork, Ireland.

[www.subtune.org](http://www.subtune.org)

[www.tu-darmstadt.de](http://www.tu-darmstadt.de)

# Deep UV LEDs with record external quantum efficiency

**External quantum efficiency for 278nm deep ultraviolet light-emitting diode exceeds 10% at a CW injection current of 20mA.**

**U**S-based researchers have reported record external quantum efficiencies (EQE) of 10.4% for deep ultraviolet light-emitting diodes (DUV-LEDs) emitting at a wavelength of 278nm at a continuous-wave current of 20mA [Max Shatalov et al, Appl. Phys. Express, vol5, p082101, 2012]. The collaborators were associated with Sensor Electronic Technology Inc, Rensselaer Polytechnic Institute, and US Army Research Laboratory.

The improvements are attributed to increased light extraction from encapsulating the LEDs, and through creating a more transparent p-contact. The researchers also added a reflector to the p-contact and, in addition,

measured improved internal quantum efficiency (IQE), indicating a reduction in the density of extended defects that degrade performance.

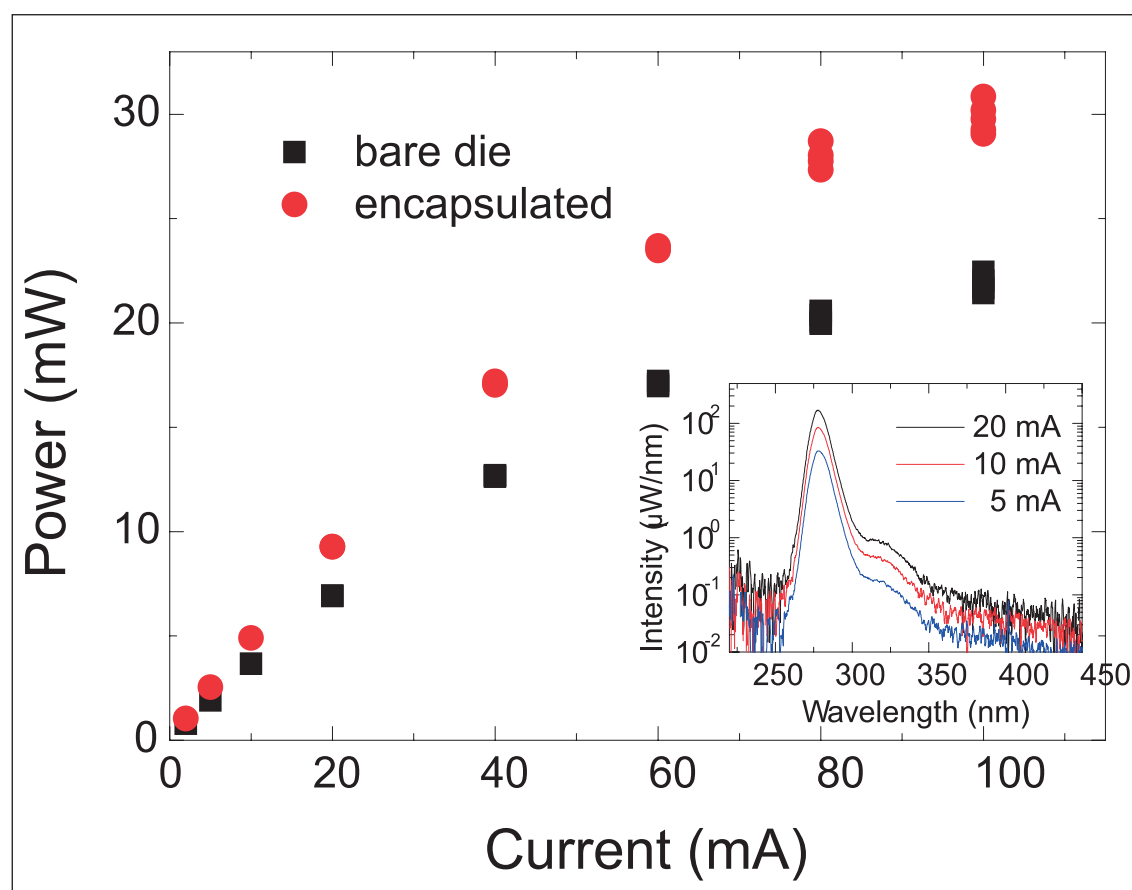
Target applications for such devices include security, bio-analysis, medicine, chemical sensing, curing, and disinfection/sterilization. The attractions of LEDs over competing mercury vapor lamps are compact, fast, reliable and low-cost light sources, emitting at wavelengths between 210nm and 365nm. However, for wider application, LEDs need to be more efficient, particularly at shorter wavelengths. In particular, light extraction efficiency and material quality need improvements.

The epitaxial layers for the record-breaking LEDs were grown on sapphire using a combination of

metal-organic chemical vapor deposition (MOCVD) and migration-enhanced MOCVD (MEMOCVD). In particular, MEMOCVD was used to create a low threading dislocation density (TDD) 10 $\mu$ m-thick layer of aluminium nitride (AlN) at temperatures in excess of 1300°C. The very high growth temperature encouraged the movement of the Al atoms on the growth surface. This Al-migration is beneficial in bending and annihilating dislocations.

Further layers consisted of AlN/AlGaIn superlattice strain relief, n-AlGaIn bottom cladding/contact, a multi-quantum-well light-emitting active region, and finally a p-AlGaIn top cladding/contact.

Transmission electron micrographic (TEM) measurements gave a TDD of 2x10<sup>8</sup>/cm<sup>2</sup> for all types of dislo-



**Figure 1. Light output power versus current (L-I) characteristics of DUV LEDs packaged with and without encapsulation. Inset: spectral power distribution at several current levels for encapsulated LED.**



cation. Varying the amount of Al in the top p-AlGaIn from 0 to 35% increased the transmission of UV from 5% to 60% (optical losses from  $10^5/\text{cm}$  to less than  $1000/\text{cm}$ ). Adding a UV reflective p-metal layer to enable multiple-pass light extraction increased the light output by 2x for the UV-LEDs.

The epitaxial material was processed into devices measuring  $350\mu\text{m} \times 350\mu\text{m}$  and flip-chip mounted into TO-39 packages. The light from the devices is thus emitted through the sapphire substrate. The process was optimized for uniform current spreading.

Some of the devices were completely encapsulated in a stable, UV-transparent material to enhance light extraction efficiency (LEE). The index of refraction and shape of the encapsulation was optimized through use of ray-tracing simulations. The nature of the encapsulation is not further specified in the paper. Traditional polymer encapsulation materials tend to absorb UV light and also degrade with exposure.

The use of encapsulation produced a 35% increase in light output power at 20mA CW injection current from 6.9mW to 9.3mW, "the highest power reported to date for DUV LED with emission shorter than 365 nm at this drive current". The encapsulated chip gave 30mW light output power at 100mA (Figure 1). The researchers attribute 9% of the improved light extraction over a conventional device to the change from p-GaN to p-AlGaIn and they attribute nearly 30% of the improved light extraction to the encapsulation.

