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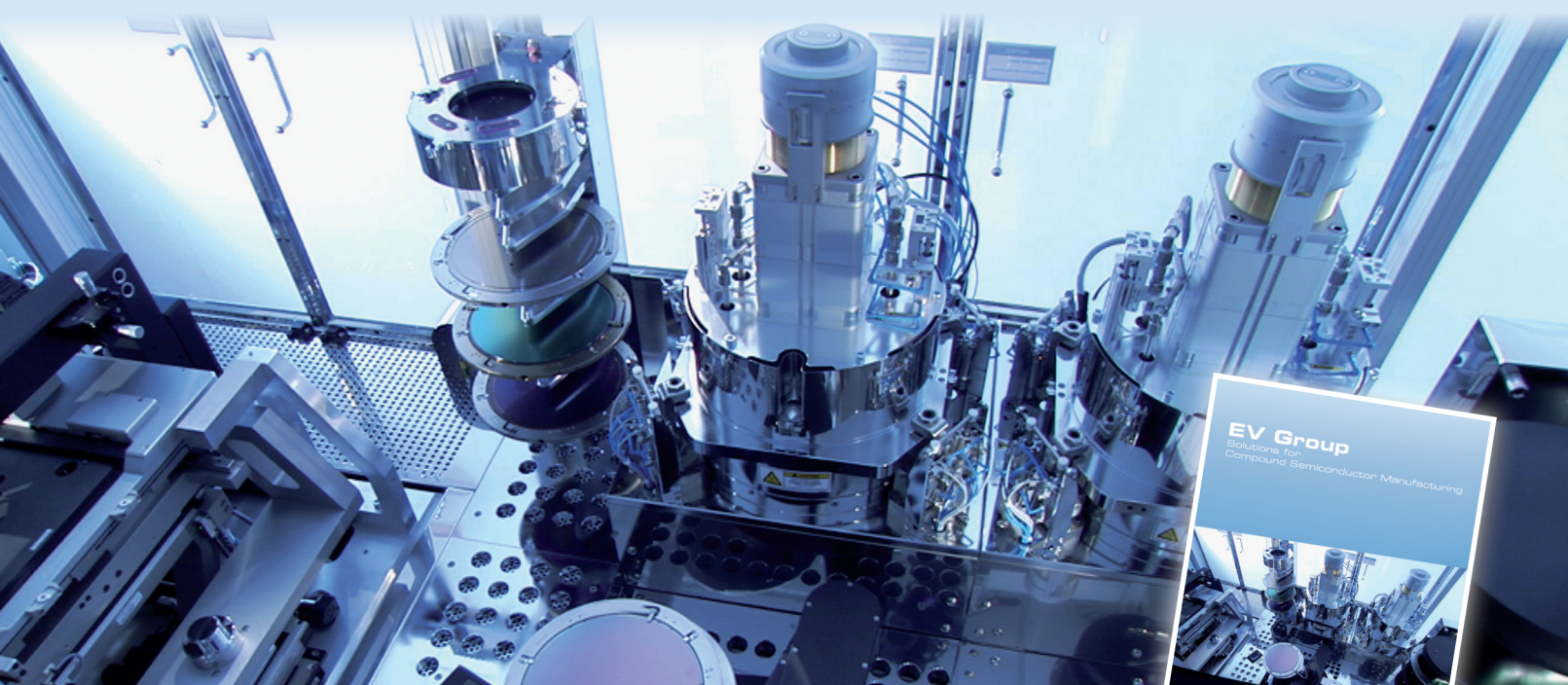
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# semiconductor**TODAY**

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. 9 • Issue 9 • November 2014

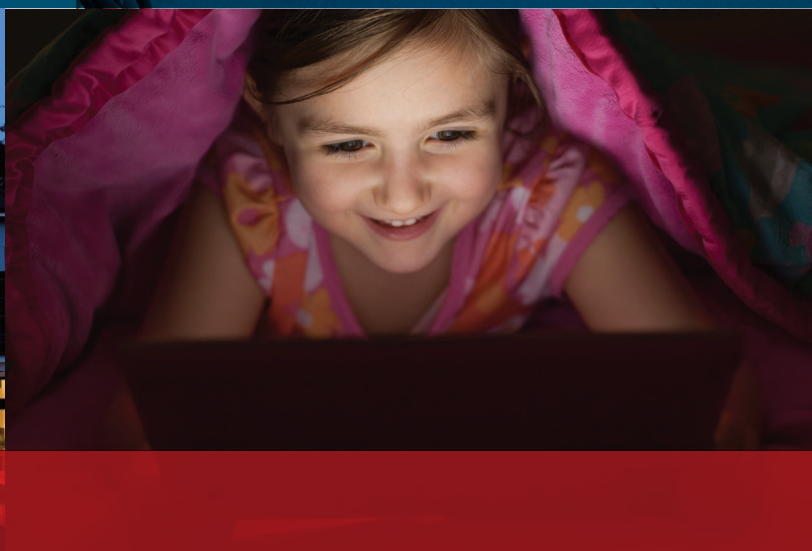
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## Next-generation MOCVD systems for GaN LED mass production



Record 147lm/W achieved for 530nm all-InGaN green LED •  
MACOM acquiring BinOptics • Ascent Solar raises \$35m





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

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

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

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

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

Contact us at [www.veeco.com/EPIK700](http://www.veeco.com/EPIK700) to learn more.



Veeco's New TurboDisc EPIK700 GaN MOCVD System

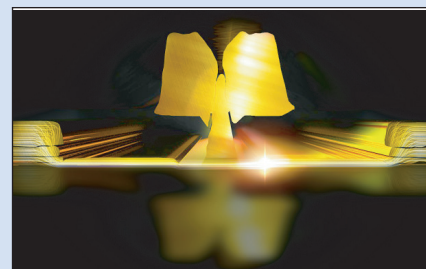
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## semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

Vol. 9 • Issue 9 • November 2014



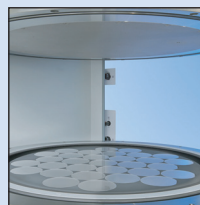
**p19** Chalmers University has shown how noise in a microwave amplifier is limited by self-heating at very low temperatures.



**p25** Toshiba has extended its SiC range with a 3300V, 1500A power module.



**p37** Veeco's new Propel Power GaN MOCVD system for developing power electronic devices.



Cover: Aixtron's new AIX R6 next-generation MOCVD system for GaN LED mass production system — launched at SSL CHINA 2014 — can be delivered in this 31x4"-wafer configuration, as well as 12x6" and 121x2"-wafer configurations.

**p39**



## GaN powers next generation

On pages 87–89 we give an overview on technology trends in the mobile wireless market such as the transition to 4G/LTE networks and the effects on the financial performance of RF device suppliers RFMD, TriQuint, Skyworks and Anadigics. Also, from September-quarter results on news page 8–15 it can be seen that Skyworks' revenue has grown a more-than-forecasted 50% year-on-year to \$718m (benefiting from its diversity in not just GaAs but also silicon wireless technology and "adjacent" markets). In contrast, RFMD and TriQuint have grown a mere 16.7% and 8% respectively to \$363m and \$272m. This makes a combined \$635m for RFMD and TriQuint (whose merger, as Qorvo is now to be finalized at end-December), i.e. less than Skyworks (which is now forecasting \$3bn for its next annual revenue, versus Qorvo's targeted \$2bn). Just a year ago, RFMD and TriQuint's combined revenue of \$562m was significantly greater than RFMD's \$477m. It was only in fiscal 2010 that Skyworks surpassed RFMD alone (exceeding \$1bn in annual revenue).

A driver for RFMD in forming Qorvo is TriQuint's filter technology (such as its LowDrift and now the new NoDrift filters, detailed on page 13), especially as average filter content in global LTE smartphones is now \$7.24 versus just \$0.25 in 2G. This compares with power amplifier content of \$0.30 in 2G but only \$3.25 in global LTE (less than a third of filter value) albeit supplemented by switching/tuning content of \$2.25. This is also why RFMD has acquired a controlling stake in Panasonic's Filter division and has begun volume production of 4G/LTE modules using proprietary TC-SAW filters (page 14).


Apart from its Mobile Product business, the other driver for Qorvo is its Infrastructure & Defense Products business, building on TriQuint's strengths for example in gallium nitride (GaN) wireless technology. Also in this issue, on pages 84–85, we include an article by one of the backers of GaN Systems stating the case for GaN in future power electronics devices. Indeed, Lux Research forecasts over 30% growth in both GaN and SiC to a combined 13% share of overall power electronics device revenues in 2024 (versus silicon's 87%) — see page 7. In fact, on page 37, we report Veeco's launch of its Propel Power single-wafer (200mm) GaN MOCVD system targeting development of GaN-based power electronic devices.

In September, Veeco launched its EPIK700 MOCVD system for volume production of GaN LEDs (accommodating 31x4"-, 12x6" or 6x8" wafers). Now, at November's SSL CHINA event, rival Aixtron has launched its AIX R6 12x6"/31x4"/121x2"-wafer GaN LED production MOCVD system (page 39).

Such 'next generation' MOCVD systems are being banked on by both Aixtron and Veeco to revive their fortunes, as LED makers' fab utilization rates rise and capacity expansions boost orders following the hiatus pending launch of the new systems. In Q3/2014, Veeco reported MOCVD orders up 23% year-on-year (to their highest since Q3/2011), driving a return to EBITDA profitability in Q4/2014, while September's acceptance by Taiwan's Epistar of the EPIK700 should boost orders in first-half 2015 (see page 36). Likewise, although Aixtron's losses worsened in Q3/2014 due to the costs of the AIX R6 launch, in September Aixtron received its largest ever multiple tool order from San'an Optoelectronics (China's largest LED maker) for 50 next-generation MOCVD systems (for delivery starting in Q4) — see page 38 — helping to recoup the increased R&D expenses from product development.

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**semiconductorTODAY**  
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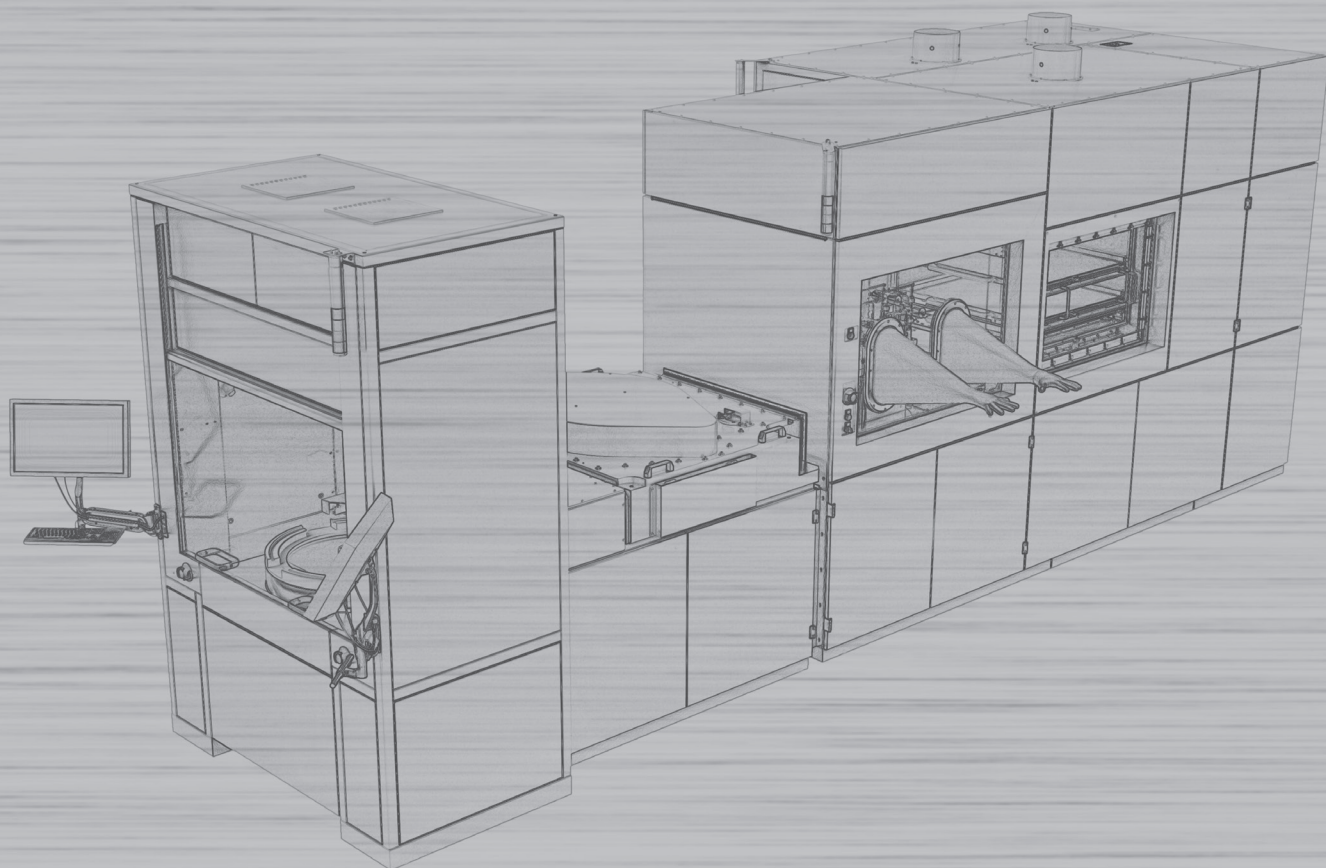
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# DISCOVER AIX R6



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# LED lighting to grow to \$25.7bn in 2015 as penetration of lighting market reaches 31%

Europe to comprise 23%, China 21%, USA 19% and Japan 9% of LED lighting market

The global LED lighting market will reach \$25.66bn and its market penetration will rise to 31% in 2015 as the overall lighting market grows to \$82.1bn, according to a report by LEDinside, a division of Taiwan-based market intelligence firm TrendForce.

Despite its lack of large-scale subsidies for LED lighting users, Europe is the largest LED lighting market, comprising 23% of the LED lighting market says LEDinside assistant manager Joanne Wu. She adds that in Europe (where electricity prices are high) demand for LED lighting for commercial and architectural lighting applications is increasing.

China comprises 21% of the overall LED lighting market. As the manufacturing base of most LED lighting producers, China has a complete LED supply chain and many cost advantages, says the report. Traditional lighting manufacturers, lighting OEMs, emerging LED lighting manufacturers, and LED packaging manufacturers are all expanding their LED lighting businesses. This year, developing viable channel distribution is a top priority for vendors in China, says LEDinside. Looking ahead to 2015, the lighting market in China should continue to grow due to stable demand for lighting. However, since the market is highly competitive and there is little variation in product quality between different manufacturers, vendors will compete mainly on price, making the proba-

bility of a price war high, says Wu. At the same time, without proper distribution channels, manufacturers will be forced to exit the market, she adds.

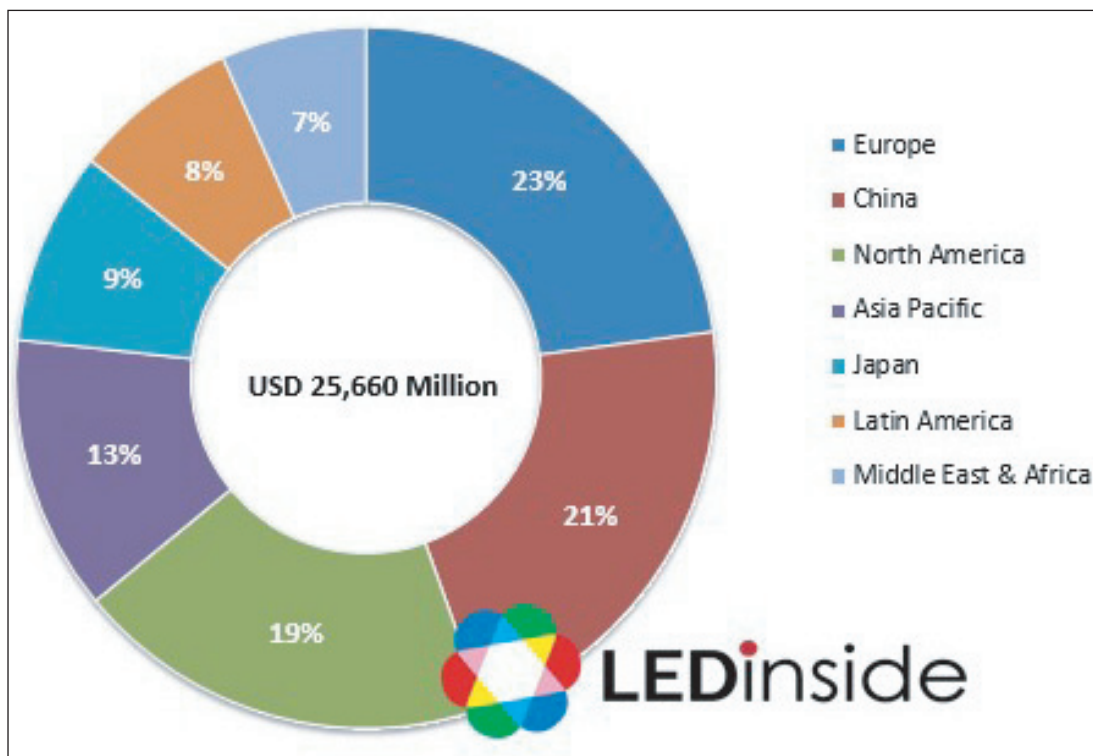
The USA comprises 19% of the overall LED lighting market. Currently, there is a push in the industry to obtain certification from the US Environmental Protection Agency (ENERGY STAR) and US-based non-profit organization DesignLights Consortium (DLC). Firms that receive certification from these organizations are eligible for subsidies from local utilities providers. Additionally, LED lighting product quality is improving, aiding US growth of commercial LED lighting. The fastest-growing segment is light tubes.

Japan comprises just 9% of the

global LED lighting market. Indeed, the Japanese LED lighting market is relatively mature. LED commercial lighting is already common in Japan's schools, hospitals and retail chain stores. Still, the outdoor and industrial LED lighting segments have considerable potential to expand, reckons the report.

The remaining 28% of the global LED lighting market consists of emerging markets, including Asia Pacific (13%), Latin America (8%) and the Middle East & Africa (7%). Looking ahead to 2015, growth prospects in these markets are especially promising due to rapid population growth, favorable government policies and an abundance of private-sector LED lighting projects, concludes the report.

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



LED lighting market in 2015, by region.

# Power electronics discrete component market to grow 77% to \$23bn in 2024

**Silicon to retain 87% share, while SiC and GaN to grow 30% and 32% annually to 13% share**

The market for discrete power electronics components — used to convert and manage electricity in devices ranging from mobile phones to pumps and motors — will grow by 77% from \$13bn today to \$23bn in 2024, according to the report 'Sizing-up the \$23 Billion Discrete Power Electronics Market in 2024' (part of market analyst firm Lux Research Inc's Energy Electronics Intelligence service).

Silicon-based devices will remain the main technology of choice with an 87% share in 2024, but silicon carbide (SiC) and gallium nitride (GaN) technologies will be the fastest-growing (at 30% and 32% annually, respectively), gaining a combined share of 13%, forecasts Lux Research.

"As power demands in applications from consumer electronics to the power grid get more demanding,

silicon is running up against physical limits, offering opportunities for both SiC and GaN," says analyst Pallavi Madakasira, the lead author of the report.

"GaN is a direct threat to silicon, as it can replace silicon in many applications, while SiC transistors can actually create additional new opportunities for silicon in high-voltage applications that will use SiC and silicon components together," she adds.

Lux Research evaluated the market for discrete power electronics, assessing market drivers and diverse technologies. The findings include the following:

● **Tablet computers fuel growth.**

Consumer electronics and IT will account for 48% of the market in 2024 (about \$11bn). Consumer electronics make up most of this segment, rising from \$7bn in 2014

to \$10bn in 2024, driven by growth in low-power tablet computers as well as the ongoing popularity of mobile phones.

● **Transportation drives both SiC and GaN.** Worth nearly \$1.2bn in 2024, transportation applications will be the big driver for both SiC and GaN, account for 65% of the total market for SiC and 41% of the total market for GaN.

● **SiC adoption limited by price; GaN by availability.** Notwithstanding their high growth rates, SiC and GaN remain a small total share of the market. For SiC, high costs will make SiC transistors less viable in many applications, while GaN's adoption will be held back by delayed product roll-outs and capacity expansions, concludes Lux Research.

[https://portal.luxresearchinc.com/research/report\\_excerpt/18253](https://portal.luxresearchinc.com/research/report_excerpt/18253)

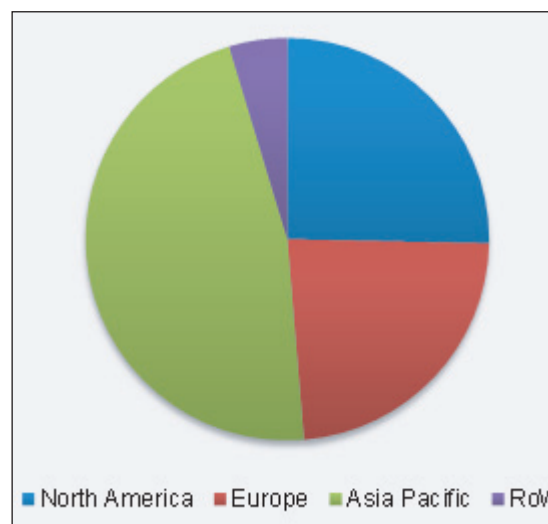
# Laser diode market growing at CAGR of 12.6%

**Market to grow from \$4.6bn in 2013 to \$10.26bn in 2020**

The laser diode market will rise at a compound annual growth rate (CAGR) of 12.6% from 2014 to 2020, according to the report 'Laser Diode Market — Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2014 – 2020' from Transparency Market Research. The market was valued at \$4.6bn in 2013 and is expected to be worth \$10.26bn by 2020.

The automotive segment accounted for 25.35% of the market in terms of revenue in 2013. That year saw market domination by feedback laser diode technology, with 23.2% market share, and infrared laser diode technology held the wavelength segments by 26.2%.

Laser diodes based on AlGaInP (aluminium gallium indium phosphide)



**Laser diode market revenue share, by geography (2013).**

led the market in 2013 due to their increasing preference in optical

discs, DVD players, laser pointers, and data communication devices. The report expects this segment to keep growing throughout the forecast period.

The report also divides the laser diode market according to applications in consumer electronics, industries, automobiles, medical, defense, healthcare, and others. Of these, the automotive segment dominated the market in 2013 because of the heavy use of laser diodes in engraving, lighting, molding and marking of automobile plastic in manufacturing plants, notes the report.

[www.transparencymarketresearch.com/laser-diode-market.html](http://www.transparencymarketresearch.com/laser-diode-market.html)



# Anadigics' revenue falls 19% in Q3/2014 due to decline in legacy Mobile business

**Losses improved due to ahead-of-target cost cutting; 8–12% revenue growth expected in Q4**

For third-quarter 2014, broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported revenue of \$18.9m, down 19% on \$23.3m last quarter and almost halving from \$37m a year ago.

Sales of Mobile products were \$8.8m (47% of total revenue), down 32% on \$13.1m (56% of total revenue) last quarter due to an expected decline in sales of legacy products plus inventory reductions in the sales channel, and down 69% on \$28.5m a year ago.

Sales of Infrastructure products were \$10m (53% of total revenue), down 2% on \$10.2m (44% of total revenue) last quarter due solely to inventory reductions in the distribution channel, but still up 18% on \$8.5m a year ago.

There were four greater-than-10% customers (Huawei, Samsung and the distributors Arrow Richardson and Alltech) and four customers in the 5-10% range (with a solid representation from Infrastructure). "We are pleased with the broader list of key customers resulting from the better balance between Mobile and Infrastructure," comments VP & chief financial officer Terry Gallagher.

Despite capacity utilization falling further (from 5-50% in Q1 and 35% in Q2 to about 30% in Q3), non-GAAP gross margin has risen by 321 basis points (exceeding the expected 200 basis points) from 12.8% last quarter to 16%, driven mostly by a more favorable mix of Infrastructure products plus expense reductions associated with the firm's restructuring (announced on 26 June).

Operating expenses have been cut by 18.6% (exceeding the targeted 15%) from \$10.7m last quarter to \$8.7m (with R&D expenses down 22.2% from \$6.7m to \$5.2m, and

selling & administrative expenses down 11.9% from \$3.9m to \$3.5m), reflecting the improvements outlined in the firm's combined \$25m cost-reduction initiative.

Hence, despite the drop in revenue, net loss has been cut further, from \$9.5m (\$0.11 per share) a year ago and \$7.8m (\$0.09 per share) last quarter to \$5.7m (\$0.07 per share). Likewise, earnings before interest, taxes, depreciation and amortization (EBITDA) loss has improved from \$5.9m a year ago and \$4.7m last quarter to \$3.2m.

After being cut from \$1.3m in Q4/2013 to \$400,000 in Q1/2014 then \$350,000 in Q2, capital expenditure has been cut further, to basically zero. As of 27 September, cash and cash equivalents totalled \$13.5m. However, after excluding \$4m drawn under the firm's credit facility, net cash was \$9.5m, down slightly from \$9.7m at the end of June. "This performance was driven by higher gross margins, lower operating expenses, and lower working capital requirements," says VP & chief financial officer Terry Gallagher. Anadigics also benefited from the sale of \$1.9m in surplus assets that are no longer strategic, more than offsetting restructuring payments of \$1.6m.

During Q3, inventories were reduced from \$18m to \$15.3m. "We anticipate bringing inventory down further during Q4, which will again lower working capital and cash usage," says Gallagher. In addition, Anadigics expects that, in Q4, additional asset sales will contribute cash in excess of restructuring cost. "We expect only a modest further reduction in net cash by year end," he adds.

"Anadigics has made tremendous progress during the last three months towards realizing both our financial and market goals," says

chairman & CEO Ron Michels. "Our new product launches have been very well received in their targeted markets, and have led us to enjoy a significant increase in customer engagements and strategic design-win activity," he adds. During the quarter, Anadigics announced that its front-end integrated circuits (FEICs) are enabling Wi-Fi connectivity in LG's G3 Beat smart-phone and that its Wi-Fi solutions have been selected by a leading North American infrastructure manufacturer, while its small-cell power amplifiers have been selected by Nextivity. Anadigics also expanded its DOCSIS 3.1 CATV infrastructure portfolio and launched gallium nitride (GaN) line amplifiers with what were claimed to be the industry's highest output power levels. Also, in October, Anadigics introduced TD-LTE small-cell power amplifiers, and announced that its ProEfficient-Plus power amplifiers are being used in Samsung's GALAXY Note 4. "Due to these improvements, we believe we are on target to realize the strategic goals I outlined last June," says Michels.

For Q4/2014, Anadigics expects revenue to rise sequentially by 8–12%, due primarily to a seasonal increase in Mobile revenue. Driven by the increased sales and lower manufacturing costs, gross margin is expected to improve by about 200 basis points, despite lower factory utilization due partly from a further inventory reduction (followed by further increases in gross margin in 2015 as the firm continues to improve product mix). Q4 operating expenses should be roughly flat sequentially, as incremental restructuring savings will be "prudently" used to fuel investments in Infrastructure R&D and sales. "Continued execution on our plan

► will further reduce our EBITDA loss by 25–30% in Q4,” Gallagher believes. “Consequently, we are anticipating only a modest reduction in our net cash during the quarter, driven by better financial performance and inventory reductions,” he adds. “Looking further down the road, we believe our new operating model will deliver EBITDA break-even at quarterly revenue well below \$25m.”

“We recently [on 24 October] closed with Silicon Valley Bank on a new, more flexible \$10m credit facility [replacing the previous \$11m credit

facility with PNC Bank] that, if needed, provides additional capital to fund growth,” Gallagher notes. “The new agreement does not include the compensating balance requirements we had with PNC and aligns with covenants with our strategic plan,” he adds. “We believe the improved cash efficiency of our new operating model, combined with existing net cash and the back-up of the new credit facility, provides us with the resources we need to realize cash-flow-positive operation.”

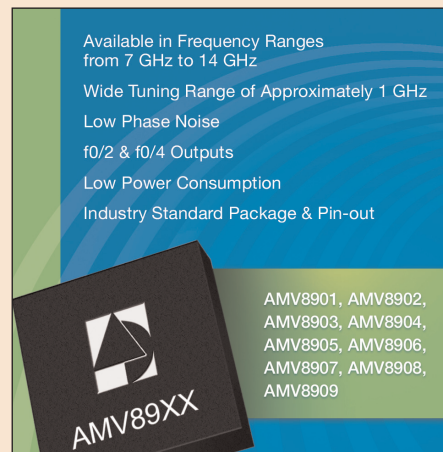
## Infrastructure product line expanded with VCOs for point-to-point wireless backhaul

Anadigics has launched a family of voltage-controlled oscillator (VCO) products, starting with the following:

- AMV8901 (7.3–8.2GHz);
- AMV8902 (7.8–8.8GHz);
- AMV8903 (8.4–9.6GHz);
- AMV8904 (9.0–10.2GHz);
- AMV8905 (9.5–10.8GHz);
- AMV8906 (10.4–11.6GHz);
- AMV8907 (11.1–12.5GHz);
- AMV8908 (11.5–12.7GHz); and
- AMV8909 (12.4–13.7GHz).

The new VCOs are optimized for point-to-point wireless backhaul networks, which provide reliable access to high-speed data and voice services without fiber-optic infrastructure connectivity. According to a recent report by market research firm iGR, the North American market for wireless backhaul metro-cells will rise at a compound annual growth rate (CAGR) of 146% over the next five years. Anadigics claims that its new VCOs offer outstanding output power and phase noise performance at the industry’s highest-order quadrature amplitude modulation (QAM).

“Point-to-point wireless backhaul networks solve the placement, zoning and construction challenges associated with traditional infrastructure equipment, which requires fiber-optic and telecom connectivity,” says Tim Laverick, senior VP of Infrastructure Products.



“By leveraging our advanced design capabilities and unique wafer process technologies, we have developed a new family of wireless infrastructure catalog products that expand our market reach into point-to-point applications,” he says, adding that the new VCOs enable stable, high-throughput connectivity in the newest generation of wireless backhaul devices.

Using Anadigics’ heterojunction bipolar transistor (HBT) process, the VCOs also feature integrated divide-by-2 and divide-by-4 with internal resonators in a compact 5mm x 5mm, 32-lead QFN package to reduce board-space requirements. An industry-standard pin-out with 5V and 220mA supply simplifies RF system design and speeds time-to-market, says the firm.

Samples of the new VCOs are available for qualified programs.

## IN BRIEF

### Anadigics’ front-end IC enabling WiFi connectivity in Huawei’s Ascend Mate 7 smartphone

Anadigics is shipping production volumes of its AWL9281 front-end integrated circuit (FEIC) to Huawei for the new Ascend Mate 7 which, with a 6.0-inch display, 2.9mm narrow bezel and 7.9mm ultra-thin metal body, is reckoned to be one of the most compact large-screen smartphones on the market.

This latest design win strengthens Anadigics’ long history of powering wireless connectivity in Huawei’s devices, says Jerry Miller, senior VP of worldwide sales & applications.

Anadigics’ family of WiFi FEICs leverages its patented InGaP-Plus technology and design architectures to combine a power amplifier (PA), low-noise amplifier (LNA) with bypass option, and SP3T Tx/Rx RF switch with Bluetooth on a single die. This level of integration greatly improves manufacturability and reliability, reduces PCB space requirements, and simplifies RF front-end design to speed time-to-market, says Anadigics.

The compact 2.5mm x 2.5mm x 0.4mm QFN package also incorporates a high-accuracy integrated power detector and RF ports internally matched to 50 Ohms to reduce PCB space requirements.

The AWL9281 FEIC provides what is claimed to be outstanding error vector magnitude (EVM) and noise figure performance, enabling high data throughput. The AWL9281 also delivers low current consumption, extending battery-life in mobile applications.

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



# RFMD quarterly revenue grows 14.7% to \$362.7m

## Revenue, gross profit, operating income & EPS all hit quarterly records

For its fiscal second-quarter 2015 (to 27 September 2014), RF Micro Devices Inc of Greensboro, NC, USA has reported record revenue of \$362.7m, up 14.7% on \$316.3m last quarter and 16.7% on \$310.7m a year ago.

"Revenue strength was broad-based and well diversified, and RFMD had two greater-than-10% customers," comments chief financial officer Dean Priddy.

Revenue for RFMD's Multi-Market Products Group (MPG) was \$64m, up 16% on \$55m both last quarter and a year ago (remaining about 17.5% of total revenue). Growth was supported primarily by high-performance Wi-Fi, 4G wireless infrastructure, and gallium nitride (GaN)-related revenue.

Revenue for RFMD's Cellular Products Group (CPG) was \$298m, up 14% on \$261m last quarter and \$255.4m a year ago (remaining about 82% of total revenue). During the quarter, CPG started shipping envelope tracking (ET) power management integrated circuits (PMICs) to a leading smartphone maker in support of multiple basebands. It also supported new customer engagements for RF Fusion, a complete RF front-end solution for 4G world phones and tablets. In particular, 3G/4G is now about 90% of CPG revenues (up from 80% in the December 2013 quarter) compared with under 10% for 2G.

"RFMD continued to benefit from the increasing global demand for mobile data," says president & CEO Bob Bruggeworth. "Consumers

want more bandwidth for their data-hungry applications, carriers want greater throughput from their available spectrum, and device manufacturers want greater functionality within the same product footprint," he adds.

On a non-GAAP basis, gross margin has risen from 36.2% a year ago and 47.1% last quarter to 48%. Operating expenses have rebounded from \$70m last quarter to \$73.8m (while dropping from 22% of revenue to 20.3%). The rise was driven by R&D expenses growing from \$42.6m to \$46.4m, while general & administrative (G&A) expenses of \$10.9m and sales & marketing expenses of \$16.5m remained level.

Net income has risen from \$33.9m (\$0.12 per diluted share) a year ago and \$71.3m (\$0.24 per diluted share) last quarter to \$90m (a record \$0.30 per diluted share).

Net cash flow from operating activities has risen further, from \$36.3m last quarter to \$58.7m. Purchases of property and equipment (capital expenditure) have almost doubled from \$9.8m to \$19.3m. Free cash flow has hence risen further, from \$26.5m to \$39.4m. During the quarter, cash, cash equivalents and short-term investments rose from \$197m to \$241.3m.

"RFMD's revenue, gross profit, operating income, and earnings per share were all quarterly records," says Dean Priddy, chief financial officer & VP of administration.

"RFMD is enjoying multiple diversified, long-term growth opportuni-

ties across markets, customers, and product categories," says Bruggeworth. "This is enabling RFMD to capture increasing content across a broad range of mobile data devices and outpace the growth rate of our underlying markets."

"In the December quarter, RFMD anticipates continued superior financial performance as we execute on our financial model," says Priddy. "Our growth drivers are broad-based, we are identifying new opportunities to expand gross margin, and we see continued improvement in operating income, earnings per share, free cash flow, and return on invested capital," he adds. For the December quarter, RFMD expects revenue of \$385m (up 6%), gross margin roughly flat sequentially, operating expenses to be roughly flat, and diluted EPS of about \$0.33. "The company has never been better-positioned for revenue growth greater than the industry, and EPS growth well ahead of our revenue growth," says Priddy.

On 5 September, shareholders of RFMD and TriQuint Semiconductor Inc voted in favor of the pending merger between RFMD and TriQuint (announced on 24 February).

In the meantime, at the request of customers, RFMD and TriQuint have executed multiple three-way non-disclosure agreements (NDAs) with leading smartphone makers. "We are working together to drive higher levels of functional integration, to help our customers accelerate products to market as early as next year," notes Bruggeworth.

## Merger between RFMD and TriQuint to close on 31 December

After approval by China's Ministry of Commerce, RFMD and TriQuint have received all necessary shareholder and regulatory approvals to move forward with their merger and have set 31 December as the anticipated closing date.

Trading in the common stock of the new combined firm Qorvo Inc is expected to start on the NASDAQ Global Select Market on 2 January under the ticker symbol 'QRVO'.

TriQuint shareholders will receive 1.675 shares of Qorvo and RFMD

shareholders will receive 1 share of Qorvo for each TriQuint or RFMD share held. At the closing of the transaction, the firm will execute a one-for-four reverse stock split.

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

## RFMD earns Huawei's Supplier of the Year Award

At a ceremony at Huawei's headquarters in Shenzhen, China, RF Micro Devices Inc of Greensboro, NC, USA has received Huawei's Supplier of the Year Award for the second consecutive year. The award recognizes RFMD as Huawei's best supplier of RF components, which are used in mobile phones and infrastructure products.

RFMD supplies Huawei Technologies Co Ltd (which manufactures smartphones and mobile devices)

with a growing suite of RF solutions including antenna switches and switch modules, power amplifiers, power management ICs, and Wi-Fi amplifiers for mobile devices as well as key components that support Huawei's wireless infrastructure and cellular backhaul business.

"RFMD was the only RF supplier to earn a Gold Medal from Huawei this year," notes Xiong Lening, Huawei's VP of supply chain management. "This award reflects RFMD's ability as a key strategic partner to pro-

vide Huawei innovative technology and products, outstanding local service and support, and excellent on-time delivery," he adds.

"This award is a tribute to the hard work of our global team and our ability to deliver industry-leading products in very high volume to support one of the fastest-growing companies in the world," comments RFMD's president & CEO Bob Bruggeworth.

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

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

## Ka-band HPA & BUC for single-carrier SatCom equipment

Analog Devices Inc (ADI) of Norwood, MA, USA (which provides ICs for analog and digital signal processing applications) has launched two Ka-band devices for use in single-carrier satellite communications equipment. The HMC7053 block upconverter and HMC7054 high-power amplifier (HPA) operate in the 29–31GHz frequency output range, feature –60dBc spurious-free dynamic range performance, and cover both commercial and military bands while meeting military environmental conditions.

The HMC7053 fully integrated Ka-band block upconverter (BUC) is upconverted to 29–31GHz at a linear output power of –30dBm to



5dBm. The 5.72" x 4.51" x 1.63" device (weighing 0.6lbs) features a 1–2GHz dual-input IF at 0dBm typical and 20dB conversion gain. The new module was designed with a dual upconversion scheme to ensure no phase inversion and maximum spurious rejection. Other

features include dual L-band inputs, an SMA input and a 2.9mm output connector, digital gain control and thermal monitoring and gain compensation.

The HMC7054 fully integrated Ka-band HPA achieves linear output power of 37dBm, a 42dB small-signal gain and operates at 5V while drawing 14 amps. The new 5.0" x 4.51" x 1.145" device (weighing 1.6lbs) has a 2.9mm input connector and WR28 waveguide output.

Both the block upconverter and HPA are designed for conduction cooling and operate over the –20°C to +80°C temperature range.

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

## MwT launches GaAs MMICs compatible with both epoxy and AuSn eutectic die attach

MicroWave Technology Inc (MwT) of Fremont, CA, USA, has launched a family of GaAs MMICs that are fully compatible with both epoxy and AuSn eutectic alloy die attach.

Many of the GaAs based MMIC products on the market can only use epoxy for die attach, says MwT, but certain commercial, military and high-reliability/space applications demand eutectic die attach, which provides improved electrical performance and thermal dissipation,

enhancing long-term reliability of the MMIC parts under operation.

MwT recently converted its key MMIC products to be compatible with both eutectic and epoxy die attach. In this unique device technology, a special non-wet metal layer is placed to the backside via holes regions to prevent the melted AuSn eutectic alloy from penetrating through the backside via holes and damaging features/circuits on the front side of the MMIC chip during die attach.

"This unique technology feature will allow our customers to utilize our high-performance GaAs-based MMIC products for applications that demand robustness and stringent long-term reliability," says general manager Dr Greg Zhou. "We have already had several key MMIC products with the eutectic die attachment compatibility designed into various sockets and have begun receiving the production orders."

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



# TriQuint's revenue grows a more-than-expected 18% in Q3 to a record \$272m, driven by 4G/LTE build-out

## CapEx increased to double filter capacity

For third-quarter 2014, RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported record revenue of \$272.1m, up 18% on \$230.8m last quarter and up 8% on \$250.8m a year ago. This was also well above the guidance of \$255–265m (up 4% year-on-year).

The end-market revenue split was 68% from Mobile Devices, 22% from Network Infrastructure, and from 10% Defense & Aerospace, compared with last quarter's 63% from Mobile Devices, 26% from Network Infrastructure, and 11% from Defense & Aerospace. The subcontract assembly firm Foxconn Technology Group accounted for 30% of total revenue (up from 25% last quarter).

Defense & Aerospace revenue was \$28.4m, up 7% on \$26.4m last quarter. "Similar to last quarter, we launched many new gallium nitride (GaN)-based products with continued strong customer interests," says president & CEO Ralph Quinsey.

Networks Infrastructure revenue was \$58.6m, down slightly on \$60m last quarter but still up 45% on \$40.4m a year ago. Of Networks Infrastructure revenue, the base-station market accounted for 44%, or \$25.6m, up 53% on \$16.7m a year ago, driven by the worldwide 4G LTE build-out. The transport market accounted for 43%, or \$25.4m, up 58% on \$16.1m a year ago. The transport market is expected to remain strong as TriQuint continues to accumulate key wins in next-generation designs.

Collectively, revenue for Infrastructure and Defense Products (IDP) was \$86.9m, flat sequentially but up 24% on a year ago. Growth in IDP came from solid execution coupled with strong demand for base-station products supporting the worldwide expansion of LTE (primarily in China). In IDP,

130 new products have been launched so far this year.

Mobile Devices revenue was \$185.2m, back above the \$180.8m a year ago (after falling as low as \$103.5m in Q1/2014) and up 28% on \$144.4m last quarter, due to a large product ramp at a major customer and continued strong demand (driven by filters) from a broad set of customers (primarily in China). After rapid revenue growth, there are now over 50 unique customers for discrete filter products.

Of Mobile Devices revenue, 4G/LTE was \$132m (up 49% on \$88.4m a year ago, rising from 49% of Mobile Devices revenue to 71% now), while 3G/2G was \$36.8m (down 46% on \$68.6m a year ago, falling from 38% of Mobile Devices revenue to 20% now) and WLAN was \$16.5m (down 30% on \$23.8m a year ago, falling from 19% of Mobile Devices revenue to 13% now).

"Our financial results in the third quarter were well above expectations due to strong demand and an improved product mix driven by a strategic focus on delivering high-performance solutions. Success we are seeing today is due to years of investment in BAW/SAW and high-performance GaAs/GaN

solutions in each of our markets," says Quinsey. "The success we are seeing today is due to years of investment in bulk acoustic wave/surface acoustic wave [BAW/SAW] and high-performance GaAs/GaN technologies."

On a non-GAAP basis, gross margin was 46.6%, up sharply from 41.7% last quarter and 38% a year ago (and above the guidance of 43–45%). "Active management of our portfolio highlighted by strong growth in our premium filter business and reductions in lower-margin revenue contributed to the dramatic improvement," says chief financial officer Steve Buhaly. "Efficient factory execution and the cost reductions taken earlier this year also contributed."

Operating expenses have risen further, from \$68.6m a year ago and \$72m last quarter to \$74.7m (above the expected \$70m). TriQuint hired additional premium filter designers and incurred higher costs for variable compensation.

Net income was a record \$51.4m (\$0.28 per diluted share, well above the guidance of \$0.23–0.25), up from \$23.6m (\$0.13 per diluted share) last quarter and \$26.3m (\$0.16 per diluted share) a year ago.

