

# semiconductor **TODAY**

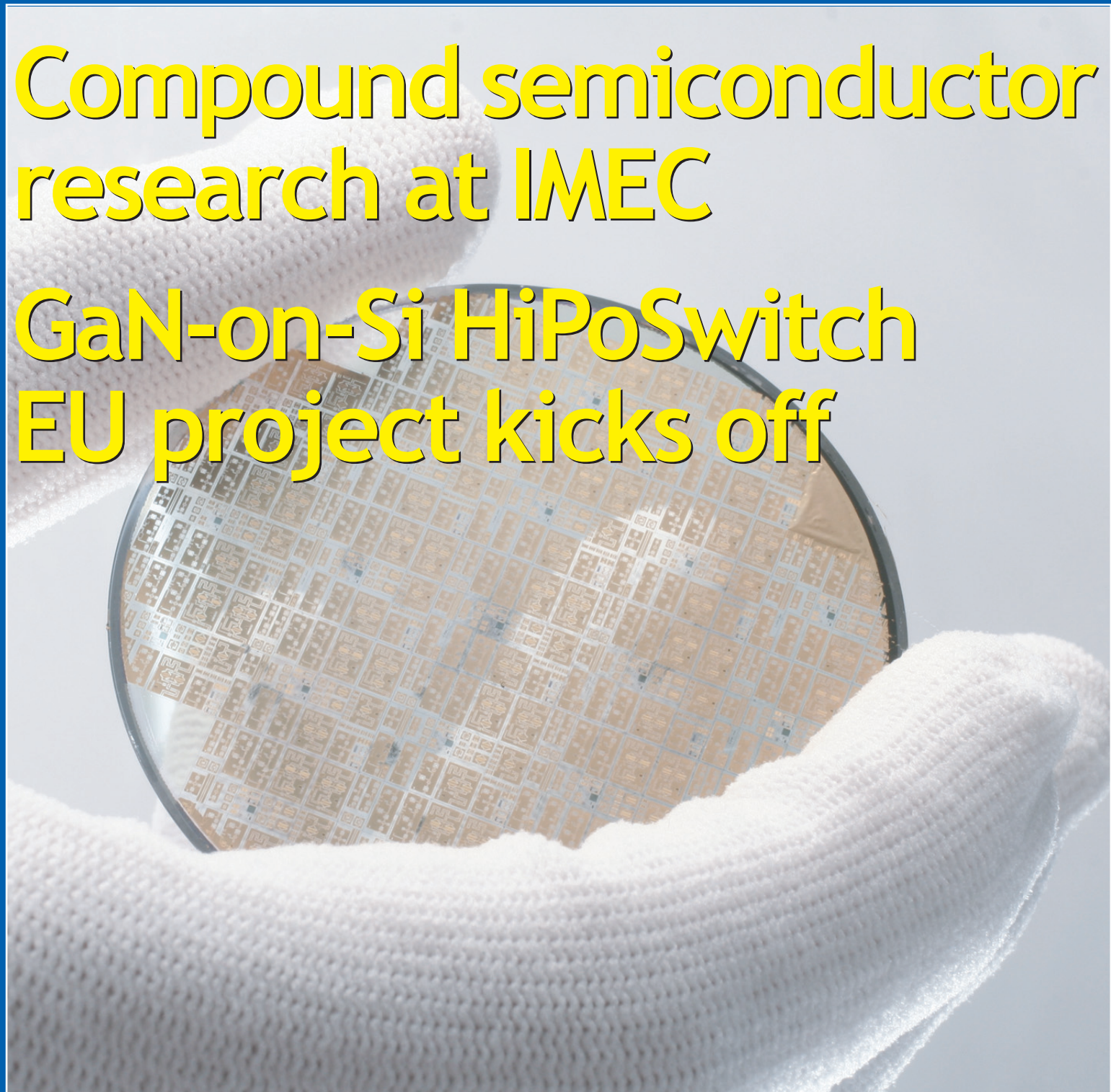
C O M P O U N D S & A D V A N C E D S I L I C O N

Vol. 6 • Issue 8 • October/November 2011

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## Compound semiconductor research at IMEC

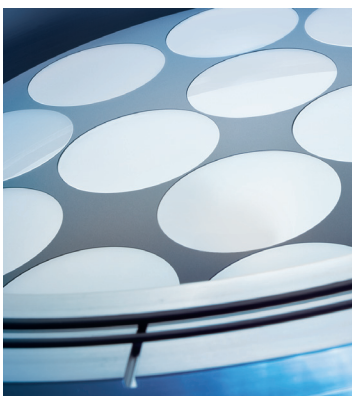
### GaN-on-Si HiPoSwitch EU project kicks off



GaN Systems raises funds • Aixtron launches 19x4" CRIUS II-XL  
Kyma launches AlN- & GaN-on-Si templates • 3S buys Manlight

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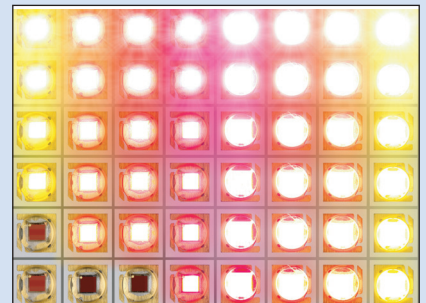
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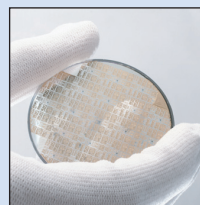
**p37** Aixtron's new 19x4"-wafer CRIUS II-XL MOCVD system, expanded from the 16x4" CRIUS II-L reactor.



**p60** Osram's latest InGaAlP chip technology boosts its Oslon SSL red, orange & yellow LED output by 10–20%.



**p89** First Solar's new factory in Frankfurt (Oder) — inaugurated after reaching full production in October, doubling production capacity in Germany to 250MW.



**Cover:** GaN HEMTs on 2" SiC substrates, processed at the Berlin-based Ferdinand-Braun-Institut. FBH is coordinating the new three-year EU-funded project

HiPoSwitch, which aims to develop more compact and powerful energy converters, for use in information and communication technology and solar inverters etc. **p26**

# Slowdown short term

Shortly after we finalized the last issue, firms started to report their financial results for third-quarter 2011, covered in detail in this issue. However, already last issue it was apparent that Q3 would be impacted by macroeconomic factors, as well as sector-specific factors such as the slowdown in LED manufacturing demand (mainly in China) and the effect of the flooding in Thailand on Fabrinet's contract assembly for optical communications component makers Oclaro, Opnext, JDSU, Infinera and Emcore.

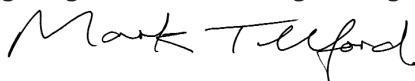
Flooding has disabled production at one of Fabrinet's two Thai sites until at least the end of 2011. Despite enacting contingency plans to shift production either to their own plants or other contract manufacturers, Opnext has warned of a significant impact on Q4/2011 (see page 75). JDSU's December-quarter revenue should be reduced by \$35–45m (to \$375–405m) due to the expected recovery of its Communications & Commercial Optical Products (CCOP) sector being delayed (see page 81). Oclaro expects its December-quarter revenue to be reduced by \$25–30m (to \$75–85m) and its March-quarter revenue to be reduced by \$10–20m. However, the June quarter should be "back to normal" (see pages 76–77). Emcore has still not reported its September-quarter results, but has said that it expects a significant impact on operations and its ability to meet demand for fiber-optic products in the December quarter (see page 83).

However, this flooding-related impact comes on top of an existing underlying slowdown in demand from Asia due to customer inventory corrections (as well as slower Asian deployment of 40G, says Oclaro, which expects softness in the December quarter from top-tier customers including China's Huawei). In an effort to reduce costs (and enhance its flexibility), Oclaro is in the process of divesting its final assembly & test operations in Shenzhen to a "major contract manufacturer".

In the LED sector, Q3 saw the first year-on-year fall in unit shipments of MOCVD systems in over two and a half years, according to IMS Research (see page 7). Consequently, Veeco reported MOCVD system orders down more than 50% on Q2/2011 (see page 34). This is attributed to "weak near-term LED industry demand [particularly from the TV sector], low MOCVD equipment utilization rates in Asia [50–70%], and decreased business activity in China [due to credit tightening and funding availability]. In addition, negative global macro-economic data points caused customers to slow or cut their capacity expansion plans." Similarly, Aixtron reported a 50% drop in revenue and 77% drop in orders in Q3 (see page 36). The previously high investment activities by Asian LED makers (driven by government funding) have become restrained by an unscheduled but significant slowdown in demand, explains the firm, due partly to insufficiently developed end-market demand but also partly to financing pressures on Asian LED makers (including increasing credit tightness). Correspondingly, IMS Research has cut its forecast for MOCVD system unit shipments in 2011 by 9%, from its most recent forecast of 833 (which had itself been reduced from the initial forecast of 1097) to less than 700. The forecast for 2012 has been cut from 583 to under 400 (down 43% on 2011). Nevertheless, both Aixtron and Veeco expect that, despite short-term market challenges, adoption of LED lighting will still drive long-term growth.

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

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

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- feature articles (technology, markets, regional profiles);
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# ALWAYS ONE STEP AHEAD



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## LED lighting 52% of commercial building market by 2021

### Commercial lighting to peak at \$54bn in 2012 then fall to \$30bn due to extended life of fluorescents and LEDs

Although quite low now, the market share of LED solid-state lighting (SSL) will reach 52% of commercial lighting by 2021, forecasts the report 'Energy Efficient Lighting for Commercial Markets' from Pike Research.

LEDs are gaining significant momentum as an alternative to incandescent and fluorescent lighting in commercial buildings, particularly as the cost of LED lighting technology continues its rapid decline, notes the market consulting firm, which expects that LED lighting costs for various SSL products will be reduced by 80–90% in many cases during the next decade.

"The production of white LEDs, which began in the late 1990s, is starting to transform the lighting industry, and the transition to this new technology is likely to occur very quickly," says research analyst Eric Bloom. "Rapidly evolving technologies, such as semiconductors and software, are finding their way into the lighting market, catapulting this traditional, historically slow-moving industry into a new era of high technology."

Incandescent and less efficient T12 and T8 fluorescent lamps will be almost completely eliminated over the next 10 years, adds Bloom.

To take more than 50% of the market, LEDs will take share from compact fluorescent lamps (CFLs), high-intensity discharge (HID) lighting, and general linear fluorescents.

Pike forecasts the global market for commercial lighting will reach \$42bn in 2011 and peak at nearly \$54bn in 2012 before gradually falling to about \$30bn by 2021. The decline will be due to the extended lamp life of both fluorescents and LEDs as they become the main lamp types, increasingly displacing demand for replacements for less efficient and shorter-life incandescent lamps.

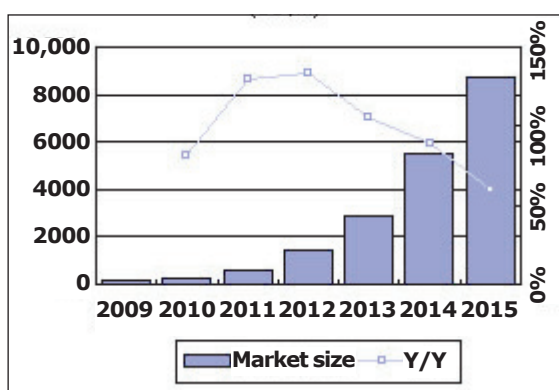
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## LEDs to hit 70% lighting market penetration in Japan

### China LED lighting market to grow 90% in 2014

Digitimes Research is projecting marked growth in LED markets across Asia over the next five years, according to its latest Special Report 'Standards and scale of Asia LED lighting markets'. In particular, Japan already had a higher LED light bulb usage rate than other countries, but the power shortages in the wake of the T\_hoku earthquake and tsunami in March have accelerated the pace of the country's switch to LED lighting, which is expected to achieve a penetration rate of 70% by 2015. Meanwhile, the South Korean government has launched the LED Lighting 15/30 Popularization Plan, which aims to make LEDs account for 30% of the country's overall lighting market by 2015. In addition, China has a potentially enormous LED lighting market, which is estimated to see growth of 90% in 2014 followed by 60% in 2015.

While China has a vast potential market, Taiwan has the world's second largest LED industry by value,



**China general LED lighting market, 2009–2015 (US\$).**

as well as a constantly advancing level of LED technology. Taiwan-based firms hence attach great importance to their presence in the China market, says Digitimes.

Also, in recent years, China and Taiwan have entered into discussions regarding the creation of joint standards for LED lighting. As manufacturers become increasingly concerned about their presence in the LED lighting market, LED standards are playing an ever more important

role, says Digitimes Research. LED lighting standards not only provide a model for manufacturers to follow when creating products, but also ensure consumers' peace of mind with regard to issues such as safety and performance.

LED standards in China and Taiwan already have a great deal of overlap, with LED lighting products used in major public construction projects exhibiting particularly strong similarities, says the market

research firm. Taiwan has made more rapid progress than China in terms of indoor LED lighting standards, and it is entirely possible that future standards for indoor LED lighting in China will adopt the specifications of the Taiwan standards, it adds. Such a move would be of great potential benefit for the establishment of shared standards for the two regions, reckons Digitimes Research.

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

## MOCVD tool shipments fall to 170 in Q3; 2011 forecast cut to 700 tools; 2012 GaN tool forecast cut to 400, down 43% on 2011

Unit shipments of metal-organic chemical vapor deposition systems for all applications fell both quarter-on-quarter and year-on-year to 170 in Q3/2011, according to the MOCVD chapters of the 'Quarterly GaN LED Supply/Demand Report', from IMS Research, which reveals significant changes in both MOCVD market share and outlook.

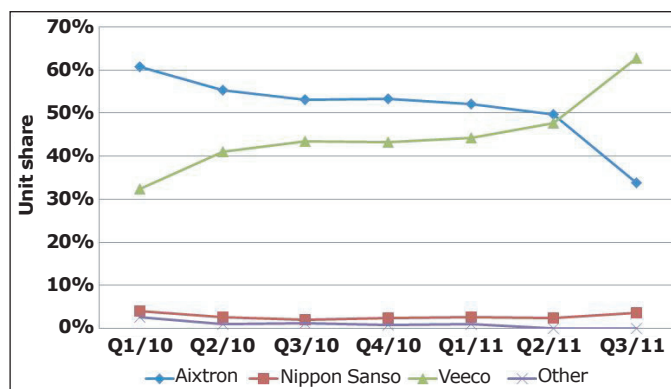
Q3 was the first year-on-year fall in shipments in at least 2.5 years. The drop is attributed to depressed utilization in the gallium nitride LED sector, along with growing oversupply in LEDs, tight credit, facility readiness and expiring subsidies in China. A bright spot was rising shipments of systems for GaN on silicon.

MOCVD system revenues were down sequentially for the third consecutive quarter and down year-on-year for the first quarter in at least 2 years, falling to \$340m.

Veeco Instruments Inc of Plainview, NY, USA led in both total MOCVD unit shipments and revenues for the first time, earning a 63% share of tools shipped and 65% share of revenues. The share of Germany's Aixtron AG fell from 50% to 34% in units and 52% to 32% of revenues. Veeco benefitted from the recognition of previously shipped MaxBright reactors to the GaN LED market. However, if those were excluded, Veeco would still have enjoyed a commanding 56%:40% unit share advantage, indicative of the acceptance of this new platform and Aixtron's customer delays.

### GaN MOCVD shipments

Since they are used to produce blue/green LEDs, GaN is the dominant application for MOCVD tools. In Q3/11, GaN MOCVD tools accounted for 90% of the total MOCVD market, with shipments of 152 units (down 18% quarter-on-quarter and 34% year-on-year), the lowest total since Q1/2010. If previously shipped but unrecognized reactors from Veeco had not been included, shipments would have been the lowest since Q4/2009.



Total MOCVD unit share per supplier.

GaN MOCVD system revenues were down sequentially for the third consecutive quarter, falling 21% quarter-on-quarter and 37% year-on-year to \$308m.

China took its highest share of unit shipments to date, at 82%. No other region had a double-digit share. India took its first MOCVD system for GaN in at least three years. Of the top 13 customers in Q3/2011, 11 of them installed tools in China. Elec-Tech was the top customer, then Epilight and Tongfang Opto.

Veeco's unit share of GaN MOCVD tools surged from 48% to 70%, while Aixtron's share fell from 49% to 26%. If previously shipped but unrecognized MaxBright reactors were excluded, Veeco would still have had a share of 63% versus 32% for Aixtron. Veeco's share was even larger on a revenue basis.

Veeco had the two best-selling models in Q3, with its MaxBright and K465i each enjoying over 30% share. They were followed by Aixtron's CRIUS I, CRIUS II and G4.

By region, Veeco led in China for the fourth consecutive quarter and also led in Taiwan for the first time. By wafer diameter, 2" systems once again dominated (due to China's dominance), with an 87% share of tools installed in Q3. Including all of its majority-owned subsidiaries in China, Taiwan's Epistar had the highest number of merchant MOCVD systems installed, followed by Korea's Samsung LED and China's San'an tied for second.

### Market outlook

As a result of Q3's weakness, reduced guidance from MOCVD manufacturers and discussions with LED makers, IMS has cut its forecast for system shipments in 2011 by 9%, from its most recent forecast of 833 (which had itself been reduced from the initial forecast of 1097) to less than 700.

This quarter, IMS has provided LED makers' optimistic, base and pessimistic forecasts for 2012 GaN MOCVD installations. The base forecast is now less than 400 tools (cut from the prior forecast of 583 tools), down 43% on 2011. However, the firm still sees 2012 as the third best year ever for GaN MOCVD installations due to additional players entering from China, the existence of multi-year MOCVD subsidy agreements between certain Chinese provinces and local MOCVD suppliers, and existing players buying new, more cost-effective tools with wider process windows to go after new markets. China is expected to account for a 71% share of the 2012 market, down from 77% in 2011. Taiwan's share is expected to rise from 12% to 13%, with Korea's rising from 6% to 8%.

IMS also expects to see 4"- and 6"-wafer installations surge as companies prepare for growth in lighting market demand.

"The remainder of the Q4/11 issue of our Quarterly GaN LED Supply/Demand Report will be distributed shortly and will include updated forecasts for lighting demand, given China's recent incandescent ban announcement and the latest backlighting results and forecasts factoring in new, low-cost direct LED backlights introduced into developing markets," says IMS Research senior VP Ross Young.

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

# GaAs epi substrate area to grow at a CAAGR of 6% over 2010–2015

## 6" to grow at 9% CAAGR to 80% of total GaAs epi demand

As mobile handsets and network infrastructure become more sophisticated, gallium arsenide device usage in these applications is increasing, driving growth in the consumption of GaAs epitaxial wafers. Commercial and military applications resulted in demand for semi-insulating (SI) GaAs epi substrates (merchant and captive) growing by more than 30% to slightly more than 29600 ksi (kilo square inches) in 2010, according to the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) Forecast and Outlook 'Markets for SI GaAs Epitaxial Substrates: 2010–2015'. Growth in GaAs devices

will lead to a compounded average annual growth rate (CAAGR) of 6% over 2010–2015 to more than 40,200 ksi. However, falling prices will limit the growth in total market value to a CAAGR of 1%, to revenue of \$543m in 2015.

The market research firm forecasts that 6-inch GaAs epi substrates will be the most prevalent, accounting for slightly more than 80% of total device demand over the forecast period. With cost-sensitive, high-volume markets dominating demand for GaAs devices, the report forecasts a CAAGR of 9% for 6-inch GaAs epi substrates.

"Strong growth in the overall GaAs device market in 2010 propelled

the GaAs epitaxial substrate market to solid gains," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. "The GaAs substrate market is tied closely to wireless communications and Strategy Analytics anticipates continued growth in these areas," he adds.

"We continue to see similar growth rates for MOCVD and MBE epitaxial substrate material, and the ability to supply both types of material is solidifying IQE's position as the largest supplier," notes Asif Anwar, director in the Strategy Analytics Strategic Technologies Practice.

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

# Next-gen power semiconductors to grow at CAGR of 72%

## SiC and GaN devices to reach \$500m in 2015

Traditional silicon-based power semiconductors are reaching their theoretical limitations but fortunately, because of their superior material properties, silicon carbide (SiC) and gallium nitride (GaN) wide-bandgap power semiconductor devices can offer orders-of-magnitude better performance, notes the report 'Next-Generation Power Semiconductors: Markets Materials, Technologies' by market research firm The Information Network.

"The commercial battle for next-generation power semiconductors is evolving. As a result, many semiconductor manufacturers are attempting to enter the market," says president Dr Robert Castellano. "Already it's a \$50m market, although small compared to the \$14bn silicon-based power semiconductor market," he adds.

Silicon-based insulated-gate bipolar transistors (IGBTs) and power metal-oxide-semiconductor field-effect transistors (MOSFETs)

are seen as the main growth drivers. "We project 3.7% average annual growth of the power semiconductor market over the next three years, from \$14.2bn in 2011 (+6% year-on-year) to \$16.7bn in 2013," Castellano says. "We look for strongest growth from IGBTs, although power MOSFETs had the largest market share in 2010 due to its fast switching speed, near-perfect gate impedance, excellent stability, and a relatively low on-state resistance," he adds.

But because of their attractive performance, wide-bandgap power semiconductor devices have been the subject of intense R&D. In development since the early 1990s, SiC material for power device applications has gone through the longest period and come furthest in terms of maturity and reliability. "We project the next-generation power semiconductor will exhibit a compound annual growth rate of 72% between 2010 and 2015,

reaching values of more than \$500m," says Castellano.

Benefiting from the growth of these wide-bandgap devices will be processing equipment. Significant improvements in the technique of growing GaN material on silicon substrates have enabled high-quality, crack-free GaN epi layers grown on Si, overcoming the 17% crystal mismatch between the two materials crystal faces. For GaN epitaxy on Si or SiC, deposition system suppliers Veeco and Aixtron will benefit and grow strongly, utilizing their expertise in LED epitaxy, reckons The Information Network.

Silicon MOSFETs use wirebonding and traditional SO or TO packages. GaN-on-Si can be bonded using flip chip. Companies that should benefit include equipment suppliers to the flip-chip industry, such as NeXX Systems, concludes the market research firm.

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



# Smartphone shipments up less-than-expected 42.6% in Q3

## Samsung leaps to number one, while HTC overtakes RIM

Despite a slowdown in key mature markets, smartphone shipments still grew 42.6% year-on-year from 82.8 million units a year ago to 118.1 million units in third-quarter 2011, according to the International Data Corporation's 'Worldwide Mobile Phone Tracker'. However, this growth was lower than IDC's forecast of 49.1% growth and lower than Q2/2011's 66.7%.

Smartphone growth was lower than expected due to the delayed launch of the updated Apple iPhone. In previous years, the introduction of a new iPhone resulted in a spike in shipment volumes in Q3. Western Europe and the USA (two key regions for the iPhone launch each year) still posted sizable year-on-year gains, but lower than expected. Nonetheless, the worldwide market grew by double digits, underscoring the growing popularity of smartphones, says IDC.

"Samsung's ascendancy to the leadership position is the direct result of its broad and deep product portfolio," comments Ramon Llamas, senior research analyst with IDC's Mobile Phone Technology and Trends team. "Ever since the first Galaxy device launched last year, the company has aggressively expanded and refreshed its selection to include the latest innovations and most popular features. At the same time, its line-up of bada-branded smartphones has earned a welcome reception within key markets," he adds.

"At the same time, Samsung's position will be a challenge to maintain, both in the fourth quarter and beyond," believes Llamas. "Apple's fourth-quarter launch of the iPhone 4S and lower pricing of older models will certainly boost volumes, and Nokia's recent launch of Windows Phone smartphones marks the beginning of a new era for the company. While these point to larger volumes in the quarters to come, they will also lead to increased competition," he adds.

"Vendors will struggle to maintain leadership of the global smartphone market this year, given its continued high growth, with opportunities for multiple companies to grow," says Kevin Restivo, senior research analyst with IDC's Worldwide Mobile Phone Tracker. "Competitors will release smartphones with components, such as 3D displays, dual-core processors, and enhanced audio capabilities, that will help them drive higher shipment volumes and potentially leapfrog competitors."

### Top five mobile phone vendors

● Samsung became the new leader in the smartphone market, with its total smartphone shipments exceeding 20 million units for the first time. As in previous quarters, its Android-powered smartphones drove volume growth, and joining the product mix was its refreshed Galaxy S II. In addition, its bada-powered smartphones continued to gain prominence in the market, and a new Windows Phone smartphone is expected to launch in Q4/2011.

● Apple, after taking the number-one spot last quarter from Nokia, slipped to number two worldwide. But, even after relying on the iPhone 4 for five quarters and the iPhone 3G S for nine quarters, demand for the iPhone remained strong enough for Apple to realize double-digit growth year-on-year. Now that Apple has launched its iPhone 4S and re-priced its older models in multiple countries, the firm is poised to challenge Samsung for the leadership position.

● Nokia maintained its third place position on the strength of its Symbian phones. Its most popular smartphones included older models, including the 5230, C5 and the C7. In addition, it launched four models based on its newly enhanced Symbian Belle OS, including the Nokia 600, 603, 700 and 701 as well as its first MeeGo-powered smartphone, the N9. While these new models kept Nokia's selection fresh, the N9 is expected to see limited availability and the Nokia 600 has been cancelled.

● HTC moved up one place and maintained its upward momentum during third-quarter 2011. HTC launched several devices for specific segments, including the multimedia-optimized Sensation, female-oriented Rhyme, and the entry-level Explorer. HTC expects to ship similar volumes in Q4/2011.

● BlackBerry maker Research In Motion (RIM) began shipping its new BB OS 7 smartphones to the market during Q3/2011, including updated versions of the BlackBerry Bold, the Curve and the Torch. However, as in previous quarters, the firm's volumes consisted primarily of older and less expensive models, leading to its first quarter of year-on-year decline and fifth place worldwide. This was still enough for RIM to maintain a presence among the top five vendors, with a sizable margin ahead of others.

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

### Shipments (millions) and market share (top five vendors).

| Vendor       | Q3/11 units  | Q3/11 share | Q3/10 units | Q3/10 share | Year-on-year change |
|--------------|--------------|-------------|-------------|-------------|---------------------|
| Samsung      | 23.6         | 20.0%       | 7.3         | 8.8%        | 223.3%              |
| Apple        | 17.1         | 14.5%       | 14.1        | 17.0%       | 21.3%               |
| Nokia        | 16.8         | 14.2%       | 26.5        | 32.0%       | -36.6%              |
| HTC          | 12.7         | 10.8%       | 5.9         | 7.1%        | 115.3%              |
| RIM          | 11.8         | 10.0%       | 12.4        | 15.0%       | -4.8%               |
| Others       | 36.1         | 30.6%       | 16.6        | 20.0%       | 117.5%              |
| <b>Total</b> | <b>118.1</b> | <b>100%</b> | <b>82.8</b> | <b>100%</b> | <b>42.6%</b>        |

# RFMD's quarterly revenue rises 14% to \$243.8m

## Sales of 3G/4G cellular products grow 50% sequentially

For its fiscal second-quarter 2012 (ended 1 October 2011), RF Micro Devices Inc of Greensboro, NC, USA has reported revenue of \$243.8m, down 14.7% on \$285.8m a year ago but up 13.8% on \$214.2m last quarter (well ahead of the growth rate of underlying markets). Nokia has "bottomed" at a little under 15% of revenue (down from about a third just two quarters ago, and about half at the beginning of fiscal 2011).

RFMD's Multi-Market Products Group (MPG) saw a double-digit decline in revenue caused by broad-based softness across its end markets. However, this was more than offset by sequential growth in the Cellular Products Group (CPG), which is attributed mainly to broad-based market share gains in 3G/4G cellular handsets and smartphones as well as other emerging market business rebounded sharply.

Sales of 3G/4G cellular products grew more than 50% sequentially to over 40% of cellular revenue, supporting aggressive new product ramps at Foxconn, HTC, Samsung, Huawei, ZTE, RIM, LG, Motorola and others.

During the quarter, RFMD continued to ramp its ultra-high-efficiency 3G/4G power amplifier (PA) in support of HTC, Research In Motion, Lenovo, and others. It also secured multiple PA design wins on a Qualcomm reference design for the 3G entry market. Shipments of PowerSmart products more than doubled sequentially and surpassed

\$25m, in support of Samsung, LG, and Research In Motion (exceeding already the annualized \$100m run rate targeted for the end of this fiscal year). RFMD also secured major design wins in smart energy/advanced metering infrastructure (AMI), point-to-point (P2P) radio for cellular backhaul, and gallium nitride (GaN)-based military radar products.

"We believe this is the beginning of a multi-year product and technology cycle, during which we will achieve consistent growth, diversification and market share gains," says president & CEO Bob Bruggeworth.

On a non-GAAP basis, gross margin was 39.1%, down from 39.8% a year ago but up from 38.5% last quarter. Net income was \$31.1m, down from \$52.3m a year ago but up from \$21.3m last quarter. Operating cash flow was \$38.4m (doubling from \$19.1m last quarter). After capital expenditure (CapEx) of \$7.8m (down from \$19.9m last quarter), free cash flow was hence \$30.6m. During the quarter, RFMD repurchased about 1.7 million shares of common stock at an average price of \$5.72. Overall, total cash, cash equivalents and short-term investments have hence risen from \$255.6m to \$276.6m.

RFMD believes that the demand environment in its end markets supports its expectation for December-quarter revenue to grow sequentially to about \$250m. MPG revenue is expected to decline further, by about 10%, but this should

again be more than offset by CPG revenue outpacing the cellular market, driven by further 3G/4G market share gains. Based on the projected revenue mix, RFMD expects gross margin to be roughly flat. Operating expenses should rise by about \$1m.

"Today's overlapping macro trends of mobility, broadband data and energy efficiency present the RF industry with a significant, long-term growth opportunity, while RFMD's industry-leading products and technologies position us to outpace our industry and deliver market share gains," says Bruggeworth.

"In the markets served by MPG, we continue to broaden our customer base and expand our product offerings. We are particularly enthusiastic about the increasing customer adoption of our industry-leading GaN technology in strategic market segments like military radar and CATV line amplifiers," he adds.

"In the cellular market, we are expanding our customer relationships and winning additional content at the world's leading smartphone manufacturers," Bruggeworth continues. "Our newest design wins set up continued dollar content expansion in both smartphones and 3G entry handsets, while leveraging our already significant exposure to the industry's leading baseband providers. Today these include Qualcomm, Intel, ST Ericsson, MediaTek, Spreadtrum, and others."

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

## RFMD honored with Huawei's Supplier of the Year award

At an awards ceremony in Shenzhen, RFMD's president & CEO Bob Bruggeworth accepted the 2011 'Best Supplier Award' from China's Huawei Technologies Co Ltd in recognition of "commitment to excellence in on-time product delivery, local customer support,

and product and technology leadership". RFMD support's Huawei for applications including cellular handsets, smartphones, wireless infrastructure, and point-to-point cellular backhaul.

"RFMD is a strategic partner to Huawei whose dedication to cus-

tom service and support contribute directly to our success, especially in the areas of technology development and performance, field applications support, and product delivery," said Anders Karlborg, VP of Huawei Supply Chain Management.

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

## Broadband portfolio expanded with differential amplifiers for CATV

At the SCTE Cable-Tec Expo 2011 in Atlanta, Georgia (15–17 November), RF Micro Devices Inc of Greensboro, NC, USA introduced a new product family of high-performance differential amplifiers for cable television (CATV) access networks worldwide.

RFMD's newest broadband CATV products (the RFCM2680, RFPP2870, RFAM2790, and RFCA8818) leverage the firm's combination of compound semiconductor technologies, high-volume module assembly, and manufacturing scale to enable what are claimed to be measurable improvements in efficiency, size, and performance. In particular, RFMD's gallium nitride technology delivers what are said to be unprecedented gains in performance and power efficiency, at a time when both are increasingly critical to CATV network deployment.

"To accommodate the explosive consumer demand for digital content, multi-system operators (MSOs) are seeking more bandwidth, higher output and lower distortion, while also requiring lower power consumption to reduce operating expenses and lower total system cost to mitigate the cost of capital-intensive network changes," says Alastair Upton, general manager of RFMD's Broadband Components business unit. "RFMD's broadband CATV products are designed to address these challenges and meet our customers' current and future needs for efficiency, size, and performance," he adds.

The new GaN-based broadband CATV products include the following:

- The RFCM2680 is claimed to be the world's first GaN-based surface mount power doubler. Capable of delivering +61dBmV output power, it consumes 20% less current for the same linearity performance, compared to GaAs technology. Also, the surface-mount package allows up to 50% savings in board area over industry-standard SOT115J packages.

- The RFPP2870 is a hybrid push-pull amplifier module employing GaN HEMT, GaAs MESFET and GaAs pHEMT die in an industry-standard SOT115J package. Operating from 40MHz to 1003MHz, it provides minimum gain of 28dB at 1003MHz and output power of +46dBmV. It also has what is claimed to be excellent linearity and superior return loss performance with extremely low distortion characteristics (–75dBc CSO and –68dBc CTB). The maximum current is 270mA at 24V<sub>DC</sub> and the noise figure is 4.5dB.

- The RFAM2790 functions as an Edge QAM amplifier or a push-pull amplifier module employing a GaAs pHEMT die, a GaAs MESFET die, a continuously adjustable inter-stage attenuator with 8–28dB gain at 45–1003MHz, and a power-enable feature in a 9-pin, small-outline (11mm x 11mm x 1.375mm) multi-chip module (MCM) surface-mount package. It provides high output power (+46dBmV) and features power-down functionality for power-save mode. The current is 410mA (typical) at 12V<sub>DC</sub>, and the noise figure is 4dB. The part meets DOCSIS 3.0 specifications with 7dB margin. Applications include CATV Edge QAM systems and line amplifiers, 45–1003MHz downstream Edge QAM RF modulators, and head-end equipment.

- The RFCA8818 is a high-linearity, low-noise (2dB), GaAs MESFET 75Ω push-pull broadband amplifier targeted at 40–1008MHz CATV MDU amplifier, drop amplifier, line amplifier, amplifier driver stage and FTTx/xPON/ONU driver amplifier applications. Operating from a single +5–8V power supply and containing internal input and output matching in a thermally enhanced SOIC-8 package, it provides 17dB of small-signal gain and features distortion of –72dBc CSO and –70dBc CTB at an output power of +34dBmV.

<http://expo.scte.org>

### IN BRIEF

#### RFMD creates VP business development

RFMD has appointed technology veteran Hans Schwarz to the newly created position of corporate VP, business development, based in its West Coast office in Silicon Valley. Reporting to president & CEO Bob Bruggeworth, he will have responsibility for corporate business development initiatives, including strategic planning, merger & acquisition (M&A) strategy and execution, and IP-based acquisition and licensing.

Schwarz has over 30 years of technology industry expertise as well as involvement in business development and M&A activity.

Before RFMD, Schwarz was managing director for a \$300m late-stage venture capital fund, responsible for searching for and investing in innovative companies in semiconductors, storage, networking and telecom, cleantech and other industries.

Prior to that, Schwarz spent 15 years at programmable logic firm Xilinx Inc (most recently as VP of business & strategy development), where responsibilities included global strategy development, managing a \$300m strategic investment fund, corporate partnerships, and developing and implementing an M&A process. Previously, he held management, marketing and engineering positions at Chips and Technologies Inc, LSI Logic and Fairchild.

"I am pleased with the successes our corporate development team achieved in the past through several strategic business and manufacturing asset acquisitions," says Jerry Neal, co-founder & executive VP of corporate marketing. The organizational changes will allow Neal to continue to focus on RFMD's branding, strategic marketing and other corporate marketing initiatives.

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

# TriQuint's revenue falls 6% in Q3

## Year-to-date growth of 30% for 3G/4G offsets 58% drop for 2G

For third-quarter 2011, RF front-end product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported revenue of \$216m (down 6% on \$228.8m last quarter and 9% on \$237m a year ago). This is below the original guidance of \$225–235m but higher than the revised guidance (issued on 22 September) of \$210–215m.

Of total revenue by end market, Mobile Devices comprised 70%, Networks 20%, and Defense & Aerospace 10%. Foxconn Technology Group accounted for 35% of revenue (the only customer exceeding 10%).

The overall decline was due to reduced Connectivity revenues in Mobile Devices (particularly from Foxconn), weakness in the communications infrastructure market, and softening demand in China.

Mobile Devices revenue was \$152m, down 5% on \$159.9m last quarter (due mainly to the reduced demand from Foxconn and weakness from China-based customers including distribution partner Avnet Asia). Connectivity revenue is down as TriQuint transitions from commercial foundry to standard products in support of a wireless LAN reference design partner.

Networks revenue was \$44m, down 5% on \$45.8m last quarter. Radio Access revenue (dominated by base-stations) grew 10% sequentially (due to increased end-of-life shipments to TriQuint's foundry customer), partially offsetting a 15% decline in Transport.

Defense & Aerospace revenue was about \$21m, down 10% on \$23m last quarter.

Year-on-year for Q3, both Mobile Devices and Networks revenue fell 9%, and Defense & Aerospace fell 7%. However, total year-to-date revenue (for Q1–Q3) rose 7% from \$625.3m to \$669.1m, including growth of 14% in Mobile Devices

offsetting drops of 3% and 14%, respectively, in Networks and Defense & Aerospace. In Mobile Devices, year-to-date revenue from 3G/4G applications was up nearly 30% on 2010, offset by a 58% drop from 2G products due mainly to declines in legacy CDMA and GSM revenue streams (driven by decisions in 2010 to shift capacity and focus from 2G products to 3G, due to supply constraints at that time).

On a non-GAAP basis, gross margin has fallen from 41.4% last quarter to 36.3% (well below original guidance of 40–42%). This is due largely to a shift in product mix to lower-margin products, increased costs associated with new product ramps, and lower factory utilization.

However, despite \$4.1m of legal expenses related to anti-trust and IP claims against Avago, operating expenses have been cut from \$65.6m (28.7% of revenue) last quarter to \$58.7m (27% of revenue), comprising operational spending down by \$3.4m and litigation expenses down by \$3.5m. This is well below the original guidance of \$64–65m and below even the revised guidance of \$60m.

Net income has fallen from \$44.2m a year ago and \$28.9m last quarter to \$19m. Although capital expenditure has reduced from \$60.7m last quarter to

\$47.3m, this was only partially offset by operating cash flow of \$12.4m (down on \$31.6m last quarter). During the quarter, total cash and investments hence fell by about \$33.6m, from \$180.9m to \$147.2m.

For fourth-quarter 2011, TriQuint expects revenue of \$215–225m (flat to up slightly on Q3). Weak product mix and lower factory utilization (as TriQuint burns through excess inventory, particularly in optical communications) will reduce gross margin to 32–34%. Operating expenses should be cut further to \$59–60m (despite about \$3.5m of litigation expense).

Capital expenditure should be cut further, to just \$35m (for completion of previously committed capacity expansions), adding to year-to-date capital expenditures of \$159.9m. During 2011, TriQuint has expanded total capacity by about 40% across its gallium arsenide (GaAs), surface acoustic wave (SAW) and bulk acoustic wave (BAW) lines. It also plans to be internally second sourced via its Texas 6-inch GaAs line (a copy-exact line replicating the Oregon 6-inch GaAs capabilities, but on a smaller scale).

However, beginning in Q1/2012, this will add about \$5m in quarterly cost to manufacturing operations (including about \$3m in depreciation expense) and will impact margins until it ramps to sufficient volume.

"The investments we're making in increased capacity will allow us to participate in the strong market growth we anticipate over the next several years," says chief financial officer Steven J. Buhaly. "We expect to reduce our capital expenditures in 2012, and our spending will be largely focused on capital for new capabilities versus capacity expansion."

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

## ZTE's Blade and new Skate smartphones supported by TriQuint

TriQuint Semiconductor says that its power amplifier modules are incorporated into the ZTE Blade and the new ZTE Skate, two models in the global line of smartphones made by wireless communication equipment maker ZTE Corp of Shenzhen, China. In March ZTE named TriQuint its 'Best Global Partner' for the fourth consecutive year.

The Blade and Skate feature the TQM7M5012H and TQM7M5022 modules, respectively. Both products are part of TriQuint's RF front-end line of discrete power amplifier modules. TriQuint claims that its success is due in large part to its CuFlip technology, a strategic differentiator enabling superior RF performance, design flexibility, faster manufacturing and lower costs.

The Skate is expected to build on the success of the Blade smartphone, which has been ZTE's flagship product. The Blade was one of the first smartphones priced below €100 when it launched in the European market in fourth-quarter 2010. After launching in China this April, Blade won awards for best market performance and best



Chinese-made 3G phone. As a key step in ZTE's entry into the middle-to-high end smartphone market, ZTE announced the new Skate with Android 2.3. After September launches in Brazil, Spain and Hong Kong, Skate's global rollout will continue this year in European countries including the UK and France, in Asian countries including Malaysia, Indonesia and China, and in the USA.

"We congratulate ZTE on becoming one of the world's top five international mobile manufacturers, and we are pleased to support its broad portfolio of smartphones," says TriQuint's president & CEO Ralph Quinsey. "More consumers are choosing smartphones. TriQuint's RF technology allows phone vendors to meet attractive cost points while still delivering a feature-rich smartphone," he adds.

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

## Global Supplier Award from Sony Ericsson

RF front-end product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has received the Special Recognition Supplier Award in the field of electronics from mobile communications product maker Sony Ericsson at its 10th Annual Global Supplier Conference in Malmo, Sweden. TriQuint was one of 11 award recipients from the 300 suppliers invited to attend.

"TriQuint has demonstrated a strong management commitment and flexible support in securing supply for Sony Ericsson's portfolio," says Peter Carlsson,

Sony Ericsson's VP, head of Sourcing and Partner Management. "We consider TriQuint and its innovative RF technology solutions an important partner for delivering our mobile communications products," he adds.

"We will continue to deliver next-generation RF solutions and outstanding support, to enable Sony Ericsson's high-performance communications and entertainment devices for the global market," comments TriQuint Semiconductor's president & CEO Ralph Quinsey.

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

## IN BRIEF

### TriQuint awarded Huawei Green Partner certification

RF front-end product and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has received the 'Huawei Green Partner' award for the first time in recognition of its ability to provide an environmental management system that ensures product content and manufacturing processes meet or exceed the stringent green requirements of Huawei Technologies Co Ltd of Shenzhen, China, one of the world's largest manufacturers of optical networking equipment for the telecoms industry.

Huawei aims to provide customized telecom products, services and solutions, and has always embraced environmental protection as a key part of its sustainable development; the Huawei Green Partner program was established to encourage suppliers to produce components with minimal environmental impact. The Green Partner certification demands the elimination of banned or controlled hazardous materials, the use of environmentally friendly materials, and the development of environmental audits and action plans. Suppliers can achieve Huawei Green Partner status by meeting these requirements and by demonstrating compliance via an on-site audit.

"Huawei's Green Partner program is among the most highly regarded of such programs," says Steven R. Grant, TriQuint's VP worldwide operations. "Certification as a Huawei Green Partner highlights TriQuint's strong commitment to quality products and environmental responsibility," he adds.

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

## IN BRIEF

## CFO/COO resigns; VP, finance & controller promoted

Thomas Shields has resigned from the positions of chief operating officer, executive vice president, chief financial officer and secretary to pursue career opportunities outside Anadigics. He has agreed to provide consulting services to the firm for a period of time to ensure an orderly transition of all of his current responsibilities.

"He has been instrumental in helping me transition from my previous role to my current chief executive officer role," says CEO Ron Michels. "I would like to thank him for his assistance in that regard as well as for his many years of service and contributions to Anadigics," he adds. Shields has been CFO since 1999.

"Ron and the Anadigics team have accomplished a great deal in a short period of time," comments Shields, who expresses confidence in the future of Anadigics.

Terrence Gallagher, who was VP, finance & controller, has been promoted to the positions of VP & chief financial officer.

"I have worked with Terry for many years. He is a seasoned semiconductor industry veteran with an outstanding knowledge of both finance and the Anadigics business," notes Michels.

"The breadth and depth of Terry's financial experience will enable him to make very meaningful contributions as we maintain our focus on a product leadership strategy that delivers improved financial performance as quickly as possible," he adds. "I am committed to working closely with the entire Anadigics management team to return our business to profitability," Gallagher comments.

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

## Anadigics grows 4.7% in Q3 to \$37.3m WCDMA and LTE offset drop in WiMAX

For third-quarter 2011, GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported net sales of \$37.3m, down 39.2% on \$61.3m a year ago but up 4.7% on \$35.6m last quarter, driven by increased sales at key wireless OEMs. The top customers were Samsung, ZTE, RIM, Cisco, Huawei, LG, World Peace Group, and Richardson Electronics.

After falling 29% in Q2 to \$25.7m (mostly due to falling revenue with RIM), Wireless revenue rebounded by 9.1% to \$28m in Q3 (rising from 72% of total revenue to 75%). This is attributed to increases in market share with a number of key wireless customers, offsetting the further decline with RIM.