The peak emission occurred at 278nm, with a secondary peak around 320nm, probably related to recombination in the p-AlGaIn. The parasitic peak needs to be reduced through prevention of spill-over of electrons into the p-contact by adding a suitable electron-blocking layer.

The EQE of the encapsulated device was 10.4% at 20mA, compared with 7.8% for the device without. A peak EQE for the encapsulated LED of 12% was attained at lower current. The wall-plug efficiency (WPE) of the encapsulated device was 5.5% at 20mA due to the high forward voltage of 8.4V.

The researchers see the development of DUV LEDs with wall-plug efficiencies greater than 10% as an enabling condition for their use in power-demanding applications, such as disinfection, decontamination, and curing.

The researchers comment: "Further optimization of the p-layer heterostructure and vertical conductivity is needed for the reduction of the forward voltage and higher WPE".

Devices with larger active areas of  $0.5\text{mm}^2$  (about 4x that of  $350\mu\text{m}$  square device) reached peak EQEs of 10.9% at 20mA (a current density  $4\text{A}/\text{cm}^2$ ) and WPEs of 7.8%. The researchers comment that their results indicate a significant reduction of non-radiative recombination associated with defects typically limiting efficiency at low current density. ■

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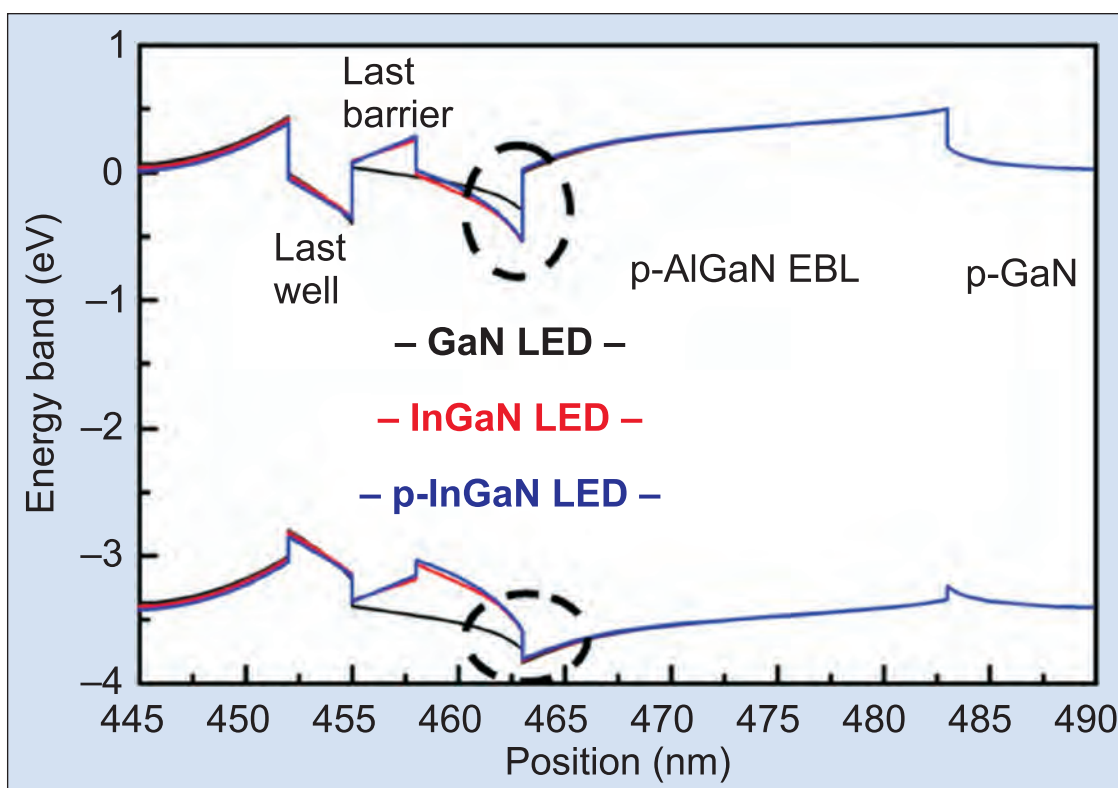
# Improving transport, reducing polarization in nitride LEDs

**Mike Cooke** reports on research aiming to increase LED efficiency for LCD and general lighting applications.

**N**itride semiconductor LEDs are being developed for white light applications such as liquid-crystal display backlights and general illumination with reduced power consumption. However, these devices suffer from a degradation of efficiency at higher currents, also known as 'droop'. Researchers have tried various methods to overcome this droop to allow higher-efficiency operation of these devices at higher currents. Solving the problem would enable wider use of LEDs at lower cost both through more efficient operation and the need for fewer devices in a module.

A variety of explanations have been offered for the droop behavior. These tend to focus on the recombination process, carrier transport into the device, and the large spontaneous and strain-dependent (piezoelectric) polarization due to the more strongly ionic nature of the III-nitride bond compared with other semiconductor materials.

The main explanation based on recombination is the Auger process, where the energy release by electron transitions into hole states is transferred to a third carrier rather than producing a photon. Some researchers believe the Auger effect is too small at the relevant carrier densities to be dominant. Others suggest that there is an enhancement due to a resonance with