Cash flow from operations of \$47m plus cash proceeds from employee stock option exercises of \$28m was partially offset by capital expenditure being increased from \$21.3m last quarter to \$54.2m (almost entirely for premium filter capacity). During the quarter, total cash and investments hence rose by \$24.4m from \$223.5m to \$247.9m.

"We have made considerable progress transitioning away from low-margin and non-strategic foundry revenue while serving a growing demand for our higher-value products," says Quinsey. "Our improved financial performance is a result of many years of fundamental technology investment and product development in growth markets for premium filters, advanced GaAs/GaN products, and highly integrated solutions."

TriQuint achieved another record with 55 new products released in Q3. "These investments have positioned us for sustainable and profitable

► growth supporting long-term growth markets such as the build-out of the worldwide communications infrastructure, continued smartphone adoption, and the deployment of advanced electronics with critical defense applications," he adds.

"We continue to see robust demand and are raising our outlook for the fourth quarter," says Quinsey. "With strong demand in design-win momentum in place, I anticipate Q4 will also be a record quarter."

For fourth-quarter 2014, TriQuint expects revenue of \$330–340m, up 23% sequentially, with Network business relatively flat but growth in Defense & Aerospace and Mobile Devices. Gross margin should be 46–48%, driven by driven by product mix, better yields, and lower factory costs. Operating expenses are expected to be about \$75m. Capital expenditure should rise further to \$75–100m as the firm aligns its factories to keep pace with market demand by doubling

premium filter capacity across both BAW and TC-SAW. "These incremental investments will directly address an exciting set of market opportunities where we see intense customer interest," says Buhaly. Net income per diluted share should be \$0.40–0.45.

TriQuint is fully booked to the midpoint of Q4 revenue guidance, which would yield full-year 2014 revenue up about 14% on 2013's \$892.9m (specifically, in Mobile Devices, TriQuint now expects discrete filter revenue to more than triple on 2013 and MMPA [multi-mode, multi-band power amplifier] revenue to grow by about 30%). "Growth would be 28%, disregarding the \$100m headwind caused by our exit from low-margin and non-strategic foundry business," notes Quinsey. "Additionally our strategic investments, combined with solid operational excellence, is expected to push gross margin performance through a 14-year high in 2014, with more

margin upside and better-than-market growth anticipated in 2015."

TriQuint expects to maintain annualized base-station revenue of \$100m through 2015 and likely well into 2016 as carriers continue to build out their 4G LTE networks worldwide (with an estimated 1 billion subscribers, including India, eager to transition to LTE in broadband smartphones).

"Regarding our pending merger with RF Micro Devices to form Qorvo, we received overwhelming shareholder support [on 5 September] and expect to close once we complete final regulatory approvals prior to the end of the year," notes Quinsey. "Our time since the February announcement has been used constructively with significant progress being made by integration teams to ensure we maintain momentum into a successful launch of the company while creating a platform for strong ongoing business results as a combined entity."

## TriQuint's new NoDrift and LowDrift RF filter technologies target LTE coexistence challenges

### Temperature stability improved to reduce interference as frequency bands squeezed together

TriQuint says that its advances in filter technology are achieving what is claimed to be unmatched temperature stability. Specifically, the specialty LowDrift and NoDrift filters utilize the firm's proprietary technology processes to tackle some of the industry's toughest LTE interference challenges.

As more LTE frequency bands are squeezed next to existing bands worldwide to accommodate rapidly increasing mobile traffic usage, interference problems are rising significantly. Traditional filter technologies often are unable to meet the most challenging interference requirements, particularly for temperature-sensitive applications.

TriQuint says that it has developed fabrication processes that dramatically improve filter temperature

stability, resulting in less service disruptions, fewer dropped calls, and improved insertion loss and mobile device battery life. As the table shows, the firm's LowDrift technologies for surface acoustic wave and bulk acoustic wave (SAW and BAW) filters decrease temperature drift significantly, and its newest NoDrift technologies can virtually eliminate it.

"As temperature stability becomes a more critical filter performance factor, TriQuint's NoDrift and LowDrift filter processes solve band coexistence problems which our customers are unable to address with any other technology," says Sean Riley, TriQuint's VP of Mobile Products. "We plan to expand our premium filter portfolio significantly in the months ahead

as we continue to capitalize on the need for highly specialized filtering solutions and drive higher addressable content opportunities."

Analysts are predicting that demand for high-performance filters will rise even further as LTE deployments accelerate worldwide. "We expect premium filter sales to continue to out-strip expectations near-term and, with less than 10% of world subscribers on LTE, peak filter demand remains years away," comments Edward Snyder, managing director of Charter Equity Research.

TriQuint says its premium filters are supporting more than 50 unique customers worldwide and have garnered multiple reference design wins with all major chipset providers.

[www.triquint.com/products/lowdrift-nodrift-filters](http://www.triquint.com/products/lowdrift-nodrift-filters)



# Skyworks' quarterly revenue grows 22% to record \$718m

## Year-on-year growth of 50% targets \$3bn annually & 50% gross margin

For its fiscal fourth-quarter 2014 (to 3 October), Skyworks Solutions of Woburn, MA, USA (which makes analog and mixed-signal semiconductors) has reported revenue of \$718.2m, up 22% on \$587m last quarter and 51% on \$477m a year ago. This exceeds the original guidance (given on 17 July) of \$680m (up 16% sequentially and 43% year-on-year).

Of total revenue, power amplifiers represented 36% (down from 41% last quarter), integrated mobile systems 39% (up from 33%) and broad markets 25% (compared with 26%).

Growth was healthy across all product categories, but the strongest was integrated mobile systems (which includes Skyworks' integrated systems portfolio as well as mobile analog products such as power management, Wi-Fi and GPS). The broad markets product lines (which serve the Connected Home, networking, media, automotive and medical markets) have grown by more than 30% over the course of fiscal 2014, significantly outpacing the broader semiconductor industry, says the firm.

During fiscal Q4, Skyworks began volume production of custom 4G/LTE modules leveraging proprietary TC-SAW filter technology; delivered switching and connectivity modules for Xiaomis Mi3 platform; ramped analog control ICs at GoPro for action video cameras; and supported Rockwell Collins with custom ASICs for GPS applications in avionics platforms. Design wins also included: multiple diversity receive modules at a Tier 1 LTE smartphone maker; providing a suite of devices for Netgear's latest Nighthawk X6 tri-band WiFi 802.11ac router; enabling ZigBee-based thermostat and lighting platforms at GE and iControl; and capturing short-range communications sockets at General Motors for vehicle-to-vehicle collision avoidance systems. Skyworks also

introduced low-power Bluetooth solutions for Tile Inc's item location applications, and it has expanded wearable designs (including connectivity modules for three new Smartwatch programs).

"Skyworks is aggressively executing on our strategy to deliver sustainable, above-market growth with diversified analog semiconductor returns," says chairman & CEO David J. Aldrich. "Our advanced solutions are at the heart of mobile connectivity and the Internet of Things, and are empowering exciting new applications spanning mobile payments, to streaming music services, to on-demand media," he adds. "Given our accelerating design-win momentum and deep product pipeline, we have never been better positioned to grow demonstrably faster than our addressable markets and, in turn, to deliver best-in-class financial returns," believes Aldrich.

On a non-GAAP basis, gross margin has risen from 44.4% a year ago and 45.4% last quarter to 45.9% (at the upper end of the 45.5–46% guidance range). This is despite operating expenses rising further, from \$87.5m last quarter to \$93.9m, with R&D expenses up from \$53.8m to \$58.2m and selling, general & administrative (SG&A) expenses up from \$33.7 to \$35.8m.

Operating income has risen further, from \$130.3m (operating margin of 27.3%) a year ago and \$179.1m (operating margin of 30.5%) last quarter to \$235.7m (operating margin of 32.8%).

**We expect margins to continue to trend positively over the course of fiscal 2015, as we leverage a higher mix of integrated systems, improve volume utilization and realize the benefits of our joint venture with Panasonic**

Likewise, net income has grown from \$121.2m (\$0.64 per diluted share) a year ago and \$160.8m (\$0.83 per diluted share) last quarter to \$216.1m (\$1.12 of per diluted share, above both the original guidance of \$1.00 and the revised guidance, given on 14 October, of \$1.08, due in the latter case to \$0.01 from better-than-expected operating results plus \$0.03 from a fiscal year-end tax benefit).

Cash flow generated from operations has risen from \$166m a year ago and \$199m last quarter to \$201m. Capital expenditure has more than doubled, from \$38m a year ago through \$68m last quarter to \$83m.

During the quarter, cash and cash equivalents fell from \$893.3m to \$806m. However, this was after Skyworks repurchased 875,000 shares of its common stock. Also, on 7 July the firm agreed to pay \$148.5m to acquire a 66% controlling stake in Panasonic's Filter division (with provisions to buy the remaining 34% about 2 years from now). "This venture makes Skyworks the performance leader in TC SAW (temperature-compensated surface acoustic wave) filters, with shipments approaching 100 million units per quarter, broadening our technology portfolio, enriching our systems capabilities and enhancing our financial returns," comments chief financial officer Donald W. Palette.

Skyworks' board of directors has also declared a quarterly cash dividend of \$0.13 per share (an 18% increase on last quarter's dividend), payable on 11 December.

Through its dividend plan and ongoing share repurchasing, Skyworks returned about \$200m to shareholders during fiscal 2014, representing 35% of free cash flow. "We continue to view in allocation of roughly 40% of free cash flow as an appropriate balance between internal investment for growth initiatives and shareholder returns," says Palette.

► For full-year fiscal 2014, revenue was a record \$2.29bn, up 28% on fiscal 2013's \$1.79bn. "Fiscal 2014 was a record year for Skyworks as we exceeded key metrics in each and every quarter and crossed the \$2bn revenue threshold," says Palette. Gross margin rose from 43.4% to 45.2%. Operating income grew by over 50%, from \$457m to \$687m, boosting operating margin from 25.5% to 30%. Net income was \$623.2m (\$3.24 per diluted share), up from fiscal 2013's \$423.5m (\$2.20 per diluted share). Cash flow generated from operations was \$773m, up from \$508m.

Free cash flow rose from \$384m to \$564m (the second consecutive year with free cash flow yield of nearly 8%).

For fiscal first-quarter 2015, Skyworks expects revenue of \$770m (up 7% sequentially and 52% year-on-year), the first quarter with an annualized revenue run rate over \$3bn. Gross margin should rise further, to 46.5%, yielding \$1.18 of diluted earnings per share. "Based on broad customer demand and crisp operational execution, we are now scaling to more than a \$3bn revenue run-rate with annualized non-GAAP earnings per

share approaching \$5.00," Palette notes.

"We expect margins to continue to trend positively over the course of fiscal 2015, as we leverage a higher mix of integrated systems, improve volume utilization and realize the benefits of our joint venture with Panasonic," says Palette. "As a result, of all these positive factors, we now recommend modeling at 52% drop-through of incremental revenue to the gross profit line for the remainder of fiscal 2015 and beyond," he told analysts at the firm's quarterly conference call.

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

## Skyworks announces new \$300m stock repurchase program

Skyworks Solutions says that its board of directors has authorized the repurchase of up to \$300m of the firm's common stock from time to time prior to 11 November 2016, on the open market or in privately negotiated transactions, in compliance with applicable securities laws and other legal requirements. The newly authorized stock repurchase program

replaces in its entirety the \$250m stock repurchase program that was approved by the board on 16 July 2013, and had \$63.9m of repurchase authority remaining.

The timing and amount of any shares that are repurchased will be determined by management based on its evaluation of market conditions and other factors. The repurchase program may be sus-

pending or discontinued at any time. Any repurchased shares will be available for use in connection with its stock plans and for other corporate purposes.

Skyworks currently expects to fund the repurchase program using its working capital. As of 3 October, the firm had cash and cash equivalents of about \$805.8m.

## Cavendish Kinetics raises \$7m to support RF MEMS tuner design wins for LTE smartphones

### Former TI and Anadigics executive Delfassy appointed to board

Cavendish Kinetics of San Jose CA, USA, which provides RF MEMS tuning solutions for mobile and wearable wireless devices, has closed a \$7m funding round, co-led by Tallwood Venture Capital and Wellington Partners, with participation from Qualcomm Ventures and other existing investors. The firm has also appointed Gilles Delfassy to its board of directors.

The funding will be used to support Cavendish's growing number of customer design wins, following its first commercial product launch earlier this year. The nubia Z7 LTE smartphone for China Mobile uses Cavendish's RF MEMS tuner to exceed China Mobile's radio per-

formance requirements for the 2GHz LTE frequency bands.

"The explosive growth of smartphones and wireless network traffic is driving the use of additional spectrum, which traditional smartphones cannot support efficiently," says CEO Paul Dal Santo.

"Cavendish's innovative RF MEMS solutions are dramatically improving smartphone connection speed and battery life over the entire LTE spectrum, resolving this conundrum," he claims. "The continued support of our investors and the addition of industry veteran Gilles Delfassy to our board is a strong endorsement of our roadmap and achievements thus far."

Delfassy began his career in the semiconductor and mobile/wireless industry with Texas Instruments, where he created and built the company's wireless business. He has also served as president & CEO of both GaAs RF device maker Anadigics Inc and ST-Ericsson.

"The wireless industry is beginning to push for better radio performance," comments Delfassy. "Cavendish solutions have the potential to disrupt the LTE RF component market by significantly improving signal strength, data throughput and battery life of mobile devices," Delfassy believes.

[www.cavendish-kinetics.com](http://www.cavendish-kinetics.com)



# Japan Fair Trade Commission approves Murata's acquisition of Peregrine Semiconductor

In August, Murata Electronics North America Inc, a subsidiary of Murata Manufacturing Co Ltd of Kyoto, Japan, agreed to acquire all outstanding shares of Peregrine Semiconductor Corp of San Diego, CA, USA that are not already owned by Murata, for \$12.50 per share in cash (a total transaction value of \$471m, or \$465m excluding Murata's existing holding).

Peregrine Semiconductor has now

announced that the Japan Fair Trade Commission has granted clearance for the proposed acquisition.

Peregrine's board of directors has established the close of business on 13 October as the record date for its special meeting of shareholders to consider and vote on, among other things, the proposed merger. The shareholder meeting is scheduled for 19 November. Peregrine

will file with the US Securities and Exchange Commission (SEC) definitive proxy materials related to the proposed merger as soon as reasonably practicable.

Completion of the merger remains subject to approval by Peregrine's shareholders and remaining regulatory approvals, but is expected during fourth-quarter 2014.

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

## GigOptix withdraws proposal to acquire GSI

GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical communications components for fiber-optic and wireless networks) has withdrawn its previous offer to acquire GSI Technology Inc of Sunnyvale, CA, USA — a provider of static random access memory (SRAM) products primarily incorporated in networking and telecoms equipment — for per-share consideration of \$6.50, consisting of (i) \$2.00 per share in cash, (ii) GigOptix common stock worth \$1.33 (based on the volume-weighted average price of GigOptix' common stock for the three trading days ending one day prior to the closing of the combination) and (iii) a special dividend of \$3.17 per share in cash payable by GSI.

"We were disappointed that, despite the fact that (i) our offer was in an amount equal in value per share to the price paid by GSI Technology in its recently completed Dutch auction tender offer, (ii) was at a substantial premium to GSI Technology's share price, (iii) offered, as we believe, a meaningful path to resolve the expensive litigations of GSI Technology, and (iv) represented, in our opinion, a compelling opportunity for its stockholders altogether (a number of whom tendered shares in the Dutch auction tender offer that were not repurchased), our offer

was dismissed without giving us the opportunity to discuss its merits directly with their board," comments GigOptix's chairman & CEO Dr Avi Katz. "Given the implementation by the GSI Technology board of directors, subsequent to our proposal, of an executive retention and severance plan which would result in members of the management of GSI Technology potentially receiving substantial cash payments in the event of an acquisition, and the continued reluctance of GSI Technology's board of directors to engage in substantive discussions with us despite GSI Technology's continued lackluster performance in the most recent quarter and public statements and what we believe is other outreach to GSI Technology by some of their stockholders following their most recent earnings announcement encouraging such engagement, we have now formally withdrawn our proposal to acquire all of the shares of GSI," he adds.

GigOptix first proposed the acquisition in a letter to GSI's board on 19 August. The firm says that it has reiterated this proposal on several occasions during

**We will consider any changed circumstances involving GSI, operational or economic, in determining whether to so engage**

the intervening three-month period, stating that it continued to seek a negotiated agreement with GSI, and would continue to explore all necessary steps to ensure that GSI's stockholders were provided with the opportunity to realize the value inherent in the proposal.

"It has been our sincere hope that we would be able to explore together a friendly combination of our two companies that would provide premium value to GSI Technology's stockholders and benefit its customers, representatives and associates around the world," says Katz. "We have not asked the GSI Technology board of directors to accept our proposed purchase price or to agree to sell GSI Technology, but only to sit down and discuss whether there might be a common basis for pursuing a transaction that we believe would be beneficial to all parties, including the stockholders of both companies. We are surprised by the unwillingness of the GSI Technology board of directors to do so," he adds.

"If in the future we are asked by GSI Technology or by its major stockholders to engage in discussions with GSI Technology, we will consider any changed circumstances involving GSI Technology, operational or economic, in determining whether to so engage, and on what terms we would be willing to do so."

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

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

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# Northrop Grumman sets record with terahertz IC amplifier

**DARPA-funded program raises record from 850GHz set in 2012**

Northrop Grumman Corp of Redondo Beach, CA, USA has developed the world's fastest integrated circuit amplifier, which has been recognized by Guinness World Records. The amplifier uses 10 transistor stages to reach an operating frequency of 1 trillion cycles per second (1 terahertz, or  $10^{12}$ Hz) — surpassing the firm's own record of 850 billion cycles per second (850GHz) set in 2012.

Researchers have long sought to exploit the terahertz high-frequency band lying between microwaves and infrared light waves in the electromagnetic spectrum, but have been unable to detect, process and radiate the necessary high-frequency signals without resorting to frequency translation or multiplication (hence the term 'terahertz gap').

Northrop Grumman's terahertz monolithic integrated circuit (TMIC) effectively bridges the gap by using a super-scaled 25nm gate-length indium phosphide (InP) high-electron-mobility transistor (HEMT) that measures at a gain of 10dB at 1THz and 9dB at 1.03THz. In comparison, existing smart-phones operate at 1–2GHz and wireless networks at 5.7GHz.

The circuit is the culmination of the firm's three-phase contract with the US Defense Advanced Research Projects Agency (DARPA) to demonstrate transistor-based electronics operating at frequencies of 670GHz, 850GHz and 1THz. All three milestones were completed by Northrop Grumman within five years.

"This breakthrough by the Northrop Grumman team could lead to revolutionary technologies such as high-resolution security imaging systems, improved collision-avoidance radar, communications networks with many



**Philip Robertson (center), representing Guinness World Records, presents the certificate for the fastest integrated circuit amplifier to (from left): Dr Dale Burton, sector VP & chief technology officer Northrop Grumman Aerospace Systems; DARPA director Dr Arati Prabhakar; DARPA's Terahertz Electronics program manager Dr Dev Palmer; and Northrop Grumman's Terahertz Electronics program manager Dr William Deal.**

times the capacity of current systems, and spectrometers that could detect potentially dangerous chemicals and explosives with much greater sensitivity," comments DARPA's Terahertz Electronics program manager Dr Dev Palmer.

Additional applications of the THz circuit could include atmospheric sensing, radio astronomy and medical imaging. It is also expected to improve system range, and to reduce the size, weight and power consumption of existing systems.

"A decade ago, there was no consensus in the scientific community whether an integrated circuit operating at 1 terahertz was technologically possible," says Northrop Grumman's Terahertz Electronics program manager Dr William Deal. "An interdisciplinary team of scientists and engineers worked together in scaling all facets

of our MMIC technology to enable this result," he adds. "Now, as a result of DARPA's investment in high-speed transistor processes, it will become routine to fabricate wafers containing thousands of terahertz integrated circuits."

DARPA has made strategic investments in terahertz electronics through its High Frequency Integrated Vacuum Electronics (HiFIVE), Sub-millimeter Wave Imaging Focal Plane Technology (SWIFT) and Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST) programs. Each program built on the successes of the previous program, providing the foundational research necessary for frequencies to reach the terahertz threshold. Northrop Grumman has partnered with DARPA on each program.

[www.northropgrumman.com/mps](http://www.northropgrumman.com/mps)  
[www.darpa.mil](http://www.darpa.mil)

# Noise in microwave amplifier limited by self-heating at low temperature

**InP transistors optimized by Chalmers for sensitive signal detection**

Researchers have demonstrated how noise in a microwave amplifier is limited by self-heating at very low temperatures (J Schlee et al, 'Phonon black-body radiation limit for heat dissipation in electronics', *Nature Materials*, 10 November: doi:10.1038/nmat4126). The research has been performed as part of a collaboration between Chalmers University of Technology in Sweden and the California Institute of Technology, together with co-authors from the University of Salamanca and Chalmers spin-off Low Noise Factory.

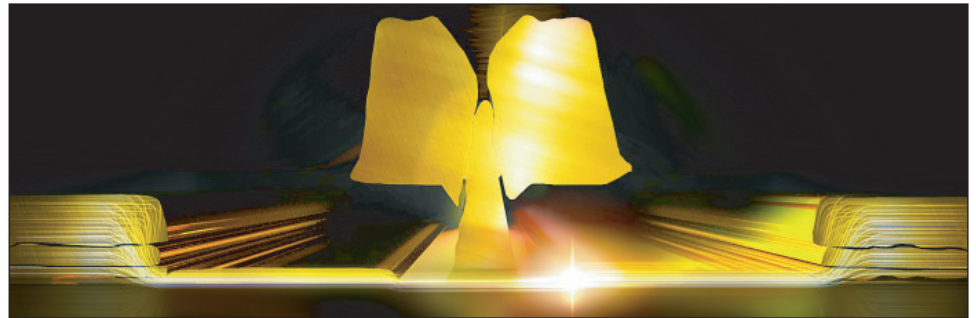
The findings could be important for future discoveries in areas of science such as quantum computers and radio astronomy, it is reckoned.

Many significant discoveries in physics and astronomy are dependent on registering a barely detectable electrical signal in the microwave regime (e.g. the discovery of cosmic background radiation that helped confirm the Big Bang theory, or the detection of data from scientific instruments in space missions en route to distant planets, asteroids or comets).

Faint microwave signals are detected by transistor-based low-noise amplifiers. Researchers at Chalmers have now optimized indium phosphide (InP) transistors using a special process for this purpose. Low Noise Factory designs and packages the amplifier circuits.

"Cooling the amplifier modules to  $-260^{\circ}\text{C}$  enables them to operate with the highest signal-to-noise ratio possible today," says Jan Grahn, professor of microwave technology at Chalmers. "These advanced cryogenic amplifiers are of tremendous significance for signal detection in many areas of science."

Combining measurements and simulations, the researchers investigated what happens when a



**Cross-sectional image of ultra-low-noise transistor. Electrons, accelerated in the high-mobility channel under the 100nm gate, collide and dissipate heat that fundamentally limits the noise performance of the transistor.**

**Illustration: Lisa Kinnerud and Moa Carlsson, Krantz NanoArt.**

microwave transistor is cooled to a tenth of a degree above absolute zero ( $-273^{\circ}\text{C}$ ). It was thought that noise in the transistor was limited by hot electrons at such extreme temperatures, but the study shows that noise is actually limited by self-heating in the transistor.

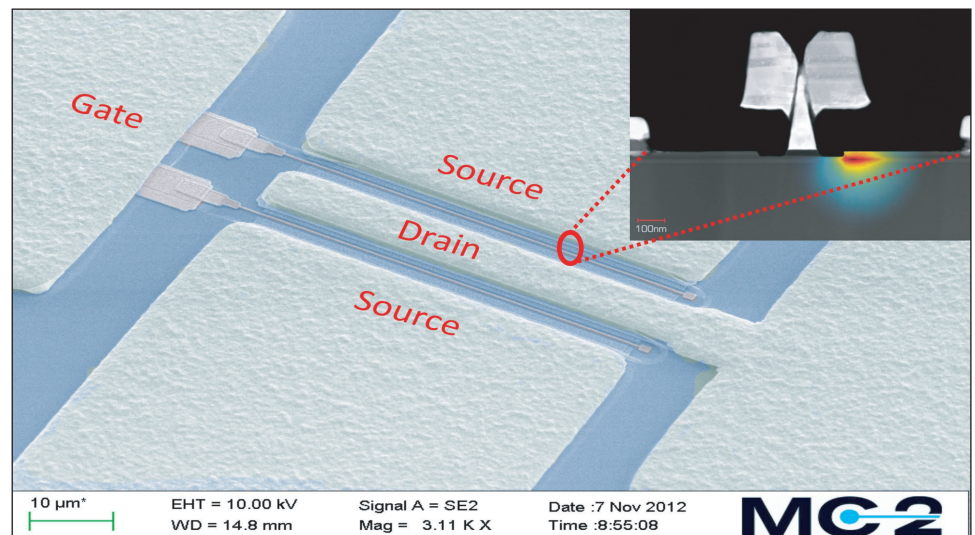
The self-heating is associated with radiation from phonons (quantum particles that describe the thermal conductivity of a material) at very low temperatures. The results of the study are based on experimental noise measurements and simulations of phonons and electrons in the transistor at low temperatures.

"The study is important for the fundamental understanding of how a transistor operates close to absolute zero temperature, and also how we should design even more sensitive low-noise amplifiers for future detectors in physics and astronomy," says Grahn.

The study was conducted at the Gigahertz Centre, a joint venture between Chalmers, research institutes, company partners, and the Swedish Governmental Agency for Innovation Systems (Vinnova).

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

[www.nature.com/nmat/journal/vaop/ncurrent/full/nmat4126.html](http://www.nature.com/nmat/journal/vaop/ncurrent/full/nmat4126.html)



**Electron microscope image of an InP HEMT. The region affected by the self-heating process is highlighted in the cross section.**



# North Carolina researchers transfer atomic-scale thin films to arbitrary substrates

## Transfer of molybdenum disulfide using room-temperature water, a tissue and tweezers targets flexible devices

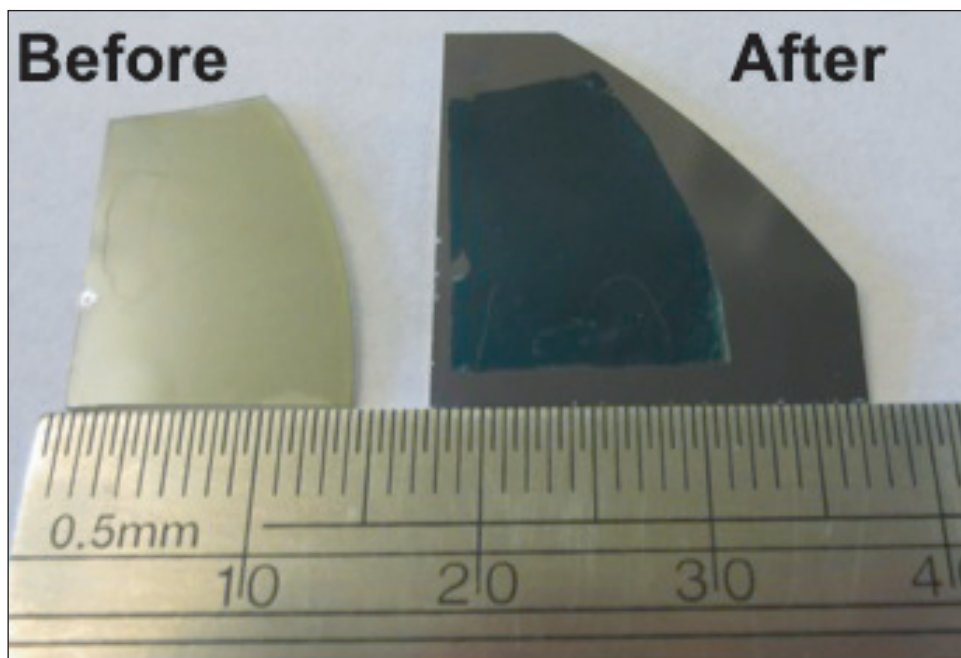
Researchers at North Carolina State University (NCSSU) and the University of North Carolina at Charlotte have developed a new way to transfer thin semiconductor films onto arbitrary substrates, paving the way for flexible computing or photonic devices ('Surface Energy-Assisted Perfect Transfer of Centimeter-Scale Monolayer and Fewlayer MoS<sub>2</sub> Films onto Arbitrary Substrates' published online on 27 October in ACS Nano; DOI: 10.1021/nn5057673.). The technique is much faster than existing methods and can transfer the atomic-scale thin films from one substrate to others without causing any cracks, it is claimed.

At issue are molybdenum sulfide (MoS<sub>2</sub>) thin films that are only one atom thick, first developed by Linyou Cao, an assistant professor of materials science and engineering at NCSU. MoS<sub>2</sub> is an inexpensive semiconductor material with electronic and optical properties similar to materials already used in the semiconductor industry.

"The ultimate goal is to use these atomic-layer semiconducting thin films to create devices that are extremely flexible, but to do that we need to transfer the thin films from the substrate we used to make it to a flexible substrate," says senior author Cao. "You can't make the thin film on a flexible substrate because flexible substrates can't withstand the high temperatures you need to make the thin film," he adds.

Cao's team makes MoS<sub>2</sub> films that are an atom thick and up to 5cm in diameter. The researchers needed to find a way to move that thin film without wrinkling or cracking it (challenging due to the film's extreme delicacy).

Existing techniques for transferring such thin films from a substrate



**Image of thin film on original growth substrate (left) and after being transferred (right). Photo credit: Linyou Cao.**

rely on chemical etching, but the chemicals involved in the process can damage or contaminate the film. Cao's team has developed a technique that takes advantage of the MoS<sub>2</sub>'s physical properties to transfer the thin film using only room-temperature water, a tissue and a pair of tweezers.

MoS<sub>2</sub> is hydrophobic and hence repels water. But the sapphire substrate that the thin film is grown onto is hydrophilic and attracts water. Cao's new transfer technique works by applying a drop of water to the thin film and then poking the edge with tweezers or a scalpel so that the water can begin to penetrate between the MoS<sub>2</sub> and the sapphire.

Once it has begun to penetrate, the water pushes into the gap, floating the thin film on top. The

**The ultimate goal is to use these atomic-layer semiconducting thin films to create devices that are extremely flexible,**

researchers use a tissue to soak up the water and then lift the thin film with tweezers and place it onto a flexible substrate. The whole process takes a couple of minutes, whereas chemical etching takes hours.

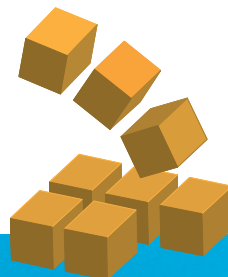
"The water breaks the adhesion between the substrate and the thin film — but it's important to remove the water before moving the film," Cao says. "Otherwise, capillary action would cause the film to buckle or fold when you pick it up," he adds.

"This new transfer technique gets us one step closer to using MoS<sub>2</sub> to create flexible computers," Cao adds. "We are currently in the process of developing devices that use this technology."

The research was funded by the US Army Research Office under grant number W911NF-13-1-0201 and the National Science Foundation (NSF) under grant number DMR-1352028.

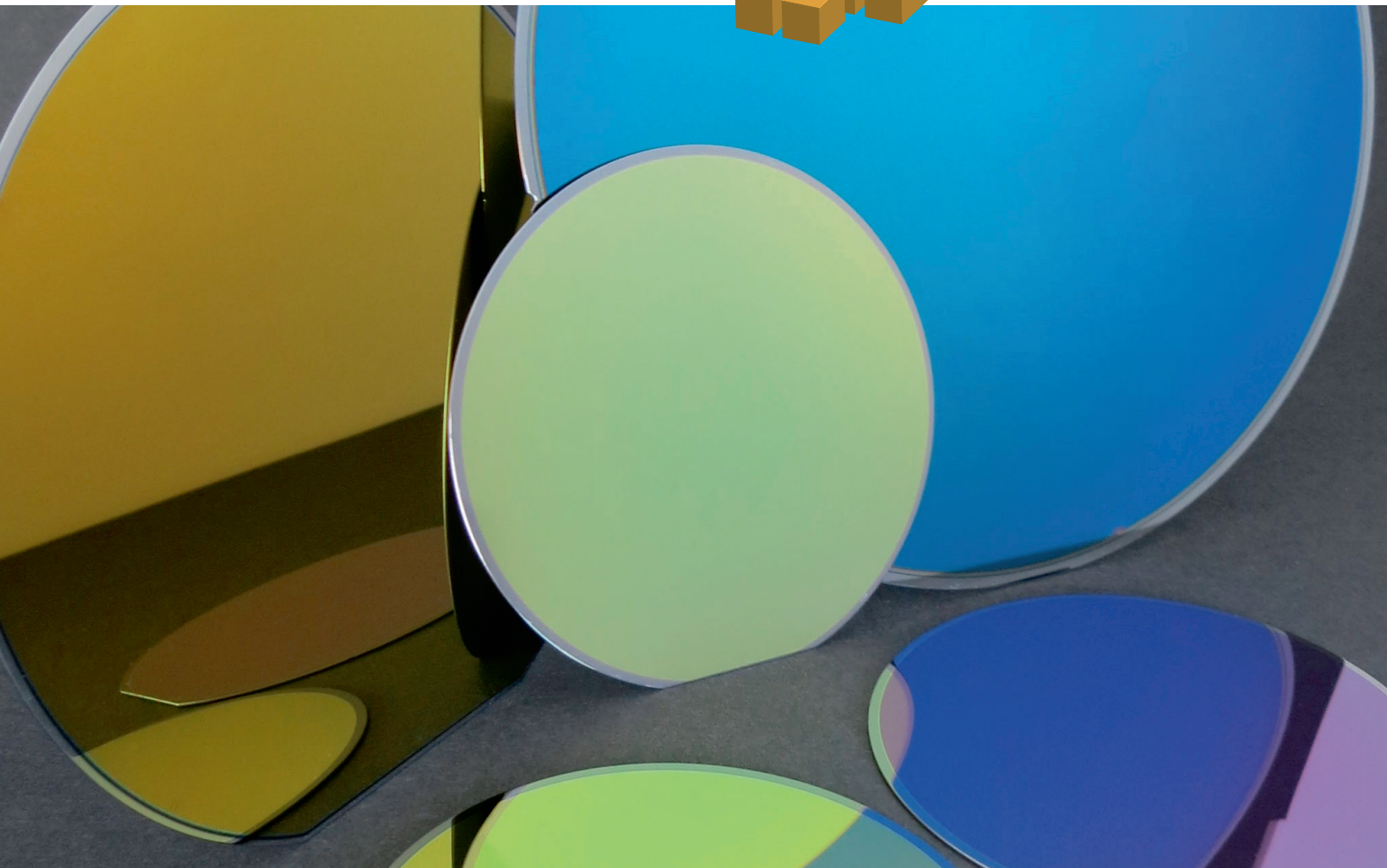
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# AKHAN announces exclusive patent licensing agreement with Argonne National Laboratory

## Intellectual property to accelerate the development and scalable manufacturing of diamond technology

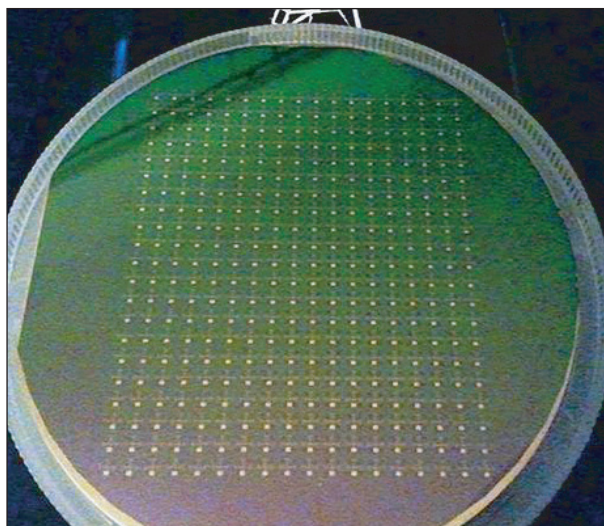
AKHAN Semiconductor Inc of Chicago, IL, USA and the US Department of Energy's Argonne National Laboratory have reached an exclusive licensing agreement on a patent portfolio that will provide AKHAN with the intellectual property to become a fully integrated semiconductor designer, developer and manufacturer.

AKHAN Semiconductor Inc was formed in 2012 as a subsidiary of AKHAN Technologies Inc, which was founded in 2007 by Adam Khan to commercialize Diamond Lattice Technology for diamond-based semiconductor devices.

The agreement covers the life of the patents, providing AKHAN with what it reckons to be a competitive advantage in becoming the first company to fully develop the entirety of the diamond semiconductor process, allowing full-scale commercialization across a wide range of commercial applications.

"This agreement gives us the exclusive rights to develop or license product lines that will serve faster supercomputers, advanced aviation and satellite technology, as well as develop superior radar communication and next-generation telecommunication technologies," says CEO & founder Adam Khan.

AKHAN will be able to exclusively expand the capabilities of the diamond semiconductor platform, allowing improved performance and thermal efficiency of existing silicon-based devices. The agreement should enable incorporation with other next-generation high-performance materials such as graphene, sapphire and quartz, which means greater market addressability and vertical integration of AKHAN's business and greater market serviceability for both existing and potential customers, the firm reckons.



**AKHAN Technologies' Miraj Diamond platform.**

The standalone patent portfolio covers critical semiconductor processes such as depositing a layer of polycrystalline diamond on a wafer, as well as doping. The portfolio also covers forming circuit elements such as transistors, capacitors and resistors (for connection into memory devices, logic devices and microprocessors etc). Finally, the patents cover the integration of electronic circuits fabricated on a single chip.

The agreement is the result of more than two years of collaboration between AKHAN Semiconductor

and Argonne National Laboratory. The company and researchers from Argonne's Center for Nanoscale Materials first collaborated on the development of the low-temperature diamond deposition technology as well as diamond semiconductor research that demonstrated improved current-carrying capability and dramatically reduced thickness. The agreements are also part of a public-private partnership model that national labs

have used to move research from the lab to market applications quickly.

"This agreement represents a stellar example of how Argonne is partnering with industry to move our technology into the marketplace," comments Argonne's director Dr Peter Littlewood. "The investment that the American people continue to make in basic science continues to pay dividends in marketable technologies that have the potential to transform entire industries."

The license agreement follows an announcement made by the State Governor's office in September that supported a proposed \$15m investment in northern Illinois by AKHAN Semiconductor. AKHAN will receive about \$3.5m in state investment support and has pledged to create 80 jobs in two years, with the potential for many more. AKHAN is currently expanding its domestic and international operations, and aims to use the funds to help relocate and expand its corporate and manufacturing headquarters in Illinois.



**AKHAN Technologies' founder Adam Khan. [www.akhantech.com](http://www.akhantech.com)**

# Silvaco joins Japan project on gallium oxide power devices

## Fundamental technologies for $\text{Ga}_2\text{O}_3$ to be established by 2018

Yokohama-based Silvaco Japan Co Ltd — a branch of Silvaco Inc of Santa Clara, CA, USA, a provider of technology computer-aided design (TCAD), circuit simulation and electronic design automation (EDA) software tools — has joined the cross-ministerial Strategic Innovation Promotion (SIP) program next-generation power electronics project 'Research and Development on Fundamental Technologies of Gallium Oxide Power Devices' promoted by New Energy and Industrial Technology Development Organization (NEDO). Other participants in the project include National Institute of Information and Communication Technology (NICT), Tamura Corp, Tokyo University of Agriculture and Technology, and New Japan Radio Co Ltd.

The NICT, Tamura Corp and KOHA Co Ltd have developed what is reckoned to be the first MOSFET

using the wide-bandgap semiconductor material gallium oxide. To promote gallium oxide as the next-generation power device material, the project included R&D ranging from the basic physical properties to the technologies for future industrial applications, such as bulk and thin-film crystal growth technology, device process technology and module technology. The project's target is to establish the fundamental technologies for gallium oxide power devices by 2018.

Transistors and diodes with  $\text{Ga}_2\text{O}_3$  are expected to have advantages in power device characteristics such as higher breakdown voltage, higher output and lower dissipation compared to traditional compound semiconductor devices. Moreover, it is theoretically possible with  $\beta\text{-Ga}_2\text{O}_3$  to create large-diameter single-crystalline substrates by the melt

growth method, at low energy and at low cost, enabling the production of bulk single crystal. It is reckoned that these characteristics will offer significant advantages for industrial applications.

"Silvaco has many years of experience in the development, sales and technical support of semiconductor process and device simulators," says Silvaco Japan's president Iliya Pesic. "Silvaco has key advantages in simulation technology for silicon and compound semiconductor power devices," he adds. "Silvaco's leading-edge technologies with proven performance in wide-bandgap semiconductors will enable it to make a significant contribution to the project."

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

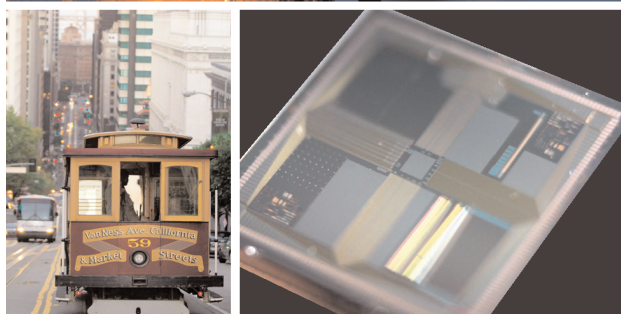
[www.nict.go.jp](http://www.nict.go.jp)

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## GeneSiC releases gate driver evaluation board and SPICE models for SiC junction transistors

Silicon carbide (SiC) power semiconductor supplier GeneSiC Semiconductor Inc of Dulles, VA, USA has announced availability of a gate driver evaluation board and has expanded its design support for its SiC junction transistor (SJT, claimed to be the industry's lowest-loss switches) with a fully qualified LTSPICE IV model.

Using the gate driver board, power conversion circuit designers can verify the benefits of the sub-15ns temperature-independent switching characteristics of SiC junction transistors, with low driver power losses. Incorporating the new SPICE models, circuit designers can evaluate what are claimed to be the SJT's benefits in achieving a higher level of efficiency than is possible with conventional silicon power switching devices for comparably rated devices.

SiC junction transistors have significantly different characteristics compared with other SiC transistor technologies as well as silicon transistors. Gate driver boards that

can provide low power losses while still offering high switching speeds are needed to provide drive solutions for utilizing the benefits of SiC junction transistors, says GeneSiC. The fully isolated GA03IDDJT30-FR4 gate driver board takes in 0/12V and a TTL signal to optimally condition the voltage/current waveforms required to provide small rise/fall times, while still minimizing the continuous current requirement for keeping the normally-OFF SJT conducting during the on-state. The pin configuration and form factors are kept similar to other SiC transistors. GeneSiC has also released Gerber files and BOMs (bill of materials) to end-users to enable them to incorporate the benefits of the driver design innovations realized.

SJTs offer well-behaved on-state and switching characteristics, making it easy to create behavior-based SPICE models that agree remarkably well with the underlying physics-based models as well. Using well-established and under-

stood physics-based models, SPICE parameters were released after extensive testing with device behavior. GeneSiC says that its SPICE models are compared to the experimentally measured data on all device datasheets and are applicable to all 1200V and 1700V SiC junction transistors released.

The SJTs are capable of delivering switching frequencies that are more than 15 times higher than IGBT-based solutions, reckons the firm. Their higher switching frequencies can enable smaller magnetic and capacitive elements, shrinking the overall size, weight and cost of power electronics systems, it adds.