Specifically, market share with top customer Samsung has doubled year-on-year (via Anadigics being in new smartphones such as the Galaxy S2, WAVE 3, Galaxy Tab 4G, and Galaxy Note). Overall, its CDMA market share was just a couple of percent a year ago and is now 16%, while WCDMA has gone from 3% to 15% in the last four quarters. Anadigics has seen most traction lately with WCDMA and LTE design wins, rather than CDMA. "It's where our strength is and it's where things are heading down the road, with all of our multi-band parts that we're developing," says president &

CEO Ron Michels.

However, after rising by 36% in Q2 to \$9.9m, Broadband revenue fell back by 6.1% to \$9.3m in Q3 (dropping from 28% of total revenue to 25%). This was due mainly to WiMAX falling from \$1.5m to \$1m, while all other product lines were flat (\$2.3m for set-top boxes, \$1.3m for WiFi, \$4.7m for cable infrastructure).

Gross margin was 20% (level with last quarter), with fab utilization remaining in the low 50s. On a non-GAAP basis, net loss has been cut from \$9.4m last quarter to \$7.8m, due mainly to operating expenses dropping by \$1.1m to \$15.5m. However, this compares with a profit of \$4.4m a year ago.

Cash used in operating activities was \$800,000 and capital expenditure was \$1.5m. During the quarter, cash, cash equivalents and short- and long-term marketable securities fell from \$103.4m to \$100.6m.

"We continued to make notable progress with the largest reference design partner [Qualcomm] on next-generation product development," says Michels. "Additionally, we are expanding our served available market with new product introductions, including PADs [power amplifier and duplexers], MMPAs [multi-mode power amplifiers] and dual-band PAs, which will be the driving force behind our future growth," he adds.

## HELP4 PAs enable S 4G and SII X additions to Samsung's Galaxy smartphone family

Anadigics is shipping production volumes of AWT6622 and AWT6624 fourth-generation High-Efficiency-at-Low-Power (HELP4) power amplifiers (PAs) to Samsung Electronics for its new Galaxy S 4G and Galaxy SII X smartphones.

The PAs deliver high HSPA+ efficiency to extend battery life in 4G handsets, smartphones, tablets, netbooks, and notebooks.

Operating at 1850–1910MHz (band 2), the AWT6622 has efficiency of 40% at +28.6dBm, 34% at +17dBm and 24% at +8dBm. Operating at 1710–1785MHz (bands 3, 4, 9, & 10), the AWT6624 has efficiency of 39% at +28.3dBm, 36% at +17dBm and 26% at +8dBm. Average current consumption reduction is 30% over previous-generation PAs.

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# Skyworks grows quarterly revenue more-than-expected 13% to \$402.3m

## Analog acquisitions and market share gains driving growth

For its fiscal 2011 (to end September), Skyworks Solutions Inc of Woburn, MA, USA (which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment), has reported revenue of \$1.419bn, up 32% on fiscal 2010's \$1.072bn.

"We expanded our market share, and we are now the clearly established leader in mobile connectivity," claims president & CEO David J. Aldrich. "We grew our 3G front-end module shipments by more than 150% over the year," he adds.

For the fiscal fourth-quarter, revenue was a record \$402.3m, with 70% coming from handsets and 30% from linear high-performance analog (HPA) products (compared with 75% and 25% last quarter, and 80% and 20% a year ago). Revenue was up 13% on \$356.1m last quarter and up 28.4% on \$313.3m a year ago (and exceeding guidance of \$400m). However, excluding revenue from the acquisition of fabless RF front-end IC supplier SiGe Semiconductor (on 10 June), Skyworks grew organically by 6% sequentially and 18% year-on-year.

"Skyworks' solid performance demonstrates the strength of our diversified business model, continued share gains and operational leverage," says president & CEO David J. Aldrich.

On a non-GAAP basis, gross margin is up from 43.8% a year ago to 44.7%, though down slightly from 44.9% last quarter. Nevertheless, full-year gross margin has risen from fiscal 2010's 43% to 44.6%.

Operating expenses have risen from \$62.5m last quarter to \$70.3m. Despite this, operating income for Q4 was \$109.4m, up from \$97.6m last quarter and \$81.8m a year ago. Full-year

operating income has risen from fiscal 2010's \$246.3m to \$384.7m. Net income has risen from \$78.8m a year ago and \$93m last quarter to \$103.8m, boosting full-year net income from fiscal 2010's \$229.5m to \$360.3m.

During the quarter, Skyworks generated a record \$122.8m in cash flow from operations (boosting the full year to \$366m). Capital expenditure was reduced again (from \$20m last quarter to \$15.3m, returning to steady-state levels after capacity investments in the firm's facilities in Mexicali and Newbury Park).

Free cash flow was hence \$108m. However, after repurchasing 500,000 shares, cash and cash equivalents fell from \$459m to \$410.8m.

During the quarter, Skyworks ramped 3G/LTE multimode, multiband solutions for Samsung's next-generation Galaxy S II smartphone platforms; supported ZTE's launch of tablets and notebooks with

**Guidance reflects near-term market weakness, largely offset by new program ramps. Despite the current economic environment, we believe that long-term industry fundamentals remain strong as analog content and complexity continue to increase... Skyworks is strategically well positioned to capitalize on the growing number of platforms that are becoming wirelessly enabled and, in turn, to outperform our addressed markets**

EDGE and WCDMA/LTE front-end solutions; introduced a family of low-noise amplifiers for wireless infrastructure and networking applications; shipped switch matrix solutions to Siemens Healthcare for deployment in their magnetic resonance imaging (MRI) scanners; was designed into a leading manufacturer's platform for hearing aids using ultra-low-power amplifiers; and started volume shipments of ZigBee-enabled solutions to multiple ODMs in support of home security applications

For fiscal first-quarter 2012, Skyworks expects revenue of \$390m, down 3% sequentially but up 16% year-on-year. Gross margin outlook should fall slightly to 44–44.5%.

"Our guidance reflects near-term market weakness, largely offset by new program ramps," says VP & chief financial officer Donald W. Palette. The guidance excludes any contribution from the acquisition of Advanced Analogic Technologies Inc of Santa Clara, CA, USA (a semiconductor firm focused on enabling energy-efficient devices for application-specific power management in feature-rich consumer electronic devices as well as devices in computing, industrial, medical and communications applications).

"Despite the current economic environment, we believe that long-term industry fundamentals remain strong as analog content and complexity continue to increase," says Aldrich. "Given our differentiated product portfolio, technology leadership, broad customer engagements and scale, Skyworks is strategically well positioned to capitalize on the growing number of platforms that are becoming wirelessly enabled and, in turn, to outperform our addressed markets," he reckons.

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



## Kopin's III-Vs revenue falls 3% in Q3 ...but Q4 and full-year 2011 growth to be driven by BiHEMT demand up 6x on 2010

For third-quarter 2011, Kopin Corp of Taunton, MA, USA has reported revenue of \$29.6m, down 6% on \$31.4m last quarter and \$31.6m a year ago.

Revenue from Displays (used in mobile applications including smartphones and tablet PCs, military thermal weapons sights and wearable computers) was \$14.1m, down 8% on \$15.4m last quarter and 6% on \$15m a year ago. Revenue from III-V heterojunction bipolar transistor (HBT) epiwafers was \$15.5m, down 3% on \$16m last quarter and 6.6% on \$16.6m a year ago.

"Our III-V revenues were affected by a shift in wireless handset sales as various OEMs are adjusting their product offering dates from a pattern which focused on the US holiday season to more year-round introductions of handsets and tablets," notes president & CEO Dr John C.C. Fan.

"Despite the uncertain economic environment, our performance through the first nine months of 2011 has been quite strong," says Fan. Nine-month revenue was \$95.9m (up 10% year-on-year from \$87.2m), comprising Display revenue of \$46.8m (up 17% from \$40.1m) and III-V revenue of \$49.1m (up 4% from \$47.1m).

Gross margin for Q3/2011 (as a proportion of product revenue) was 33.2%, up from 32.3% a year ago but down from 35% last quarter. However, for the first nine months of 2011, gross margin was 34.0%, up year-on-year from 28.1%.

R&D expenses were \$6.4m (22% of revenue), down from \$7.1m (23% of revenue) last quarter but up from \$4.8m (15% of revenue) a year ago, reflecting Kopin's investments in its Golden-i technology, III-V smartphone products and capacity expansion, military display products, and the addition of Forth Dimension Displays (FDD, acquired in January). For the first nine

months of 2011, R&D expenses totaled \$19.9m, up year-on-year from \$13.9m. "Income from operations has more than doubled to \$2.4m for the first nine months of 2011 [despite a \$212,000 loss in Q3], even as we have invested \$6m more in R&D this year over last year," Fan says.

Net income in Q3/2011 was \$0.8m, level with last quarter but down from \$1.4m a year ago. Nevertheless, during the first nine months of 2011, Kopin generated \$10.6m in cash from operating activities. "This has enabled us to maintain a strong balance sheet — \$103m in cash and marketable securities [up from \$99.3m at the end of Q2] and no debt — while at the same time aggressively investing to grow our business organically and through acquisitions," says Fan.

Based on current business trends, Kopin expects fourth-quarter revenue to be up on Q3 due to increased demand for its III-V BiHEMT products plus display sales driven by new design wins for digital still cameras and increased military product shipments. Full-year 2011 revenue should be \$128–132m (up 8% on 2010's \$120.4m).

"During periods of economic volatility as we are experiencing, we understand that there is one school of thought to scale back on investment and R&D and wait for the market to bounce back," says Fan. "Our philosophy is to use opportunities like this to invest in our business — including BiHEMT structures, the TWS program, night vision technology and Golden-i — to extend our leadership position while still maintaining our financial strength," he adds. "Our BiHEMT activities are having the most immediate impact, as demand for this product is up six-fold from 2010 and we expect it to continue to ramp through 2012."

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

### IN BRIEF

## Skyworks' MMMB PA modules power Samsung's next-gen Galaxy smartphones

Skyworks is supplying Samsung's Galaxy S II LTE and Galaxy Note smartphones with fully integrated multimode, multiband power amplifier modules — the first solutions supporting all leading baseband architectures.

According to the September Equity Research Industry Update report of investor research firm Oppenheimer, the proliferation of 3G bands and complexity, coupled with the start of 4G LTE ramps, is playing a key role in handset makers and smartphone providers migrating towards smaller, less power hungry and more cost-effective multimode, multiband (MMMB) architectures.

"Size and performance are the leading drivers for today's smartphone platforms," says Gregory L. Waters, Skyworks' executive VP & general manager of front-end solutions. "Skyworks has the ability to offer customers design flexibility and customization, regardless of integration specifications."

The SKY77606 MMB module supports quad-band GSM/EDGE and bands I, V and VIII for WCDMA/HSDPA/HSUPA and HSPA+ handsets. It is fully controllable via three line logic and band-enabled interfaces. A compact, low-profile, surface-mount technology package allows a highly manufacturable solution.

The SKY77604 MMB module supports quad-band GSM/EDGE and bands I, II, IV/X, V and VIII for WCDMA/HSDPA/HSUPA and HSPA+ handsets. It delivers a claimed best-in-class DG09 current consumption and is fully controllable through a Serial Peripheral Interface (SPI).

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

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

## M/A-COM Tech showcases new products at MILCOM

At the MILCOM 2011 tradeshow in Baltimore (7–10 November), M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) showcased its portfolio of new products suitable for military communications.

Product solutions on display included:

- gallium nitride on silicon carbide (GaN-on-SiC) transistors and higher-level pallet amplifiers (powered by a proprietary 0.5µm HEMT design).
- a family of surface-mount voltage-controlled oscillators (VCOs) supporting applications from 45MHz to 4GHz (joining its range of diodes, transistors, MMICs, and passive products), providing a comprehensive solution set for military radio communications.
- modules with a small, compact footprint, up to 25dB gain, and 50Ω input/output, as well as pallets designed for CW or pulsed applications (allowing gate biasing and sequencing for GaN on SiC designs).
- the HMIC high-power SPDT switch family, including the new 80-Watt MASW-000932 in a surface-mount 4mm PQFN package, offering wide-band performance from 1MHz to 4000MHz with high isolation-to-loss ratio for both TX and RX states (suited for high-power military radio as well as LTE, TD-SCDMA and WiMAX applications).
- the MADR-010574, a 250V PIN diode driver that features CMOS ASIC technology in a small 7mm PQFN plastic package (with bias current up to 170mA, it biases four diodes simultaneously, and supports series-shunt architectures, offering high power-handling capability for military communication and public safety radios).

[www.milcom.org](http://www.milcom.org)

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

## M/A-COM Tech showcases new products for networks, aerospace & defense and multi-market applications

At the European Microwave Week (EuroMW2011) in Manchester, UK (11–13 October), M/A-COM Technology Solutions showcased a broad portfolio of new products for networks, aerospace & defense, and multi-market applications.

These include:

- a complete chipset solution for 42GHz point-to-point radio applications (a systems-driven approach to integrating innovative IC and package design capabilities, resulting in faster time to market with optimal performance);
- best-in-class optical modulator drivers and TIAs for 40/100G fiber networks;
- RF amplifiers for node, fiber-to-the-home (FTTH) and RF-over-glass infrastructure applications;
- new phase shifter family with integrated CMOS driver (featuring low DC power consumption, minimal attenuation variation over

phase-shift usage, 30Ω impedance, in a 4mm PQFN package);

- GaN on silicon carbide transistors and highly integrated pallet amplifiers (powered by a proprietary 0.5µm HEMT design);
- the next-generation multi-function phased array radar (MPAR) for the Federal Aviation Administration's air-traffic and weather surveillance systems (recently named as one of R&D Magazines' 2011 R&D 100 Winners);
- a new family of power detectors that are low cost, yet provide accurate directive power and include full temperature compensation; and
- the firm's newest line of 1–18GHz low-noise amplifiers (LNAs), which are 66% smaller than traditional LNAs, and feature better noise figure (NF) and bandwidth, it is claimed, suiting meter readers or medical transponders.

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

## CATV/broadband transformer designers' kit

M/A-COM Tech has launched a new 75Ω transformer designers' kit for CATV/broadband applications. The kit features 12 transformer models covering multiple impedance ratios and wind schematics.

The MABA-000001-75KIT1 transformer designers' kit contains full RoHS-compliant components. Transformer configurations include flux-coupled, transmission line, and auto transformer. All parts in the kit are surface-mount devices featuring ceramic, plastic or FR4 substrates. In addition, baluns meeting MoCA and DOCSIS requirements are also included. The kit comes with a CD-ROM containing datasheets, S-parameters and application notes.

"M/A-COM Tech offers a broad portfolio of RF baluns and transformers," says product manager

Graham Board. "This designers' kit is a representative sampling of that portfolio." It covers multiple impedance ratios, schematic configurations and footprints, he adds.

At the SCTE Cable-Tec Expo 2011 in Atlanta (15–17 November), M/A-COM Tech showcased a broad portfolio of new products for cable TV and broadband applications. These include:

- FTTx and optical node variable-gain amplifiers;
- EdgeQAM head-end integrated solutions;
- DPON and EQAM voltage-controlled oscillators (VCOs), amplifiers, baluns, and step attenuators; and
- MoCA front-end ICs, filters, active splitters, and passive devices.

<http://expo.scte.org>

<http://macomtech.com/>

## Agilent's latest RF design and 3D EM simulation platforms enhance multi-technology design & speed simulation

Agilent Technologies of Santa Clara, CA, USA has announced new versions of its Advanced Design System and Electromagnetic Professional software.

ADS 2011.10, the latest release of Agilent's flagship RF design software, and EMPro 2011.11, the firm's updated 3D modeling and simulation platform, both feature enhancements to further speed and improve RF design and verification.

Agilent demonstrated ADS 2011.10 and EMPro 2011.11, along with other products and services for wireless communication, at the European Microwave Week (EuMW2011) in Manchester, UK (11–13 October) and the IEEE Compound Semiconductor IC Symposium (CSICS 2011) in Waikoloa, Hawaii, USA (16–19 October).

ADS is electronic design automation (EDA) software for RF, microwave and signal-integrity applications. ADS 2011.10 provides users with continued enhancements for RF printed circuit board (PCB), MMIC and multi-technology design, including:

- A design documentation notebook that makes it easy to create and share all or selected views of schematics, layout & data displays, and generate PDF and PostScript outputs files.
- The ability to more easily create native air bridges in ADS layout and the substrate editor for Momentum and finite-element method (FEM) 3D EM simulation.
- RF power amplifier design and analysis improvements to the Load Pull Design Guide.
- An easier multi-technology EM assembly simulation setup (from the ability to use a single substrate definition for both Momentum and FEM simulators), an improved user interface, and a new FEM multi-threaded iterative solver that delivers a 2x speed improvement.

- Improved PCB interoperability stemming from a more effective transfer of PCB via Pad stacks and ODB++ import improvements.

ADS 2011.10 also now supports Agilent's new 89601B Vector Signal Analysis software, and offers re-driver/re-timer models for the HSD channel simulator, as well as native ADS 2011 process design kit (PDK) documentation and a sample design kit. Agilent has also improved ease of use and error detection for Desktop LVS.

Tightly integrated with Agilent's ADS, EMPro is used to create 3D models and analyze electrical performance of packages, connectors, antennas and other RF components. The EMPro 2011.11 release builds on advances made available in 2011.07, introducing key improvements to the FEM simulator:

- A fast FEM iterative solver that provides an additional 2x speed improvement (on top of the 2x speed-up already realized in the 2011.07 release) for simulations that include internal ports.
  - User-defined passive loads capability that allows users to include ideal passive loads directly in a FEM simulation to represent matching circuits and surface-mount components. (The loads are defined in the EM setup environment, which consists of common series and parallel RLC network topologies, enabling accurate field visualization results and radiation patterns that take into account passive loads.)
  - A fast, two-dimensional port solver that simplifies FEM simulation port setup, allowing users to quickly and easily determine the number of modes, reference impedance and optimum impedance line placement.
- ADS 2011.10 is due to ship in late October, when EMPro 2011.11 will be available for download. Pricing starts at \$8000 and \$7000.

[www.agilent.com/find/eesof](http://www.agilent.com/find/eesof)

### IN BRIEF

## Hittite sees rebound in margins and profits in Q3/2011 ...but revenue to fall further in Q4

For third-quarter 2011, Hittite Microwave Corp of Chelmsford, MA, USA (which designs and supplies analog, digital and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems as well as instrumentation) has reported revenue of \$68.1m, up 6.2% on \$64.2m a year ago but down 0.5% on \$68.5m last quarter.

Of total revenue, 44.4% came from the USA (\$30.3m, down from \$31.3m last quarter) and 55.6% came from outside the USA (\$37.8m, up on \$37.2m last quarter).

Gross margin has rebounded from 72.7% last quarter to 74.5%, almost level with 74.6% a year ago. Operating income has risen further, from \$32m (46.8% of revenue) last quarter to \$33.3m (48.8% of revenue).

Likewise, net income has risen from \$20.8m (\$0.69 per diluted share) both a year ago and last quarter to \$22.4m (\$0.73 per diluted share). During the quarter, total cash and cash equivalents rose by \$25.5m to \$351.1m.

However, for fourth-quarter 2011 Hittite expects revenue to fall 12.6% to \$58–61m and net income to fall to \$15.2–16.5m (\$0.50–0.54 per diluted share).

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

## IN BRIEF

## M/A-COM Belfast adds active load-pull

Mesuro Ltd (a spin-off from Cardiff University's Centre for High Frequency Engineering) says the Belfast, UK business unit of M/A-COM Technology Solutions has added its Active Load Pull test & measurement capabilities to its existing line-up.

M/A-COM Technology Solutions Inc of Lowell, MA, USA makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications. Having worked with Cardiff University and then Mesuro, its Belfast Design Centre is equipped with the latest CAD software, automatic assembly tools and test & measurement equipment. It designs ICs and modules for the satellite communications, point-to-point communications, and radar components markets. The new capabilities should cut its design cycle times, reducing its time to market and improving device/process analyses, allowing it to demonstrate greater system performance.

"We see the Waveform Engineering methodology as a key part in our iterative design process," says Andrew Patterson, engineering manager at M/A-COM Tech Belfast. "Its ability to provide insight into process characteristics enables us to highlight potential problems before they become a reality. The latest tools, including behavioural model extraction, allow us access to more relevant data when building our design," he adds.

"The continued relationship with M/A COM Technology Solutions' Belfast facility, and their use of the 'Waveform Engineering' principal, demonstrates the value it offers to power-amplifier designers," reckons Mesuro's CEO Richard Emsley.

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

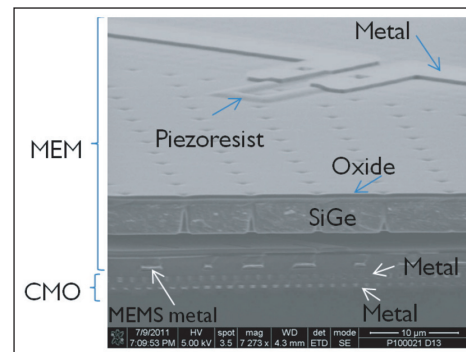
## Imec demos CMOS-integrated poly-SiGe piezoresistive pressure sensor

### First poly-SiGe MEMS device processed on top of Cu-backend CMOS

Imec of Leuven, Belgium has realized an integrated poly-SiGe-based piezoresistive pressure sensor fabricated directly above 0.13 $\mu$ m copper (Cu)-backend CMOS silicon technology. The research institute claims that this represents not only the first integrated poly-SiGe pressure sensor fabricated directly above its readout circuit, but also the first time that a poly-SiGe MEMS device has been processed on top of Cu-backend CMOS.

Polycrystalline silicon germanium (SiGe) has emerged as a promising micro-electro-mechanical system (MEMS) structural material since it provides the desired mechanical properties at lower temperatures compared to poly-silicon, allowing the post-processing on top of CMOS. The MEMS-last approach is the most interesting approach for CMOS-MEMS monolithic integration, believes Imec, as it leads to smaller die areas and enables integration of the MEMS without introducing any changes in standard foundry CMOS processes. Compared with alternative technologies, for example using the CMOS top interconnect layers to fabricate the MEMS device, poly-SiGe offers a more generic and flexible technology for above-CMOS integration, due to the fact that the MEMS fabrication can be completely decoupled from the CMOS fabrication, says Imec.

Imec says that it has previously proved the potential of poly-SiGe for MEMS above-aluminum-backend CMOS integration. However, aggressive interconnect scaling has led to replacement of the traditional aluminum metallization by copper metallization, due to its lower resistivity and improved reliability. Imec's latest results now broaden the applications of poly-SiGe to the integration of MEMS with the advanced CMOS technology nodes.



**Integrated sensor, with two Cu metal lines of CMOS circuit at the bottom, and MEMS layers (poly-SiGe membrane and piezoresistors, oxide sealing layer and metal interconnects) at the top.**

The integrated sensor (fully fabricated at Imec) includes a surface-micromachined piezoresistive pressure sensor, with a poly-SiGe membrane and four poly-SiGe piezoresistors, and an instrumentation amplifier fabricated using Imec's 0.13 $\mu$ m standard CMOS technology, with copper interconnects (two-metal layers), oxide dielectric and tungsten-filled vias.

To enable above-CMOS integration, the maximum processing temperature of the complete sensor, including the poly-SiGe piezoresistors, is kept below 455°C. Also, an appropriate passivation layer was included to protect the electronic circuit from the aggressive etch and deposition steps needed to fabricate MEMS devices.

Imec says that the CMOS circuit showed no significant deterioration after the MEMS processing. Despite the low processing temperature, the poly-SiGe piezoresistive sensor alone (250 $\mu$ m x 250 $\mu$ m membrane) showed a sensitivity of about 2.5mV/V/bar. The integrated sensor (same sensor + Cu-based CMOS amplifier underneath) showed a sensitivity of about 158mV/V/bar, which is about 64 times higher than the standalone sensor.

[www.imec.be](http://www.imec.be)

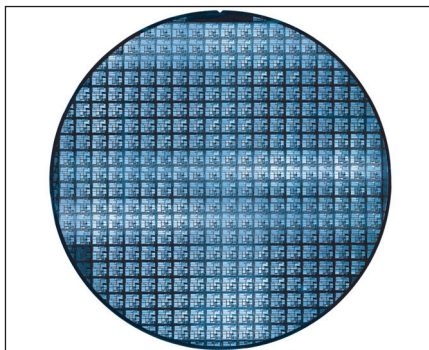
## TowerJazz signs memorandum of understanding for process transfers and projects in India and Brazil

Specialty foundry TowerJazz (which has two fabrication plants at Tower Semiconductor Ltd in Migdal Haemek, Israel, as well as one each at its subsidiaries Jazz Semiconductor in Newport Beach, CA, USA and TowerJazz Japan Ltd) has signed a non-exclusive memorandum of understanding (MOU) with a European entity to seek process transfer opportunities and projects in India and Brazil. TowerJazz will supply training, manufacturing know-how, project management and technical support, while its partner will supply the intellectual property licenses, supporting services and training.

TowerJazz regards the Indian and Brazilian semiconductor markets to be among the highest growth potential markets in the world, and decided to join efforts with what it describes as a "world leader in nanoelectronics research" to collaborate on technology transfer to support this growing trend. Both India and Brazil are emerging as promising markets in the semiconductor industry. It is estimated that India's semiconductor market will reach hundreds of billions of dollars by 2020.

TowerJazz and its European partner share more than 15 years of collaboration in various process transfer activities and transactions. The firms have the capabilities to collaborate on all technology nodes ranging from 1 micron to 32nm including micro-electro-mechanical systems (MEMS). Together, they will target Indian and Brazilian fabless companies and integrated device manufacturers (IDMs) with India and Brazil as their end markets.

"We are extremely pleased with this continued alliance with our European partner to bring together the competencies of both companies to engage in project transfer opportunities in growing markets



**Pictured left: a patterned 8"-diameter silicon wafer produced by TowerJazz.**

such as India and Brazil," comments TowerJazz's president Dr Itzhak Edrei. "With our TOPS (Transfer Optimization Process Services) business unit, we are well equipped for such activities," he reckons.

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

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## SemiSouth's SiC JFETs used by Japan's FUPET in record output power density, small-volume inverter

SemiSouth Laboratories Inc of Starkville, MS, USA, which designs and manufactures silicon carbide (SiC) transistor technology for high-power, high-efficiency, harsh-environment power management and conversion applications, says that its SiC junction field-effect transistor (JFET) are being used in small inverters (measuring 0.5 litres in volume) to achieve an output power density of 30kW/l. If inverters of this size and capacity are used with photovoltaic (PV) panels, then one inverter could supply enough electricity for up to five households, it is claimed.

A team at the Japanese academia and industry R&D Partnership for Future Power Electronics Technology (FUPET), involving Fuji Electric, Nissan Motor, Sanken Electric and Toshiba, aims to deliver power converters that operate at high temperature with high output power density. Using SiC JFETs from SemiSouth, the team developed a three-phase 500cc inverter that delivers 15kW output power when



**SemiSouth's silicon carbide JFETs.**

connected to a three-phase motor with a conversion efficiency of 99%. Featuring a compact, optimized cooling system, the power modules can operate at up to 2000°C (Shinji Sato et al, Yusuke Zushi, Kohei Matsui, Yoshinori Murakami and Satoshi Tanimoto: International Conference on Silicon Carbide and Related Materials (ICSCRM 2011), paper Tu-P-23).

"This is the world's highest output power density for a small-volume inverter," believe Satoshi Tanimoto, chief researcher at FUPET's

R&DCenter. "SemiSouth's JFETs have been instrumental in helping us maximize efficiency and power density," he adds.

SemiSouth's JFETs are compatible with standard gate driver ICs, and feature a positive temperature coefficient for ease of paralleling; extremely fast switching with no 'tail' current at up to a maximum operating temperature of 1500°C and a low

$R_{DS(on)max}$ . Devices are available in TO-247 packaging and in some cases they are also available in die form for integration into modules.

"The FUPET team achieved these results at 50kHz, which is their minimum frequency target, and the module also has a very low inductance module with only 5nH," comments president & chief technology officer Jeff Casady. The FUPET team aims to achieve an inverter with 40kW/l output power density next year.

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

## Power Integrations to be sales rep for SemiSouth's SiC devices

Power Integrations Inc of San Jose, CA, USA, which supplies high-voltage integrated circuits for compact, energy-efficient power conversion in electronic products for AC-DC, DC-DC and LED lighting applications, has agreed to act as a sales representative worldwide (with the exception of Europe) for SemiSouth Laboratories.

SemiSouth says that its SiC diodes and junction field-effect transistors (JFETs) deliver significant efficiency and durability benefits in high-power applications such as solar inverters, motor drives, telecom rectifiers, uninterruptible power supplies (UPS), three-phase inverters and electric vehicles. In October 2010, Power Integrations announced a \$30m

strategic investment in SemiSouth, which included an equity investment, a technology license and other financial commitments to support the continued expansion of SemiSouth's SiC manufacturing operations.

"SemiSouth's rugged, ultra-efficient SiC JFETs and diodes are a natural extension of our product line, perfectly complementing products such as TOPSwitch and TinySwitch which are used in standby power supplies for many high-power systems," comments Power Integrations' VP of sale Ben Sutherland. "With the SemiSouth SiC JFET and diode portfolio, we will be able to address the main power conversion and inversion circuits in those same applications

by replacing silicon diodes, MOSFETs and IGBTs with higher-performance SiC technology," he adds.

"The growth of applications that benefit from extremely high levels of efficiency, such as solar energy and electric vehicles, is creating significant opportunities for our high-efficiency SiC power devices," notes SemiSouth's VP of sales Dieter Liesabeths. "This agreement with Power Integrations will substantially increase our sales and support bandwidth in regions where PI has a very robust presence."

SemiSouth devices are available worldwide through Farnell and Newark as well as local distributors.

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

# EPC introduces fully functional buck power conversion demonstration board featuring e-mode GaN FETs

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) used in power conversion applications, has introduced the EPC9101, a fully functional buck power conversion demonstration circuit. The board is an 8–19V input to 1.2V, 18A maximum output current, 1MHz buck converter.

The board uses the EPC2014 and EPC2015 eGaN FETs in conjunction with the recently introduced National LM5113 100V half-bridge gate driver from Texas Instruments. The LM5113 is said to be the industry's first driver designed specifically for e-mode GaN FETs. The EPC9101 demonstrates the reduced size and performance capabilities of high-switching-frequency eGaN FETs when coupled with this dedicated eGaN driver.

The power stage footprint of the EPC9101 circuit is just 8mm x 16mm (about 0.2 square inches) and about 8mm high when taking components from both sides into consideration. Despite its small size, the board has a peak power efficiency of 88% and is capable of delivering 18A of current at 1.2V.

To assist design engineers, the EPC9101 is easy to set up to evaluate the performance of the EPC2014 and EPC2015 eGaN FETs and LM5113 gate driver, claims the firm. The board is intended for bench evaluation with low ambient temperature and convection cooling. Additional heat sinking and forced-

**The LM5113 is said to be the industry's first driver designed specifically for enhancement-mode GaN FETs**

air cooling can be used to evaluate beyond the rated current capability of the demonstration circuit.

A similar fully functional buck power conversion demonstration board, the LM5113LLPEVB, is available from Texas Instruments, featuring the LM5113 driver in operation with 100V EPC2001 eGaN FETs. The LM5113LLPEVB demo board is a 15–60V input to 10V, 10A, 800kHz, buck converter. Like the EPC9101, this board demonstrates the size and performance enhancement that can be achieved using the EPC2001 eGaN FETs and the LM5113 gate driver.

EPC9101 demonstration boards are priced at \$150 each and are available from Digi-Key Corp.

A 'Quick Start Guide' is included with the EPC9101 demonstration board for reference and ease of use.

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

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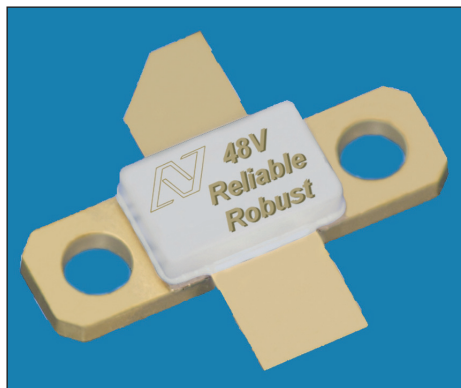
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## Nitronex develops 48V GaN-on-Si NRF2 process

Nitronex Corp of Durham, NC, USA, which designs and makes gallium nitride on silicon (GaN-on-Si) RF power transistors for the defense, communications, cable TV, and industrial & scientific markets, has developed a 48V GaN-on-Si process platform. The new NRF2 platform delivers double the power density, 1-2dB higher gain, improved broadband performance, higher breakdown voltage and higher supply voltage operation compared with the firm's existing 28V NRF1 process technology. Initial 48V samples are available now, with pre-production and production quantities available in early 2012.

The NRF2 process platform leverages the existing NRF1 platform, which has been used to ship more than 500,000 production devices (including more than 50,000 MMICs) since volume shipments began in 2009. However, the new technology further increases reliability for GaN-on-Si, with more than 1 million hours (114 years)



**RF power transistor using Nitronex's 48V GaN-on-Si process.**

mean time to failure (MTTF) at an operating junction temperature of 230°C using a stringent 10% drift failure criteria. In addition, improvements in thermal management in initial 48V products have demonstrated a reduction in thermal resistance of more than 40% compared with existing Nitronex products.

"A robust and reliable high-voltage process can deliver superior performance in high-power RF

applications," says VP of engineering Ray Crampton. "We have developed several semi-custom products for customers with high-volume applications using the NRF2 48V technology," he adds. "In addition to increased reliability and RF performance, we have demonstrated robustness to 15:1 output VSWR at all angles at 90°C flange temperature under saturated drive conditions."

Nitronex claims that its patented SIGANTIC GaN-on-Si process is the only production-qualified GaN process using an industry-standard 4" silicon substrate. The firm says that this results in a robust, scalable supply chain and positions it well for the growth expected from emerging GaN markets such as military communications, CATV, radar, commercial wireless, satellite communications and point-to-point microwave. Additional technology under development includes a 48V MMIC process platform.

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

## NRF1 GaN process qualified for volume production at foundry GCS

Nitronex has completed qualification of its NRF1 discrete process (its proprietary 100mm GaN-on-Si process) for volume production at Global Communication Semiconductors Corp (GCS) of Torrance, CA, an open foundry services provider that supports III-V compound semiconductors such as HBT, PHEMT, MESFET and optoelectronics.

NRF1 has been used by Nitronex to ship more than 500,000 production devices since volume shipments began in 2009. Now, under a long-term supply agreement, GCS will exclusively provide Nitronex with NRF1 discrete and MMIC foundry services.

Devices fabricated at GCS show equivalent performance across the board to devices fabricated at Nitronex's facility. Qualification includes extensive DC, RF, thermal,

reliability and other parametric testing. Nitronex plans to work closely with customers through a Process Change Notification (PCN) to ensure a smooth transition as it establishes GCS as a qualified wafer source for all of its products.

"When evaluating GaN suppliers, our customers tell us they want to compare performance, reliability, manufacturability, and cost," says Nitronex's CEO Charlie Shalvoy.

"Our current NRF1 discrete and MMIC-based processes have enabled us to develop a family of products that, for many market applications, meet or exceed our customers' needs relating to performance and reliability — and we have the data to prove it," he believes.

"Partnering with GCS gives Nitronex a significant increase in capacity, improves our near- and

long-term cost reduction roadmap, and provides access to capabilities that allow us to develop new GaN technologies," Shalvoy continues. "The combination of our proprietary 100mm GaN-on-Si process, and the full suite of production and new process development capabilities at GCS, gives us the ability to be a leader in the rapidly emerging market of GaN RF power devices," he believes.

"We are pleased to partner with Nitronex and add GaN-on-Si to our extensive compound semiconductor capability," comments GCS' CEO Jerry Curtis. "Nitronex's unique technology gives us access to a new and growing GaN RF market," he adds. "Now that NRF1 process is qualified at GCS, we look forward to working closely with Nitronex and moving to volume production."

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

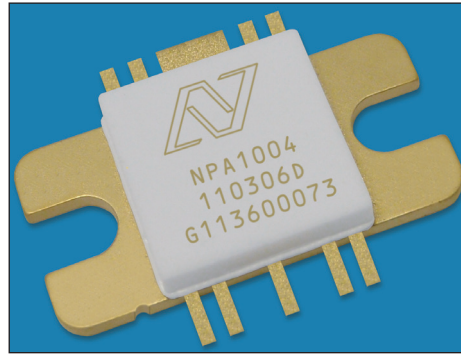


## Nitronex launches smallest L-band 50W MilCom PA

Nitronex Corp of Durham, NC, USA, which designs and makes gallium nitride on silicon (GaN-on-Si) RF power transistors for the defense, communications, cable TV, and industrial & scientific markets, has developed the NPA1004, a 1–2GHz, 50W high-gain power amplifier (PA) for the military communications market.

Fully integrated input matching, inter-stage matching, and RF biasing is provided in a small 0.28in<sup>2</sup> package, allowing subsystem designers to significantly shrink the footprint of the PA signal chain compared to competing solutions, it is claimed. The miniature NPA1004 also features an off-chip output match that allows designers to tailor performance response to their unique system needs.

The NPA1004 achieves 27dB small-signal gain, 50W saturated



**Nitronex's NPA1004 L-band 50W power amplifier.**

output power and 55% typical drain efficiency across the frequency range 1–2GHz. The high gain of the monolithic microwave integrated circuit (MMIC) PA allows designers to eliminate a driver stage, and the high levels of integration reduce board space, while simplifying design and manufacturing processes.

"We worked closely with leading prime contractors and PA suppliers to define and develop the NPA1004," says VP of sales & marketing Gary Blackington. "Our close relationships with these customers have enabled us to develop products that are ideally suited to their end applications," he claims.

"The NPA1004 is a prime example of our ability to deliver high-performance, highly integrated GaN MMICs at solution costs as good as or better than discrete FET-based amplifiers," adds VP of engineering Ray Crampton. "Our proprietary GaN-on-Si process, which has been used to ship over 50,000 production MMICs, allows us to offer more functionality in a smaller footprint than competing technologies."

The NPA1004 is available in sample and pre-production quantities.

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

## GaN Systems closes first-round funding VC funding adds to Canadian support for NRC power device start-up

GaN Systems Inc of Ottawa, Ontario, Canada, which is a fabless semiconductor manufacturer developing gallium nitride (GaN)-based diodes and transistors for power conversion and control applications, has closed its Series A financing round, led by Chrysalix Energy Venture Capital (claimed to be the world's most active cleantech venture capital firm in 2010) and Rockport Capital (which partners with cleantech entrepreneurs worldwide).

The funding builds on ongoing government support from the National Research Council of Canada (NRC) and the Ontario Centres of Excellence. The firm has also received support from Sustainable Development Technology Canada (SDTC) for a project to further develop and demonstrate its patented GaN technology, which targets more energy-efficient and lower-cost electronic products and renewable energy solutions.

GaN overcomes the speed, temperature, and power handling limitations of traditional silicon power conversion approaches, says CEO & co-founder Girvan Patterson. "Cleantech will require a social transition and financial investment unequalled since the industrial revolution, and it will take radical electronics innovation to make it happen," he adds.

"We will offer the Cool Switching product line of highly efficient, low-loss diodes, transistors, and integrated systems," says chief technology officer & co-founder John Roberts. "We will also partner with other semiconductor companies looking to leverage the strengths of gallium nitride using our patented designs," he adds. "Our unique island-based topology builds on years of gallium nitride process research at the NRC and will enable power devices that are typically four times smaller (resulting in lighter

weight), more efficient, have longer battery life, and are lower cost," Roberts reckons. "In cleantech applications, power conversion efficiency is a universal requirement and our designs dramatically impact the economics of that goal," he claims.

"The National Research Council of Canada helps entrepreneurs such as GaN Systems grow," says Dr Ian Potter, VP, NRC Engineering.

"Together, we take ideas from concept to reality, allowing them to commercialize their technologies in a global marketplace," he adds.

"After four hard but exciting years working on the cutting edge of GaN research, we're excited to now have the opportunity to deliver on our vision of a new generation of power conversion products," comments Patterson. "Although venture backing has been slow in the region this year, Ottawa has an astounding talent pool to draw from."

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

# EU-funded HiPoSwitch project launched, targeting more efficient power electronics

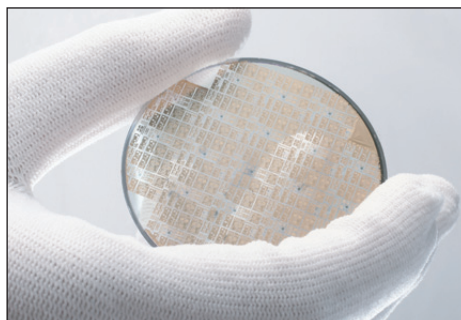
## High-voltage normally-off GaN-on-Si power transistors with vertical device architecture to be developed

With a budget of €5.57m (including nearly €3.58m of funding from the European Union), the three-year HiPoSwitch ('High Power Switch') project has been launched (lasting from September 2011 to end-August 2014). The aim is to develop more compact and powerful energy converters, e.g. for use in information and communication technology and solar inverter technology, transforming continuous and alternating current into the effective voltages used by systems.

Low energy consumption and high output power are the core requirements for modern power converter systems, which need to preserve natural resources and cope with the increasing power consumption in communication infrastructure required for further increased data rates. Project activities cover the whole value-added chain, ranging from the development of power devices based on gallium nitride (GaN) transistors to their industrial applications.

HiPoSwitch focuses on GaN-based transistors as the key switching devices promising increased efficiency in future power converter systems, as well as smaller volume and weight along with enhanced performance. The efficiency of existing systems is largely limited by the active components that are used. These are mostly based on silicon, and are therefore reaching material-related limits. Alternatively, silicon carbide (SiC) is rather expensive, inhibiting widespread applications.

In contrast, due to the much lower on-state resistance of GaN power transistors, combined with much reduced input and output capacitances, GaN can form the basis of power switches operating at much higher frequencies without suffering from major switching losses.



**GaN HEMTs on 2" SiC substrates**  
(© FBH/schurian.com).

The increase in switching frequency also means that the volume of passive components such as inductors, current transformers and capacitors can be significantly reduced. So, the whole assembly can be smaller and lighter.

For HiPoSwitch, the GaN transistors will be fabricated on cost-efficient silicon substrates, making them more attractive economically. Long term, they should combine much improved technical properties with comparatively low cost.

Coordinated by Berlin-based Ferdinand-Braun-Institut, Leibniz-Institut für Hochfrequenztechnik (FBH), eight European project partners provide complementary competencies covering the complete value-added chain, from R&D (FBH; the Slovak Academy of Sciences, Institute of Electrical Engineering; Vienna University of Technology in Austria; and Italy's University of Padua) to industrial application (German deposition equipment maker Aixtron SE, Artesyn Austria GmbH & Co KG, Belgian epiwafer supplier EpiGaN, and Infineon Technologies Austria AG).

Throughout the project, normally-off GaN power transistors in vertical device architecture will be jointly developed by FBH and Infineon Technologies Austria. Processing will be carried out mainly on GaN-on-Si wafers provided by Imec spin-off

EpiGaN but also benchmarked against GaN-on-SiC epitaxial wafers delivered by FBH. The work aims to rapidly transfer the process modules from FBH to the high-volume process line at Infineon. Exploratory concepts towards novel normally-off power transistors and devices operating at high temperatures up to 250°C, for example, will also be investigated, predominantly at the Technical University Vienna and the Slovak Academy of Sciences in Bratislava. Hence, the basis for further technological improvements in the future will be established during the project. All device developments will be supported continuously by intensive reliability testing and failure mode investigations. For this, the University of Padua in particular will contribute its comprehensive experience in GaN device reliability and failure mechanisms.

In parallel to device development, the industrial partners will concentrate on transferring the technology that is developed to a high-volume production environment: EpiGaN is focusing on 200mm GaN-on-Si epitaxy developments, while Aixtron will establish the prerequisites for high-volume epitaxy by optimizing the corresponding growth reactors. Infineon Technologies Austria AG will evaluate the transistor concepts and the GaN-on-Si epiwafers from EpiGaN in their process line. Finally, Artesyn Austria will demonstrate the capability of the technology by building a highly efficient kilowatt-class inverter system, to be implemented, for example, in new-generation base-stations for mobile communications.

The aim is that, after project completion, GaN power transistors and 200mm GaN-on-Si substrates will be commercially available and marketed worldwide.

[www.fbh-berlin.com](http://www.fbh-berlin.com)

## CISSOID releases high-temperature, high-reliability isolated gate driver for high-density power converters

Fabless high-temperature semiconductor firm CISSOID of Mont-Saint-Guibert, Belgium has launched HADES, the first isolated gate driver solution designed to drive high-temperature power transistors, specifically (but not exclusively) silicon carbide and gallium nitride fast-switching devices.

With HADES, it is claimed, system engineers can develop power converters that are five times smaller and lighter than before, with better efficiency, and get power converters able to operate in a high-temperature ambient, if required. No matter what the ambient temperature is, the system's life-time will be an order of magnitude longer than traditional solutions, it is reckoned.

HADES has been designed to drive SiC power transistors, which have low switching losses. It can switch them at high frequencies, which allows passive and magnetic components to be smaller and lighter. Furthermore, due to its ability to sustain high temperatures, HADES can be located next to the power transistors, which reduces parasitic capacitances and inductances, further improving the associated losses and delays in the system.