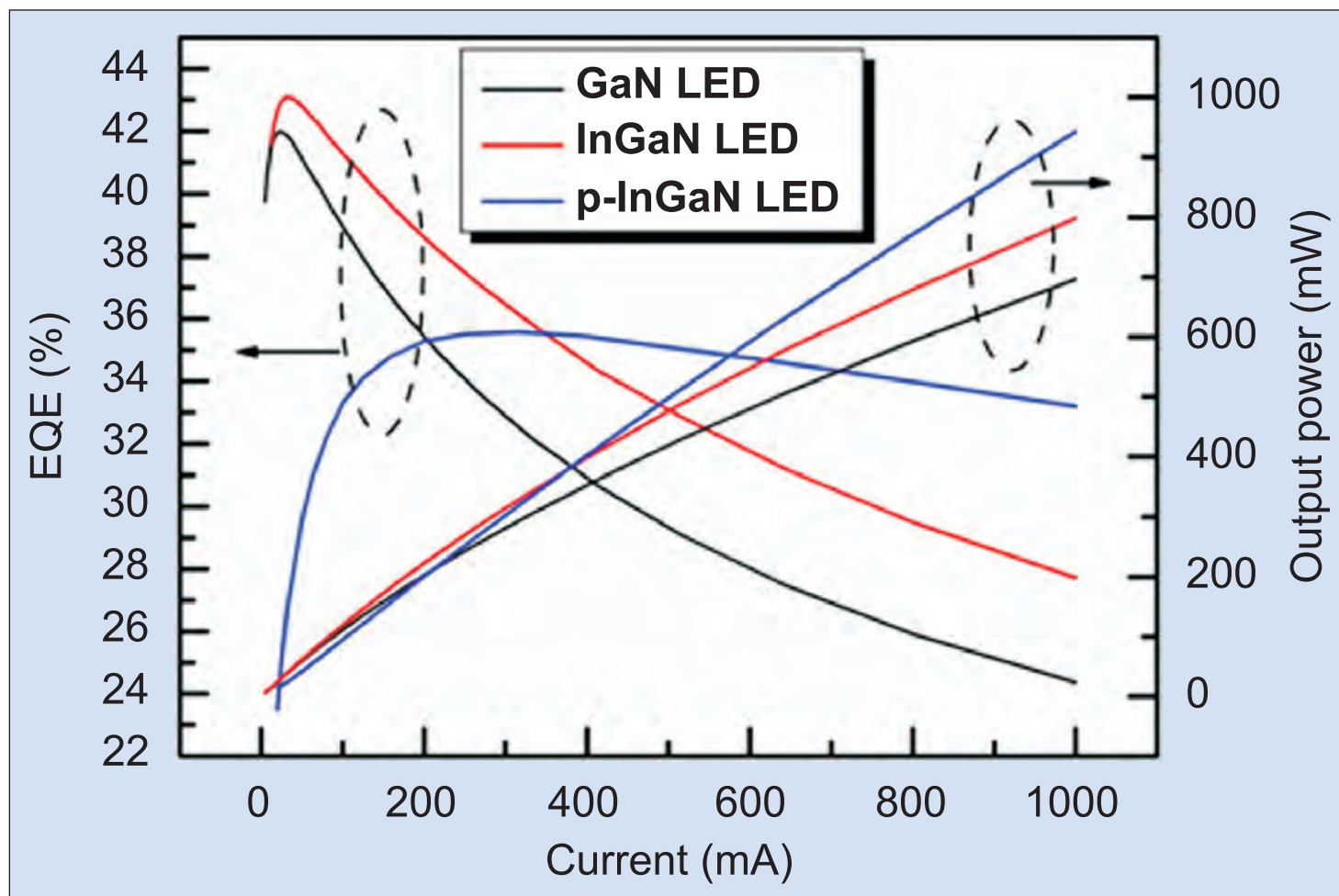
**Figure 1.** Calculated band diagrams for GaN, InGaN, and p-InGaN LEDs at forward current of 20mA.

higher excitation bands, particularly in the green wavelength range of the spectrum [reviewed in Mike Cooke, *Semiconductor Today* May/June 2011, p112].

Here we look at structures developed in Taiwan and China that aim to tackle transport and polarization aspects.

Carrier transport affects the distribution of the electrons and holes in the active light-emitting region of diode structures. While electrons often flow beyond the active region of the device into the p-contact, holes barely make it beyond the first well. The electron overflow also reduces efficiency by reducing the number of holes available for injection into the active region. Nitride LEDs frequently have an electron-blocking region of





**Figure 2.** External quantum efficiencies (EQEs) and output powers of GaN, InGaN, and p-InGaN LEDs plotted with respect to forward current.

aluminium gallium nitride (AlGaIn) to reduce electron overflow, but this then further impedes the flow of holes.

Strong polarization arises in indium gallium nitride (InGaIn) MQW structures due to strain effects with large differences in lattice constant of the well and barrier materials. The resulting electric field in the active region makes it difficult for electrons and holes to recombine as photons/light, since the field tends to pull carriers of opposite charge apart.

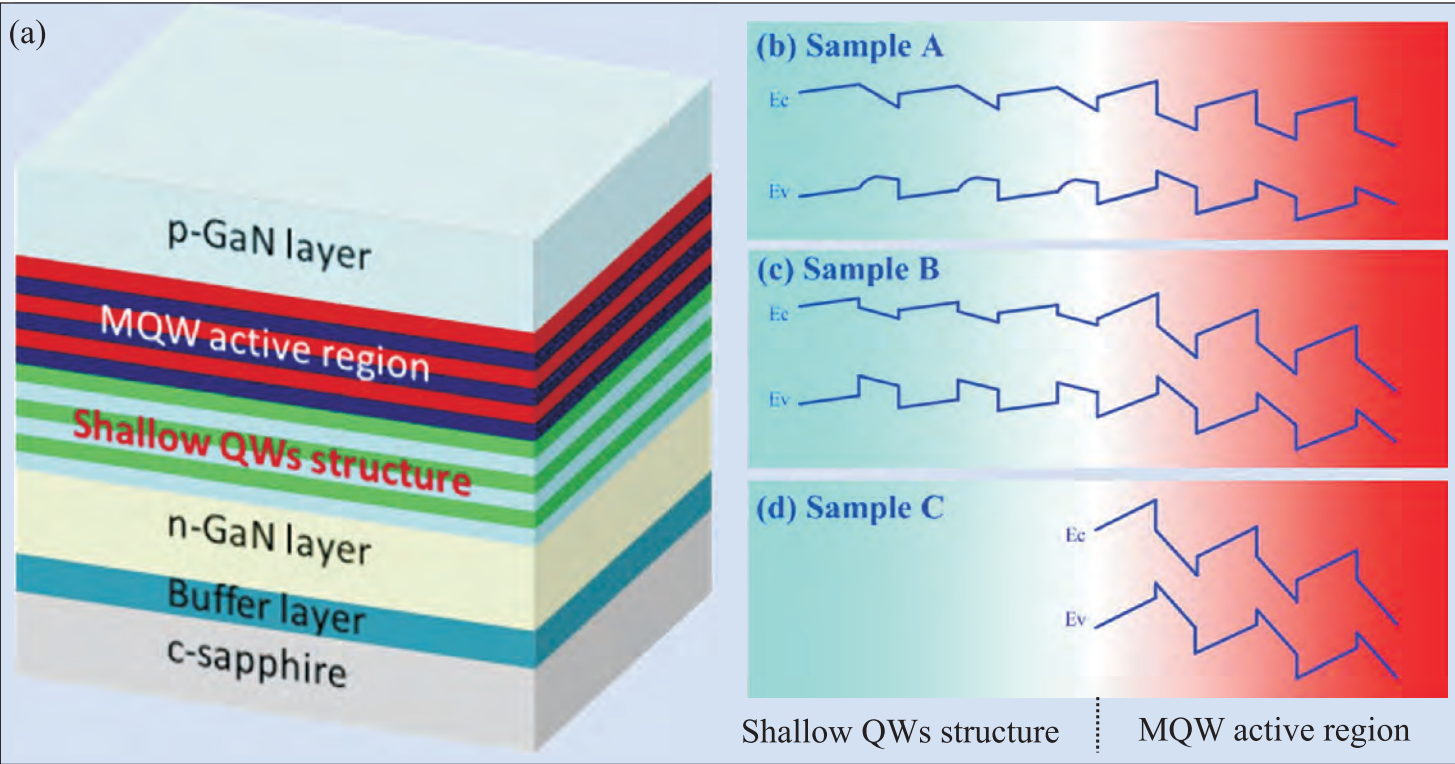
### Layer insertion

Taiwan researchers have reduced efficiency droop from 42% to 7% by inserting p-type indium gallium nitride (p-InGaIn) between the active light-emitting and electron-blocking layers of a nitride semiconductor LED [Ray-Ming Lin et al, Appl. Phys. Lett., vol101, p081120, 2012]. The researchers were based at Chang Gung University, National Cheng Kung University, and MOME Business Development Group (LED Division). The researchers see their p-InGaIn insertion as a way to overcome the asymmetry between electron and hole transport in nitride LEDs.