The SPICE model adds to GeneSiC's suite of design support tools, technical documentation, and reliability information to provide the design resources necessary to implement the firm's family of SiC junction transistors and rectifiers into the next generation of power systems.

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

## Nidec develops first drive system using magnet-less motor driven by SiC-based inverter

Nidec Corp of Kyoto, Japan says the Nidec Research and Development Center has developed a motor-drive system based on a silicon carbide (SiC) inverter (making what it claims is the first concept model of a drive system using a magnet-less motor with a SiC based inverter) by applying the drive technology to an SR (switched reluctance) 44kW liquid-cooled motor which is free of permanent magnets.

Future drive systems need to be compact, lightweight and energy efficient (since motor-driven equipment accounts for 57.3% of all power consumption in Japan).

As superior alternatives to silicon for power semiconductor devices,

Nidec Research and Development Center has applied SiC and GaN to a compact and lightweight motor drive system, focusing on SiC (which offers reduced power losses, improved heat resistance and higher current capacity). Also, the volume and weight of the concept model (including motor and inverter) are 32% and 69%, respectively, of a conventional motor drive system.

The SiC power semiconductors were developed via the Kyoto super-cluster program of the Japan Science and Technology Agency, which is supported by universities, working with corporations and public research organizations. A core institution is the Advanced Scien-

tific Technology & Management Research Institute of Kyoto. Specifically, Nidec Research and Development Center collaborated with Kyoto-based ROHM and Nichicon, and the universities of Kyoto, Osaka and Ritsumeikan. Nidec has also collaborated with Yokohama National University on thermal analysis for motor drive systems, including circuit simulation of the SiC based inverter.

As well as developing a motor-drive system using a SiC based inverter, in 2015 Nidec aims to develop an integrated motor-drive system (with the inverter inside the motor housing).

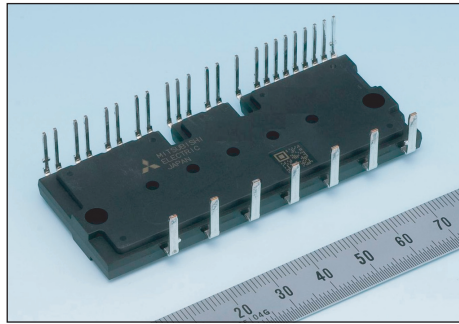
[www.nidec.com](http://www.nidec.com)



# Mitsubishi Electric launching large hybrid SiC DIIPM power modules for PV power conditioning

Tokyo-based Mitsubishi Electric Corp has launched its large hybrid silicon carbide (SiC) transfer-mold dual in-line package intelligent power module (DIIPM), incorporating a SiC Schottky barrier diode (SBD) and seventh-generation IGBT chips featuring a carrier-stored trench-gate bipolar transistor (CSTBT) structure. Built-in chips include an inverter bridge with IGBT, SiC-SBD and LVIC chips. The dimensions are 31mm x 79mm x 8mm (the same as the large DIIPM version 4 series).

The new 50A/600V module (PSH50YA2A6) can reduce the power consumption and size of photovoltaic (PV) inverters. Power loss is reduced by about 25% compared with Mitsubishi Electric's existing PS61A99 module for PV applications. Functions include



**Mitsubishi Electric's PSH50YA2A6 large hybrid SiC DIIPM module.**

short-circuit protection (with current detection) and control power supply under-voltage protection (with FO output on N-side protection). The IGBT chip has a current-sensing pin that could detect a can of thousands of the main collector current and can be used for external short-circuit protection function.

The current-sensing pin eliminates the need for a large external shunt resistor. Together with the modified short-circuit protection scheme, this helps to downsize PV power conditioner inverter systems.

Mitsubishi Electric commercialized its first DIIPM transfer-mold intelligent power module in 1997, the beginning of its ongoing effort targeting miniaturization and energy saving in inverter systems. Development of the new DIIPM was partially supported by Japan's New Energy and Industrial Technology Development Organization (NEDO). The PSH50YA2A6 module is compliant with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS).

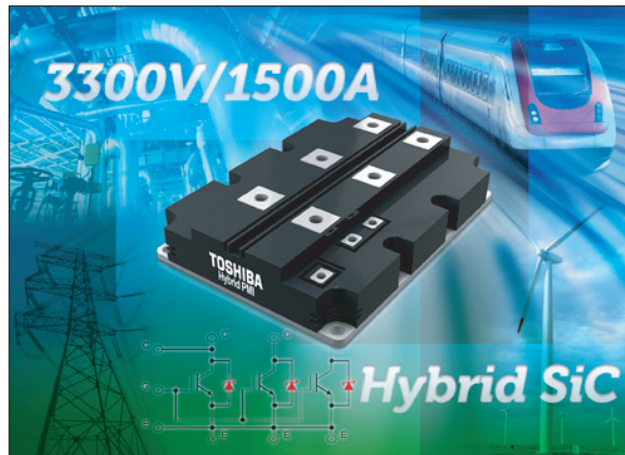
[www.mitsubishielectric.com](http://www.mitsubishielectric.com)

# Toshiba extends series of compact SiC hybrid power modules to 3300V and 1500A

Toshiba Electronics Europe (TEE) of Düsseldorf, Germany has extended its family of silicon carbide (SiC) devices with the launch of a high-efficiency 3300V, 1500A power module. The MG1500FXF1US71 PMI (plastic case module IEGT) integrates an N-channel IEGT (injection-enhanced gate transistor) and an SiC fast recovery diode (FRD) into a package with a footprint of just 140mm x 190mm.

Toshiba says that the new module can save energy, space and weight and reduce acoustic noise in high-power switching inverter and motor control designs. Target applications include rail traction, industrial motor control, renewable energy systems and electricity transmission and distribution.

The firm says that, compared with silicon alternatives, the use of an SiC Schottky barrier diode (SBD) significantly decreases reverse recovery current, and leads to a



**Toshiba's new MG1500FXF1US71 3300V, 1500A power module.**

corresponding decrease in turn-on loss. A combination of the diode and an improved internal package design to reduce stray inductances allows the MG1500FXF1US71 to operate with a reverse recovery loss up to 97% lower than a module that uses a conventional silicon diode.

The MG1500FXF1US71 offers an isolation voltage rating of 6000V<sub>AC</sub> (rms for 1 minute) and can handle a peak turn-off collector current of 3000A. Collector power dissipation (at 25°C) is 5000W. An operating temperature range of -40°C to 150°C is compatible with the extended temperature environments that characterize the target applications.

During development, the 3300V, 1500A hybrid module was incorporated into a rail traction inverter design. By using the module the size of the motor control sub-assembly (including cooling system) was cut by 40%. The module also helped to reduce acoustic noise and improve ride quality, says Toshiba.

[www.toshiba-components.com](http://www.toshiba-components.com)

# Advantech Wireless' GaN devices win North American Frost & Sullivan Award for New Product Innovation

Based on its recent analysis of the gallium nitride (GaN)-based devices market, Frost & Sullivan has recognized Advantech Wireless of Montreal, Canada (which makes satellite, RF equipment and microwave systems) with the 2014 North American Frost & Sullivan Award for New Product Innovation Leadership.

Frost & Sullivan presents the award annually to the company that has developed an innovative element in a product by leveraging leading-edge technologies. The award recognizes the value-added features/benefits of the product and the increased return on investment (ROI) that it offers customers which, in turn, increases customer acquisition and overall market penetration potential.

The market research firm says that Advantech Wireless's new series of GaN-based solid-state power amplifiers (SSPAs), together with other telecom devices, have revolutionized the GaN device market with their small form factor, reduced power consumption and heat generation, as well as capital and operating cost-efficiency.

Until recently, GaN's linearity, processing, biasing and cost characteristics appeared to limit the semiconductor's use to devices in low-frequency commercial applications and defense communications, where price was not much of an issue. Aiming to bring the mat-

erial into higher-power commercial markets, Advantech Wireless was convinced of GaN's potential in radio-frequency power amplification and other telecom applications.

Advantech Wireless says it hence dedicated significant resources to developing technologies such as its high-power amplifier, which can simultaneously transmit to all satellite transponders from a single antenna. This capability facilitates cost-efficient, energy-saving communications connectivity by enabling the replacement of multiple antennas and up to hundreds of travelling-wave tubes (TWTs)/klystrons, the firm adds.

"Advantech Wireless noted that the introduction of GaN high-electron-mobility transistors (HEMTs) in early 2000 left an undeniable mark on the satellite communication landscape," comments Frost & Sullivan research analyst Mike Valenti. "Therefore, the company launched its ambitious R&D program in 2006 to design and manufacture a complete line of C-, X-, and Ku-band SSPAs [solid-state power amplifiers] that could meet the most demanding satellite communication applications."

Another outcome of the company's intense R&D efforts is the SapphireBlu Series of UltraLinear GaN technology-based high-power amplifiers. The greater ground power, linearity and cost-savings of

the SapphireBlu Series, along with Advantech Wireless' 13m A-line antenna in a major direct-to-home (DTH) uplink system in Latin America, allowed viewers in Latin America and Brazil to watch the World Cup 2014 soccer tournament played in Brazil over the summer.

Advantech Wireless says that its products can enable key reductions in the size, weight and power of telecoms equipment from the ultra-high frequency (UHF) band to the Ka-band in satellite communications.

"Advantech Wireless develops solutions that balance satellite spectral efficiency to provide the smallest occupied bandwidth at enhanced link availability," comments Valenti. "This results in capital and operating cost-savings that can be passed along to the customer."

With regard to device efficiency, the firm's GaN-based SSPA provides a 65% increase in mean time between failure (MTBF) compared with its similar GaAs-based SSPA product due to the reliability of components, number of components, and the electrical efficiency of the former. The SapphireBlu Series high-power SSPAs are able to achieve up to 6kW in RF power, proving their reliability in the most environmentally stringent and demanding work conditions, it is claimed.

[www.awards.frost.com](http://www.awards.frost.com)

## Advantech launches 100W Ku-band GaN airborne-grade SSPB/BUC

Advantech Wireless of Montreal, Canada (which manufactures satellite, RF equipment and microwave systems) has launched the 2500-G Series 100W Ku-band gallium nitride (GaN)-based airborne-grade SSPB/BUC (solid-state power block up-converter), which is designed to meet stringent commercial airborne specifications.

The new SSPB/BUCs provide high linearity and high energy efficiency. The units are ARINC 791 compliant and are suitable for airborne SatCom applications.

"GaN-based SSPBs are ideally positioned for the next-generation Airborne SatCom terminals," says Cristi Damian, VP business development. "They provide high power with extremely high linearity and

efficiency, while maintaining very high reliability," he adds.

The design of the 2500-G Series is based on Advantech Wireless' industry-proven, reliable solid-state high-power amplifiers. The new Ku-band GaN BUCs are weatherproof and ready for high-order modulation schemes, says the firm.

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





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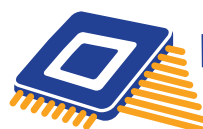
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# EPC launches monolithic GaN half-bridges enabling high system efficiency in high-frequency DC–DC conversion

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) for power management applications, has launched two new enhancement-mode monolithic GaN transistor half-bridges: the 60V EPC2101 and the 80V EPC2105.

In both cases, by integrating two eGaN power FETs into a single device, the interconnect inductances and the interstitial space needed on the PCB are eliminated, halving the board area occupied by the transistors compared with a discrete solution. This increases both efficiency (especially at higher frequencies) and power density, while reducing assembly costs to the end-user's power conversion system.

The EPC2101 is suitable for high-frequency DC–DC conversion. For a complete buck converter, system efficiency approaches 87% at 14A,

and over 82% at 30A when switching at 500kHz and converting from 28V to 1V.

Each device within the EPC2101 half-bridge has a voltage rating of 60V. The upper FET has a typical  $R_{DS(on)}$  of 8.4m $\Omega$  and the lower FET has a typical  $R_{DS(on)}$  of 2m $\Omega$ .

The EPC2105 is suitable for high-frequency DC–DC conversion and enables efficient single-stage conversion from 48V directly to 1V system loads.

Each device within the EPC2105 half-bridge has a voltage rating of 80V. The upper FET has a typical  $R_{DS(on)}$  of 10m $\Omega$ , and the lower FET has a typical  $R_{DS(on)}$  of 2.3m $\Omega$ .

In both the EPC2105 and EPC2101, the high-side FET is about a quarter the size of the low-side device to optimize efficient DC–DC conversion in buck converters with a high  $V_{IN}/V_{OUT}$  ratio.

Both the EPC2105 and EPC2101 come in a chip-scale package for

improved switching speed and thermal performance (measuring just 6.05mm x 2.3mm for increased power density).

Measuring 2" x 1.5", the development boards EPC9037 and EPC9041 (containing one EPC2101 and one EPC2105 integrated half-bridge component each, respectively) use the Texas Instruments LM5113 gate driver, supply and bypass capacitors. The boards have been laid out for optimal switching performance and there are various probe points to facilitate simple waveform measurement and efficiency calculation.

In 1000-unit quantities, the EPC2101 and EPC2105 half-bridge cost \$6.92 and \$7.17 each, respectively. The EPC9037 and EPC9041 development boards both cost \$137.75 each. All are available for immediate delivery from Digi-Key.

[www.digikey.com/Suppliers/us/Efficient-Power-Conversion](http://www.digikey.com/Suppliers/us/Efficient-Power-Conversion)

# HSR waiting period expires for Infineon acquisition of IR

International Rectifier Corp (IR) of El Segundo, CA, USA has announced the expiry on 24 October of the waiting period under the Hart–Scott–Rodino Antitrust Improvements Act of 1976 (HSR) with respect to its acquisition (announced on 19 August) by Infineon Technologies AG of Munich, Germany.

Expiration of the HSR Act waiting period satisfies one of the conditions required to finalize the acquisition. The transaction remains subject to other closing conditions, including the receipt of additional regulatory clearances as well as approval of the transaction by International Rectifier stockholders, among others, as set forth in the company's proxy statement filed with the US Securities and Exchange Commission (SEC) on 7 October.

The product portfolios of Infineon

and International Rectifier are reckoned to be highly complementary. IR's expertise in low-power, energy-efficient insulated-gate bipolar transistors (IGBTs) and intelligent power modules,

power MOSFETs and digital power management ICs will integrate with Infineon's range of power devices and modules.

With IR, Infineon acquires a manufacturer of

**Infineon acquires a manufacturer of GaN-on-Si based power semiconductors. The transaction will result in a broad range of products creating a comprehensive provider of silicon, SiC- and GaN-based power devices and ICs**

gallium nitride on silicon (GaN-on-Si) based power semiconductors. It is reckoned that the combination will accelerate Infineon's position in GaN discretes and GaN system solutions, improving its ability to pursue a strategically important technology platform with significant future growth potential.

The transaction will result in a broad range of products creating what is described as a comprehensive provider of silicon-, silicon carbide (SiC)- and gallium nitride (GaN)-based power devices and integrated circuits. Infineon believes that the increase in exposure to the distribution channel will allow it to meet the needs of a broader range of customers.

The transaction is expected to close in late 2014 or early 2015.

[www.irf.com](http://www.irf.com)  
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# Keithley's touchscreen SourceMeter with higher-current sourcing and measurement

Electrical test instrument and system provider Keithley Instruments Inc of Cleveland, OH, USA has launched the Model 2460 SourceMeter, its latest bench-top source measure unit (SMU) instrument, which has a capacitive touchscreen graphical user interface.

The Model 2460 offers users higher-power sourcing (up to 105V, 7A DC/7A pulse, 100W maximum) with 0.012% basic measurement accuracy and 6½-digit resolution, making it suitable for high-power, high-precision I-V characterization of modern materials and high-power devices. Keithley says that the Model 2460's features give it the adaptability needed for use in a wide range of applications:

- Its flexible, four-quadrant voltage and current source/load, coupled with precision voltage and current measurement capabilities, make it suitable for R&D on high-power devices made of wide-bandgap materials such as silicon carbide (SiC) and gallium nitride (GaN). These features also make it suited to characterizing elements of power conversion and management systems, such as solar cells/panels, new materials, and power management devices for telecommunications, consumer electronics, automotive, and medical products.
- For characterizing optoelectronic devices such as LEDs, OLEDs, HB-LEDs and laser diodes, the 7A DC capability provides the high current needed for forward- and reverse-bias I-V characterization; the 7A pulse current capability minimizes device self-heating during leakage current testing.
- The Model 2460 brings together the functionality of a power supply, true current source, 6½-digit multimeter, electronic load and trigger controller in a single tightly integrated, half-rack instrument, so it can integrate the capabilities of IV systems, curve tracers and semiconductor analyzers at a fraction of their cost. In response to changes

in the test & measurement market (including shrinking product design/development cycles, fewer personnel devoted exclusively to test engineering, and the growing number of instrument users who are relatively new to test), the Model 2460's design incorporates ease-of-use features that ensure a faster 'time-to-answer' than competitive solutions, it is claimed.

The Model 2460 offers a variety of features that speed up and simplify lab/bench-top work:

- *Full-color, 5-inch touchscreen user interface:* A simple GUI and icon-based menu structure allows reaching any measurement set-up panel with just a touch, allowing novice users to operate the instrument with confidence.
- *Extended current measurement ranges:* The 7A DC and pulse current capability eliminates the need to configure an additional high-current power supply into a test system.
- *Graphical plotting:* A full graphical plotting window converts raw data and displays it immediately as useful information, such as semiconductor IV curves and voltammograms. The touchscreen supports 'pinch and zoom' operation to allow examining data in the graph in detail.
- *Built-in context-sensitive help function:* Help information is provided where it is needed through the touchscreen, minimizing the need to review a manual.
- *Quickset modes:* With a single touch, four Quickset modes simplify setting the Model 2460 up to make a measurement without the need to configure the instrument indirectly for this operation.
- *KickStart start-up software:* The 'no-programming' instrument control software simplifies taking and graphing data in minutes. For more complex analyses, data can be easily stored to disk, and then exported to Microsoft Excel or another software environment. Up to four Model 2460s can be configured for multi-pin testing.

The Model 2460 is also engineered to simplify integration into automated test systems:

- *Embedded Test Script Processor (TSP) Technology:* An onboard Test Script Processor embeds complete test programs into non-volatile memory within the instrument itself to provide higher test throughput by eliminating the GPIB/USB/LAN traffic problems common to systems dependent on an external PC controller. TSP technology even supports testing multiple devices in parallel, with each instrument in the system able to run its own complete test sequence, creating a fully multi-threaded test environment.
- *TSP-Link Channel Expansion Bus:* Test system builders can connect multiple Model 2460s and other TSP instruments such as the Model 2450 SourceMeter SMU instrument, Series 2600B System SourceMeter SMU instruments, and Series 3700A Switch/Multimeter systems in a master-slave configuration that operates as one integrated system. The TSP-Link expansion bus supports up to 32 units per GPIB, USB or IP address, scaling a system to fit an application's particular requirements.
- *TriggerFlow triggering system:* This system provides tight user control over instrument execution. Users can build triggering models from very simple to complex with up to 255 block levels. The Model 2460 also includes basic triggering functions, including immediate, timer, and manual triggering.
- *PC connectivity and automation:* A rear-panel mass termination connector, remote control interfaces (GPIB, USB 2.0, and LXI/Ethernet), D-sub 9-pin digital I/O port (for internal/external trigger signals and handler control), instrument interlock control, and TSP-Link jacks make it simple to configure multiple instrument test solutions and eliminate investment in extra adapter accessories.

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



# Keysight supporting B4G/5G technology development at National Taiwan University's High-Speed Radio Frequency and mmWave Center

Keysight Technologies Inc of Santa Rosa, CA, USA (spun off as a subsidiary of Santa Clara-based Agilent Technologies Inc in August), which provides electronic measurement instruments and systems and related software, software design tools and services, has announced sponsorship of the B4G MIMO Lab, part of National Taiwan University's (NTU) High-Speed Radio Frequency and mmWave Center.

Keysight has also joined the B4G/5G Technology Forum. The lab is one of the projects at the center aiming to develop key components used in Beyond 4G and 5G mobile communication systems.

With 5G becoming a critical component for addressing increasing mobile internet usage, the Taiwan government is supporting academia to develop future technologies. It has called upon NTU to (1) set up the High-Speed Radio Frequency and mmWave Center, (2) perform advanced research and (3) further assist local industries. Keysight has donated a 4x4 MIMO measurement system for the center to develop the key components used in next-generation communication systems,



**National Taiwan University's president Dr Pan-Chyr Yang (left) and Guy Séné (right), senior VP, measurement solutions & worldwide sales at Keysight, exchange the donation contract on the B4G MIMO Lab.**

such as CMOS-based monolithic microwave integrated circuits (MMICs), LTCC-based SiP (system-in-package), smart antenna and power amplifier (PA) front-end modules. Several local industrial firms have agreed to commercialize the developed technologies.

The B4G/5G Technology Forum was held on the same day as the center's grand opening. Keysight and other industrial partners delivered presentations on a variety of

5G related topics and solutions. Keysight's test solutions include:

- 5G design and simulation environment;
- Power Amplifier Reference Solution with envelope tracking and digital pre-distortion;
- 4x4 MIMO measurement system;
- Multi-antenna Calibration Reference Solution for phased-array antennas; and
- E-band signal generation and analysis system.

"Keysight has the most complete solutions and experiences including EDA tools and measurement environment to help speed up our work from design to test and verify our prototypes," comments center chairman professor Tzong-Lin Wu (chairman of NTU's Graduate Institute of Communication Engineering).

"We have the core measurement science and NTU is highly acclaimed for its talent and advanced research," comments Allen Chang, Keysight Taiwan general manager. "This joint effort will help speed up the next-generation technology development."

[www.keysight.com/find/5G](http://www.keysight.com/find/5G)  
[www.ntu.edu.tw/engv4](http://www.ntu.edu.tw/engv4)

## Keysight begins trading as independent company

Keysight says that its separation from Agilent (first announced in September 2013) was completed on 1 November through a distribution of 100% of the outstanding common stock of Keysight (about 167.5 million shares) to Agilent shareholders of record as of the close of business on 22 October. Agilent shareholders received one share of Keysight common stock for every two shares of Agilent common stock they held. The newly independent company has begun 'regular-way' trading on the New York Stock Exchange (NYSE)

under the ticker symbol KEYS.

Keysight provides electronic measurement technology and solutions for engineers, scientists, manufacturers, businesses, researchers and government agencies in more than 100 countries. Keysight's electronic measurement instruments, systems, software and services are used in the design, development, manufacture, installation, deployment and operation of electronic equipment. Industry segments include communications; aerospace & defense; and industrial, computers

and semiconductors. With 9700 staff and 12 R&D centers worldwide, the business had revenue of \$2.9bn in fiscal 2013.

"As an independent company, the top opportunities within the electronic measurement market are now the top opportunities for Keysight," says president & CEO Ron Nersesian. "With a 75-year heritage of market and technology leadership and our strong business model, we look forward to delivering superior value to our customers and shareholders."

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

# Rudolph receives multi-system metrology orders from mobile device makers

Rudolph Technologies Inc of Flanders, NJ, USA, which provides defect inspection, packaging lithography, process control metrology and data analysis systems and software, has received multi-system orders from several customers for its latest MetaPULSE G metal metrology system in support of their mobile device components ramp. The MetaPULSE systems will provide critical process control metrology enabling the manufacture of multi-band and multi-mode frequency components used in the latest generation of smartphones and mobile devices. The MetaPULSE G system is the most capable metrology tool for measuring multilayer films simultaneously within a device, says Rudolph.

"Consumer demand for more power and higher functionality from handheld devices and the burgeoning Internet of Things (IoT) are driving

continued technological innovation in the mobile and connected device markets. As a result, we see tremendous growth in specialty components such as MEMS sensors, frequency filters and power devices supporting the mobile and wireless IC market," notes Tim Kryman, director of metrology product management. "Many of these critical components are being manufactured using 200mm legacy infrastructure accompanied by newly developed processes and expanded capacity to support the continued market growth. Rudolph's metrology systems are uniquely positioned to take advantage of this growth," he reckons.

"MetaPULSE G systems are being adopted for the process control of critical devices driving growth in expanding mobility and IoT markets," Kryman continues. "Not only are we providing advanced process

control metrology to our customers, but we also deliver wafer handling solutions tailored to the smaller substrate sizes used for these devices."

The MetaPULSE system uses a laser-induced ultrasonic sonar pulse to characterize thickness, density and other parameters of single layers or multi-layered stacks of opaque materials, non-destructively and without interference from underlying layers. The MetaPULSE G system delivers for metal films is optimized for thin single and multi-layer applications that are critical in advanced logic, memory and 3D packaging processes. Unlike optical and x-ray techniques, PULSE Technology can be used in active die without special test pads. The 10µm x 10µm spot size assures measurement capability on product wafers in 15µm x 15µm test sites.

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

## EpiGaN in Global Cleantech 100's 'Ones to Watch' list

III-nitride epitaxial material supplier EpiGaN nv of Hasselt, Belgium has been named in the 2014 Global Cleantech 100's Ones to Watch list, produced by San Francisco-based Cleantech Group (whose mission is to connect corporates to sustainable innovation through the i3 market intelligence platform, expert consulting services, and global events).

The inaugural Ones to Watch list highlights a group of upcoming firms that are catching the eye of leading players in the market. They are companies who did not quite have enough market support to make the 2014 Global Cleantech 100 list itself, who have never been on a previous Global Cleantech 100 list, but who carry pockets of support among key corporations, investors and analysts within Cleantech Group's Expert Panel (a group of 84 panelists who help determine the annual Global Cleantech 100 list).

Incorporated in 2010, EpiGaN was founded by chief executive officer Dr Marianne Germain, chief technology officer Dr Joff Derluyn and chief operating officer Dr Stefan Degroote as a spin-off of nanoelectronics research center Imec of Leuven, Belgium. The founders jointly developed gallium nitride-on-silicon (GaN-on-Si) technology on 4" and 6" wafers at Imec, part of which has been licensed to EpiGaN. In mid-2012, EpiGaN closed its first capital round of €4m, to allow it to start volume production of GaN-on-Si epitaxial material. Investors include Capricorn Cleantech Fund, Robert Bosch Venture Capital, and LRM.

"We are currently expanding our leading GaN-on-Si epiwafer production capacity to process larger wafer diameters of up to 200mm, offering a very high breakdown voltage," says Germain. "The new

facility is based on our unique in-situ SiN capping layer concept. It is equipped to support the volume demand from our worldwide industrial customers who are developing a new generation of highly efficient and energy-saving power systems solutions," she adds.

"We are excited to release a second list under the Global Cleantech 100 program, to recognise 60 other rising stars that, from the process we ran, we can see are catching the attention of some important players in the market," says Richard Youngman, Cleantech Group's managing director, Europe & Asia and creator of the Global Cleantech 100 program. "We look forward to following their progress, and hopefully seeing some of them graduate to future editions of the Global Cleantech 100."

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

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## 5N Plus reports Q3 revenue up 5% year-on-year

For third-quarter 2014, specialty metal and chemical products firm 5N Plus Inc of Montreal, Québec, Canada has reported revenue of \$114.4m, down 16% on \$136.6m last quarter but up 5% on \$108.6m a year ago.

"We reported another solid quarter despite the usual summer slowdown and some margin erosion in our solar business," says president & CEO Jacques L'Ecuyer.

5N Plus provides specialty purified metals such as bismuth, gallium, germanium, indium, selenium and tellurium, and also produces related semiconducting compounds such as cadmium telluride (CdTe), cadmium sulphide (CdS) and indium antimonide (InSb) as precursors for the growth of crystals for solar, LED and eco-friendly materials applications. The firm also has fully integrated closed-loop recycling facilities.

Net earnings were \$4.2m

(\$0.05 per share), up from \$1.3m (\$0.02 per share) a year ago but down slightly from the \$4.4m (\$0.05 per share) last quarter. Adjusted EBITDA was \$8.1m, down from \$10.8m last quarter but up from \$5.8m a year ago. "Combined with the results of the first two quarters of the year we are heading towards a record adjusted EBITDA level for 2014," says L'Ecuyer.

"Demand remains strong in most market segments, as reflected in our backlog and bookings levels," L'Ecuyer. "This is especially true for our bismuth products which are on track to reach a record level for a second consecutive year," he adds. Order bookings were \$101.3m, up on \$99.6m last quarter and up 14% on \$88.6m a year ago. Bookings for the nine-month period to end-September were \$360.5m, up by 17% year-on-year from \$307.2m.

"We continue to focus on improving operational efficiency and expect to

see gains in terms of costs, throughput and inventory levels in the coming quarters as we leverage several initiatives for which we have yet to reap the full benefits," says L'Ecuyer. "These include ramping up of our bismuth refining activities in Laos as well as optimization of our footprint," he adds.

"We are excited by progress made in several new areas including our semiconductor substrate business, where we continue to make both technical and commercial progress in material systems which now extend beyond germanium," says L'Ecuyer. "This progress is a key component of our growth strategy as we aim to expand our range of value-added products and develop a stronger foothold in recycling and primary sourcing," he adds. "We expect to report further progress in these areas in the coming quarters as they gradually positively impact our bottom line."

## 5N Plus ranked in Deloitte's Technology Fast 50 list for fifth year

5N Plus has been ranked among the Deloitte Technology Fast 50 and Technology Fast 500 awards for a fifth consecutive year.

Deloitte's Technology Fast 50 program is a ranking of Canada's 50 fastest-growing technology companies for technological inno-

vation, entrepreneurship, rapid growth and leadership, based on the percentage of revenue growth over five years. 5N Plus' revenues rose by 581% from 2009 to 2013, resulting in a 23rd place ranking.

5N Plus also ranked 179th on the Technology Fast 500 list, Deloitte's

ranking of the 500 fastest-growing technology, media, telecoms, life sciences and clean technology companies in North America based on percentage growth over a five year period.

[www.fast50.ca](http://www.fast50.ca)

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

## 5N Plus receives approval for share repurchase plan

The Toronto Stock Exchange (TSX) has approved 5N Plus' normal course issuer bid (NCIB). Under the NCIB, 5N Plus has the right to purchase for cancellation, from 19 November 2014 to 18 November 2015, up to 4,691,230 common shares, representing 10% of the 46,912,306 shares forming 5N Plus' public float. As of 14 November, 5N Plus had 83,979,657 common shares issued and outstanding.

Any purchases will be via the TSX as well as alternative Canadian trading platforms, at prevailing

market rates, and any common shares purchased by the firm will be cancelled.

5N Plus can repurchase up to 41,495 shares during any one trading day, (25% of the average daily trading volume of 165,982 shares for 5N Plus shares on the TSX in the last six-month period). The firm can also make, once per calendar week, a block purchase of shares not directly or indirectly owned by insiders of 5N Plus. The firm will fund the purchases through available cash.

5N Plus' board believes that the underlying value of the firm may not be reflected in the market price of its common shares from time to time and that, at appropriate times, repurchasing its shares through the NCIB represents good use of financial resources, protecting and enhancing shareholder value when opportunities or volatility arise.

5N Plus has entered into an automatic share purchase plan with National Bank Financial Inc to allow for purchases during 5N Plus' 'black-out' periods.



## AXT's revenue grows a more-than-expected 8% in Q3 as new applications emerge across substrate portfolio

### Cost-cutting drives further rebound in profit

For third-quarter 2014, AXT Inc of Fremont, CA, USA, which makes gallium arsenide, indium phosphide and germanium substrates and raw materials, has reported revenue of \$23.1m, up 8% on \$21.4m last quarter and 13% on \$20.5m a year ago.

After a dip to 14.1% in Q1/2014, gross margin has rebounded further, from 19.4% last quarter to 23%.

After cost-saving initiatives cut operating expenses from \$5.1m in Q1, operating expenses in Q3 were roughly unchanged from Q2's \$4.7m.

Compared with a net loss of \$2m

(\$0.06 per diluted share) in Q1, net income has rebounded further, from \$319,000 (\$0.01 per diluted share) in Q2 to \$644,000 (\$0.02 per diluted share).

"Revenue came in ahead of our expectations, and we achieved another quarter of profitability through improved gross margins and tight expense control," says CEO Morris Young. "We are diversifying our customer base throughout our product portfolio and are pleased to be gaining traction in several areas that have been a strong focus of

our sales efforts," he adds.

"The changes in the gallium arsenide landscape over the past two years have had an adverse impact on our business. However, these changes are finally beginning to settle and new applications for our products are emerging across our substrate portfolio," Young continues. "I am very pleased to have a strong team in place with the expertise to maximize our potential as we evolve our business to meet new opportunities."

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

## AXT announces \$5m stock repurchase program

AXT has announced a program authorizing the repurchase of up to \$5m of its common stock, to be funded from existing cash balances and cash generated from operations.

Any repurchases will be made through open market purchases, block trades, unsolicited negotiated transactions, a repurchase plan under Rule 10b5-1 of the Securi-

ties Exchange Act of 1934, or any manner that complies with Rule 10b-18 of the Exchange Act.

The firm is not obligated to repurchase any particular amount of common stock during any period and may suspend or discontinue the repurchase program at any time.

Shares repurchased through the program will become authorized

but unissued shares. As of end-September, the firm had about 32.7 million shares of common stock outstanding.

The stock repurchase program "underscores our confidence in the long-term growth opportunity in the business and our commitment to delivering stockholder value," says CEO Dr Morris Young.

## IQE's Infrared Division wins its largest single purchase order for InSb products, worth \$1.1m

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has agreed a long-term supply contract for its infrared materials with a leading global semiconductor manufacturer.

Worth about \$1.1m over the next 12 months, the new order represents the largest single purchase order for indium antimonide (InSb) products manufactured by IQE Infrared's UK substrate manufacturing business unit.

IQE says that further details of the specific customer, product and application cannot be disclosed at this time due to confidentiality designed to protect the customer's

IP and retain its competitive advantage. However, the firm adds that InSb is the material of choice for a wide range of sensing devices employed in a growing number of consumer, defence, security, medical and industrial applications.

IQE Infrared is uniquely positioned as a global supplier of InSb materials, with IQE's US (Galaxy) and UK (Wafer Technology) operations offering the largest antimonide wafer production capacity in the industry, using multiple production tools (crystal growth pullers), providing a secure, dual-sourced supply of InSb wafers.

"This is a significant new order for

our world-leading InSb products from a significant industry player with whom we have enjoyed a long relationship," comments IQE's CEO Dr Drew Nelson. "The scale of the commitment is a result of IQE Infrared's industry reputation for offering a high-quality, volume manufacturing capability for InSb materials," he adds. "Our investment in state-of-the-art crystal growth, wafer production and polishing capabilities enables us to fully meet the growing antimonide product demands of our customers, both in terms of volume and quality, across a full 2-6" product range."

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

# Veeco cuts losses, but growth in MOCVD revenue offset by MBE and Data Storage

## EBITDA profitability targeted from Q4

For the third-quarter 2014, epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has reported revenue of \$93.3m, down on \$99.3m a year ago and \$95.1m last quarter (and below the mid-point of the \$92–100m guidance range).

Data Storage revenue was \$16m (18% of total revenue), down on \$18m (19% of total revenue) last quarter (due primarily to a shipment to a Data Storage customer being delayed to November). "The shipment push-out is a sign of the limited market pull we are seeing in the Data Storage segment," says chief financial officer Shubham Maheshwari.

LED & Solar revenue was \$77m (82% of total revenue), roughly level with last quarter but up on \$75m (76% of total revenue) a year ago. "This trend of the LED segment contributing more and more towards our overall revenue continues," says Maheshwari.

In particular, market recovery gained further momentum in metal-organic chemical vapor deposition (MOCVD) revenue of \$71m, up 6% on \$67m last quarter. However, molecular beam epitaxy (MBE) revenue was \$6m, down 40% on \$10m last quarter. Overall, weakness in MBE and Data Storage offset the growth in MOCVD.

Due to the higher MOCVD revenue, a favorable MOCVD product mix and cost-reduction activities, non-GAAP gross margin has risen from 30.8% a year ago and 32% last quarter to 35.5% (above the guidance of 31.5–33.5%). "We have been steadily improving Veeco's bottom-line performance this year by lowering our operating expenses," comments chairman & CEO John R. Peeler. Although up from \$38m a year ago (38% of revenue), operating expenses have been cut from \$43m last quarter to \$42m (45% of rev-



enue) as Veeco continued to see the benefit from expense reduction and business streamlining activities in Data Storage.

Net loss was \$0.76m (\$0.02 per share), cut from \$3m (\$0.08 per share) a year ago and \$6.1m (\$0.16 per share) last quarter, and significantly better than the guidance of \$2.9–6.1m (\$0.07–0.15 per share). Adjusted earnings before interest, taxes, depreciation and amortization (EBITDA) was a loss of \$1.8m, level with a year ago but better than \$4m last quarter. During the quarter, cash & short-term investments rose from \$485m to \$487m.

For the fourth consecutive quarter, Veeco's book-to-bill ratio was over 1 (at 1.1). Orders have grown for a third consecutive quarter, to \$107m, up 3% on \$104m last quarter and up 17.5% on \$91m a year ago.

With no capacity purchases by hard-drive customers, Data Storage orders fell 38% from \$23m (22% of total orders)

last quarter to \$14m (just 13% of total orders).

LED & Solar orders have risen from \$73m (80% of total orders) a year ago and \$81m (78% of total orders) last quarter to \$93m (87% of total orders), the highest since Q3/2011.

This was driven by MOCVD orders up 23% on \$66m a year ago and up 8% on \$75m last quarter to \$81m (due mostly to a few large deals in the two biggest regions, China and Korea). There were no order cancellations in the quarter. "We are experiencing more pull-in requests than push-outs," says Maheshwari. "Lead times for MOCVD tools have stretched a little bit as compared to the situation six months back."

MBE orders were the highest level this year, at \$9m (all R&D-related, after winning several key deals), up on \$6m last quarter.

"We also booked our prototype FAST-ALD system for development of flexible OLED displays at our key customer," says Maheshwari. "We remain heavily engaged with this customer for further product development activities," he adds. ➤

**We are experiencing more pull-in requests than push-outs**



► For Q4/2014, Veeco expects revenue to rise to \$100–115m. Gross margin should be steady at 34–36%. Operating expenses (OpEx) are expected to fall again, to about \$41m (and should be below \$40m on a quarterly basis by Q1/2015). Earnings are expected to be between a loss of \$0.03 per share and a gain of \$0.09 per share. Veeco is forecasting a return to EBITDA profitability in Q4 (with adjusted EBITDA of \$1.7–6.7m — followed by break-even or better on a quarterly basis going forward).

"Second-half 2014 orders are currently expected to be higher than the first half, driven by growth in MOCVD, as LED unit demand and quoting activity remain strong,"

notes Peeler. "Veeco is making progress improving bottom-line performance through a combination of better business conditions, execution on growth initiatives, and a more streamlined company with lower operating expenses."

"We are seeing good initial traction for EPIK [the new-generation TurboDisc GaN MOCVD system launched in September], and we are expecting to ship multiple systems this quarter," says Maheshwari. "We will wait to recognize revenue for the first few units until final acceptance is achieved, as compared to recognizing revenue upon shipment for the existing products," notes Maheshwari.

"Due to this reason, although we

would be shipping and installing EPIK tools, we would defer revenue on the balance sheet for 1–2 quarters or so," he adds. "Our Q4 revenue guidance already incorporates this effect, and the shipments there are expected to be higher than the revenue."

"Calendar 2015 is expected to be a year of growth for our MOCVD business," says Maheshwari. "With that said, our order visibility remains less than 6 months, and that too is driven by a few customers for any given quarter. In this landscape of consolidated customers, bookings predictability remains difficult and volatile in the short-term, but steady and encouraging in the long term."

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

## Veeco launches MOCVD platform for development of gallium nitride power electronic devices

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has introduced the Propel Power gallium nitride (GaN) metal-organic chemical vapor deposition (MOCVD) system, which incorporates single-wafer reactor technology for film uniformity, yield and device performance. The new 200mm MOCVD system and technology targets the development of highly efficient GaN-based power electronic devices that will accelerate the transition from R&D to high-volume production.

Veeco says that, in response to strong consumer demand for power electronic devices, GaN MOCVD is advancing a new generation of power switching devices that feature higher efficiency, smaller form factors and lower device weight. According to market analyst firm IHS Research, the GaN power electronics market is expected to rise at a compound annual growth rate (CAGR) of more than 90% from 2014 to 2020 as new devices are applied to consumer electronics, solar and wind power, power supplies, auto-

motive and other applications.

"Leading power electronics manufacturers are currently progressing from R&D to pilot production, developing and qualifying novel device structures, with a focus on improved reliability, yield and cost," says executive VP William J. Miller PhD. "Propel is a platform that will provide exciting future growth opportunities for our customers and for Veeco."

Featuring a single-wafer 200mm reactor platform capable of processing 6- and 8-inch wafers and designed specifically for the power electronics industry, the new Propel Power GaN MOCVD system deposits GaN films resulting in the production of highly efficient power electronic devices. The single-wafer reactor is based on Veeco's TurboDisc MOCVD design and includes the new IsoFlange and SymmHeat technologies that provide homogeneous laminar flow and uniform temperature profile across the entire wafer. Users can transfer processes from Veeco's K465i and MaxBright systems to the new Propel Power GaN MOCVD platform.

The Propel system features long campaign runs and low particle defects for both yield and flexibility. In addition, the proprietary SymmHeat technology drives uniform thermal control for both thickness and compositional uniformity. Providing a seamless wafer size transition, the system can deposit GaN epitaxial layers on silicon wafers that are 6- and 8-inches in diameter.

"Beta testing by power electronics industry leaders has shown that the Propel system is ideally suited for fast cycles of learning with excellent particle performance," says Jim Jenson, senior VP & general manager of Veeco MOCVD. "This validation is great news for customers as they work to develop innovative processes and technologies for their product roadmaps," he adds. "As we've demonstrated in the LED industry, Veeco's goal is to help power electronics customers also improve device efficiency, reduce manufacturing costs, and ultimately move into high-volume manufacturing," Jenson concludes.

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

# Aixtron's losses worsen in Q3, driven by product launch, sales mix and upfront investments

## Large MOCVD order to boost future revenue

For third-quarter 2014, deposition equipment maker Aixtron SE of Aachen, Germany has reported revenue of €45.6m, down just 1.3% on €46.2m both last quarter and a year ago. The utilization rates of most tier-one LED chip makers have recently fallen, notes the firm.

Operating expenses have risen further, from €22.7m a year ago and €23.2m last quarter to €24.4m. This mainly reflects a rise in R&D expenses (from €15.5m last quarter to €16.3m) due mainly to pre-launch development costs in next-generation Showerhead metal-organic chemical vapor deposition (MOCVD) tools as well as progress made in the organic light-emitting diode (OLED) sector. Gross margin was just 14%, down on 27% last quarter and 23% a year ago.

Earnings before interest and taxes (EBIT) has worsened from an operating profit of €2.9m a year ago and an operating loss of –€10.6m last quarter to an operating loss of –€17.9m in Q3, reflecting the business environment during the quarter.

Due mainly to the losses and a scheduled increase in inventories for the next-generation MOCVD tool in advance of respective customer deposits, free cash flow has fallen further, from –€6.5m a year ago and –€17.5m last quarter to –€21.7m. Cash and cash equivalents has fallen from €306.3m at the end of 2013 to €260.5m at the end of September.

Equipment order intake was €37.6m, up 5% on €35.7m a year ago but down 2% on €38.2m last quarter. Nevertheless, although still down 3% on €72.8m a year ago, total equipment order backlog of €70.7m at the end of September was up on €66.4m at the end of June, €64.2m at the end of March, and up 21% on €58.1m at the start of 2014.