HADES is a reference design and an evaluation board delivered with full documentation. It can drive two SiC MOSFET power switches on a DC bus voltage up to 1200V. The reference design is scalable up to  $\pm 20A$  gate current, while the evaluation board features  $\pm 4A$ . A specific variant of board for normally-on JFETs will also be available, and other types of switching devices (normally-on/off JFETs, BJTs and IGBTs) can be supported with minor changes.

As an example, HADES' operation and performance were demonstrated in a 3kW Buck DC-DC converter, driving SiC MOSFETs, at 175°C ambient and switching at 150kHz, with rise times of less than 25ns. In

these operating conditions, HADES, which has been designed for high dV/dt immunity (50kV/ $\mu$ s) and IC junction temperatures up to 225°C, runs with comfortable safety margins, says CISSOID.

In terms of efficiency, the combination of HADES with the newest SiC switches in advanced power converter topologies should bring efficiencies in excess of 98%, even at switching frequencies above 100kHz.

The HADES gate driver suits high-power converters such as motor drives, battery chargers and power distribution used in applications like railways, aircraft, renewable energy and hybrid/electric vehicles (HEV). It delivers high power density, simplified cooling and high reliability. The fast-switching ability of HADES, plus the fact that it can operate reliably at the same temperature as the switches (200°C junction and above), suits the new generation of intelligent power modules (IPM), says CISSOID.

HADES is built from CISSOID's chipset CHT-THEMIS, CHT-ATLAS and CHT-RHEA. With its on-board isolated power supply based on CISSOID's PWM controller CHT-MAGMA and derived from STROMBOLI technology, HADES requires a single +12V supply. All HADES' active components are guaranteed for normal operation over the full temperature range of -55°C to +225°C. The magnetic isolation of the power supply also sustains reliably high temperatures, as opposed to optocouplers.

On-board protection functions include under voltage lockout (UVLO) and desaturation detection, which monitors the drain-to-source voltage of the power transistor to detect over-currents. The board also implements an active Miller clamping function, which prevents parasitic turn-on due to the Miller capacitor of the power switch.

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

### IN BRIEF

#### RFMD launches 30–512MHz, 9W and 50–1000MHz, 15W GaN wideband PAs

RF Micro Devices Inc of Greensboro, NC, USA has launched two GaN power ICs (PICs), wideband power amplifiers designed for continuous-wave and pulsed applications such as military communications, electronic warfare, power amplifier stages for commercial wireless infrastructure, civilian and military radar, two-way public mobile radio, and general-purpose Tx amplification.

Using a high-power-density gallium nitride (GaN) high-electron-mobility transistor (HEMT) process, the RFHA1000 and RFHA1003 amplifiers achieve, respectively, high power-added efficiencies of 60% and 70%, and flat gains (17dB and 19dB) and output powers (15W and 9W) over large instantaneous bandwidths of 50–1000MHz and 30–512MHz, each in a single amplifier design.

Operating at 28V, the GaN discrete amplifiers are internally input-matched to 50 $\Omega$ , and packaged in a small-form-factor (5mm x 6mm) SOIC-8 outline air-cavity ceramic package that provides what is claimed to be excellent thermal stability through the use of advanced heat-sink and power dissipation technologies.

Ease of integration is accomplished through the incorporation of an optimized input matching network within the package that provides wideband gain and power performance in a single amplifier. An external output match offers the flexibility of further optimizing power and efficiency for any sub-band within the overall bandwidth. Large-signal models are also available.

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

## IN BRIEF

## RFMD launches 30–2500MHz, 9W GaN wideband PA

RF Micro Devices Inc of Greensboro, NC, USA has launched the RF3826, a wideband power amplifier (PA) designed for continuous-wave and pulsed applications such as power amplifier stages for commercial wireless infrastructure, civilian and military radar, Class AB operation for public mobile radio, test & instrumentation, and general-purpose Tx amplification.

Using a high-power-density gallium nitride (GaN) high-electron-mobility transistor (HEMT) process, the amplifier achieves high output power (9W), large instantaneous bandwidth (30–2500MHz), flat gain (12dB), and high power-added efficiency (45% at 30–2500MHz and 50% at 200–1800MHz), all in a single amplifier design.

The RF3826 is internally input-matched to 50Ω, and packaged in an air-cavity ceramic package that provides what is claimed



to be excellent thermal stability through the use of advanced heat-sink and power dissipation technologies.

Ease of integration is accomplished through the incorporation of optimized input matching network within the package that provides wideband gain and power performance in a single amplifier. An external output match offers the flexibility of further optimizing power and efficiency for any sub-band within the overall bandwidth. Large-signal models are also available.

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

## Voltaix appoints new CEO; interim CEO succeeds president

Voltaix LLC of Branchburg, NJ, USA, which manufactures specialty materials that enhance the performance and manufacturability of semiconductors and photovoltaics, has named Peter A. Smith as CEO and board member.

Smith is a 20-year high-tech industry veteran, having served at Motorola, Honeywell and, most recently, as VP of corporate strategy for the Bussmann Division of Cooper Industries in St Louis, MO.

Using expertise in silicon, germanium and boron chemistry, Voltaix manufactures electronics products including germane, trisilane, diborane and trimethyl boron, using proprietary synthesis, purification, and packaging technology developed in-house, as well as designing and building its own equipment for use in its manufacturing operations. Products are custom designed for demanding applications including advanced DRAM computer memory; silicon germanium (SiGe) transistors for wireless communications chips; strained silicon for high-speed logic computer chips (CPUs); copper-enabling low-k dielectrics for computer chips; and high-efficiency thin-film silicon solar cells. Voltaix claims that its materials improve manufacturability by minimizing defect formation and increasing machine throughput.

"Over the last four years Voltaix has embarked on a plan that has increased sales and expanded manufacturing capacity," says chairman Peter B. de Neufville. "As we considered the impact of this growth and the potential for continued expansion, the board of directors sought a chief executive with vision and distinguished operating and technical leadership experience," he adds.

"Peter is a top notch strategist who has proven himself developing specialty materials at Honeywell, scaling the MEMS business at Dover and significantly enhancing

performance at a Cooper Industries wireless unit," says Voltaix director and former Renewable Energy Corp CEO Reidar Langmo. "He brings a broad array of leadership and management talents with a track record of successfully implementing corporate growth in North America, Asia and Europe."

Smith succeeds Mark K. Fine, who has been interim CEO since January 2010 and will succeed John P. de Neufville as president. Fine will have responsibility for a number of the firm's strategic initiatives and will oversee relationships with distributor partners worldwide. "Mark Fine has played a key role in our development plan from the beginning and, as interim CEO for the past 22 months, has strengthened the company's leadership position," comments de Neufville.

de Neufville will continue as chief scientist, overseeing chemical research and end-use applications development. He will also remain a member of the board and chairman of the executive committee.

At Cooper Industries, Smith led the acquisition of power management device maker Martek and improved Cooper's industrial wireless business. Previously, he led the consumer electronics product group at Dover Knowles, which he grew from \$150m to \$240m.

Earlier, Smith focused on semiconductor and display manufacturing at Motorola and later worked on behalf of one of its key suppliers, Three-Five Systems, where he managed M&A activities and oversaw manufacturing productivity in the Philippines and China.

Smith has a PhD in Materials Science and Engineering and a BS in Materials Engineering (both from Rutgers, The State University of New Jersey) and an MBA from Arizona State University. He is associate editor for the Journal of the Society of Information Display.

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

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## IN BRIEF

## Mesuro appoints IQE veteran as non-executive chairman

Mesuro Ltd, a spin-off from Cardiff University's Centre for High Frequency Engineering that provides RF testing equipment and device measurement services, has appointed Dr Godfrey Ainsworth as non-executive chairman.

Chartered accountant and corporate financier Ainsworth has over 20 years of experience in the compound semiconductor industry with AIM-listed IQE, where he is non-executive chairman. He is also a board member of the Cardiff Partnership Fund and Cardiff Business School International Advisory Board.

"Godfrey has been working with the board and management team at Mesuro for the past year," says David Baynes, CEO of university IP commercialization company Fusion IP plc (which has a 47.2% stake in Mesuro). "His extensive knowledge of the sector from his 20 year relationship with IQE is proving invaluable," he adds.

Mesuro's technology addresses the needs of device makers to obtain the highest performance from their designs, maximizing their efficiency, reducing power consumption and accelerating time to market. "The company is building an impressive sales pipeline with leading global players," says Ainsworth. "With sales already made or confirmed to the US, Europe and Japan, it is clear that we will need to look for strategic partners to leverage Mesuro's potential," he adds.

"Mesuro has had a transformational year and has secured significant sales, released a number of new products, including our VNA-based active load-pull system, has a strong order book and a healthy pipeline of sales for 2012," says CEO Richard Emsley.

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

## IQE launches customizable SOI with improved thickness and doping control

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has announced the availability of ultra-smooth, customizable silicon-on-insulator (SOI) with improved thickness and doping control.

IQE says that, since its introduction into mainstream manufacturing, SOI has been integrated into a steadily growing number of applications, including advanced microprocessors, high-voltage devices and complex MEMS (micro-electro-mechanical systems) and sensors.

The electrostatic benefits of replacing bulk silicon wafers with SOI include the reduction of parasitic device capacitance and resistance to latch-up, says IQE. SOI also has desirable mechanical properties, e.g. the provision of an excellent etch-stop at the interface between the silicon device layer and the buried oxide, facilitating substrate removal for applications such as MEMS and sensors.

SOI is manufactured using a variety of methods including:

- Hydrogen implanted layer transfer (HILT), where a layer of implanted hydrogen atoms produces a cleave plane below the surface of a donor wafer. This thin layer is then exfoliated from the donor wafer to an oxidized handle wafer and annealed. This method produces thin-body SOI with excellent cross-wafer thickness uniformity, says IQE. However, it is limited by the depth at which an implanter can form a cleave plane in the donor wafer. SOI wafers produced by this method have an upper thickness limit of between 1–2µm. The range of available doping options is also typically limited.

- Bond and etch-back involves directly bonding an oxidized silicon wafer with a second substrate. Most of the second substrate is subsequently removed, by a combination of physical grinding and

chemical etching to leave a thinner device layer. The major limitation of this method is the poor control of cross-wafer uniformity, which becomes more challenging as more of the device layer is removed.

- Other methods include ELTRAN and SIMOX, but these are not commonly used in high-volume SOI manufacturing.

IQE Silicon Compounds Ltd is now able to offer a new range of SOI products and what is claimed to be one of the few commercial opportunities that allows customers to tune the SOI parameters to their own specifications in terms of doping type and device layer thickness. It can also provide customized SOI in volumes from as little as 50 wafers for smaller, niche-driven applications.

Another differentiator is that SOI device layers are typically epitaxial silicon films, which exhibit excellent crystal quality, improved gate oxide integrity and are COP (crystal originating particle)-free, says IQE. "Because we are able to determine the structure of the device layer epitaxially, it is possible to have very tight control of the important film parameters whilst at the same time having the flexibility to produce structures which are not available using current SOI production methods," the firm adds. "This includes SOI with multiple silicon layers with different doping, or multiple layers of Si, Ge and SiGe alloys."

To address the issues highlighted by its customers, IQE Silicon Compounds has launched its own SOI product range, offering high uniformity on both thin and thick device layers. It is also able to address SOI availability in small order quantities of between 50 and 500 wafers. The primary demand for SOI wafers is in 100mm, 150mm and 200mm wafer sizes, and IQE says that it can provide the complete range of products at these diameters.

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# AXT's revenue falls 5.7% in Q3 to \$28.3m

## Further drop to \$20-23m expected in Q4

For third-quarter 2011, AXT Inc of Fremont, CA, USA, which makes gallium arsenide, indium phosphide and germanium substrate and raw materials, has reported revenue of \$28.3m, up 5.6% on \$26.8m a year ago but down 5.7% on \$30m last quarter and below the expected \$30.5-31.5m. Of total revenue:

- gallium arsenide (GaAs) substrate revenue was \$18.7m, up 3.8% on \$18m last quarter but down 2.6% on \$19.2m a year ago;
- indium phosphide (InP) substrate revenue was \$1.5m, down slightly on \$1.6m last quarter but up 50% on \$1m a year ago;
- germanium (Ge) substrate revenue was \$3m, up 11% on \$2.7m last quarter and 30% on \$2.3m a year ago; and
- raw materials sales were \$5.1m, down 34% on \$7.7m last quarter but up 16% on \$4.4m a year ago.

Although up on 39.3% a year ago, gross margin has fallen from 46.7% last quarter to 43.2%. Despite still being higher than \$3.8m a year ago, operating expenses have been cut from \$4.4m last quarter to \$4.2m. Nevertheless, although up on \$6.7m a year ago, income from operations has fallen \$9.6m last quarter to \$8.1m. Likewise, net income has fallen from \$7.1m (\$0.21 per diluted share) last quarter to \$6.5m (\$0.19 per diluted share), but this is still more than the \$5.6m (\$0.17 per diluted share) a year ago.

For fourth-quarter 2011, AXT expects revenue to fall further to \$20-23m, and net income per share to fall further to \$0.08-0.12.

"The current environment is presenting both great challenges and great opportunities for AXT. While we are heading into a challenging quarter, we believe that we have

established a solid foundation to build upon when markets improve," says CEO Morris Young. "In all of our key markets, we are in a great competitive position and are actively engaged with new potential customers that can help us to broaden and deepen our footprint in the markets we serve," he adds.

"Our engineering, manufacturing and operations teams continue to execute well against our goals to provide a broad portfolio of high-quality products and strong customer support," continues Young. "Further, we have a solid business model that is allowing us to weather near-term weakness, while generating cash and delivering profitability... these factors will provide tremendous opportunity for us as the demand environment improves," he believes.

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

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# 5N Plus expands Asian activities

## Firm acquiring remainder of Lao tellurium JV and setting up Korean gallium chemicals plant with Golden Harvest

5N Plus Inc of Montreal, Canada, a producer and provider of high-purity metals, compounds and wafers for electronic applications, has reached an agreement to acquire the remaining 40% ownership interest in the joint venture Lao Industrial Resources Co Ltd of Vientiane, Laos, which focuses on refining metals (including tellurium).

5N Plus is also to set up a gallium chemicals plant in Korea in conjunction with Hong Kong-based Golden Harvest, a producer of primary gallium. 5N Plus and Golden Harvest have been joint venture partners in a gallium refining facility in Shenzhen, China since 2009. The new Korean facility will produce gallium chemicals for the growing LED market and is expected to be operational by mid-2012.

"Expansion of our activities in Asia is part of our growth strategy as we expect to see increasing demand for our products in this part of the world," says president & CEO Jacques L'Écuyer. "Our Laos and new Korean facilities will be instrumental in allowing us to leverage this demand and the corresponding business opportunities," he adds.

Founded in 2000, 5N Plus currently focuses on

specialty high-purity metals such as tellurium, cadmium, selenium, germanium, indium, antimony


and bismuth and also produces related II-VI semiconducting com-

pounds such as cadmium telluride (CdTe), cadmium sulphide (CdS) and indium antimonide (InSb) as precursors for the growth of crystals for electronic applications, including solar photovoltaic, radiation detector and infrared markets. 5N Plus owns four material subsidiaries: 5N PV GmbH (Eisenhuttenstadt, Germany), Firebird Technologies Inc (Trail, BC, Canada), 5N Plus Corp (DeForest, WI, USA) and Sylarus Technologies LLC (St George, UT, USA). Also, in April, 5N Plus acquired MCP Group SA of Tilly, Belgium (the world's leading producer and distributor of bismuth and bismuth chemicals, and a supplier of specialty metals including gallium, indium, selenium and tellurium). MCP owned 60% of Lao Industrial Resources.

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

**5N Plus is also to set up a gallium chemicals plant in Korea in conjunction with Hong Kong-based Golden Harvest**

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# Veeco's Q3 growth suppressed by slowdown in TV demand and China push-outs

## Orders down 50%, heralding revenue dip in 2012

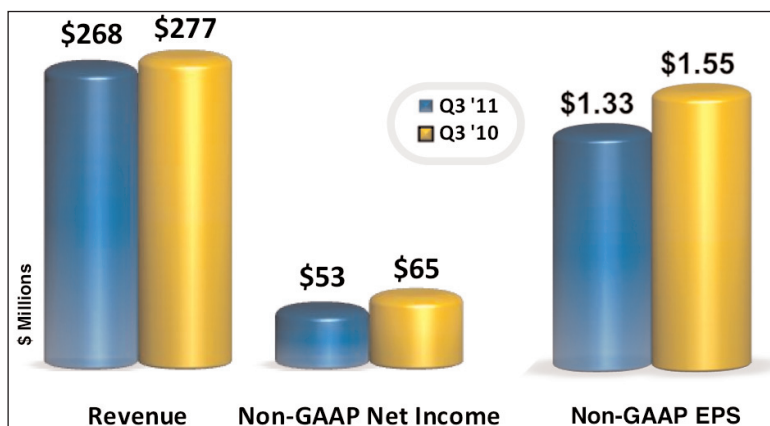
For third-quarter 2011, epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has reported revenue of \$268m, up 1% on \$264.8m last quarter but down 3% on \$277.1m a year ago for continuing operations (reflecting discontinuation of the CIGS Solar Systems business at the start of Q3, and excluding the Metrology business, sold to Bruker Corp of Billerica, MA, USA in October 2010).

Of total revenue, 13% came from Data Storage revenue of \$34.1m, down 25% on \$45.7m last quarter but roughly level with \$34.5m a year ago. The other 87% comprised LED & Solar revenue of \$234m, up 7% on \$219.1m last quarter but down 4% on \$242.6m a year ago. This included metal-organic chemical vapor deposition (MOCVD) revenue of \$220m, up on \$206m last quarter.

"Veeco has continued to execute within the challenging overall business environment, particularly in China, where customer facility readiness and credit tightening remain significant issues," says CEO John R. Peeler. Since opening in May, the number of engineers trained at Veeco's China Training Center is now more than 200 and should be over 300 by the end of 2011.

"Veeco's new MaxBright MOCVD system represented nearly half of the quarter's MOCVD revenue, including broad-scale customer acceptance at tier-one LED manufacturers," he adds.

Gross margin was 46.6%, down on 49.6% a year ago and 51.1% last quarter due to a high concentration in the revenue mix of MaxBright MOCVD systems (for which first shipments carry higher costs). "We'll begin to see cost improvement early next year," notes executive VP & chief financial officer David D. Glass. Non-GAAP



**Veeco's Q3/2011 revenue and income, down from Q3/2010.**

net income was \$53.3m, down from \$63.4m last quarter and \$65.4m a year ago, but at the high end of the guidance range of \$41.3–\$57.7m.

During Q3, Veeco purchased \$154m in stock at an average price of \$38.63 per share, completing a \$200m board-authorized share buy-back program initiated in August 2010. The firm also used \$31m of cash in contractual settlements for closure of the CIGS Solar Systems business. With working capital changes roughly offsetting the positive cash flow generated from operating income, during the quarter Veeco's cash and short-term investments hence fell overall from \$633m to \$449m.

"Veeco's third quarter orders were impacted by weak near-term LED industry demand [particularly from the TV sector], low MOCVD equipment utilization rates in Asia [50–70%], and decreased business activity in China [due to credit tightening and funding availability]," says Peeler. "In addition, negative global macro-economic data points caused customers to slow or cut their capacity expansion plans."

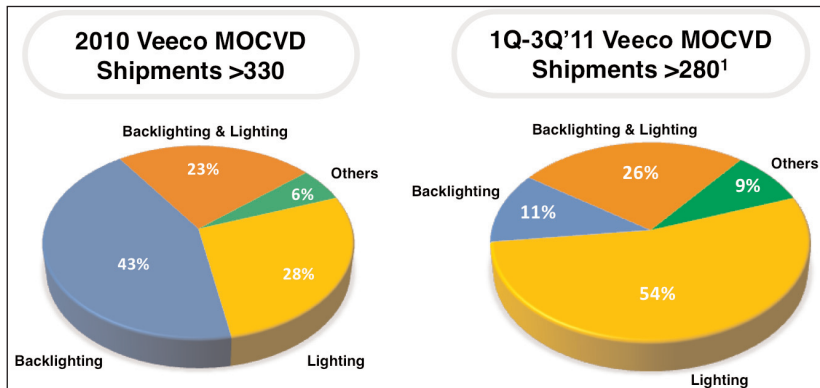
In particular, by application sector, of Veeco's MOCVD system shipments in Q1–Q3/2011 of more than 280 (versus more than 330 for full-year 2010), 54% were for lighting (up from just 28%) and

just 11% were for backlighting (down from 43%).

Third-quarter bookings were \$133m, down 57% on the record \$311m last quarter and down 52% on \$278.2m a year ago.

Of total bookings, 16% came from Data Storage orders of \$21m, down 44% on \$37.5m last quarter and down 39% on \$35m a year ago. Of the other 84%, LED & Solar orders were \$112m, down 59% on the record \$273.3m last quarter and down 54% on \$243.2m a year ago. This includes MBE (molecular beam epitaxy) orders of \$9m (down on a strong \$24m last quarter) and MOCVD orders of \$103m, down on \$250m last quarter. After recording backlog adjustments of \$34m during the quarter (due mainly to several MOCVD customers who cancelled or pushed out the dates for tools on order), total order backlog has fallen from \$558.2m to \$389m (about \$303m of which is for MOCVD).

After factoring in facility readiness issues and shipment timing uncertainty, for fourth-quarter 2011 Veeco expects revenue to fall to \$175–215m. Due to the lower volume and continued impact of first MaxBright systems, gross margin should fall further to 44–45%. Net income is expected to fall to \$21.1–33.6m. Operating spending should be \$49–51m. For full-year 2011, Veeco expects revenue of \$963–1003m, with gross margin of 48–49% and net income of \$199.2–211.6m. Operating spending should be \$193–195m. ➤



**MOCVD shipments for lighting grow to over 50% in Q1-Q3/2011.**

► “Despite the difficult overall environment, we are proud that the company expects to deliver \$1bn in 2011 revenue, at the high end of guidance,” says Peeler. “This speaks to our technology leadership position, close connectivity to our global customers and ability to execute in a challenging environment,” he adds.

“Our current expectation is [MOCVD] orders will remain depressed for a few quarters,” notes Peeler. “While there are many data points indicating that LED lighting is accelerating, weak backlighting

ing effect on our business heading into 2012,” he adds. “With our variable cost model, combined with plans to decrease spending levels to reflect the challenging business environment, we are confident we will remain profitable and expect to deliver double-digit EBITA performance next year.” Reductions of about 100 temporary workers and contract manufacturing staff have already occurred.

“While we do not know how long this slowdown will last, LED pricing declines will continue to stimulate

demand continues to cause low factory utilization rates... global macro-economic concerns will likely have a dampen-

demand for solid-state lighting on a global basis,” believes Peeler. “We expect wide-spread adoption of LED lighting, led first by the commercial, municipal and industrial sectors, which make up 75% of the lighting market, followed by residential users as economic benefits of using LED-based products become more apparent,” he adds.

“Despite some level of cyclicality which is to be expected [with 2012 to be a down year, following two very strong years], there is an enormous multi-year growth opportunity for MOCVD, aligning with our overall expectation of 5000+ reactors from 2011 to 2015,” continues Peeler, who adds that industry data points suggest that the downturn could be very short lived. “With the industry’s most productive MOCVD platforms, Veeco’s market position is the best it has ever been. We believe the company can continue to gain share as LED lighting hits an inflection point in 2012 and 2013,” he concludes.

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

## Riber sells three MBE systems to Russian research institutes

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, says that it has sold three research systems to two leading research institutes in Russia. The Epineat, Compact12 and Compact 21 systems will be supplied in 2012.

Specifically, two systems will be delivered to the St Petersburg Academy of Sciences’ Nanotechnology Research and Education Centre in connection with the ‘Alferov-Riber MBE Academy’ (set up jointly in October 2010 by the Nobel Prize winning physicist professor Zhores Alferov and Riber).

Riber says that the new orders confirm its growing reputation among the scientific community in

Russia, enabling it to strengthen its position in that market, where it says the semiconductor industry is booming.

The firm says that the results also illustrate the characteristics of its business model, which is focused on:

- continuing to strengthen its market leadership in MBE systems; capitalizing on the installed base and growing sales of epitaxy equipment, spare parts and accessories, as well as corresponding services; and
- rolling out a diversification policy, including launching a range of high-value-added equipment (cells and sources) for high-growth applications (thin-film solar panels, OLED lighting and flat-panel displays, etc).

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

### IN BRIEF

#### Three systems for Europe and Asia

Riber has sold three research MBE systems in Europe and Asia.

Poland’s University of Rzeszow has ordered a double-chamber Compact21 MBE research system. It will enable the Institute of Physics to strengthen its development capacities for designing III-V and II-VI component-based semiconductor systems.

Also, in Asia, Riber has sold two systems to major research labs. In China, a Compact 21 system will allow the lab to boost its nitride optoelectronics research. In Singapore, a research lab has bought an MBE412 system to complement its existing fleet. With its capacity for large-size substrates, the MBE412 is a flexible R&D resource, Riber says.

# Aixtron's Q3 revenue down nearly 50% due to Asian market correction and credit tightness

## Drop of 77% in orders leads to immediate cost reductions

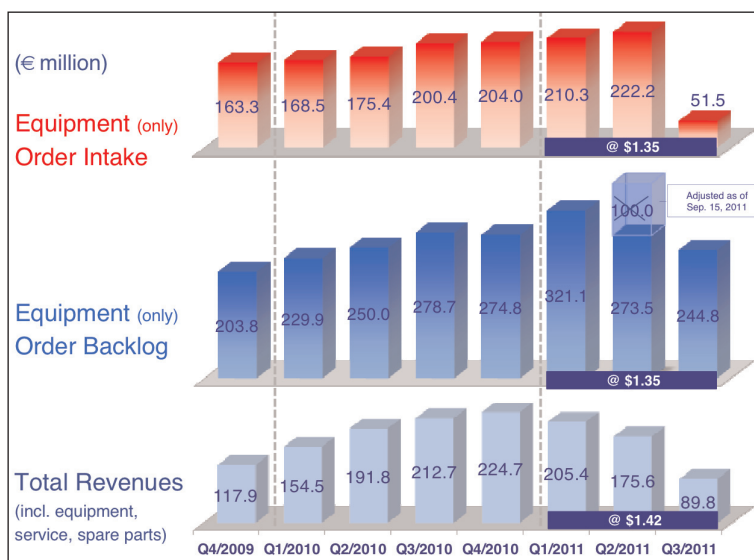
For third-quarter 2011, deposition equipment maker Aixtron SE of Herzogenrath, Germany has reported revenue of €89.8m (down 49% on €175.6m last quarter and 58% on €212.7m a year ago). Of total revenue, 86% came from equipment sales and 14% from spare parts and services. By region, 86% came from Asia, 4% from Europe, and 10% from the USA.

The sudden drop in revenue is attributed mainly to a small number of significant customer-delayed deliveries, which are also reflected in the order backlog adjustment (announced on 15 September). The previously high investment activities by Asian LED makers (driven by substantial government funding) have become restrained by an unscheduled but significant slow-down in demand, explains Aixtron. This partially resulted from insufficiently developed end-market demand, but is also evidence of some financing pressures on the Asian LED makers, including increasing credit tightness in the region, the firm adds.

Gross margin has fallen further, from 52% a year ago and 44% last quarter to 43%. EBIT (earnings before interest and taxes) operating profit has fallen from €82.6m (39% operating margin) a year ago and €54.3m (31% margin) last quarter to just €0.6m (1% margin). However, without non-operational currency-related effects, EBIT would have been €13m (14% margin).

Net income has fallen from €56.8m a year ago and €38.2m last quarter to just break-even. Free cash flow was -€29.3m, versus €8.8m in Q2 and €77m a year ago. Cash reserves are down from €444.6m a year ago and €342.2m in Q2 to €318.6m.

As a consequence of the slowdown in Q3, equipment order intake was just €51.5m, down by 77% from €222.2m in Q2. During the quarter, equipment order backlog fell by



**Aixtron's revenue, order intake & backlog in the last 24 months.**

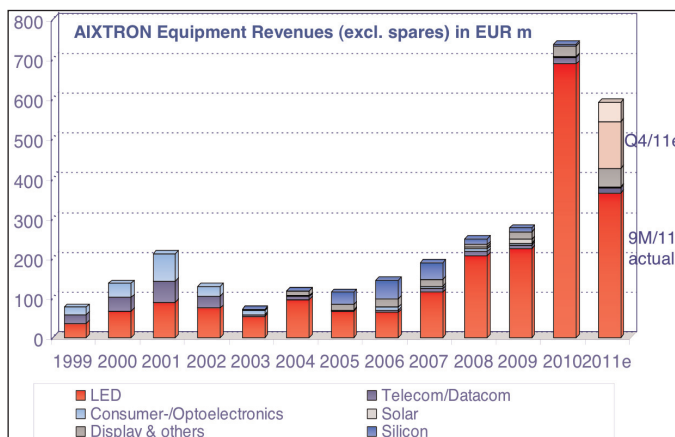
34% from €373.5m to €244.8m (after management lowered backlog by €100m on 15 September).

Despite the current market correction, Aixtron's management remains convinced that this temporary period of uncertainty will be followed by the development of a sustainable LED lighting industry. "There can be no doubt in anybody's mind that the LED lighting investment cycle will come and will be the biggest end-market opportunity this industry has ever seen," asserts president & CEO Paul Hyland. "It is not a question of 'if'; it is only a question of 'when,'" he adds.

"In the difficult market conditions we face today, we are exercising our operational business flexibility and

longer-term market opportunities, into which we are continuing to extensively invest in, through our R&D programs," he continues. "We have a comprehensive pipeline of product developments in progress which directly address the needs of our customers to produce the highest-quality products at the lowest possible manufacturing cost... the products in development, will reinforce our traditionally very strong positioning in all of the markets we serve," he believes.

Aixtron confirms the revised guidance for full-year 2011 that it gave on 15 September, i.e. an EBIT margin of 25–30% on revenue of €600–650m (the €470.8m in actual



**Aixtron's annual equipment revenue, by application.**

revenue from Q1–Q3/2011, plus €118–168m ship-pable equipment orders out of the €244.8m backlog and €11m in assumed Q4 spares and non-equipment revenues). The firm's original guidance was for EBIT margin of 35% on revenue of €800–900m.

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

## Aixtron launches 19x4-inch CRIUS II-XL MOCVD reactor, expanded from 16x4-inch CRIUS II-L

### New susceptor plate expanded from CRIUS II-L's 16x4-inch capacity

After introducing the CRIUS II-L metal-organic chemical vapor deposition (MOCVD) system in early July, deposition equipment maker Aixtron SE of Herzogenrath, Germany has launched the CRIUS II-XL system.

Compared with the CRIUS II-L's capacity of 69x2-inch or 16x4-inch wafers,

the new configuration offers a reactor capacity as high as 19x4-inch, providing what is reckoned to be the world's highest throughput and productivity. Also, CRIUS II-XL provides what is claimed to be best-in-class cost of ownership and footprint efficiency.

CRIUS II-XL builds on the hardware setup of CRIUS II-L. "The only part that needs to be exchanged is the susceptor plate, which means that the larger capacity comes with virtually no extra cost," says Dr Johannes Lindner, program manager for Close Coupled Showerhead (CCS) reactor technology. "This was one of the key design criteria in order to make the transition from CRIUS II-L to CRIUS II-XL as smooth as possible," he adds. "Furthermore, only very minor process tuning factors need to be applied to transfer processes to CRIUS II-XL."

Aixtron says that this latest version of the CRIUS reactor family is again a result of a detailed analysis of market requirements, in particular with respect to LED manufacturing cost. "There is a strong need for cost-efficient LED manufacturing,



**CRIUS II-XL reactor, showing 19x4"-wafer capacity.**

and we know how much MOCVD can contribute to this cost reduction," says VP of marketing Dr Rainer Beccard. "Amongst many parameters, it is the reactor capacity which has the biggest impact on the total cost of ownership. Thus we have decided to design a 19x4-inch setup," he adds. "This configuration has been extensively tested in Aixtron's application lab, making sure it provides perfect uniformity and yield together... The system is optimized for wafer sizes between 2-inch and 8-inch; changing from one wafer size to another requires a simple carrier plate exchange without further hardware or process adjustment."

CRIUS II-XL is the latest addition to the CCS product line, which Aixtron says has proven to provide process stability and robust operation over many years. Standard features of the MOCVD system include an in-situ reactor height adjustment, allowing choice of the optimum reactor geometries for any process regime, and the unique ARGUS in-situ monitoring device.

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

## IN BRIEF

### Aixtron delivers eight more MOCVD systems to Hualei

Aixtron says that, to boost its capacity for GaN HB-LEDs, Xiang Nang Hualei Optoelectronics Ltd of Hunan Province, China has ordered eight new MOCVD reactors: six CRIUS II reactors in 55x2" wafer configuration and two AIX G5 HT reactors in 56x2"-wafer configuration. A local Aixtron service team has installed and commissioned the systems in Hualei's facility in Chenzhou.

Previously in 2009, Hualei Optoelectronics placed Aixtron's largest ever single order for MOCVD systems from China at that time, for multiple CRIUS MOCVD systems.

"The acquisition of further Aixtron MOCVD reactors represents another step in our shift away from an earlier reliance on heavy industry towards high-tech," comments a spokesperson from Hualei Optoelectronics. "Entering the high-brightness LED business was our strategic target and, by working closely with Aixtron, Hualei has achieved its goals quickly and efficiently. Hualei is completely satisfied with the Aixtron Close Coupled Showerhead technology we used in Phase 1 of our GaN HB-LED program, and that is why we will continue to choose Aixtron systems for our next expansion phases," he adds.

"Aixtron was the first company to install a commercial MOCVD reactor in China and since then we have enjoyed excellent relations with the leading institutes and companies," notes Dr Bastian Marheineke, VP sales at Aixtron. The repeat order from Hualei "not only reaffirms the ongoing enthusiasm for investment in new technology in China but also reflects the continued trust in Aixtron-based process technology and support," he adds.

## Singapore's Nanyang Technological University receives Aixtron CCS system for solid-state lighting research

Deposition equipment maker Aixtron SE of Herzogenrath, Germany has announced that Nanyang Technological University (NTU) Singapore has received its new Close Coupled Showerhead (CCS) metal-organic chemical vapor deposition (MOCVD) system. Commissioned by the local Aixtron support team, the CCS 3x2-inch wafer configuration system is being used for research into ultra-high-brightness LEDs and related material systems.

"We have established a solid-state lighting (SSL) lab to develop cost-saving, green solutions to generate and harvest light," comments NTU associate professor Hilmi Volkan Demir, director of Luminous! Center of Excellence for Semiconductor Lighting and Displays. "Already we have fabricated and tested nanostructured white LEDs of nanocrystal quantum dot emitters for high-quality mesopic SSL. Areas where the CCS system will be absolutely vital include III-N epitaxy, doping engineering and epitaxial growth optimization as well as color-converting LEDs with high scotopic/photopic ratio," he adds.

"As well as being dedicated to GaN LED research, the CCS will provide a much needed teaching facility for our school students getting familiar with MOCVD technology," Demir continues. "So, in more than one way the CCS is already proving its usefulness and will continue to do so for many years to come."

Demir is a faculty member of

**We have established a solid-state lighting (SSL) lab to develop cost-saving, green solutions to generate and harvest light. Already we have fabricated and tested nanostructured white LEDs of nanocrystal quantum dot emitters for high-quality mesopic SSL... The CCS will provide a much needed teaching facility for our school students getting familiar with MOCVD**

the Division of Microelectronics at the School of Electrical & Electronic Engineering and Division of Physics and Applied Physics at School of Physical and Mathematical Sciences. He is a recipient of awards including the Singapore National Research Foundation (NRF) Fellowship, the European Science Foundation European Young Investigator Award (EURYI), and the Marie Curie Intra-European Fellowship. He completed his PhD at Stanford University, USA.

The Luminous! Center of Excellence for Semiconductor Lighting and Displays is focused on multidisciplinary studies offering solutions addressing energy efficiency and photometric quality problems in lighting, including the Super-Excitons Program funded by the NRF Competitive Research Program. Luminous! pursues an integrated approach including materials research, device physics, and applications. The MOCVD facility is dedicated to SSL and displays by developing a new class of solid-state lighting white LEDs integrated with semiconductor nanophosphors.

[www.luminous.eee.ntu.edu.sg](http://www.luminous.eee.ntu.edu.sg)

## Aixtron provides Infineon with G5 HT MOCVD reactor for power HEMT GaN-on-silicon development

Deposition equipment maker Aixtron SE of Herzogenrath, Germany says that its customer Infineon Technologies AG has reached the first stage in its plans to evaluate gallium nitride on silicon (GaN-on-Si) power HEMTs with the final acceptance of its new Aixtron AIX G5 HT MOCVD reactor.

In September, Infineon confirmed process acceptance of the system in 8x6"-wafer configuration, with the option to upgrade to 5x8".

"We look forward to further enhance our plans in the field of

GaN on silicon. Our teams are confident that this is an excellent match to our strategy of delivering high-quality, high-reliability devices with outstanding performance," says Dr Franz Auerbach, senior director R&D for Power Management & Supply Discretes at Infineon Technologies. "This is fully consistent with Infineon's strategy to continue to lead the power conversion market, enabling customers to help reduce energy losses," he adds.

"The industry is reaching a new level in power electronic devices

where high performance and cost effectiveness are demanded," comments Aixtron chief operating officer Dr Bernd Schulte.

"To achieve these challenging, sometimes conflicting requirements only the best process equipment will do. We are very proud to share with this prestigious customer all of the state-of-the-art technology that comes with our latest generation MOCVD system, the AIX G5 HT," he adds.

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

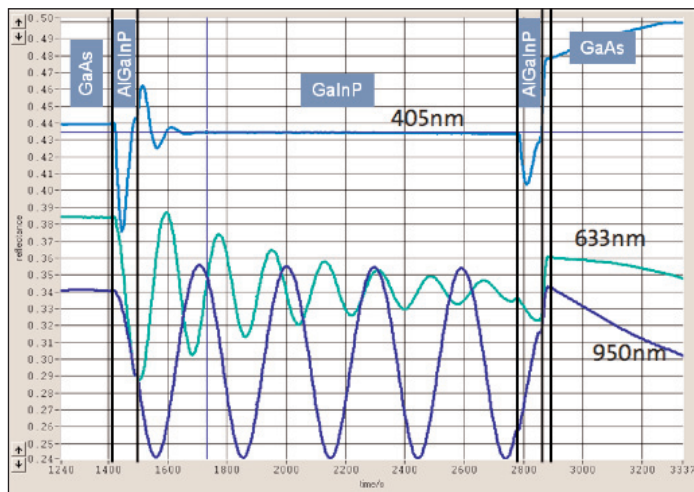
## LayTec launches EpiTT 3W for simultaneous reflectance

In response to growing market demand, LayTec AG of Berlin, Germany (which makes in-situ metrology systems for MOCVD) has launched a new version of its EpiTT reflectometer that offers three simultaneous reflectance measurements. With EpiTT 3W, more complex in-situ

growth studies of compound semiconductor devices composed of materials with wide band edges can now be performed.

Tobias Roesener at Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg was one of the first customers to use the EpiTT 3W. He is working on III-V growth on silicon for future solar cell applications in an Aixtron CRIUS MOCVD system.

"The reflectance measurements at 633nm and 950nm have already been very helpful for us," comments Roesener. "Now with the addition of the 405nm reflectance measurement in my case I got far more sensitive access to the surface morphology. Particularly, it allows me a much better monitoring of surface morphology evolution in thinner layers such as GaInP after only 50 to 100nm [pictured]," he adds. "The 633nm reflectance measurement is perfectly suited for GaInP growth control. At this wavelength we determine growth rates of layers



**Typical AlGaInP/GaInP double hetero-structure on GaAs grown for test purposes.**

which are below 100nm thick. The reflectance at 950nm is better suited for thicker layers."

Roesener adds that, for growth of germanium layers, the application of the 950nm signal is extremely useful. For homo-epitaxial growth of germanium under different growth conditions (temperature, pressure, gas flows) the growth rate and the decomposition of the source materials can be derived in-situ in one single epitaxial process. "This saves me a lot of development time," he states.

The EpiTT 3W is equipped with 405nm, 633nm and 950nm reflectance as a standard and is hence suited to all III-As/P and III-nitride processes.

The new 3W option is also available for LayTec's EpiCurve TT systems. All existing EpiTT, Twin TT and EpiCurve TT systems in the field can be upgraded on-site.

### Sales engineers sought

LayTec plans to expand its international sales department and is looking for new sales engineers. Interested parties with a technical or scientific background in the field of semiconductor epitaxy, thin-film technologies or

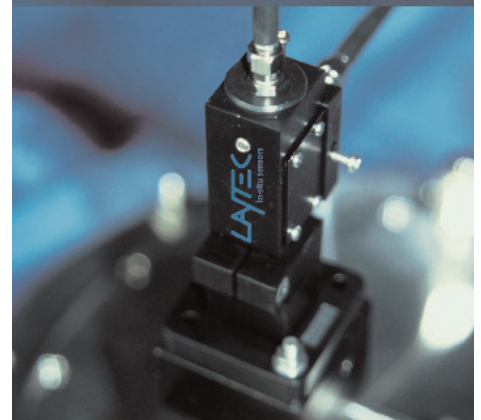
optical metrology can contact Walter Gibas (phone +49 (0)30/39 800 80-18 or e-mail [walter.gibas@laytec.de](mailto:walter.gibas@laytec.de)).

Relevant experience as a sales engineer is welcome.

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

# Buy 2, Get 3!

EpiTT 3W is LayTec's new metrology system for combined emissivity corrected pyrometry and reflectance measurement. Having now three instead of two reflectance measurements at once – 950, 633 and 405nm – enables even better growth control of thick and thin films across wafers, wafer-to-wafer and reactor-to-reactor!



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## SPTS makes industry veteran non-executive chairman

Plasma etch, deposition and thermal processing equipment maker SPTS Technologies Ltd of Newport, Wales, UK has appointed Henry R. 'Hank' Nothhaft as non-executive chairman, providing leadership to the board of directors and assisting senior management with business and corporate development strategies, as well as providing end-market insights.

SPTS says that Nothhaft is recognized as an entrepreneur and industry trailblazer in high-tech markets, having grown several successful companies as CEO and chairman, including Danger Inc (later acquired by Microsoft) and Concentric Network Corp. From 2004 to 2011, he was a board member and, from 2008, chairman, president & CEO of Tessera Technologies Inc, a developer of semiconductor packaging technology.

Nothhaft has also served on a number of boards of directors, including DSC Communications, VMX Systems, Concentric Network Corp, Ocular Networks, Vertical Networks and David Systems, and has recently been appointed to the board of Openwave Systems Inc. He also served on the telecommunications advisory board of Compaq Computer Corp.

"I've observed their amazing growth over the past 2 years, and am looking forward to working with a motivated and talented management team," says Nothhaft about SPTS.

SPTS was formed by parent firm Sumitomo Precisions Products (SPP) in October 2009 to merge Surface Technology Systems plc (STS) with assets acquired from Aviza Technology Inc, including Newport-based single-wafer process equipment subsidiary Aviza Technology Ltd (ATL) and Aviza's US-based Thermal Products business. Also, last December saw the transfer of ownership from SPP to SPTS of Primaxx Inc of Allentown, PA, USA, which provides residue-free micro-electro-mechanical systems (MEMS) dry etch release equipment.

SPTS provides etch, PVD, CVD and thermal process equipment for applications including MEMS, power management, advanced packaging, high-speed RF components on GaAs and high-brightness LEDs. With about 560 staff in manufacturing, sales and service operations across 19 countries, SPTS serves device makers from its main manufacturing facilities in Newport, Wales, UK and San Jose, CA, USA. In 2010 it generated sales of \$217m and earnings before interest, taxes,

depreciation and amortization (EBITDA) of \$58m. This June, SPTS was acquired from SPP by its management, backed by European private equity firm Bridgepoint.

"Our company is on an exciting growth path following the June 2011 management acquisition, and Hank's record of growing technology companies demonstrates a unique ability to see beyond current market needs," says SPTS' president & CEO Dr William Johnson. "We believe Hank's extensive business acumen in taking different businesses to market and making them successful further strengthens an already impressive SPTS executive team," comments Bridgepoint partner and SPTS board member Kevin Reynolds.

An advocate for government policies that nurture innovation, small businesses and start-ups, Nothhaft has authored articles and editorials, including the book 'Great Again: Revitalizing America's Entrepreneurial Leadership', a call to revive America's entrepreneurial spirit. Nothhaft has an MBA from the George Washington University in Information Systems Technology and a BS with distinction from the US Naval Academy.

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

## SPTS ships 600th AVP vertical thermal processing system

SPTS has shipped its 600th Advanced Vertical Processor (AVP) batch thermal processing system to Cypress Semiconductor Corp for its S8 technology platform (supporting TrueTouch, PSoC 3, PSoC 5, CapSense and NVSRAM products).

Manufactured at SPTS' Thermal Products Division in San Jose, CA, the AVP furnace is used for a diverse range of diffusion and low-pressure chemical vapor deposition (LPCVD) applications in the semiconductor, power management, MEMS and compound semiconductor markets. The division maintains development capability on the

common wafer sizes for all these markets, from 100mm to 300mm.