The InGaIn-based blue LEDs were produced from material grown on c-plane sapphire with an SR2000 metal-organic chemical vapor deposition (MOCVD)

reactor supplied by Taiyo Nippon Sanso. The layer sequence consisted of 25nm GaN nucleation layer, a 1µm undoped GaN buffer, 3µm of Si-doped n-GaN, two pairs of 3nm InGaIn (10%-In) and 12nm GaN strain relaxation layers, a multi-quantum well (MQW) of four pairs of 3nm InGaIn (16%-In) wells and 12nm GaN barriers followed by a 3nm last well and 3nm last barrier, 5nm GaN, an InGaIn (7%-In) or p-InGaIn insertion layer, a 20nm p-AlGaIn (20%-Al) electron-blocking layer, and a 100nm p-GaN contact. The active region was designed to emit 440nm-wavelength blue light. The LEDs were formed from 1mm x 1mm chips of the material.

Based on simulations (Figure 1), the researchers believe that the effect of the InGaIn insertion is to block electron overflow and increase hole injection into the LED structure, increasing external quantum efficiency (EQE). By doping InGaIn as p-type, there is also the benefit of a lower activation energy for hole generation compared with p-GaN. The simulation suggested a reduction of almost three orders of magnitude in electron overflow and more than one order of magnitude increase in hole concentration in the last well when LEDs with p-InGaIn insertion were operated at 1A injection current.



**Figure 3. (a) Schematic diagram of the epitaxial LEDs with shallow QW structure. (b) Schematic band profiles of shallow QW structure and active region of LEDs with shallow TQW (Sample A), (c) LEDs with shallow RQW (Sample B), and (d) conventional LEDs (Sample C). Diagram is not to scale.**

Processed devices were tested up to 1A using a 700μs 0.1%-duty-cycle, pulsed signal to avoid self-heating effects (Figure 2). The undoped InGaN insert provided the highest peak efficiency and a slight mitigation of the droop effect. The researchers comment: “We attribute this improvement to the enhanced hole injection efficiency and greater retardation of electron overflow as a result of the bandgap energy of In<sub>0.07</sub>GaN being lower than that of GaN.”

The p-doping of the InGaN insert reduced the peak while pushing it out to higher current of about 316mA. The efficiency droop at 1A was 7% compared with the peak. The droop of the conventional device was 42%. “Accordingly, we observed a dramatic increase in the light output power from the p-InGaN LED because of its extremely low efficiency droop,” the researchers write. The output power at 1A was 950mW, i.e. 1.35x that of the conventional LED.

However, the peak efficiency of the p-doped insert was significantly lower than the conventional and undoped-insert LEDs. It is frequently the case that measures taken to tackle droop also result in reduced peak efficiency.

In this case, secondary-ion mass spectroscopy (SIMS) of the epitaxial structures indicated the presence of magnesium (Mg) p-type dopant in the MQW region of the p-doped insert LED. Such diffusion of Mg into the active region would be expected to reduce efficiency from non-radiative recombination processes through material quality damage and ionized acceptor levels.

The researchers propose that improved LED performance would result from optimizing the doping profile of the Mg metal-organic source of bis(cyclopentadienyl) magnesium (Cp<sub>2</sub>Mg) and tuning the epi process condition to minimize the impact of back-diffusion of Mg atoms into the MQW active region.

**Triangular quantum wells**

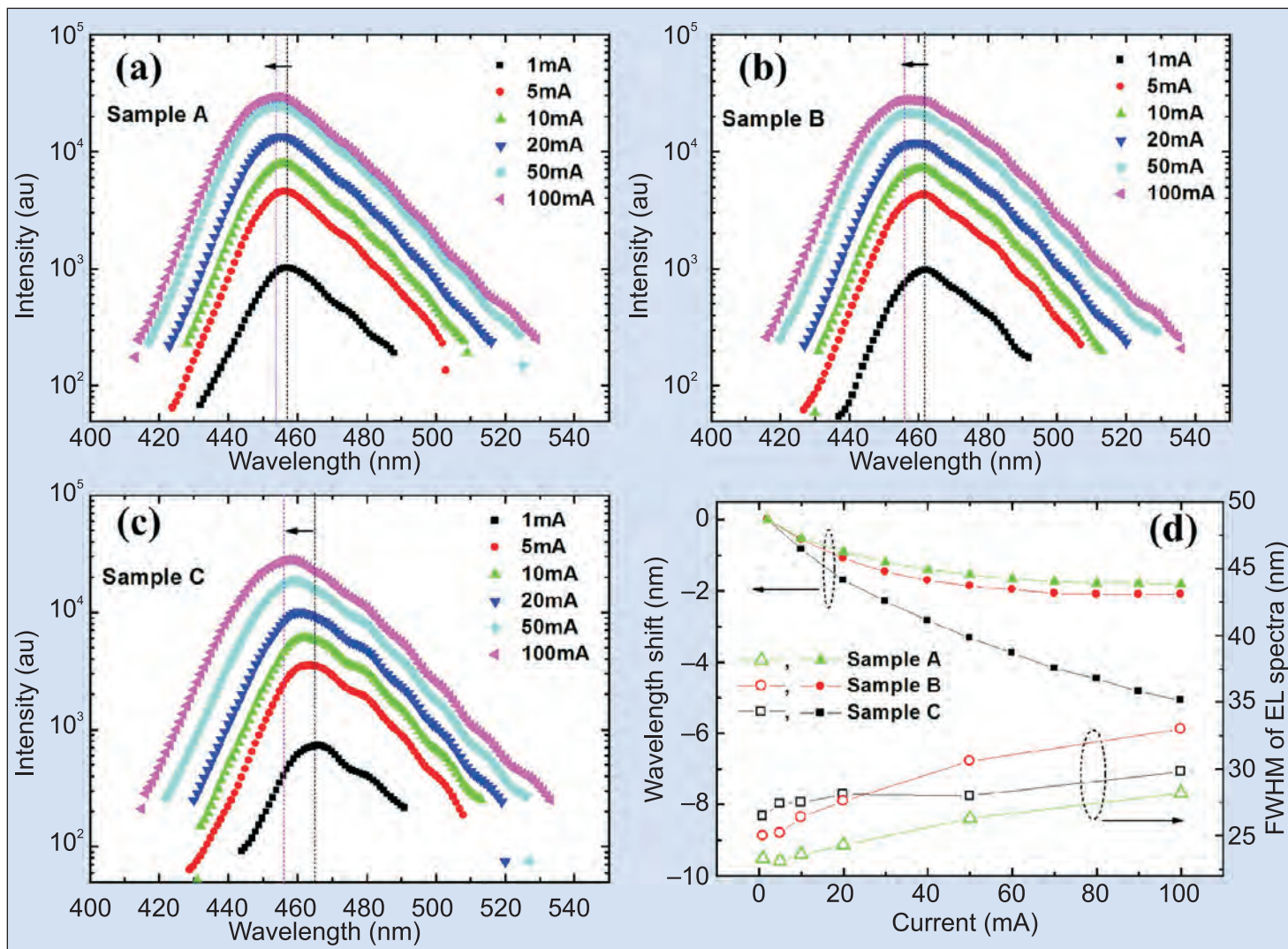
The State Key Laboratory of Optoelectronic Materials and Technology of Sun Yat-sen University in China has reduced the forward voltages and increased the device efficiency of nitride semiconductor LEDs by up to 80% by inserting a triangular quantum well region (TQW) before the usual MQW active region [Shanjin Huang et al, Appl. Phys. Lett., vol101, p041116, 2012].