The imminent availability of more efficient MOCVD tool generations by the major equipment manufacturers could have a positive impact

### 24 - Month Business Development

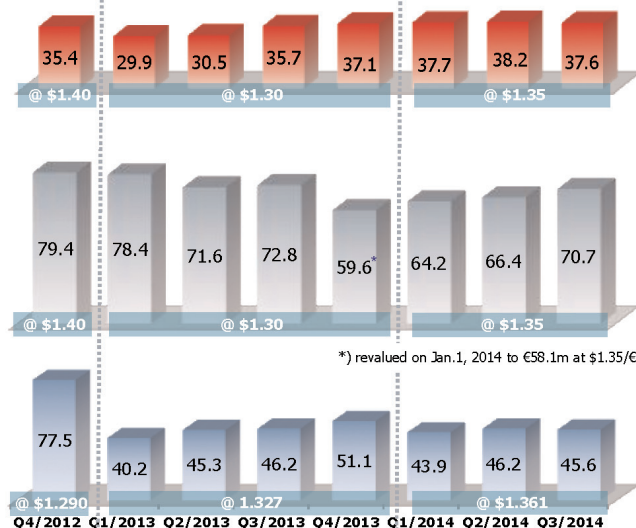
(€ million)

Equipment (only)  
Order Intake

Equipment (only)  
Order Backlog

Total Revenues  
(incl. equipment,  
service, spare parts)

USD order intake and backlog were recorded at the prevailing budget rate (2014: \$1.35/€)  
USD revenues were converted at the actual period average FX rate (9M/2014: \$1.361/€)



on the low levels of equipment demand, says Aixtron. In particular, at the end of September Aixtron received its largest ever multiple tool order from San'an Optoelectronics Co Ltd (China's largest LED maker). The order, for 50 next-generation Showerhead MOCVD systems, is being processed and the equipment will be delivered starting in Q4/2014, and will have a positive impact on order intake, revenue and earnings development in future quarters. "We have received this important order for our newly developed MOCVD tool from one of the world's leading LED manufacturers and the ramp-up of our production is in full swing," says president & CEO Martin Goetzeler.

"In the OLED area, we have recently received the crucial hardware for our Gen8 demonstration tool for the cost-efficient production of large-area OLEDs," says Goetzeler. "Additionally, we are experiencing a pick-up in customer interest for our non-LED technologies and applications," he adds.

"These developments are positive examples of the progress we are making in the markets we choose to address," notes Goetzeler. "On

the other hand, we need to acknowledge that our customers are facing very competitive industry dynamics which could lead to further consolidation and also to continued requirements for lower total cost of ownership of MOCVD equipment," he adds. "Therefore it is extremely important for us to execute our 5-Point-Program to further reduce COGS [cost of goods sold] and OPEX [operating expenses] in order to secure healthy margins and to support our dedication to return to profitability in the foreseeable future."

Aixtron's 5-Point-Program focuses on supply chain, service, R&D and production processes. A specific focus to improve gross margin is on the recently expanded and accelerated Design-to-Cost programs in order to reduce the cost of materials and components on a continuous basis.

Aixtron has reiterated its original full-year guidance (from February) for revenue in line with last year (€182.9m). However, it does not expect an EBIT profit. Nevertheless, management continues to expect a year-on-year improvement in earnings due to progress made in cost savings and restructuring.

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



# Aixtron launches next-generation MOCVD system

## 12x6", 31x4", 121x2" wafer configurations target GaN LED production

At the 11th China International Forum on Solid State Lighting (SSL CHINA 2014) in Guangzhou (6–8 November), deposition equipment maker Aixtron SE of Aachen, Germany launched its next-generation metal-organic chemical vapor deposition (MOCVD) system. Designed for the mass production of LEDs based on gallium nitride (GaN), the new AIX R6 can be delivered in 12x6", 31x4" and 121x2" wafer configurations. The firm says that technical innovations allow the new tool to lower operational costs significantly while simplifying usability and process control.

"Our new AIX R6 addresses the most important challenges that LED manufacturers face today: highly competitive markets with consistently decreasing device prices driving the need for production equipment with lower cost of ownership," says CEO & president Martin Goetzeler. "The AIX R6 is designed to fulfill our customers' needs for highly efficient production, enabling them to optimize their cost of manufacturing," he adds. "The ground-breaking order we have received from [China's] San'an Optoelec-



**Aixtron's new AIX R6 MOCVD system.**

tronics [in late September, for 50 systems] proves that our new AIX R6 already convinced a key market player through its performance and value proposition ahead of today's official launch of the tool."

The AIX R6 is based on Aixtron's Close Coupled Showerhead (CCS) concept, which has achieved a high level of recognition in numerous

markets, says the firm, being particularly known for its chemical efficiency and intrinsic deposition uniformity. The AIX R6 enables what is reckoned to be a more than 30% improvement in cost of ownership and a throughput increase of more than 120% compared to current-generation systems.

"We put great emphasis on maximizing the throughput by greater capacity, more automation, increased reliability and longer uptime," stresses chief technology officer Andreas Toennis.

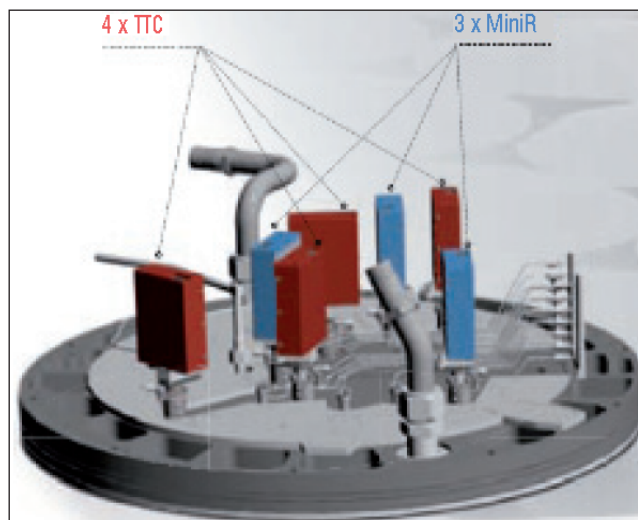
"Improved process control through enhanced temperature monitoring and control systems is another key feature of the AIX R6," he adds. "A new process control system eliminates temperature variation for increased reproducibility and yield, and also enables shorter cycle times and fast calibration."

[www.sslchina.org/en](http://www.sslchina.org/en)  
[www.aixtron.com](http://www.aixtron.com)

## LayTec's in-situ metrology used in Aixtron's new AIX R6

In-situ metrology system maker LayTec AG of Berlin, Germany says that the reactor feedback control capabilities of Aixtron's latest generation of metal-organic chemical vapor deposition (MOCVD) system (AIX R6) for manufacturing high-brightness light-emitting diodes (HB-LEDs) - launched on 6 November at the 11th China International Forum on Solid State Lighting (SSL CHINA 2014) - are based on two fully integrated LayTec OEM metrology sub-systems (Inside MiniR and Inside TTC) with typically seven metrology heads in total.

Emissivity-corrected susceptor surface temperature and double-



wavelength reflectance is provided by industry-proven LayTec in-situ

metrology. As additional options, wafer bow and GaN surface temperature can also be measured by Inside MiniRC and Inside P400 (OEM versions of LayTec's Pyro 400 pyrometry tool).

The engineering teams of Aixtron and LayTec worked closely together to provide the in-situ metrology solution for both firms' customers in the LED industry.

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

# Showa Denko qualifies Aixtron's next-generation 8x150mm SiC production system

Deposition equipment maker Aixtron SE of Aachen, Germany says that Japanese manufacturer Showa Denko has qualified its most recent system for manufacturing silicon carbide (SiC) epitaxial wafers. The new AIX G5 WW (Warm-Wall) chemical vapor deposition (CVD) system is configured to handle 8x150mm and 12x100mm SiC substrates. The firm says that it is currently the largest production system available on the market, enabling highest throughput and lowest running cost per wafer.

Showa Denko began the transition from 4" (100mm) to 6" (150mm) production in 2013 and is now expanding its 150mm SiC capacity with Aixtron equipment. The 150mm SiC technology provides opportunities for a significant reduction in production costs, says Aixtron.

The AIX G5 WW system was qualified by Aixtron's Japanese service and process team by meeting the tight time schedule of the customer: after installation in first-quarter 2014, the equipment was released for production in the first half of April.



**Aixtron's AIX G5 WW (Warm-Wall) CVD system.**

The SiC growth process demands on-wafer temperatures up to 1600°C. Due to the Planetary design concept (where each individual wafer rotates under a horizontal laminar flow of precursors during the processing), the AIX G5 WW delivers superior uniformity, says Aixtron. The system provides precise process control of layer thickness and dopant uniformity with a very low SiC defect density, hence meeting high-production

requirements, adds the firm.

Silicon carbide high-power devices are enabling energy-efficient power electronics systems. Ranging from 600V to 3.3kV, SiC transistor and diode devices are used in power supplies and designed into DC-DC converters, inverters for the solar industry and power converters for traction applications.

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

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

## Nippon Sanso to install GaN MOCVD system at Epistar

Taiyo Nippon Sanso Corp (TNSC) of Tokyo, Japan is to install its UR25K mass-production gallium nitride (GaN) metal-organic chemical vapor deposition (MOCVD) system (in 7 x 6-inch wafer configuration) at Taiwan's largest LED chipmaker

Epistar Corp in Hsinchu Science-based Industrial Park. The system will be used for the development of light-emitting diodes (LEDs) grown on 6-inch sapphire substrates.

TNSC says that, with the two firms' foresight into the 6" LED market,

it will be working with Epistar to improve the hardware aspects of the equipment. Epistar and TNSC aim to improve and develop 6" MOCVD mass production of LEDs.

[www.epistar.com.tw](http://www.epistar.com.tw)

[www.tn-sanso.co.jp/en](http://www.tn-sanso.co.jp/en)

## SENTECH presents Real Time Monitor at ALD China

SENTECH Instruments GmbH of Berlin, Germany, which manufactures equipment for plasma etching and deposition, atomic layer deposition (ALD) and thin-film measurement, has presented its new ALD Real Time Monitor in Asia at the 3rd China ALD Conference at

the Crowne Plaza Shanghai Fudan (16-17 October).

For the first time, the patented monitor allows the direct monitoring of absorption and desorption processes on the substrate surface during ALD processes within ALD half cycles.

"Using the ALD Real Time Monitor enables efficient and fast process optimization," says Dr Gargouri, SENTECH's specialist for ALD processes, who gave a speech during the conference.

[www.c-ald.org](http://www.c-ald.org)

[www.sentech.de](http://www.sentech.de)



# Aixtron receives solid-state lighting industry award from International SSL Alliance at SSL CHINA 2014

At the 11th China International Forum on Solid State Lighting (SSL CHINA 2014) in Guangzhou (6–8 November), deposition equipment maker Aixtron SE of Aachen, Germany has received the 'Award of Outstanding Achievement for Global SSL Development' from the International SSL Alliance (ISA). The ISA jury recognized Aixtron for its role in providing key foundations for the initiation and growth of the global solid-state lighting (SSL) industry.

Previous recipients of the annual award (which recognizes companies and individuals for their achievements and contributions to global SSL development) include University of California Santa Barbara (UCSB) professor Shuji Nakamura (this year's recipient of the Nobel Prize for Physics) and University of Illinois at Urbana-Champaign pro-



fessor Nick Holonyak (the inventor of the red LED).

"Over the last three decades, Aixtron has been an important bridge between research, development and the application of these technologies in the area of solid-state lighting," said Aixtron's president & CEO Martin Goetzeler in his acceptance speech. "In this period, we

have successfully introduced a number of innovations supporting the successful commercialization of solid-state lighting and the transition of the general lighting industry."

With more than 3000 deposition systems delivered since 1983, Aixtron says that it has installed the majority of compound semiconductor production tools worldwide. The firm

is continuing to improve production efficiency, highlighted by the introduction of the new AIX R6 Closed Coupled Showerhead next-generation metal-organic chemical vapor deposition (MOCVD) system (launched at SSL CHINA 2014).

[www.isa-world.org](http://www.isa-world.org)  
[www.sslchina.org/en](http://www.sslchina.org/en)  
[www.aixtron.com](http://www.aixtron.com)

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# SEMI-GAS Systems launches mini gas enclosure model for sub-atmospheric gas delivery

SEMI-GAS Systems, a division of Applied Energy Systems Inc of Malvern, PA, USA and a manufacturer of high-purity gas source and distribution systems, is offering the Xtursion MGE-XV, a new custom mini gas enclosure model that stores and delivers hazardous gases at sub-atmospheric pressures from small process cylinders. The MGE-XV is targeted at increasing operator safety and significantly reducing the risk of large, rapid gas cylinder leaks by drawing very low-pressure gases from a vacuum in the process tool. It harbors two separate steel compartments, each containing a sub-atmospheric gas delivery manifold, which feed two completely independent gas processes in one consolidated package.

"We continuously strive to design systems that minimize risks involved with the handling of hazardous production materials," says SEMI-GAS Systems division manager Jim Murphy.

"By developing the new MGE-XV system for delivering sub-atmospheric gases, we are significantly reducing the odds of a potential gas leak for our electronics manufacturers and ion implant gas users."

The MGE-XV uses a SEMI-GAS GigaGuard GSM controller to continuously monitor system delivery pressures and user-specified alarms. The controller's proprietary software makes cylinder changes, purging sequences and system monitoring seamless on the 4.3" color touch screen. If a process deviates from normal operation, an automatic shutdown will occur and visual and audible signals will signify a change in status to the operator.

All MGE-XV systems are custom engineered to meet each user's application, operational preferences, and process specifications. To further provide a flexible, precisely tailored fit-up, each unit is equipped with adjustable steel

shelves and cylinder straps as well as adjustable exhaust ducts. Reinforced mounting holes are included for wall installations, and a welded steel rack option is also available to accommodate any free-standing facility requirements.

All MGE-X systems include an 11-gauge steel enclosure and meet uniform fire code requirements. Self-closing and lockable doors and windows, as well as a UL-approved fire sprinkler and 1/2" safety glass windows are standard MGE safety containment features for handling hazardous production materials.

As with all SEMI-GAS ultra-high-purity gas systems, the internal manifold components are orbitally welded, helium leak-tested, and certified to meet the highest industry standards, and all valves, regulators, gauges, tubing and fitting bodies are 316L stainless steel to resist breakdown from any corrosive chemicals.

<http://semi-gas.com>

## SEMI-GAS customizes Centurion Fully Automatic Gas Cabinet

SEMI-GAS has added custom gas handling capability to its Centurion Fully Automatic Gas Cabinet line, to support quality control requirements for gas companies and manufacturers that perform sample analyses of gas production runs.

New customized system sequences allow for the delivery of multiple process gases to on-site gas analyzers for data collection. Following analysis, the sequences monitor the ventilation of the process gases to the facility's exhaust system. SEMI-GAS says that this customization leverages the performance and safety features inherent in its standard Centurion product line, building on the cabinet's automatic purging and cylinder switchover capabilities, intuitive operating interfaces, and other distinct features with the

additional monitoring and control capabilities needed for sample gas testing.

"By customizing our existing Fully Automatic Gas Cabinets — which have been market-proven for decades as extremely safe, high-quality solutions for supplying hazardous process gases — we are also able to support the quality assurance processes of our gas production customers," says Jim Murphy, general manager of Applied Energy Systems. "We recognize that process requirements vary, and this system is another example of our unique ability to accommodate those needs with tailored solutions equal in safety, quality and performance to our standard product lines," he adds.

Key features of the custom-adapted Centurion system include:

- A GigaGuard PLC controller that automates purging and cylinder switchover, with a color touch-screen that also displays real-time status information.
- PROFIBUS Communications for system-to-system connection and facility-wide equipment monitoring, control, and data collection.
- Modified Mechanical Design, including an analytical manifold to enable process gas flow through analytical instruments and return for safe venting.
- Customized software, to provide application-specific fully automatic control, monitoring and communications capabilities.

"Now, SEMI-GAS can provide custom solutions to our specialty gas production partners to enable effective sample gas analysis to meet the most stringent quality control demands," says Murphy.

## SPTS wins 'Green Manufacturer' Made in Wales award

At a ceremony on 23 October at Mercure Holland House Hotel in Cardiff (organized by UK-based business publisher Insider Media Ltd), plasma etch, deposition and thermal wafer processing equipment maker SPTS Technologies Ltd of Newport, Wales, UK was presented with the top prize in the 'Green Manufacturer' category at the Made in Wales Awards.

The award recognizes how SPTS has implemented a number of green initiatives to ensure that the firm uses resources efficiently, reduces waste, and minimizes the effects of its operations on the environment. Additional environmental benefits extend globally to the environmentally friendly products made using the energy-saving semiconductor and microelectronic devices produced using SPTS equipment, e.g. power management chips, LED lights, and micro-electro-mechanical systems

(MEMS) that can reduce energy used or even harvest energy from external vibrations.

"It is a testament of the commitment by the management team and our employees to significantly reduce our carbon footprint," comments SPTS' VP of operations Mike Hewlett. "We have made significant investment in our building management system and installed energy-efficient gas boilers which have reduced the company's gas consumption by 67% compared to pre-2012 levels," he adds. "We have also achieved significant reductions

in the electricity and water used at our factory in Newport and benefited from resultant cost savings."

SPTS encourages its employees to recycle as much waste as possible and has been able to reduce non-recyclable waste year-on-year. The firm also participates in the UK Government's Cyclescheme, which allows employees to purchase a bicycle tax-free. Electric car charging points have also been installed for the use of both employees and customers.

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

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

On the eve of the UK Investment Summit Wales in Newport in late November, the Welsh Government's First Minister Carwyn Jones unveiled six investment projects, including one for SPTS Technologies.

The firm has been awarded a £4.6m grant towards a three-year

research project to develop wafer processing techniques for advanced packaging applications in manufacturing the latest generation of ICs and MEMS. The project will create 30 full-time roles. SPTS currently employs more than 260 staff.

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# Aachen R&D develops nanoscale optical analysis of GaN

## Near-field microscopy studies structural and electronic properties

The Fraunhofer Institute for Laser Technology ILT of Aachen, Germany has worked with RWTH Aachen University's Institute of Physics (IA) to develop an analysis technology that, for the first time it is claimed, allows the structural and electronic properties of gallium nitride (GaN) and GaN composites to be studied optically at the nanometer level.

Industry's need for mass-producible LEDs is growing, whether for smartphone, computer and TV screens or for the lighting sector. A key reason is that LEDs use much less energy than incandescent bulbs, halogen bulbs or even energy-saving bulbs. The development of the blue LED was the last step in creating white LED light — pleasant light that significantly boosts user acceptance of the technology, e.g. in home applications. Developing increasingly efficient components will rely on a quick and cost-effective analysis technique.

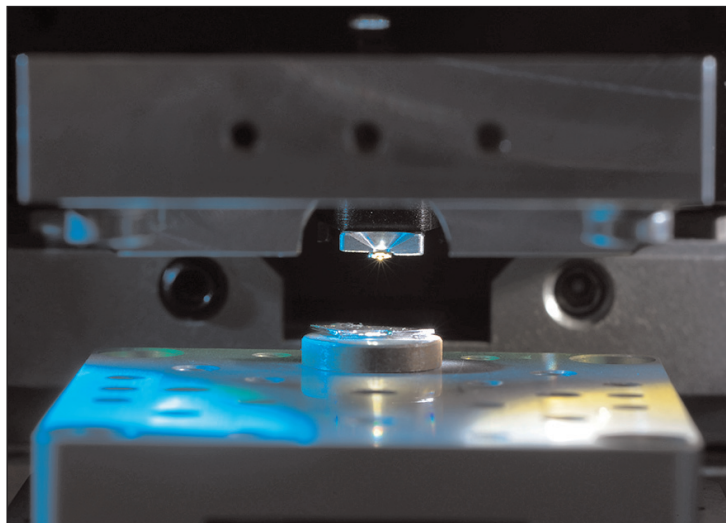
### Optical analysis on the nanoscale

The resolution of conventional optical microscopes reaches its physical limits when confronted with objects on the nanometer scale. Because of the light source employed, structures in the nanometer range cannot be brought into focus, ruling out optical analysis techniques. However, near-field microscopy can circumvent this fundamental limitation and penetrate the nanometer domain to provide an optical view. This places extremely high demands on the light source used.

### Laser system for using near-field microscopy on GaN

Collaborating with fellow researchers from the Chair for Experimental Physics at RWTH Aachen University, scientists at Fraunhofer ILT have spent the past few years developing a broadband tunable laser system that is geared towards the particular requirements of semiconductor analysis.

The wavelength can be adjusted to the material under inspection, which enables the new system to



**Near-field microscope with a fragment of GaN wafer.**

investigate a wide range of materials. In contrast to the solutions available on the market to date and those employed in R&D, it is claimed, the Aachen system enables much faster spectroscopic analyses. It also opens up access to material systems that were beyond the capacities of previous systems, including GaN and GaN composites, it is reckoned.

Using the new analysis system, last year the researchers obtained an optical 2D image showing tensions in the crystal structure of undoped GaN wafers for the first time. Computer simulations helped to quantify the exact extent of the tension. Recently the technique was also applied to a variety of doped GaN layers within complex structures. This is the first time that an optical technique has been available for studying the structural and electronic properties of GaN and GaN composites on the nanoscale, it is reckoned.

### Cost-effective, precise and non-destructive

Near-field microscopy offers cost and quality benefits over standard analysis techniques, say the researchers. The structural properties of thin GaN layers are currently studied using transmission electron microscopy (TEM), but the costs incurred are extremely high due partly to the laborious sample

preparation process. In contrast, near-field analysis can usually be conducted without any preparation.

Another benefit concerns secondary-ion mass spectrometry (SIMS), which is used to study the electronic properties.

Although this technique can be used to determine

electronic properties along an axis at the nanometer level, it is not yet possible to laterally ascertain the concentration of doping atoms at a comparable resolution. The technique also damages the samples. In contrast, near-field microscopy offers nanoscale resolution in all dimensions. It is also a completely non-destructive technique and can be implemented under normal conditions.

### Potential applications

Near-field microscopy is suitable for a range of applications, say the researchers. For example, when used in close consultation with the developers of new semiconductor components, the method can help to optimize process parameters in a targeted way. The analysis also aids the understanding of physical processes from a very early stage in development, particularly at the interfaces between individual layers.

The researchers reckon that these findings can shape subsequent development stages significantly. In high-frequency and high-power electronics too, GaN is becoming increasingly common as a component due to its physical properties. Near-field microscopic analysis techniques are well suited to researching these materials, it is concluded.

[www.ilt.fraunhofer.de](http://www.ilt.fraunhofer.de)

[www.rwth-aachen.de](http://www.rwth-aachen.de)



## Lake Shore Cryogenics exhibits probe stations and terahertz materials characterization system at EuMW

At the 44th European Microwave Week (EuMW) conference in Rome, Italy (7–9 October), Lake Shore Cryotronics Inc of Westerville, near Columbus, OH, USA, which makes scientific sensors, instruments and systems for measurement and control under extreme temperature and magnetic field conditions, exhibited its platforms for the study of devices and materials using high-frequency measurement.

Platforms include Lake Shore's probe stations for non-destructive probing of materials and test devices, for the study of electrical, magneto-transport, DC, RF or microwave properties. They are particularly useful for carbon-based nanotube (CNT), graphene, MEMS, gallium nitride (GaN), silicon germanium (SiGe), superconducting device and organic semiconductor research.

Lake Shore probe stations are designed specifically for on-wafer probing and measurement of device samples as a function of

temperature and field. Interrogating samples at cryogenic temperatures and in high magnetic fields can reveal certain mechanisms of novel materials, particularly in semiconductor and nanoscale device research. Low-temperature operation is becoming increasingly important in the development of new electronic devices, including high-speed SiGe-based transistors, says the firm.

Lake Shore offers cryogen-free CCR probe stations and liquid cryogen models, as well as probes, sample holders and other options to enable the configuring of a station for a specific application. These include ground-signal-ground (GSG)-style probes for 40GHz or 67GHz frequency ranges and designed for optimum microwave measurement performance at cryogenic temperatures.

In addition, Lake Shore is currently working with several firms and university researchers to develop terahertz-frequency,

on-wafer contact probing for cryogenic applications. The goal is to enable high-speed device probing and performance measurements at variable temperatures and fields for next-generation electronics R&D.

Also at EuMW, Lake Shore discussed its turnkey Model 8501 THz system for non-contact characterization of materials at variable temperature and in high field. This complete platform includes management and analysis software and features an integrated high-field cryostat and uniquely designed continuous wave (CW) THz emitter and detector components. Supporting the ability to measure at 200GHz to 1.5THz frequencies with spectral resolution of better than 500MHz, the system's CW-THz spectroscopy can reveal properties that other techniques miss because many phenomena have been found to align with these frequencies, says Lake Shore Cryotronics.

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

## Microsanj launches 800ps-resolution thermal analyzer for high-speed devices

Microsanj LLC of Santa Clara, CA, USA, which provides high-resolution thermoreflectance imaging analysis (TIA) systems, tools and consulting services, has announced the availability of the NT410A high-performance thermal analyzer in its Thermoreflectance Nanotherm Series.

The TIA systems are based on the optical thermoreflectance principle coupled with digital signal processing and advanced software algorithms to support microelectronic component thermal characterization for thermal design validation, defect analysis, and reliability analysis. Microsanj claims to offer the highest-resolution thermal imaging systems on the market.

The firm says that the NT410A represents another step forward in

the development of thermal analyzers capable of meeting the stringent requirements necessary to meet the challenges of complex high-performance microelectronics devices. With a time resolution of 800ps, sub-micron spatial, 1°C temperature resolution, and mega pixel full-field thermal images, the NT410A can provide device designers with key time-dependent thermal performance data that was, up to now, not easily attainable, says the firm. This information helps to ensure long-term device reliability and enables more optimal designs of ultra-fast logic devices, fast pulsed radar components, and other high-speed semiconductor devices, it adds.

"This latest addition to the Microsanj thermal imaging product

line is the most advanced system available for thermal imaging," claims CEO Dr Mo Shakouri.

"The NT410A has the capability for top-side and through-the-substrate thermal imaging with the accuracy and resolution necessary to fully characterize and analyze the thermal behavior of today's advanced high-performance semiconductor devices."

A paper was presented at the IEEE Compound Semiconductor IC Symposium (CSICS) in La Jolla, CA, USA on 20 October describing how the sub-nanosecond time resolution of the NT410A can be applied to ultrafast thermal imaging of high-power gallium nitride (GaN) transistors.

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

# Rubicon's revenue dips in third-quarter 2014 due to oversupply in 2-inch sapphire

## Growth expected in Q1/2015, driven by recovery in 4-inch market

For third-quarter 2014, Rubicon Technology Inc of Bensenville, IL, USA (which makes monocrystalline sapphire substrates and products for the LED, semiconductor and optical industries) has reported revenue of \$8m (at the bottom of the \$8–12m guidance range), down by \$6.5m on \$14.5m last quarter (following five consecutive quarters of growth).

This is mainly due to revenue for 2-inch cores plummeting by \$5.5m (from \$6.4m to \$0.85m, down on \$6.8m a year ago), while 4-inch rose slightly (from \$3.2m to \$3.3m, up on just \$0.3m a year ago). Revenue for polished wafers fell from \$2.6m to \$1.8m. Revenue from patterned sapphire substrate (PSS) wafers remained just \$0.25m (although almost double the \$0.13m a year ago).

"Although the pricing environment improved in the first half of the year, the excess supply of 2" in the third quarter drove pricing for 2" core 30% lower than the previous quarter," says interim CEO & chief financial officer William Weissman. With the LED market migrating from 2" to 4" substrates, much of the remaining 2" demand is coming from the mobile device market.

"While usage of 2" material for the mobile device market continued to grow in the third quarter, that demand was largely satisfied by the considerable inventory of 2" material in the supply chain," says Weissman. "In addition, there has obviously been capacity added in the marketplace this year to serve the mobile device market," he adds. "As a result, there were limited opportunities to sell 2" material in the quarter. However, we are seeing a meaningful increase in 2" orders in the fourth quarter [as inventory levels of 2-inch material in the supply chain have now been significantly reduced]."

Nevertheless, despite the drop in revenue, non-GAAP loss was cut from \$10m (\$0.39 per share) to \$9.3m (\$0.36 per share, better than the guidance of \$0.39–0.44, due to a combination of reduced product costs and product mix).

However, this excludes \$4.4m in non-cash charges, including \$2.6m related to writing down consumables and equipment that became obsolete with changes made to Rubicon's wafer polishing platform. The firm expects to recover that amount through the corresponding reduction in wafer costs by the end of 2015. In addition, \$1.8m of finished goods inventory was written down as changes in customer specifications made it unlikely to be able to realize the full inventory value.

For fourth-quarter 2014, Rubicon expects GAAP loss per share to be \$0.38–0.42. While the firm expects a continued reduction in product costs, Q4 will be impacted by the reduced core pricing and product mix. However, with inventory levels of 2" material in the supply chain declining, Rubicon hopes to see improvement in 2" material pricing in first-quarter 2015.

"While we are seeing increasing interest in 2" material in the fourth quarter, 4" demand is very weak due to seasonality in the LED market," says Weissman. "While the general lighting

segment is growing steadily, the backlighting market continues to represent a large portion of overall LED demand and that segment continues to experience seasonality, with the fourth quarter typically being the weakest quarter," he adds. "This year, the seasonality is more impactful because of a higher level of inventory in the supply chain." As a result, Rubicon expects fourth-quarter revenue to be similar to Q3 but then to begin improving in first-quarter 2015, with a recovery in the 4" market along with continued growth in wafer business.

Rubicon expects continued progress in fourth-quarter 2014 in growing the wafer business, particularly with PSS wafers. "We are now qualifying with nearly all of the world's top-tier LED chip manufacturers," says Weissman. "The size of the orders from certain customers will begin to increase over the next six months as we progress from initial qualification toward full qualification with those customers," he adds. "We expect production orders by mid next year and, based on the progress we are making, we believe that our PSS capacity should be fully utilized by the end of next year."

"The shift from 2" to 4" this past year has been dramatic, and we are now seeing more interest in 6" wafers and are providing 6" polished and 6" PSS wafers to several different chip manufacturers that currently do not use 6" wafers in production," says Weissman. "While current low-cost performance wafers could delay 6" adoption for some of these customers, we expect one or two to move into production on 6" next year," he adds. "To our knowledge, we remain the only vertically integrated sapphire producer with volume 6" PSS capability, and volume 6" polished ➤

**The shift from 2" to 4" this past year has been dramatic, and we are now seeing more interest in 6" wafers and are providing 6" PSS wafers to several different chip manufacturers that currently do not use 6" wafers in production**

► wafer capability," notes Weissman.

"The outlook for commercial sapphire remains very bright, with strong growth expected from both the LED and mobile device markets," says Weissman. "However, the sapphire market remains a relatively young industry with new applications, seasonality and changes in the competitive landscape. Like other advanced materials industries, as the industry matures, the industry leaders will be companies with scale, but more importantly with the strongest capability in terms of vertical integration," he adds.

"While the build-out of our vertical integration model is costly in the near-term, we believe it will position us well to continue to innovate and capture significant market share in the evolving LED market."

"Our margins will improve with increasing volume and experience in our new product lines and as customer specifications become better defined," reckons Weissman.

"We will also reduce our idle plant cost and our wafer product cost," he adds. "We continue to carry a high idle plant cost associated with low utilization of our wafer operations." Rubicon expects to see considerable improvement in this next year, particularly in second-half 2015.

In crystal growth, Rubicon is in the process of slightly modifying the geometry of its boules, which is increasing yield and hence reducing crystal cost. This modification will be implemented in all of its furnaces over the next 12–18 months. The firm is also continuing to lower its raw material cost in crystal growth. "The current low cost of our raw material production is not yet fully reflected in our statement of operations," remarks Weissman. "Back at the prior market peak, we were concerned about a potential bottleneck in the raw material part of the supply chain, and we accumulated a significant inventory of the material

that we used at that time... that material continues to flow through our production. As a result, the cost of raw material and our cost of goods sold is nearly double that of our current raw material production cost... Those costs, as well as our raw material inventory balance, will come down," Weissman believes. "We made progress in the quarter in reducing polished wafer cost, through some changes in the consumable formula and upgrading some equipment. We are also working on some more significant changes to our polishing platform which, if successful, would significantly reduce wafer cost and require minimal additional capital expenditure. Polishing is the area where we have the greatest opportunity to reduce cost, and an area where we must reduce cost, in order to fully realize the benefit of our vertical integration strategy," Weissman concludes.

[www.rubicon-es2.com](http://www.rubicon-es2.com)

## RASIRC technology used to clean and prepare Ge surfaces

RASIRC Inc of San Diego, CA, USA, whose products purify and deliver ultra-pure liquids and gases, has announced independent test results by University of California, San Diego (UCSD) that show high-purity hydrogen peroxide vapor delivered to process by RASIRC technology enables the removal of carbon-based contaminants from germanium surfaces. A subsequent anneal removes oxygen. In addition, the hydrogen peroxide dosing creates a suitable surface for atomic layer deposition (ALD). RASIRC develops dynamic vapor generation technology that delivers high-purity vapor to key semiconductor and photovoltaic manufacturing processes.

"RASIRC is the only company able to create a consistent hydrogen peroxide vapour," claims RASIRC's founder & president Jeffrey Spiegelman. For high-purity hydrogen peroxide vapor generation and delivery, RASIRC offers a range of products that can deliver hydrogen

peroxide concentrations up to 30,000ppm and flow rates from 10sccm to 30slm. "Alternative delivery techniques generate droplets that contaminate and pit germanium surfaces," he adds.

UCSD performed a series of tests to determine the best method to clean and prepare germanium surfaces for ALD. Germanium is an attractive material for electronics manufacturers because of its much faster data transmission potential. Previous cleaning methods that involved liquid baths are not suitable for germanium because it easily dissolves and is removed from thin layers and new architectures, says RASIRC. Contaminants must be removed without any damage to germanium in the underlying surface. Similarly, cleaning and preparation must be performed in-situ, as any transfer from bath to chamber leads to more contamination.

Initial tests used high-purity hydrogen peroxide dosing at

300miliTorr and 300°C. This greatly reduced the carbon signal and generated some germanium oxide. Subsequent heating to 700°C desorbed the oxide and eliminated the oxygen contamination. Another loop of dosing and annealing further reduced the carbon. A final longer dose of hydrogen peroxide resulted in a contaminant-free surface that was planar.

Because high temperatures can damage surfaces, a second test used atomic hydrogen dosing in place of the annealing step. This process was also effective at removing the residual oxygen layer. A final short-pulse, high-temperature anneal left a well-ordered surface with low roughness.

"The industry is reaching the limits of liquid chemistry for cleaning new materials and architectures," thinks Spiegelman. "In the near future, many processes will have to move to vapor. RASIRC technology is ready to support these processes."

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

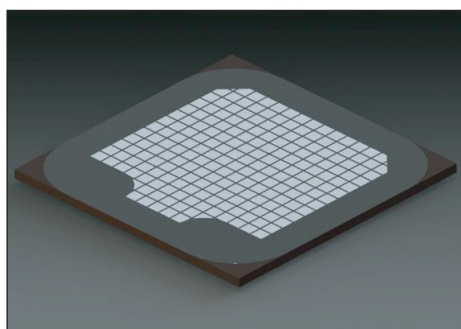


# Plessey Semiconductor presents large-die GaN-on-Si LED technology demonstrator

UK-based Plessey has announced the realization of high-volume, large-die LED performance based on its gallium nitride on silicon MaGIC (Manufactured on GaN-on-Si I/C) high-brightness LED (HBLED) technology.

The large die benefits from three core features of Plessey's process: the low thermal resistance of silicon; a single-surface emitter die design; and 6-inch wafer processing. To exploit these benefits, Plessey has produced a 20mm<sup>2</sup> die design (i.e. 4.5mm x 4.5mm) that can generate up to 5W of blue light over a 400–480nm wavelength range. This die is produced as a technology demonstrator to enable meaningful engagement with customers to determine the optimum application fit.

Large-area LED die can help in many ways, particularly for



**Plessey's 4.5mm x 4.5mm large-die GaN-on-Si LED.**

chip-on-board (CoB) products in providing a much simpler, more uniform light emitter while reducing die attach and wire bond overheads. The low thermal resistance of the silicon substrate allows easier thermal management and enhanced reliability resulting from lower temperature operation. The die uses Plessey's vertical design structure,

which has a cathode top contact and anode bottom contact, making it suitable for scaling the effectiveness in applying large die. Plessey also says that 6-inch wafer processing, coupled with what is claimed to be best-in-class across-wafer uniformity, makes such large die a commercial proposition.

"The next wave of general lighting products will see LEDs applied in ways that truly exploit the benefits obtained through Plessey's leading GaN-on-Si technology," believes marketing director David Owen.

"This announcement marks the start of a phase where we engage with our key partner customers in defining the commercial realization of lighting products based on Plessey's large GaN-on-silicon LED die."

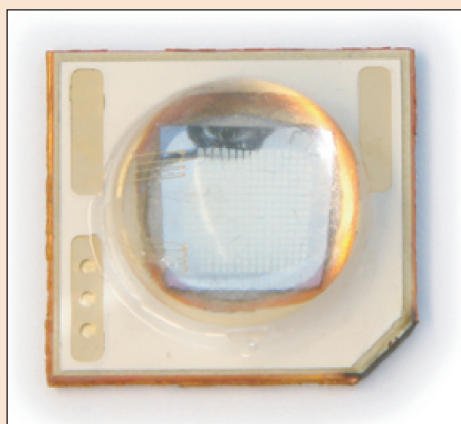
[www.plesseysemiconductors.com/led-plessey-semiconductors.php](http://www.plesseysemiconductors.com/led-plessey-semiconductors.php)

## Plessey demonstrates large-area GaN-on-Si LED die with Litecool's heat management module

At LuxLive (the UK's biggest lighting show) at ExCel London (19–20 November), Plessey of Plymouth, UK presented the results of its partnership with Litecool Ltd of Sheffield, UK (which manufactures heat management solutions for LED lighting products), showcasing its large-area LED die assembled in the Litecool MicroSpot product.

Litecool's module allows the LED diodes to be mounted directly onto the heat spreader without anything underneath to obstruct the escaping heat. This is claimed to offer lighting product designers an LED module that stays cooler, allowing the use of smaller, lower-cost heat sinks and hence helping the LED to stay efficient, maintain good light quality and last longer.

Litecool has packaged Plessey's large 4.5mm single-source LED emitter into its 10 Watt MicroSpot package with thermal resistance (junction to heat-sink) of just



**Plessey's large-area LED.**

0.7C/Watt, producing a beam angle of just 18° and a luminance size of just 42mm.

"We have used our latest generation of technology to ensure groundbreaking thermal resistance for this unique package," claims Litecool's CEO James Reeves. "This powerful single-source emitter works exceptionally well with secondary optics and with our tech-

nology keeping it cool," he adds, highlighting the spotlight market, where high lumen density is essential.

The heat management of LED die is a critical aspect of the design of lighting products adopting LEDs, notes Plessey's marketing director David Owen. "The use of Litecool's LED module technology enables us to maintain the lumen density not just at source but at luminaire level — a 10 Watt spotlight that is just 42mm in diameter."

"Recent performance improvements in the efficacy of our LEDs have enabled Plessey's GaN-on-Si MaGIC LEDs to be competitive with any LED technology," he adds. "Plessey's technology has already shown how we can overcome what up to now has been a significant cost barrier in large-scale LED illumination."

[www.litecool.co.uk](http://www.litecool.co.uk)  
[www.luxlive.co.uk](http://www.luxlive.co.uk)

# Plessey's GaN-on-Si LEDs achieve 120lm/W efficacy

## Light output doubled in six months

UK-based Plessey says that its gallium nitride on silicon MaGIC (Manufactured on GaN-on-Si I/C) high-brightness LED (HB-LED) technology has achieved light output of 120 lumens per watt with greater than 50% light output efficiency. The first engineering samples in the 5630 PLCC2 package are now shipping, with other package variants available on demand. Blue die with a wavelength of 455nm are also available and being shipped to lead customers.

"Having developed and put into production the first of our MaGIC LEDs in 2013, the next step was to demonstrate that the GaN-on-silicon

technology could deliver output performance levels comparable with other LED technologies," says chief technology officer Keith Strickland. "Whilst 120lm/W for an LED may be considered 'acceptable' to industry, we must remember that we have doubled our LED light output in the past six months," he adds. "I see no reason why we cannot reach state-of-the-art in LED die output performance within the next six months. This current process technology will become the base for our Application Specific LEDs, the ASLED that bridges the gap between the LED component suppliers and the solid-state lighting

fixture designers and OEMs," Strickland continues.

"The combination of expertise and a sustained period of light output performance improvement in the core LED material is due to our holistic approach to LED development — our in-house experts in epitaxy growth, process development and die design all working together," comments operations director Mike Snaith. "This way of working will continue and strengthen as we drive towards the next generation of higher-efficiency, silicon-based integrated LED solutions and away from discrete, plastic-packaged LED components."

## Syscom Electronique appointed for France and Tunisia distribution

Plessey has entered into a distribution agreement with Syscom Electronique, headquartered near Paris, France, to expand its European network with coverage in the France and Tunisia markets for its GaN-on-silicon LED products.

"This advanced LED technology will help Syscom's customers to successfully develop and market

distinctive and innovative solutions," says Syscom's president Regis du Manoir. "Plessey's solutions can give French customers an edge in the highly competitive LED lighting market place," he believes.

"Plessey is very pleased to work with a distributor who has significant history in supplying the solid-state lighting market in France,"

says Plessey's marketing director David Owen. "Syscom Electronique has a dedicated team working in the lighting segment and therefore a considerable knowledge of the growing French lighting industry and customer base which will accelerate the time to market for Plessey GaN-on-silicon LEDs in this region."

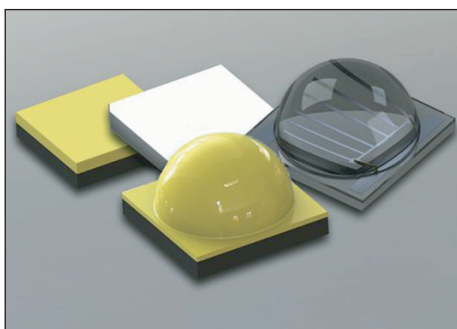
[www.syscomelectronique.com](http://www.syscomelectronique.com)

# Plessey advances to chip-scale and wafer-level packaging, targeting application-specific LEDs

UK-based Plessey has expanded into chip-scale packages and wafer-level packaging, leading to its application-specific AS-LED.

The firm says that recent performance improvements in key areas (including lumens/watt) have elevated its gallium nitride on silicon (GaN-on-Si) technology MaGIC (Manufactured on GaN-on-Si I/C) high-brightness LEDs (HBLEDs) to be competitive with any LED technology.

"Our most recent advancements in performance to greater than 50% wall-plug efficiency, coupled with our unique semiconductor technologies and manufacturing



capabilities, have pushed us to our next stage of technology development," says chief technology officer Dr Keith Strickland. "We will have our first chip-scale package solution available for sampling later this quarter," he adds.