The AVP system is available in a single- or dual-boat configuration, providing flexibility and a low cost-of-ownership (CoO) for all process types, SPTS says. In-situ clean technology enables the AVP to run LPCVD processes for up to 2 years between quartz change, improving system uptime and maximizing productivity. Key processes include wafer annealing from 100°C to >1200°C and the deposition of low-temperature silicon germanium (SiGe), thick doped polysilicon and stress-controlled silicon nitride (SiN).

"SPTS is a key partner in enabling our high-performance SONOS (Silicon-Oxide-Nitride-Oxide-Silicon) technology," comments Cypress' executive VP Shahin Sharifzadeh. "Its expertise in thermal processing technology and commitment to customer service are invaluable in helping us to deliver our products to market," he adds.

"This shipment demonstrates both the success of the AVP product line and pays testament to the strong partnerships we develop with our customers," says Vivek Rao, VP & general manager of SPTS' Thermal Products Division.



## OIPT boosts customer support with dedicated training facilities

Etch, deposition and growth equipment maker Oxford Instruments Plasma Technology (OIPT) has recently created a dedicated Training Facility at its Bristol, UK headquarters and extended its training course schedule as part of an ongoing programme of expansion and facility improvements.

The firm says it recognizes the importance to customers of maximizing their machine uptime and process knowledge, and aims to provide the best training in order to ensure machines are maintained and used to their full capabilities. While Oxford Instruments offers extensive Customer Support maintenance & service packages, it says that it is always beneficial for customers to have enough knowledge to maintain and run their own machines on a day-to-day level. The courses aim to assist customers in achieving this.

The course schedule includes training on PlasmaPro System 80/800, PlasmaPro System 100/133, PlasmaPro NGP 80, PlasmaPro NGP1000 systems, plus the HINE/EMS robotic transfer arm, and end-point detection.

"For both the production and R&D markets, we realize the importance of machine maintenance and uptime," says customer service & support manager Pete Hunt. "Courses are designed to improve process knowledge and system maintenance techniques for engineers and technicians," he adds. "They are given by our experienced training officer, Nick Curtis, with the support of the company's process and system engineers, who not only know the systems but understand our customers' individual requirements."

Course numbers are limited.  
[www.oxford-instruments.com](http://www.oxford-instruments.com)

### IN BRIEF

#### New white paper on ion beam etching

OIPT's new technical White Paper (on ion beam etching) is now available.

Authored by senior ion beam application and technology specialists Dr Sebastien Pochon and Dr Dave Pearson, the white paper considers the main applications and advantages of using the technology for etching processes compared to technology such as plasma etching. An overview of how an ion beam is generated is followed by a presentation and discussion of process applications.

"We offer our customers many technical papers, such as this White Paper, in addition to a process library of over 6000 recipes," says Applications Team Manager Robert Gunn.

The white paper is available from [process.news@oxinst.com](mailto:process.news@oxinst.com)

# Instrumental in change

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- Nanoscale Growth Systems
- Hydride Vapour Phase Epitaxy



For more information, please contact Oxford Instruments Plasma Technology:  
Tel: +44 (0)1934 837 000 Email: [plasma@oxinst.com](mailto:plasma@oxinst.com)

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## SEMI-GAS launches Blixer for precisely blending gases

SEMI-GAS Systems, a division of Applied Energy Systems Inc of Malvern, PA, USA and a manufacturer of ultra-high-purity gas source and distribution systems, has launched Blixer, a custom gas blender that provides a continuous flow of precisely blended gases more economically than buying pre-mixed cylinder gases, it is claimed. On-site blending with a gas blender reduces or completely eliminates the labor required to monitor and exchange gas cylinders, saving time and money while increasing safety, the firm adds.

Blixer — SEMI-GAS Systems' XturionT gas blender — is commonly used to blend two component-forming gas mixtures, but can be used to blend three, four or more gas components into uniform, controlled mixtures for use in the semiconductor, solar, R&D and other high-purity markets.

Each Blixer gas blender is engineered to meet application-specific requirements for flow, pressure,



**SEMI-GAS' Blixer gas blender.**

mixture percentage and blending accuracy. The percentages can also be adjusted by the operator during use via the onboard touch-screen interface. Blixer can support fluctuating usage and variable flow rates

from multiple points, each with independent duty cycles.

Blixer uses mass flow controllers (MFCs) to ensure a highly accurate mixture. An optional gas analyzer confirms mixture percentages and provides a control loop to further improve blending accuracy up to 1% of the minor gas component. Blending routines are completely automated.

SEMI-GAS says that Blixer continuously monitors system performance and safety conditions. The blender will automatically send notifications or shut down if an alarm is triggered.

The enclosure is constructed of welded 11 gauge steel and is 86" tall, 40" wide and 23" deep, with a self-closing, self-latching door and window. The window features ¼"-thick safety glass. The blender includes a UL-approved fire sprinkler and polycarbonate face shield, and the entire system sits on a durable, corrosion-proof, non-skid floor mat.

[www.semi-gas.com](http://www.semi-gas.com)

## Sales of Johnson Matthey V-Purge Systems up among US and European compound semiconductor manufacturers

Johnson Matthey's Gas Purification Technology (GPT) group of West Chester, PA, USA says that 2011 sales of its PureGuard V-Purge System to compound semiconductor manufacturers are up in the USA and Europe.

Johnson Matthey, which designs, manufactures and distributes point-of-use gas purification equipment to the global electronics industry, has shipped its PureGuard V-Purge Systems, hydrogen purifiers and other products to new and expanding fabs for semiconductor and analytical applications including compound semiconductor, crystal growth and photovoltaic (PV) deposition processes.

"While China and Taiwan are still the largest markets for our products, V-Purge System sales are strong in

the US and Europe," says GPT group business manager Jeff Lucht. "These systems are designed to meet the needs of today's largest MOCVD production platforms, particularly for manufacturing high-brightness (HB) and other types of LEDs," he adds.

Lucht says that he expects GPT PureGuard V-Purge System sales to be strong in 2012 "based on the fact that long-term LED market opportunities remain very positive".

The V-Purge System enhances the performance of Johnson Matthey and other hydrogen purifiers for higher flow rates typical in production fabs. The patented system, which employs palladium membrane technology, offers flow rates of 1–200slpm and removes water, oxygen, carbon monoxide, methane,

nitrogen, carbon dioxide and THC (total hydrocarbon) to produce the purest possible hydrogen.

The system provides heat management capable of handling any flow change, what is claimed to be superior protection from power failure and pressure surges, and can switch from full nitrogen to full hydrogen immediately. When the automated purge is activated, it takes the V-Purge System minutes to remove all hydrogen.

Earlier this year Johnson Matthey's GPT group reported that 2010 Asia sales had increased dramatically for its bulk and point-of-use PureGuard PSH Series hydrogen purifiers, due largely to the continuing rapid growth of LED production using MOCVD tools.

[www.pureguard.net](http://www.pureguard.net)

## ATMI acquires full control of Safe Delivery Source rights

ATMI Inc of Danbury, CT, USA (which provides specialty semiconductor materials and high-purity materials handling and delivery solutions) has taken control of, and responsibility for, worldwide distribution of ATMI's proprietary Safe Delivery Source (SDS) gas storage and delivery system and related technologies from Matheson Tri-Gas Inc of Basking Ridge, NJ, USA. The two firms have signed an agreement that terminates Matheson's license, manufacturing and distribution agreement in exchange for a \$95m cash payment.

"SDS technology has delivered tremendous efficiency improvements to the ion-implantation process in the semiconductor industry," says ATMI's chairman, CEO & president Doug Neugold. "ATMI and Matheson worked effectively to develop the product and application to the benefit of customers worldwide. Both parties agree that now is the right time to change our relationship," he adds.

"We are assuming responsibility for all aspects of the product, including manufacturing, distribution, logistics and — most critically — the direct sales interface with

customers," continues Neugold. "Bringing this product and future ion-implantation technologies directly to customers through ATMI's applications and global customer support teams will allow us to deliver the best product and service to them," he adds.

Also, Matheson's parent firm Taiyo Nippon Sanso Corp has agreed to continue as ATMI's distributor of the SDS product line in Japan. Matheson will continue to manufacture a portion of the SDS products for up to two years and will provide distribution and logistics services to ATMI during a transitional period.

"We are appreciative of the long history of distribution success with our partner, Matheson Tri-Gas, which was instrumental in establishing the SDS product line as the industry standard for delivery of hazardous gases into the ion-implantation marketplace," comments Neugold.

The deal will strengthen ATMI's base revenues, margins and earnings, reckons chief financial officer Tim Carlson. "The transaction will be highly accretive and is expected to generate \$7–8m of incremental product revenues and \$0.08–0.09

of incremental earnings per diluted share on a quarterly basis, beginning in the second quarter of 2012," he notes. Over fourth-quarter 2011 and first-quarter 2012, revenue will be impacted by reversals related to previously recognized product shipments into the Matheson distribution channel, as well as inventory burn in regions where Matheson will continue to sell the product until ATMI secures the appropriate licenses and permits to fully conduct business. The expected unfavorable impact on revenues over the combined next two quarters could be up to \$16m, compared to the expected post-transaction revenue level. Also, under existing accounting rules, ATMI expects to take a one-time contract termination charge of \$80–85m in the fourth quarter, subject to completion of a fair value analysis.

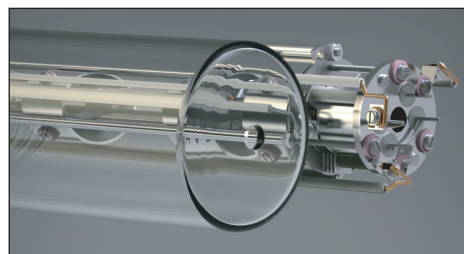
"By bringing the SDS products completely in-house, we are leveraging our advanced-node-focused development capabilities and product portfolio, further strengthening our interactions with customers," Neugold adds.

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

## Hidden launches 3FD mass spectrometer for fast, direct digital signal detection

Hidden Analytical Ltd of Warrington, UK says that, with the new 3FD model, its 3F-series of quadrupole mass spectrometers now features direct digital signal detection for its fastest response and most sensitive detection levels, addressing research needs in the UHV/XHV vacuum regime through to specialized fast-event gaseous studies at pressures to atmosphere and beyond.

The system integrates triple-stage mass filter technology with digital data acquisition by direct positive ion counting (pulse counting) to combine a continuous detection range of seven full decades with a detection rate from just 1 ion per



Probe with quartz shroud (removed).

second and abundance sensitivity measurements to the parts per billion regime. The integral data accumulation mode enables operation with time-functioned data acquisition for the suppression of fundamental ion statistical noise. Vacuum partial pressures to

$5 \times 10^{-15}$  mbar are detectable.

Ionization source options are available for conventional residual gas analysis, for surface desorption studies, and for molecular/laser beam measurements. Single-stage and multiple-stage pressure reduction systems are available for operation at higher pressures beyond the UHV range. Requirements for the measurement of externally generated positive ions and for the measurement of both positive and negative ions are addressed by the alternative EP/EQ series. A custom design service is available for specialized applications.

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

## EVG launches ZoneBOND-capable equipment and open platform for temporary bonding materials

EV Group (EVG) of St Florian, Austria, a supplier of wafer bonding and lithography equipment for the MEMS (micro-electro-mechanical system), nanotechnology and semiconductor markets, has launched a suite of temporary bonding and debonding (TB/DB) equipment modules that support ZoneBOND technology.

ZoneBOND technology is said to provide an approach for temporary wafer bonding, thin wafer processing, and debonding applications that overcomes the last remaining limitations associated with thin wafer processing. It allows the use of silicon, glass and other carriers, is compatible with existing, field-proven adhesive platforms, and enables debonding at room temperature with virtually no vertical force being applied to the device wafer. To support grinding and backside processing at high temperatures and to allow for low-force carrier separation, ZoneBOND defines two distinctive zones on the carrier wafer surface with strong adhesion in the perimeter (edge zone) and minimal adhesion in the center zone. Therefore, only low separation force is required for carrier separation once the polymeric edge adhesive has been removed by solvent dissolution or other means.

EVG says that its new EZR (Edge Zone Release) and EZD (Edge Zone Debond) modules can be easily integrated in the firm's high-volume manufacturing equip-



EVG's GEMINI-TB configuration.

ment platforms such as the EVG850 Series automated temporary bonding and debonding systems. The modules will begin shipping to industrial customers before the end of 2011. Already, earlier this year, Germany's Fraunhofer IZM ASSID (All Silicon System Integration Dresden) received EZR and EZD modules for ZoneBOND processes and materials qualification as part of a joint development agreement with EVG.

In parallel to the launch of the modules, EVG has opened its TB/DB equipment platform to enable the use of a wide range of adhesives from various suppliers to give customers the most flexible choice of bonding materials. Through an open materials platform approach, EVG aims to establish a

stronger supply chain for its TB/DB technologies. It plans to qualify a wide range of adhesives from various materials suppliers for the ZoneBOND process. In support of this effort, EVG has defined standard test procedures that allow for fast and reliable qualification of additional adhesives. The firm

says that it will soon disclose the initial, new materials suppliers supporting the ZoneBOND process.

"Integrating ZoneBOND technology into our field-proven, high-volume temporary bonding/debonding platform is an important part of EVG's efforts to not only ensure our customers have access to the most advanced technology available, but also to continue driving the commercialization of 3D ICs," says Markus Wimlinger, corporate technology development and IP director. "A key advantage of our EZR and EZD modules is their ability to support a variety of adhesive materials, which in turn provides our customers with increased flexibility during thin wafer processing," he adds.

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

## Brewer Science and EVG agreement to enable commercialization of ZoneBOND temporary wafer bonding technology

EVG and Brewer Science Inc of Rolla, MO, USA, which manufactures specialty materials, process solutions and equipment for the microelectronics industry, have announced an agreement that will enable both firms to commercialize

ZoneBOND technology for customers in the temporary wafer bonding market.

"Combining Brewer Science's advanced material development and process integration and EVG's field-proven equipment and

process solutions, ZoneBOND will enable customers to achieve a quantum leap in thin wafer processing," reckons EV Group's executive technology director Paul Lindner.

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

## Summit Partners invests in wet processing tool maker Solid State Equipment

Growth equity firm Summit Partners has completed an investment in Solid State Equipment LLC of Horsham, PA, USA, a manufacturer of single-wafer wet processing equipment.

Solid State Equipment says that it will continue to focus on high-growth segments of semiconductor manufacturing, including advanced packaging processes, mobile communications and mobile computing products, and LEDs.

Founded in 1965, Solid State Equipment designs and makes capital equipment for semiconductor manufacturers. The firm provides products and services for the integrated circuit industry that can be configured to a specific customer's needs, while leveraging standard platforms and proprietary technology to drive efficiencies. Solid State Equipment provides sales and technical support through its global net-

work of direct and independent representatives, including its offices in Horsham, PA and San Jose, CA, USA; Regensburg, Germany; Cramlington, UK; Taiwan; Shanghai, China; Woodlands, Singapore; Gyeonggi, Korea; and Laguna, Philippines.

**Solid State Equipment will continue to focus on high-growth segments of semiconductor manufacturing, including advanced packaging processes, mobile communications and mobile computing products, and LEDs.... Summit Partners has provided us with the growth capital necessary**

"Solid State Equipment has established an exceptional track record through its proprietary technology and exceptional engineering capabilities," comments John Carroll, a managing director at Summit Partners who will join the Solid State Equipment's board of directors. Peter Rottier, a vice president with Summit Partners, is also joining the board. "Solid State Equipment has maintained impressive growth and consistent profitability for nearly two decades," he notes.

"Summit Partners has provided us with the growth capital necessary," says Solid State Equipment's president & CTO Herman Itzkowitz. "Summit Partners' industry experience will be an invaluable resource as we enter our next stage of growth," adds chairman Rich Richardson.

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

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

## Nanometrics TSM metrology tool — now with PL scanning — installed by CIGS PV maker

Nanometrics Inc of Milpitas, CA, USA (a supplier of process control metrology systems primarily for manufacturing semiconductors, high-brightness LEDs, data storage devices and solar photovoltaics) says that a major manufacturer of thin-film PV cells has installed the latest generation of its TSM (Trajectory Solar Monitor) metrology system for in-line process monitoring and control of copper indium gallium diselenide (CIGS) films. Established as a tool for rapid film thickness measurement, the TSM now includes photoluminescence (PL) scanning, expanding its applications and market opportunities.

"Nanometrics' in-line photoluminescence monitoring tools enable PV manufacturers to improve cell efficiency and production yield by closely monitoring and controlling

production processes in a real-time environment," says Nikos Jaeger, director of the Materials Characterization business unit. "The rapid, data-rich process control and feedback provided by the TSM leads to lower costs, improved performance and increased competitiveness," he claims.

The new system incorporates the capability for measuring extremely rough films, enabling monitoring and further yield improvement. "By combining the analytical capabilities of the Nanometrics' NanoDiffract software analysis engine with the data generated by the TSM, our customers are now able to address the high roughness found in latest-generation CIGS solar cells," says director of engineering Lior Levin.

Nanometrics says that, in the

highly competitive thin-film solar market, the need for higher cell efficiency and rapid feedback is vital and requires metrology tools that are both fast and accurate. Backed by Nanometrics' range of technology, applications experience and worldwide support, the TSM product family is aligned to support these requirements, as well as advancements in solar PV manufacturing within the emerging CIGS market, the firm adds.

The systems were installed at the thin-film PV cell maker as a complement to TSM reflectometry tools currently used for in-line buffer, transparent conductive oxide (TCO) and CIGS thickness monitoring, providing a comprehensive, integrated process control solution for PV cells.

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

## Rubicon's revenue falls less-than-expected 22% in Q3

### Strong 6" sales offset 2-4" drop, but excess inventory through Q4

For third-quarter 2011, Rubicon Technology Inc of Bensenville, IL, USA, which makes monocrystalline sapphire substrates and products for the LED, RFIC, semiconductor and optical industries, has reported revenue of \$33.6m (up 64% on \$20.5m a year ago but down 22% on \$43m last quarter). However, this is at the high end of the \$28-34m guidance.

"Although overall substrate demand from the LED market declined in the third quarter, major LED chip manufacturers continue to focus on migrating to larger-diameter substrates in order to gain efficiencies," says president & CEO Raja Parvez. "As a result, we had strong growth in revenue from our 6-inch polished wafers [by 79%, from \$13.9m last quarter to \$24.9m], which helped to compensate for reduced orders of 2- through 4-inch sapphire cores," he adds.

However, driven by a favorable product mix and higher-than-anticipated pricing on 2- through 4-inch cores sales, gross margin was 48%, above the 40-45% guidance but down from 63% last quarter and 54% a year ago. Net income was \$8.2m (\$0.35 per diluted share), down from \$9.9m (\$0.41 per diluted share) last quarter and roughly back to the \$8.3m (\$0.35 per diluted share) of a year ago.

During the quarter, Rubicon repurchased about 425,000 shares of its common stock at an average price of \$12.90 per share (for about \$5.5m in total, leaving \$19.5m authorized for future repurchases under the \$25m program announced last quarter). Cash and short-term investments fell from \$83.5m to \$72.6m.

"Previously, we had anticipated improved demand for sapphire products by the end of the third quarter," says Parvez. "However,

we now expect to see continued softness in the LED market at least through the fourth quarter," he adds. "Although inventory levels at our customers are in decline, there continues to be excess inventory throughout the supply chain, limiting our visibility on future orders for 2- through 4-inch sapphire cores. As a result, we expect prices for those products will decline further in the fourth quarter," he adds.

"Additionally, the prolonged weakness in the LED market could also impact 6-inch polished wafer volumes and pricing, making projecting fourth quarter results particularly challenging," he continues.

As a result of these challenging market conditions, for Q4/2011 Rubicon expects revenue to fall 36% to \$20-23m, gross margin to decline to the low- to mid-30% range, and diluted earnings per share (EPS) of just \$0.07-0.10.

## Rubicon ships 200,000th large-diameter sapphire wafer

Rubicon Technology says that it has shipped a total of 200,000 six-inch sapphire wafers to the LED manufacturing industry.

Rubicon says that it was instrumental in the development of large-diameter sapphire wafers for use in the RFIC market and further developed the process to serve other markets requiring large-diameter sapphire wafers, such as LED lighting and other semiconductor applications.

"Rubicon has significantly more experience in producing large-diameter sapphire wafers than any of our competitors," believes president & CEO Raja Parvez. "LED manufacturers understand that migration to a large-diameter sapphire wafer platform offers an opportunity to achieve production and cost efficiencies," he adds. "This is increasingly important as

LED manufacturers seek to reduce costs throughout the LED manufacturing process to help the industry lower prices of LED-based lighting and encourage adoption worldwide."

Bringing down the price of LEDs is a key element in supporting the worldwide commercial adoption of solid-state lighting based on LEDs as a light source. Government entities around the world including Australia, Canada and the USA have introduced legislation to require energy-efficient lighting. The transition to larger-diameter wafers in LED production has started, with several key LED chip makers having announced plans to migrate to and/or test large diameter wafers in 2011/2012, notes Rubicon.

"There is significant large-diameter wafer activity among LED

manufacturers, with nearly a half dozen working with six-inch in some way," comments Dr Philippe Roussel, LED senior project manager at market research firm Yole Developpement. "By 2016, our research projects that large-diameter wafers measuring six inches and greater will capture more than 50% of the market," he adds.

According to market research firm DisplaySearch, TV applications currently dominate the LED market, but LED lighting will capture the lead by 2014. The LED lighting penetration rate was 1.4% in 2010 and will reach 9.6% in 2014, with growth due to government incentive programs plus commercial applications and consumer adoption worldwide, forecasts the firm.

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

## AlN- and GaN-on-Si templates

Kyma Technologies Inc of Raleigh, NC, USA, which provides crystalline gallium nitride, aluminum nitride and aluminum gallium nitride materials and related products and services, has announced advances in its AlN and GaN on silicon template product lines.

AlN-on-Si templates are fabricated using the firm's patented plasma vapor deposition of nanocolumns (PVDNC) technology, which provides a surface for subsequent deposition GaN- and AlN-based structures.

GaN-on-Si templates are fabricated using patented hydride vapor phase epitaxy (HVPE) technology, which is performed on the PVDNC AlN-on-Si template. The associated manufacturing processes are as follows:

- PVDNC AlN growth process + Si substrate = AlN-on-Si template; and
- HVPE GaN growth process + AlN-on-Si template = GaN-on-Si template.

Key facts associated with the AlN-on-Si template process include:

- no slip lines;
- qualified for customer growth of semi-insulating GaN for FETs; and
- shipped in 2", 100mm and 150mm diameter form factors, and demonstrated in 200mm and 300mm.

Key facts associated with the GaN-on-Si template process include:

- no slip lines;
- higher yield and more reliable process;
- faster and more reliable delivery schedules; and
- available in 2" and 100mm diameters.

"Customer interest is great due to the device performance benefits that nitride semiconductor materials support, along with the cost and diameter advantages of an underlying silicon substrate," says technical sales engineer Tamara Stephenson.

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

## Ranor wins first manufacturing chamber order from sapphire maker

TechPrecision Corp of Center Valley, PA, USA, which makes precision large-scale fabricated and machined metal components and systems for renewable energy, medical, nuclear, defense and aerospace, says its subsidiary Ranor Inc of Westminister, MA has won an order from one of the largest sapphire producers in the USA to deliver an initial chamber to qualify production in December/January. TechPrecision expects volume production shipments to be made in fiscal first-quarter 2013. This is the third sapphire customer TechPrecision has added since July, and the first for its Ranor subsidiary.

With large countries (including China) mandating the use of LEDs and fluorescent bulbs to reduce energy demands, TechPrecision is rapidly expanding its presence in the market for manufacturing chambers required to produce LEDs on sapphire substrates.

"TechPrecision has the ability to manufacture proprietary chambers for the sapphire industry, which is a rapidly growing addressable market for us with strong long-term prospects," says CEO James Molinaro.

"Our Ranor division has the reputation and certifications necessary to provide high-quality and cost effective production of chambers."

TechPrecision aims to complete initial articles in the next few months. "At projected volume, this customer has the potential to fill approximately one-half the capacity which was created when we shifted certain production work from Ranor to our Asia-based Wuxi Critical Mechanical Components Co Ltd (WCMC) subsidiary," Molinaro continues.

"The addition of our third sapphire customer demonstrates our ability to meet the exacting requirements of sapphire customers."

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

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# Haotian opens sapphire manufacturing plant

GT Advanced Technologies Inc of Merrimack, NH, USA says that its sapphire equipment customer Haotian Optoelectronics Technology (HTOT) has celebrated the opening of its sapphire production facility (and its entrance into the sapphire material sector) at its new facility in Guiyang City, Guizhou Province, China.

The city's Vice Mayor hosted the celebration, which included attendance of provincial and local party officials as well as HTOT sapphire material customers, and GT's president & CEO Tom Gutierrez, Cheryl Diuguid (VP & general manager of GT's sapphire material and equipment business) and Jeff Ford (GT's VP & general manager of Asia).

GT announced the sale of its ASF (Advanced Sapphire Furnace) sapphire crystal growth furnaces to HTOT in April. In the 6 months since then, HTOT has built a production facility and is in the process of completing the installation of equipment and ramping to volume production. When the plant is fully operational it will be capable of producing 30,000,000 TIE (2-inch equivalents) of sapphire material annually.

"Over the coming months we will work closely with the HTOT team to ensure a smooth ramp to volume production in their new state-of-the-art facility, which incorporates our ASF crystal growth equipment,"

says Gutierrez. "In their initial production runs, HTOT has successfully grown four high-quality boules, all of which were over 100kg," he adds.

"GT has a proven track record of partnering with companies to accelerate their entry into new markets by giving them the tools and support they need to become key industry players," continues Gutierrez. "Over the next few months we expect several of our other key sapphire customers in Asia to start producing sapphire, and we look forward to working with these customers to ensure their smooth entrance into the sapphire growth industry."

<http://ghtot.com>

## GT lowers fiscal full-year 2012 guidance after drop in orders

For its fiscal second-quarter 2012 (which ended 1 October 2011), GT Advanced Technologies Inc of Merrimack, NH, USA (a provider of polysilicon production technology as well as sapphire and silicon crystalline growth systems and materials for the solar, LED and other specialty markets) has reported revenue of \$217.7m, down 5.8% on \$231.1m last quarter and 5% on \$229.3m a year ago. Revenue by business segment was \$98m in polysilicon (up from \$23.9m last quarter), \$111.2m in photovoltaics (down from \$198.6m), and \$8.5m in sapphire, all of which was sapphire materials revenue (roughly level with \$8.6m).

Although still up on 40.6% a year ago, gross margin has fallen from 49.1% last quarter to 43.7%. Net income was \$36.9m, down from \$52.1m last quarter and \$42.8m a year ago.

During the quarter, cash reserves rose from \$473.4m to \$494m (despite the use of \$61m of cash for the acquisition in August of Confluence Solar Inc, which has developed continuously fed Czochralski growth technology).

"We are pleased to report solid financial performance in the second quarter with revenue and earnings above our guidance and gross margin expansion over the prior year," says president & CEO Tom Gutierrez. "We continued to generate strong cash flow from operations and strengthened our balance sheet, while continuing our investments to extend GT's technology leadership in the polysilicon, PV and sapphire businesses," he adds.

New orders totalled \$65.4m (\$51m in polysilicon, \$3.4m in PV and \$11m in sapphire, down from \$464.7m, \$95.2m and \$776.8m last quarter, respectively). Also, \$27m of adjustments to backlog yielded net orders of \$38.4m. Order backlog has hence fallen from \$2.3bn to \$2.1bn (\$918.6m polysilicon, \$247.2m PV, \$955m sapphire), including \$460.8m of deferred revenue.

"Business activity in our polysilicon segment was robust in the second quarter with bookings by OCI, one of the top polysilicon producers in the world, as well as an engineering services contract with an incumbent polysilicon producer," continues Gutierrez. "In our sapphire business

there were successful ASF start-ups at Saifei and HTOT. In addition, we completed a blind study with a third-party wafer manufacturer that demonstrated the sapphire produced by our ASF system is of the highest quality in the industry," he adds.

"On the PV side of the business, the industry downturn is more severe than most expected and, as a result, we now expect to see additional push outs of PV deliveries into fiscal-year 2013," Gutierrez concludes. "Although we believe our sapphire and polysilicon equipment revenues will strengthen this fiscal year and that we will maintain our leading PV market share, we are adjusting our guidance range to reflect conditions in the PV industry."

After raising its original full-year fiscal 2012 revenue guidance from \$850m-1bn in late May, GT has now lowered its guidance from \$1.0-1.1bn to \$950m-1.05bn (up 10% on fiscal 2011's \$899m). However, the firm has maintained its gross margin guidance of 43-45% (after raising it in August from 42-44%).

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



## GT authorizes \$100m share buyback ...repurchases \$75m of its stock from UBS

The board of directors GT Advanced Technologies Inc has approved an authorization to repurchase up to \$100m of the firm's common stock.

As part of this, under an accelerated share repurchase (ASR) scheme (using available cash on hand), on 21 November GT agreed to buy back \$75m worth of its stock from Swiss financial services firm UBS AG. The number of shares will be determined upon final settlement, with the effective per-share repurchase price based on the volume-weighted average share price of its common stock (minus a discount) during a period of up to four months.

GT is immediately retiring the UBS shares. This will impact earnings per share (EPS) for fiscal 2012.

"We believe our shares are undervalued and that a repurchase makes good economic sense, given the solid fundamentals and outlook of our business," says president &

CEO Tom Gutierrez. "Our cash flows are strong and we remain confident in our ability to grow and invest in our core businesses and to continue to pursue other strategic growth opportunities," he adds.

Repurchases under the remaining \$25m of the authorization may be made from time to time through open market repurchases or privately negotiated transactions. The authorizations do not obligate GT to purchase stock and may be modified, suspended or terminated at any time.

GT also expects to enter into a new credit facility this quarter, replacing a credit agreement with Credit Suisse AG (terminated on 18 November, since it did not meet the needs of GT's growing business). The increase in EPS for fiscal Q3/2012 (to end-December 2011) is expected to be offset by costs related to early termination of the credit facility.

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

### IN BRIEF

#### Massachusetts award

GT is a bronze winner in the 8th annual Team Massachusetts Economic Impact Awards of MassEcon (Massachusetts Alliance for Economic Development), which celebrate firms that have made an outstanding contribution to the Massachusetts economy.

Recognized at a luncheon on 22 November in Boston, winners from five regions (West, Central, Southeast, Northeast, and Greater Boston) were selected based on job growth, facility expansion, and investment since 1 January 2010, plus criteria including community involvement.

GT's award was based on investing \$27m in its new manufacturing plant in Salem. In July 2010, GT acquired Salem-based Crystal Systems. Staffing there has since more than doubled.

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



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# SETi prepares high-volume manufacturing of UV LEDs

## Firm buys new facility and begins building production line

Sensor Electronic Technology Inc (SETi) of Columbia, SC, USA has put in motion a plan to both expand its R&D efforts and to transition its production line to high-volume manufacturing, making it what it claims is the first high-volume supplier of ultraviolet (UV) LEDs shorter than 365nm (initially scaling to supply quantities of more than 100 million LEDs per year).

SETi says it was first to market with short-wavelength UV LEDs in 2004 and has since supplied a portfolio of LEDs and high-power LED lamps from 240nm to 355nm.

SETi currently operates a 15,000ft<sup>2</sup> ISO9001-certified facility, where it runs a vertically integrated

R&D and small-volume production line with epitaxial growth, chip fab, packaging and test and analysis, plus a prototyping line for integration of its LEDs into complete systems.

The first phase of the expansion, which is currently underway, involves retrofitting this facility to 20,000ft<sup>2</sup> and converting it into the firm's R&D center. The expansion in this facility will be focused predominantly around additional cleanroom space for chip fab and device packaging, where new mask designs, processing techniques and packaging solutions will be developed to further improve the performance of SETi's UVTOP and UVClean devices

and to ensure that SETi maintains its position in the UV LED market.

SETi recently closed on the purchase of a new property, where it will focus its high-volume manufacturing lines. The firm's growth plans include expansion of this new facility to 130,000ft<sup>2</sup>. Initially, it will house SETi's proprietary production MOCVD reactors, where the company will focus on the high-volume manufacturing of its migration-enhanced MOCVD (MEMOCVD) process that will be used for the scale up in volume of its UV LEDs and a new Engineering Center for the development of new applications and the production of custom solutions.

[www.s-et.com](http://www.s-et.com)

## SETi powers next-gen phototherapy systems from Psoria-Shield

UV LED maker Sensor Electronic Technology Inc has announced a strategic partnership with Psoria-Shield Inc, the manufacturer of the world's first deep-UV LED powered phototherapy system.

SETi says that Psoria-Shield's flagship device, the Psoria-Light, benefits from the advantages of LEDs to deliver a high power density of narrow band UV light to rapidly treat specific targeted areas of skin conditions including psoriasis, eczema and vitiligo.

SETi's UVClean LED array technology has been incorporated into the Psoria-Light's patent-pending emitter, which enables a compact handset to deliver very high-power deep UV light in the range 300–320nm (the optimum wavelength range for a variety of phototherapies). Psoria-Light systems are sold to dermatology healthcare providers for targeted UV phototherapy.

Bulky, high-voltage class IV laser systems use hazardous gases that need special handling and regeneration, require rigorous safety precautions, and can only be used by operators with specialized



**UVClean products together with UVTOP LEDs.**

medical qualifications. In contrast, Psoria-Light targeted UV phototherapy is available for use without a warm up period, is compact and user friendly, does not suffer the same safety concerns or require a specialized healthcare certification to operate. These benefits significantly reduce cost of ownership for doctors, and that results in improved patient access to this low toxicity, safe and effective therapy. This is only possible with UV LEDs that are fast switching (instant on/off), compact, low-voltage, easier to integrate into systems, and are environ-

mentally friendly.

Psoria-Light is the first phototherapy treatment product to be launched with SETi's UVClean lamps. However, SETi provides UVTOP LEDs and UVClean lamps and solutions that span the UV wavelength range from 240nm to 355nm in a variety of markets including medical, military, space and industrial for applications that include analysis, imaging, sensing and disinfection. SETi's products are backed by an ISO9001-certified business model, ensuring that the tightest of customer specifications can be met for any application, claims the firm.

The UVClean product line includes a range of customized UV LED based solutions such as multi-chip lamps (for high-power or multi-wavelength applications), power supplies, drivers, integrated light sources/modules and full, turn-key UV LED based systems.

SETi and Psoria-Shield exhibited the products at the MEDICA/COMPAMED trade show in Dusseldorf, Germany (16–19 November).

[www.psoria-shield.com](http://www.psoria-shield.com)

## SemiLEDs' revenue falls a further 5% due to delayed China lighting demand Revenue and loss to rebound in December quarter

For fiscal fourth-quarter 2011 (to end August), LED chip and component maker SemiLEDs Corp of Boise, ID, USA (which has chip fabrication facilities in Hsinchu Science Park, Taiwan) has reported revenue of \$5.3m (below the expected \$5.5–6.5m). This is down 54% on \$11.5m a year ago but down only 5% on \$5.6m last quarter (slowing from a 43% drop that quarter). Full-year revenue was \$33.9m, down 5.2% on fiscal 2010's \$35.8m.

Founded in 2005, SemiLEDs' manufactures proprietary blue, green and ultraviolet (UV) LED chips under the MvpLED (metal vertical photon LED) brand for sale mainly to chip-packaging customers in China, Taiwan and other parts of Asia such as Korea, or to distributors who sell to packagers. It also packages some of its chips into LED components for sale to distributors and end-customers in selected markets (mainly for general lighting applications, including street lights and commercial, industrial and residential lighting).

"The market remained challenging in Asia for LED chips and components," says chairman & CEO Trung Doan. "The China market is not improving due to inflationary and monetary issues together with depressed economic conditions around the world. We continue to see pricing pressure due to the weak demand in the China outdoor street lighting market, together with the overcapacity of backlight that has spilled over to the general lighting market," he adds. "The ASP [average selling price] erosion is not as extreme as in prior quarters and prices have stabilized somewhat."

Fiscal Q4 gross margin was -93%, compared with +9% last quarter and +53% a year ago. However, margin was negatively impacted by charges of \$4.3m for the write-downs of inventory and \$1.1m for bad debt reserve.

Net loss was \$13.6m, compared to \$5.1m last quarter and net income of \$5.3m a year ago. Full-year net loss was \$16.1m, compared to net income of \$10.8m for fiscal 2010. Cash used in operations during the quarter was \$2m. Cash and cash equivalents fell from \$94.4m to \$83.6m.

For fiscal first-quarter 2012 (to end-November 2011), SemiLEDs expects revenue to rebound to \$6-7m. Gross margin is expected to remain negative, but net loss should be cut back to \$8-8.5m.

"With so much uncertainty, we remain cautious in our near-term outlook but continue to believe in the industry's long-term market opportunities," says Doan. "When the Chinese government releases funds for the five-year plan, we expect to benefit, given that we are one of the few companies that meets the program's requirements and that we have local presence with our JV, China SemiLEDs [formed in January 2010 in Foshan, Guangdong Province]."

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



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# Current spreading for higher nitride LED output power

## Lateral current flow improved with two-dimensional electron gases in n-type layer

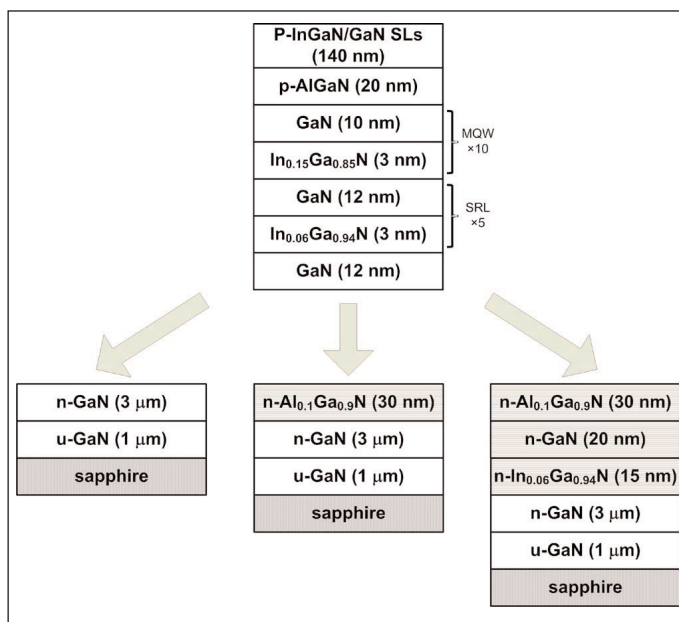
Taiwan National Central University researchers have used two-dimensional electron gas (2DEG) layers in the n-type region of nitride light-emitting device to improve current spreading [Hsueh-Hsing Liu et al, IEEE Electron Device Letters, published online 30 August 2011]. This resulted in lower forward voltages, and higher output power and wall-plug efficiency.

Three device structures were grown for comparison on c-plane sapphire using MOCVD — see Figure 1. The devices differed in having layers inserted between the n-GaN buffer layer and the subsequent stack of active and p-contact layers. This stack included a five-period strain-reducing layer (SRL), p-Al<sub>0.1</sub>Ga<sub>0.9</sub>N electron-blocking layer (EBL), and modulation-doped p-GaN/InGaN superlattice p-contact. The p-type doping was achieved using magnesium.

The epitaxial structures were processed into 1mm x 1mm LEDs with indium tin oxide (ITO) alloy transparent conducting layers on the p-contact.

The three LED n-layer current spreading insertions were: none (LED A); one n-AlGaIn layer (LED B); and three layers consisting of n-InGaIn, n-GaN, and n-AlGaIn (LED C). The extra layers, if present, were designed to improve lateral current spreading through the LED structure. Transmission line method (TLM) measurements on epitaxial structures, without the subsequent LED structures, gave sheet resistances for the LED n-type bases of 50 per square (A), 20 per square (B), and 10 per square (C).

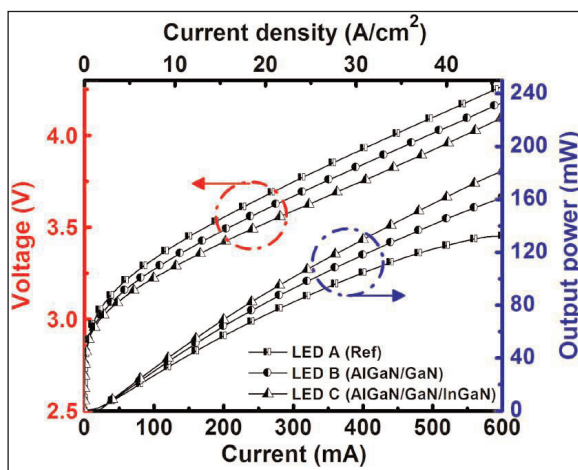
The increase in conductivity in structures B and C arose from the presence of 2DEGs at the n-AlGaIn/n-GaN and n-GaN/n-InGaIn interfaces due to the polarization field differences between the respective materials. Such 2DEGs are used in nitride high-electron-



**Figure 1. Layer structures of the LEDs investigated.**

mobility transistors (HEMTs).

LED B had one 2DEG due to spontaneous polarization and LED C had two due to both spontaneous (n-AlGaIn/n-GaN) and strain-dependent piezoelectric (n-GaN/n-InGaIn) polarization. Simulations suggest that the AlGaIn/GaN 2DEGs had carrier densities of  $\sim 2 \times 10^{19}/\text{cm}^2$  and the GaN/InGaIn 2DEG had a carrier density of  $\sim 4 \times 10^{19}/\text{cm}^2$ ,



**Figure 2. Output powers and forward voltages of LEDs A, B, and C under CW operation. LED C, which has an n-Al<sub>0.1</sub>Ga<sub>0.9</sub>N/GaN/In<sub>0.06</sub>Ga<sub>0.94</sub>N current-spreading layer, exhibits the highest output power and lowest forward voltage compared with LEDs A and B.**

'consistent' with the TLM results.

The simulation shows a potential drawback from including AlGaIn in the n-type layers as being a raised barrier to electron injection into the active light-emitting layers. In fact, the forward voltage of the devices at 350mA was found experimentally (Figure 2) to be reduced in LEDs B and C due to the better current spreading under the

active region: 3.84V for LED A (normal device), 3.76V for LED B, and 3.67V for LED C.

The output powers of these devices at 350mA injection current were 109mW, 118mW and 129mW, for LEDs A–C, respectively. The output power of C was increased by 18% over A. The increase in wall-plug efficiency was 22%, giving a lower junction temperature in C.

The variation in light emission across the three devices was measured at 32%, 24% and 21%, for LEDs A–C, respectively.

The researchers believe these improvements in performance could be carried over to devices with optimized thickness and doping level and/or multiple stacks of the heterostructure current spreading layer.

Tekcore Company assisted in device processing and professor Y-R Wu of the National Taiwan University performed device simulations for the research.

<http://dx.doi.org/10.1109/LED.2011.2163490>



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## Bridgelux LED arrays used by Korea's Ilsung Moolsan in Seoul hotel downlights

LED chip and lighting array maker Bridgelux Inc of Livermore, CA, USA (which claims to be the only vertically integrated maker of LED solid-state light sources specifically for the lighting industry) says that luminaire manufacturer Ilsung Moolsan of Korea has selected Bridgelux LED arrays for the installation of 1000 of its downlights at the new Sheraton Hotel at D-Cube City in Seoul.

Bridgelux's RS and ES LED arrays are specified to light various areas of the hotel, including the lobby, lounge, public gathering areas, banquet halls, and the indoor swimming pool and sauna. Incorporating LED lighting should reduce energy consumption by up to 63% compared with the typical use of halogen and compact fluorescent downlights in these areas of the hotel.

"We selected Bridgelux LED arrays as the light source for our luminaires because they deliver the high quality of light and product reliability demanded by both our company and the Sheraton Hotel's



**Sheraton hotel in Seoul's D-Cube city.**

rigorous lighting standards," explains Ilsung Moolsan's president John Cho. "The Bridgelux arrays offer a high-quality, highly cost-effective and easy-to-integrate solution while providing the beautiful, natural warm white light required for this high-end hotel environment," he adds.

Bridgelux's LED light sources are supporting government-led programs such as the Korea's 'LED Lighting 2060 Plan' (announced in June), which aims to promote greater energy efficiency by increasing the use of LED lighting.

"Switching to LED lighting now offers not only energy savings and maintenance avoidance, but also delivers the quality of light demanded by even the top hotels in the industry," says Bridgelux's chief sales & marketing officer Jim Miller.

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

## Energy Focus achieves DesignLights Consortium listing

Energy Focus Inc of Solon, OH, USA, which provides LED lighting products and turnkey lighting solutions, says that its LED Retrofit Kit has achieved listing by the DesignLights Consortium (DLC), a collaboration of utility companies and regional energy efficiency organizations committed to raising awareness of the benefits of efficient lighting in commercial buildings.