The researchers ascribe the improved performance to weakening of the polarization field in the MQW active region induced by the TQW structure.

The epi material was grown on c-plane sapphire using MOCVD (Figure 3). The MQW region consisted of InGaN with GaN barriers (InGaN/GaN, 2.7nm/7.5nm, In-16%).

The shallow QW region was inserted before the MQW active region. Two types of shallow QW were created. Sample A had linearly increasing In-content (0% to 12%) due to decreasing growth temperature from 820°C to 780°C, giving TQWs (InGaN/GaN 3.78nm/7.53nm). Sample B had rectangular QWs (RQWs) of 6%-In InGaN grown at 800°C (InGaN/GaN, 3.36nm/8.01nm). A further structure, Sample C, was produced without shallow QWs, representing a conventional LED material.





**Figure 4. Electroluminescence spectra of (a) Sample A (with shallow TQW), (b) Sample B (with shallow RQW), (c) Sample C (w/o. shallow QWs) at various injection currents. (d) Magnitude of blue-shift and FWHM of electroluminescence emission peak in the three samples as function of injection current.**

The materials were processed into  $200\mu\text{m} \times 250\mu\text{m}$  lateral LEDs. Pulse currents (10msecs) were used to test the devices to avoid self-heating effects.

The TQWs of Sample A gave the lowest forward voltage of 2.70V at 1mA. The respective values for samples B and C were 2.75V and 3.05V. The improved performance of Sample A was attributed to weakening of the polarization field, allowing carriers to overcome potential barriers and enhancing carrier transport in the active region.

At 20mA current injection, the light output from Sample A was 14% more than Sample B and 57% more than the conventional device based on Sample C. The lower forward voltage and increased light output indicated increased efficiency for Sample A devices of 80% over Sample C LEDs and 16% over Sample B LEDs.

X-ray diffraction analysis suggests that the inclusion of TQWs partially releases strain in the upper active MQWs. As a result the strain-dependent piezoelectric polarization field is reduced.

Another effect of introducing TQWs was to reduce the

spectral blue-shift with increasing current (Figure 4). Between 1mA and 100mA, the peak wavelength shifted 1.8nm for LEDs based on Sample A, compared with 5.1nm for Sample C devices.

Such blue-shift can be due to combined effects of coulomb screening of polarization-induced quantum-confined Stark effects (QCSEs), and band filling of localized states under high carrier injection. The reduced polarization field of Sample A from reduced strain would lead to reduced QCSE effects. However, increased peak widths for all the LEDs also suggest the presence of band-filling effects. The full-width at half-maximum (FWHM) values for 100mA injection were increased over those at 1mA by 21%, 32% and 13%, for LEDs based on samples A, B and C, respectively.

The researchers suggest that the insertion of the TQW structure may result in both weakening of QCSEs and enhancement of band filling. ■

*Mike Cooke is a freelance technology journalist who has worked in semiconductor and advanced technology sectors since 1997.*



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[www.sicrystal.de](http://www.sicrystal.de)

**sp3 Diamond Technologies**

2220 Martin Avenue,  
Santa Clara, CA 95050, USA  
Tel: +1 877 773 9940  
Fax: +1 408 492 0633  
[www.sp3inc.com](http://www.sp3inc.com)

**Sumitomo Electric  
Semiconductor Materials Inc**

7230 NW Evergreen Parkway,  
Hillsboro, OR 97124, USA  
Tel: +1 503 693 3100 x207  
Fax: +1 503 693 8275  
[www.sesmi.com](http://www.sesmi.com)

**III/V-Reclaim**

Wald 10,   
84568 Pleiskirchen,  
Germany  
Tel: +49 8728 911 093  
Fax: +49 8728 911 156  
[www.35reclaim.de](http://www.35reclaim.de)  
III/V-Reclaim offers reclaim  
(recycling) of GaAs and InP wafers,  
removing all kinds of layers and  
structures from customers' wafers.  
All formats and sizes can be  
handled. The firm offers single-side  
and double-side-polishing and  
ready-to-use surface treatment.

**Umicore Electro-Optic Materials**

Watertorenstraat 33,  
B-2250 Olen, Belgium  
Tel: +32-14 24 53 67  
Fax: +32-14 24 58 00  
[www.substrates.umicore.com](http://www.substrates.umicore.com)

**Wafer Technology Ltd**

34 Maryland Road, Tongwell,  
Milton Keynes, Bucks, MK15 8HJ,  
UK  
Tel: +44 (0)1908 210444  
Fax: +44 (0)1908 210443  
[www.wafertech.co.uk](http://www.wafertech.co.uk)  
Wafer Technology Ltd  
is a UK-based  
producer of III-V  
materials and epitaxy-  
ready substrates  
offering the widest product range in  
the business.