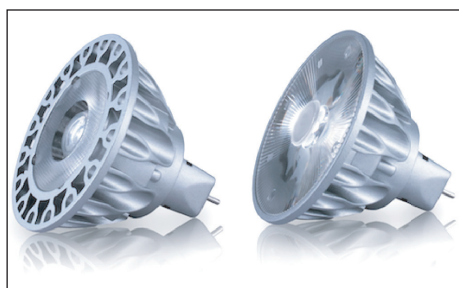
"We need to move the conversation from lumens/watt to how the semiconductor industry can provide the capability for mass customization needed for the solid-state lighting industry," Strickland continues. "Our LED components are more than competitive with any sapphire or silicon carbide solution, but the industry needs far more," he adds. "We believe our AS-LED provides the solution to the mass customization needed in the solid-state lighting markets."

[www.plesseysemiconductors.com](http://www.plesseysemiconductors.com)  
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# Soraa launches constant-current MR16 LED lamp to solve compatibility issues

Soraa Inc of Fremont, CA, USA, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates, has introduced a compatible version of its MR16 LED lamp. Featuring full-visible-spectrum light, the constant-current MR16 LED lamp is suitable as a lighting solution for restaurants, retail, high-end residential and office environments where superior light quality and dimming are essential, says the firm.

Equipped with a standard GU5.3 two-pin base, the constant-current MR16 LED lamp fits into any MR16 fixture and fully conforms to the ANSI/IECE-compatible form factor. Unlike other MR16 LED lamps, the constant-current LED lamp is designed to accept an external driver that supplies it with low-voltage DC input current, eliminating the need to fit a transformer in limited space.



**Constant current MR16 LED lamp.**

Providing dimming and control flexibility, light output can now be programmed to the desired level when using a programmable or remote driver. The lamp also achieves zero flicker when used with a DC driver and is available in 10°, 25° and 36° versions.

"Incompatibility issues between LED lamps, fixtures, dimmers and transformers continue to hinder the advancement and adoption of LED technology," says George Stringer, senior VP of North America sales. "Our new constant-current MR16

LED lamp overcomes these hurdles, enabling flexibility and choice without compromising on performance and quality," he adds.

The constant-current MR16 LED lamp features Soraa's point-source optics for high intensity and uniform beams, and unique Violet-Emission 3-Phosphor (VP<sub>3</sub>) LED technology for rendering of colors and whiteness. Utilizing every color, especially deep red emission, VP<sub>3</sub> Vivid Color renders warm tones accurately, and achieves a color-rendering index (CRI) of 95 and deep red (R9) rendering of 95 at color temperatures of 2700-4000K. Also, unlike blue-based white LEDs without any violet/ultraviolet emission, the VP<sub>3</sub> Natural White is achieved by engineering the violet emission to properly excite fluorescing agents including natural objects like human eyes and teeth, as well as manufactured white materials such as clothing, paper and cosmetics.

## Soraa boosts full-visible-spectrum GU10 LED lamps to 500 lumens

Soraa has upgraded the performance of its MR16 GU10 base 120V LED lamp line with the company's third-generation GaN-on-GaN LED. Featuring full-visible-spectrum light, the new GU10 LED lamps are suitable as lighting for restaurants, retail, high-end residential and office environments where superior light quality and smooth dimming are essential, says the firm.

The new lamps boost efficacy by 40% over the firm's previous generation of GU10 LED lamps. "They are true retrofit sized — unlike other high-output GU10 products on the market today — making them highly compatible with a broad range of enclosed, non-ventilated, indoor and outdoor fixtures," claims George Stringer, senior VP of Americas sales & marketing.

Soraa says that its Point Source

Optics technology produces high-intensity, uniform beams, and enables a 10° narrow spot version with a center-beam candle power (CBCP) of 7300Cd (not available in halogen or from other LED makers, the firm claims). Soraa also offers a 25° narrow flood version that has a CBCP higher than halogen and all other GU10 LED products on the market, the firm adds.

The lamps also feature Soraa's unique Violet-Emission 3-Phosphor (VP<sub>3</sub>) LED technology for rendering of colors and whiteness. Utilizing every color, especially deep red emission, VP<sub>3</sub> Vivid Color renders warm tones accurately, and achieves a color-rendering index (CRI) of 95 as well as deep red (R9) rendering of 95. Also, unlike blue-based white LEDs without any violet/ ultraviolet emission, the VP<sub>3</sub> Natural White is achieved

by engineering the violet emission to properly excite fluorescing agents including natural objects like human eyes and teeth, as well as manufactured white materials such as clothing, paper and cosmetics.

The GU10 LED lamps are available in 50W (Soraa 95CRI VIVID 400 lumen) and 65W (Soraa 80CRI BRILLIANT 500 lumen) halogen-equivalent light output; 10°, 25°, 36° and 60° beam angles; and 2700K, 3000K, 4000K and 5000K color temperatures.

Additionally, Soraa's 10° lamps work with its magnetic accessory SNAP system. With a simple magnetic accessory attachment, beam shapes can be altered and color temperature can be modified, allowing flexibility in design and display.

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





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# SemiLEDs' quarterly revenue halved as manufacturing facilities consolidated

## Revenue to return to growth next quarter

For its fiscal full-year 2014 (to end-August), LED chip and component maker SemiLEDs Corp of Hsinchu, Taiwan has reported revenue of \$14.5m, down 19% on \$18m in fiscal 2013 (with LED chips falling 12%, LED components 23%, and lighting product 18%).

Most recently, for fiscal fourth-quarter 2014, revenue was \$2.3m, down by a third from \$3.4m a year ago and by a half from \$4.6m last quarter (with LED chips falling by 57% sequentially, lighting products 56%, and LED components 42%).

"We experienced a reduction in production capacity as we consolidated manufacturing facilities [including closing the Sinwu Facility] and relocated the related manufacturing equipment to our other facilities [involving reducing headcount and exploring opportunities to reduce idle capacity, in an effort to conserve cash]," says chairman, president & CEO Trung Doan.

Gross margin for full-year 2014 was -78%, better than the -82% in 2013. However, in fiscal Q4/2014, gross margin has worsened to -134%, compared with -61% last quarter and -103% a year ago.

Selling, general & administrative (SG&A) expenses have fallen further, from \$4.1m a year ago and \$2.5m

last quarter to \$1.8m in fiscal Q4. R&D expenses have been cut further, from \$1.5m a year ago and \$1m last quarter to \$0.8m. Total operating expenses have been cut further, from \$4.1m a year ago and \$3.6m last quarter to \$2.7m. Nevertheless, although better than -523% a year ago, operating margin worsened from -138% last quarter to -251%.

On a non-GAAP basis, net loss was \$5m (\$0.17 per diluted share), cut from \$7.3m (\$0.26 per diluted share) a year ago. Net loss for fiscal 2014 was \$22.5m (\$0.80 per diluted share), cut from \$27.8m (\$1.01 per diluted share) for fiscal 2013.

Cash used in operations has risen from \$14.5m in full-year 2013 to \$15.7m in full-year 2014. Including capital expenditure of \$2.7m (level with last year), free cash flow for full-year 2014 was -\$18.4m, compared to -\$17.2m for 2013.

For fiscal Q4/2014, cash used in operating activities has been cut from \$4.1m last quarter to \$1.9m. Hence, despite capital expenditure rising from \$500,000 last quarter to \$771,000, free cash flow has improved from -\$4.6m to -\$2.7m. During the quarter, cash and cash equivalents fell from \$16.1m to \$12.6m. As of end-August, working capital was \$16.5m.

With consolidation actions mostly complete, SemiLEDs expects revenue to return to growth in its target markets. For fiscal first-quarter 2015 (to end-November), SemiLEDs' revenue should rise to \$2.9-3.1m. The firm also expects further sequential growth in fiscal Q2/2015 (to end-February).

"While relocation efforts were largely complete by the end of the fourth quarter, we continued to experience lingering effects of these activities in the first fiscal quarter as we completed the hook-up and start-up of this equipment," says Doan. "We expect to realize the full benefits of operating cost reductions and operational efficiencies from these efforts starting in the second quarter of our fiscal 2015," he adds.

"Looking beyond our operational activities in the quarter, we continue to see strength in our target markets including UV applications, particularly for component products," Doan continues. "By leveraging the combination of our new product developments and the integration of LED component technology and manufacturing capacity we acquired, we believe we are well positioned to take advantage of the opportunity ahead of us."

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

## Luminus launches 1W SMD LED with 170° emission angle

Luminus Devices Inc of Billerica, MA, USA, which makes PhlatLight (photonic lattice) LEDs for solid-state lighting (SSL) applications, has launched the XNOVA Cube, a 1 watt SMD LED with a 170° viewing angle, which provides designers with the ability to improve system efficacy, reduce cost, and simplify omni-directional products, it is said.

Unlike traditional mid-power LEDs, which were originally designed for LCD backlighting, the XNOVA Cube

is engineered specifically for illumination applications with high quality of light requirements, has the industry's widest viewing angle, emits more light than any mid-power LED, and delivers this from a compact 1.9mm by 1.9mm package.

"The XNOVA Cube has opened-up new design options for our customers in the highly competitive panel lighting, linear and omni-directional lamp markets," says Jim Miller, executive VP of sales &

marketing. "They are able to reduce LED count by as much as 30% and at the same time cut power consumption by 10%, which enables further cost reductions in drivers, thermal systems, and optical components," he reckons.

Luminus Devices exhibited its XNOVA illumination product line at the Hong Kong International Lighting Fair (27-30 October).

[www.luminus.com/products/xnova.html](http://www.luminus.com/products/xnova.html)



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# Germany's Osram-led Hi-Q-LED project achieves record 147lm/W for 530nm all-InGaN green LED

## Phosphor-conversion LED's record >200lm/W diminishes 'green gap'

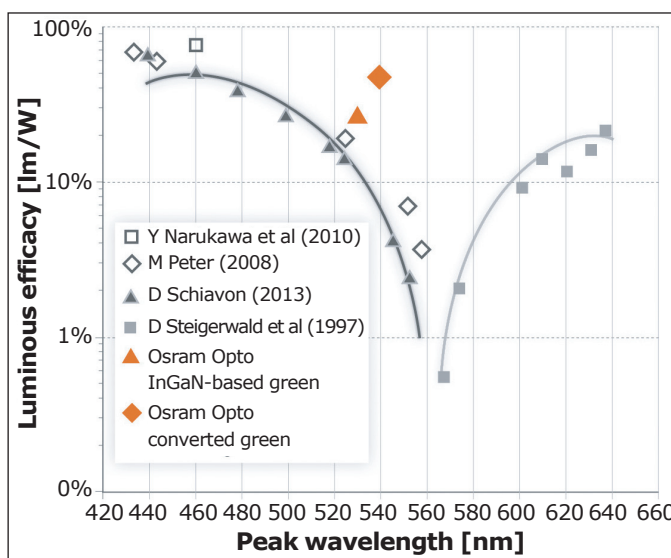
Funded by Germany's Federal Ministry of Education and Research (BMBF) and coordinated by Osram Opto Semiconductors GmbH of Regensburg, Germany, the Hi-Q-LED project has made advances with green LEDs, diminishing the 'green gap' phenomenon (the drop in efficacy above 500nm in the green spectral range). The result is a green-emitting LED based on indium gallium nitride (InGaN) that achieves record luminous efficacy of 147lm/W at a wavelength of 530nm and a spectral width of 35nm. In addition, another green LED developed by combining a blue chip with a phosphor converter has achieved record efficacy exceeding 200lm/W.

As part of the LED Lead Market Initiative funded by the BMBF, the working group for 'Efficient LED Solutions with High Color Rendering Indices' in the Hi-Q-LED project headed by Osram Opto has developed two green LED prototypes.

### Green all-InGaN LEDs close 'green gap'

Research activities in the framework of the project have enabled the development of a narrowband green LED with record efficacy of 147lm/W for a chip size of 1mm<sup>2</sup> and a driving current of 350mA (a current density of 45A/cm<sup>2</sup>). The central wavelength is 530nm and the forward voltage is 2.93V at this current density. Key factors are a reduction in the carrier density in the light-emitting layers and significantly improved material quality.

Due to a much reduced dependency of the efficacy on operating current compared to conventional green LEDs, the prototype shows greatly improved performance at higher current densities and achieves as much as 338lm at 125A/cm<sup>2</sup>. "InGaN-based LEDs, in which the light output is generated by an InGaN semiconductor exclusively, offer a much more narrowband



Efficacy drop of LEDs in 'green gap' spectral range.

emission with a spectral width of about 35nm compared to green LEDs that are based on phosphor conversion," says project manager Dr Andreas Löffler. "This breakthrough is an enabling technology for highly efficient projection systems requiring a high color rendering index (CRI)," he adds. "A high color rendering index or an increased color gamut means a more vivid, higher-quality image."

### Record efficacy of >200lm/W with green full conversion phosphor solution

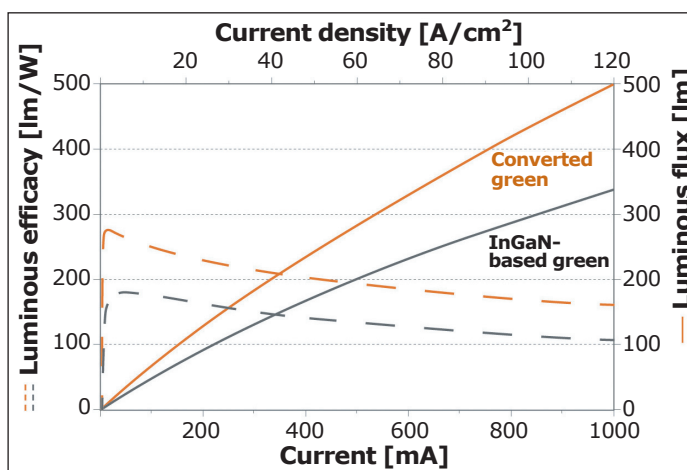
The project's second approach—to create an even more efficient

boost light output to above 500lm. Despite high current density, efficacy reaches 160lm/W. It peaks at 274lm/W for 1.5A/cm<sup>2</sup>.

The exceptional performance figures have been achieved due to the optimized interaction of chip and converter technologies, says research engineer Dr Thomas Lehnhardt. "Continuous improvement of the blue LED chips, an optimized excitation wavelength and an increased degree of conversion of the phosphor converter are the winning combination underlying this new record-breaking LED."

### From prototypes to series production

At the moment, figures achieved by the two LED prototypes still can only be ranked as development data. Further time will be needed to develop products based on the project's findings that offer optimized price and performance and are suited to mass production.



Luminous flux and efficacy versus operating current for both InGaN-based green LED and a conversion LED.

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

# Osram launches first surface-mountable LED with oval light-radiating characteristics

Osram Opto Semiconductors GmbH of Regensburg, Germany has launched the surface-mountable Displix Oval, which is claimed to be the first LED with oval light-radiating characteristics for large-screen video walls, gas station price signs and digital road signs. The beam angles are 110° (horizontal) and 60° (vertical).

Due to a compact housing measuring just 2.1mm x 2.7mm x 1.5mm (including lens), almost twice as many LEDs can now be mounted on a board than with ordinary radial diodes, doubling both the pixel density and the resolution of displays. The images displayed are hence extremely vivid with a high color homogeneity.

An extra advantage of this high pixel density is that the pixel brightness required is lower, so the



individual LEDs require a lower current. In combination with the durable housing materials, this lower output extends the lifetime of the diodes.

The Displix Oval has a black QFN (quad flat no leads) housing, which further increases image quality. This reduces reflections and increases the contrast and color quality of the images displayed across the entire display: "Being surface mounted, SMT LEDs like the Displix Oval have

very low tilt tolerances per diode," says product marketing manager Andrew Lin. "A display fitted with the new Displix Oval LEDs has a stable and very homogenous color appearance," he adds.

Both the processes and the processing of the Displix Oval are much simpler than with radial LEDs, greatly reducing customers' processing costs, says the firm. Being very flat, the LED requires less silicone for the potting of the boards to protect the contacts from rain, moisture and corrosive outdoor environments. This enables a reduction in the amount of material used, which again has a considerable impact on costs.

The Displix Oval is available in yellow, red, green and blue (with brightnesses at 20mA of 1cd, 1cd, 6cd and 600mcd, respectively).

## Osram Compact LEDs used for adaptive headlights on new Mercedes

Osram Opto Semiconductors says that the headlights on the new Mercedes Benz CLS class of cars are equipped with its Osram Compact high-power LEDs, which can be arranged very close together in the headlight with a high degree of flexibility so that adaptive front lighting systems can be achieved. In addition to this current project, Osram and Daimler AG are working together to develop future innovative automotive lighting systems – as partners in the  $\mu$ AFS research project sponsored by the German Federal Ministry of Education and Research (BMBF).

For the new CLS headlights, the car maker uses an adaptive front lighting system (AFS), with the aim of providing greater visibility in every situation and offering road users better protection from accidents. Each module in the headlight is equipped with 24 Osram Compact LEDs. Due to the firm's UX:3 chip technology, the



LEDs achieve high luminous efficacy even at high currents. With package dimensions of 1.6mm x 1.2mm, the LEDs provide the basis for both AFS and light guide solutions.

### Camera and controllers help to achieve best distribution of light

To achieve the optimum distribution of light with the Osram LEDs, the car maker uses a camera mounted on the windshield to cover the area in front of the vehicle. Four controllers in the vehicle perform calculations 100 times per second to determine the best

lighting for the driver. LED-based adaptive lighting systems enable the road ahead to be automatically illuminated with exceptionally bright light and with precisely controlled distribution without dazzling other road users, says Osram.

### Cooperation for future automotive lighting

In the  $\mu$ AFS project, Daimler AG and Osram Opto Semiconductors are also working with other partners on possible automotive lighting of the future. The aim of the project is to develop the technical principles for a new class of energy-efficient LED headlamps, which may then provide the basis for AFS. "In October 2014 we were able to reach the first major milestone when we presented a new type of LED chip with no less than 256 pixels," notes Osram Opto's project coordinator Stefan Grötsch.

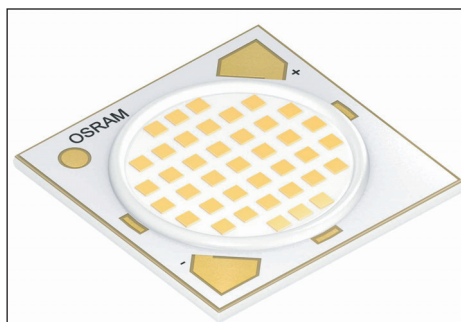
[www.osram-os.com](http://www.osram-os.com)

## Osram extends Soleriq P series with compact, high-flux P 13

At the Electronica 2014 trade fair in Munich, Germany (11–14 November), Osram Opto Semiconductors GmbH of Regensburg, Germany unveiled the P 13 as the latest addition to its Soleriq P series of LEDs.

The Soleriq P 13 has a brightness of up to 6800 lumens, making it the highest-power LED in the Soleriq P series. Together with a small light-emitting surface measuring just 13.5mm in diameter, the P 13 is a highly compact and powerful light source for multiple lighting applications, suitable for high-powered spotlights used in retail, museum and commercial lighting.

The P 13 is available in two versions with different color rendering indexes (CRI). The CRI 80 version delivers a brightness of 4000lm even at high temperatures (85°C, 1050mA) and can be overdriven to deliver up to 6800lm. The entire package measures 18mm x 18mm x 1.5mm, facilitating compact and bright lighting solutions for indoor spotlights and high-bay lighting. Alternatively,



**The new high-flux Soleriq P 13 LED.**

for ambitious spotlight applications demanding high color quality, small beam angles and a high lumen output, the CRI 90 version delivers 3300lm on average and up to 5600lm in overdriven conditions.

The P 13 has similar light output to the existing 4000–5000lm Soleriq S 19. "In fact, the new Soleriq P 13 has smaller dimensions and is therefore the right choice for more compact lighting solutions," says Marc Dyble, product marketing manager for General Lighting at Osram Opto. Compared to other products in the Soleriq P series (the

P 9 or the P 6), fewer LEDs are needed to achieve the same light output. The small light-emitting surface permits a simpler lens design, costing less and enabling more compact lighting solutions. Binning of the LEDs (at a current of 1050mA) takes place at 85°C ('hot binning'). This high temperature very closely matches normal operating conditions and enables the brightness and color values of the LEDs to be precisely determined in line with their subsequent use.

Products in the Soleriq family have certain features in common. The LEDs are all based on chip-on-board (CoB) technology (ensuring uniform color and light appearance), while their light-emitting surface is compatible with the international Zhaga standard. The accessories tailored to the Soleriq family (such as connectors, optics and drivers) are all available on the market and can be obtained via the Osram partner network LED Light for you (LLFY).

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

## Daylight and Thorlabs partner to develop QCLs

Daylight Solutions Inc of San Diego, CA, USA — which makes molecular detection and imaging systems based on mid-infrared quantum cascade lasers (QCLs) for scientific research, life science, industrial process control and defense applications — and vertically integrated photonics product maker Thorlabs Inc of Newton, NJ, USA have formed a strategic partnership to advance the development of QCLs to meet the increasing demands of defense and security markets. Specifically, they will work together to enhance QCL performance, expand product and manufacturing capabilities, and capture new business opportunities in defense and security markets.

Announced separately, Thorlabs also recently acquired Corning Inc's QCL business and associated optical semiconductor technologies research group, which produces

QCLs for sensing, scientific and defense markets. The acquisition allows Daylight to transfer its six-year collaboration and partnership with Corning to Thorlabs, where the joint effort to define and execute on technology roadmaps, develop best-in-class QCL components, and test and qualify QCL sub-systems for commercial and military acquisition programs will continue.

Thorlabs Quantum Electronics (TQE) will integrate Corning Inc's QCL business and associated optical semiconductor technologies research group into its 60,000ft<sup>2</sup>, vertically integrated manufacturing facility in Jessup, MD, USA. As part of the integration strategy, the existing QCL manufacturing equipment, facilities and staff at Corning will remain fully operational as full-rate production capacity is brought up at TQE. This strategy aims to

ensure a significant period of overlapping production of QCL devices throughout the transition period.

"Consolidating Corning's QCL technology into Thorlabs' existing facility will significantly contribute to Thorlabs' vision of providing a stable portfolio of readily available and low-cost QCL devices to the mid-IR market," says Thorlabs' president & founder Alex Cable. "We are excited about the opportunity to expand our ongoing relationship with Daylight Solutions by providing the QCL technology, products and US-based manufacturing capacity required to serve the US defense and security markets," he adds. "Daylight has a long-standing relationship with Thorlabs as a trusted supplier," notes Daylight's CEO Dr Timothy Day.

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

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



## Osram's blue and green lasers plus Corning's Fibrance Light-Diffusing Fiber promoted for integrating light sources into product designs

Osram Opto Semiconductors GmbH of Regensburg, Germany and Corning Inc announce a co-marketing agreement to promote Corning Fibrance Light-Diffusing Fiber, a first-of-its-kind technology that embeds lighting into products using Osram laser diodes.

Fibrance fiber uses Corning's glass optical fiber designed for thin, colorful, aesthetic lighting and Osram's blue and green laser diodes. Fibrance fiber is optimized for applications such as automotive interior, architecture, consumer electronics, and major appliances.

The flexibility and tight-bend capability of the fiber allows it to curve, wrap or contour around objects, while maintaining bright and uniform light. The fiber is so small and thin that it is nearly invisible when the light source is off, enhancing a product's overall aesthetics. Fibrance fibers disperse light, rather than transferring it, allowing it to emit vibrant, clear colors up to 50m in product length.

"We expect the automotive and consumer markets to be early adopters of this technology," says Osram marketing manager, Sevugan Nagappan. "While Fibrance fiber is ideal for vehicle interior applications, the design possibilities and product integration opportunities are truly endless," he believes.

Osram Opto Semiconductors has been a pioneer in the development of direct green laser diodes based on indium gallium nitride (InGaN). The efficiency of the firm's blue and green laser diodes minimizes their temperature increase and improves performance life, it is claimed. In order to emit light, Fibrance fiber must be coupled to such a laser light source.

"With this fiber, designers can enhance a product's appeal and functionality by adding light how and where they want it," says Curt Weinstein, VP & general manager,

Advanced Optics, at Corning Specialty Materials. "Our long-term goal is to get Fibrance Light-Diffusing Fiber into the hands of designers and let the capabilities of the product create new lighting possibilities."

Osram Opto Semiconductors featured Fibrance fiber at the Electronica International trade show and conference in Munich, Germany (11-14 November).

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

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# POET appoints Ajit Manocha as co-chairman and seeks permanent CEO

POET Technologies Inc of Toronto, Canada — which, through subsidiary OPEL Defense Integrated Systems (ODIS Inc) of Storrs, CT, USA, has developed the proprietary planar-optoelectronic technology (POET) platform for monolithic fabrication of integrated III-V-based electronic and optical devices on a single semiconductor wafer — has announced the appointment of Ajit Manocha as co-chairman of its board of directors, his appointment to the Corporate Governance and Nominating Committee with the mandate to identify a permanent CEO, and the resignation of Dr Samuel Peralta from the board (due to other commitments).

Manocha joined the board in July as vice-chairman and was previously CEO of GlobalFoundries (the world's second-largest semiconductor foundry). "Ajit has brought with him a wealth of experience and knowledge in the semiconductor and foundry industry," notes co-chairman & interim CEO Peter Copetti. "Ajit has been working actively with the company to raise the market

awareness of our novel semiconductor process technology targeting Tier 1 customers and potential partners," he adds. "Working out of the San Jose office positions me well to play a bigger role within the POET executive team on the current lab-to-fab to monetization path," comments Manocha.

The duties of the office of the chairman will be divided between the co-chairmen to take advantage of their respective strengths. Copetti will continue to be responsible for the overall management and leadership of the board as well as financial aspects of the company, including operational and funding requirements. Manocha will be focused on setting and developing policy, direction and strat-

**This is an important step forward for the company as we get ready to demonstrate our technology at smaller geometries**

egy, including the investigation of possible venture, partnership or other relationships with industry.

Appointment to the Corporate Governance and Nominating Committee (subject to board approval) gives Manocha the mandate to identify and consider candidates for the permanent CEO role. The firm says that, since Copetti was named chairman & interim CEO in February, it has reached financial stability with good cash in hand and has a well-established monetization path with a clear technical roadmap set for 2015. The firm's restructuring phase is over.

The board has set a target of early 2015 to appoint the new CEO and a few other senior executives during the latter part of 2015. "This is an important step forward for the company as we get ready to demonstrate our technology at smaller geometries like 100nm and 40nm," says Copetti. "This is a good time to further strengthen the management team with a permanent CEO."

[www.poet-technologies.com](http://www.poet-technologies.com)

# Firecomms demonstrates expanded range of RedLink optical transmitters and receivers

At the Electronica 2014 trade fair in Munich, Germany (11–14 November), Firecomms Ltd of Cork, Ireland and Tongxiang, China (which makes fiber-optic solutions and optical transceivers for communications networks) demonstrated an expansion of its RedLink range of optical transmitters and receivers.

Specifically, Firecomms is expanding its range of features in the RedLink form factor. The ability to switch 20V directly from a receiver output using integrated MOSFET technology is reckoned to be a first for optical products in this component space. "Customers require lower pulse width distortion when switching 12V and 15V gate drive

signals," says Michael O'Gorman, VP of marketing. "Traditionally the rise and fall time is artificially high, as a limiting resistor is required to protect the optical receiver," he adds. "By integrating the current-handling capacity of a MOSFET, the series resistance can be lowered, which in turn reduces pulse width distortion."

Also on Firecomms' list of offerings at Electronica are analog transceivers, with high-performing analog RedLink devices being a key sensor requirement in many applications. "Analog links are becoming more important in the POF [plastic optical fiber] world as the GigE solutions currently emerging from the IEEE

802.3 GEP working group are based on multi-level encoding schemes requiring highly linear POF transceivers," says chief technology officer John Lambkin.

Firecomms is now providing in RedLink the RCLED (resonant-cavity light-emitting diode) and photodiode options previously available in its bare fiber OptoLock connector.

"Providing the same optical components in a variety of connector options enables designers to leverage the exiting qualified cable assemblies and, when appropriate, embrace new solution options such as bare POF links," comments CEO Hsin China.

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



# Mellanox's EDR 100Gb/s InfiniBand solutions chosen for CORAL supercomputer project

Mellanox Technologies Ltd of Sunnyvale, CA, USA and Yokneam, Israel, a supplier of end-to-end InfiniBand and Ethernet interconnect solutions and services for data-center servers and storage systems, says that its EDR 100Gb/s solutions have been selected as key components of new supercomputers at two of the USA's premier national labs — Oak Ridge National Laboratory (ORNL) and Lawrence Livermore National Laboratory (LLNL).

The hybrid supercomputer design will interconnect thousands of compute nodes containing both IBM POWER CPUs and NVIDIA GPUs via Mellanox's EDR 100Gb/s InfiniBand-based solutions, providing what is claimed to be one of the most advanced architectures of its kind for high-performance computing.

CORAL (Collaboration of Oak Ridge, Argonne and Lawrence Livermore National Labs) is a project launched

in 2013 to develop the technology and meet the Department of Energy's 2017–2018 leadership computing needs with supercomputers. The collaboration between Mellanox, IBM and NVIDIA was selected by the CORAL project team after a comprehensive evaluation of future technologies from various vendors. Development of these supercomputers is well underway, with installation expected in 2017.

"The new embedded capabilities will significantly enhance the ability of applications to effectively communicate latency-sensitive data," says Jim Rogers, director of operations for the National Center for Computational Sciences at ORNL. "The net result will be a well-balanced system that can dramatically improve performance for DOE's mission-critical applications," he adds.

"Simulations of the safety and reliability of elements of the American

nuclear deterrent require arguably the most complex and sophisticated 3D applications on the planet," says Michel McCoy, head of Livermore's Advanced Simulation and Computing program. "These require the full capability of machines of this magnitude and, for these systems to effectively run these codes, extremely low-latency, high-bandwidth communication across the platform is essential," he adds.

"Organizations and research facilities are required to process and analyze more information than ever before and to do it in less time," comments Mellanox's chief technology officer Michael Kagan. "Mellanox interconnect solutions deliver the highest performance and scalability, and provide the most advanced roadmap that paves the road to Exascale computing," he claims.

[www.ornl.gov](http://www.ornl.gov)

[www.llnl.gov](http://www.llnl.gov)

## Mellanox samples 100Gb/s direct attach copper and AOCs

Mellanox Technologies has announced sample availability of 100Gb/s direct attach copper (DAC) and active optical cables (AOCs) for both EDR 100Gb/s InfiniBand and 100 Gigabit Ethernet data-center networks. Mellanox demonstrated 100Gb/s DAC cables of 2, 4, 6 and 8m lengths and 100 and 200m active optical cables at Supercomputing 2014 (SC14, the International Conference for High Performance Computing, Networking, Storage and Analysis) in New Orleans (16–21 November).

"Mellanox is the first and only company to offer plug-and-play 100Gb/s copper, VCSEL [vertical-cavity surface-emitting laser] and silicon photonics cables in the QSFP28 form factor," claims VP of marketing Gilad Shainer. "Our ability to drive 100Gb/s throughput over long-distance DAC cables delivers a major cost advantage to

our customers and reduces overall data-center CapEx and OpEx," he adds. "All our cables are designed to make 100Gb/s deployments as simple as 10Gb/s ones."

Mellanox 100Gb/s AOCs take advantage of a new generation of ICs that fully integrate multiple 25Gb/s clock & data recovery (CDR) functions. At the same time, these ICs reduce power consumption for the optical engine to far less than 3.5W (the requirement of the small QSFP package).

The new cables are the first 100Gb/s additions to the LinkX portfolio of 10, 40 and 56Gb/s copper and fiber cables, serving both Ethernet and InfiniBand infrastructures. Mellanox's roadmap also includes new cables and transceivers to interconnect 25G and 50G ports with 100G ports.

Mellanox says that, to ensure that all LinkX cables and transceivers

work first time and every time, it subjects its products to a full system test in a stressed environment. Network engineers do not have to waste time debugging a new installation with untested products, the firm adds. With LinkX products, installation experts can bring up new clusters rapidly, with fewer interconnect problems and higher quality and signal integrity.

To maximize overall data-center performance, all commercial versions of LinkX interconnect products endure full system testing to a bit error rate (BER) of  $10^{-15}$  (giving 1000x fewer transmission errors than many competing products, it is claimed). Fewer transmission errors translate to fewer re-tries, higher system performance, and more revenue-generating traffic, notes Mellanox.

<http://sc14.supercomputing.org>  
[www.mellanox.com](http://www.mellanox.com)



# MACOM acquiring BinOptics for \$230m to complement optoelectronic IC portfolio

## Wafer-scale InP lasers target supply-constrained opto sector

M/A-COM Technology Solutions Inc (MACOM) of Lowell, MA, USA (which makes semiconductors, components and subassemblies for analog, RF, microwave and millimeter-wave applications) has agreed to acquire BinOptics Corp of Ithaca, NY, USA (an ISO-certified merchant provider of indium phosphide lasers for data centers, mobile backhaul, silicon photonics and access networks) for \$230m in cash (subject to customary post-closing adjustments).

The transaction is expected to:

- broaden MACOM's optical portfolio with highly differentiated edge-emitting and surface-emitting Fabry-Perot and DFB lasers;
- bring proprietary Etched Facet Technology (EFT) for lasers that enable wafer-scale economics in both device manufacturing and testing;
- double MACOM's serviceable addressable market (SAM) within the optical component market; and

- expand growth opportunities and addressable market in data-center networks, including silicon photonics.

"This acquisition further extends MACOM's preeminent position in what we expect will be a strong secular growth driver for many years to come," says president & CEO John Croteau. "BinOptics' wafer-scale model for indium phosphide lasers will play perfectly to our strength in compound semiconductor manufacturing, allowing us to quickly address what is currently a supply-constrained part of the optical component industry," he believes.

"BinOptics' business model is consistent with our gross margin and operating margin aspirations, and we expect the transaction to be accretive to non-GAAP gross margin and EPS [earnings per share] within the first full quarter of combined operations," Croteau adds.

"This acquisition underscores MACOM's strategy to expand our market and growth opportunities through mergers & acquisitions (M&A)," Croteau continues.

"We have a successful track record of integrating acquisitions, both large and small, to expand our addressable market, while also achieving cost synergies for improved profitability and margin expansion."

MACOM expects to fund the purchase price of the acquisition from a combination of cash on hand and incurring additional indebtedness from its existing \$100m revolving credit facility.

Closing of the acquisition (which is expected by the end of MACOM's fiscal first-quarter 2015, at end-December 2014) is subject to the satisfaction of customary conditions, including expiration of the waiting period under the Hart-Scott-Rodino Antitrust Improvements Act.

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

## Eyelit's MES software supporting BinOptics' production ramp

Eyelit Inc of Toronto, Canada, which provides manufacturing execution software (MES) for visibility, control, and coordination of manufacturing operations, says that BinOptics Corp of Ithaca, NY, USA (an ISO-certified merchant provider of monolithically integrated optoelectronic components based on indium phosphide for data centers, mobile backhaul, silicon photonics and access networks) has selected the Eyelit MES suite for its fabrication facility.

Implementation of Eyelit MES, Asset Management, Automated Data Services, and Reporting modules is nearing completion.

"We saw Eyelit MES in use at other hi-tech manufacturers nearby and were impressed with the capabilities of the software

suite and the capabilities of their customer service staff," comments BinOptics' chief operations officer William Fritz. "We also have team members who have had a positive experience deploying the system prior to coming to BinOptics," he adds. "We wanted an MES solution we could deploy quickly without a large IT staff or the need to contract a third party for implementation services."

Eyelit says that the dynamic nature of BinOptics' manufacturing processes requires the flexibility of its software for configuring conditional process flows and business rules, including the ability to bin components into multiple part numbers from a single parent wafer. The abilities to communicate with external data sources,

incorporate automation, and enable scalability to support high transaction volumes provide the solid foundation as BinOptics ramps up production. Implementation should also enable BinOptics to capture and consolidate information in the MES database for reporting, eliminating paper travelers and spreadsheets that it had relied on to record data.

"The quality of Eyelit's products, services and support consistently enable outstanding and valuable customer references. This was a critical part of the sale to BinOptics as they have a very close working relationship with one of our customers," notes Dan Estrada, Eyelit's VP of sales & marketing.

[www.eyelit.com](http://www.eyelit.com)  
[www.binoptics.com](http://www.binoptics.com)



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# JDSU's quarterly revenue falls 3% to \$433.6m

## Operating margin rises due to cost cutting

For its fiscal first-quarter 2015 (ended 27 September 2014), JDSU of Milpitas, CA, USA has reported revenue of \$433.6m (exceeding the high end of the \$405–425m guidance range). This is down 3.3% on \$448.6m last quarter but up 1.1% on \$429m a year ago (or up 8.7%, excluding about \$30m of 3D sensing and last-time-buy revenue a year ago).

The Americas (\$193.9m), Asia-Pacific (\$134.7m) and EMEA (\$105m) comprised 44.7%, 31.1% and 24.2%, respectively, of total revenue, compared with 48.3%, 29.3% and 22.4% last quarter.

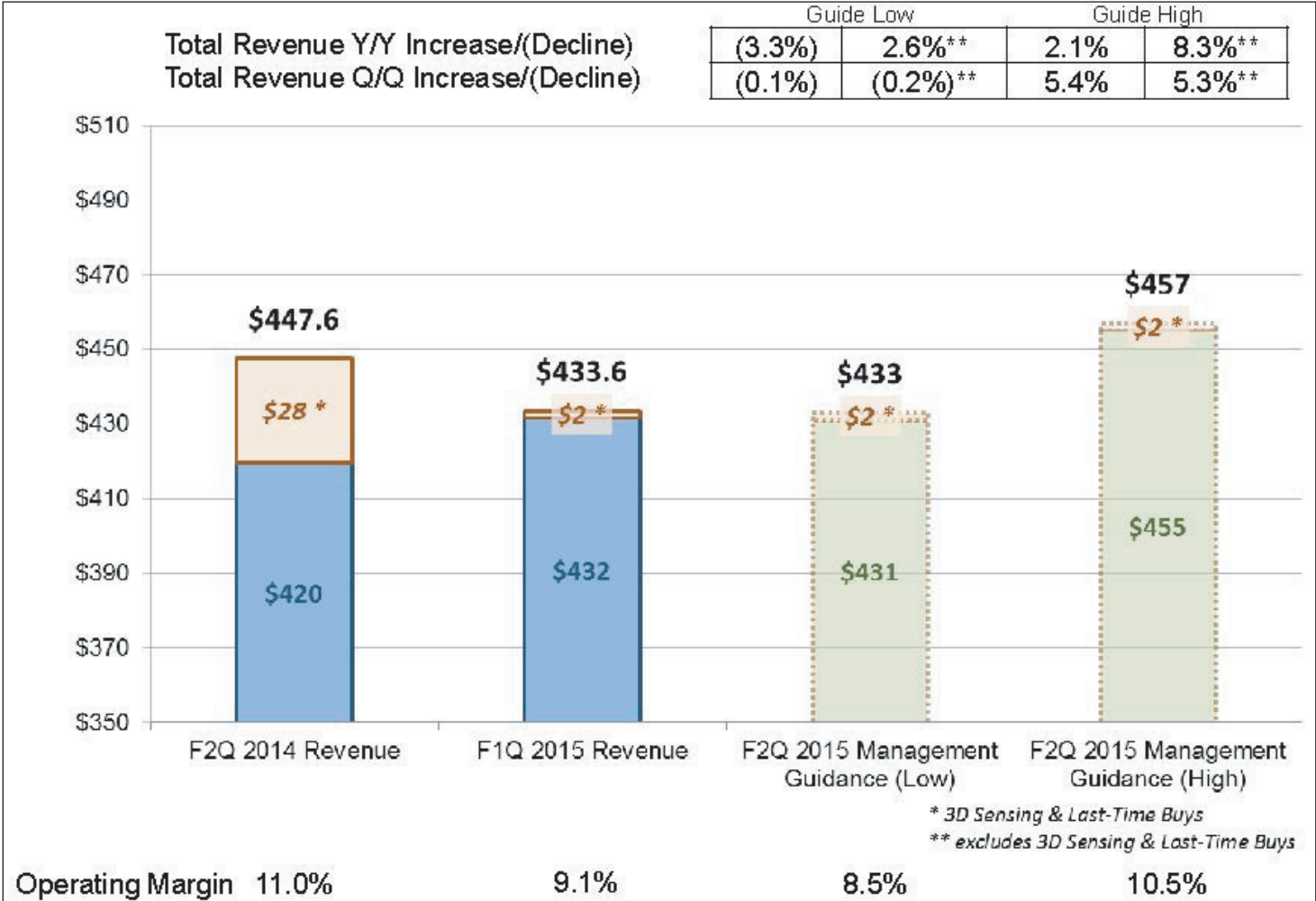
By application sector, revenue for Network Enablement (NE) was \$132.8m (30.6% of total revenue), down 19.8% on \$165.5m last quarter and 8.5% on \$145.1m a year ago. Revenue for Service Enablement

(SE) was \$48.2m (11.1% of total revenue), up 10.6% on \$43.6m last quarter and 79.9% on \$26.8m a year ago. Revenue for Optical Security and Performance Products (OSP) was \$43.3m (10% of total revenue), down 17.5% on \$52.5m a year ago (reflecting the exit of the lower-margin businesses, which contributed about \$6m a year ago) but up 1.6% on \$42.6m (9.5% of total revenue) last quarter (reflecting growth in anti-counterfeiting business and a slight increase in government business).

Revenue for Communications and Commercial Optical Products (CCOP) was \$209.3m (48.3% of revenue), up 6.3% on \$196.9m (43.9% of revenue) last quarter and 2.3% on \$204.6m a year ago (and near the top of the \$200–210m guidance range).

Of this, CCOP's Commercial Laser revenue rose to its second consecutive record of \$42.2m, up 3.7% on \$40.7m last quarter and 48.6% on \$28.4m a year ago. Growth was driven by fiber-laser revenue rising by 12.7% from \$11m last quarter to \$12.4m as partner Ramada continues to ramp use of the Gen2 kilowatt fiber laser for industrial cutting applications.

CCOP's Optical Communications revenue was \$167.1m, up 7% on \$156.2m last quarter but down 5.2% on \$176.2m a year ago, reflecting lower 3D sensing revenue (down by over \$4m sequentially to about \$22m) partially offset by higher revenues for Telecoms and Datacoms. In particular, in Telecoms, 40G & 100G modulator revenue grew 29% sequentially. Datacom revenue grew 2.4%





► year-on-year and 14.8% sequentially (with 40G and 100G growing from 41% of overall transmission revenue last quarter to 48%). Sales mix was 75% Telecom, 18% Datacom and 7% consumer and other (compared with 66%, 17% and 17%, respectively, a year ago).

The quarter-on-quarter decline in the average selling price (ASP) for Optical Communications components was 3.8%, higher than typical first quarters. However, JDSU continues to expect that the decline in ASP through fiscal-year 2015 will be consistent with its recent range of 10–14%.

On a non-GAAP basis, gross margin of 49%, down from 50% last quarter but up from 46.3% a year ago, reflecting continued operational discipline, favorable product mix from SE, strength in Commercial Lasers, and OSP's last-time-buy product exits last year.

In particular, CCOP gross margin was 32.5%, down from 33.3% last quarter but up from 32% a year ago. This was due mainly to higher product mix of Commercial Lasers (for which gross margin rose from 47.5% a year ago and last quarter's record of 49.9% to a new record of 50.7%). In contrast, Optical Communications gross margin has fallen from 29.5% a year ago and 28.9% last quarter to 27.9%, due mainly to lower fab absorption from the decline in 3D sensing revenue.