Energy Focus' LED Retrofit Kit uses a single high-output LED array made by LED chip and lighting array maker Bridgelux of Livermore, CA, USA (which claims to be the only vertically integrated maker of LED solid-state light sources specifically for the lighting industry), in combination with

Energy Focus' patented heat dissipation system. It can be used to retrofit existing fixtures including Wallpack luminaires used to illuminate building facades, 'Shoebox' fixtures found in gas station canopies, as well as overhead parking garage fixtures.

DLC listing qualifies the LED Retrofit Kit for energy usage reduction rebates offered by member utilities. Energy Focus says that, with its kit, energy usage can be reduced drastically. For example, when used to replace HID bulbs in existing building 'Wallpack' fixtures, energy savings can exceed 180W.

"Being DLC listed qualifies our customers for rebates from member utilities as well as from many

non-member utilities who consider DLC listings a qualifier for their rebate programs," says marketing manager Julia Dolsen. "Rebates can make all the difference for a customer. In some cases a rebate can be large enough to pay for the LED Retrofit Kit," she adds.

"DLC listing recognizes the important economic value Energy Focus LED lighting products bring to our customers," claims CEO Joe Kaveski. "Energy Focus LED products are not only 'Military Tough', as evidenced by our recent contract to begin re-lighting the military fleet, they also make sound economic sense."

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

[www.designlights.org](http://www.designlights.org)

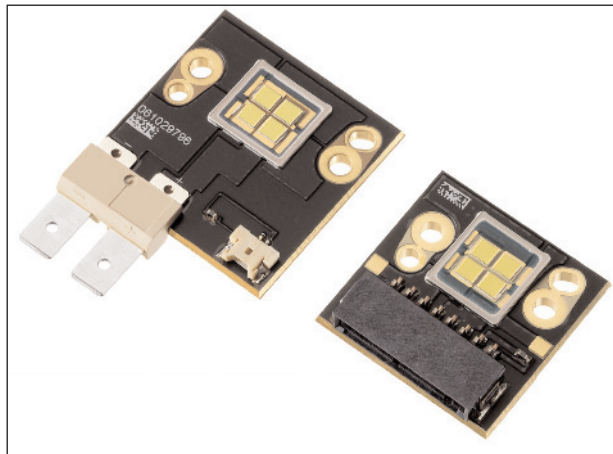
[www.bridgelux.com](http://www.bridgelux.com)

## Luminus' CBM-360 LED powers High End Systems' Trackspot Bolt entertainment lighting fixture

Luminus Devices says that its CBM-360 Big Chip LED is powering the newest generation of Trackspot Bolt entertainment lighting fixtures made by High End Systems Inc of Austin, TX.

The CBM-360 delivers 4000 lumens from what is claimed to be the smallest total source area of any LED package in its class, enabling a compact, high-efficiency imaging optical system for a gobo spot. Luminus says that the Trackspot Bolt builds on its legacy as the industry standard for moving mirror fixtures with pure white-light output from a single CBM-360. Even with high lumen output, the LED provides bright and even light over time using less power, and the fixtures dissipate less heat than the original models, says Luminus.

In what is said to be a unique move, High End Systems is offering



**Lumileds' CBM-360 LEDs.**

a trade-in program through the end of this year for lamp-based Trackspot fixtures. "Luminus' LED engine and the feature set in the Trackspot Bolt come together to offer small clubs and stages state-of-the-art lighting," says High End Systems' product manager

Brad Schiller. "The original Trackspot was extremely popular, and most are still in operation today," he adds. "Our trade-in program helps customers move to modern LED technology and stunning new effects while providing operational savings, extra dependability and long-term service," Schiller continues.

"A compact light engine built around our CBM-360 LED has allowed High End Systems to revive the Trackspot Bolt with more light and features while reducing power consumption at the same time," comments Don McDaniel, Luminus' director of Global Entertainment.

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

## Vice president & general manager of Global Operations appointed

Luminus has appointed Rodolfo Archbold as VP & general manager of Global Operations. He joins from SolarOne Solutions, where he held senior leadership roles including chief operating officer.

Archbold will be responsible for global fabrication and contract manufacturing, assembly, supply chain management, procurement, quality, and continuous improvement programs at all Luminus facilities.



**Rodolfo Archbold.**

including ISO initiatives and development of strategic alliances with worldwide partners," says president & CEO Keith T.S. Ward. "To continue our rapid worldwide

"Rodolfo brings global expansion experience that will be essential to execute our operations strategy,

growth, we need the manufacturing leadership and vision Rodolfo Archbold brings to Luminus; he will enhance all aspects of our global operations," he adds.

Archbold has also held executive positions with Evergreen Solar, Nypro, Hewlett-Packard and Exxon. He holds a B.S. in Chemical Engineering from the University of Puerto Rico, and an M.B.A. in Finance and International Business from New York University.

## Luminus appoints director of sales for North America

Luminus Devices Inc of Billerica, MA, USA, which manufactures PhlatLight (photonic lattice) LEDs for illumination applications, has appointed David Rubin as director of sales for North America.

Rubin assumes the leadership role in managing sales for direct and distribution customers in markets include general lighting, entertain-

ment lighting, displays & signage, and ultraviolet applications.

Rubin joins Luminus from Everlight Americas, where he was president, growing sales in the evolving LED market. He has also held the position of senior VP, sales & marketing, at Brinkman Corp, where he led the consumer and commercial portable LED lighting

business. Prior to Brinkman, he served with Lighting Science Group, developing and delivering LED products to market.

Rubin has a B.A. from University of Texas at Austin, and an executive M.B.A. from University of Texas at Dallas. He is also a member of the Illuminating Engineering Society.

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

## Cree grows sales 11% in Q3, driven by Ruud acquisition 150mm-wafer LED product qualifications to combat pricing pressure

For its fiscal first-quarter 2012 (ended 25 September 2011), Cree Inc of Durham, NC, USA (which makes LED chips, lamps and lighting fixtures as well as GaN and SiC power-switching and RF/wireless microelectronic devices and SiC substrates) has reported revenue of \$269m, up 0.2% on \$268.4m a year ago and 11% on \$243m last quarter.

Growth was driven by about \$20m from just over a month's revenue from outdoor LED lighting firm Ruud Lighting Inc of Racine, WI, USA (acquired on 17 August for \$525m, with the aim of accelerating LED lighting adoption and expanding the market for LED components). Cree has hence promoted Norbert Hiller to executive VP for LEDs and Ty Mitchell to executive VP for Lighting (both new positions). Also, starting this quarter, it is presenting revenue broken into three categories:

- \$196.8m for LED products (components, chips and materials);
- \$51.7m for Lighting products (indoor lighting and Ruud Lighting);
- \$20.5m for Power & RF products.

In particular, Cree saw strong growth in sales of indoor LED lighting products as well as solid growth for XLamp LED components across lighting applications. However, this was offset by lower sales for LED chips and for Power & RF devices (which fell due to lower market demand for solar inverters and high-efficiency power supplies).

On a non-GAAP basis, operating expenses rose from \$61.4m last quarter to \$67.9m, although this was below the expected \$69m. In particular, although R&D expenses rose \$4.1m (\$1.1m higher than targeted, due mainly to increased spending on the 150mm wafer program), selling, general & administrative (SG&A) expenses rose just \$2.3m (\$2.7m lower than targeted, due mainly to lower-than-expected acquisition integration costs and selling expenses).

Gross margin has fallen further, from 49% a year ago and 38.8% last quarter to 37.4% (below the targeted 38%). Factors included: factory utilization that was slightly higher but still relatively low overall; sales of higher-cost LED inventory produced in Q4; an increased percentage of LED lighting products (with slightly lower margins); and the continuing competitive LED pricing environment; partially offset by yield improvements and other cost reductions.

Sales through LED component distributor partners grew again in fiscal Q1, and Cree was able to further reduce channel inventories. "Although demand has improved over the last two quarters, we continue to operate in a competitive environment with short lead times and limited visibility, which makes it challenging to forecast the business," says chairman & CEO Chuck Swoboda. "We continue to manage factory starts to reduce inventory while also trying to maintain flexibility to respond to short lead-time expectations in the market," he adds. "As a result, non-Ruud-related inventory declined from Q4 [by \$11m]."

Net income has fallen further, from \$66.3m a year ago and \$30.6m last quarter to \$28.1m (at the low end of the targeted \$28-31m). Operating cash flow has fallen from \$65.4m last quarter to \$41.6m. After capital expenditure of \$34m (down from \$47.9m), free cash flow was \$8m (down from \$16.6m). During the quarter, cash and investments fell by \$453.6m (from \$1085.8m to \$632.2m) due to using \$457m for acquiring Ruud.

**We have only scratched the surface of LED lighting adoption, and there is growing demand for products that offer innovative solutions and good payback**

While still operating in a short-lead-time environment with limited visibility, order backlog is tracking ahead of fiscal Q1's run rate, and overall demand trends are similar, says Swoboda. Growth in demand is coming from LED components and LED lighting, including both indoor products and BetaLED outdoor products. "The strength in lighting demand reflects the growing reality that LED lighting adoption is happening now," he believes.

During fiscal Q1, Cree launched TEMPO evaluation services, claimed to be the industry's first complete testing service and designed to leverage the firm's experience in LED systems design to help lighting OEMs speed time-to-market and overcome common design challenges. Cree also launched a new XLamp XP-G LED that delivers luminous efficiency up to 140 lumens per watt.

"We secured significant new business in Q1 based on the merits of our lighting technology and ability to deliver products with compelling payback to the customer," says Swoboda. "The buying decisions on these large commercial products do not rely on government subsidies. Rather, they are decided on the quality of the light and standard ROI [return on investment] or payback calculations that take into account energy and maintenance savings," he adds. "Although we have seen tremendous growth in LED lighting sales over the last few years, it is clear that we have only scratched the surface of LED lighting adoption, and there is growing demand for products that offer innovative solutions and good payback," he comments.

"There are some concerns about the health of the global economy that have caused other semiconductor companies to forecast a potential slowdown in the December quarter. We see a similar trend in our LED chip and Power product lines," notes Swoboda. "However, we con-



tinue to forecast growth in lighting and LED components based on our current sales trends and forecasts.”

For fiscal second-quarter 2012 (ending 25 December 2011), Cree expects revenue to grow to \$300–320m, driven by solid growth in lighting from indoor LED lighting products, BetaLED outdoor lighting products and addition of Ruud revenue for an entire quarter, and flat-to-higher LED product sales (including growth in LED components), despite slightly lower LED chip sales and lower Power & RF sales.

Gross margin should be 37–38%, with benefits from yield-improvement and cost-reduction programs offsetting the competitive pricing environment. Operating expenses are targeted to rise by \$10m to \$78m. In particular, selling expense should rise by \$7.5m and G&A (general & administrative) by \$2m,

due mainly to a full quarter of expenses from Ruud Lighting and about \$1m of integration costs. R&D expense should rise by \$1m to support LED chip development, 150mm LED chip product qualifications (after shipping the first chips from 150mm wafers in Q1), new LED component platforms, plus continued investment in LED lighting products. Net income is expected to rebound to \$29–33m.

“We continue to work in qualifying additional 150mm products over the next several quarters. The conversion is on track,” notes Swoboda. “However, the cost benefit is largely a function of factory utilization which remains relatively low. We currently target cost benefits in the second half of fiscal 2012 as we come off the learning curve,” he adds.

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

## Cree subsidiary Ruud Lighting breaks ground on expansion 208,000ft<sup>2</sup> facility to focus on LED luminaire manufacturing, assembly and warehousing

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA says that its Ruud Lighting subsidiary in Racine, WI, has held a groundbreaking ceremony to highlight a 208,000ft<sup>2</sup> expansion to its manufacturing facility. The \$24.5m investment will focus on manufacturing and assembly of LED lighting and is expected to create 469 new full-time jobs over the next 4 years.

“Cree’s recent acquisition [in August] of Ruud Lighting and its BetaLED products brought together two leading LED lighting companies under one roof,” says Cree’s chairman & CEO Chuck Swoboda. “Last month this facility shipped its 500,000th LED luminaire — further evidence of the market demand for the latest LED technology and a need to expand our facilities.”

The expansion will extend component and product storage capacity and house several new manufac-

turing lines for new and existing Cree LED lighting products. The investment will also include equipment needed to expand manufacturing operations. Most of the full-time jobs will be assembly positions, with other opportunities to follow growing demand for LED lighting products. “It’s a long-term investment in the people of Racine County and the community’s manufacturing base,” comments Ruud Lighting’s president Christopher Ruud.

To help offset the \$24.5m investment, Ruud Lighting will receive funding and incentives related to local job creation from sources including the Wisconsin Economic Development Corporation (WEDC), Racine County, Racine County Economic Development Corporation (RCEDC), and the Village of Sturtevant, totaling over \$8m.

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

### IN BRIEF

#### DesignLights Consortium qualifies troffer replacements

Cree says that its entire family of LED-based troffer replacements, including the latest CR series of troffers (launched in April), have been qualified by the DesignLights Consortium (DLC), ensuring that they meet the highest level of quality standards. Cree’s CR14, CR 22 and CR24 troffers, along with the LR24 and LR24-HE troffers, are the most efficient and have the highest color rendering index (CRI) of any products rated in the DLC ‘Linear Panel’ categories.

A collaboration of utility companies and regional energy-efficiency organizations, the DLC has taken the lead in certifying the quality and performance of energy-efficient lighting. Its goal is to ensure that high-quality, energy-efficient lighting design becomes commonplace in all commercial lighting installations. The DLC Qualified Product List is used by utilities around the USA to incentivize the deployment of high-performance solid-state lighting fixtures not covered by existing ENERGY STAR standards, such as LED-based troffers and low/high-bay fixtures.

“For non-ENERGY STAR lighting categories, the DLC Qualified Product List is the de-facto standard for high-quality, energy-efficient lighting,” says Craig Lofton, Cree, VP of sales, LED Lighting. “Cree continues to drive the commercial lighting market, particularly with the release of our LED-based troffer family, and we are pleased that many utilities are now offering rebates on our products to accelerate the LED lighting revolution,” he adds. “In fact, the Cree CR14 and CR24 are the only 1x4 and 2x4 troffers qualified by the DLC.”

[www.designlights.org](http://www.designlights.org)

## Cree launches 10% brighter MT-G LEDs with high color quality and consistency

Cree Inc of Durham, NC, USA has launched new XLamp MT-G LEDs that deliver what is claimed to be higher brightness levels, unparallel color quality and proven lighting-class reliability.

The new MT-G LED is now more than 10% brighter, and can deliver up to 1670 lumens at 85°C in warm-white (3000K) color temperatures. MT-G LEDs are now also available in high color rendering index (CRI) versions optimized for applications such as retail and restaurant lighting, where high CRI and lighting uniformity are required. The new capabilities can enable users to extend existing MT-G designs, and enable new applications traditionally supported by halogen light sources, says Cree.

USAI Lighting of New Windsor, NY, USA is one of the first lighting manufacturers to incorporate the new MT-G high-CRI LED into a luminaire — its award-winning NanoLED

lighting solution. Cree says that the MT-G-based NanoLED provides designers with color quality, efficiency, flexibility and control via proprietary optics to bridge striking aesthetics with functional application in a variety of interior installations.

“Superior color quality is an essential part to ensuring our customers a high-performing lighting solution,” says USAI Lighting’s president Bonnie Littman. “Being able to offer our customers halogen-like color and brightness, along with the energy-efficient benefits of LEDs, is going to be a game-changer,” he believes.

“MT-G LEDs are the flagship product to bring real freedom to lighting OEMs,” says Mike Watson, Cree, senior director of marketing, LED components. “Real freedom is providing options to customers who want the ability to order their LEDs in 2-step or 4-step color consistency

at many color points,” he adds. “Cree was the first in the industry to offer LED components binned at operating temperature,” Watson claims.

XLamp MT-G LEDs are now available with brighter flux and with 90-minimum CRI options. Cree also offers more than 6000 hours of IESNA LM-80 published lifetime data, which can assist lighting manufacturers with ENERGY STAR qualification. With color temperature options ranging from 2700K to 5000K, all MT-G LEDs are available in 2- and 4-step EasyWhite color temperatures, with the option of either 6V or 36V forward voltages. The full range of MT-G LEDs are available for sampling immediately, and production volumes are available with standard lead times.

Cree exhibited its XLamp MT-G LEDs at the Hong Kong International Lighting Fair (27–30 October).

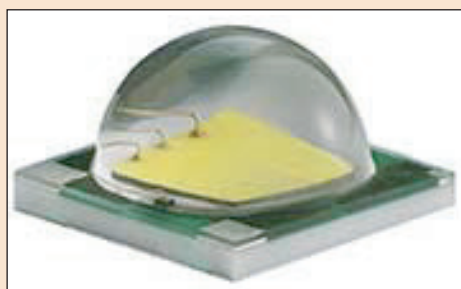
<http://mtg.cree.com>

## Cree launches high-voltage XLamp XT-E and XM-L LEDs

Cree Inc of Durham, NC, USA has announced the commercial availability of high-voltage XLamp XT-E and XM-L LEDs. The new LEDs can enable the use of more efficient, smaller drivers to lower costs for compact lighting applications such as candelabras and retrofit lamps, the firm claims.

“The XLamp XM-L High-Voltage LED eliminates the trade-off between size and efficacy, allowing us to take advantage of the efficacy of high-voltage drivers,” comments Ken Chakravarti, chief technology officer of LED lamp maker Ledzworld. “This translates to more efficient, better and more cost-effective small LED lamps and luminaires such as the B10 replacement lamp,” he adds.

Small-form-factor lighting, like candelabras, historically presented a host of challenges for LED tech-



**Cree’s XLamp XM-L LED.**

nology, says Cree. Prior LEDs were unable to deliver the required system-level performance in the form factor that consumers demand.

“Maximizing the LED voltage, as Cree has done in the new high-voltage XM-L and XT-E LEDs, is a very effective way to minimize current through the LED driver output rectifier,” comments Peter Vaughan, director of applications engineering at IC maker Power Integrations Inc of San Jose, CA,

USA. “This can reduce losses and heat dissipation in the driver and increase the overall system luminous efficacy by several percentage points,” he adds.

“Never before have lighting OEMs been able to leverage the benefits of high-voltage LEDs with this level of performance,” claims Paul Thieken, Cree’s director of marketing, LED components. The XLamp XM-L LED delivers up to 600lm in cool white (6000K) and up to 462lm in warm white (3000K) at 6W, 85°C. The XLamp XT-E LED delivers up to 300lm in cool white (6000K) and up to 228lm in warm white (3000K) at 6W, 85°C. Both LEDs have a typical voltage of 46V at binning conditions.

XLamp XT-E and XM-L LEDs are available now in production quantities with standard lead times.

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

# Why we brag about

Ultra Precision Dispensing Nozzles  
**ARQUÉ™**

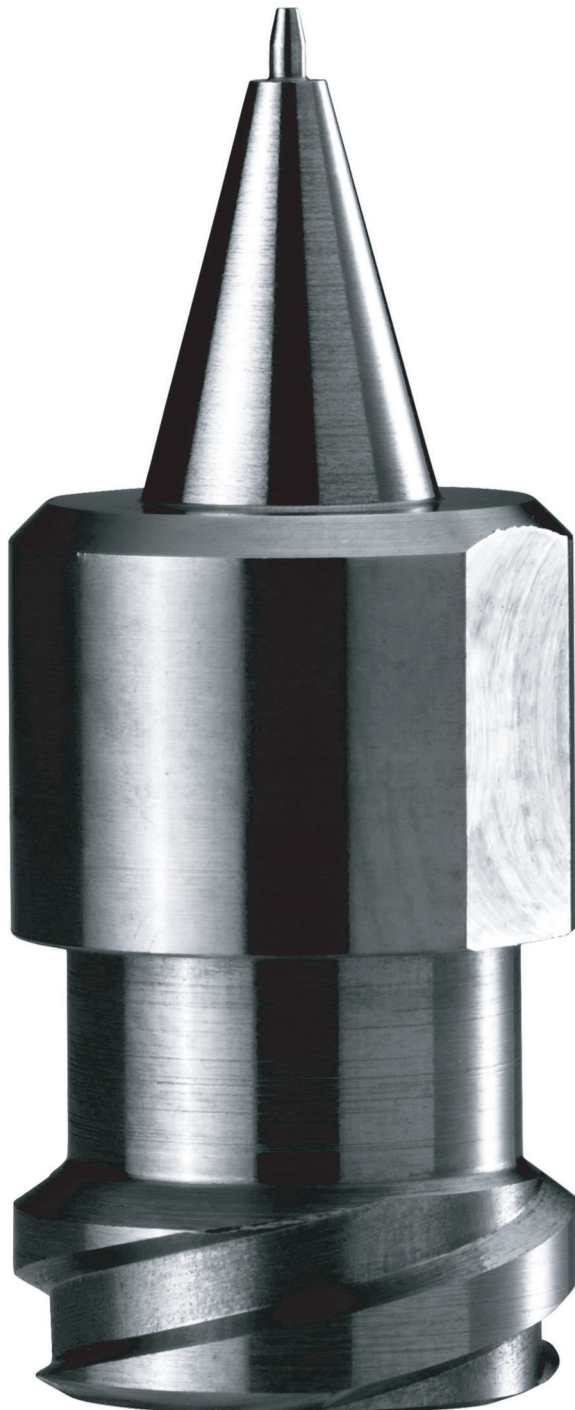
LCD

CXO and TCXO

BGA and CSP Packaging

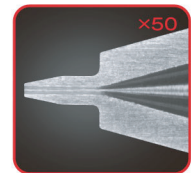
LED Packaging

CCD



## ① Uniquely Polished Internal Surface for

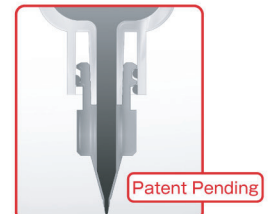
- Exceptional anti-clogging performance
- Precise, predictable shots



Arque Nozzle

## ② Perfect Channel Matching and Alignment to

- Maintain constant flow pressure
- Maximize dispensing yield
- Alleviate bubbling



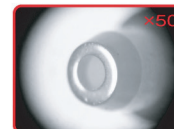
Tecdia Internal Taper

## ③ Lapped Nozzle Tip

- To minimize surface tension stiction



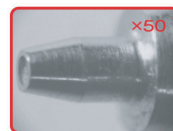
Stainless Steel Nozzle Tip



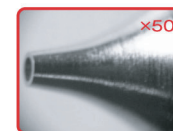
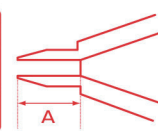
Ruby Nozzle Tip

## ④ Wide Selection of Shapes & Sizes

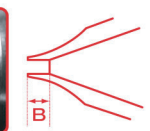
- Providing the right tool for the job



ARQUE



ARQUE-S



## ⑤ Double-Threaded Connector

- Provides secure attachment
- Eliminates loose connection leakage

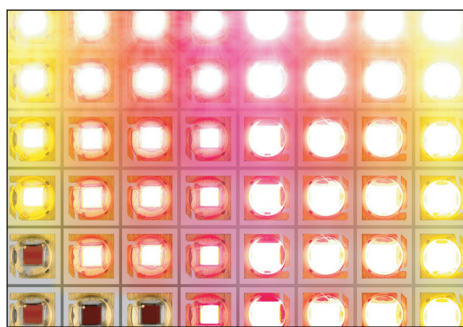
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# New InGaAlP chip technology boosts output and thermal stability of Osram red, orange & yellow Oslon SSL LEDs

Osram Opto Semiconductors GmbH of Regensburg, Germany says that the latest developments in its indium gallium aluminium phosphide chip technology (InGaAlP) have boosted light output of its Oslon SSL LEDs by up to 20% compared with their predecessors and offer improved thermal stability, particularly in Hyperred (660nm wavelength). Energy-efficient applications such as commercial horticulture can therefore be much more efficient.

Powerful, efficient long-life light sources are key for lighting systems that are in operation for many hours day and night, such as those used in commercial horticulture, archtainment and stage lighting, says Osram Opto. The latest chip developments enable the new generation of Oslon SSL LEDs to offer high efficiency and good thermal stability, combined with a low thermal resistance of 7K/W, making them more attractive as light sources that precisely meet such requirements.



**Increased output from colored Oslon SSL LEDs: up to 49% of the current is converted into light.**

Depending on the wavelength (590–660nm), the new LEDs achieve output increases of between 10% and (for the flagship 660nm Hyperred version) 20%. With a brightness of 400mW at an operating current of 400mA, the LED is much brighter than the predecessor model. It converts 46% of the current into light. At an operating current of 350mA it achieves an output of 355mW, corresponding to a conversion rate of 49%.

The LED also has a long life: at an operating current of 700mA and a

temperature of 80°C it will last for more than 100,000 hours (L70/B50) so, in practical applications, fewer LEDs are needed to achieve a particular brightness level, or the same number of LEDs can be used to produce a higher brightness level.

“Our customers benefit from the large increase in brightness because it leads to much shorter payback times,” says marketing manager Martin Wittmann. “In commercial horticulture, for example, lighting systems with these LEDs can result in huge energy savings and low electricity costs.”

With their compact package size of just 3mm x 3mm and a choice of beam angles (80° and 150°), the Oslon SSL LEDs are particularly good for clustering, says Osram Opto, so high brightness can be achieved on a small footprint.

When combined with LEDs in the Deepblue color (450nm), they create a light color that is tailor made for the requirements of commercial horticulture, the firm adds.

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

## Oslon SSL LEDs used in BEKA's LEDlume street-lighting luminaires

Osram Opto Semiconductors' Oslon SSL LEDs are being used in all variants of the LEDlume, the latest family of luminaires from street-lighting maker BEKA (Pty) Ltd of Johannesburg, South Africa, which are designed to improve the energy efficiency and durability of street lighting on the African continent.

In 2010, BEKA equipped its luminaires for the World Cup stadia in South Africa with Osram Opto LEDs. For the new LEDlume street lights, Oslon SSL LEDs are particularly compact, with housing dimensions of 3mm x 3mm, enabling a large range of design possibilities. With a light colour of 4500K and a color rendering index (CRI) of 70, the luminaires ensure aesthetically pleasing light conditions, it is claimed.

A benefit of the LED street lighting is the high efficiency of Oslon LEDs, which yield more than 100lm/W at a drive current of 350mA. As a consequence, the BEKA LEDlume uses about 50% less energy than the existing technology. The BEKA LEDlume can also be optionally furnished with Osram Opto's SFH5711 ambient light sensor, which automatically adapts the brightness of the luminaires to the ambient light or to customer-specified preferences. Thus, by dimming or intelligent switching of the luminaires on or off, more energy can be saved.

The BEKA LEDlume is available in versions ranging from 16W to 90W power consumption, incorporating 12–60 Oslon SSL LED per lumi-

naire. The street lights thus comply with the specific requirements of the African continent. For example, the 12V and 24V versions are also suitable for operation with solar power. The special thermal conditions of the continent have also been taken into account: the luminaires are designed for ambient temperatures of 35°C and as a result, in spite of the high temperatures, the durability of the LED is not affected. Lasting more than 50,000 hours, the average durability of the LED also complies with the L80 Standard so that, once the service life of the luminaire has expired, it will still generate more than 80% of the original brightness.

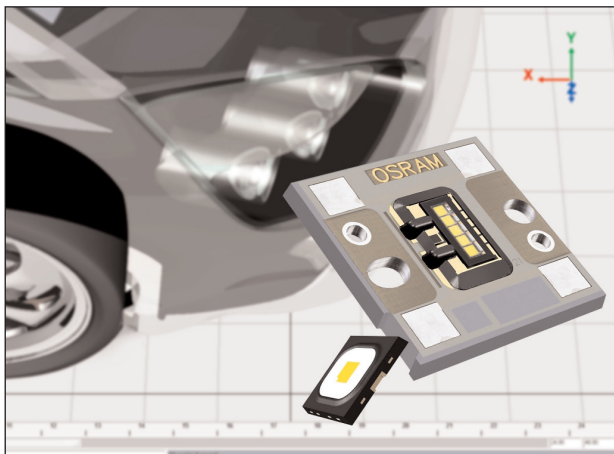
[www.beka.co.za](http://www.beka.co.za)

## Osram launches prototype LEDs for headlights

At the International Symposium on Automotive Lighting (ISAL 2011) in Darmstadt (26–28 September), Osram Opto Semiconductors GmbH showcased two new LED prototypes that combine new chip and package technologies to provide high light output (even at high currents), a uniform light pattern, thermal stability and good contrast ratio. The OSOLON Black Flat and OSTAR Headlamp Pro are matched to the requirements of headlight systems and are designed to provide headlight manufacturers with superior performance and optimized cost.

More flexibility is needed for the light sources used in headlights, says Osram. Not only do they have to be reliable and provide the appropriate amount of light in all visibility and driving conditions, they have to perform various functions and adjust to changing ambient conditions, including high temperatures in the headlight itself. Osram says that it has developed the new LEDs to meet all of these requirements.

OSOLON Black Flat is the latest addition to the OSOLON Black Series and is equipped with a ceramic converter and a QFN package. Its typical thermal resistance of 5K/W is 20% better than the traditional OSOLON Black Series. The black package represents high stability because the coefficient of thermal expansion of the LED matches the coefficient of expansion of the metal core board. The flat top, lens-free design suits the close coupling needed for light guide designs and maximizes the in-coupling of light,



**OSOLON Black Flat (left); OSTAR Headlamp Pro (right).**

says the firm. The solder pad is identical to the other members of the OSOLON family (OSOLON Black, OSOLON MX and OSOLON SX), which enables a wide range of light output from a largely identical board design. With a power draw of 2.3W and an operating current of 700mA, the new OSOLON Black Flat achieves a typical luminous flux of 190lm.

The OSTAR Headlamp Pro is able to meet a wide range of requirements in terms of output and adaptability to ambient conditions. It offers a more uniform light pattern, better thermal stability (more usable warm lumens) and greater brightness than its OSTAR Headlamp predecessor. The new 20mm x 20mm high-flux LED is available in two- to five-chip configurations. The new OSTAR LED offers headlight makers better performance at lower costs, claims the firm. AFS (Adaptive Frontlighting System) functionality can now be achieved with chips that can be controlled

individually or in series. This leads to configurations that allow matrix chip solutions. Typical luminous fluxes are about 250lm for a single chip (1A operating current), equating to 1250lm for the 5-chip version. The thermal resistance of the 5-chip version has been reduced to 2.1K/W, which is 0.5K less (a 20% improvement) compared with its predecessor.

"The two new prototypes combine new technologies with new functionality and are perfectly matched to the demanding automotive requirements of headlight systems," claims Peter Knittl, Osram's director of Automotive LED. "This makes them particularly attractive for widespread use in all vehicle classes," he adds. The design of the prototypes uses Osram's new UX:3 chip technology (which produces high light output even at high currents) and a ceramic converter (which provides a uniform light pattern). Additionally, encapsulation of the chips directly in the reflector produces a defined light/dark boundary in the light pattern, providing a particularly good contrast ratio for simpler and improved optical designs. Such properties make the LEDs suitable for efficient use in headlights, claims Osram.

Initial samples are available now. Market launch is due for Q3/2012.

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

## Mouser to distribute Panasonic's semiconductor products

Mouser Electronics Inc is to stock the product line of Japanese firm Panasonic Industrial Company's semiconductor group, which offers a variety of semiconductors and LED emitters.

The agreement aims to provide design engineers and buyers rapid access to Panasonic's semiconduc-

tor technologies through Mouser's distribution process.

"Bringing our specialized distribution expertise to back Panasonic's premier semiconductor technology will ensure a seamless, efficient experience for design engineers and the essential competitive edge for their latest designs," believes

Mike Scott, Mouser's VP of Semiconductors.

"Mouser has the ability to rapidly get Panasonic's products into the hands of design engineers and buyers," says Jeff Howell, director of Components Group, Panasonic Industrial Company.

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

## IN BRIEF

## Karlsruhe court rules that Dominant violates Osram's LED patents

The higher regional court Karlsruhe in Germany has confirmed that Malaysia-based LED maker Dominant Semiconductors is illegally using or has used technology belonging to Germany's Osram AG in relation to seven patents.

As the court of first instance, the regional court Mannheim had already reached the same verdict regarding three of these patents on 25 July 2007. Osram had sued Dominant on several patents and industrial properties. "The ruling of the court of appeal in Karlsruhe is an important confirmation of our intellectual property rights," says Aldo Kamper, CEO of Osram Opto Semiconductors GmbH in Regensburg, Germany.

The key group of patents (whose infringement the appeal court in Karlsruhe has confirmed) effects conversion technology that helps to produce homogeneous white light. Osram says that the group of patents is essential, as they are used in multiple forms of white LEDs.

Osram says that its legal position against Dominant has already been confirmed in other countries. In the USA, the International Trade Commission (ITC) imposed an import ban on certain Dominant products in February 2006 due to patent infringement. Conversely, suits filed by Dominant against Osram for inadmissible claims of patent infringement and improper exploitation of patent positions have been rejected by courts in both the USA and Malaysia.

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

## Osram's new IR Power Topled boosted by 80% with Nanostack technology

Osram Opto Semiconductors GmbH of Regensburg, Germany says that its new Power Topled with lens (SFH 4258S/4259S) has an optical output of 80mW from an operating current of 70mA, which is 80% higher than the standard version of its infrared LED, despite having the same surface area and the same current.

This boost comes from a special thin-film chip which, due to Nanostack technology, has not just one but two p-n junctions grown one on top of the other. The resultant increased range will most benefit applications in the security sector and in gesture recognition, says the firm.

More light from the same surface area will always be needed if space is tight, if a greater range is required, or if light has to be distributed evenly over a greater area. This can often be achieved more flexibly with a large number of small LEDs than with a small number of large LEDs, and price also plays a key role. Apart from the Nanostack chip and the associated higher output, the new infrared Power Topled is the same as the standard version and can therefore be used as a simple direct replacement. The package dimensions (footprint) remain the same, so existing designs can continue to be used. Because of the series circuit, the voltage is higher by about a factor of two.



**The IR Power Topled with Nanostack technology chips provide high optical output and open up new design options — particularly in the security sector.**

The new infrared Power Topled emits at a wavelength of 850nm and is therefore a good compromise between maximum spectral sensitivity for CCD and CMOS cameras and suppressed visibility for the human eye. It is available with beam angles of  $\pm 15^\circ$  (SFH 4258S) and  $\pm 25^\circ$  (SFH 4259S) from two different lens types.

**The new infrared Power Topled emits at a wavelength of 850nm and is hence a good compromise between maximum spectral sensitivity for CCD and CMOS cameras and suppressed visibility for the human eye**

Osram Opto says that the new LED is particularly useful for infrared illumination, especially in security systems. In CCTV applications the range can be increased significantly with the same number of LEDs. The main area of application in the consumer sector involves camera-based gaming, as this is where high optical output has the greatest benefit. "These high-output mid-segment IR LEDs provide greater flexibility in designing individual customer solutions," comments Dr Jörg Heerlein, senior marketing manager for the industrial sector.

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

## Osram launches DURIS E 5 LED for residential retrofits

Osram Opto Semiconductors says that its new DURIS E 5 LED is intended for the LED retrofit market and has been designed to achieve uniform distribution of light. In particular, with its broad color temperature spectrum, high efficiency and natural color rendering, it is suited to the residential sector and to any other general illumination tasks.

The LED has a high color rendering index (CRI 85) in all available color temperatures and therefore achieve natural color rendering. The LED is suitable for retrofits in the residential sector due to color temperatures of 2700K and 3000K, which are precisely the same as the pleasant light from a classic light bulb. At 89lm/W (3000K) the LED is highly efficient. "Our new DURIS E 5 offers an excellent price/performance ratio," says Andreas Vogler, product manager SSL. "This means that efficient retrofits with high quality of light can be completed at reasonable cost," he adds.

The new LEDs have a package size of 5.6mm x 3mm, which complies with industry standard 5630, and can be arranged tightly next to each other. Coupled with their beam angle of 120°, they offer a uniform appearance in a lamp with no shadows or visible points of light.

The DURIS E 5 is also available in color temperatures of 4000K,

5000K, 5700K and 6500K, making it a versatile light source for a wide range of applications. With just one type of LED it is possible to create neutral-white or cold-white lighting (the kind of lighting that is often required in offices and shops). The LED can be installed in incandescent lamp retrofits, panel lights and downlights. They are also suitable

for the standard soldering process.

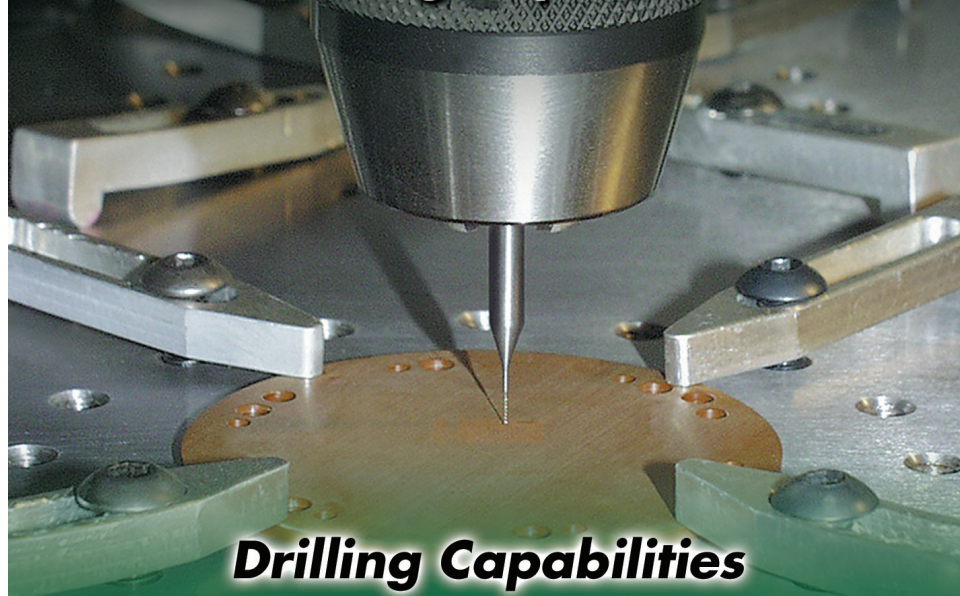
DURIS E 5 is the latest addition to the portfolio of low-power LEDs (<1W) for the SSL sector. The initial product in the family, the smaller (3mm x 1.4mm) DURIS E 3 (launched in June), is now also available in all color temperatures with a typical CRI of 85.

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



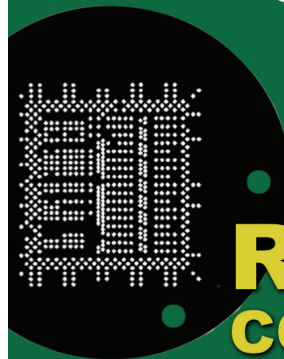
Osram Opto's DURIS E 5 LED.

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## Modulight adds 1W blue laser to LimeLight family

Laser manufacturer Modulight Inc of Tampere, Finland has extended its LimeLight product family with the introduction of blue (1W@465nm) single-emitter-based laser systems suited to medical diagnostics and therapy. Applications in medical field include acne treatment and teeth whitening. Blue laser systems can also be used in applications such as illumination and laser projection.

The LimeLight family comprises lasers for medical, industrial and defense applications in the range 465–1550nm with output powers up to 1.5W. Standard products come with fiber output with



**Modulight's 1W LimeLight blue laser.**

SMA-905 connector, integrated driver, and cooling controller. LimeLight systems can be controlled

**Applications in medical field include acne treatment and teeth whitening**

through a USB port with a standard PC user interface or by an analog/digital control signal directly, supporting both CW and pulsed operation. Module dimensions are 140mm x 56mm x 41mm.

Other package types, as well as an OEM version with varying wavelength and power configurations, are available on request. Currently the following wavelengths and maximum powers are offered as standard configuration: 465nm (1W), 635nm (400mW), 650nm (750mW), 808nm (1.5W), 1470nm (700mW) and 1550nm (500mW).

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

## ISO 13485 certification received for medical laser manufacturing

In October, Modulight was certified by Det Norske Veritas (DNV) according to the ISO 13485:2003 international standard, which states the requirements of the Quality Management System (QMS) for the design and manufacture of medical devices. This adds to the ISO 9001:2008 and ISO 14001:2004 certifications received in 2002 and 2004, respectively, and assures that the firm has the fundamental quality management systems in place for manufacturing lasers for a variety of application, now including medical equipment too.

Modulight is a vertically integrated laser diode maker with design and manufacturing capabilities from chips to complete laser systems over the wavelength range from 465nm to 1650nm. The firm has already offered OEM laser solutions to the medical market for several years, including applications like fluorescence, photodynamic therapy, surgery and dentistry. The ISO 13485 certification further supports the strategy to offer OEM laser component and system solutions for original medical equipment manufacturers.

Apart from the wide variety of component solutions, Modulight also offers SparkLight turnkey laser systems designed to meet the safety and design requirements of medical applications. The SparkLight laser platform can be adapted to power any of Modulight's high-power lasers, offering broad wavelength coverage: 635nm (4W), 650/690nm (5W), 808nm (35W), 980nm (35W), and 1470/1550nm (15W). The same wavelength range is supported with the lower-power (400mW to 2W) and more compact LimeLight laser systems (based on fiber coupled single-emitter lasers).

"Adapting our processes and products to support medical laser equipment

**Having the ISO 13485 certification in place allows us to also offer turnkey laser solutions to medical equipment manufacturers, including possible third-party type approval for a complete laser system**

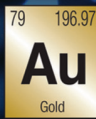
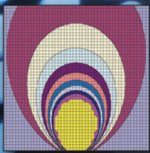
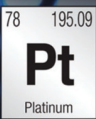
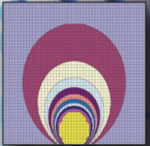
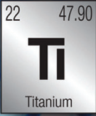
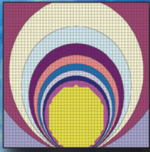
manufacturing is an important milestone for the company and assures our medical OEM customers that our manufacturing processes support directly their product control and approval processes," says president & CEO Dr Petteri Uusimaa. "We clearly see the need for medical equipment manufacturers to rely more and more on external design and manufacturing expertise in the fast-developing laser field. We have already helped a number of companies in medical and life-science markets to save costs and improve the performance of their system by choosing our tailored laser solutions," he adds.

"Having the ISO 13485 certification in place allows us to also offer turnkey laser solutions to medical equipment manufacturers, including possible third-party type approval for a complete laser system for our customer," Uusimaa continues. "We are already doing this for some companies right now and they are seeing the benefits in the form of saving time and money by us choosing the right technical solutions and meeting their end-user requirements from the very beginning."



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*Temescal*

## 3S acquires fiber amplifier & laser maker Manlight

### Diversification promotes components linked to LIDAR and industrial fiber laser markets

With the help of Paris-based private equity firm Eurazeo (which acquired 83% of its capital in October), 3S Photonics Group of Nozay, France, which makes chips, optical discrete modules and passive components for the laser, sensing and telecom markets, has acquired Manlight S.A.S. of Lannion France.

Founded in 2006 through the acquisition of Lannion-based Highwave Optical Technologies S.A., Manlight's 30 staff (who have expertise in fiber amplification and laser technologies) design and manufacture products for telecom networking (from transport to broadband access), industrial, security (LIDAR) and defense.

"The integration of Manlight into the 3S Photonics Group is an important turning point, anticipating terrific growth opportunities," reckons founder & former Highwave Optical Technologies CEO Eric Delevaque. "Commercial and technical synergies will enable us to benefit from the full value of Manlight's know-how and intellectual property," he adds.

Manlight will be a subsidiary of 3S Photonics Group. 3S' president & CEO Alexandre Krivine is appointing Delevaque as Manlight's general manager.

**The Manlight product range allows us to expand our offering for our historical telecom customers**

"This deal fits perfectly into the development strategy we have established for 3S Photonics," says Krivine. "The Manlight product range allows us to expand our offering for our historical telecom customers, and to continue the diversification of our activities by promoting Group components linked to the LIDAR and industrial fiber laser markets, thus enabling us to climb the value chain," he adds.

Earlier in November, 3S Photonics reported a consolidated turnover for fiscal 2011 (to end June) of €51m, up 64% on fiscal 2010 (or up 44% for continuing business). [www.manlight.com](http://www.manlight.com)  
[www.3sphotonicsgroup.com](http://www.3sphotonicsgroup.com)

## 3S reports annual revenue up 64% year-on-year to €51m

For its fiscal 2011 (to end June), 3S Photonics Group of Nozay, France, which makes chips, optical discrete modules and passive components for the laser, sensing and telecom markets, has reported consolidated turnover of €51m, up 64% on fiscal 2010 and within the €50–55m guidance given in April. This includes activities of entities in its French, Canadian and Korean subsidiaries (3S has a 20% stake in COSET Inc). For continuing business, turnover was up 44%.

Growth was driven particularly by the firm's historical market sector of submarine long-distance transmission. The firm also attributes the growth to its expansion in the terrestrial long-distance market, which now represents a 10% revenue share (versus 7% in 2010).

Consolidated EBITA (earnings before interest, income taxes and amortization) was €6.6m. Operating profit was €3.8m. Despite the strong increase in turnover, operating expenses remained stable compared to 2010.

3S says that the fiscal year was marked by successful integration and a pursuit in organic growth objectives thanks to the group's synergies with all subsidiaries, reinforcing its international position and consolidating its product portfolio.