**Wafer World Inc**

1100 Technology Place, Suite 104,  
West Palm Beach, FL 33407, USA  
Tel: +1-561-842-4441  
Fax: +1-561-842-2677  
E-mail: [sales@waferworld.com](mailto:sales@waferworld.com)  
[www.waferworld.com](http://www.waferworld.com)



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## 4 Epiwafer foundry

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Hudson, NH 03051, USA  
Tel: +1 603 595 8900  
Fax: +1 603 595 0975  
[www.spirecorp.com](http://www.spirecorp.com)

**Cambridge Chemical Company Ltd**

Unit 5 Chesterton Mills,  
French's Road, Cambridge CB4 3NP,  
UK  
Tel: +44 (0)1223 352244  
Fax: +44 (0)1223 352444  
[www.camchem.co.uk](http://www.camchem.co.uk)

**The Fox Group Inc**

(see section 3 for full contact details)

**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](http://www.intelliepi.com)

**IQE**

Cypress Drive,  
St Mellons, Cardiff  
CF3 0EG,  
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Tel: +44 29 2083 9400  
Fax: +44 29 2083 9401  
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**OMMIC**

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Tel: +33 1 45 10 67 31  
Fax: +33 1 45 10 69 53  
[www.ommic.fr](http://www.ommic.fr)

**Picogiga International S.A.S.**

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](http://www.picogiga.com)

**SemiSouth Laboratories Inc**

201 Research Boulevard,  
Starkville, MS 39759, USA  
Tel: +1 662 324 7607  
Fax: +1 662 324 7997  
[www.semisouth.com](http://www.semisouth.com)

## 5 Deposition materials

**Akzo Nobel  
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AkzoNobel HPMP is a global leading  
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magnesium (Cp<sub>2</sub>Mg). In addition,  
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Trimethylaluminum (TMAI SOLAR)  
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## Asia Pacific:

Akzo Nobel (Asia) Co Ltd,  
Shanghai, China  
Tel: +86 21 2216 3600  
Fax: +86 21 3360 7739  
metalorganicsAP@akzonobel.com

## Americas:

AkzoNobel Functional Chemicals,  
Chicago, USA  
Tel: +31 600 828 7929 (USA only)  
Tel: +1 312 544 1000  
Fax: +1 312 544 7188  
metalorganicsNA@akzonobel.com

## Europe, Middle East and Africa:

AkzoNobel Functional Chemicals,  
Amersfoort, The Netherlands  
Tel: +31 33 467 6656  
Fax: +31 33 467 6101  
metalorganicsEU@akzonobel.com

## Cambridge Chemical Company Ltd

Unit 5 Chesterton Mills,  
French's Road,  
Cambridge CB4 3NP,  
UK  
Tel: +44 (0)1223 352244  
Fax: +44 (0)1223 352444  
[www.camchem.co.uk](http://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](http://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](http://www.mathesontrigas.com)

## Mining & Chemical Products Ltd (see section 1 for full contact details)

## Power + Energy Inc

(see section 10 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](http://www.praxair.com/electronics)

## SAFC Hitech

Power Road, Bromborough,  
Wirral, Merseyside CH62 3QF, UK  
Tel: +44 151 334 2774  
Fax: +44 151 334 6422  
[www.safchitech.com](http://www.safchitech.com)

## Williams Advanced Materials

2978 Main Street,  
Buffalo, NY 14214,  
USA  
Tel: +1 716 837 1000  
Fax: +1 716 833 2926  
[www.williams-adv.com](http://www.williams-adv.com)

## 6 Deposition equipment

### AIXTRON SE

Kaiserstrasse 98,  
52134 Herzogenrath,  
Germany  
Tel: +49 241 89 09 0  
Fax: +49 241 89 09 40  
[www.aixtron.com](http://www.aixtron.com)

**AIXTRON**

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.

### Oxford Instruments Plasma Technology

North End, Yatton,  
Bristol, Avon BS49 4AP,  
UK  
Tel: +44 1934 837 000  
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[www.oxford-instruments.co.uk](http://www.oxford-instruments.co.uk)

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USA  
Tel: +1 727 577 4999  
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[www.plasmatherm.com](http://www.plasmatherm.com)



Plasma-Therm, LLC is an established leading provider of advanced plasma processing equipment for the semiconductor industry and related specialty markets.

## Riber

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95873 Bezons Cedex,  
France  
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Fax: +33 (0) 1 39 47 45 62  
[www.riber.com](http://www.riber.com)

## SVT Associates Inc

7620 Executive Drive,  
Eden Prairie, MN 55344,  
USA  
Tel: +1 952 934 2100  
Fax: +1 952 934 2737  
[www.svta.com](http://www.svta.com)

## Temescal, a part of Ferrotec

4569-C Las  
Positas Rd,  
Livermore,  
CA 94551,  
USA  
Tel: +1 925 245 5817  
Fax: +1 925 449-4096  
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**Veeco Instruments Inc**

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Woodbury, NY 11797,  
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Tel: +1 516 677 0200

Fax: +1 516 714 1231

[www.veeco.com](http://www.veeco.com)



Veeco is a world-leading supplier of compound semiconductor equipment, and the only company offering both MOCVD and MBE solutions. With complementary AFM technology and the industry's most advanced Process Integration Center, Veeco tools help grow and measure nanoscale devices in worldwide LED/wireless, data storage, semiconductor and scientific research markets—offering important choices, delivering ideal solutions.

## 7 Wafer processing materials

**Air Products and Chemicals Inc**

7201 Hamilton Blvd.,  
Allentown, PA 18195,  
USA

Tel: +1 610 481 4911

[www.airproducts.com/compound](http://www.airproducts.com/compound)

**MicroChem Corp**

1254 Chestnut St. Newton,  
MA 02464,  
USA

Tel: +1 617 965 5511

Fax: +1 617 965 5818

[www.microchem.com](http://www.microchem.com)

**Power + Energy Inc**

(see section 10 for full contact details)

**Praxair Electronics**

(see section 5 for full contact details)

## 8 Wafer processing equipment

**EV Group**

DI Erich Thallner Strasse 1,  
St. Florian/Inn, 4782,  
Austria

Tel: +43 7712 5311 0

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Logitech Ltd is a leading designer and manufacturer of high-precision cutting, lapping, polishing and CMP equipment enabling high-specification surface finishes to be prepared with precise geometric accuracy.

**Oxford Instruments Plasma Technology**

(see section 6 for full contact details)

**Plasma-Therm LLC**

(see section 6 for full contact details)

**Power + Energy Inc**

(see section 10 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](http://www.samcointl.com)

**SPP Process Technology Systems Ltd**

Imperial Park, Newport NP10 8UJ,  
Wales, UK

Tel: +44 (0)1633 652400

Fax: +44 (0)1633 652405

[www.spp-pts.com](http://www.spp-pts.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](http://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**

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Cambridge CB3 8SQ, UK

Tel: +44 (0)1954 786800

Fax: +44 (0)1954 786818

[www.cambridge-fluid.com](http://www.cambridge-fluid.com)

**CS CLEAN SYSTEMS AG**

Fraunhoferstrasse 4,  
Ismaning, 85737,  
Germany

Tel: +49 89 96 24 00 0

Fax: +49 89 96 24 00 122

[www.cscleansystems.com](http://www.cscleansystems.com)

**Power + Energy Inc**

106 Railroad Drive,  
Ivyland, PA 18974, USA

Tel: +1 215 942-4600

Fax: +1 215 942-9300

[www.powerandenergy.com](http://www.powerandenergy.com)

**SAES Pure Gas Inc**

4175 Santa Fe Road,  
San Luis Obispo, CA 93401,  
USA

Tel: +1 805 541 9299

Fax: +1 805 541 9399

[www.saesgetters.com](http://www.saesgetters.com)

## 11 Process monitoring and control

**k-Space Associates Inc**

2182 Bishop Circle  
East, Dexter,  
MI 48130, USA

Tel: +1 734 426 7977

Fax: +1 734 426 7955

[www.k-space.com](http://www.k-space.com)



k-Space Associates Inc specializes in in-situ, real-time thin-film process monitoring tools for MBE, MOCVD, PVD, and thermal evaporation. Applications and materials include the research and production line monitoring of compound semiconductor-based electronic, optoelectronic, and photovoltaic devices.