Although up from \$163.1m a year ago, operating expenses have been cut from \$185.1m last quarter to \$173m, with R&D expenses

falling from \$76.1m to \$72.6m and selling, general & administrative (SG&A) expenses falling from \$109m to \$100.4m, driven by benefits from restructuring activities initiated in fiscal 2014. Operating margin has hence risen from 8.3% a year ago and 8.7% last quarter to 9.1% (exceeded guidance of 6–8%).

Net income was \$33.8m (\$0.14 per share), down from \$34.2m (\$0.14 per share) last quarter but up from \$30.2m (\$0.13 per share) a year ago (significantly exceeding guidance).

"JDSU's strategy to diversify in non-telecom markets drove a solid first quarter as we exceeded revenue and EPS guidance and saw sequential growth in solutions for the enterprise and commercial lasers markets," says president & CEO Tom Waechter. "Enterprise market performance included growth in Datacom and Service Enablement, which generated an operating profit ahead of schedule," he adds. "We are pleased with the performance of these growth drivers for CCOP, NE, and SE, and remain on track for the planned separation of SpinCo (CCOP) and NewCo (NE/SE/OSP) by calendar third quarter 2015."

Cash flow generated from operations was \$40.8m, down from \$50.2m last quarter but continuing JDSU's eight straight years of positive cash flow. Nevertheless, total cash and investments fell slightly during the quarter from \$881.3m to \$880.9m.

For fiscal second-quarter 2015 (ending 27 December 2014), JDSU

expects revenue of \$433–457m (up 5.6% year-on-year in core business). Operating margin should be 8.5–10.5% and earnings per share \$0.12–0.18. In particular, JDSU expects CCOP revenue of \$200–210m (up 3.5% on \$198m the prior year), driven by Commercial Lasers, telecom and datacom revenues and offsetting about \$15m lower 3D sensing revenue. CCOP operating margin should be low (at 10.5–12.5%), reflecting lower Commercial Laser revenue along with continued growth in R&D.

JDSU's quarterly operating model targets include CCOP revenue of over \$210m, gross margin of 33–35%, and operating margin of 12–14%.

On 10 September, JDSU announced plans to separate into two publicly traded companies (to be named at a later date): an optical components and commercial lasers company ('SpinCo') consisting of JDSU's Communications and Commercial Optical Products (CCOP) segment, and a network and service enablement company ('NewCo') consisting of JDSU's Network Enablement (NE), Service Enablement (SE) and Optical Security and Performance Products (OSP) segments. The separation is expected to occur through a tax-free pro rata spinoff of CCOP to JDSU shareholders, although the structure is subject to change based on various tax and regulatory factors. JDSU expects the separation to be completed by calendar third-quarter 2015.

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

## JDSU earns Huawei's Excellent Core Partner Award for fourth time

At its recent core partner convention in Shenzhen, China, Huawei Technologies Co Ltd, one of the world's largest telecom networking equipment manufacturers, granted JDSU its Excellent Core Partner Award for a fourth time in the past five years. JDSU previously received the award in 2010, 2012 and 2013 for its "service, solutions and close collaboration". The award is the high-

est honor given by Huawei to any of its base of about 1000 suppliers.

JDSU received the 2014 award for its next-generation portfolio, focus on high-quality solutions and strategic partnership with Huawei. The firm provides a wide range of solutions to Huawei including optical components, modules and transmission/transport products for the development of next-generation

networks that support more flexible network management and higher data rates of 100G and beyond.

"We look forward to continued collaboration with Huawei on the design of faster and next-generation network architectures," comments Alan Lowe, president of JDSU's Communications and Commercial Optical Products segment.

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

# Oclaro's quarterly revenue dips while China digests CFP/CFP2 100G shipments

## Focus on 100G and tunable product lines targets EBITDA breakeven in September 2015 quarter

For its fiscal first-quarter 2015 (ended 27 September 2014), Oclaro Inc of San Jose, CA, USA (which provides components, modules and subsystems for optical communications) has reported revenue of \$89.2m (at the high end of the \$83-91m guidance range). However, this was down about 7% on \$96.6m a year ago and \$95.9m last quarter due to a temporary delay of CFP and CFP2 100G client-side business in China (as some major customers digested shipments from a very strong fiscal Q4) plus an expected reduction in legacy 40G line-card business. This was partially offset by strong demand for 100G coherent micro-ITLAs and lithium niobate modulators as well as a revival in demand for 10G tunable products (with collective growth for these products of several million dollars).

Sales of 40G & 100G Transmission products were \$43.5m, down 11% on \$48.8m last quarter but up 12% on \$38.9m a year ago (rising from 40% to 49% of total revenue). Sales of 10G-and-lower Transmission products were \$38.2m, down 3% on \$39.4m last quarter and 24% on \$50.5m a year ago (falling from 53% to 43% of total revenue).

By end-market, Datacom product revenue fell by 15% from \$44.2m last quarter to \$37.7m (falling from 46% to 42% of total revenue), due mainly to the drop in client-side 100G CFP and CFP2 business in China. Telecom product revenue stayed level at \$44m (rising from 46% to 49% of total revenue) despite product exits in legacy 40G business. Industrial & Consumer revenue was \$7.5m, down slightly from \$7.7m last quarter (remaining about 8% of total revenue).

There were three greater-than-10% customers: Coriant (rising further, from 24% last quarter to 26%),

Cisco (rising from 11% to 13%) and Huawei (falling from 13% to 11%). By region, the Americas contributed 32% of revenue (up from 29%), China 23% (down from 28%), Europe 21% (down from 23%), South-east Asia 20% (up from 14%) and Japan 4% (down from 6%).

On a non-GAAP basis, gross margin has continued to rise, from 12.4% a year ago and 14.1% last quarter to 16.5% (above the expected 12-16%), due to lower inventory charges and better factory utilization from 100G product ramps. This was despite \$2m of additional charges from instituting tighter business processes around inventory management as the firm continues to "clean up poor practices from the past [related to Japan operations]".

At the end of fiscal Q4/2014, Oclaro closed the ex-Mintera facility in Acton, MA, USA. This contributed to restructuring-induced reductions year-on-year in both R&D spending (from \$17.6m to \$13.6m) and SG&A spending (from \$20.5m to \$14.8m) in fiscal Q1. Total operating expenses have hence fallen by 25% from \$38.1m to \$28.4m.

Driven by the improved gross margin, adjusted EBITDA (earnings before interest, taxes, depreciation and amortization) loss has been cut further, from -\$19.1m a year ago and -\$9.4m last quarter to -\$8.9m (better than the expected -\$13-9m), although this included about \$2m of positive adjusted EBITDA from Industrial & Consumer (I&C).

Net cash used in operations was \$5.7m. Capital expenditure (CapEx) has risen again, from \$3m last quarter to \$4.7m. During the quarter, cash, cash equivalents, restricted cash & short-term investments hence fell further, from \$104.1m to \$94m.

"Our revenue, gross margin and adjusted EBITDA results for the first quarter came in at the high

end of our guidance," says CEO Greg Dougherty. "Improved financial results reinforce the effectiveness of the major components of our turnaround plan and our strategy to focus the business on 100G and tunable product lines for both client- and line-side markets," he adds.

"We continue to take some of the remaining actions of our restructuring plan," says Dougherty. "Earlier this quarter, we exited one of our three buildings in San Jose by consolidating our high-bit-rate design team and testing lab into our San Jose headquarters."

On 27 October, Oclaro completed the sale of its Industrial & Consumer business in Komoro, Japan to Japan's Ushio Opto Semiconductors Inc and initially received \$14.8m of cash (to be reflected in December-quarter results). As part of the deal, 82 staff (equivalent to about \$2.2m in quarterly operating expense) have transferred to Ushio. "We not only eliminated a semiconductor fab but also, more importantly, the significant cost and distraction to relocate it," notes Dougherty. "The sale further streamlines our global footprint and allows us to focus on expanding our market leadership in 100G, where we continue to see strong demand," he adds.

Closure of the San Jose and Acton sites plus the sale of I&C business has reduced Oclaro's total number of sites from 20 at the beginning of fiscal 2014 to just eight. Headcount is now 1250.

"While we will continue to do targeted restructuring to continuously improve our business model, we have completed most of the main objectives of our initial restructuring plan and did so about five months ahead of schedule," says Dougherty. "Our infrastructure cost is now consistent with our target breakeven point," he adds. ➤

► For fiscal second-quarter 2015 (ending 27 December 2014), Oclaro expects revenue of \$80–88m. However, excluding \$2m from the Industrial & Consumer business up to its sale on 27 October means that revenue should be flat to slightly up on fiscal Q1. In particular, Datacoms revenue is recovering, driven by 100G CFP and CFP2 client-side business in China rebounding (after digesting inventory) plus continued strong demand from North American and European equipment suppliers of high-end routers and packet optical systems. Despite selling the I&C business, Oclaro's core businesses should still show continued improvements in gross margin (13–17%) and adjusted EBITDA (negative \$10m to negative \$6m).

Demand for 100G coherent micro-ITLAs, lithium niobate modulators and 10G tunable product is expected to continue to grow in fiscal Q2 and beyond. In particular, demand for coherent CFP2 pluggable solutions continues to be strong. "Our market leadership has positioned us well as we expect the revenue for this product to be very meaningful in the second half of 2015," believes Dougherty.

"As we bring new 100G client-side products to market and as we ramp our 100G CFP2 coherent family, these products are highly differentiated and should offer us higher gross margins," says Dougherty. "Volumes from these products will be considerably higher than our current output and can be achieved with little additional manufacturing overhead. The result of this is much improved factory utilization and increased gross margins," he adds.

Also, Oclaro still expects the 40G business to continue to decline, but now over a less rapid two-year time-scale, into mid or late 2016.

"We continue to invest heavily in R&D to develop new products at 100G to serve the long-haul, metro, client and data-center markets," says Dougherty. "We are seeing very strong customer engagements across all of these segments," he

adds. At ECOC in September, Oclaro showcased its coherent CFP2 pluggable transceiver and 100G client-side pluggable optics, including a second-generation CFP2 LR4 transceiver. "Our most significant demonstration at ECOC was of our coherent CFP2 transceiver operating at 200Gb/s under a 16-QAM data format using a commercially available DSP [digital signal processor]," continues Dougherty. "This was an important milestone for us as it showed that the CFP2 coherent is capable of operating at 200G and works well with different modulation schemes as well as DSPs from multiple vendors," he adds. "We are the only company that has delivered CFP2 coherent modules and are also the first company to demonstrate a 200G coherent transceiver in the CFP2 package," he claims. "The CFP2 platform leverages our indium phosphide [InP] photonic integration circuit [PIC] technology, which we believe provides us with significant differentiation. Customer feedback on the performance of our CFP2 coherent products has been very positive." In the December quarter, Oclaro will begin building beta units on its new pilot-

**We are continuing our investment in new 100G client form factors using single-mode fiber for data-centers and high-end packet optical systems. CFP4 will be our next product release, followed by a variety of QSFP28 flavors. This interest is driven by our unique distributed feedback and tunable laser technologies**

production line in the UK [at Caswell], which should allow the customer base to be expanded further. The units built there will also be used for both internal qualification as well as by customers for their system qualifications.

"A key element for our success will be our ability to ramp production of the CFP2 coherent," believes Dougherty. "By establishing a pilot-production line in the UK, co-located with our design engineers, we have made a key change to how Oclaro previously launched products into production," he adds. "In addition to the faster cycle times enabled by the proximity of the design engineers, we also have stationed several operators and engineers from our Shenzhen manufacturing facility in the UK to work on the pilot line. This team will then be part of the transfer team as we move to volume production in Shenzhen in the second half of calendar year 2015," Dougherty explains. "We are in the process of completing a similar approach of piloting new products in the UK and transferring them to Shenzhen for production with our new tunable TSFP+ product line as we speak," he adds.

"Leveraging our market success on 100G CFP and CFP2, we are continuing our investment in new 100G client form factors using single-mode fiber for data-centers and high-end packet optical systems," says Dougherty. "CFP4 will be our next product release, followed by a variety of QSFP28 flavors," he adds. "This interest is driven by our unique DFB [distributed feedback] and tunable laser technologies, which are ideally suited for large-scale low-cost deployment of single-mode fiber in hyperscale data-center architectures."

Even without the I&C business (which historically contributed about \$8m of revenue, a 50% gross margin and \$2m of positive adjusted EBITDA), Oclaro reckons that it is on track with its initial breakeven objective. With the planned ramp of coherent CFP2 product as well as the restructuring efforts, Oclaro's target is still to achieve its adjusted EBITDA breakeven model in the September 2015 quarter (fiscal Q1/2016) with \$100m revenue, 20% gross margin and 25% operating expenses.

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



# First Solar's revenue grows 63% in Q3 to \$889m

## Full-year guidance lowered from \$3.7–4bn to \$3.6–3.9bn

For third-quarter 2014, First Solar Inc of Tempe, AZ, USA — which makes thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services — has reported net sales of \$889m, down 30% on \$1266m a year ago but up 63% on \$544m last quarter due mainly to increased revenue recognition on the Desert Sunlight project.

Compared with \$156m a year ago (which included \$57.3m of restructuring and asset impairments), operating expenses have risen from \$90.8m last quarter to \$105.5m. In particular, R&D expenses have risen from \$32.6m to \$37.6m and selling, general & administrative (SG&A) expenses have risen from \$57.7m to \$66.5m, inflated by \$1.4m in production start-up costs.

Although down from \$195m (\$1.94 per fully diluted share) a

year ago, GAAP net income has rebounded from just \$4.5m (\$0.04 per fully diluted share) last quarter to \$88.4m (\$0.87 per fully diluted share) due to higher profit from the Desert Sunlight project and other systems projects under construction as well as a one-time income tax benefit of \$0.26 per fully diluted share.

Cash flow used in operations during the quarter was \$47m. Due to the construction of multiple utility-scale power plants that have not yet been sold, cash and marketable securities fell by \$234m from \$1.3bn to \$1.1bn. First Solar continues to construct these projects while determining the optimal sales strategy for them. Net cash has fallen from \$1.2bn to \$0.9bn.

"Following the project delays experienced in the prior quarter, our third quarter earnings have improved, and we continue to make progress towards our financial

targets for the year," says CEO Jim Hughes. "Year-to-date book-to-bill ratio is well above our objective of a one-to-one ratio, and we are on track to meet or exceed our bookings goal for the year." In Q3, new bookings were 521MW<sub>dc</sub>, bringing year-to-date bookings to 1.7GW<sub>dc</sub>.

First Solar maintains its full-year guidance for earnings per share of \$2.40–2.80 (excluding the impact of the \$0.26 per share one-time tax benefit in Q3) and operating cash flow of \$300–500m. Otherwise, First Solar has revised its guidance for net sales from \$3.7–4bn to \$3.6–3.9bn, for gross margin from 18–19% to 19–20%, for operating expenses from \$380–395m to \$390–400m, for operating income from \$290–340m to \$300–340m, and for capital expenditure from \$300–350m to \$250–300m. The production target of 1.8–1.9GW is unchanged.

## First Solar and BELECTRIC break ground on fourth UK project

First Solar and Germany-based solar EPC firm BELECTRIC GmbH have broken ground on a new 46MW<sub>DC</sub> utility-scale power plant, in Oxfordshire, Southern England. When completed, the facility will produce 45 million kilowatt-hours (kWh) of solar electricity per year, sufficient to power about 14,000 average homes or 25% of the estimated 55,400 households in the city of Oxford.

The project is the fourth executed in the UK under a First Solar and BELECTRIC joint venture announced in 2013. With its recently built solar farms in Wiltshire and East Anglia, the JV is expecting to reach a total capacity of 80MW<sub>DC</sub> in the UK. Together, the farms generate almost 80 million kWh per year, while displacing an estimated 35,000 tons of greenhouse gases.

"Dramatic efficiency gains and increased cost competitiveness,

particularly those driven by First Solar, have created an undeniable tipping point for solar power, not only in the UK but around the world," says First Solar's VP for Europe Christopher Burghardt. "Thanks to the UK's renewable energy roadmap, solar PV will help reinforce the country's efforts to address its need for sustained energy independence."

More than 483,000 First Solar modules will be used to power the facility, while BELECTRIC is responsible for the construction and the balance-of-systems (BoS) requirements. By displacing 20,000 tons of greenhouse gases each year, the plant will help to maximize the share of climate-friendly power generation in the UK. The project will be in compliance with stringent sustainability standards designed to minimize its impact in the local environment and support biodiversity initiatives.

Furthermore the land under the solar farm will continue to remain in food production, with sheep grazing the site, as was the case before the project was constructed.

"When we connect this project in the coming months, it will be the UK's largest and most technologically advanced solar energy plant," says BELECTRIC UK's CEO Tod-dington Harper. "This single project will produce enough secure, home-grown, solar energy to drive an electric vehicle over 200 million kilometers per year," he adds. "Combined with the fact that the land under the solar arrays will remain in agricultural use, with areas set aside to support biodiversity, this is a prime example of the multiple benefits that best-in-class solar farm projects can deliver to the UK," he adds.

[www.belectric.com](http://www.belectric.com)  
[www.firstsolar.com](http://www.firstsolar.com)

# NanoFlex extends research agreement with universities of Southern California and Michigan

## GaAs and organic photovoltaic development and commercialization to continue to 2021

NanoFlex Power Corp of Scottsdale, AZ, USA, which develops photovoltaic technologies and intellectual property, has signed an extension to its agreement with the University of Southern California (USC) and its subcontractor University of Michigan to continue their R&D of thin-film photovoltaic cells — including both gallium arsenide (GaAs) and organic photovoltaics (OPV) technologies — to 2021.

Under the agreements, NanoFlex Power will provide funding for its research partners to optimize the power conversion efficiency of both GaAs and OPV cells, demonstrate low-cost production processes, and improve operating lifetimes. As with prior agreements, all IP derived from the research program will be licensed exclusively to NanoFlex Power.

"We are pleased to continue our long-standing collaborative relationships with USC and the University of Michigan. Their research efforts have resulted in over 750 issued or pending patents worldwide," says NanoFlex Power's president & chief operating officer Robert Fasnacht. "With this new agreement, we ensure that they will be our primary research partners for the critical development and commercialization phases for both our GaAs and OPV technologies," he adds.

"This long-term commitment from NanoFlex Power will accelerate our development of thin-film photovoltaic materials and technologies," comments Dr Mark Thompson, Professor of Chemistry, Materials Science and Chemical Engineering at USC. "This extension will enable us to rapidly advance our efforts in achieving technical and performance goals for power conversion efficiency, reliability, form factor, and cost," he adds.

"We are at a critical point in the development of OPV and GaAs technologies," believes Dr Stephen Forrest, the Paul G. Goebel Professor of Engineering in the Departments of Electrical Engineering and Physics at the University of Michigan. "Our partnership with NanoFlex will position us to achieve key steps critical for the commercialization and market acceptance of these technologies."

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

# Midsummer halves its CIGS layer thickness, reducing manufacturing cost

Midsummer AB of Järfälla, Sweden, a supplier of production lines for manufacturing flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic (PV) solar cells, has halved the thickness of its CIGS layer, to 800nm (less than half of what other suppliers can offer, it is claimed), while maintaining performance.

This lays the foundation for lower manufacturing cost, strengthening the business case for Midsummer's CIGS solar cells, reckons CEO Sven Lindström.

The solar cell is made on stainless-steel substrates, contains no cadmium buffer layer, and the production process is an all-dry, all-vacuum process where all layers (including the buffer layer) are deposited by sputtering, notes

Lindström.

Earlier this year, Midsummer boosted the efficiency of the whole solar cell to 16.2% for the full 156mm x 156mm aperture area. It has since raised this further, to 16.7%. Now, with the help of a new, aggressive grading of the CIGS layer, the firm has also been able to thin the CIGS layer (which is normally 2000nm thick) to 800nm. Most of the light is absorbed in the first 800nm so, for productivity reasons the absorber layer can be kept thin.

CIGS is the most expensive layer in the solar cell, so reducing the thickness has major cost advantages. Also, production time is reduced (increasing productivity) and it takes less energy to coat the layer, as well as reducing the time

during which the substrate needs to be kept warm.

Midsummer sees the opportunity to reduce the thickness even further with a reflective back contact, i.e. any photons that have passed through the CIGS layer would be reflected and have the chance to do work on the way back.

"Our scientists are constantly working on reducing the thickness, and they will now start to work on this opportunity," says Lindström. "As soon as we are done, we will report it," he adds. "We are always aiming to increase the productivity in our machines while many of our competitors are chasing records, which means their CIGS layers turn out to be thicker than ours," concludes Lindström.

[www.midsummer.se](http://www.midsummer.se)

## Ascent Solar raises \$35m from institutional investor Proceeds to fund expansion of retail channels, brand building, and launch of additional EnerPlex products

Ascent Solar Technologies Inc of Thornton, CO, USA, which makes lightweight, flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic modules integrated into off-grid applications and its EnerPlex series of consumer products, has raised \$35m in financing from an institutional investor.

The firm has issued:

- (i) \$32m principal amount of senior secured convertible notes;
- (ii) \$3m of Series D convertible preferred stock; and
- (iii) warrants to purchase shares of

its common stock.

The economic terms of the notes and the Series D Preferred Stock are substantially similar.

At closing, Ascent Solar received unrestricted access to \$4.5m, while the remaining \$30.5m of gross proceeds has been deposited into a restricted control account of the firm. Once stockholder approval for the share issuances relating to the financing is obtained and Ascent's resale registration statement is declared effective, the it will receive a further \$2.5m of unrestricted

gross proceeds from the control account. The firm will receive an additional \$6m from the control account 75 days later. The remaining gross proceeds of \$22m will be released for use in \$6m installments every 90 days thereafter.

Ascent intends to use the proceeds of the offering to fund the continued operations and expansion of its retail channels for its EnerPlex products in the USA, Europe and Asia, brand building, and the launch of additional EnerPlex products.

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

## Hitfar Concepts signed as preferred EnerPlex distributor in Canada

Ascent Solar has signed Hitfar Concepts Ltd as the preferred distribution partner of EnerPlex consumer products in Canada.

Hitfar is Canada's largest wireless accessory distributor, working with all the major Canadian telecoms firms (e.g. Bell, Rogers & Telus) as well as national retailers such as Glentel (Canada's largest independent mobile phone retailer, which has over 500 locations country-wide).

"Our main goal at Hitfar is to provide real value to our clients and customers; the EnerPlex product

line will allow us to accomplish this in a new way, empowering our customers to leave the outlet behind during their adventures while still staying powered up," says Jason Osborne, senior manager – Product & Inventory at Hitfar.

"EnerPlex products represent and enable a shift in how consumers in Canada and across the world will use their portable electronics in the future," he adds.

EnerPlex offers a complete portable power solution by uniting its lightweight and rugged solar with

power storage solutions. With ruggedized products, which can withstand harsh environments, EnerPlex provides charging solutions for consumers who want to get off the grid.

"The Canadian market provides a strong brand and revenue growth opportunity, and our partnership with Hitfar will allow us to immediately leverage their robust distribution network across Canada," says EnerPlex general manager Richard Hashim.

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

## Ascent Solar's Q3 reaffirms full-year guidance of four-fold growth over 2013

For third-quarter 2014, Ascent Solar has reported revenue of \$1.1m, the second consecutive quarter in which revenue exceeded \$1m.

To this point in Q4, the firm has shipped or has backlog scheduled to ship in excess of \$2m. As a result, Ascent Solar has reaffirmed its full-year revenue guidance (given on 6 March) of \$5–6m, representing four-fold growth over 2013.

"Since Ascent Solar began to reposition its business model in second-half 2012 by pivoting into

consumer goods and specialty applications, we are experiencing accelerated acceptance of our flagship EnerPlex products," says president & CEO Victor Lee. "We expect to continue this growth trend, while maintaining our focus on sales of products which capture the entire consumer value chain and at prices that are a premium to other solar manufacturers," he adds.

"The clear indication that Q4 revenue will be more than double

the September quarter reinforces the viability of the transformational business model that we embarked on in second-half 2012," Lee believes. "As we continue to build and expand our EnerPlex distribution channels domestically and internationally, we expect to achieve higher sales, better economies of scale, and dramatically reduce our overall costs, enabling meaningful improvements in product margin."

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



# Ascent Solar's largest shareholder completes second tranche of stock investment

## Further \$4m in proceeds as TFG Radiant raises stake to 24%

Ascent Solar Technologies Inc of Thornton, CO, USA, which makes lightweight, flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic modules integrated into off-grid applications and its EnerPlex series of consumer products, has announced completion of the second tranche of common stock investment following the stock purchase agreement (SPA) dated 29 August and approved at a special shareholder meeting on 22 October.

In the first tranche (which closed on 29 August) the firm issued 845,309 common shares to a Series A investor and 845,309 shares to Ascent's largest shareholder, TFG Radiant Investment Group Ltd at a fixed per share price of \$2.366, representing a 30% premium to the closing price of \$1.82 per share on 28 August. The first tranche closure resulted in net proceeds of \$4m.

In the second tranche, Ascent issued an additional 1,425,000

common shares to TFG Radiant at a fixed per-share price of \$2.80 (a 54% premium to the closing price on 28 August and about 44% premium to the closing price on 10 November). The closure results in additional net proceeds of about \$4m. TFG

**We have been able to create a new type of solar energy company where we are able to sell our products at a price that can be factors of 10 or greater than other solar manufacturers. Our focus in the near future will be to expand the portfolio of products, increase and expand the distribution channels, and reduce manufacturing costs by shifting our production to China**

Radiant's ownership of Ascent Solar has now risen to about 24% of the outstanding common stock.

"We hope to reap the rewards of the hard work incurred in repositioning the company," says Ascent Solar's chairman Dr Amit Kumar. "We have been able to create a new type of solar energy company where we are able to sell our products at a price that can be factors of 10 or greater than other solar manufacturers," he reckons. "Our focus in the near future will be to expand the portfolio of products, increase and expand the distribution channels, and reduce manufacturing costs by shifting our production to China, aided by the funding expected to be received from the municipal government of Suqian," Kumar adds.

"We are very encouraged by the progress that Ascent has made since they embarked on a new business strategy, especially with the introduction of the EnerPlex family of products," comments TFG Radiant's chairman Winston Xu.

## EnerPlex products to be distributed by WYNIT business unit Navarre, expanding retail channel in North America

Ascent Solar Technologies Inc of Thornton, CO, USA, which makes lightweight, flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic modules integrated into off-grid applications and its EnerPlex series of consumer products, has announced a new distribution partnership with Navarre, a business unit of WYNIT Distribution LLC of North Syracuse, NY, USA.

WYNIT's Navarre business unit has a long history of connecting brands and consumers through their partnership with well-known retailers throughout North America.

"The response to our EnerPlex products in 2014 has been overwhelmingly positive, and our partnership with Navarre will allow

us access to an even wider range of retailers and consumers," says EnerPlex general manager Richard Hashim. "EnerPlex will certainly benefit from their experience and knowledge of the consumer marketplace, and will leverage this knowledge to continue our growth," he adds.

"EnerPlex provides a truly unique set of products for consumers, ones which we feel fill a very specific need which currently is not met by other products in the market," comments Ward Thomas, executive VP, Navarre Division. "We believe EnerPlex can quickly become a leader in the consumer portable power space."

Ascent says that, for solar-

integrated consumer electronics, EnerPlex provides lightweight, powerful and durable charging solutions for portable electronics. Surfr, a line of solar- and battery-integrated phone cases, allows users to charge their phone anywhere and in cases of emergency. Kickr, a line of portable solar chargers, provides a charging solution for most USB-enabled devices, suiting emergency preparedness. The addition of the Jumpr line of portable batteries provides a complete, integrated, solar charging and storage solution.

[www.navarre.com](http://www.navarre.com)  
[www.goenerplex.com](http://www.goenerplex.com)  
[www.wynit.com](http://www.wynit.com)  
[www.AscentSolar.com](http://www.AscentSolar.com)

# Solar Frontier installing enhanced CIS production lines in new Tohoku Plant

Tokyo-based Showa Shell Sekiyu subsidiary Solar Frontier — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — is installing newly enhanced proprietary CIS production lines at its upcoming production facility, Tohoku Plant. Based on established technology at Solar Frontier's Kunitomi Plant, the improved production lines will enable what are claimed to be best-in-class production costs with new product advantages.

On track with its planned construction schedule, the plant is due to be completed in March. The Tohoku Plant features upgrades from Solar Frontier's existing production lines using technology developed in R&D at the firm's Atsugi Research Center (ARC).

"Precise processes such as the formation of the CIGS absorption layer (the heart of CIS thin-film modules), the patterning process, and electrode formation are now faster and can be controlled more accurately," says chief technology



**Exterior of the Tohoku Plant.**

officer Satoru Kuriyagawa. "With significant advances in all areas, this factory delivers faster, more compact and more efficient production, in turn enabling significant cost reductions."

The new lines will also enable product upgrades, including adjustments to the voltage and current of the modules. The upgrades should enable more freedom in system design and make placement of cables and other wiring more efficient. Also, leveraging Solar Frontier's record 20.9% conversion efficiency technology, modules coming off the mass-production line should achieve

efficiencies of over 15%.

The product improvements build on the performance advantages of CIS technology, which generates more kilowatt-hours per kilowatt-peak in real-world conditions than crystalline silicon panels. Generating more kilowatt-hours per kilowatt-peak installed is a key factor in the financial success of

residential rooftop and commercial projects, says Solar Frontier. The firm claims that, whether partially covered by shadow or when operating at higher temperatures, its CIS modules show more robust, stable power output than crystalline silicon panels in real operating conditions.

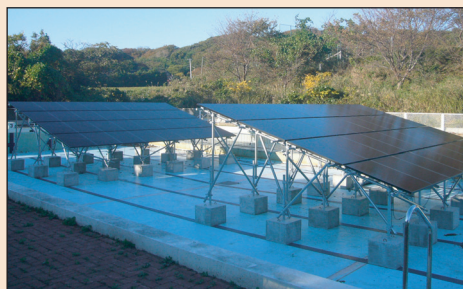
Solar Frontier says that its Tohoku Plant will become a model for future global expansion, and that the firm is currently assessing possible sites for production facilities outside Japan, in line with worldwide demand growth and Solar Frontier's mid-term growth plans.

[www.solar-frontier.com](http://www.solar-frontier.com)

## Solar Frontier's CIS PV modules powering brewery

Solar Frontier has completed installation of its CIS solar modules at a Japanese sake brewery on Sado Island, Japan. Using a building that until four years ago housed an elementary school, the modules will be used to make Obata Brewery's new 'Gakko Gura' (School Celler) brew.

As part of its 'Gakko Gura Project', Obata Brewery is leasing the former school building from Sado City. Sado City and IR3S (the University of Tokyo Integrated Research System for Sustainability Science) have partnered with Showa Shell Sekiyu K.K. (Solar Frontier's parent company) and Obata Brewery to complete the project. The 10kW system is



installed in the emptied swimming pool of the former school and will provide 20% of the energy needed to power the brewery.

"This project is the embodiment of our mission to help achieve local production for local consumption," says Solar Frontier's CEO Atsuhiko Hirano. "This is a model initiative for local governments everywhere to build a low-carbon society."

Solar Frontier says that its modules were selected for the Gakko Gura initiative because of their power output in real-world conditions. Sado Island has a relatively low amount of sunlight and, especially under these conditions, Solar Frontier's CIS modules can provide a higher energy output than its competitors, it is claimed. The modules are already proven in the Niigata region at the Yukigunigata Megasolar installation.

Solar Frontier says that it will continue to focus on collaborations with industry, academia and government, promoting distributed energy generation model initiatives rooted in local regions.

[www.solar-frontier.com](http://www.solar-frontier.com)

# UCLA develops hybrid perovskite photodetector with high detectivity

**Thin solution-processed perovskite could improve quality and manufacturing efficiency of imaging devices**

Led by Yang Yang, the Carol and Lawrence E. Tannas Jr Professor of Engineering at the Henry Samueli School of Engineering and Applied Science, researchers at University of California, Los Angeles (UCLA) have developed a photodetector that uses thin coatings of solution-processed perovskite material — rather than silicon or other common materials — which could reduce manufacturing costs and improve the quality of medical and commercial light sensors, it is reckoned ('Solution-processed hybrid perovskite photodetectors with high detectivity' by Letian Dou et al, *Nature Communications* 5 p5404).

Perovskite is an organic-inorganic hybrid material with a crystal structure that is extraordinarily efficient for converting light into electricity. In recent years, the use of perovskite materials has led to rapid advances in the efficiency of solar cells, note the researchers.

The photodetector is made using a process that essentially coats layers of the device in a liquid form of perovskite at about 300°F. The process does not require the energy-consuming high heat or

powerful vacuum procedures used to develop existing commercial photodetectors, say the researchers.

The perovskite coating is about 300nm thick, while the silicon layer in common photodetectors is more than 330 times as thick (100µm). As a result, the device efficiently and quickly transports signals with minimum loss. It also offers improved sensitivity under dim light.

"Our innovation is using the perovskite material on a photodetector, and then putting it in the proper structure so that the material can work most efficiently," says paper co-author Ziruo Hong, a research engineer in Yang Yang's lab.

Researchers also inverted the typical design of a perovskite-based photovoltaic cell, altering the materials that interface directly with the perovskite layer to improve its performance, especially response speed.

Operating at room temperature, the photodetectors exhibit a large detectivity (the ability to detect weak signals) approaching  $10^{14}$  Jones, a linear dynamic range over 100dB and a fast photoresponse with 3dB bandwidth up to 3MHz. The

performance is significantly better than most organic, quantum dot and hybrid photodetectors reported so far, it is claimed, and is comparable, or even better than, traditional inorganic semiconductor-based photodetectors.

"This device has the potential to improve the efficiency and contrast in optical sensors used in various applications," says principal investigator Yang Yang, a member of the California NanoSystems Institute. With appropriate device interface design, perovskite materials are promising candidates for low-cost, high-performance photodetectors, it is reckoned. "Production requires less energy and time than is currently needed to make photodetectors, and so promises to make manufacturing on the industrial scale very cost-efficient," he concludes.

The research was supported by the US National Science Foundation and the Air Force Office of Scientific Research.

[www.nature.com/ncomms/2014/141120/ncomms6404/full/ncomms6404.html](http://www.nature.com/ncomms/2014/141120/ncomms6404/full/ncomms6404.html)  
<http://yylab.seas.ucla.edu>

## Magnolia receives US patent for roll-to-roll flexible CIGS solar cell production

Magnolia Solar Corp of Woburn, MA and Albany, NY, USA says that on 21 October the United States Patent and Trademark Office (USPTO) issued its subsidiary Magnolia Solar Inc a patent (US Patent No. 8,865,506) describing a roll-to-roll process for fabricating flexible solar cells employing copper indium gallium selenide (CIGS) absorber materials.

Magnolia is working on the devel-

opment of flexible, lightweight, high-efficiency solar cell technologies for a wide range of portable power applications. The firm's technology portfolio includes nanostructured anti-reflection coatings, advanced photovoltaic absorber structures, and novel, low-cost manufacturing processes.

"We have been aggressively pursuing more than a dozen US patent applications as a means to protect

our intellectual property (IP) in the field of flexible photovoltaics," says president & CEO Dr Ashok K. Sood. "The 8,865,506 patent pertains to a novel manufacturing method utilizing roll-to-roll solution processes," he adds. "This technology has the potential to significantly reduce the manufacturing costs associated with the production of flexible photovoltaic modules."

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



# Single-crystal gallium arsenide on metal foil

**Technique could open way to low-cost high-efficiency solar cells with roll-to-roll production.**

**R**esearchers in USA have produced single-crystal gallium arsenide (GaAs) films on metal foil with a view to low-cost roll-to-roll production of optoelectronic devices such as high-efficiency solar cells [P. Dutta et al, Appl. Phys. Lett., vol105, p092104, 2014]. Doped films were produced with high carrier mobility.

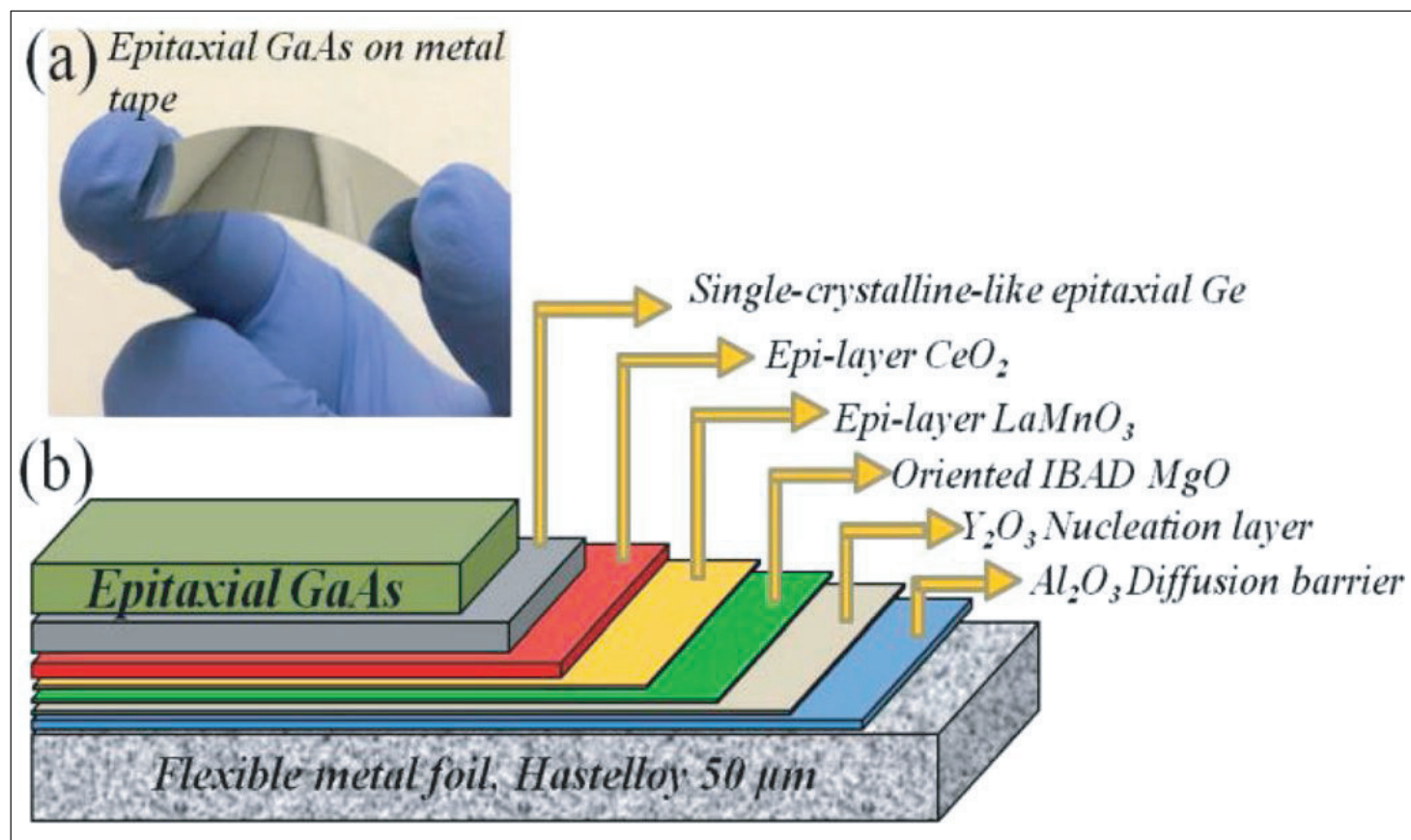
The research was carried out at University of Houston, South Dakota School of Mines and Technology, and NASA Johnson Space Center. Although high-efficiency solar cells are based on direct-bandgap GaAs, such devices tend to be expensive to produce. It is estimated that more than half the production cost of GaAs solar cells comes from the expensive GaAs or germanium (Ge) substrates used.

High cost restricts GaAs solar cells to specialist applications such as space satellites, where payload weight is at a premium. For earth-bound application, produc-

tion cost is generally the primary consideration and therefore the much less efficient silicon technology is the standard.

The US researchers comment on their work: "High-quality single-crystalline GaAs thin film on inexpensive metal foil can be a promising step towards high-efficiency and cost-effective thin-film III-V solar cells and can eventually pave the path for scalable large-area processing of III-V solar cells for terrestrial applications."

Templates for the GaAs crystal film consisted of germanium grown on Hastelloy metal foil using sputtering and ion-beam-assisted deposition (Figure 1). For the GaAs deposition, the researchers used a custom-made vertical metal-organic chemical vapor deposition (MOCVD) reactor. The system employed radio-frequency induction heating. The single-crystalline-like Ge



**Figure. 1. (a) Photograph of epitaxial GaAs thin film on flexible metal foil. (b) Schematic of multi-layer template architecture used to grow epitaxial GaAs thin films on metal foil.**

templates were loaded into the system on graphite susceptor.

The GaAs MOCVD precursors were trimethyl gallium and arsine ( $\text{AsH}_3$ ) in hydrogen carrier. Selenium (n-type) and zinc (p-type) doping was provided by diethyl-diselenide and dimethyl-zinc, respectively.

Before GaAs deposition, the Ge surface was pre-annealed in arsine at  $650^\circ\text{C}$  for 10 minutes to remove native oxide. During GaAs deposition, the substrate was rotated 400 times per minute in order to achieve a uniform film.

The optimum growth temperature was found to be  $575^\circ\text{C}$ . The chamber pressure was 20Torr. Doping concentration was controlled by varying the hydrogen dilution.

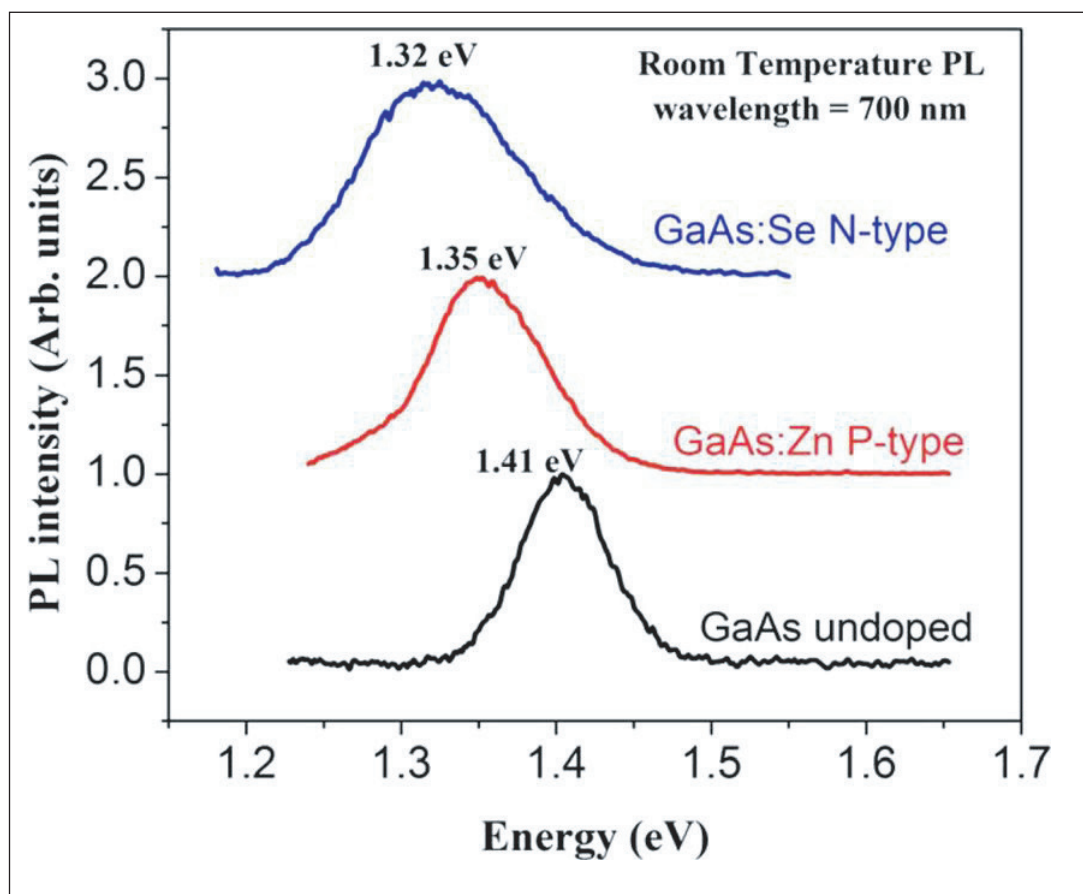
The researchers report:

"The GaAs films were mechanically robust, exhibited good adhesion and no signs of cracking during bending tests, suggesting minimal effect of thermal mismatch and strain between the epilayers." Further, electron diffraction analysis suggested that the film had a zincblende single-crystal structure.