"The excellent results of our 2011 fiscal year demonstrate the success of our consolidation and diversification strategy, especially on the terrestrial long-distance market. It is also a testimony to the continued trust our customers have in the quality of our products," says president & CEO Alexandre Krivine. "Furthermore, the expansion and strategic

**The coming year also promises to be successful thanks to new investments and to a diversification of our activities beyond the telecoms market**

partnerships policy we have undertaken allow us to pursue our international growth," he adds.

"The coming year also promises to be successful thanks to new investments and to a diversification of our activities beyond the telecommunication market," Krivine continues. "Eurazeo's entry in our capital structure allows us to be confident," he concludes.

In October, Paris-based private equity firm Eurazeo purchased the holdings of several 3S investors, including Fonds Stratégique d'Investissement (FSI) for which 3S was one of its first investments. Eurazeo is also investing in a capital increase of €10m to finance 3S' growth, making a total equity investment of €37m (and increasing Eurazeo's stake in 3S to 83%). Eurazeo aims to help 3S consolidate its position in its traditional telecoms markets and broaden its presence in the industrial laser market by supporting its external growth policy, including through future reinvestment.

## Silicon photonics firm Kotura receives New Product Innovation Award for VOA from Frost & Sullivan

At Frost & Sullivan's 2011 Excellence in Best Practices Awards Banquet in San Antonio, TX, Kotura Inc of Monterey Park, CA, USA, which designs and makes silicon photonics application-specific integrated circuits (ASICs) for the communications, computing, sensing and detection markets, has received a New Product Innovation Award from Frost & Sullivan for its variable optical attenuator (VOA) for optical communications. The firm's Ultra VOA Array is a variable optical attenuation system that enables new optical networking functions like wavelength tracking and transient control.

The Frost & Sullivan Best Practices Awards are based on independent, primary analyst research, and recognize unique innovations, commendable leadership, successful business strategies and industry best practices. For the New Product

Innovation Awards, five criteria are used to benchmark products against competitors: innovative element of the product, leading-edge product technologies, value-added features/benefits, increased customer return on investment, and customer acquisition/penetration potential.

"Kotura's use of silicon photonics makes their offering unique in the market, allowing them to bring performance and functionality advantages," comments Frost & Sullivan research analyst Jacek Debowski. "Their Ultra VOA Array device provides benefits to the communications industry by enhancing the capabilities of fiber-based interconnect systems to address the ever-growing requirements for faster optical communications," he adds.

Kotura's Ultra VOA was born out of the growing requirement to better manage the optical channels in

dense wavelength division multiplexing (DWDM) networks. Manufactured using a standard CMOS process, "The Ultra VOA Array is an example of successful implementation of silicon photonics technology in a commercial application," Debowski says.

"To recognize the technology behind our Ultra VOA gives us great satisfaction as we continue our development of next-generation silicon photonics products," says Kotura's president & CEO Jean-Louis Malinge.

Kotura claims to be one of the largest suppliers of VOAs, offering Ultra VOAs in versions supporting 1, 4 and 8 channels. The firm says that its technology platform enables to integrate more functionality on a single chip, resulting in high-performance solutions with a small form factor.

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

## Intense makes chief commercial officer Laughlin CEO

Intense Inc of North Brunswick, NJ, USA, which makes monolithic laser array products, high-power single-emitter laser diodes, and electro-optical subsystems, has appointed Kevin Laughlin as CEO.

Intense says that, as a 26-year veteran of the industry, Laughlin has a broad array of experience, from laser design and optics applications to senior-level positions in product management, sales, and marketing. Most recently, he was chief commercial officer at Intense, where he worked with the management team and investors to consolidate its business units in North Brunswick and Glasgow, Scotland, UK. These now form a single US site providing global manufacturing, sales and service for laser diode components, electro optical sub-modules, and integrated, turnkey laser systems.

"With Intense's individual business units and investor base now consol-

idated, we are well positioned to take advantage of the new growth opportunities in the industry," Laughlin reckons. "Post-consolidation, we will continue to invest in technology, people, and product development," he adds. "Engineering and manufacturing capabilities, innovative QWI [quantum well intermixing] technology, and highly skilled employees combine to produce unique packaged laser solutions that are paving new paths in defense, print, medical, and industrial applications."

Laughlin was Intense's first US employee when he was hired as VP of sales in 2006. In 2007, with its acquisition of High Power Devices Inc in North Brunswick, he took on the role of VP of global sales & business development for both the UK and US business units.

Prior to Intense, Laughlin worked at Nuvonyx in St. Louis, MO, USA

as VP of sales & marketing. He has also held management positions at PRC Laser in Landing, NJ and Strip-pit/LVD in Buffalo, NY.

Laughlin is former chairman of the Industrial Laser Advisory Board for the Laser Processing Consortium at Penn State Applied Laser Research Lab. He is also a former chairman of the AMT's Laser Products Systems Group and has acted as chairman of many technical laser conferences.

Laughlin is currently an active member of the Fabricators & Manufacturers Association (FMA), Association of Manufacturing Technology (AMT), Society of Manufacturing Engineers (SME), and Laser Institute of America (LIA). He has also published more than 40 technical papers and articles, and graduated with a degree in Electrical Engineering and Robotics.

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

## EU-funded researchers demonstrate reliability of IQE-grown VCSELs at 40Gb/s

### First 40Gb/s packaged VCSELs, complete with OM3 fiber pigtail and high-frequency electrical V-connector

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK says that researchers working on the European Commission funded Vertically Integrated Systems for Information Transfer (VISIT) program (for which IQE produces wafers) have demonstrated high-reliability vertical-cavity surface-emitting laser (VCSEL) devices operating at record data rates of up to 40Gb/s, which is four times faster than the current single-channel (serial) data rate used in commercial systems.

VISIT is an EU-funded program with the remit to focus on strategic, high-value photonic components and subsystems for scalable economic broadband access and local-area networks. The central objective of the program, which started in October 2008, is the research, development, test and exploitation of system-enabling optical transmitters having a completely novel design and/or largely improved functionality compared to current technology.

The directly modulated VCSEL devices fabricated on material grown by IQE in Cardiff operate at 850nm, which is the current standard wavelength for optical fiber applications used in short-reach data communication and storage-area networks.

The new technology increases data throughput by up to 400 times

the speed of current copper Ethernet systems and four times that of the latest optical technologies. The VISIT researchers demonstrated VCSELs operating at data rates of up to 30Gb/s at 85°C, and up to 40Gb/s at 25°C with bit-error ratios of less than  $10^{-12}$  which, for many data communication applications, is considered 'error-free'.

The VCSELs also demonstrated temperature stability in the linear region of the light power versus current characteristic with a sub-25µW/°C change in emission power for operation below 6mA at temperatures of 20–100°C. The peak output power exceeded 8mW for multi-mode operation and up to 4mW for single-mode operation, all with differential slope efficiencies exceeding 70% at up to 40°C.

Multi-mode VCSEL device operation was demonstrated at current densities well below 10kA/cm<sup>2</sup>, which is a critical factor in determining device reliability. This is expected to greatly improve with the further development of single-mode VCSELs.

The VISIT team has also produced the first 40Gb/s packaged VCSELs, complete with an OM3 fiber pigtail and a high-frequency electrical V-connector for ease of system-level optical link testing and development.

The prototype VCSELs fabricated using new device processing techniques and device geometries

on wafers produced by IQE's optoelectronic facility in Cardiff operated reliably at 40Gb/s in initial tests, making them suitable for optical interconnectors as well as for optical fiber networks for high-data-rate applications such as data centers.

The next development stage under the VISIT program will focus on final directly modulated VCSEL benchmarking and design and processing refinement, including device designs for reliability and manufacturability. The team will also work on further improvements in the packaging and testing of optical transmitter subassemblies.

VISIT is funded by the European Commission Framework 7 Programme, with Dr Michael Hohenbichler as project officer. It is led by professor Dieter Bimberg of the Technical University of Berlin (Germany), and also includes the following project partners: IQE (UK), Intel Performance Learning Solutions Ltd (Ireland), VI Systems GmbH (Germany), Chalmers University of Technology (Sweden), The University of Cambridge (UK), University College Cork via the Tyndall National Institute (Ireland), Riber S.A. (France), and the A.F. Ioffe Physical-Technical Institute of the Russian Academy of Sciences (Russia).

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

[www.visit.tu-berlin.de](http://www.visit.tu-berlin.de)

## Homogenized conduction-cooled line-source module

DILAS of Mainz, Germany is now delivering a new conduction-cooled, multi-bar, line-source module with a homogeneous top hat optical beam profile in the slow-axis and diffraction-limited profile in the fast-axis. The module is capable of 600W power output in 880nm±5nm.

DILAS has obtained a 97.5% (±2.5%) homogenized intensity profile in the slow-axis. The line dimensions are 10.5mm x 325µm (nominal). Customized focus geometries can be offered as well.

Designed for materials processing applications, the homogenized,

conduction-cooled, multi-bar modules suit solar, plastics welding, semiconductor processing and thermal annealing. They are also available with optional features to include a power monitor and user-exchangeable protection window.

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

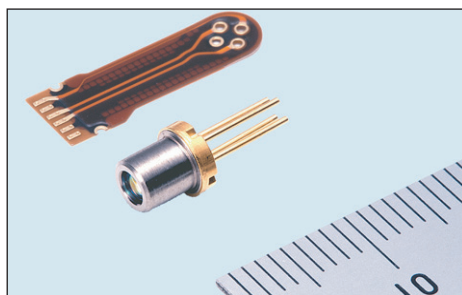
## Mitsubishi to launch DFB and APD for 10G-EPON optical network units

Tokyo-based Mitsubishi Electric Corp has launched the ML7xx42 distributed feedback laser diode (DFB-LD) and the PD8xx24 avalanche photodiode (APD), suitable for the optical network units (ONU) in symmetric 10 gigabit Ethernet passive optical networks (10G-EPON).

While current fiber to the home (FTTH) services are mainly based on 1Gbps Gigabit Ethernet passive optical networks (GE-PON), symmetric 10G-EPON offering 10Gbps upstream and downstream performance are expected to be commercialized soon. However, 10G-EPON are simple networks that use optical couplers and require high-power DFB-LDs and high-sensitivity APDs due to optical loss in the couplers.

Mitsubishi Electric's new high-power, low-current DFB-LD and high-sensitivity APD are both suitable for symmetric 10G-EPON ONUs and hence can contribute to network simplification and faster broadband service, says Mitsubishi.

The new DFB-LD has an aluminum gallium indium arsenide (AlGaInAs) active layer and offers output power of 10mW (with a peak light emission wavelength of 1270nm)



**The ML7xx42 DFB laser diode.**

despite a low operating current of 70mA at high-temperature conditions up to 75C, as well as 10Gbps high-speed performance due to improved modulation bandwidth. The ML7xx42 comes in a 4.8mm TO-CAN package with an aspherical lens cap with high coupling efficiency of 60% (typical).

The new low-noise APD has an aluminum indium arsenide (AlInAs) multiplication layer and operates in the 1570nm wavelength band. With a 5.4mm TO-CAN package with a ball lens cap, the PD8xx24 has a minimum sensitivity of -31.5dBm and an APD responsivity of 0.8A/W (typical). The bandwidth is 6.5GHz (typical value, at a multiplication factor of M=10). A new high-frequency circuit board yields suppressed noise output.

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

## AAG network to be upgraded to 40G

Mitsubishi Electric is to upgrade the 10Gbps transpacific Asia America Gateway (AAG) Cable Network by incorporating 40Gbps DWDM and increasing transmission design capacity up to fivefold to 5.2Tbps. The upgrade, involving installing submarine line terminal equipment (SLTE) in eight countries, should be completed by third-quarter 2012.

Set up in 2009, the AAG network is owned by a consortium of 19 telecoms carriers and consists of over 20,000km of cable linking 10 landing stations in seven South-east Asian countries and the USA.

A field trial conducted on the network proved that Mitsubishi's new coherent high-speed fiber-optic technology enables 40Gbps DWDM transmission beyond 6600km.

"Having received an order for similar work on the transatlantic TAT-14 Cable Network, Mitsubishi Electric will become the first supplier of 40Gbps upgrades to both transpacific and transatlantic networks," notes Masahiro Tsukamoto, general manager of Mitsubishi Electric's Telecommunication Systems Department.

[www.asia-america-gateway.com](http://www.asia-america-gateway.com)

## IN BRIEF

### Mitsubishi's new 10Gbps EML-TOSA transmitter module halves power usage

Tokyo-based Mitsubishi Electric has launched a 10Gbps optical transmission device that halves power consumption compared to conventional models used for high-speed large-volume data transmission between data centers.

The FU-613REA consists of an electro-absorption modulator laser (EML) with a central emission wavelength of 1530–1565nm coupled with a transmitter optical sub-assembly (TOSA).

The EML-TOSA module's newly developed EML chip typically achieves a low power penalty (difference in power before and after transmission) of less than 1.0dB, a high extinction ratio (optical output ratio between 'on' and 'off' modes) of over 10dB, and a high mask margin (indicating the performance of the optical output waveform) of more than 20%. This results in the capability for long-range transmission of data up to 40km.

Mitsubishi Electric says that the increasing use of high-speed, large-volume optical transmission devices at data centers accounts for the consumption of considerable amounts of electrical power. Consumption for the FU-613REA of just 0.6W is about half of the FU-612REA. Also, EML operability at high temperatures (-5°C to 85°C) has allowed the thermoelectric coolers to be downsized.

The module complies with the 10Gbps miniature device multi-source agreement (XMD-MSA) on package size and electrical interface. Mitsubishi Electric has also adopted CAN-type packaging suitable for mass production, replacing box-type packaging used in conventional models.

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

# NeoPhotonics grows margin in Q3 despite 16% revenue drop to \$44m

## Santur acquisition to offset Huawei slowdown in Q4

For third-quarter 2011, NeoPhotonics Corp of San Jose, CA, a vertically integrated designer and manufacturer of photonic integrated circuit (PIC)-based modules and subsystems for bandwidth-intensive, high-speed communications networks, has reported revenue of \$44m, down 16% on \$52.1m in Q2 and down 7% on \$47.2m a year ago, and below the original guidance (given on 4 August) of \$48–53m.

“Lower-than-projected volumes from our largest customer during the quarter negatively impacted our top line,” notes chairman, president & CEO Tim Jenks. China’s Huawei Technologies fell from 51% to 42% of total revenue (with the remaining top-10 customers comprising 46% of revenue, including second-largest Alcatel-Lucent at 10%). The drop is attributed to reduced capital expenditure on 10G and 40G transport and metro systems in China, as well as slower-than-anticipated consumption of access products for GPON and GEAPON fiber-to-the-home (FTTH) networks. “This FTTH network aspect emerged late in the quarter and was surprising to us, given Huawei’s strength in national broadband deployments as well as the rapid rise in demand for these products experienced during the first half of the year, notably to support China Telecom,” comments Jenks.

Also, demand in the second half of September was exceptionally weak. “Accordingly, our vendor-managed inventory for all customers of \$8.4m (as of the end of the quarter) was also considerably higher than our internal projections,” Jenks says. NeoPhotonics total inventory hence rose during the quarter from \$28.9m to \$35.9m. “If we had shipped about half of our vendor-managed inventory as of the end of the quarter as we expected, then revenue for the third quarter would have been within our original projections,” he notes.

“Nevertheless, we continued to experience sequential growth from many of our other customers [6 out of the top 10], notably in the US and Europe,” Jenks says. In contrast to the demand for ‘Access’ products falling from 43% to 35% of total revenue, demand for ‘Speed and Agility’ products continued (rising from 32% to 36% of total revenue), including a fourth sequential quarter of growth in 100G coherent products. Demand for ‘Other Telecom’ products (legacy products such as DWDM, SONET and SDH devices) rose from 25% to 29% of total revenue.

As Speed and Agility products generally have higher gross margins than Access products, the positive revenue mix plus continued growth in 100G coherent products contributed to the third sequential quarter of margin expansion. On a non-GAAP basis, gross margin was 27.5%, down from 30.9% a year ago but up from 26.2% in Q2 (and above the projected 26%).

Net loss was \$3.2m, compared to break-even in Q2 and net income of \$1.2m a year ago. CapEx was \$3.3m. Cash, cash equivalents and short- and long-term investments fell to \$103.4m from \$107.5m last quarter.

During Q3, NeoPhotonics added to its SFP+ transceiver product suite with products that enhance its existing portfolio of 6G and 10G SFP+ transceivers for Common Public Radio Interface (CPRI), 10G Ethernet and SONET/SDH transport applications. The transceivers are designed to support the environmental impact initiatives of carriers as they seek to reduce their broadband networks’ power consumption and carbon footprint.

NeoPhotonics also made available samples of its first extended-reach transceiver module for 10G PON applications in an XFP form factor (designed to enable carriers to leverage investments in existing infrastructure by being backward compatible for upgrading fiber-optic broadband access networks from 1.25G and 2.5G to 10G data rates), as well as its first 40G transceiver module in a CFP form factor for cloud and data-center applications (designed to meet increasing bandwidth demand in data centers). Compared with a traditional 10G approach, the new pluggable transceiver module transmits four times the data over single-mode fiber at

During Q3, NeoPhotonics signed leases to establish facilities including: a design and sourcing center in Tokyo, Japan (to support high-speed network module design for next-generation systems and sourcing); a design center in Wuhan, China’s ‘Optics Valley’ (to support next-generation optical subsystem and integration design); and a production facility in Dongguan, Guangdong province, southern China (45 minutes’ drive from the firm’s existing facility in Shenzhen, to provide greater manufacturing capacity for its global customer base). The 80,000ft<sup>2</sup> factory will be facilitated in phases, involving CapEx of about \$9m over the next 5–7 quarters (including \$3m for the first phase), becoming operational by end 2012.

NeoPhotonics has also amended its credit facilities with Comerica Bank to provide an increased \$35m facility including a revolving line of credit, term loan and an equipment loan. The firm drew \$28m of this in October to partially fund buying Santur Corp of Fremont, CA, a designer and manufacturer of indium phosphide (InP)-based PICs.

Founded in 2000, Santur has focused on commercializing PIC-

**The inventory oversupply issue at the beginning of this year has played out**

► based laser array and packaging technologies for communications, shipping about 400,000 active PIC-based products to date. It has about 140 staff in a facility that includes an InP fab, labs, and engineering and administrative space. Its primary assembly & test capability is provided by a contract manufacturer in Malaysia. NeoPhotonics says that Santur's technology includes established telecom designs offering wide tunability as well as high-speed transceivers. Products are designed to provide reduced size, power consumption and cost for a wide range of DWDM, coherent and client-side networking applications in 10G, 40G and 100G networks.

In contrast, NeoPhotonics has focused on PIC products that use hybrid integration technologies to combine internally produced silica on silicon chips, while purchasing InP devices for certain advanced products. Santur boosts NeoPhotonics' number of product families to 43.

Although there is some overlap in customer bases, such as Alcatel-Lucent, Ciena and Huawei, Santur brings certain data-networking customers, such as Google, that expand NeoPhotonics' customer base. "The acquisition of Santur improves our consolidated customer mix, decreases our customer concentration, and increases our exposure to data networking from a telecom focus and can provide sales synergies over time," believes Jenks.

"With Santur, we have acquired a broad-based InP capability that includes tunable lasers, arrays of lasers, InP modulators, transmitters, and components for coherent receivers," says Jenks. "By combining active InP PICs from Santur with our hybrid PICs, we can provide the transmit side of coherent systems as well as the receive side. We can also create highly integrated PICs that contain multiple channels of 10, 40 and 100G together. Combined, the two companies complement each other's PIC technologies and expand our spectrum of key technologies, product opportunities and materials expertise," he adds. "The acquisition enhances our leading position in PIC-based modules and subsystems for high-speed networks and can further accelerate our growth in the 100G coherent and cloud computing markets."

Santur recorded revenue of \$21m for first-half 2011, and about \$10m in Q3. In future, NeoPhotonics will report Santur's revenue within its Speed and Agility product group.

For Q4/2011, NeoPhotonics anticipates that results could be impacted by continued volatility in volumes demanded by its largest customer (due to lower-than-projected demand in China), the flooding in Thailand (indirectly, since some customers' systems use components of other suppliers that use contract manufacturing there), and uncertainty in the macro-economic environments

in Europe and North America.

"The inventory oversupply issue that characterized the industry at the beginning of this year has played out; we do not believe that oversupply will continue to materially impact the industry in the fourth quarter," believes Jenks. "Nevertheless, we do not expect a 'snap back' in demand, because our experience is that demand that is pushed to the future does not generally have a cumulating effect on top of the next quarter's more natural demand," he adds. Accordingly, for Q4/2011 NeoPhotonics expects revenue to rise only slightly to \$45-50m (including \$5-6m from Santur, from 13 October) and gross margin to fall to 19-22% (impacted by below-corporate-average margin from Santur products).

"Though we will remain cautious in our outlook for Q4, we also remain firm believers that the demands for greater bandwidth, elimination of network bottlenecks and higher transmission speeds will continue, and that these trends will continue to drive the demand for our products," concludes Jenks. "While Santur has not been profitable historically, we believe that as a combined entity, we can grow the business and manage expenses to drive Santur's operations to contribute to earnings," he adds. "We currently expect that Santur's operations would contribute to earnings in five to seven quarters."

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

## NeoPhotonics receives Huawei's Golden Supplier Award

NeoPhotonics has received the Golden Award as an Excellent Core Partner from China's Huawei Technologies Co Ltd (one of the world's largest makers of optical telecoms networking equipment).

At a ceremony at Huawei's headquarters in Shenzhen, NeoPhotonics was honored for its contributions as a supplier of innovative technology, plus high-quality and on-time delivery of its optical products for high-speed, agile and access communications networks.

Of the more than 1000 suppliers that Huawei works with each year, the award is given only to firms that consistently deliver the highest-performance and quality products that meet Huawei's specialized requirements. Out of 30 vendors of optical products, Huawei chose six as Core Partners, of which four were given the Golden Award for supplier excellence. This is the third time that NeoPhotonics has been recognized as a Core Partner.

"Recognition by Huawei is a testa-

ment to the high-quality products and volume manufacturing capabilities of NeoPhotonics," said NeoPhotonics chairman & CEO Tim Jenks.

Huawei has grown to become the second largest mobile network equipment provider in the world, serving more than 470 telecoms operators in over 130 countries. Huawei was one of the earliest customers of NeoPhotonics, which has supported Huawei's expansion over most of the last decade.

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

## Infinera cuts loss as Q3 revenue rebounds by 8% on Q2 ...but sales still down 20% year-on-year

For third-quarter 2011, Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has reported revenue of \$104m, down 20% on \$130.1m a year ago but up 8% on \$96m last quarter.

"We remain encouraged by our recent revenue performance and the momentum in booking activity as customers continue to address their increased bandwidth needs with Infinera-based networks," says president & CEO Tom Fallon. "Several factors are contributing to these trends — our significant installed base, the broader application of our product line, our expanded sales force, and a stronger focus at Infinera on key vertical markets and across geographies," he adds.

Fallon notes that the top customer in Q3 was one of North America's leading cable companies and that Infinera's pipeline remains active, with opportunities in the submarine space and with wholesale carriers in North America and Europe. One of the Tier 1 customers was among its top five customers in Q3.

**Fallon notes that the top customer in Q3 was one of North America's leading cable companies and that Infinera's pipeline remains active, with opportunities in the submarine space and with wholesale carriers in North America and Europe**

On a non-GAAP basis (excluding restructuring and other related costs and non-cash stock-based compensation expenses), gross margin was 41%, down from 51% a year ago but level with last quarter. Net loss has been cut from \$11.7m last quarter to \$9.2m, although this compares with net income of \$18.7m a year ago.

"We were also pleased with the recent launch of the DTN-X, our new multi-terabit packet optical network platform based on our third-generation 500Gb/s PICs, a pair of chips that integrate more than 600 optical functions and will deliver the world's first 500Gb/s FlexCoherent super-channels," says Fallon. "Customer response to the value proposition of the DTN-X — as well to the newly enhanced features of the DTN — has been very positive," he adds.

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

## TeliaSonera and Infinera complete world's first Terabit trial based on 500Gb/s super-channels

Infinera and TeliaSonera International Carrier of Farsta, Sweden, which provides fiber-based telecoms services and infrastructure, have completed what is claimed to be the world's first Terabit optical transmission based on 500Gb/s super-channels.

The demonstration spanned 1105km of fiber between Los Angeles and San Jose in California, marking what is reckoned to be a milestone in optical networking and offering a glimpse of what the network will be. The trial was conducted with elements of the new Infinera DTN-X platform and demonstrated twice the capacity of previous trials by adding a Terabit of capacity to a route carrying 300Gb/s of production capacity.

"As 10Gb/s services proliferate and 100Gb/s router ports emerge, we are trialing advanced solutions

that scale optical networks beyond 100Gb/s," says TeliaSonera International Carrier's president Erik Hallberg.

"We are delighted to work with TeliaSonera International Carrier to validate the 500Gb/s super-channel implementation that is the foundation of this Terabit demonstration," says Infinera's CEO Tom Fallon. "We share a common vision of delivering the scale, simplicity and agility needed to win in a highly competitive environment."

Infinera claims to be the first firm to demonstrate super-channels based on 500Gb/s photonic integrated circuits (PICs). A super-channel is a large unit of optical capacity created by combining multiple optical carriers into a single managed entity, so that optical networks can scale capacity without scaling operational cost and

complexity. Super-channels based on PICs enable operators to simply provision 500Gb/s of capacity with a single operational maneuver. The DTN platform, ATN platform and Infinera Managed Services are elements of Infinera's portfolio as well as the recently announced DTN-X packet optical transport network platform that supports 500Gb/s super-channels.

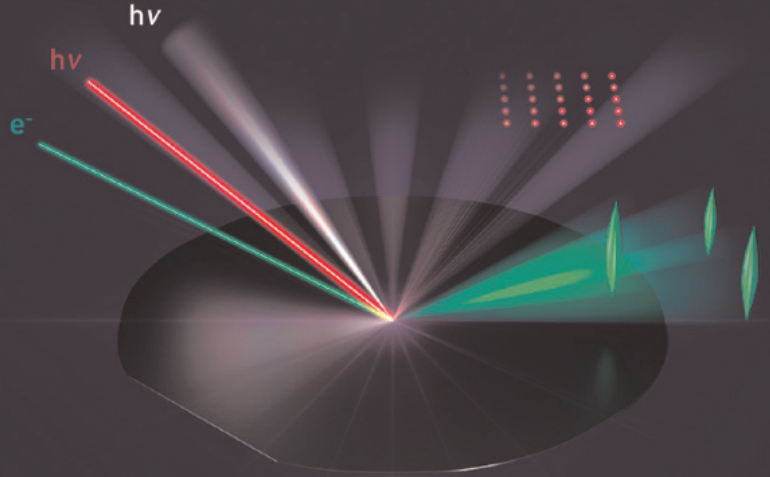
TeliaSonera International Carrier is part of TeliaSonera, Europe's fifth largest telecoms group, which has 164 million subscribers generating revenues of over \$11bn. The firm continues to expand the North American footprint of its global network, driven by strong demand from both operators and content players for IP, DWDM, voice and specialist-mobile services.

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





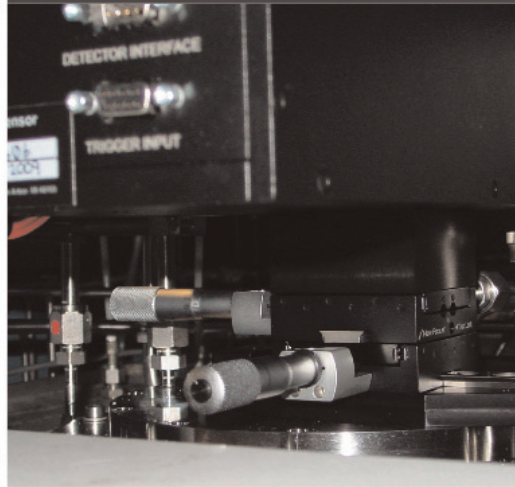
## Control Your Process! Real-Time Process Monitoring for MOCVD, MBE, Sputtering, and Thin-Film PV Deposition



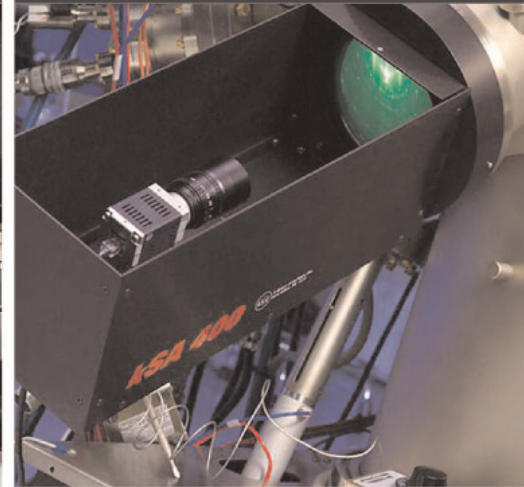
kSA BandiT Wafer Temperature



kSA MOS and kSA Mini-MOS  
Thin-Film Stress



kSA 400 Analytical RHEED



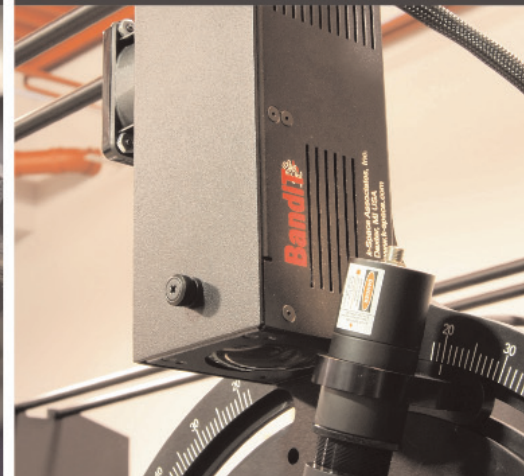
kSA MOS Ultra-Scan and  
Thermal-Scan Stress Mapping



kSA Rate Rat Pro Thickness &  
Deposition Rate



kSA BandiT PV Process Tuning



## IN BRIEF

## TE launches compact CWDM module for easy fiber capacity expansion

TE Connectivity has launched its Compact CWDM (CCWDM) module, a new addition to TE's Fiber Optic Splice Closure (FOSC) family of products for service providers that want to expand the capacity of their fiber plants without the expense of deploying additional fiber cables. The CCWDM module splits out four or eight wavelengths from a single fiber and can be installed in the field or in the factory. In addition, the CCWDM module comes with a unique carrier that snaps into TE's FOSC closure trays to securely hold the CWDM module in place.

The CCWDM module is available in 4- or 8-wavelength versions, with or without upgrade and 1310nm ports, to multiplex or de-multiplex wavelengths. This provides greater cable plant versatility while provisioning commercial customers with high-speed data, digital phone and video services. The module features low optical loss and is compatible with most TE FOSC closures. Up to two CCWDM modules can be mounted in a single FOSC A, B or C closure tray and more than two devices can be mounted into a single FOSC D closure tray. Also, when used without the carrier, the CCWDM module can be mounted in most competitive splicing trays as well.

"Its compact size and carrier tray set it apart from the competition by making it easier to deploy in a variety of field situations," claims Jaxon Lang, VP of TE's Telecom Networks Americas business unit.

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

## OIF approves new project for 100G Integrated Dual Polarization Quadrature Modulated Transmitter Assembly

Project to address cost and performance trade-offs to open higher-volume applications

Members of the Optical Internet-working Forum (OIF) have approved a new project on Integrated Dual Polarization Quadrature Modulated Transmitter Assembly (ITXA), targeting lower-cost, higher-density applications.

The project provides a common electrical interface that allows the inclusion of other modulator technology that may offer substantial cost and size reduction for a transmitter assembly. Carried out under the 100G umbrella program, the project recognizes the increasing need for adoption of other modulator technologies and for size and cost reduction.

"Our existing Polarization Multiplexed Quadrature Modulated Transmitter has been successfully adopted in ultra-long-haul and metro markets," says Karl Gass, the OIF's Physical and Link Layer Working Group vice-chair and a consultant to TriQuint Semiconductor Inc of Hillsboro, OR, USA. "This companion project will address cost and performance trade-offs necessary to open higher-volume applications."

**OIF Day at China Telecom**  
OIF vendor members attending the fourth-quarter meeting were invited to attend the OIF Day at China Telecom interactive symposium (a collaborative and educational workshop featuring OIF and

China Telecom subject matter experts covering OIF projects and directions, intelligent optical networking, 100G and beyond). "China Telecom was pleased to host the first OIF Day event in Asia," says Chengliang Zhang, deputy chief engineer of China Telecom Beijing Research Institute. "By opening our doors to OIF members, we were able to increase the depth of discussion with vendors, and express our specific challenges and strategies," he adds.

### Election results

Newly elected to the position of Technical Committee vice chair is Nathan Tracy of TE Connectivity. Re-elected to Interoperability Working Group chair for a two-year term is Jim Jones of Alcatel-Lucent. Jones was also re-elected to a two-year term to the board of directors, where he will continue as OIF president. Also re-elected to the OIF board (both for one-year terms) are Torsten Wuth of Nokia Siemens Networks and Martha Fratt of AT&T, where she will continue as OIF treasurer/secretary. Steve Joiner of Finisar returns to the board, elected to a two-year term.

### Additional implementation agreements from OIF

The following implementation agreements (IAs) were approved by members. The 'Security for Management Interfaces to Network Elements', the 'Update to Security Extension for UNI and E-NNI 2.0' and the 'Update to OIF Control Plane Logging and Auditing with Syslog version 1.1' implementation agreements all address different security issues in the network. The IAs are available to the public at:

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

# Opnext's revenue falls 7.6% as China OEMs start producing 40G modules internally

## Thailand-impacted manufacturing to re-start elsewhere by December

For its fiscal second-quarter 2012 (to end-September 2011), optical module and component maker Opnext Inc of Fremont, NJ, USA has reported revenue of \$86m, down 7.6% on \$93.1m last quarter and down 0.5% on \$86.4m a year ago.

Cisco Systems Inc was the only customer to exceed 10% of total revenue. The Americas represented 54% of total revenue, Europe 13%, Japan 11%, and the rest of Asia 21%.

The shortfall on August's guidance of \$89–95m was due mainly to soft demand for 40G subsystems and line-side modules. Also, the shift by larger OEMs in China from externally purchased 40G modules to internally produced modules was faster than expected.

Revenue from 40Gbps and above products of \$32.1m has risen by 43.9% from \$22.3m a year ago but fallen 5.9% from \$34.1m last quarter; \$1.5m of the \$2m drop coming from 40G subsystems while lower revenue from 40G line-side modules was partially offset by higher 40G and 100G client-side module revenue.

Revenue from 10Gbps and below products of \$44.9m is down 11.3% on \$50.6m last quarter and down 20.4% on \$56.4m a year ago due to lower 10G telecom and SFP module revenue, partially offset by higher 10G datacom revenue.

Revenue from industrial & commercial products is up 16.9% on \$7.7m a year ago and 7.1% on \$8.4m last quarter to \$9m, representing the ninth consecutive quarter of growth.

On a non-GAAP basis, after rising from 22.2% a year ago to 23.5% last quarter, gross margin has fallen to 21.9%.

Adjusted earnings before interest, taxes, depreciation and amortization (EBITDA) has fallen from \$1.9m last quarter to just \$0.1m, but this is still an improvement on negative \$4.4m a year ago. "Despite lower-

than-expected revenues and continued appreciation of the yen, we achieved positive adjusted EBITDA, which is indication that our efforts to reduce product cost and control expenses are working" says chairman & CEO Harry Bosco.

Although down from \$6.2m a year ago, cash used in operations has risen from \$1.7m last quarter to \$1.9m. Opnext also used \$2.2m for capital expenditure (CapEx) and \$2.4m to fund capital lease obligations. During the quarter, cash and cash equivalents hence fell by \$6.7m, from \$97.2m to \$90.5m.

Opnext's primary contract manufacturer of 10G modules — as well as some of the TOSAs (transmitter optical sub-assemblies) used in them — is Thailand-based Fabrinet Co Ltd, which accounted for \$37.3m (43%) of Opnext's total quarterly revenue. These products are

made at Fabrinet's Chokchai campus in Pathum Thani, where operations have been suspended since 22 October when floodwaters infiltrated the ground floor offices and manufacturing space. In addition, production was limited in the week prior to shutdown as operations were impacted by local transportation and utility issues.

Opnext currently has about \$16m of inventory in Thailand (\$8m of raw materials and \$8m of finished goods). Most finished goods were undamaged, but most of Fabrinet's work in process (WIP) has been damaged, including some raw mat-

erials. Opnext also has production equipment at Chokchai (mainly 10G module test sets with a new original cost of about \$31m). Some of the more sophisticated measurement equipments was moved by Fabrinet to the second floor of the building and has escaped damage. Fabrinet expects the insurance provided contractually by them to be adequate to cover the cost of replacing any damaged inventory and equipment.

Fabrinet believes that it is unlikely that production will resume at Chokchai before the end of 2011. "Following the flooding in Thailand, Opnext is executing business continuity contingency plans, expanding the capacity at our manufacturing facility in Totsuka, Japan for our 10G products while moving some capacity [the lower-end 10G products] to our contract manufacturers in China and our facility in Fremont," says Bosco. "Although this approach of expanding internal manufacturing capacity is inconsistent with our long-term strategy of moving module manufacturers to low cost regions, this is fastest path to recover production and support our customers," he adds.

"Operationally, our direction is clear. What is less clear is the full extent of the impact of this situation on our financial results for the current and future quarters," Bosco says. "We will not be able, however, to transition capacity quickly enough to avoid a significant impact on our results for the December quarter," he adds. The firm is working towards starting manufacturing at the alternative locations by the beginning of December. "Opnext's priority is to invest the necessary resources to minimize the number of customers impacted and to limit the impact on those affected," concludes Bosco.

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

**Opnext is expanding the capacity at our manufacturing facility in Totsuka, Japan for our 10G products while moving some capacity to our contract manufacturers in China**

# Oclaro's quarterly revenue flat due to Asian telecom slowdown

## Shenzhen assembly & test to be divested to contract manufacturer

For its fiscal first-quarter 2012 (ended 1 October 2011), optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has reported revenue of \$105.8m, down 3% on \$109.2m last quarter and 12.8% on \$121.3m a year ago. However, about \$2.8m of shipments got held up at the end of the quarter due to a major typhoon in Hong Kong.

Revenue for Telecom Components (including lasers, modulators, laser pumps, receivers and integrated lasers and modulators) was \$24.8m, down 20% on \$31.1m last quarter (and down \$11m since the December 2010 quarter, due largely to market slowdowns in Asia). Also, there was an impact of about \$3m from a customer-specific evaluation issue on a legacy product which is now being resolved, although the corresponding revenues are not expected to begin to ramp back until the March quarter.

Revenue for Transmission Modules (including 10 & 40G transponders and transceivers) was \$24m, up 8% on \$22.2m last quarter, although the overall calendar year has seen a drop in 10G transponders, due largely to a soft economy and related market slowness, offset by substantial growth in 40G transponders (including more than \$10m in 40G DPSK transponders).

Revenue for Amplification Filtering and Optical Routing (including amplifiers, micro-optics, dispersion compensation, wavelength-selective switching modules, and subsystems in ROADM line cards) was \$40m, down just 3% on \$41.2m last quarter but down 23% on \$51.7m a year ago after a decline in tunable dispersion compensation due to slower Asian deployment of 40G. Nevertheless, the amplifier portfolio has shown stability, even on a relatively soft telecom market, and WSS and ROADM products continue to gain traction.

Revenue for Industrial & Consumer products (including high-power lasers and VCSELs) was \$17.1m, up 17% on \$14.6m last quarter and 25% on \$13.7m a year ago. At a record \$15m, high-power laser revenue has fully recovered from the fab transfer from Tucson, AZ, USA to Europe. However, consumer markets for VCSEL lasers are going through a soft period.

Major customer revenues included Huawei at 13%, Fujitsu at 11%, Cisco at 11% and Alcatel-Lucent at 10%. This compares with Fujitsu at 17%, Huawei at 10%, and Alcatel-Lucent and Ciena both just under 10% last quarter.

Growth in relatively high-margin industrial laser products was offset by drops in revenues for similarly high-margin telecom components and 10G transponders. On a non-GAAP basis, gross margin was 23%, up slightly from 22.9% last quarter. However, this is down from 29% a year ago. The telecom slowdown in 2011 has hit Telecom

Components and 10G transponders harder than other product categories. Since the December 2010 quarter, these products have fallen from 45% of the firm's product mix to just 32% (a major factor in the gross margin decline).

"We are accelerating our new product momentum and intensifying our focus on our core competencies," says chairman & CEO Alain Couder. Apart from shipping over \$10m in 40G DPSK transponders, Oclaro reckons to be the market leader in coherent modules and components,

with \$2.4m in 40G coherent modules shipped during the quarter, as well as shipping 40G/100G modulators and 100G receivers. The firm also claims a strong position in 10G tunable transponders, pluggables and lasers, with volume shipments of tunable XFP (TXFP) modules to one of the top 2 OEMs and one of the top service providers, as well as being first to market with a zero-chirp TXFP (now sampling to multiple customers). Also during the quarter, Oclaro launched two new high-power 980nm pump lasers (including a 600mW dual-chip pump) and sampled a high-port-count 1x23 wavelength-selectable switch (WSS).

Adjusted EBITDA was -\$4.5m, cut slightly from -\$4.7m last quarter but compared with +\$10.9m a year ago. Net loss was \$11m, up slightly from \$10m last quarter and compared with a profit of \$6.6m a year ago.

Capital expenditure (CapEx) has been almost halved from the average of \$11.5m over the prior three quarters to just \$6.2m. Nevertheless, during the quarter, total cash, cash equivalents and restricted cash continued to fall, from \$63.4m to \$51.7m. On 26 July Oclaro secured an increase in its line of credit from \$25m to \$45m and extended its term through 1 August 2014. As of 1 October, the amount drawn under the line of credit was \$19.5m.

"Gross margin and adjusted EBITDA were at the higher end of our guidance ranges, despite continued soft market conditions which led to an expected sequential decline in revenues," says Couder. "Our results demonstrate that the company's cost-reduction initiatives are gaining traction," he adds.

By the June 2012 quarter, Oclaro aims to reduce its adjusted EBITDA breakeven to \$110m in quarterly revenue, and its cash flow breakeven to slightly above this \$110m threshold (depending on CapEx invest-

**The firm is in final negotiations to outsource all of its final assembly & test operations in Shenzhen to a major contract manufacturer**

ments). "We expect to see additional improvements from these actions, continuing beyond June to the end of 2012," says Couder.

Specifically, Oclaro targets a reduction in staffing, as well as returning R&D spending back towards 13% of revenue (from 16.7% currently). It also aims to transfer back-end high-power laser production from its plant in Zürich, Switzerland to Shenzhen, China (saving \$1m per quarter in the next fiscal year). In addition, it is initiating the next step in its long-term site consolidation strategy, and evaluating the divestiture of a couple of non-core product lines.

In addition to its breakeven action plan, Oclaro is taking other measures to move towards a more variable cost model (shifting about \$8m per quarter — or a third of its manufacturing overhead — from its fixed-cost base). With the aim of improving its balance sheet, reducing its fixed costs, and focusing on its differentiating core competencies, Oclaro is enhancing the flexibility of its business model.

Specifically, the firm is in final negotiations to outsource all of its final assembly & test operations in Shenzhen to a major contract manufacturer. (Although Oclaro will maintain a presence there of about 220 staff in R&D and new-product introduction, overall company staffing will fall from 2800 to 1200.) This should generate \$30–40m in net proceeds when the transaction closes in calendar first-quarter 2012 (with additional potential consideration to be received in the future). Oclaro is also finalizing a supply agreement with this contract manufacturer with the goal of reducing product costs over time. "Many of our customers have a long relationship with our potential contract manufacturing partner, and as a result we would expect the transition to be seamless," comments Couder. "By keeping production in Shenzhen we can ensure continuity of the process and quality for our customer and create a good transition for our staff."

Oclaro has also signed a new supply agreement with its Thailand-based primary contract manufacturer Fabrinet Co Ltd (which makes 30% of Oclaro's total finished goods), with a term extending through calendar 2013.

However, on 22 October, flood waters in Thailand infiltrated the offices and manufacturing floorspace in buildings 1 and 2 at Fabrinet's Chokchai campus in Pathum Thani and cut off production at buildings 3, 4 and 5 at its Pinehurst campus (about 7 miles north of Chokchai). Pinehurst produces high-power laser (HPL) and assembles printed-circuit boards (some of which are used in Shenzhen). HPL production was due to resume on 14 November. But Chokchai represents 60–70% of Oclaro's Fabrinet-produced revenue and remains flooded. Recovery of inventory and equipment is in process. In the meantime, its production of tunable dispersion compensation, amplifier and modulator products is being restarted instead mostly in Pinehurst. "Our top priority is to restart production in Thailand in order to minimize customer impact," says Couder. "Many of our resources are being redeployed to support the recovery efforts," he adds.