## KLA-Tencor

One Technology Dr,  
1-22211, Milpitas,  
CA 95035,  
USA  
Tel: +1 408 875 3000  
Fax: +1 408 875 4144  
[www.kla-tencor.com](http://www.kla-tencor.com)

## LayTec AG

Seesener Str.  
10-13,  
10709 Berlin,  
Germany  
Tel: +49 30 39 800 80 0  
Fax: +49 30 3180 8237  
[www.laytec.de](http://www.laytec.de)



LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

## Optical Reference Systems Ltd

OpTIC Technium,  
St Asaph Business Park,  
St Asaph, LL17 0JD,  
UK  
Tel: +44 (0)1745 535 188  
Fax: +44 (0)1745 535 186  
[www.ors-ltd.com](http://www.ors-ltd.com)

## WEP

(Ingenieurbüro Wolff  
für Elektronik- und  
Programmentwicklungen)  
Bregstrasse 90, D-78120  
Furtwangen im Schwarzwald,  
Germany  
Tel: +49 7723 9197 0  
Fax: +49 7723 9197 22  
[www.wepcontrol.com](http://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](http://www.bruker-axs.de)

## 13 Characterization equipment

### J.A. Woollam Co. Inc.

645 M Street Suite 102,  
Lincoln, NE 68508, USA  
Tel: +1 402 477 7501  
Fax: +1 402 477 8214  
[www.jawoollam.com](http://www.jawoollam.com)

### Lake Shore Cryotronics Inc

575 McCorkle Boulevard,  
Westerville, OH 43082,  
USA  
Tel: +1 614 891 2244  
Fax: +1 614 818 1600  
[www.lakeshore.com](http://www.lakeshore.com)

## 14 Chip test equipment

### Keithley Instruments Inc

28775 Aurora Road,  
Cleveland, OH 44139,  
USA  
Tel: +1 440.248.0400  
Fax: +1 440.248.6168  
[www.keithley.com](http://www.keithley.com)

### SUSS MicroTec Test Systems

228 Suss Drive,  
Waterbury Center, VT 05677,  
USA  
Tel: +1 800 685 7877  
Fax: +1 802 244 7853  
[www.suss.com](http://www.suss.com)

## 15 Assembly/packaging materials

### ePAK International Inc

4926 Spicewood Springs Road,  
Austin, TX 78759, USA  
Tel: +1 512 231 8083  
Fax: +1 512 231 8183  
[www.epak.com](http://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](http://www.gelpak.com)

## Wafer World Inc

(see section 3 for full contact details)

## Williams Advanced Materials

2978 Main Street,  
Buffalo, NY 14214, USA  
Tel: +1 716 837 1000  
Fax: +1 716 833 2926  
[www.williams-adv.com](http://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](http://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](http://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](http://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](http://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](http://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](http://www.compoundsemi.co.uk)

### United Monolithic Semiconductors

Route departementale 128,  
BP46, Orsay, 91401,  
France

Tel: +33 1 69 33 04 72

Fax: +33 169 33 02 92

[www.ums-gaas.com](http://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](http://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](http://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](http://www.ansoft.com)

### Crosslight Software Inc

121-3989 Henning Dr.,  
Burnaby, BC, V5C 6P8,  
Canada

Tel: +1 604 320 1704

Fax: +1 604 320 1734

[www.crosslight.com](http://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](http://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](http://www.ClassOneEquipment.com)

### Brumley South Inc

422 North Broad Street,  
Mooresville,  
NC 28115,  
USA

Tel: +1 704 664 9251

Fax: +1 704 664 9246

[www.brumleysouth.com](http://www.brumleysouth.com)

As an ISO 9001 registered global leader in the remanufacturing of wafer inspection systems, Brumley South Inc specializes in designing, installing and supporting upgrades for ADE, Nanometrics, Dryden and KLA-Tencor Surfscan tools, polysterene



latex sphere calibration standards, particle deposition systems, and semiconductor parts and service.

## 23 Services

### Henry Butcher International

Brownlow House, 50-51

High Holborn,  
London WC1V 6EG,  
UK

Tel: +44 (0)20 7405 8411

Fax: +44 (0)20 7405 9772

[www.henrybutcher.com](http://www.henrybutcher.com)

### M+W Zander Holding AG

Lotterbergstrasse 30,  
Stuttgart,  
Germany

Tel: +49 711 8804 1141

Fax: +49 711 8804 1950

[www.mw-zander.com](http://www.mw-zander.com)

## 24 Consulting

### Fishbone Consulting SARL

8 Rue de la Grange aux Moines,  
78460 Choisel,  
France

Tel: + 33 (0)1 30 47 29 03

E-mail: [jean-luc.ledys@neuf.fr](mailto:jean-luc.ledys@neuf.fr)

## 25 Resources

### SEMI Global Headquarters

3081 Zanker Road,  
San Jose, CA 95134, USA

Tel: +1 408 943 6900

Fax: +1 408 428 9600

[www.semi.org](http://www.semi.org)

### Yole Développement

45 rue Sainte Geneviève,  
69006 Lyon,  
France

Tel: +33 472 83 01 86

[www.yole.fr](http://www.yole.fr)

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**7–10 October 2012**

## International Semiconductor Laser Conference (ISLC)

San Diego Mission Valley Marriott, CA, USA

**E-mail:** [m.hendrickx@ieee.org](mailto:m.hendrickx@ieee.org)

[www.photonicsconferences.org](http://www.photonicsconferences.org)

**7–12 October 2012**

## 222nd Electrochemical Society (ECS) Meeting

Hawaii Convention Center, Honolulu, Hawaii, USA

**E-mail:** [meetings@electrochem.org](mailto:meetings@electrochem.org)

[www.electrochem.org/meetings/biannual/fut\\_mtgs.htm](http://www.electrochem.org/meetings/biannual/fut_mtgs.htm)