The defect density of a p-GaAs film was estimated to be  $3 \times 10^7/\text{cm}^2$ . Similar values in the range  $4\text{--}9 \times 10^7/\text{cm}^2$  were found for undoped- and n-GaAs. These values are about an order of magnitude higher than for GaAs grown on Ge wafer substrates. The researchers attribute the increase to the rougher template surface and higher defect density level in the 'single-crystal-like' Ge layer on metal foil.

Strong photoluminescence (PL) was seen in all the samples, with the undoped film giving a much stronger peak (Figure 2). The lower peaks in the doped samples were attributed to non-radiative recombination due to the presence of impurities.

In addition, the shape and position of PL peak changed between the undoped and doped GaAs films. The undoped GaAs peak was at 1.41eV, corresponding to bandgap transitions. The Zn-doped p-GaAs film had a peak at 1.35eV; the Se-doped n-GaAs layer at 1.32eV. The red-shift effect of doping was attributed to bandgap narrowing and/or residual strain from dopant incorporation.



**Figure 2. Room-temperature photoluminescence spectra of undoped, Zn- and Se-doped GaAs thin films on flexible metal foils.**

The widths of the peaks in the doped films (0.125eV for n-GaAs, 0.085eV for p-GaAs) were also broader than for the undoped GaAs (0.061eV). Broader lines suggest higher densities of defects.

Hall measurements of mobility and carrier concentration were carried out on films grown on 200nm GaAs buffer layers to avoid the underlying Ge material from affecting the results. The undoped intrinsic GaAs films showed high resistivity of  $10^6\Omega\text{-cm}$ . The Zn-doped GaAs had a high  $10^{19}\text{--}10^{21}/\text{cm}^3$  carrier concentration and  $12\text{--}66\text{cm}^2/\text{V-s}$  hole mobility. The Se-doped GaAs carrier concentration was  $10^{17}\text{--}10^{18}/\text{cm}^3$  with electron mobility as high as  $300\text{cm}^2/\text{V-s}$ .

The high conductivity of  $(1\text{--}5) \times 10^4/\Omega\text{-cm}$  of heavily Zn-doped GaAs films could find application as the base layer of flexible hetero-bipolar transistors (HBTs), tunnel diodes, back surface field, and emitter layer of solar cells and power transistors, according to the researchers.

The Se-doped GaAs showed a lower conductivity of  $10^1\text{--}10^2/\Omega\text{-cm}$ . The researchers comment: "Lightly doped n-type GaAs films with high carrier mobility can be utilized as base layers of solar cells. This is by far the highest reported electron mobility of crystalline GaAs film grown on flexible metal substrates by direct MOCVD." ■

<http://dx.doi.org/10.1063/1.4895388>

Author: Mike Cooke

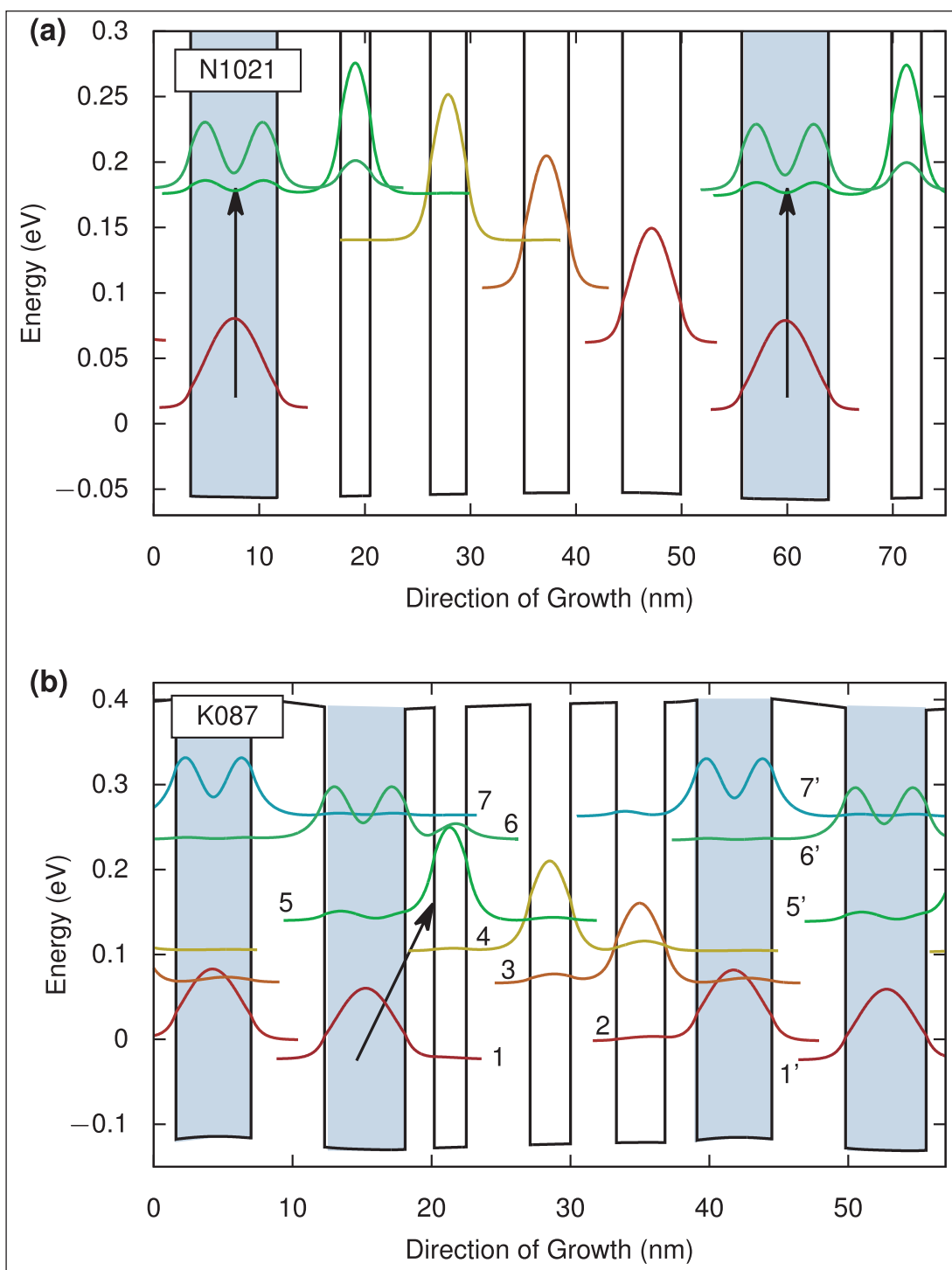
# Diagonal quantum cascade transition improves photodetector performance

The room-temperature response of quantum cascade detectors at 8 $\mu\text{m}$  wavelength has been boosted by almost an order of magnitude.

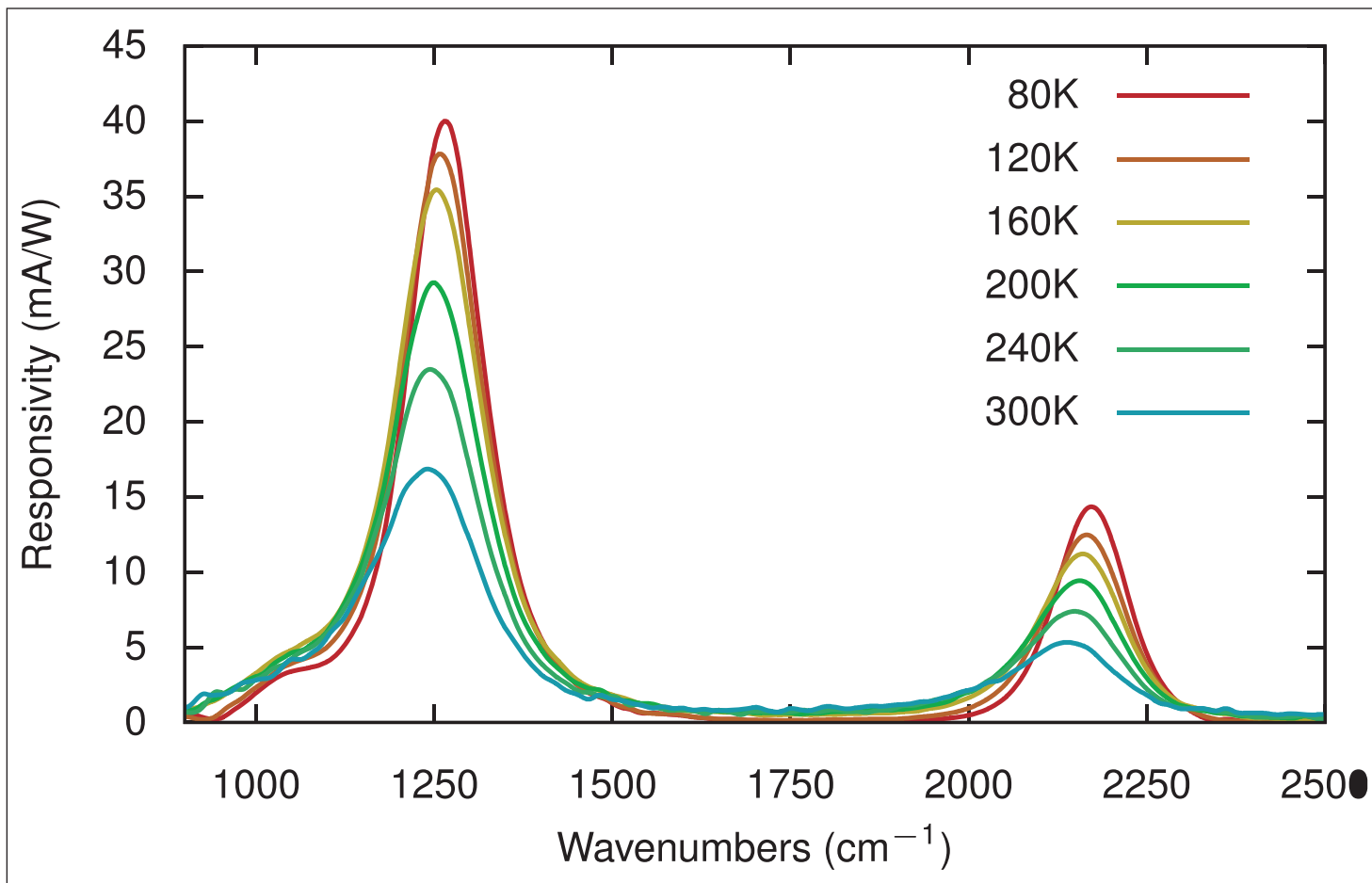
**V**ienna University of Technology in Austria has developed 8 $\mu\text{m}$ -wavelength quantum cascade (photo)detectors (QCDs) based on 'diagonal' transitions, resulting in almost an order of magnitude improved photocurrent response at room temperature [Peter Reininger et al, Appl. Phys. Lett., vol105, p091108, 2014].

The researchers designed two cascade structures (Figure 1): a reference design with a conventional vertical transition within one well, and the other with a diagonal transition between adjacent wells. The team first performed simulations to show that the reduced optical coupling to the diagonal transition was compensated by improved electron extraction and reduced noise. The charge separation does not depend on resonant tunneling as in conventional vertical QCD structures, increasing extraction efficiency.

**Figure 1. Band structure of quantum cascade designs with vertical (a) and diagonal (b) optical transitions, indicated by black arrows.**







**Figure 2. Measured photocurrent spectrum of diagonal transition QCD.**

Also, the simulations suggested that the diagonal design is more robust with the potential for a wider range of devices to be developed for different wavelength detection. In the diagonal design, a 10% variation in the layer thicknesses led to only a 12% drop in response (peak wavenumber 1200/cm–1375/cm). By contrast, the vertical design was expected to have a lower response with a sharp decrease as the layers were thinned and the emission wavelength extended.

The robustness of the diagonal design could be of importance in other less intensively

**The simulations suggested that the diagonal design is more robust with the potential for a wider range of devices to be developed for different wavelength detection. In the diagonal design, a 10% variation in the layer thicknesses led to only a 12% drop in response (peak wavenumber 1200/cm–1375/cm). By contrast, the vertical design was expected to have a lower response with a sharp decrease as the layers were thinned and the emission wavelength extended**

studied material systems where deposition methods are less mature, leading to wide variance of grown structures.

The InGaAs/InAlAs layers for the QCD were produced using molecular beam epitaxy (MBE) on indium phosphide substrate. A 30-period cascade structure was produced between silicon-doped InGaAs top (200nm) and bottom (600nm) contact layers. Mesa devices were fabricated with wet etching and deposition of germanium/gold/nickel/gold top and bottom contacts. The mesa devices were illuminated through a 45° polished facet.

The photocurrent (Figure 2) from the diagonal QCD device showed two peaks at 1250/cm and 2150/cm wavenumbers (1/(wavelength)). The room-temperature peak response was 16.9mA/W for 8μm wavelength (1250/cm wavenumber). This response is almost an order of magnitude better than for other reported 8μm-wavelength QCDs at room temperature.

The researchers attribute the main 1250/cm peak to a transition between levels 1 and 5 in the calculated band structure (Figure 1). The smaller 2150/cm peak is thought to arise from a transition between levels 1 and 6. A small bump at 1050/cm is explained as being due to a small overlap between levels 1 and 4. ■

<http://dx.doi.org/10.1063/1.4894767>

Author: Mike Cooke

# VCSEL quasi-array of four devices outputs 210W at 110A

Researchers see wide application prospects such as laser fusion welding, medical treatment, car-sensing, and laser ranging.

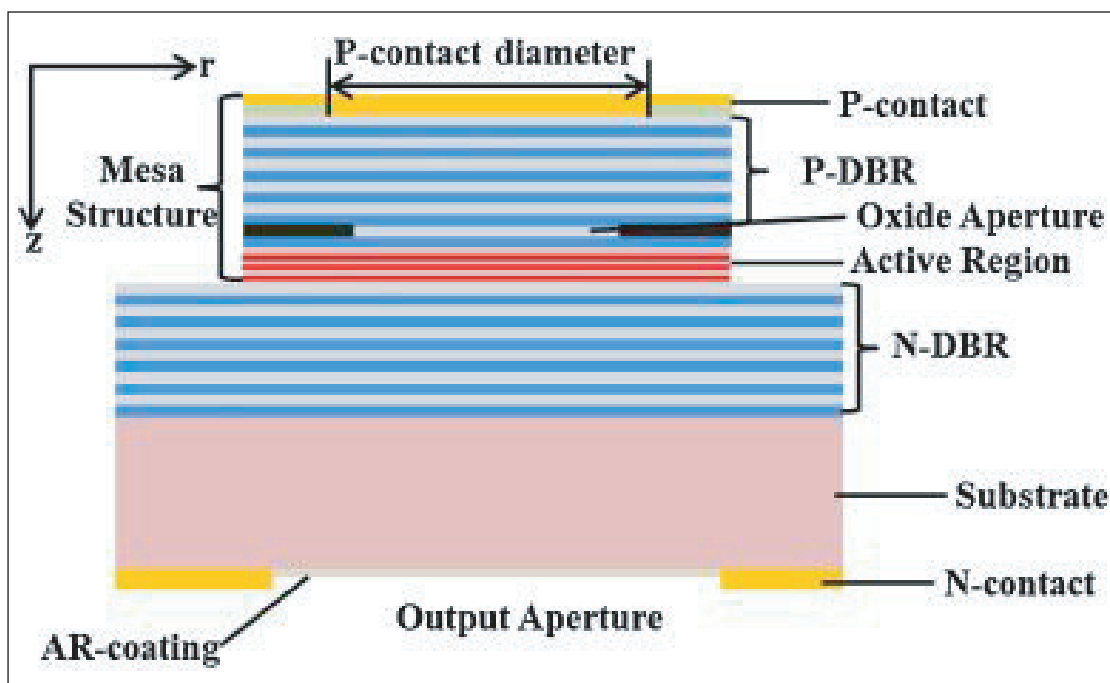
China's Changchun Institute of Optics, Fine Mechanics and Physics has developed a module containing four vertical-cavity surface-emitting lasers (VCSELs) capable of emitting 210W at 110A current injection in short-pulse operation [Jianwei Zhang, Jpn. J. Appl. Phys., vol53, p070303, 2014]. The researchers comment: "To the best of our knowledge, this is the highest value reported for a VCSEL module consisting of single emitters."

The researchers quote comparisons of 92W from a single VCSEL and 123W from an emitter array containing 16 devices.

High-power-output laser diodes find application in laser fusion welding, medical treatment, car-sensing, and laser ranging. VCSELs are attractive for such applications due to good production yields and high reliability in short-pulse operation. The structure suffers less from self-heating that can degrade performance of the active region. Also, the VCSEL architecture does not suffer from the catastrophic optical damage (COD) seen in edge-emitting devices.

The VCSEL structure (Figure 1) was grown using metal-organic chemical vapor deposition (MOCVD) on n-type gallium arsenide (n-GaAs) substrate. The multiple quantum well (MQW) active region consisted of three 8nm In<sub>0.2</sub>Ga<sub>0.8</sub>As wells emitting at 980nm. Distributed Bragg reflectors (DBRs) for such devices typically consist of alternate layers of AlGaAs (or even AlAs) and GaAs.

The mesa etching was carried out using inductively coupled plasma. The oxide current aperture was created using nitrogen gas bubbled through water at 90°C and delivered to the VCSEL structure at 420°C. The device structure included a 30nm Al<sub>0.98</sub>Ga<sub>0.02</sub>As layer above the active region to allow for the selective oxidation.



**Figure 1. Schematic of 980nm VCSEL structure.**

A plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide insulation layer on the mesa was etched to give a window for the gold p-contact electrode. The bottom of the substrate was coated with an anti-reflection layer for the emission window and gold was used for the n-contact electrode. The devices were cleaved and packaged in TO mountings.

The researchers carried out simulations to find the optimum diameters for the oxide aperture and p-contact. As a result, devices with 200µm, 300µm and 400µm oxide apertures were produced with 160µm, 240µm, and 320µm p-contacts, respectively. The 200µm/160µm device showed the most uniform emission profile, with the larger-diameter devices increasingly suffering the effects of current crowding at the edge of the aperture.

With 100µs quasi continuous wave (QCW) 100Hz pulsed operation the devices suffered from self-heating effects, particularly the smaller-diameter device. In this mode, the 300µm oxide aperture device had the best maximum output power of 3W. The severe current crowding of the 400µm aperture device reduced its efficiency compared with the 300µm device, although its maximum output exceeded that of the 200µm device.

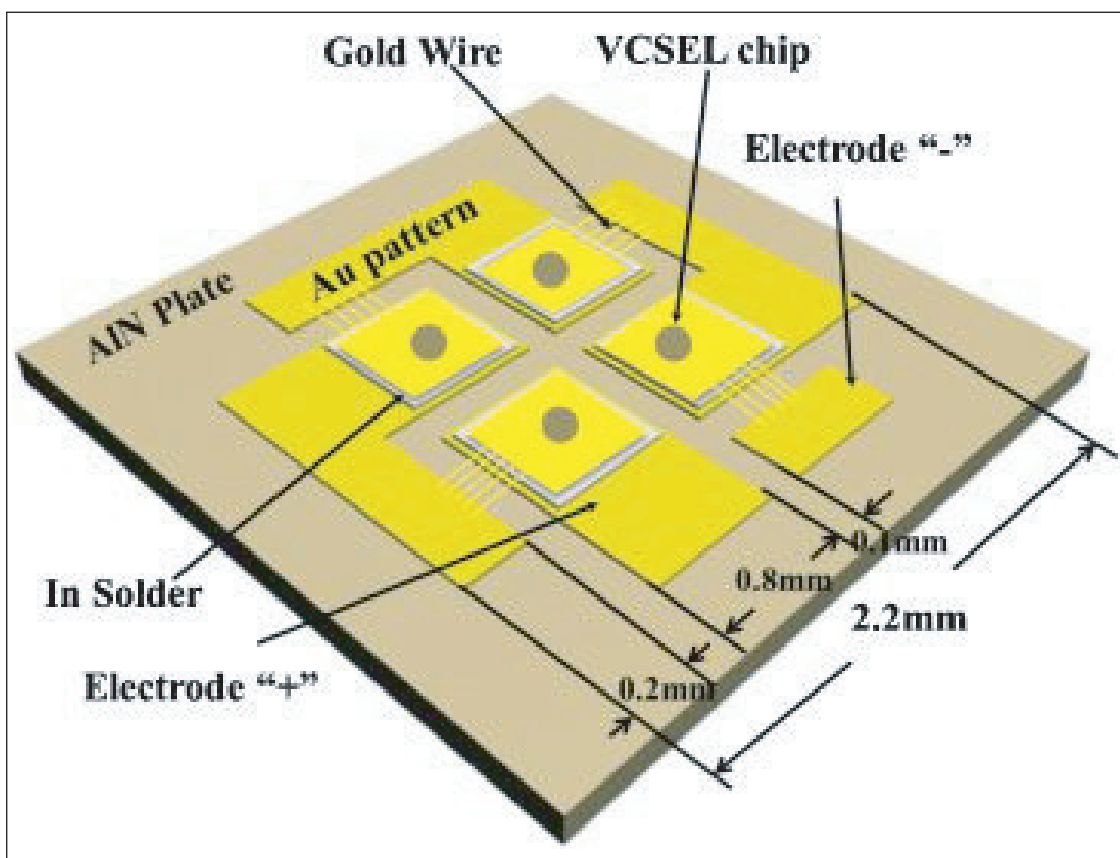
With short 30ns 5kHz pulses, 'thermal rollover' was not observed in any of the devices. The power ordering was the same as for QCW operation. The poor performance of the 200µm device was attributed to carrier leakage at the higher current density relative to the other devices. Such leakage is a more serious problem with very short pulses where carriers injected at a high level into the active region don't have time to recombine and emit light. The researchers estimate that the current density in the active region of the 200µm device is ten times that of the other VCSELs at the same injection current.

The 400µm device suffered from non-uniformity of the current distribution across the diameter.

The 300µm VCSEL had an external efficiency of 0.62W/A, which is comparable to the reported performance of 5-QW devices. "Moreover, the maximum power of 62W is achieved, which was higher than the record power of proton-implanted single emitters and arrays," the researchers add.

The researchers also developed a 'quasi-array' module (Figure 2) containing four 300µm/240µm oxide aperture/p-contact VCSELs as an alternative to monolithic VCSEL arrays. Problems with monolithic arrays include high operation current, and electrical and thermal crosstalk.

The gold interconnections were designed to be as short as possible to ensure a good short-pulse response of the module. The devices were connected in series. An aluminium nitride (AlN) plate was used as the sub-



**Figure 2. Schematic of VCSEL quasi-array consisting of four single emitters connected in series.**

mount due to the material's high thermal conductivity. The module was packaged into a TO-39 holder.

In short-pulse operation, the module's light output was 210W at 110A current input. The performance was limited by the capability of the power supply. This performance is somewhat less than  $4 \times 62W = 248W$ , which the researchers suggest could be due to inductance and capacitance current losses.

The emission wavelength at 110A was 980.5nm with full-width at half-maximum (FWHM) of 1nm. The far-field emission pattern was broad, with a FWHM divergence angle of more than 40°. While this is not desired for applications, the researchers suggest it could be handled with the use of collimating micro-lenses and field lenses. ■

<http://dx.doi.org/10.7567/JJAP.53.070303>

Author: Mike Cooke

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# Cantilever bridge to higher bandwidth from VCSELs

**Thermal wavelength drift reduced by factor of four compared with conventional vertical-cavity surface-emitting lasers.**

**R**esearchers at Japan's Tokyo Institute of Technology and King Abdulaziz University in Saudi Arabia have developed a multiple-wavelength vertical-cavity surface-emitting laser (MW-VCSEL) array with a thermal wavelength drift of less than 0.017nm/K by the use of micro-electro-mechanical system (MEMS) cantilever structures to vary the cavity length [M. Nakahama et al, Appl. Phys. Lett., vol105, p091110, 2014].

The drift was 4x smaller than for conventional VCSELs, according to the researchers. With a channel spacing of 2.5nm, the devices could be operated over a 100K range without overlap.

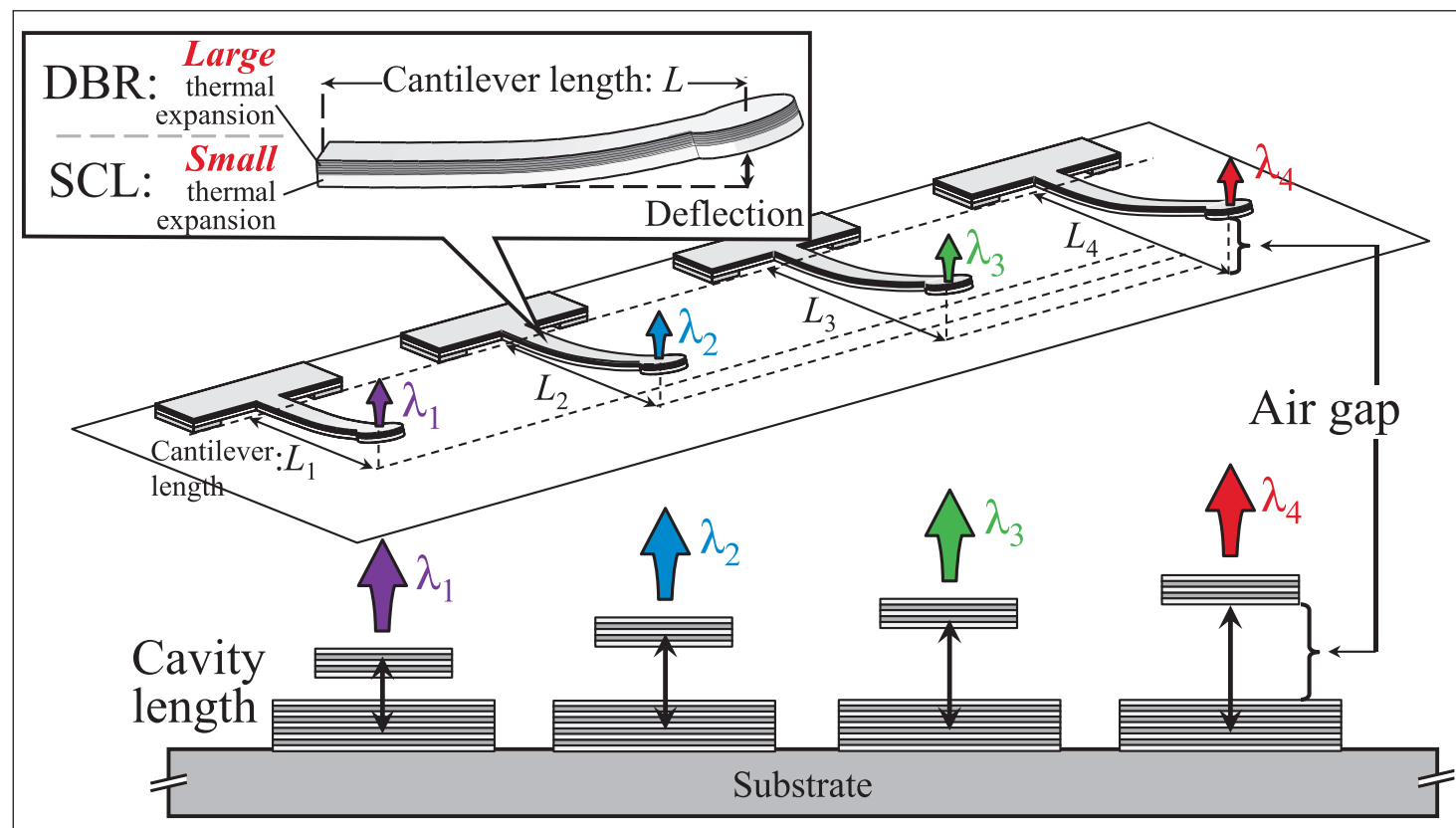
The researchers see the devices as potential candidates for high-bandwidth optical data transmission based on wavelength division multiplexing (WDM) with application to warehouse-scale data centers and high-performance supercomputers. Traditional VCSELs allow only coarse WDM due to thermal wavelength drift. The

researchers comment: "If the temperature dependence of wavelength is reduced, more channels are allocated in narrower spacing, resulting in larger transmission capacities."

The team hopes that its technology could lead to narrow channel spacing, allowing bandwidths beyond 100 gigabits per second (Gbps).

The top distributed Bragg reflector (DBR) of each VCSEL in the array was sited on a cantilever (Figure 1). The cantilevers consisted of aluminium gallium arsenide (AlGaAs) of varying composition. The  $\text{Al}_{0.85}\text{Ga}_{0.15}$  strain compensation layer had a smaller expansion coefficient compared with the AlGaAs DBR. The cantilevers were produced using a combination of selective wet etching and critical point drying.

The researchers also used an aluminium oxide layer as an anti-reflection layer on the bottom half VCSEL to reduce Fresnel reflection effects at the interface between the semiconductor cavity and the air gap and



**Figure 1. Design concept of 4-channel athermal multiple wavelength VCSEL array.**

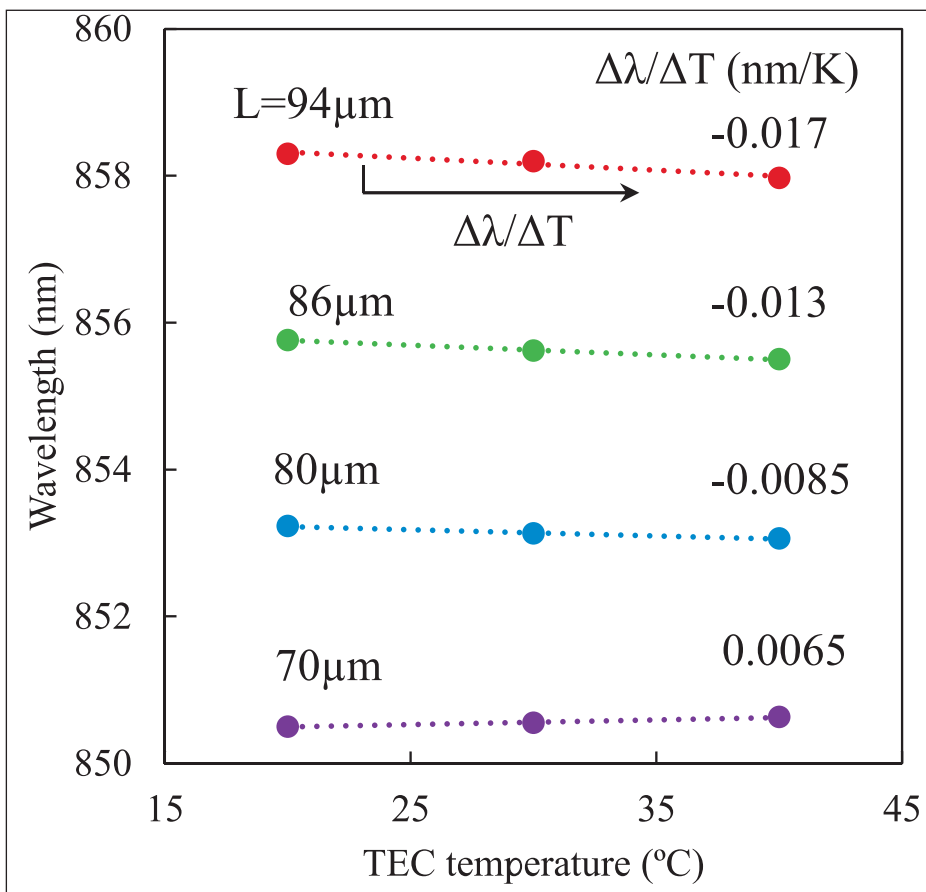
to eliminate coupled cavity effects.

The thermal performance of the array was measured on a copper stage with a thermoelectric cooling element. At 20°C the maximum output power varied between 0.07mW and 0.22mW, while the threshold currents were in the range 1.2–1.5mA. The researchers hope that optimized fabrication would reduce the variations. In particular, the oxide apertures varied over the range 2–3µm. Smaller apertures result in lower output power.

By varying the cantilever length between 70µm and 94µm, a wavelength span of 8nm at 20°C was achieved at 3mA injection. The devices showed single-mode operation with 30dB side-mode suppression ratio. However, at increased temperature, while the single-mode operation was maintained, the peak intensity decreased rapidly due to the poor temperature dependence of threshold current as a result of the small aperture diameters. The thermal wavelength drift was between +0.0065nm/K and -0.017nm/K (Figure 2). ■

<http://dx.doi.org/10.1063/1.4895337>

Author: Mike Cooke



**Figure 2. Peak wavelength of each device at different temperatures. Temperature coefficient of wavelength ( $\Delta\lambda/\Delta T$ ) was estimated from linear fit.**

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# Cool-white quantum dot light-emitting diode

**Researchers believe devices may prove crucial for the realization of cool- and warm-white light sources.**

**U**niversity of Michigan in the USA and OSRAM Opto Semiconductors GmbH in Germany have developed cool-white light-emitting diodes (LEDs) using quantum dot (QD) structures [Shafat Jahangir et al, Appl. Phys. Lett., vol105, p111117, 2014].

The devices consisted of indium gallium nitride (InGaN) QD active pump and convertor regions (Figure 1). The pump region emitted light with a spectral peak in the blue that was converted to longer yellow/orange wavelengths in the convertor region.

Commercially, white LEDs are mainly based on yellow or more complex phosphors pumped by blue or ultraviolet radiation. However, such devices suffer from power losses while the phosphor materials tend to degrade upon heating.

Quantum well (QW) pump/convertor systems suffer from efficiency problems arising from polarization-induced electric fields that tend to inhibit electron-hole recombination into photons (the quantum-confined Stark effect). QDs form in a strain relaxation process that reduces these polarization-induced fields, improving recombination efficiency into photons. (However, the barrier to carrier injection into QDs is usually higher than for QWs.)

The quantum dot structures were grown by plasma-assisted molecular beam epitaxy (PAMBE) on c-plane GaN on sapphire templates, using a Veeco Gen 930 system. 'Stranski-Krastanow' — or layer-plus-island — mode growth results in self-organized InGaN QDs through strain relaxation. Multiple layers of dots were separated by GaN barriers in both the convertor and pump regions. The long-wavelength converter QD stack was grown at 541–550°C with 12nm barriers. The pump stack was grown at 585–592°C with 16nm barriers.

The n-GaN 300nm buffer and 150nm contact layers were grown at 720°C. The p-AlGaIn electron-blocking and p-GaN contact layers were grown at 680°C. The researchers optimized the numbers of QD layers and the parameters of the dot formation process with the aims of true white light and efficiency.

The mesa LEDs measured 600µm x 600µm. The device incorporated a semi-transparent nickel/gold window on the p-GaN contact layer and an aluminium mirror on the back-

side of the substrate. The turn-on voltage was in the range 5.5–6.0V with a series resistance of 20–24Ω.

The devices showed smaller blue-shift with increasing current than planar QW LEDs. The researchers attribute this to smaller polarization fields in QD layers due to the strain relaxation in the growth process, compared with QW layers.

The external quantum efficiency (EQE) peaked in the injection current density range of 37–45A/cm<sup>2</sup>. The efficiency droop at 100A/cm<sup>2</sup> was 14–17%.

The researchers measured Commission Internationale de l'Eclairage (CIE) chromaticity coordinates (X, Y) and correlated color temperatures (CCT) (Table 1). The small blue-shift resulted in a small 210K shift in the CCT of device C from 4375K to 4585K for injection at 25A/cm<sup>2</sup> and 100A/cm<sup>2</sup>, respectively. The researchers say that this is better than for MQW LEDs with MQW convertors. Similar small shifts were found for the other devices.

Cool white corresponds to 4500K and warm/soft white to 3000K. The researchers comment: "These values of CCT would be difficult to achieve with all-quantum-well converter LEDs, since long-wavelength ([more than] 600nm) emission with high radiative efficiency is difficult to achieve with such InGaN/GaN quantum wells due to increasing material inhomogeneities and a strong polarization field."

QW- or phosphor-based color conversion results in higher CCTs above 5500K. The researchers believe that "InGaN/GaN quantum dot converter LEDs may prove to be crucial for the realization of cool-white and warm-white light sources." ■

<http://dx.doi.org/10.1063/1.4896304>

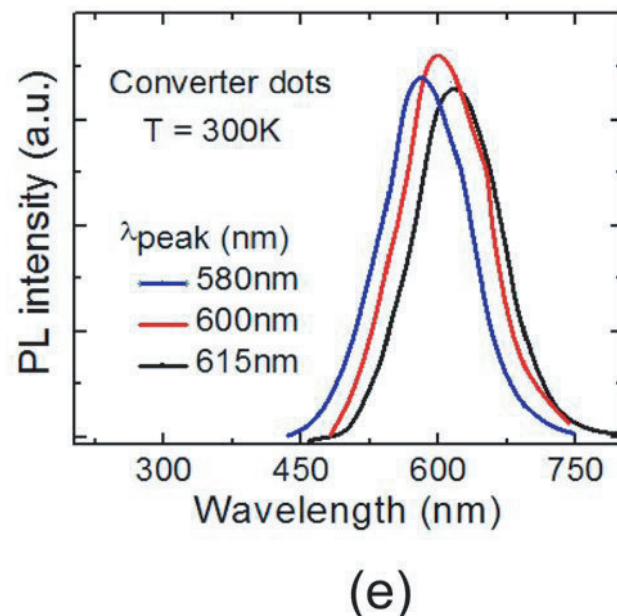
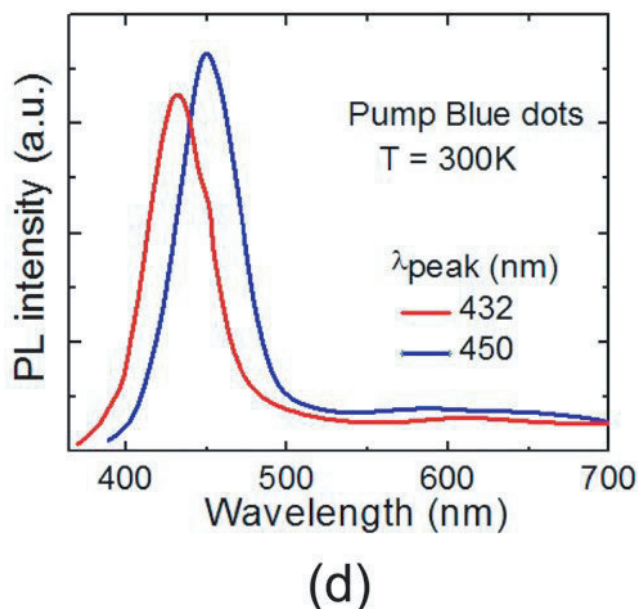
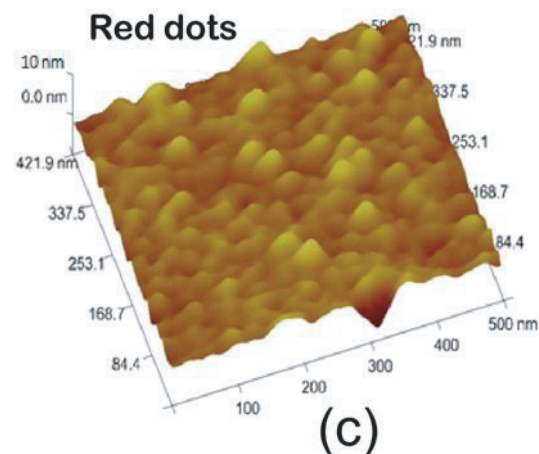
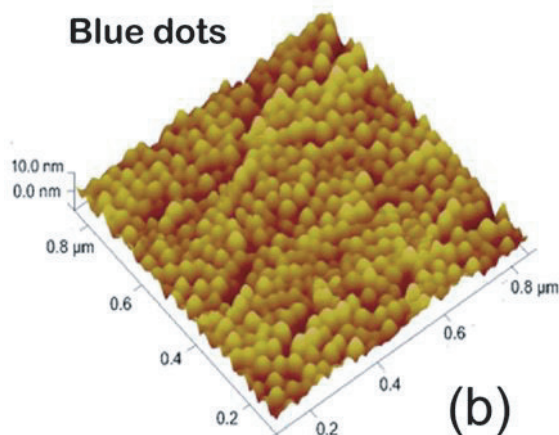
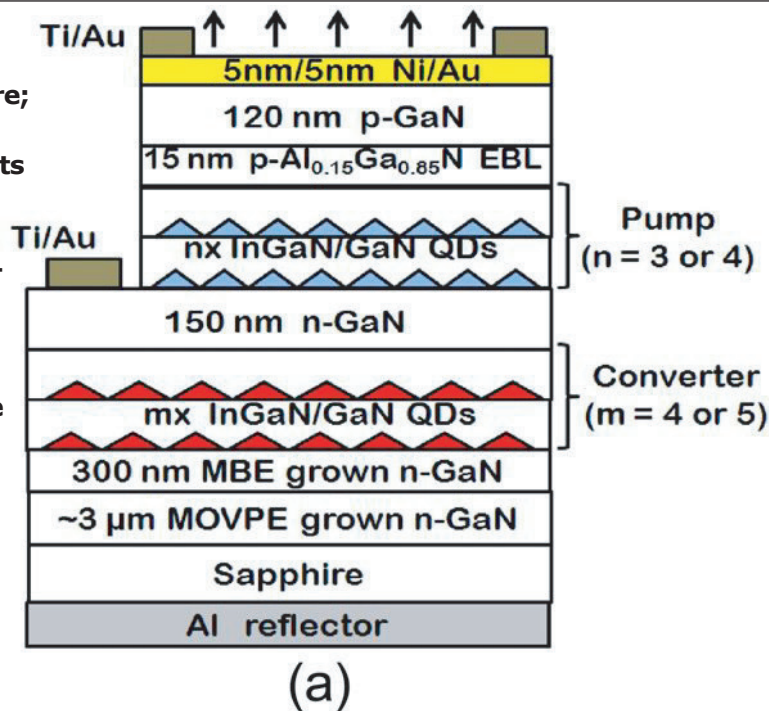
Author: Mike Cooke

**Table 1. CIE chromaticity coordinates and correlated color temperatures (CCT) of wavelength converter white LEDs at injection current density of 45A/cm<sup>2</sup>.**

LED	Pump dot emission wavelength	Converter dot emission wavelength	Chromaticity coordinates (X, Y)	CCT
A	450nm	580nm	(0.34, 0.38)	5350K
B	450nm	600nm	(0.35, 0.37)	4830K
C	450nm	615nm	(0.37, 0.35)	4420K
D	432nm	580nm	(0.33, 0.36)	5790K
E	432nm	580nm	(0.32, 0.32)	6700K



Figure 1. (a) Schematic of InGaN/GaN QD wavelength converter white LED heterostructure; atomic force microscopy images of self-organized In<sub>0.24</sub>Ga<sub>0.76</sub>N/GaN dots with peak emission at 450nm (b) and In<sub>0.37</sub>Ga<sub>0.63</sub>N/GaN dots with peak emission at 600nm (c); room-temperature photo-luminescence of blue-emitting pump dots (d); and red-emitting converter dots (e) incorporated in LED heterostructure



# Color tuning from defect engineering

**China research uses silver nanorods to create red to white gallium nitride LEDs.**

**X**i'an Jiaotong University and Shaanxi Supernova Lighting Technology Co Ltd of China have used silver nanorods to engineer gallium vacancy defects in gallium nitride (GaN) to create color tunable light emitting diodes [Yaping Huang et al, Appl. Phys. Express, vol7, p102102, 2014]. At low current the emission was red, while at higher current white light was achieved.