For fiscal second-quarter 2012 (to end-December 2011), revenue was expected to increase modestly, with some strengthening of second-tier customers counteracting softness from top-tier customers Huawei, Alcatel and Ciena. However, the flooding in Thailand is expected to lower this by \$25–30m, to \$75–85m. Gross margin should be down to 13–17%. Adjusted EBITDA is expected to worsen to –\$18–13m. Including capital expenditure associated with flood recovery, CapEx is expected to increase (though probably remaining lower than recent averages).

The flooding in Thailand is also expected to reduce revenue in the March quarter by \$10–20m, but by the June quarter revenue should be back to normal, says Oclaro.

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

## IN BRIEF

### Firecomms COO made MD as CEO & co-founder departs

Following its acquisition in 2010 by China-based ZJF Group, Firecomms Ltd of Cork, Ireland, a manufacturer of transceivers (including its OptoLock technology) for consumer plastic optical fiber (POF) networks, has announced the appointment of chief operating officer Thomas Moriarty as managing director, and the departure of CEO Declan O'Mahoney, who has left the firm to focus on other opportunities.

Moriarty, who co-founded Firecomms in 1994 with chief technology officer Dr John Lambkin, has also served as chief financial officer and chief engineer. Previously, Moriarty set up the Irish subsidiary of Moog Inc and grew it to a staff of 150.

"Firecomms is the first Irish company to be acquired by a Chinese multinational," says O'Mahoney. "Thomas and I worked on the transition over the summer, so now it's time for him and his team to continue to grow the company under the ZJF Group."

As CEO since 2002, O'Mahoney led Firecomms through expansion in worldwide sales, and strategic and institutional funding rounds. As Firecomms now expands into new growth areas, O'Mahoney leaves Firecomms with a stable management team, solid finances and new growth prospects.

"Declan guided Firecomms through a significant and complex process to where we are a global leader in our field, with the backing of a corporation that will deliver long-term growth," comments Moriarty. "I am excited to be taking our team onto the next level with new product developments, expanded manufacturing facilities, and growing our presence in the Chinese domestic market."

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

## GigOptix grows 10% in Q3 to record \$8.4m revenue Adjusted EBITDA returns to profit one quarter after Endwave

For third-quarter 2011, GigOptix Inc of San Jose, CA, USA (which supplies semiconductor and optical components including modulator and laser drivers and transimpedance amplifier ICs based on III-V materials), has reported an eighth quarter of sequential product revenue growth to a record \$8.4m, up 10% on Q2's \$7.6m (exceeding guidance of 8% growth). This is also up 16% on \$7.2m a year ago, or up 43% on \$5.9m a year ago (excluding \$1.4m of government contract revenue).

On a non-GAAP basis, after falling from 53% a year ago to 52% last quarter, gross margin has rebounded further, to 56%. After doubling from \$400,000 in Q1 to \$798,000 in Q2, net loss has been

cut back slightly to \$712,000, although this compares with net income of \$337,000 a year ago. Although still down on \$1m a year ago, adjusted EBITDA (cash flow, net of changes in working capital and capital expenditures) of \$289,000 reverses the loss of \$284,000 last quarter. Nevertheless, during the quarter cash and investments fell from \$18.3m to \$16.2m.

On 17 June, GigOptix completed its acquisition of San Jose-based Endwave Corp, which designs and manufactures high-frequency RF solutions and semiconductor products for the wireless mobile backhaul communications, satellite communications, electronic instruments, and

defense and security markets.

"With the integration of Endwave essentially complete, we are aggressively moving forward to expand our customer base, win key design-in opportunities and move to production with global tier-1 OEMs," comments chairman & CEO Dr Avi Katz. "We are also continuing to focus on bringing more innovative bundled solutions to market and advancing our leadership in the 40G and 100G component markets," he adds. "We are uniquely positioned to capitalize on a large and rapidly growing market opportunity ahead," he believes.

For fourth-quarter 2011, GigOptix expects a ninth quarter of sequential revenue growth, with product revenue up by about 5%.

### TFPS Mach–Zehnder modulators fully Telcordia qualified

GigOptix has announced the completion of reliability qualification for its Mach–Zehnder modulators (MZMs) implemented using its proprietary Thin Film Polymer on Silicon (TFPS) technology.

Full compliance of the TFPS modulator series of products — as tested against the Telcordia GR-468 standard — represents the first polymer modulator to come to market, fully qualified, that will truly disrupt the current market for MZMs, reckons GigOptix.

The TFPS modulators offer advantages over existing crystalline semiconductor technologies, claims GigOptix. The firm's proprietary material allows low drive voltage in the smallest form factor available. The low drive voltage reduces power consumption by more than 20% compared with competing modulator technologies, it is claimed, while the small form factor enables smaller 300-pin optical transponders. The modulators also offer simpler manufacturing

processes and larger bandwidth. Intrinsic polymer material properties and TFPS modulator processing allows the modulator to reside on the same silicon chip as the silicon-based drivers, offering an integration platform for small-footprint components. The technology also allows integration of the modulator, laser, and driver in a small-footprint module.

"After more than 10 years of hard work and groundbreaking innovation, our revolutionary TFPS products and materials are now fully qualified and available commercially to the market," says Dr Raluca Dinu, VP & general manager of Optics.

"Three years ago, when GigOptix acquired Lumera, we could only dream of what the proprietary polymer material could accomplish and, with the full Telcordia qualification of the TFPS modulators, we finally see one of those dreams turn to reality," says chairman & CEO Dr Avi Katz. "The team has brought a highly

innovative product from an R&D experiment into a fully qualified, highly disruptive, commercial product," he adds.

Passing the stringent requirements of the Telcordia GR-468 is essential, reckons GigOptix, as it demonstrates that the TFPS modulators meet the long-term reliability standards required by telecom sub-system and system integrators.

The TFPS modulators have passed the specific testing requirements as outline in the Telcordia GR-468 standard including: high-temperature operation lifetime (HTOL) tested at 85°C; temperature cycling; low-temperature storage; vibration, mechanical and thermal shock; and fiber pull, twist, and cable retention testing.

The LX8401 (40G DPSK) MZM is available in production quantities. The LX8220 (40G DQPSK), LX8900 (100G Dual Drive NRZ) and LX8901 (100G DPSK) MZMs are available for sampling.

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

## GigOptix sampling 25G parallel VCSEL driver and receiver amplifier

GigOptix is sampling a new chipset for short-reach 25Gb/s parallel optical interconnects.

Building on its 14Gb/s 4-channel HXT5104 VCSEL driver and HXR5104 receiver amplifier chip set and 12-channel HXT5112 VCSEL driver and HXR5112 receiver amplifier chip set (sampled in June), GigOptix now offers a 4-channel 25Gb/s vertical-cavity surface-emitting laser (VCSEL) driver (HXT5204A) and receiver amplifier (HXR5204A) array. The firm says that the components are a key factor for manufacturing compact, robust and low-power optical transmitter modules. The array addresses IEEE 802.3ba Ethernet transceivers, Infiniband EDR active optical cables (AOCs) and proprietary multi-channel optical modules, and is targeted at the datacom, avionics and consumer markets.

The HXR5204A receiver amplifier is a 3.3V silicon germanium (SiGe) device that integrates the trans-impedance pre-amplifier, the limiting post-amplifier and a versatile

CML output stage for four optical channels. The HXT5204A VCSEL driver, in conjunction with a VCSEL array, handles the complete digital-to-optical conversion, including CML input, laser driver, drive control and supervision. Standard silicon technology and a small number of additional components allow cost-effective and compact assemblies, says GigOptix.

"With the vision of continuing to reduce the power consumption per link, we are releasing our HXT/R5204 series having 400mW per link at 25Gb/s, and designing to further power consumption reduction in our future designs," says Martin Bossard, GigOptix's director of engineering and general manager for GigOptix-Helix AG in Zurich, Switzerland. The new chipset doubles data throughput per channel with ultralow power consumption, he adds.

Samples of the HXT5204A and HXR5204A are available with an evaluation board for evaluation with VCSEL and photodiodes.

## GigOptix 95th in North America on Deloitte's 'Technology Fast 500'

GigOptix has been ranked 95th on Deloitte's Technology Fast 500 list, which ranks the fastest-growing technology, media, telecoms, life sciences and clean-tech firms (both public and private) in North America, based on percentage of fiscal year revenue growth from 2006 to 2010.

GigOptix's revenue grew 1093%. CEO Dr Avi Katz attributes this to the use of a balanced mix of organic and strategic business growth and the need to leapfrog technology to concentrate on future needs (mainly 40G and 100G).

"GigOptix has built itself up with three simple pillars of strategy: (1) innovation; (2) execution; and (3) financial growth engine," says Katz.

"GigOptix has grown exponentially to be the current leader in 40G and 100G semiconductor and optical components that enable high-speed information streaming," he claims.

"GigOptix has excelled in fostering innovation and channeling it into spectacular growth — against the backdrop of one of the most challenging economies in history," says Eric Openshaw, vice chairman & US technology, media & telecoms leader, Deloitte. "GigOptix has demonstrated excellence in technological innovation, entrepreneurship and rapid growth," adds Mark Jensen, managing partner, technology & venture capital services, Deloitte & Touche LLP.

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

### IN BRIEF

#### GigOptix achieves ISO 9001 certification

GigOptix has achieved the International Organization for Standardizations' (ISO) 9001:2008 certification for its headquarters in San Jose, CA, which demonstrates commitment to quality-of-service standards. The voluntary certification assures customers of adherence to documented processes and procedures that ensure continued and ongoing improvements in delivering high-quality product and customer satisfaction.

"While our international office in Zurich, Switzerland plus our ChipX and Endwave subsidiaries have been certified for some time, this milestone marks the integration of our various teams under a single Quality Management System," says Julie Tipton, senior VP of operations. "Achieving ISO certification is a cornerstone of our focus on delivering quality products to our customers and a platform for driving constant improvement in our processes to ensure customer satisfaction so that we can continue our rapid growth."

The ISO 9001:2008 standard specifies Quality Management System (QMS) requirements focused on an organization's ability to meet and improve upon product quality requirements and customer satisfaction. As part of the certification process, GigOptix established a new QMS to ensure it continued its commitment to high-quality and high-reliability products. By identifying areas for improvement, creating recommendations to resolve identified gaps, and executing against these recommendations, GigOptix says that it is ensuring that it has the global processes necessary to consistently improve product quality on a regular, quantifiable and demonstrable basis.

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

## Avago demos embedded parallel optical transmit & receive modules for high-performance computing

At the 24th annual Supercomputing Conference (SC'11) in Seattle, WA, USA (14–17 November), Avago Technologies is showcasing parallel optical fiber technology that enables what is claimed to be industry-leading bandwidth for emerging high-performance computing (HPC) applications. Avago is demonstrating its small-footprint MicroPOD and MiniPOD embedded parallel optical transmitter and receiver modules (which deliver bandwidth of up to 120Gbps) working with technologies from companies that provide the data throughput required for cloud computing and virtual server applications.

A live joint-demonstration with PLX Technology showed the industry's first PCI Express (PCIe) Gen3 end-to-end fiber-optic link with Avago MiniPOD technology connecting a PC to an I/O expansion box. A separate mechanical sample shows Altera's optical FPGA concept working in conjunction with Avago MicroPOD technology. Avago also exhibited its portfolio of industry-standard pluggable modules.

"Avago is committed to working with innovative technology companies such as PLX and Altera to extend fiber-optic connectivity box-to-box, board-to-board and eventually

chip-to-chip," says Victor Krutul, director of marketing for Avago's Fiber Optics Products Division. "The unrivaled bandwidth and interconnect density of our embedded parallel optical modules will empower high-performance computing applications to enable the future of cloud computing and virtual servers."

The PCIe demo shows MiniPOD technology, enabled by PLX PEX8748 PCIe Gen3 switches, extending box-to-box traffic up to 30m with full 64Gbps bi-directional connectivity. Optical PCIe provides a superior solution for data centers by eliminating the complicated, latency-ridden conversion of standards, extending the reach of PCIe technology, Avago says.

"Our work with Avago is bringing the premium performance of optical solutions to PCIe Gen3 applications," comments Reggie Conley, senior director, hardware applications, at PLX. "Our joint PCIe Gen3 technology is providing maximum throughput with plug-and-play simplicity for next-generation data centers."

The Altera optical FPGA concept targets applications such as HPC, distributed server clusters, multi-chassis network switches and routers, and high-speed backplanes. The technology combines the

advantages of programmable logic, advanced SerDes, and high-density optical modules to increase signal integrity and optical port density, as well as reduce PCB area and power consumption.

Avago claims that its embedded parallel optics offer industry-leading density and bandwidth. The optical modules enable flexible inside-the-box designs, eliminating the need for EMI/RFI shielding. These benefits are leveraged in applications such as next-generation supercomputers powering scientific research, as well as for high-performance routers, switches and data-center equipment enabling cloud computing, server virtualization and video-on-demand.

The MicroPOD and MiniPOD embedded parallel optical modules offer 12 transmit or receive channels at up to 10.3125Gbps, while consuming only 125mW per channel. MicroPOD devices have an 8.2mm by 7.8mm footprint with an LGA electrical interface for ultra-dense embedded solutions, while the MiniPOD arrays have a 22mm by 18.5mm footprint with a 9mm by 9mm MegArray connector for simplified embedded solutions and ease of manufacturing.

<http://sc11.supercomputing.org>  
[www.avagotech.com](http://www.avagotech.com)

## Advanced Photonix returns to profit after quarterly revenue growth of 3.7%

For fiscal second-quarter 2012 (to end-September 2011), Advanced Photonix Inc of Ann Arbor, MI, USA (which designs and makes silicon, InP- and GaAs-based APD, PIN, and FILTRODE photodetectors, HSOR high-speed optical receivers, and terahertz instrumentation) has reported revenue of \$8.4m, up 3.7% on \$8.1m last quarter and 19% on \$7m a year ago, after strong growth in the HSOR platform in telecoms and in the THz homeland security market.

Operating expenses have risen slightly again, from \$3.8m last quarter to \$3.9m, up from \$3.1m a year ago. After falling from 44% to 42% last quarter, gross margin has rebounded to 43% due to a reduction in scrap and rework expenses on HSOR products. On a non-GAAP basis, net profit was \$155,000, down from \$209,000 a year ago but an improvement on the net loss of \$96,000 last quarter.

"The effect of the flooding in Thai-

land is impacting the telecommunication supply chain, resulting in some customers' delaying orders and deliveries," says chairman & CEO Richard Kurtz. "We are continuing to invest in our high-growth opportunities and are optimistic about our long-term future, but the impact of the flooding, and continued malaise in the macroeconomic environment is expected to reduce our growth for this fiscal year."

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



# JDSU's quarterly revenue falls 10.8% to \$421.1m

## Thai flooding pushes out OptComms recovery from December quarter

For fiscal first-quarter 2012 (ended 1 October 2011) on a non-GAAP basis, JDSU Corp of Milpitas, CA, USA has reported net revenue of \$421.1m, down 10.8% on \$472.3m last quarter but up 2.4% on \$411.3m a year ago and at the high end of the \$400–425m guidance range.

Of total revenue, 50% came from the Americas, 24% from EMEA (Europe, Middle East and Africa) and 26% from Asia-Pacific.

Advanced Optical Technologies (AOT) revenue was \$55.6m (13.2% of total revenue), down 5.3% on \$58.7m last quarter and 8.1% on \$60.5m a year ago. Communications Test & Measurement (CommTest) revenue was \$185.2m (44% of total revenue), up 1.3% on \$182.8m year ago but down 12.4% on \$211.3m last quarter.

Communications & Commercial Optical Products (CCOP) revenue was \$180.3m (42.8% of total revenue), down 10.9% on \$202.3m last quarter but up 7.3% on \$168m a year ago.

Within CCOP, Commercial Lasers revenue was \$30.2m, up 8.6% on \$27.8m last quarter and up 20.8% on \$25m a year ago (its best quarter in over two years), due to strength in Q-series solid-state lasers, CPV solar cells, and the new 4kW fiber laser for macro-machining applications.

However, Optical Communications revenue was \$150.1m, up 5% on a year ago but down 14% on \$174.5m last quarter. Over half of the fall was due to gesture recognition products falling to under 2% of total revenue; ROADMs and tunable XFP modules fell due to customer inventory correction. Nevertheless, ROADMs still comprised 28% and tunable XFP 10% of Optical Comms revenue.

New-product revenue remains strong, with 67% of Optical Communications revenue and 56% of CommTest revenue generated from products less than 2 years old.

Hence, although still down on 47.4% a year ago, gross margin has risen from 46.7% last quarter to

47.3% (despite the lower revenue), due mainly to the segment mix as well as CommTest margin rising from 59.3% last quarter to 61.9% (above the targeted 57–61%). AOT margin was 47.1% (down on 49.4% last quarter). CCOP margin was 32.3% (down from last quarter's 32.8%), including 28.8% for Optical Communications (down on last quarter's 31.1% and below the targeted 30–35%) and 49.3% for Commercial Lasers (up from 43.4% due to growth in solid-state lasers).

Operating expenses have been cut from \$162.3m last quarter to \$152.9m, due mainly to lower headcount in CommTest (a direct result of restructuring activities). Operating margin has still fallen from 12.3% last quarter to 10.9%, but this is up on 10.8% a year ago and exceeded the guidance range of 7.5–9.5%. This includes operating margin of 13% for CommTest (down from last quarter's 14.4%, but above the expected 8.5–10%), 14.2% for CCOP (down from 15.9%) and 31.5% for AOT (down from 34.1%).

"Although revenue levels are being restricted by these global headwinds, the mix of our highly innovative and differentiated products continues to grow with a favorable impact on gross margin," says president & CEO Tom Waechter. "This, combined with strong cost controls, allowed us to significantly exceed expectations for operating margins."

Net income was \$40.9m, down on \$53.9m last quarter and \$44.8m a year ago. JDSU generated \$22.9m of cash from operations (down from \$56m last quarter). CapEx was cut from \$30.9m to \$21.2m. During the quarter, total cash and investments fell from \$728.7m to \$723.3m.

During fiscal Q1, CCOP customer inventory shrank to more targeted levels and bookings strengthened. For tunable XFP modules, bookings rose 70% on last quarter and the book-to-bill ratio was over 1. For ROADMs, bookings rose nearly 25%

(its highest for three quarters) and the book-to-bill was nearly 1 (after three consecutive quarters below 1 due to the inventory build up).

However, due to complications from the flooding in south Thailand, lead times for products assembled at contract manufacturer Fabrinet (which include ROADMs, tunable XFPs, some amplifiers, and some other low-volume products) will be extended (from the current 4–6 weeks) during fiscal Q2.

"All JDSU Thailand employees [at the Pinehurst facility of contract manufacturer Fabrinet] are safe from the flooding in southern Thailand, and we have added additional employees there to help meet our customer's needs as best as possible under these difficult conditions," says Waechter. Power to the facility has been restored, and JDSU's equipment at Pinehurst is being readied for production. "We expect to have some level of production within the next week or two," he adds. "We have been able to ship some existing finished goods to our customers."

Had the Thailand flooding not occurred, the September quarter would have been the low point of CCOP revenue for the fiscal year, and Q2 CCOP revenue would have grown sequentially in the low to mid single-digit percent range.

Instead, due to uncertainty in the timing of the ramp back to full production in Thailand, for fiscal Q2/2012 (to end-December 2011) JDSU expects net revenue to be cut by \$35–45m to \$375–405m, down 15–25% sequentially (with the upper figure assuming a slow return to production).

JDSU expects operating margins of 12.5–14.5% for CommTest and 30–32% for AOT (roughly level with fiscal Q1) but just 3–7% for CCOP (due to the incremental costs being incurred to bring production back online). Total operating margin should hence fall to 5.5–8.5%.

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

## Emcore ramps production of 56Gb/s FDR AOCs

Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and solar power markets, has ramped up to full-scale production of 56Gb/s Fourteen Data Rate (FDR) active optical cables (AOCs) for high-performance computing, Ethernet router and switch applications.

The 56Gb/s FDR cable is the latest in the Emcore Connects Cables line of high-speed active optical cables produced at the firm's contract manufacturing facility in China. Emcore is the first manufacturer in full-scale production of 56Gb/s FDR AOCs.

Designed for high-performance computers, telecom routers, storage networks, and grid and cloud computing systems, Emcore claims that its 56Gb/s FDR active optical cables provide the highest



**Emcore 56Gb/s active optical cable.**

aggregated level of data throughput in a compact, lightweight form factor capable of supporting the bandwidth needs of these advanced systems. Each 56Gb/s FDR cable has four 14Gbps lanes in each direction. These lanes support InfiniBand FDR data rates and will also run at lower data rates to support 40, 20 and 10Gb/s, as well as 40 Gigabit Ethernet quad small-form-factor pluggable (QSFP) installations.

"Our 40Gbps quad data rate (QDR) cables are currently deployed in two of the top five supercomputers in the world," says VP of business development Jaime Reloj. "By leveraging our next-generation vertical-cavity surface-emitting lasers (VCSELs) and photodetectors, we will continue to advance the technology for high-performance computing applications," he adds.

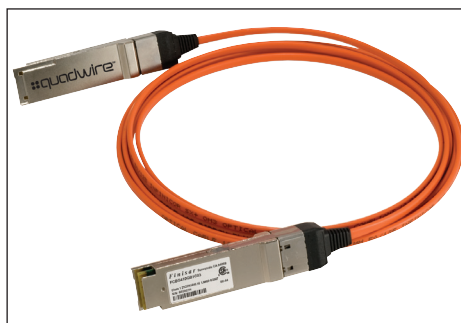
Emcore Connects Cables offer the advantages of optical interconnects for high-performance computing at an affordable price, the firm claims. They reduce the installation and maintenance costs of computer clusters, enabling very large clusters, and are suited to building systems based on any architecture that requires long distances and multiple computer nodes in very dense configurations.

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

## Finisar launches Quadwire FDR active optical cable for InfiniBand 4xFDR (56G) & 4x16x (64G) Fibre Channel

Fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has announced the commercial availability of its Quadwire FDR active optical cable, which provides high-bandwidth performance with four lanes at 14Gb/s per lane in a standard QSFP+ form factor and is suited to InfiniBand 4xFDR and 4x16x Fibre Channel applications. Finisar provided a live demonstration of its Quadwire FDR cable at the 24th annual Supercomputing Conference (SC'11) in Seattle, WA, USA (14-17 November).

As the speed of supercomputing clusters continues to accelerate, the high-performance computing (HPC) and data-center markets demand higher-speed interconnections to support the increasing bandwidth needs. Finisar says that FDR active optical cables use 14Gb/s vertical-cavity surface-



**An example of Finisar's Quadwire FDR active optical cable.**

emitting laser (VCSEL) technology to provide this next level of data throughput, and that

**As the speed of supercomputing clusters continues to accelerate, the high-performance computing and data-center markets demand higher-speed interconnections**

they are compact, lightweight and flexible to support very high-density deployments.

"The commercial availability of our Quadwire FDR cable illustrates our strong commitment to providing leading InfiniBand cable technology in the growing HPC and Datacenter markets," says product line manager Steffen Koehler. "Leveraging our unmatched expertise and vertical integration in optics technology, we provide active optical cable solutions that address bandwidth and link-distance challenges that cannot be supported by existing copper cables," he adds.

At SC'11, Finisar also displayed its complete family of active cables, including Laserwire for 10GbE, Quadwire for 40GbE and InfiniBand QDR, and C.wire for 100GbE and InfiniBand QDR.

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

<http://sc11.supercomputing.org>

## Emcore affected by floods at Fabrinet

### Significant impact to December quarter

In late October, Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and solar power markets, said that flood waters had infiltrated the offices and manufacturing floorspace of its primary contract manufacturer Fabrinet Co Ltd at its campus in Thailand. Rising water penetrated the facility, including areas used to manufacture its fiber-optic products and submerging some of its manufacturing and test equipment.

Fabrinet has said that it is unlikely that production will restart at the

main facility for the remainder of the December quarter. Emcore hence expects that the flooding will have significant impact on its operations and its ability to meet customer demand for its fiber-optic products in the December quarter.

Emcore said that its own facilities in China and the US are fully operational and it has assembled a cross-functional team to manage the issue and to work on ramping up capabilities to manufacture some products at the firm's own facilities. The solar division has not been affected by the floods.

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

## Sharp reports record efficiency of 36.9% for non-concentrator triple-junction solar cells

### Increase from 35.8% achieved by reducing resistance of junctions

Osaka-based Sharp Corp has achieved what is claimed to be record solar cell conversion efficiency of 36.9% using a triple-junction compound semiconductor solar cell in which the solar cell has a stacked three-layer structure, as confirmed by Japan's National Institute of Advanced Industrial Science and Technology (AIST) on a 1cm<sup>2</sup> cell.

Sharp has been conducting R&D of triple-junction compound solar cells since 2000. In 2009, it succeeded in improving cell conversion efficiency to 35.8% based on proprietary technology that enabled efficient fabrication of a stacked triple-layer structure with InGaAs as the bottom layer.

The latest increase in conversion efficiency was achieved through improving the maximum power output of the solar cell by reducing the resistance of the junction areas necessary to connect the solar cell layers in series.

Sharp achieved the latest breakthrough as a result of an R&D initiative promoted by Japan's New Energy and Industrial Technology Development Organization (NEDO) on the theme of 'R&D on Innovative Solar Cells'.

**The increase in efficiency was achieved by reducing the resistance**

Sharp says that, in the future, processes for transferring ultra-thin photovoltaic layers onto film substrates will make lightweight, flexible solar cells possible. Its goal in the years to come is to take full advantage of this latest development for use in concentrator-type solar cells (for which Solar Junction of San Jose, CA, USA achieved the existing record of 43.5% in April), as well as for practical applications such as on space satellites and for aircraft and land-based vehicles.

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

## IN BRIEF

### Emcore awarded solar panel contract for NASA's LADEE moon orbiter

Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and solar power markets, has been awarded a contract by ASRC Research and Technology Solutions (ARTS) of Greenbelt, MD for the design, manufacturing and delivery of 32 solar panels for NASA Ames' Lunar Atmosphere and Dust Environment Explorer (LADEE) mission.

LADEE is a robotic mission designed to orbit the Moon. Its main objective is to study and characterize the lunar atmosphere, including fine dust particles suspended above the lunar surface. The spacecraft is currently scheduled to be launched in early 2013 aboard a Minotaur V vehicle from the Wallops Flight Facility, Wallops Island, VI.

"Emcore has previously been awarded solar panel contracts for several other NASA missions, including the Lunar Reconnaissance Orbiter (LRO) and the Magnetospheric Multi-Scale (MMS) missions," says chief operating officer Christopher Larocca. "We appreciate NASA's continued confidence in Emcore to supply solar panels for their demanding spacecraft power systems," he adds.

Emcore claims to be the leading manufacturer of highly efficient radiation-hard solar cells for space power applications. With a beginning-of-life (BOL) conversion efficiency nearing 30% and the option for a patented, onboard monolithic bypass diode, its multi-junction solar cells power interplanetary spacecraft and earth orbiting satellites.

# Berkeley Lab shows external fluorescence is key to reaching Shockley–Queisser PV limit

## Alta raises single-junction efficiency record again to 28.4%

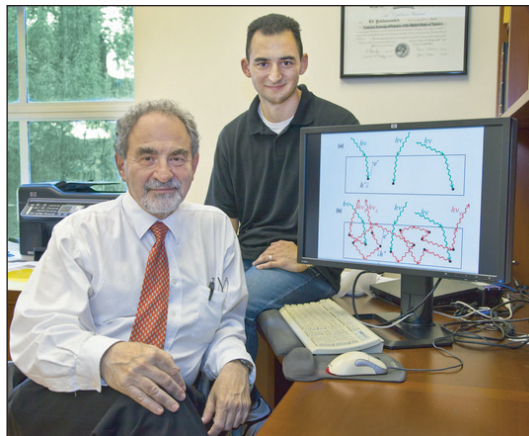
Theoretical research at the Lawrence Berkeley National Laboratory (LBNL), which is managed by the University of California for US Department of Energy (DOE)'s Office of Science, has led to record conversion efficiencies in solar cells. The researchers showed that, contrary to conventional scientific wisdom, the key to boosting solar cell efficiency is not absorbing more photons but emitting more photons ('Intense Internal and External Fluorescence as Solar Cells Approach the Shockley–Queisser Efficiency Limit', *Journal of PhotoVoltaics*).

"A great solar cell also needs to be a great light-emitting diode," says professor Eli Yablonovitch, the Berkeley Lab electrical engineer who led the research. "This is counter-intuitive... What we demonstrated is that the better a solar cell is at emitting photons, the higher its voltage and the greater the efficiency it can produce," he adds.

Yablonovitch holds joint appointments with Berkeley Lab's Materials Sciences Division and the University of California (UC) Berkeley, where he is the James and Katherine Lau Chair in Engineering, and also directs the NSF (National Science Foundation) Center for Energy Efficient Electronics Science (E3S). The paper is co-authored by Owen Miller of Berkeley Lab, and Sarah Kurtz of the National Renewable Energy Laboratory (NREL).

They describe how external fluorescence is the key to approaching the theoretical maximum conversion efficiency. This Shockley–Queisser (SQ) limit is about 33.5% for a single p-n junction solar cell.

Calculations by Miller (a member of Yablonovitch's research group) showed that gallium arsenide is capable of reaching the SQ limit. Based on this, the development-stage firm Alta Devices Inc — co-founded by Yablonovitch with Harry Atwater (Caltech's Howard Hughes professor



**Eli Yablonovitch (left) and Owen Miller.**  
(Photo by Roy Kaltschmidt, Berkeley Lab)

of Applied Physics and Material Science) with the aim of making high-efficiency solar PV economically viable — has fabricated solar cells from GaAs that have achieved a record efficiency of 28.4%.

"Owen Miller provided an accurate theory on how to reach the SQ limit that for the first time included external fluorescence efficiency," Yablonovitch says. "His calculations for GaAs showed that external fluorescence provides the voltage boost that Alta researchers subsequently observed," he adds.

The most efficient solar cells in commercial use are made from monocrystalline silicon wafers and typically have an efficiency of about 23%. High-grade silicon is expensive but is a weak collector of photons. Although more expensive, GaAs is more proficient at absorbing photons, so much less material is needed.

"GaAs absorbs photons 10,000 times more strongly than silicon for a given thickness but is not 10,000 times more expensive," says Yablonovitch. "Based on performance, it is the ideal material."

Past efforts to boost the efficiency focused on increasing the number of photons that a cell absorbs. If photo-generated electrons are not extracted quickly enough from the cell as electricity, then they decay

and release their energy. If that energy is released as heat, it reduces the cell's power output. Miller's calculations showed that if this released energy exits the cell as external fluorescence, then it would boost the output voltage. "This is the central counter-intuitive result that permitted efficiency records to be broken," says Yablonovitch.

"In the open-circuit condition of a solar cell, electrons have no place to go, so they build up in density and, ideally, emit external fluorescence that exactly balances the incoming sunlight,"

Miller explains. "As an indicator of low internal optical losses, efficient external fluorescence is a necessity for approaching the SQ limit."

Using an epitaxial liftoff single-crystal thin-film technology developed by Yablonovitch, Alta was able to fabricate GaAs-based cells that not only exceeded previous solar efficiency records but can be produced at well below the cost of any other solar cell technology. Alta expects to have GaAs solar panels on the market within a year.

"The SQ limit is still the foundation of solar cell technology," says Yablonovitch. "However, the physics of light extraction and external fluorescence are clearly relevant for high-performance solar cells."

Yablonovitch believes that the theoretical work, in combination with the performance demonstrations at Alta, could dramatically change the future of solar cells. "We're going to be living in a world where solar panels are very cheap and very efficient," he adds.

The research was funded by a grant from DOE's Light-Material Interactions in Energy Conversion Energy Frontier Research Center (LMI-EFRC).

[www.lbl.gov](http://www.lbl.gov)  
<http://arxiv.org/ftp/arxiv/papers/1106/1106.1603.pdf>

## Reflexite Soitec Optical Technology JV formed to make SOG Fresnel lens plates at planned San Diego CPV system manufacturing facility

Soitec of Bernin, France, which makes engineered substrates including silicon-on-insulator (SOI) wafers (as well as III-V epiwafers through its Picogiga International division), and Reflexite Energy Solutions Inc of Avon, CT, USA, a global supplier of microstructured optical components for the solar power, lighting, instrumentation and display industries, have formed the joint venture Reflexite Soitec Optical Technology LLC.

The new company will produce the silicone-on-glass (SOG) Fresnel lens plates used in Soitec's concentrator photovoltaic (CPV) modules and co-develop next-generation technologies that will continue to increase the efficiencies and lower the costs of SOG lens plates. The JV will be located within the new CPV manufacturing facility that Soitec is planning to open in San Diego, CA.

Reflexite is supplying the technology and manufacturing expertise to produce injection-molded SOG lens plates at the 'fab within a fab' to be built in Soitec's San Diego facility. Soitec is providing lens design expertise to achieve maximum performance across a wide range of operating conditions in CPV modules, business opportunities in the Southwest US, and the technical infrastructure of the factory. Soitec and Reflexite are now collaborating on the design of the area of the factory to be dedicated to the JV, which will employ about 100 people.

"This joint venture is unique in the CPV industry and represents a very important step in our commitment to the San Diego region and the US market," says Soitec's president, CEO & chairman André Jacques Auberton-Hervé. "It is both a technological collaboration and an innovative economic solution in the highly competitive renewable-energy market. By working together under

the same roof, we can ensure the continuous supply of superior-quality lens plates at the most competitive cost, and our future product development programs will be much more efficient by working in such close proximity," he adds.

"We have partnered with Soitec for many years to develop a durable, field-tested system that has been deployed successfully around the world, and we will bring all this experience to bear as we build up our common California base of operations together," says Reflexite's CEO Michael Foley. "By co-locating our optics facility with their CPV module assembly facility we will have the best possible logistics and even closer collaboration in the future," he adds.

The lens plate is a key element in CPV systems, incorporating a Soitec-designed Fresnel lens that concentrates sunlight more than **CPV systems have already won Soitec over 300MW in solar power projects throughout the Southwest USA**

500 times to achieve CPV technology's high solar energy conversion efficiency. Soitec claims to be the first CPV firm to use SOG to produce its lens plate design, which combines the durability of a glass surface with high-volume precision micro-replication (key to low-cost production).

Reflexite's SOG lens plates are claimed to suffer no mechanical or chemical degradation such as yellowing, cracking and delamination. The firm has been a long-time supplier to Soitec, and its optics are key elements in CPV systems that have already won Soitec over 300MW in solar power projects throughout the Southwest USA.

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

### IN BRIEF

## Regulatory approval for Californian power purchase agreements

Soitec subsidiary Soitec Solar Development LLC has received approval for five of its power purchase agreements (PPAs) with San Diego Gas and Electric (SDG&E) from the California Public Utilities Commission (CPUC).

The five projects represent a combined capacity of 155MW with electricity generated at solar power plant sites in San Diego County that will use Soitec's Concentrix concentrator photovoltaic (CPV) technology. Also, the CPUC has approved an option agreement for the right, but not the obligation, for SDG&E to purchase additional capacity from Soitec Solar Development. Soitec says that this announcement represents a significant step forward in its expansion plans and strategy in the USA.

As previously announced, the CPV modules will be made in a new Soitec factory planned for the San Diego area. To supply the projects, the new facility will use new Concentrix's fifth-generation technology, which provides a module efficiency that exceeds 30% (2-3 times the efficiency of conventional PV technology).

As well as using concentrator optics and high-efficiency cells that suit sunny regions and delivering low-cost, reliable, solar electricity, CPV technology need no water for ongoing operations (a key consideration for the water-constrained San Diego and Imperial Counties, says Soitec).

At full capacity, the San Diego manufacturing facility will generate up to 450 direct jobs and over 1000 indirect jobs in San Diego County. Its location should be announced by the end of this year.

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

## Amonix earns LEED Gold Certification for two facilities; powers solar manufacturing facility with CPV systems

Amonix Inc, which makes utility-scale concentrated photovoltaic (CPV) systems using III-V multi-junction solar cells, says that its facilities in California and Nevada have won gold-level certification for their low environmental impact construction, and high energy and water efficiency from the US Green Building Council's Leadership in Energy and Environmental Design (LEED) program.

With the direction of sustainability and energy advisers Collaborative Project Consulting, Amonix' headquarters in Seal Beach, CA and its production facility in North Las Vegas, NV both earned the internationally recognized Gold Certification in 2011, adding a total of almost 300,000 square feet to the world's inventory of buildings that consume the minimum energy and water. LEED certification grades buildings on a broad range of energy efficiency and CO2 reduction factors. Buildings are rated in 13 environmental impact cate-

gories, including climate change, indoor environmental quality, resource depletion and water intake.

Amonix makes its MegaModule CPV systems at its 214,000 square foot North Las Vegas facility, which encompasses office and production space. As part of the LEED certification, eight of the CPV systems will supply 100% of the facility's energy needs, or about 2500 megawatt hours (MWhr) per year. The facility will produce CPV systems that will generate 375,000MWhr per year (9 million MWhr over their effective lifetime), i.e. several thousand times as much energy in its lifetime as the manufacturing plant itself consumes.

Additionally, North Las Vegas' lighting arrays exceed LEED requirements by 15-20%. High-performance plumbing fixtures at both facilities decrease water usage by 41% compared to conventional buildings, and more than 70% of

Amonix' equipment and appliances are ENERGY STAR certified.

Amonix' business and engineering operations are based at the Seal Beach site, a rehabilitated 78,000 square foot facility that won LEED Gold Certification in February. That facility earned the maximum score for its lighting system designs, which minimize wasted ambient light by focusing on work areas rather than common spaces by installing tubular 'daylighting' devices to bring natural light into dark spaces.

"Our two 'green' building efforts stand as everyday symbols of our commitment to producing high-efficiency, low-cost solar power systems and reducing our environmental impact," says CEO Brian Robertson. "The LEED certification process is rewarding and proves that balancing economic advantage with sustainability is achievable."

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

### Amonix systems powering USA's largest CPV plant

Amonix says that it is now powering North America's largest utility-scale CPV power plant, a 5MW facility in Hatch, NM. The plant is owned and operated by NextEra Energy Resources LLC (a subsidiary of NextEra Energy Inc of Juno Beach, FL, USA, and the largest generator in North America of renewable energy from the wind and sun).

The Hatch Solar Energy Center generates enough electricity to supply about 1300 homes for El Paso Electric customers per year. The site was built by Blattner Energy Inc of Avon, MN (a renewable energy contractor with more than 15,000 operating megawatts to date). El Paso Electric has committed to buying the Center's power for the next 25 years from NextEra under a long-term contract.

The new plant has 84 Amonix 60kW systems, and is now the country's largest, succeeding the 2MW power plant in Arizona (also powered by Amonix systems).

The Center is expected to offset more than 9000 tons of carbon dioxide per year (equivalent to planting 3500 trees every year that it operates).

The Hatch Solar Energy Center's

**The Hatch Solar Energy Center generates enough electricity to supply about 1300 homes. The new plant has 84 Amonix 60kW systems, and is now the country's largest, succeeding the 2MW power plant in Arizona**

Amonix CPV systems incorporate what are claimed to be the world's most efficient multi-junction solar cells. Dual-axis tracking systems maximize energy production throughout the day by allowing the systems to follow the sun.

"The Hatch Solar Energy Center demonstrates all of solar CPV's advantages, from its scale to its reliability to the stability of its underlying technology," says Amonix's CEO Brian Robertson. "Hatch has the ideal conditions for solar energy development, and CPV is exactly the right technology to realize its full potential to provide a steady, long-term energy supply without consuming excessive amounts of land and water," he adds.

[www.NextEraEnergyResources.com](http://www.NextEraEnergyResources.com)  
[www.blattnerenergy.com](http://www.blattnerenergy.com)

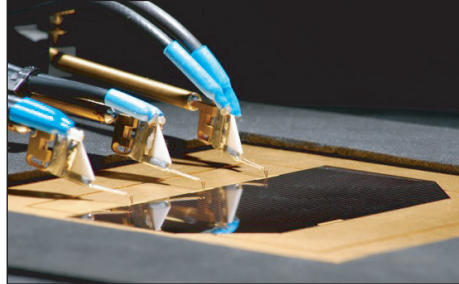
## Fraunhofer ISE and Azur Space extend cooperation on developing space-based III-V solar cells

### Cooperation agreement signed for a further 20 years

After more than 15 years of cooperating on the development and production of multi-junction solar cells based on III-V semiconductors, the strategic partnership between Freiburg-based Fraunhofer Institute for Solar Energy Systems (ISE) and Azur Space Solar Power GmbH of Heilbronn, Germany has now been confirmed for the next 20 years by signing a further cooperation agreement. In the coming years, Fraunhofer ISE will work exclusively with Azur Space on new generations of solar cells for applications in space.

Fraunhofer ISE says that, of all solar cells to date, the highest efficiencies for converting sunlight into electricity are achieved by multi-junction solar cells based on III-V semiconductors (typically gallium arsenide, aluminum gallium arsenide, and gallium indium phosphide). In contrast to silicon, III-Vs can be optimized to match specific wavelength ranges in the solar spectrum by precisely adjusting the atomic compositions. To produce a multi-junction solar cell, several III-V-based solar cells, each of which absorbs a different part of the solar spectrum from the blue to infrared range, are monolithically stacked on top of each other. The cells are internally series connected by tunnel diodes. The resulting stack can consist of up to 40 single layers.

Due to the layering principle of the subcells and the high crystalline quality of the III-V materials used, multi-junction solar cells achieve the highest conversion efficiencies. In space, efficiencies of triple-junction cells are about 30%. III-V cells have been used to power satellites since 1995. However, the potential for this application has not yet been exhausted, says Fraunhofer ISE.



**Measuring a cell's calibrated current-voltage characteristic using a multi-source solar simulator.**  
©Fraunhofer ISE.

In the future, III-V solar cells are expected to generate more electricity per cell area, weigh less and be more robust so that they can better withstand the highly charged particles encountered in orbit. Together with Azur Space, the researchers in Freiburg are addressing these aims and developing manufacturing processes for next-generation multi-junction solar cells. The work is supported by the European Space Agency (ESA-ESTEC), the German Aerospace Center (DLR), and the German Federal Ministry of Education and Research (BMBF).

Research results are being implemented in the products of Azur Space. "The manufacturing process developed at Fraunhofer ISE for multi-junction solar cells serves as the basis for the industry production carried out today by Azur Space Solar Power," says Fraunhofer ISE deputy director Dr Andreas Bett, who is also 'Materials - Solar Cells and Technology' division director. "It is the long-standing successful cooperation with Fraunhofer ISE that has made Azur Space a worldwide leader in manufacturing III-V solar cells," believes Azur Space's CEO Dr Klaus-Dieter Rasch.

[www.ise.fraunhofer.de](http://www.ise.fraunhofer.de)  
[www.azurspace.com](http://www.azurspace.com)

## IN BRIEF

### First Solar to build, operate & maintain NRG project

CdTe photovoltaic module maker First Solar Inc of Tempe, AZ, USA, is to provide engineering, procurement & construction (EPC) services for the 66MW (AC) Alpine solar project in Lancaster, CA of NRG Energy Inc. It will also provide operations and maintenance (O&M) services. Construction should start by the end of 2011 and complete in Q3/2012, creating about 250 jobs.

Electricity from the project in Los Angeles County will be sold under a 20-year power purchase agreement with Pacific Gas and Electric Company. The electricity is enough to serve a yearly average of nearly 25,000 homes, and more than double that number at maximum capacity during peak hours of the day. The project should offset about 1.5 million metric tons of greenhouse gases over 20 years (equivalent to taking more than 15,000 cars off the road annually).

"Less than two years ago, NRG and First Solar began our productive collaboration for our first solar plant at Blythe, which at 21MW was the largest solar plant in California at the time," says Tom Doyle, president of NRG's Solar and West Region. "Alpine is three times that size," he adds. NRG subsidiary NRG Solar has more than 2000MW of PV and solar thermal projects under development or in construction across the southwestern USA.

"Our experience developing and building out our 2.7GW North American pipeline of utility-scale PV projects enables us to get our customers' projects rapidly completed and connected to the grid," says Jim Lamon, First Solar's senior VP for EPC and O&M.

[www.firstsolar.com](http://www.firstsolar.com)  
[www.nrgsolarenergy.com](http://www.nrgsolarenergy.com)

# First Solar's sales rise 89% in Q3 to \$1bn

## Full-year 2011 guidance cut again to \$3–3.3bn, up 23% on 2010

For third-quarter 2011, First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services, has reported net sales of \$1006m, up 89% on \$533m last quarter and up 26% on \$798m a year ago.

Net income was \$196.5m (\$2.25 per diluted share), up from \$61.1m (\$0.70 per diluted share) last quarter and \$176.9m (\$2.04 per diluted share) a year ago. During the quarter, cash and marketable securities rose by \$279m, from \$515m to \$795m.

"First Solar's performance in the quarter reflects our superior technology, strong execution capability, and integrated business model — all of which have enabled us to weather a difficult market environment relatively well," says chairman & interim CEO Mike Ahearn.

"Going forward, our goal is not just to survive the current environment, but to transcend it by creating and expanding markets worldwide that do not depend on today's subsidy

programs. This requires that we re-focus our strategy and commit our resources to solving the pressing energy needs that exist in much of the world," he adds.