**9–11 October 2012**

## SEMICON Europa 2012

Messe Dresden, Germany

**E-mail:** [eweller@semi.org](mailto:eweller@semi.org)

[www.semiconeuropa.org](http://www.semiconeuropa.org)

**14–17 October 2012**

## IEEE Compound Semiconductor Integrated Circuit Symposium (CSICS 2012)

Hyatt Regency Hotel, La Jolla, CA, USA

**E-mail:** [customer.service@ieee.org](mailto:customer.service@ieee.org)

[www.csics.org](http://www.csics.org)

**14–17 October 2012**

## 29th North American Conference on Molecular Beam Epitaxy (NAMBE 2012)

Evergreen Marriott, Stone Mountain Park, GA, USA

**E-mail:** [della@avs.org](mailto:della@avs.org)

[www2.avs.org/conferences/nambe/2012](http://www2.avs.org/conferences/nambe/2012)

**15–16 October 2012**

## 4th Concentrated Photovoltaic Summit (CPV USA 2012)

San Jose, CA, USA

**E-mail:** [register@pv-insider.com](mailto:register@pv-insider.com)

[www.pv-insider.com/cpv](http://www.pv-insider.com/cpv)

**14–19 October 2012**

## International Conference on Nitride Semiconductors (IWN2012)

Sapporo, Japan

**E-mail:** [secretary@iwn2012.jp](mailto:secretary@iwn2012.jp)

<http://iwn2012.jp>

**28–31 October 2012**

## 7th International Workshop on Modeling in Crystal Growth (IWMCG-7)

Grand Hotel Taipei, Taiwan

**E-mail:** [kennykang@tl.ntu.edu.tw](mailto:kennykang@tl.ntu.edu.tw)

<http://iwmcg7.ntu.edu.tw>

**29 October – 2 November 2012**

## 15th European Microwave Week (EuMW2012)

Amsterdam, The Netherlands

**E-mail:** [rvaughan@horizonhouse.co.uk](mailto:rvaughan@horizonhouse.co.uk)

[www.eumweek.com](http://www.eumweek.com)

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**1–2 November 2012**

**LEDforum Taipei 2012**

Taipei, Taiwan

**E-mail:** [christseng@trendforce.com](mailto:christseng@trendforce.com)

[www.trendforce.com/event](http://www.trendforce.com/event)

**5–7 November 2012**

**9th China International Exhibition and Forum on Solid State Lighting (China SSL 2012)**

Guangzhou, China

**E-mail:** [Chinassl.forum@gmail.com](mailto:Chinassl.forum@gmail.com)

[www.exhibition.sslchina.org/eng](http://www.exhibition.sslchina.org/eng)

**21–22 November 2012**

**Forum LED Europe**

Grande Halle de la Villette, Paris, France

**E-mail:** [info@forumled.com](mailto:info@forumled.com)

[www.forumled.com](http://www.forumled.com)

**28 November – 2 December 2012**

**2012 MRS Fall Meeting & Exhibit**

Boston, MA, USA

**E-mail:** [info@mrs.org](mailto:info@mrs.org)

[www.mrs.org](http://www.mrs.org)

**29 November 2012**

**LED Market: Updates & Forecasts seminar (EuroLED kicker event)**

Birmingham Science Park Aston, UK

**E-mail:** [info@euroled.org.uk](mailto:info@euroled.org.uk)

[www.euroled.org.uk](http://www.euroled.org.uk)

**6–7 December 2012**

**DGKK (German Association for Crystal Growth) Workshop 2012**

Erlangen, Germany

[www.dgkk.de](http://www.dgkk.de)

**10–12 December 2012**

**IEEE International Electron Devices Meeting (IEDM 2012)**

Hilton San Francisco, CA, USA

**E-mail:** [iedm@his.com](mailto:iedm@his.com)

[www.ieee-iedm.org](http://www.ieee-iedm.org)

**2–7 January 2013**

**SPIE Photonics West 2013**

Moscone Center San Francisco, CA, USA

**E-mail:** [customerservice@spie.org](mailto:customerservice@spie.org)

<http://spie.org/photonics-west.xml>

**12–14 February 2013**

**Strategies in Light 2013 Conference & Expo**

Santa Clara Convention Center, CA, USA

**E-mail:** [Tcarli@pennwell.com](mailto:Tcarli@pennwell.com)

[www.strategiesinlight.com](http://www.strategiesinlight.com)

**24–28 February 2013**

**SPIE Advanced Lithography 2013**

San Jose Convention Center and Marriott, CA, USA

<http://spie.org/advanced-lithography.xml>

**17–23 March 2013**

**Optical Fiber Communication Conference & Exposition (OFC 2013)**

Anaheim, CA, USA

**E-mail:** [info@ofcconference.org](mailto:info@ofcconference.org)

[www.ofcnfoec.org](http://www.ofcnfoec.org)

**17–18 March 2013**

**China Semiconductor Technology International Conference (CSTIC 2013)**

Kerry Hotel Pudong, Shanghai, China

**E-mail:** [kwu@semi.org](mailto:kwu@semi.org)

<http://semiconchina.semi.org/cstic>

**19–21 March 2013**

**SEMICON China 2013**

Shanghai New International Expo Centre (SNIEC), China

**E-mail:** [semichina@semi.org](mailto:semichina@semi.org)

[www.semiconchina.org](http://www.semiconchina.org)

**19–21 March 2013**

**LASER World of PHOTONICS CHINA**

Shanghai New International Expo Centre (SNIEC), China

**E-mail:** [laser@mmi-shanghai.com](mailto:laser@mmi-shanghai.com)

[www.world-of-photonics.net/en/laser-china/start](http://www.world-of-photonics.net/en/laser-china/start)

**29 April – 3 May 2013**

**SPIE Defense, Security, and Sensing 2013**

Baltimore Convention Center, Maryland, USA

<http://spie.org/defense-security-sensing.xml>

**12–17 May 2013**

**223rd Electrochemical Society (ECS) Meeting**

Toronto, Ontario, Canada

**E-mail:** [meetings@electrochem.org](mailto:meetings@electrochem.org)

[www.electrochem.org/meetings/biannual/fut\\_mtgs.htm](http://www.electrochem.org/meetings/biannual/fut_mtgs.htm)

**13 May 2013**

**JEDEC's 28th Annual ROCS (Reliability of Compound Semiconductors) Workshop**

Hilton New Orleans Riverside, New Orleans, LA, USA

**E-mail:** [ptanner@jedec.org](mailto:ptanner@jedec.org)

[www.jedec.org/home/gaas](http://www.jedec.org/home/gaas)

**13 May 2013**

**2013 CS MANTECH: International Conference on Compound Semiconductor Manufacturing Technology**

Hilton New Orleans Riverside, New Orleans, LA, USA

**E-mail:** [csmantech@csmantech.org](mailto:csmantech@csmantech.org)

[www.csmantech.org](http://www.csmantech.org)



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