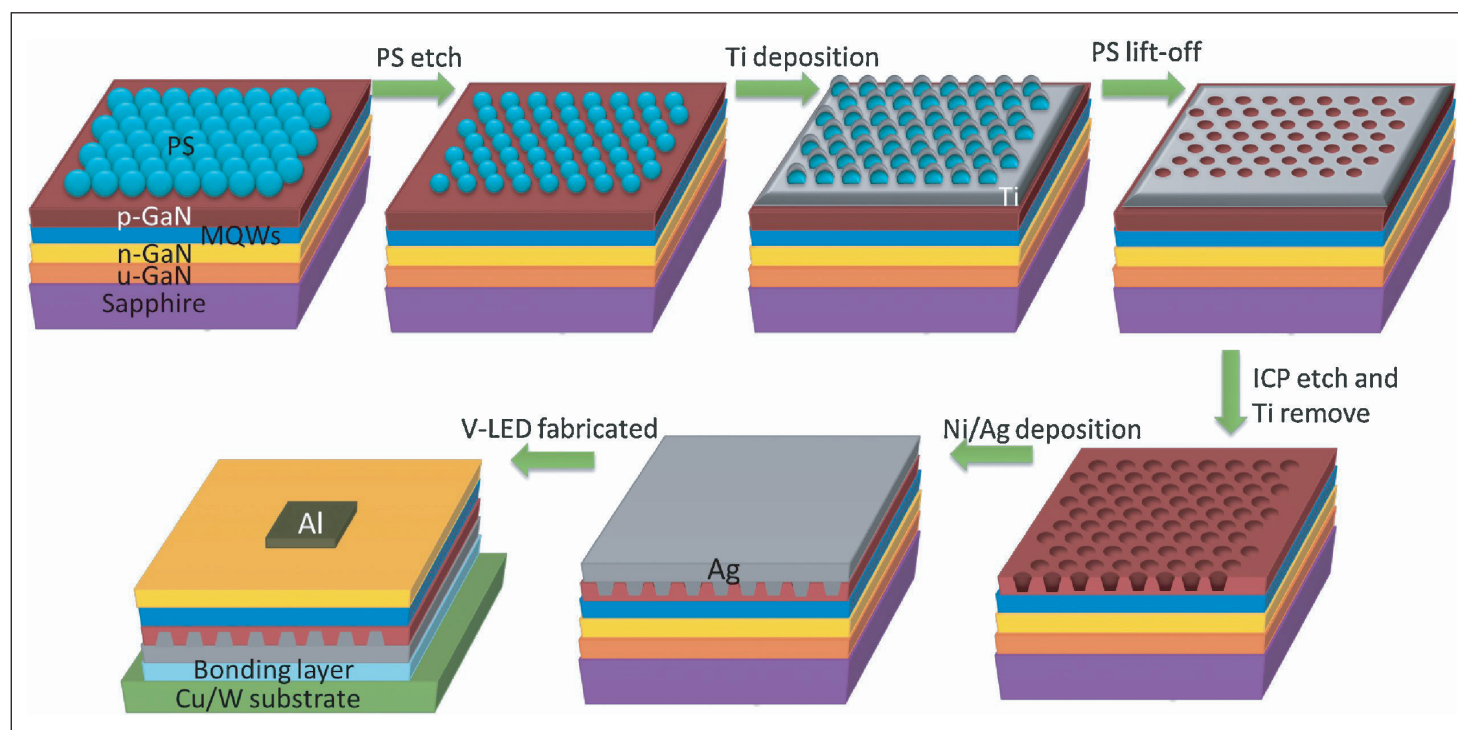
The LED heterostructure was produced using metal-organic chemical vapor deposition on c-plane sapphire. The 460nm blue light-emitting region consisted of nine 3nm indium gallium nitride (InGaN) wells separated by 9nm gallium nitride barriers. The 120nm p-GaN contact region was separated from the multiple quantum well by a 20nm electron blocking layer.

The heterostructure was used to fabricate vertical LEDs (Figure 1). First 200nm-diameter polystyrene spheres were used as a self-assembled mask to create a hexagonal array of holes in a titanium hard mask. Before titanium deposition, the spheres were reduced in diameter to 130nm by oxygen plasma etching. The titanium mask therefore consisted of 130nm-diameter holes after removal of the polystyrene.

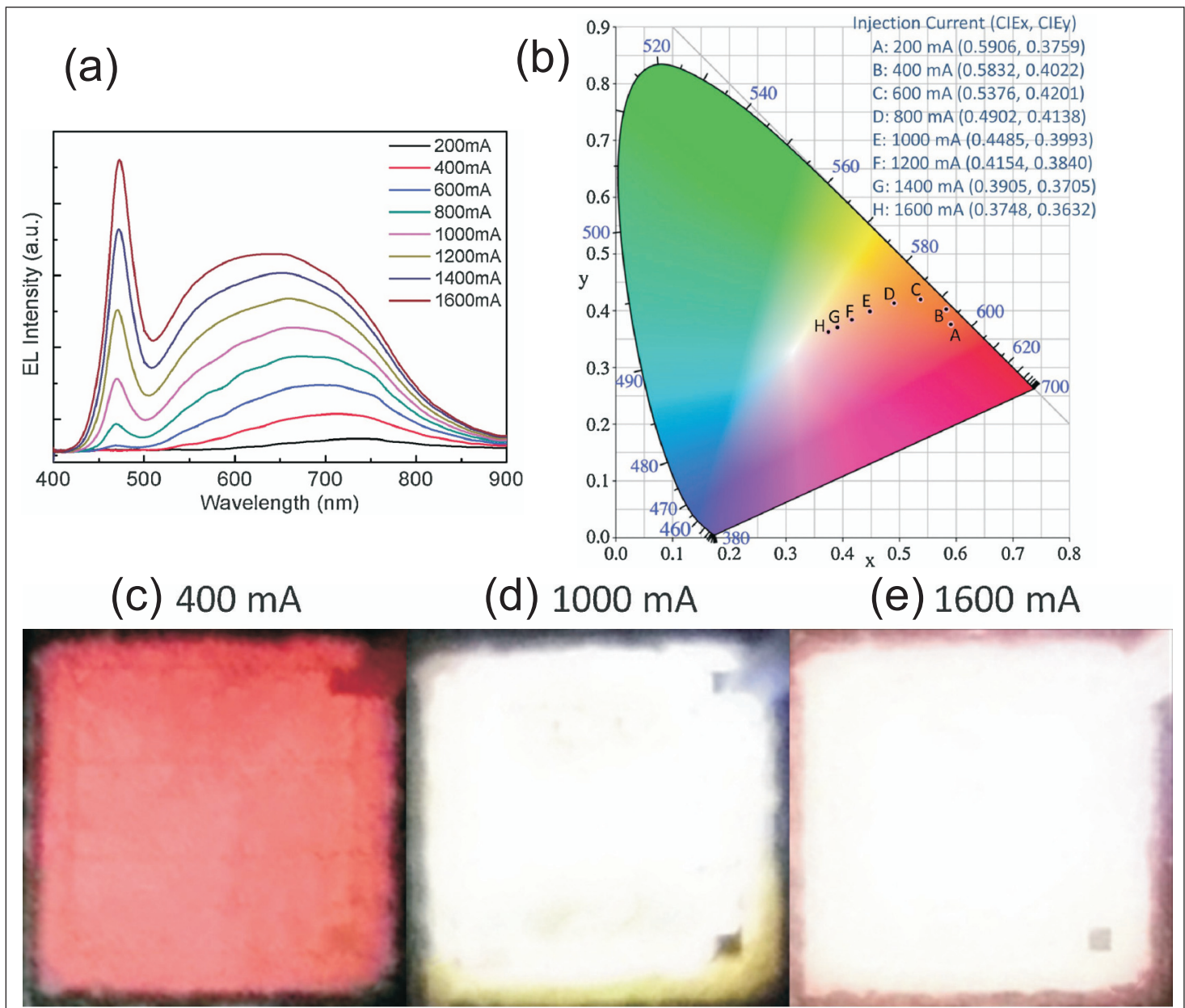
**Xi'an Jiaotong University and Shaanxi Supernova Lighting Technology Co Ltd of China have used silver nanorods to engineer gallium vacancy defects in gallium nitride to create color tunable light emitting diodes [Yaping Huang et al, Appl. Phys. Express, vol7, p102102, 2014]. At low current the emission was red, while at higher current white light was achieved**

The titanium mask was used to create 130nm deep holes in the p-GaN contact layer. The titanium was then removed and 150nm silver deposited on a 1nm nickel layer. Further metal layers of 100nm titanium and 500nm gold was applied for subsequent bonding at 380°C to a copper/tungsten substrate with titanium/tin-gold alloy (50nm/1000nm) coat.

Laser lift-off was used to remove the sapphire growth substrate. The undoped GaN buffer layer was etched away before 1500nm aluminium was applied as contact metal to the n-GaN layer.



**Figure 1: Fabrication scheme of defect-induced color-tunable vertical LEDs.**



**Figure 2: (a) Electroluminescence spectrum of vertical LEDs with silver nanorods embedded in p-GaN measured at room temperature under continuous current. (b) CIE (1931) chromaticity coordinates of vertical LEDs at various injection currents. Electroluminescence images of vertical LED chips at injection currents of (c) 400mA, (d) 1000mA, and (e) 1600mA.**

The fabricated LED measured 55milx55mil (1.4mmx1.4mm).

One effect of the silver nanorod array is to create gallium vacancies in the p-GaN layer from formation of gallium-silver solid solution at the interface between the materials during thermal annealing/bonding.

At low injection current of 200mA, the emission is red with a peak at ~750nm (Figure 2). As the current increases, the broad emission blueshifts to ~650nm at 1600mA and broadens on the high energy side. The broad red emission is attributed to donor-acceptor pair (DAP) transitions in the p-GaN from electrons that successfully tunnel through the electron blocking layer. Above 600nm, a blue emission peak emerges around 470nm, presumably direct emission from the multiple

quantum well structure.

The researchers characterize the color of LED as being red at 200mA and white at 1600mA on the basis of CIE 1931 chromaticity coordinates.

Current-voltage measurements gave a relatively high current leakage under reverse bias. The forward bias threshold for light emission was around 2V. The voltage at 200mA was 2.1V. At 600mA, the voltage was 2.9V where the MQW turns on.

The researchers admit that the efficiencies of these devices are less than those of commercial phosphor-based white LEDs and that many improvements would be needed to boost efficiency in the future. ■

<http://iopscience.iop.org/1882-0786/7/10/102102/>

Author: Mike Cooke

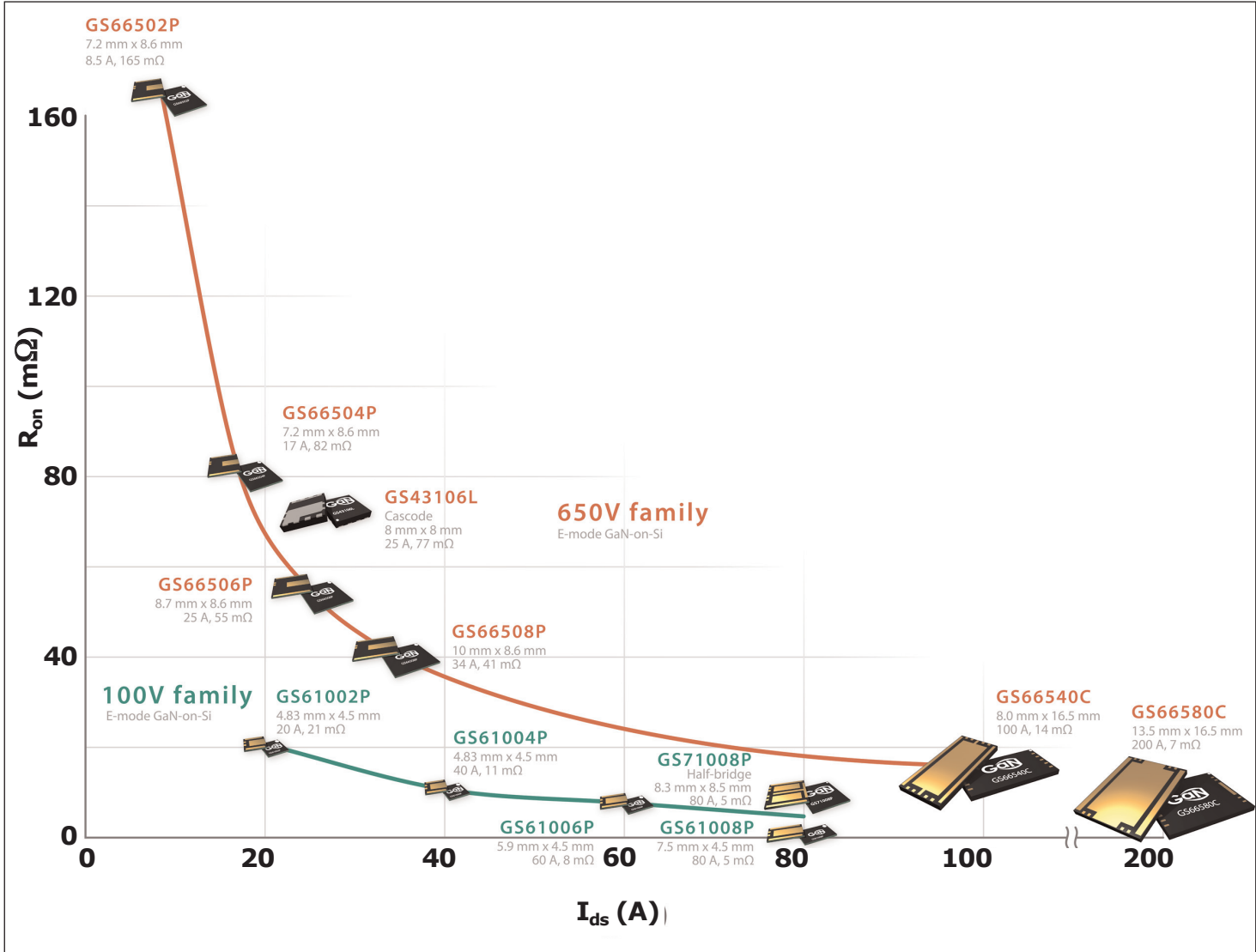


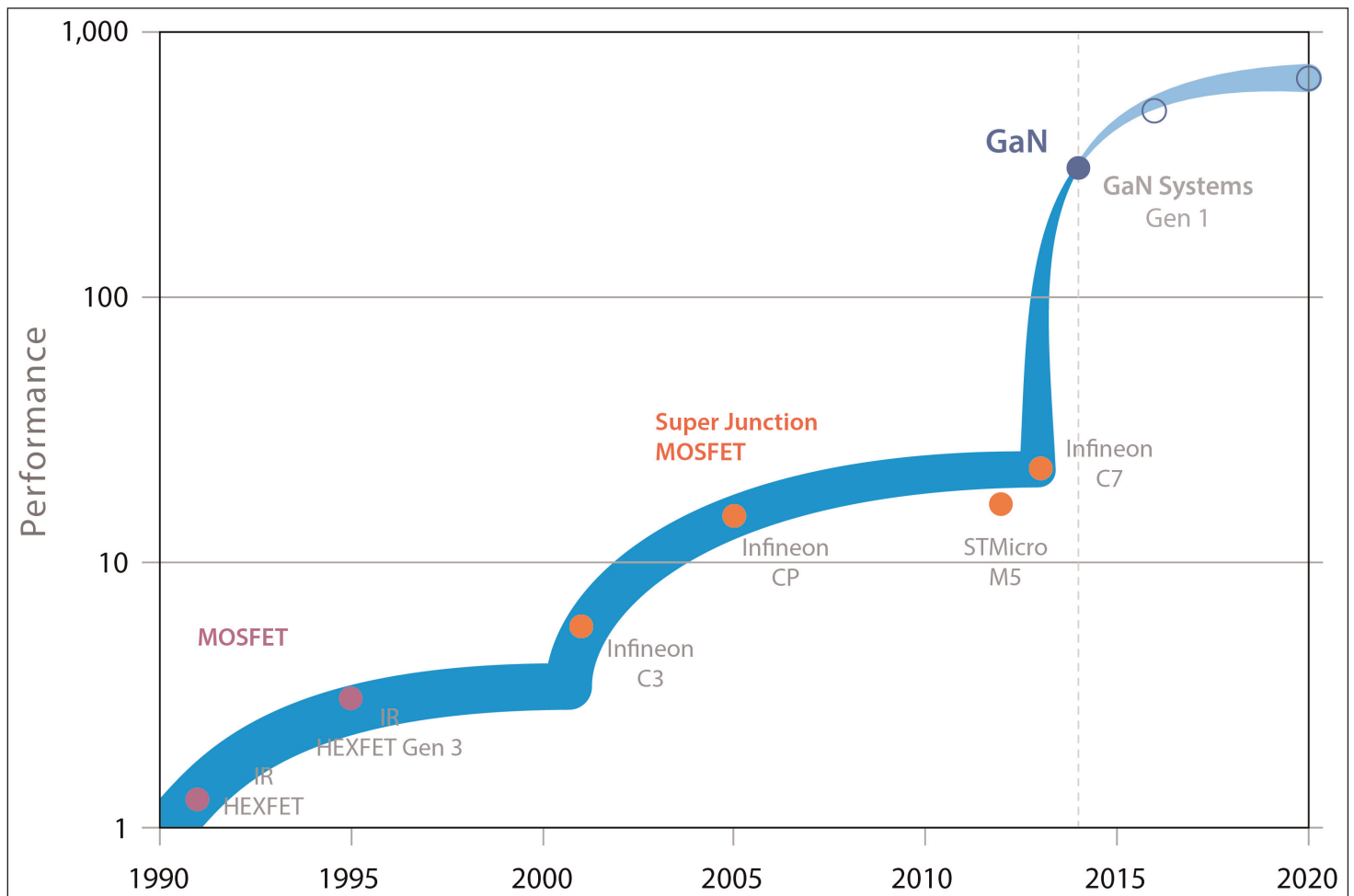
# The next era in power electronics

**Mike Sherman** of Chrysalix EVC explains how gallium nitride can cost effectively meet the demands on size and efficiency of power electronics devices.

It is estimated that 10% of all the power generated around the world is lost as heat through inefficient power conversion — that is, when electric energy is converted from one form to another, such as between AC (alternating current) and DC (direct current), changing the voltage or frequency, or some combination of these. To put this in perspective, the scale of this loss is more than double the world’s total installed capacity for non-hydro renewable electricity generation. Today, the vast majority of power conversion is accomplished using silicon switches. These devices are

used virtually everywhere that power is consumed, and they are spreading rapidly with the electrification, computerization, and connectivity of all the devices in our daily lives — from smartphones and TVs to electric vehicles (EVs) and data centers. Everyone is familiar with Moore’s law, which correctly predicted that computer microprocessor performance would increase at a steady exponential rate, doubling approximately every two years. However, this is not so for power conversion. Power electronics have typically followed a step-change





function, with new materials platforms and topologies yielding major improvements in performance only every 10-15 years or so. International Rectifier achieved market dominance with the silicon-based MOSFET transistor in the 1990s, followed by Infineon, which claimed the dominant position with the Super Junction MOSFETs in the 2000s. As the performance of those technology platforms is topping out, the market now stands poised for the next big shakeup.

Gallium nitride (GaN)-based transistors appear to be increasingly positioned to take that top seat and disrupt the \$15bn power transistor market. GaN is a very hard, mechanically stable, wide-bandgap semiconductor material with high heat capacity and thermal conductivity. The GaN materials platform has been increasingly commoditized through its application into RF antennas and LEDs, and a handful of companies are now coming out with power devices.

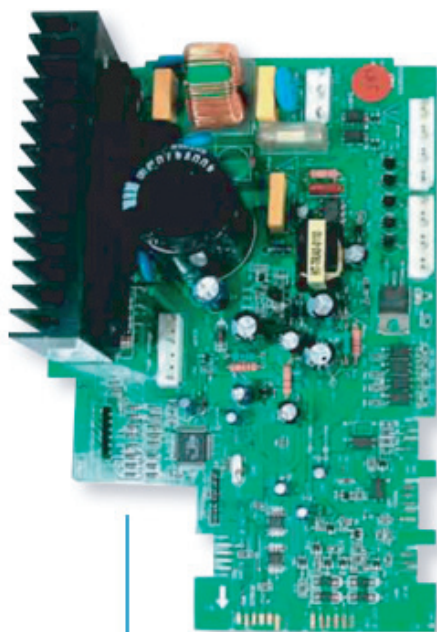
Why does this matter? GaN has the potential to eliminate 50% to 90% of the losses in power conversion. Moreover, it can reduce the size and weight of power modules by up to 75%, significantly reducing system bill of materials (BOM) costs while dramatically improving performance. GaN switches also operate 1000x faster than silicon switches and they have 10x better resistance per area and 40x better overall performance.

In energy-hungry applications such as data centers, this step change in performance is long overdue.

In order to keep up with the pace of processor innovation and the explosion of cloud computing demands, data-center designers now need to put 1.5x the power conversion in the same space, and have run out of options to accomplish this. Similarly, major automotive manufacturers are challenging their designers to halve the size of their onboard vehicle chargers and dramatically increase power electronics efficiency to meet their cost, range, and performance roadmaps. This same size and efficiency demand is consistent across industries, and GaN is seen as the only cost-effective solution capable of meeting these rising performance demands.

One of the clear leaders in realizing this potential is Chrysalix portfolio company GaN Systems. Launched earlier this year, GaN Systems' product portfolio addresses roughly \$10bn of the total \$15bn market for power transistors. About \$5bn of that market, in industrial and transportation applications above 50A (such as motor drivers, industrial power supplies, EV charging systems, and centralized solar inverters), appears to be uniquely addressable by GaN Systems' proprietary high-current technology.

Since launching its products this spring, GaN Systems has begun sampling programs with more than 50 customers across the electronics, manufacturing, EV, renewables, and Internet services industries, representing \$2bn in product applications, or roughly 20% of the serviceable addressable market. ➤



**Power Supply  
with Silicon**



**Power Supply  
with GaN switches**

► These customers are evaluating GaN Systems for a wide range of applications, from more efficient data centers and solar inverters, to thinner TVs, smaller, more powerful motors, longer-range EVs, and a multitude of other consumer, enterprise, industrial and transportation applications. Anywhere that efficiency, size, weight, cost and performance are important, GaN has a compelling value proposition.

Also, GaN Systems is uniquely positioned to unlock that potential, with the broadest product range, best performance, and easiest integration into customer applications with advanced driver and packaging technology. The company's innovative Island Technology results in devices that are approximately four times smaller, four times more efficient, and one quarter the cost of traditional silicon design approaches.

Over the last few months Chrysalix has helped GaN Systems to build an expanded world-class commercial team with the addition of seasoned industry executives

can register with GaN Systems to access previously undisclosed product and technology information, and fully leverage the firm's data sheets, PSPICE models, and packaging information.

With GaN Systems breakthrough device design, power transistors now stand to enable previously unseen switching efficiencies that could lead to more sustainable energy use and increased power efficiency, while reducing the costs and environmental impacts of some of the world's fastest-growing industries. On a global level, the impact could be a reduction in energy demand that is greater than the current adoption of solar power. In GaN Systems, Chrysalix sees the next great company capable of leading this enormous \$15bn industry through its largest innovation cycle in many decades. ■

*Author: Mike Sherman, managing partner, Chrysalix EVC*

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

in marketing, product management, business development, and applications engineering. Chrysalix is also instrumental in bringing on the additional leadership of Jim Witham as CEO in March.

GaN Systems was recently named as one of EE Times' Silicon 60: Hot Startups to Watch. The company is also supporting the Little Box Challenge, presented by Google and the IEEE Power Electronics Society, where Google has created a \$1m prize for radical size reduction in power electronics. For the first time, those participating in the Little Box Challenge

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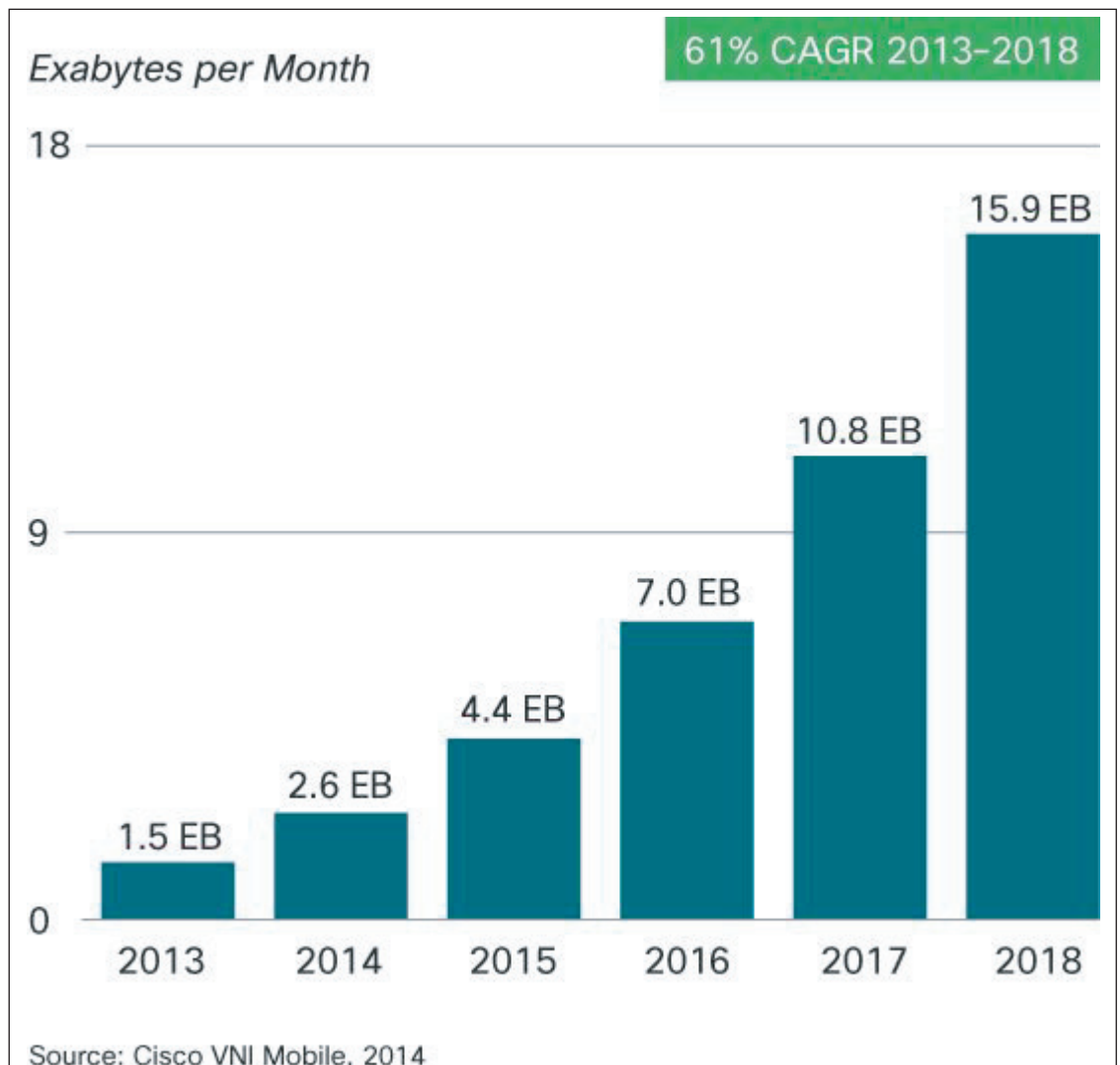
# Long-term evolution of gallium arsenide production

**Mike Cooke** offers his impressions from the latest quarter results of RFMD, TriQuint, Skyworks, and Anadigics.

**T**he transitioning of mobile networks to 4th-generation/long-term evolution (4G/LTE) capability has benefited most leading suppliers of gallium arsenide (GaAs) products in the past year. The market has been demanding products both for network infrastructure and mobile handsets.

RF Micro Devices Inc. (RFMD) president & CEO Bob Bruggeworth commented on the company's latest quarterly results: "RFMD continued to benefit from the increasing global demand for mobile data. Consumers want more bandwidth for their data-hungry applications, carriers want greater throughput from their available spectrum, and device manufacturers want greater functionality within the same product footprint."

Projections suggest that 4G/LTE will enable an exponential growth in mobile traffic, from 1.5 exabytes (EB) per month in 2013 to 15.9EB in 2018 (Figure 1). These mobile technologies require the handling of much more complex frequency bands – up to 43 in 2015, compared with 6 in 2010 and only 2 in 2005.



**Figure 1. Cisco forecast for mobile data traffic up to 2018.**

At the same time, companies more dependent on legacy 2G products, such as Anadigics, have announced restructuring steps designed to achieve profitability.

Even bullish RFMD is restructuring through a consolidation with TriQuint Semiconductor Inc, merging into

the new company Qorvo (pronounced “kor-vo”) by the end of 2014. The move was approved by shareholders on 5 September. The name supposedly reflects the ideas of “core technologies and innovation”. Qorvo’s markets will be mobile, infrastructure and defense.

RFMD and TriQuint both have facilities supporting 150mm GaAs and GaN process technologies. TriQuint has also recently announced temperature-compensating ‘NoDrift’ and ‘LowDrift’ RF filters. The company’s filters are based on surface acoustic wave (SAW) and bulk acoustic wave (BAW) technologies. RFMD also sells switch-filter modules, but has not made any recent announcements in the sector.

The companies see Qorvo as benefiting from a 15% compound annual growth rate (CAGR) in the total available market for mobile RF devices, based on expanding 4G/LTE traffic.

Although producers of silicon products using advanced technologies such as silicon-on-insulator (SOI) have announced competing devices for the handset front-end radio section, the companies involved — Qualcomm and Peregrine Semiconductor — have yet to make announcements about take-up. Also, Peregrine in recent quarters has announced corporate restructuring designed to improve profitability — Murata’s wholly owned subsidiary Murata Electronics North America is due to buy all outstanding shares not already held by it for \$471m.

RFMD (Table 1) splits its revenues into Multi-market and Cellular product groups (CPG and MPG, respectively). MPG covers defense and aerospace, cable TV/broadband, non-cellular smart energy high-efficiency power conversion, Wi-Fi, and wireless infrastructure. The latest MPG-derived quarterly revenue was \$64m, up 16% on \$55m for the previous quarter and also for the corresponding quarter of a year ago. MPG contributes about 17.5% of total revenue. The high revenues are attributed to high-performance Wi-Fi, 4G wireless infrastructure, and gallium nitride (GaN)-related revenue.

The bulk of RFMD’s revenue (~82%) came from CPG. The latest CPG revenue figure was \$298m, up 14% on \$261m from the previous quarter. A year ago, CPG brought in \$255.4m. During the latest reported quarter, RFMD reports that the cellular product group started shipping envelope tracking (ET) power management integrated circuits (PMICs) to a leading smartphone maker in support of multiple basebands. ET is a method for tuning the power supply to RF power amplifier chips in handsets for greater efficiency.

New CPG customers have also taken up RFMD’s RF Fusion complete RF front-end solution for 4G world-phones and tablets. The 3G/4G market has grown to about 90% of CPG revenue (compared with 80% in the December 2013 quarter), compared with less than 10% for 2G.

Table 1. RFMD quarterly GAAP results.		
Fiscal quarter	Q2/2015 to 27-Sept 14	Q2/2014 to 28-Sept 13
Revenue	\$362.7m	\$310.7m
Gross margin	46.2%	33.7%
Operating income	\$75.3m	\$9.5m
Net income	\$63.3m	\$5.9m
Diluted EPS	\$0.21	\$0.02

The TriQuint (Table 2) component of the new company Qorvo reported the split of its end-markets in Q3/2014 at 68% mobile devices, 22% network infrastructure, and 10% defense & aerospace. These compare with the result for the previous quarter at 63% mobile devices, 26% network infrastructure, and 11% defense & aerospace. The subcontract assembly firm Foxconn Technology Group accounted for 30% of total revenue (up from 25% the previous quarter).

Networks infrastructure revenues benefited from 4G/LTE expansion across the world. This was reflected in products for the base-station market comprising 44% of the sector revenues — in money terms \$25.6m, up 53% on \$16.7m a year ago. The sector also includes automotive radar, automotive telematics, broadband wireless access, cable/fiber to the home, GPS, multi-market standard products, optical, point-to-point radio, very small aperture terminal, and WLAN/Bluetooth

Mobile devices revenue benefited from a large product ramp at a major customer. Also, the company saw strong demand in filters from more than 50 unique customers for discrete products. The 4G/LTE build up also benefited the mobile devices sector, with 71% of revenues coming from this market driver compared with 49% a year ago. Correspondingly, the legacy 3G/2G market fell from a 38% share last year to 20% in the latest quarter. The WLAN market share has also fallen, from 19% last year to 13%.

TriQuint has worked on transitioning its production away from low-margin and non-strategic foundry revenue and has grown demand for its higher-value products. In the next quarter (Q4/2014), the company expects 23% growth on the record results of the quarter just

Table 2. TriQuint quarterly GAAP results.		
Fiscal quarter	Q3/2014 to 27-Sept 14	Q3/2013 to 28-Sept 13
Revenue	\$272.1m	\$250.8m
Gross margin	45.5%	36.8%
Operating income	\$35.9m	\$18.8m
Net income	\$26.2m	\$13.6m
Diluted EPS	\$0.14	\$0.08

**Table 3. Skyworks quarterly GAAP results.**

<b>Fiscal quarter</b>	<b>Q4/2014 to 3-Oct 14</b>	<b>Q4/2013 to 27-Sept 13</b>
Revenue	\$718.2m	\$477m
Gross margin (non-GAAP)	45.9%	44.4%
Operating income	\$198.1m	\$105.5m
Net income	\$174.9m	\$84.2m
Diluted EPS	\$0.90	\$0.44

reported. Growth is predicted for defense & aerospace and mobile devices, with network coming in relatively flat. The basestation upgrade for 4G/LTE is predicted to maintain annual revenues for such devices at \$100m through to 2016.

Skyworks (Table 3) reported the split of its total revenue as 36% power amplifiers, 39% integrated mobile systems, and 25% broad markets. Compared with the previous quarter, there was a shift from power amplifiers (down from 1%) to integrated mobile systems (up from 33%). Broad markets showed a 1 percentage point fall from 26%.

Skyworks claims to "access all key process technologies: GaAs HBT, PHEMT, BiCMOS, SiGe, CMOS and RF CMOS, and silicon".

The integrated mobile systems sector includes the company's integrated systems portfolio as well as mobile analog products such as power management, Wi-Fi and GPS. Broad markets product lines — i.e. connected home, networking, media, automotive and medical markets — grew in revenues by more than 30% over the course of fiscal 2014, significantly outpacing the broader semiconductor industry, says the firm.

During fiscal Q4, Skyworks began volume production of custom 4G/LTE modules including proprietary temperature-compensated SAW filter technology. The company also supplied switching and connectivity modules for Xiaomi Mi3 smartphone; ramped analog control IC production for GoPro's action video camera; and supported Rockwell Collins with custom ASICs for GPS avionics applications.

Skyworks recently agreed to pay \$148.5m to acquire a 66% controlling stake in Panasonic's Filter division

**Table 4. Anadigics quarterly GAAP results.**

<b>Fiscal quarter</b>	<b>Q3/2014 to 27-Sept 14</b>	<b>Q3/2013 to 28-Sept 13</b>
Revenue	\$18.9m	\$37.0m
Gross margin	15.0%	11.1%
Operating loss	-\$6.7m	-\$11.2m
Net loss	-\$6.7m	-\$11.2m
Diluted loss per share	-\$0.08	-\$0.13

(with provisions to acquire the remaining 34% about 2 years from now). "This venture makes Skyworks the performance leader in TC SAW filters, with shipments approaching 100 million units per quarter, broadening our technology portfolio, enriching our systems capabilities and enhancing our financial returns," commented chief financial officer Donald W. Palette.

Anadigics (Table 4) has been working to improve from long-term losses, but has not yet achieved profitability. The company has 150mm GaAs manufacturing and a proprietary 'InGaP-Plus' process.

In June, the company announced restructuring plans that included expanding in the market for infrastructure products, while reducing fixed costs associated with legacy mobile business. In the latest announced quarter, sales of mobile products were 47% of total revenue, down from 56% in the previous quarter and from 69% a year ago. The move was due to expected declines in sales of legacy products and inventory reductions in the sales channel.

Anadigics' infrastructure RF and optical products are aimed at applications such as cable television, cellular wireless small-cell, Wi-Fi and machine-to-machine. Infrastructure product sales increased as a share of total revenues (53% in the latest quarter; 44% in the previous quarter) but fell 2% quarter-on-quarter in money terms. The reduced sales figure is attributed to inventory reductions in the distribution channel. The infrastructure sales did show an increase of 18% on the sales of a year ago.

The company has four greater-than-10% customers (Huawei, Samsung and distributors Arrow Richardson and Alltech) and four customers in the 5–10% range. "We are pleased with the broader list of key customers resulting from the better balance between Mobile and Infrastructure," comments VP & chief financial officer Terry Gallagher.

Among the users of the company's Wi-Fi connectivity front-end integrated circuits (FEICs) is LG's G3 Beat smart-phone. Anadigics also expanded its DOCSIS 3.1 cable TV infrastructure portfolio and launched gallium nitride (GaN)-based line amplifiers with what were claimed to be the industry's highest output power levels.

The company's restructuring plans also include more efficient manufacturing and 'monetizing' (selling?) excess equipment. Resizing of capacity and staffing (about 140 positions) are naturally also likely to be involved to achieve higher revenues and profits-per-wafer, along with possibly expanding the use of external foundry production. ■

*Author:*

*Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.*



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[www.thinfilmpducts.umicore.com](http://www.thinfilmpducts.umicore.com)

### United Mineral & Chemical Corp

1100 Valley Brook Avenue,  
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[www.umccorp.com](http://www.umccorp.com)

## 2 Bulk crystal growth equipment

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Fax: +1 505 899 8172

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## 3 Substrates

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Fax: +49 8728 911 156

[www.35reclaim.de](http://www.35reclaim.de)

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**Wafer World Inc**

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Fax: +1-561-842-2677

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

**4 Epiwafer foundry****Spire Semiconductor LLC**

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## Euro - TMCS I (Theory, Modelling and Computational Methods for Semiconductors, European Session)

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## SEMICON Korea 2015

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San Diego, CA, USA

**E-mail:** [m.figueroa@ieee.org](mailto:m.figueroa@ieee.org)**www.**[oi-ieee.org](http://www.oieee.org)**22–24 April 2015****SEMICON Southeast Asia 2015**

SPICE Arena, Penang, Malaysia

**E-mail:** [skoh@semi.org](mailto:skoh@semi.org)**www.**[semiconsea.org](http://www.semiconsea.org)**10–15 May 2015****Conference on Lasers and Electro-Optics (CLEO 2015)**

San Jose Convention Center, CA, USA

**E-mail:** [custserv@osa.org](mailto:custserv@osa.org)**www.**[cleoconference.org](http://www.cleoconference.org)**18 May 2015****2015 ROCS:****Reliability of Compound Semiconductors Workshop**

Hyatt Regency Scottsdale Resort, AZ, USA

Abstract deadline: 2 March 2015

**E-mail:** [Peter.Ersland@macomtech.com](mailto:Peter.Ersland@macomtech.com)**www.**[jedec.org/home/gaas](http://www.jedec.org/home/gaas)**18–21 May 2015****CS MANTECH 2015:****International Conference on Compound Semiconductor Manufacturing Technology**

Hyatt Regency Scottsdale Resort &amp; Spa at Gainey, Scottsdale, AZ, USA

**E-mail:** [conferencechairman@gaasmantech.org](mailto:conferencechairman@gaasmantech.org)**www.**[csmantech.org](http://www.csmantech.org)**7–10 June 2015****16th European Workshop on Metalorganic Vapour Phase Epitaxy (EW MOVPE 2015)**

Lund, Sweden

**E-mail:** [ewmovpe2015@ftf.lth.se](mailto:ewmovpe2015@ftf.lth.se)**www.**[nano.lth.se/ewmovpe2015](http://nano.lth.se/ewmovpe2015)**16–18 June 2015****SEMICON Russia 2015**

Moscow, Russia

**E-mail:** [eweller@semi.org](mailto:eweller@semi.org)**www.**[semiconrussia.org/en](http://www.semiconrussia.org/en)**8–10 July 2015****SEMICON West 2015**

Moscone Center, San Francisco, CA, USA

**E-mail:** [semiconwest@semi.org](mailto:semiconwest@semi.org)**www.**[semiconwest.org](http://www.semiconwest.org)**13–16 July 2015****Intersolar North America 2015**

Moscone Center West Hall and InterContinental Hotel San Francisco, CA, USA

**E-mail:** [brade@intersolar.us](mailto:brade@intersolar.us)**www.**[intersolar.us](http://www.intersolar.us)**9–13 August 2015****SPIE Optics + Photonics 2015**

San Diego Convention Center, CA, USA

**E-mail:** [customerservice@spie.org](mailto:customerservice@spie.org)**http://**[spie.org/optics-photonics1](http://spie.org/optics-photonics1)**2–4 September 2015****SEMICON Taiwan 2015**

Taipei World Trade Center (TWTC), Taipei, Taiwan

**E-mail:** [staiwan2@semi.org](mailto:staiwan2@semi.org)**www.**[semicontaiwan.org](http://www.semicontaiwan.org)**4–8 October 2015****28th IEEE Photonics Conference (IPC 2015)**

Reston, VA, USA

**E-mail:** [c.c.scott@ieee.org](mailto:c.c.scott@ieee.org)**www.**[ipc-ieee.org](http://www.ipc-ieee.org)**20–22 October 2015****SEMICON Europa 2015**

Messe Dresden, Germany

**E-mail:** [eweller@semi.org](mailto:eweller@semi.org)**www.**[semiconeuropa.org](http://www.semiconeuropa.org)**26–29 October 2015****48th International Symposium on Microelectronics (IMAPS 2015)**

Orlando, FL, USA

**E-mail:** [blamm@imaps.org](mailto:blamm@imaps.org)**www.**[imaps.org](http://www.imaps.org)**10–12 November 2015****12th Avionics Fiber-Optics & Photonics Conference (AVFOP)**

Santa Barbara, CA, USA

**E-mail:** [m.figueroa@ieee.org](mailto:m.figueroa@ieee.org)**www.**[avfop-ieee.org](http://www.avfop-ieee.org)

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