Despite the revenue growth in Q3, First Solar has again reduced its guidance for full-year 2011 net sales to \$3–3.3bn (after previously reducing the guidance of \$3.7–3.9bn given last December to \$3.7–3.8bn in late February and then \$3.6–3.7bn in August). However, this still represents growth of 23% on 2010's \$2.6bn.

Likewise, after being cut from May's guidance of \$900–970m to \$900–960m in

**Our goal is not just to survive the current environment, but to transcend it by creating and expanding markets worldwide that do not depend on today's subsidy programs. This requires that we re-focus our strategy**

August, operating income guidance has been cut to \$650–760m.

After being cut from May's guidance of \$9.25–9.75 to \$9.00–9.50 in August, guidance for earnings per diluted share has been cut to \$6.50–7.50. Manufacturing start-up expenses should be about \$35m and factory ramp costs \$10–12m.

In preparation for 2012, the firm is reducing capital expenditures and evaluating opportunities to reallocate overhead expenses to fund increased investments in market development, sales, and R&D.

● On 25 October, First Solar said that its board of directors had asked its chairman & founder Mike Ahearn to serve as interim CEO. Rob Gillette is no longer CEO.

Gillette originally replaced Ahearn as CEO when he was appointed in September 2009. "The board of directors believes First Solar needed a leadership change to navigate through the industry turmoil and achieve our long-term goals," says Ahearn.

The board of directors has formed a search committee and is initiating a search for a permanent CEO.

## First Solar achieves 5GW PV production milestone

### Modules made to date enough to power 2.5 million homes

First Solar says that its cumulative production has reached 5GW, or 66 million cadmium telluride (CdTe) thin-film photovoltaic solar modules, which is capable of generating enough clean electricity to power about 2.5 million homes.

Five GW of solar generation displaces 3.3 million metric tons of CO<sub>2</sub>e annually (equivalent to taking 650,000 average cars off the road or planting 84 million trees each year). On a life cycle basis, systems using First Solar modules also have the lowest carbon footprint and fastest energy payback time (the amount of time a system

must operate to recover the energy that was required to produce it) of any other photovoltaic technology, it is claimed.

First Solar began commercial production in 2002 and has since grown to become one of the world's largest solar module manufacturers, with 36 production lines on three continents. "This milestone helps advance our mission of providing clean solar electricity at affordable prices," says Tymen DeJong, senior VP of global manufacturing. "Our ability to scale high-volume production has been a key factor in reducing the

cost of renewable energy," he adds.

In July, First Solar announced that implementing technologies and processes derived from its R&D program had produced a record 17.3%-efficient CdTe solar cell, resulting in average module conversion efficiency of 12.4% from its best-performing production lines during third-quarter 2011. Efficiency gains have also enabled the firm to begin production of 87W modules, which produce higher amounts of electricity when installed in the field.

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



# First Solar doubles annual production capacity in Germany to 250MW

## Second CdTe PV plant in Frankfurt (Oder) reaches full production

First Solar Inc of Tempe, AZ, USA, the world's largest manufacturer of thin-film solar photovoltaic modules, has inaugurated its second CdTe PV manufacturing plant in Frankfurt (Oder), Germany and celebrated the production of the new plant's 1 millionth module. Guests at the opening ceremony included Brandenburg's Minister President Matthias Platzeck; Katherina Reiche (State Secretary in the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety), and Jürgen Trittin (chairman of the parliamentary faction of the Greens/Bündnis 90 Party in the German Parliament).

Covering an area of about 50,000m<sup>2</sup>, the new plant (which reached full production in October) will manufacture 250MW a year of modules, doubling First Solar's annual production capacity in Germany to 500MW. The new plant became fully operational on schedule after just one year of construction and an overall investment of more than €170m. First Solar's



**First Solar's new factory in Frankfurt (Oder), Germany, inaugurated after reaching full production in October.**

staffing in Frankfurt (Oder) has almost doubled, from 650 to more than 1200.

"With the inauguration of our second German plant in Frankfurt (Oder), we're operating Europe's largest and most modern production site for advanced, thin-film solar modules," reckons Tymen DeJong, senior VP for global operations. "Our additional investment shows: Germany is a key market for solar energy and an important

production location for First Solar," he adds.

First Solar says that the new factory also demonstrates its complete life-cycle approach to manufacturing: the factory will incorporate electricity from its own rooftop solar system, helping to reduce the firm's carbon footprint. It has also voluntarily established the industry's first comprehensive, pre-funded solar module collection and recycling program and operates a

recycling facility in Frankfurt (Oder).

"First Solar and Brandenburg are a good match," comments Platzeck. "Compared with other German states, we are already leading in the area of renewable energy," he adds. "We will continue to strengthen our top position and contribute to further establishing Germany as one of the key players in protecting the climate and achieving a balance between ecology and economy."

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

## First Solar postpones Vietnam factory commissioning

### Efficiency hits 12.4% for best manufacturing lines in Q3; annual throughput 70MW/line by end 2012

First Solar has consolidated its manufacturing capacity plan and accelerated progress toward its module conversion efficiency and production throughput targets.

The firm is postponing commissioning of its Vietnam factory until global supply and demand dynamics support the additional capacity. First Solar will continue developing its factory in Mesa, AZ, in order to supply PV modules for its 2.7GW North American project pipeline, which includes the Agua Caliente, Desert Sunlight, Antelope Valley Solar Ranch and Topaz projects.

In third-quarter 2011, First Solar also began to implement technologies and processes derived from its R&D program that in July produced a record 17.3%-efficient CdTe solar cell, resulting in average module conversion efficiency of 12.4% from its best-performing production lines during the quarter. Average conversion efficiency for all production lines was 11.8%, up from 11.7% in Q2/2011.

First Solar also expects that continuous improvement programs in its production process, coupled with the efficiency gains, will

increase its average manufacturing throughput to 70MW annually per production line by the end of 2012, up from 63.5MW per line in Q3/2011.

"Our achievements in R&D continue to showcase the long-term conversion efficiency potential and scalability of our advanced thin-film technology," says chairman & interim CEO Mike Ahearn. "This consolidation will help us to balance our production with market demand, while still providing local capacity to supply our US project pipeline and the broader American market."

# Largest CIGS PV plant opened, using 200,000 Q.SMART modules from Q-Cells

Q-Cells SE of Thalheim, Bitterfeld-Wolfen, Germany, which manufactures both silicon and thin-film copper indium gallium diselenide (CIGS) thin-film solar photovoltaic (PV) modules, has supplied about 200,000 of its Q.SMART CIGS modules to GP Joule GmbH, which was founded in 2009 and based in Reußenköge in the North Frisia region of Schleswig-Holstein and specializes in the realization of solar energy, wind energy and biomass installations.

GP Joule has hence constructed what is reckoned to be the world's largest solar power plant using CIGS thin-film technology in the record time of just eight-and-a-half weeks. Backed financially by investment firm Aquila Capital, the Solarpark Ammerland plant (in the municipality of Wiefelstede in Lower Saxony) was developed by Stuttgart-based project developer Martin Bucher, while Module24 GmbH & Co KG of Heppenheim, Germany selected the Q-Cells modules for the plant. Q-Cells provided technical support during the installation phase.

The plant was installed on an area of 57 hectare at the former Oldenburg military airbase (taken out of service in 1994, and used for agricultural purposes since 2008). "We'll be able to bring fallow land back to life and take a further stride, along with the state of Lower Saxony, towards a sustainable electricity system using renewable energy sources," says GP Joule's CEO Ove Petersen. "The project clearly shows that there are forward-looking, efficient and economically sound usage ideas available for converted land, and that these ideas can be realised quickly and without too much bureaucratic red tape" he adds.

The grand opening in late October was attended by about 100 invited guests, including Lower Saxony's Minister President David McAllister,



**Solarpark Ammerland, which has a total capacity of over 20.8MWp.**

Wiefelstede's mayor Helmut Völkers and Petersen.

With a total capacity of over 20.8MWp, Solarpark Ammerland will supply the electricity needs of more than 6000 households (20 million kilowatt hours per year) and save about 11,800 tons of CO<sub>2</sub> emissions annually. "The Ammerland plant is proof of the fact that CIGS thin-film modules are eminently suitable for building efficient, profitable solar power plants," says Module24's CEO Marc Weißmüller.

With solar energy conversion efficiency of up to 14.7% in relation to aperture area, Q-Cells says that it has held the record for series-produced thin-film modules since 2009. The performance of Q.SMART modules is boosted by a 'light-soaking effect' that can increase output by an average of 2.5% above nominal output in

standard field test conditions.

Their capacity to produce high yields even when light is poor or the climate is hot makes Q.SMART modules suitable for a diverse range of applications, from roof-mounted systems for residential customers to commercial roof-mounted systems and large ground-mounted installations, claims Q-Cells.

Q-Cells guarantees 100% output in the first three years and states that linear decline in output thereafter will be limited to a maximum of 0.7% per year from the fourth year onward, i.e. the modules still deliver 85% of nominal output after 25 years.

The technology behind Q.SMART was developed in 1983 by the Ångström Solar Center at Uppsala University, Sweden, commercialized by the spin-off company Solibro in 2006, and acquired by Q-Cells in 2009. This March, Q-Cells said it had achieved the milestone of 14.7% production efficiency on the aperture area, a record for monolithically integrated CIGS thin-film modules. At the end of 2010, total production capacity in Thalheim had reached 135MWp.

[www.q-cells.com](http://www.q-cells.com)

**GP Joule has constructed the world's largest solar power plant using CIGS thin-film technology in the record time of just eight-and-a-half weeks.**

## Manz to acquire Würth Solar's CIGS photovoltaic module innovation line by early 2012

Manz AG of Reutlingen, Germany, which supplies integrated production lines for crystalline silicon solar cells and thin-film solar modules (as well as lines flat-panel displays), has signed a letter of intent to acquire the copper indium gallium diselenide (CIGS) solar module innovation line of Würth Solar GmbH & Co KG of Schwäbisch Hall. Manz plans to integrate Würth's production site, and a total of 116 staff, into the Manz Group. "We are particularly pleased that we will bundle our know-how with that of the employees at the Schwäbisch Hall location," comments CEO Dieter Manz.

The aim is to establish a factory focusing on the rapid further development of CIGS technology, which Manz says has the potential to deliver the lowest cost per watt compared to other technologies. The Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (Centre for Solar Energy and Hydrogen Research, ZSW) in Stuttgart will continue to support R&D activities. The takeover should be concluded by early 2012.

Manz says that this step follows many years of cooperation. The line has been used to date both by Würth for CIGS module production, and by Manz as part of a licensing and co-operation agreement (concluded in 2010) for the devel-

opment of CIGS system solutions. With the new agreement, the line is now intended to serve solely future R&D activities. This should allow development of the technology to be accelerated, and the cost-reduction and efficiency-enhancement potential of CIGS technology to be fully exploited, reckons Manz. The firm hence aims to contribute to quickly reducing cost per watt.

The agreement should also allow milestones that have been planned to date to be reached earlier than intended. These include the optimization of manufacturing processes, boosting efficiency, savings in terms of materials, and hence production cost reduction. Manz reckons that this will help it to offer global solar manufacturers an economically attractive production solution.

"Operating our own research line allows us to qualify our innovations directly in ongoing production operation," says Dieter Manz. "By contrast with a conventional pilot line, our innovation line, with its capacity of up to 6MWp, will produce significantly more solar modules, which Würth Solar will continue to sell in the future," he adds. "The agreement that we have now reached is the right response to the solar market's requirements. We are firmly convinced that CIGS will prevail on the market in the medium term

due to its high cost-reduction potential," Manz continues.

"Together with Würth and the ZSW, we have developed a world record module, entailing an aperture efficiency of 15.1% in production format, within a short period of time. We can further accelerate development and expand our advance in technology with the CIGS innovation line that we are creating."

Manz is to acquire the Würth production site without incurring any further one-off costs. The CIGS technology licenses (including from the research co-operation venture with ZSW) will also transfer to Manz on an unrestricted basis. The technology licensing and cooperation agreement that was concluded in 2010 will be replaced when the new contract is concluded, dispensing with the second tranche agreed in the original contract (which would have been due when the first CIGSfab production line was sold). To offset this, Manz will adopt most of the ongoing costs for operation of the innovation line.

With this step, Würth Solar will focus entirely on its core competency of selling photovoltaic systems and components (including future sales of CIGS modules produced on the innovation line), as well as complete photovoltaic plants and turnkey solar power plants.

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

## Odersun's PV modules meet criteria for higher solar power tariff in Italy

The VDE Institute (the testing and certification authority of the German Association for Electrical, Electronic & Information Technologies) has confirmed that the thin-film solar cells produced by Berlin-based Odersun AG, which makes flexible solar modules using proprietary CISCuT (copper indium disulfide on copper tape) reel-to-reel

manufacturing technology, will carry the 'Made in Europe' certificate. Solar plant operators using Odersun modules can therefore claim a 10% higher feed-in tariff than for non-certified products.

This is based on the latest Italian feed-in law (Conto Energia IV), which introduces new rules for funding solar power in Italy. The

Italian energy agency GSE will pay a 10% higher subsidy for projects incorporating European components.

In collaboration with GSE, a certificate has been developed to confirm that at least 60% of a module or its system components have been manufactured in Europe.

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

## IN BRIEF

## MiaSolé produces its 50 millionth CIGS PV cell

MiaSolé of Santa Clara, CA, USA, which was founded in 2001 to make copper indium gallium diselenide (CIGS) thin-film photovoltaic panels, has produced its 50 millionth cell. The firm says that the milestone underscores the viability of its manufacturing process, which has enabled the production of low-cost, high-efficiency, flexible solar cells at volume scale.

"This commitment to reliability is reinforced by a growing number of globally bank-financed solar projects that are using MiaSolé technology," says VP of marketing Rob DeLine.

Entering into an agreement in April with the Technical Manufacturing Services practice of Santa Clara-based microprocessor maker Intel (providing customized manufacturing services and systems, strategic consulting, operational knowledge and training) has further accelerated the firm's production ramp, and improved the repeatability required for high-volume manufacturing, resulting in consistently higher output, yield and equipment utilization, claims MiaSolé. The firm's target was to triple annualized production capacity to more than 150MW by the end of 2011.

At the heart of MiaSolé's panel is a flexible cell architecture featuring fault-tolerant, low-resistance UltraWire technology. The firm says that this has allowed it to move beyond traditional glass-glass products into the rolled-roofing and building-integrated photovoltaic (BIPV) markets, which are unavailable to leading crystalline silicon manufacturers.

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

## MiaSolé's CIGS PV modules reach 13% efficiency in volume production

MiaSolé says that its latest energy conversion efficiency of 13% is now in volume production. This efficiency gain represents a 30% improvement since the beginning of the year, while costs per watt have been cut by a similar amount over the same timeframe.

"The 13% production milestone is indicative of the ingenuity and diligence of our engineers as well as the enormous potential for CIGS thin-film solar as we continue to raise the bar," says VP of marketing Robert DeLine. "Finding the sweet spot between performance and cost will be the critical factor in driving widespread adoption," he adds.

While crystalline silicon (c-Si) PV manufacturers have traditionally sought to reduce costs through their manufacturing process alone, MiaSolé says that it continues to move towards a cost structure competitive with top-tier solar manufacturers through the combination of a proprietary low-cost physical vapor deposition (PVD)

process, low capital expenditure, and the use of abundant and less expensive raw materials.

Researcher Martin Green cited the firm's unique process and its potential in 'Solar cell efficiency tables (version 37)' in the journal *Progress in Photovoltaics: Research and Applications*, volume 19, issue 1 (January 2011), page 84.

MiaSolé says that its panels are being used for projects worldwide, with more than 55MW shipped to date. The panels have been selected for a range of segments from utility-scale fields to rooftops, and unique applications such as electric vehicle recharging stations.

"We're making steady progress on a roadmap that delivers value to our customers," says DeLine.

"We're producing 13%-efficiency modules today, and the advantages associated with the improved efficiency of our glass-on-glass products will extend to future flex products, opening a host of new applications and markets," he adds.

## HelioVolt CIGS PV modules receive UL and IEC certifications

HelioVolt Corp of Austin, TX, USA, which makes monolithically integrated copper indium gallium diselenide (CIGS) thin-film photovoltaic modules for the commercial rooftop and utility markets, says that its HVC-170X modules have received ANSI/UL-1703, IEC-61646 and IEC-61730 certifications, as tested and certified by Intertek-ETL.

HelioVolt says that its standards for module performance and reliability have been validated extensively across internal and third-party testing sites. "The rigorous outdoor testing and reliability programs we have invested in over the past three years have given us great confidence in the superior performance of our modules. We are pleased to offer the

first in a rapidly developing series of commercially available products to our strategic customers," says founder & chairman Dr BJ Stanbery.

SK TIC (Technology Innovation Company) and SK Innovation (members of Seoul-based energy, chemicals and telecoms firm SK Group, which is Korea's third largest conglomerate) invested \$50m to expand HelioVolt's Austin operations and launch global manufacturing expansion to accelerate the delivery of cost-effective and reliable solar energy solutions to numerous market segments. To date, HelioVolt m has raised more than \$200m in total to fund its move to volume production and international expansion.

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

## Safety & performance certification for Dow's Solar Shingle

The Dow Chemical Company of Midland, MI, USA says that its POWERHOUSE Solar Shingles — which incorporate thin-film copper indium gallium diselenide (CIGS) photovoltaic material — have received seven certifications for product performance and safety including three Underwriters Laboratories (UL) safety certifications for the solar module, fire, and uplift resistance; building code certification from the International Code Council Evaluation Service; International Electrotechnical Commission (IEC) performance certification; California Energy Commission (CEC) List of Eligible Equipment certification; and performance certification of ASTM wind uplift resistance.

Made in the USA, the POWERHOUSE Solar Shingle is a new roofing solution that combines the performance and protection of a conventional asphalt roof with an integrated PV system that can power the home. Dow aims to make residential solar installations as easy as installing an asphalt rooftop.

To achieve UL certifications, Dow Solar and UL worked cooperatively to identify and perform a series of tests to assess the safety of POWERHOUSE Solar Shingles against building code standards, including wind and fire resistance, and electrical code requirements such as proper wiring and PV connections. Dow's POWERHOUSE Solar Shingle passed UL certifications including: the UL 1703 Third

Edition (which tests for the National Electrical Code and Model Building Codes); the UL 790 Eighth Edition (which tests for fire resistance performance); and the UL 1897 Fifth Edition certification (which tests for wind uplift of roofing systems). Also, all the necessary CEC and IEC testing was completed at UL's San Jose PV Lab in California.

UL is a global independent safety science company offering expertise across five key strategic businesses: Product Safety, Environment, Life & Health, University and Verification Services. "We're constantly improving our rigorous standards to ensure that UL certified products are safe and reliable," says Jeff Smidt, VP & general manager for UL's Global Energy Business. "Working with Dow on a truly game-changing product that functions as both a roofing and photovoltaic shingle required a unique set of testing disciplines to ensure compliance as both," he adds. "The collaboration between Dow and UL to define the testing protocols — and ultimately certify the POWERHOUSE as a safe, dual-functioning roofing solution — is a model for our industry."

The POWERHOUSE Solar Shingle has obtained the International Code Council Evaluation Service (ICC-ES) certification, hence complying with the International Building and International Residential Codes. The ICC-ES certification requires the fire classification, wind resistance and weather resistance certifi-

cations. ICC-ES is a non-profit, limited liability company that does technical evaluations of building products, components, methods, and materials.

The POWERHOUSE Solar Shingles also passed the International Electrotechnical Commission (IEC) 61646 Second Edition standard requirements for the design of solar modules in open-air climates. The certification confirms the shingles' ability to withstand prolonged exposure to various climates. The IEC is the world's leading organization that prepares and publishes international standards for all electrical, electronic and related technologies.

The California Energy Commission (CEC) — the state's primary energy policy and planning agency — also certified the DOW POWERHOUSE Solar Shingles to be in compliance with the Guidelines for 'California's Solar Electric Incentives Program'. The shingles are listed as being eligible per the CEC's Senate Bill 1 (SB1) Guidelines.

The POWERHOUSE Solar Shingles also passed ASTM International's D3161-09 standard, which tests for wind resistance of asphalt shingles. The shingles passed the standards set for 110mph winds. Formerly known as the American Society for Testing and Materials, ASTM International is a globally recognized leader in the development and delivery of international voluntary consensus standards.

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

## Ascent Solar appoints TFG-nominated board member

Ascent Solar Technologies Inc of Thornton, CO, USA, which makes lightweight thin-film photovoltaic modules based on copper indium gallium diselenide (CIGS) using flexible substrate materials, has appointed Victor Lee as a member of its board of directors.

Lee is currently managing director of Tertius Financial Group Pte Ltd, a boutique corporate advisory and

private investment firm he founded in February 2009. He has more than 17 years of experience in corporate banking, real-estate finance and investment management, and corporate advisory services at leading worldwide financial institutions.

As a Class 3 director, Lee will stand for election at Ascent's 2014 stockholder meeting. He was appointed to the board as a designate of TFG

Radiant Investment Group Ltd pursuant to the stockholders' agreement of 12 August whereby TFG will invest in Ascent and a jointly establish CIGS PV module manufacturing facilities in East Asia.

"We look forward to benefitting from his expertise and insights, as well as continued support from TFG," says Ascent's president & CEO Ron Eller.

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

# Improving etch process control in InGaN laser diodes

UCSB has developed AlGaN as an etch-stop material using its AlGaN-cladding-free laser diode structure.

University of California Santa Barbara (UCSB), together with Japan's Mitsubishi Chemical Corp, have developed an etch technique to produce more accurate ridge waveguides in nitride semiconductor laser diodes (LDs) [Robert M. Farrell et al, Appl. Phys. Express, vol4, p092105, 2011]. The technique uses an etch-stop layer of aluminum gallium nitride (AlGaN), and is made possible by UCSB's development last year ([www.semiconductor-today.com/news\\_items/2010/SEPT/UCSB\\_140910.htm](http://www.semiconductor-today.com/news_items/2010/SEPT/UCSB_140910.htm)) of nitride LDs that do not use AlGaN for the thick cladding layers needed to confine optical modes in the structure.

Commercial indium gallium nitride/gallium nitride (InGaN/GaN) laser diodes are typically produced with ridge waveguides that need to be etched with accurate dimensions to enable stable, kink-free operation at high output power. However, existing etch methods in nitride semiconductors do not deliver the depth control needed for accuracy, reproducibility, and hence good device yields.

The purpose of ridge waveguides in laser diodes is to laterally confine the optical modes in the structure: too shallow, and optical confinement is lost and current spreading can occur, reducing injection efficiency; too deep, and higher-order modes of the cavity become dominant, leading to unstable far-field patterns and kinks in the light output power-current (L-I) performance. Sometimes the ridge can be etched right through to the active layers where surface recombination states can be set up, decreasing device lifetimes.

One technique for increased etch-depth control used in other material systems (e.g. gallium arsenide, indium phosphide) is to have an etch-stop layer through which the chosen etch method slows considerably. Such selective etching has been applied to nitride semiconductor high-electron-mobility transistors (HEMTs).

Unfortunately, one potential etch-stop material, aluminum gallium nitride (AlGaN), is used as cladding in existing InGaN/GaN LDs, precluding its use in this context. However, UCSB, and separately a Swiss consortium (EPFL, NovaGaN, Exalos), have developed nitride LDs with AlGaN-free cladding structures, which would allow the use of such etch-stop techniques.

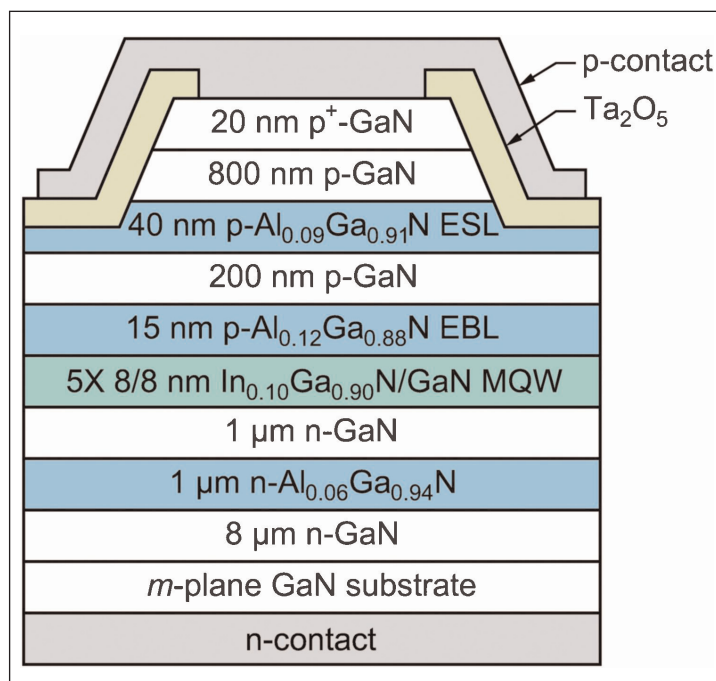


Figure 1. Cross-section of LD based on sample A.

Metal-organic chemical vapor deposition (MOCVD) was used to create laser diode structures (Figure 1) on free-standing *m*-plane GaN substrates supplied by Mitsubishi. The substrates had a deliberate misorientation of 1° toward the [000-1] *c*-direction to improve the crystal growth quality. The epitaxial structures for one sample (A) contained electron-blocking (EBL) and etch-stop (ESL) layers. Another sample (B) consisted of 8 μm of *n*-GaN, as a reference for the etch rate experiments. The dry etching was performed in a Panasonic E620 inductive coupled plasma system. The plasma consisted of a mix of boron trichloride and sulfur hexafluoride.

The researchers estimate that the etch process proceeded through GaN at the rate of 31.6nm/min (Figure 2). This compares with the rate found for the AlGaN ESL etch of 2.9nm/min, giving a GaN:AlGaN selectivity of 11:1. The researchers performed a 30-minute mesa etch for a laser diode ridge on co-loaded samples A and B, which gave etch depths of 0.86 μm and 1.03 μm, respectively. The lower value for sample A indicates that the AlGaN was successful in stopping the etch at the appropriate point. ▶

Diodes produced from sample A had threshold voltages and currents of 9.7V and 210mA, respectively. The researchers comment that the threshold current density of  $10.5\text{kA}/\text{cm}^2$  was "relatively high", compared with similar device structures. However, they hope for improvements with further optimization. In terms of spectrum, the peak shifted to longer wavelengths at higher currents (red shift) with a peak wavelength of 399.9nm (ultraviolet) and full-width at half-maximum (FWHM) of 1.1nm at 300mA.

Funding support for the research came from Solid State Lighting and Energy Center (SSLEC), based at UCSB, and the Visible InGaN Injection Laser (VIGIL) program, run by US Defense Advanced Research Projects Agency (DARPA). ■

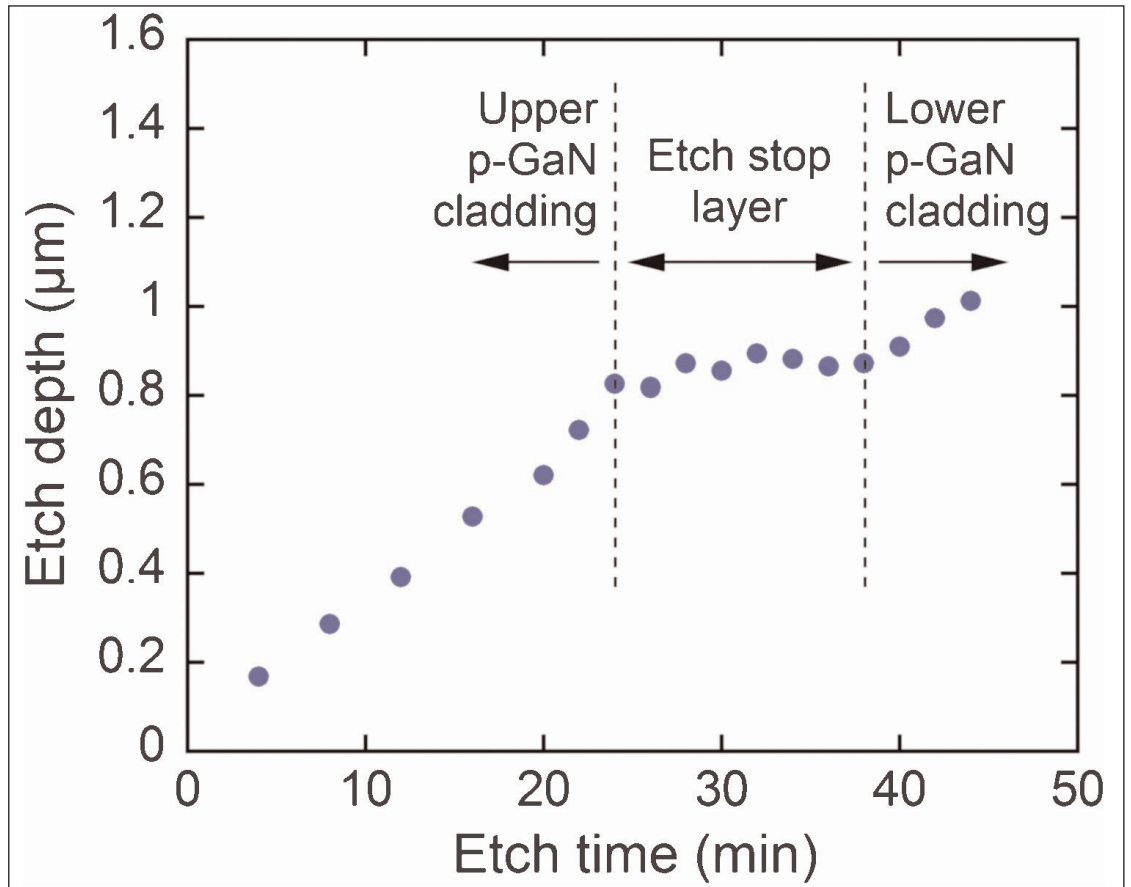


Figure 2. Dependence of etch depth on time for sample A.

<http://apex.jsap.jp/link?APEX/4/092105>

Author: Mike Cooke

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# Barrier doping increases light from semi-polar nitride quantum wells

UCSB and Mitsubishi create devices with orange-red emissions beyond 600nm.

University of California Santa Barbara (UCSB) and Mitsubishi Chemical Corp researchers have used p-type doping of the middle barrier of semi-polar nitride semiconductor double quantum well (DQW) LEDs to increase light output [Chia-Yen Huang et al, Appl. Phys. Lett., vol99, p141114, 2011]. The emission wavelengths of the devices were longer than 500nm (blue-green), and even — using aluminum gallium nitride barriers — longer than 600nm (orange-red).

The DQW structures were grown using MOCVD on free-standing (2021) semi-polar gallium nitride (GaN) substrates supplied by Mitsubishi Chemical. The thickness of the two wells of indium gallium nitride (InGaN) was estimated to be 3nm. The middle barrier was measured to be 10nm thick. The paper does not give the In fraction of either the wells or barrier.

Doping of the middle barrier was achieved using bis-cyclopentadienyl magnesium (Cp<sub>2</sub>Mg) source with flow

rates of 0 (i.e. undoped), 0.6, 1, 3 and 5 standard cubic centimeters (sccm). With 1sccm flow the Mg concentration was measured using secondary-ion mass spectrometry (SIMS) at  $6 \times 10^{18}/\text{cm}^3$ . It was assumed that the effect of these flow rates on doping concentration was linear.

Some Mg was also present in the wells at about a tenth of the concentration in the barriers, which was attributed either to diffusion or to a 'memory effect' of dopant source in the growth chamber. Ideally, one doesn't want any doping in the wells, since it is known that this increases non-radiative electron-hole recombination, reducing the internal quantum efficiency (i.e. conversion into photons) of the device.

The devices were completed with a 10nm p-type aluminum gallium nitride (AlGaN) electron-blocking layer and 100nm p-GaN cap. The resulting LED chips were  $490\mu\text{m} \times 292\mu\text{m}$  with  $0.1\text{mm}^2$  current injection area.

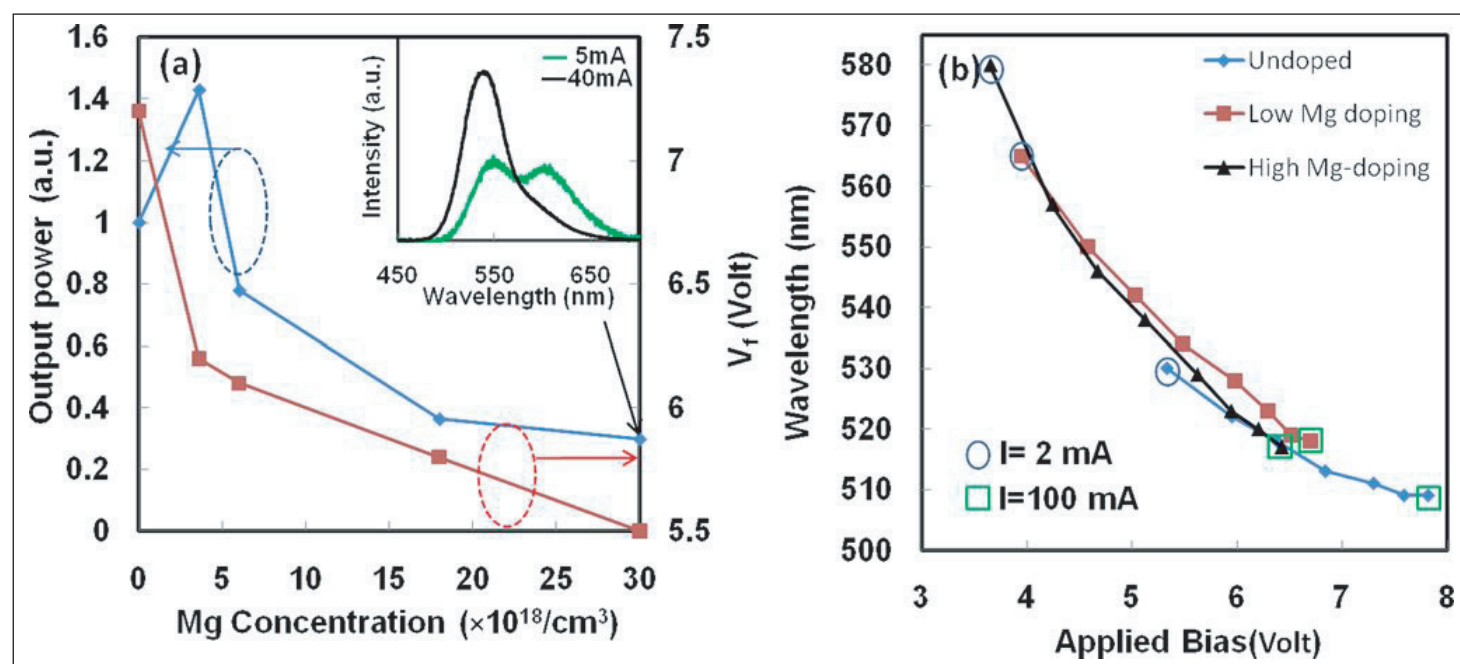
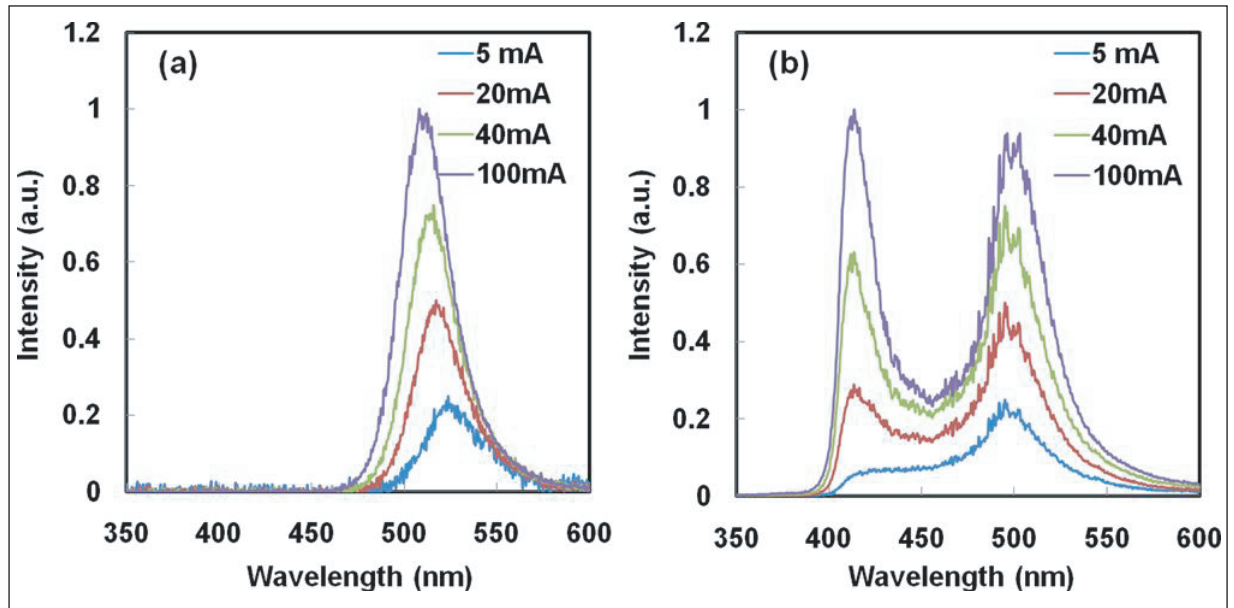


Figure 1. (a) Relative output power and forward voltage ( $V_f$ ) under 20mA injection for LEDs with different Mg doping levels in barrier. The upper right corner shows the electroluminescence (EL) spectra under 5mA and 40mA injection for LEDs with high Mg doping levels (b) EL peak wavelength versus applied bias for current injection levels ranging from 2mA to 100mA for undoped, low-doped ( $3.6 \times 10^{18}/\text{cm}^3$ ), and high-doped ( $1.8 \times 10^{19}/\text{cm}^3$ ) barriers.



► Forward voltages of the devices at 20mA drop as the doping of the barriers increases (Figure 1a). "This result suggests the existence of carrier transport issues between QWs for long-wavelength (2021) MQW LEDs," the researchers say. At the same current, the light output power peaks and then declines "significantly" with doping level.



**Figure 2. Electroluminescence spectra of dichromatic DQW LEDs with (a) undoped barriers and (b) Mg-doped barriers under various injection levels.**

The spectral content of the electroluminescent emission changes according to injection current (Figure 1a inset) and doping (Figure 1b). At low current and high doping, the spectrum has two peaks separated by about 200meV. The researchers suggest that the longer-wavelength peak may be due to transitions between the conduction band and Mg acceptor level or complexes of Mg and hydrogen atoms in the QWs. As the current increases, this route to light output saturates and becomes insignificant in the spectrum.

The reduction in light output with higher doping level is explained as being likely due to inefficiency of the conduction band to acceptor transition or due to the presence of Mg ions in the wells leading to non-radiative recombination such as through the Shockley-Read-Hall mechanism that competes with light emission. "This suggests a trade-off between carrier transport and recombination efficiency in the QWs," the team notes.

Increasing current leads to a blue-shift to shorter wavelengths that could be explained by band filling (increasing the energy separation between electrons and holes), carrier screening or band bending effects. The Mg doping creates a red-shift to longer wavelengths. However, it is to be noticed that, despite these effects, the emission wavelength depends on the applied bias in a similar way between devices (Figure 1b). Thus, the longer emission wavelengths of the more highly doped LEDs are related to their lower forward voltage.

The researchers also studied double quantum wells with different emission wavelengths (Figure 2). This was achieved by growing the n-side well at 865°C and the p-side well at 765°C. With undoped barriers, the emission spectrum appeared to be a single peak in the range 515–520nm (blue-green) with injection currents up to 100mA, suggesting that most of the radiant

recombination takes place in the p-side well. With Mg-doped barriers ( $\sim 6 \times 10^{18}/\text{cm}^3$ ), a second peak emerges in the range 410–420nm (violet) as the injection current is increased from 5mA to 100mA. At the upper end of current injection the violet peak becomes comparable in intensity to the longer wavelength.

The tendency for the holes to remain in the well nearest the p-contact in multi-quantum well structures is well known. The UCSB researchers comment: "Considering the trade-off between enhanced carrier transport and radiative efficiency in each QW, the overall radiative efficiency of the active region could be increased with an optimized Mg doping profile in barriers."

Simulations suggest that one effect of doping the middle barrier of the structure is to bend the band profiles so that the barriers to electron and, more importantly, hole injection are reduced.

The Mg-doped barrier technique has also been applied to devices with AlGaIn barriers. Such barriers are found to improve crystal quality for green semi-polar green laser diodes and for quantum wells with high indium concentration. The researchers used AlGaIn barriers with Mg-doping to create orange-red emission in continuous-wave operation. At 10mA, the emission peak is at more than 650nm, blue-shifting to 590–600nm at 100mA.

The researchers says the long wavelength at low current is due to the low bias allowed by Mg-doping. The large blue-shift at large injection current seems to be due to the strain effects caused by the large difference in lattice constant between InGaIn quantum well and AlGaIn barrier. Such strain sets up polarization electric fields due to the large piezoelectric effect in nitride semiconductors, leading to strong quantum-confined Stark effects (QCSEs).

[http://apl.aip.org/resource/1/applab/v99/i14/p141114\\_s1](http://apl.aip.org/resource/1/applab/v99/i14/p141114_s1)

Author: Mike Cooke

# Graded refractive index structures boost LED emission by up to 131%

**Total internal reflection effects have been reduced with five layers of titanium-silicon dioxide dielectric.**

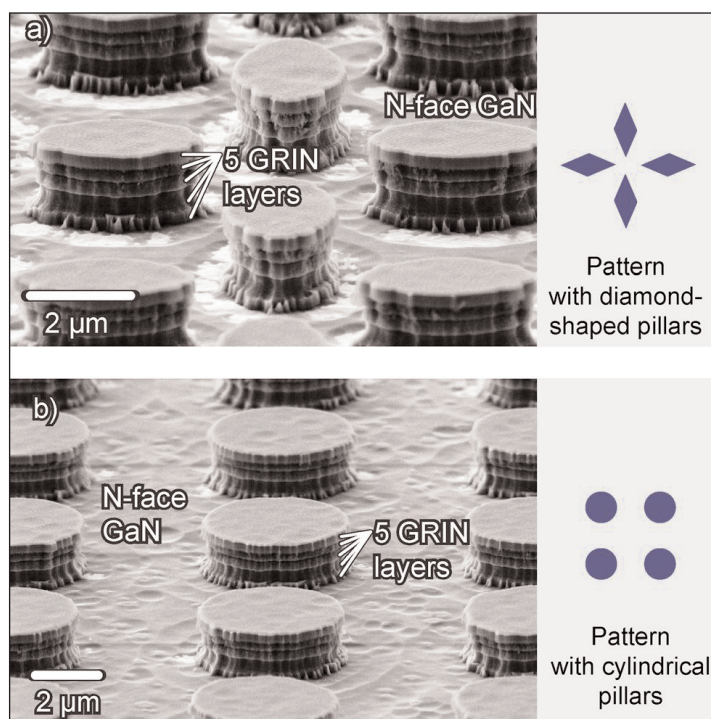
Researchers in the USA and South Korea have used patterned layers of titanium-silicon dioxide ( $\text{TiO}_2/\text{SiO}_2$ ) dielectrics to enhance light output from indium gallium nitride (InGaN) light-emitting diodes (LEDs) by up to 131% [Ahmed N. Noemaun et al, *J. Appl. Phys.*, vol110, p054510, 2011].

The layers work by stepping down the refractive index of the material through which light passes from the high value of 2.47 for GaN to 1 for air. Patterning of the graded refractive index (GRIN) coating allows light to be extracted from the side walls of the dielectric structures.

In the absence of such dielectric layers the large difference in refractive index reduces the angles at which light can emerge from an GaN/air interface to within  $24^\circ$  to the surface normal. Light hitting at greater angles ( $24-90^\circ$ ) is reflected back into the device, a situation called total internal reflection (TIR).

The researchers from Rensselaer Polytechnic Institute, Samsung LED and Pohang University of Science and Technology developed the GRIN technology using 1mm x 1mm 445nm-wavelength nitride semiconductor LEDs grown on c-plane sapphire using metal-organic chemical vapor deposition (MOCVD). The LED layers were lifted-off the underlying sapphire substrate using a 248nm krypton fluoride excimer laser beam.

The separated GaN surface was a nitrogen-face. Two reference LED types consisted of devices with no passivation and planar GaN N-face, and devices with roughened surfaces created through wet etching with



**Figure 1. Scanning electron micrographs (SEMs) of (a) an array of diamond-shaped pillars and (b) an array of cylindrical pillars etched under 1kW ICP power and 400W RIE power with 60sccm of  $\text{CHF}_3$  at 15mTorr and  $50^\circ\text{C}$ .**

10%-by-weight potassium hydroxide solution for 4 minutes at  $50^\circ\text{C}$ .

**Table 1. Thickness and refractive index of each layer in the graded-refractive-index stack is controlled by the power applied to the  $\text{TiO}_2$  and  $\text{SiO}_2$  targets and the deposition time.**

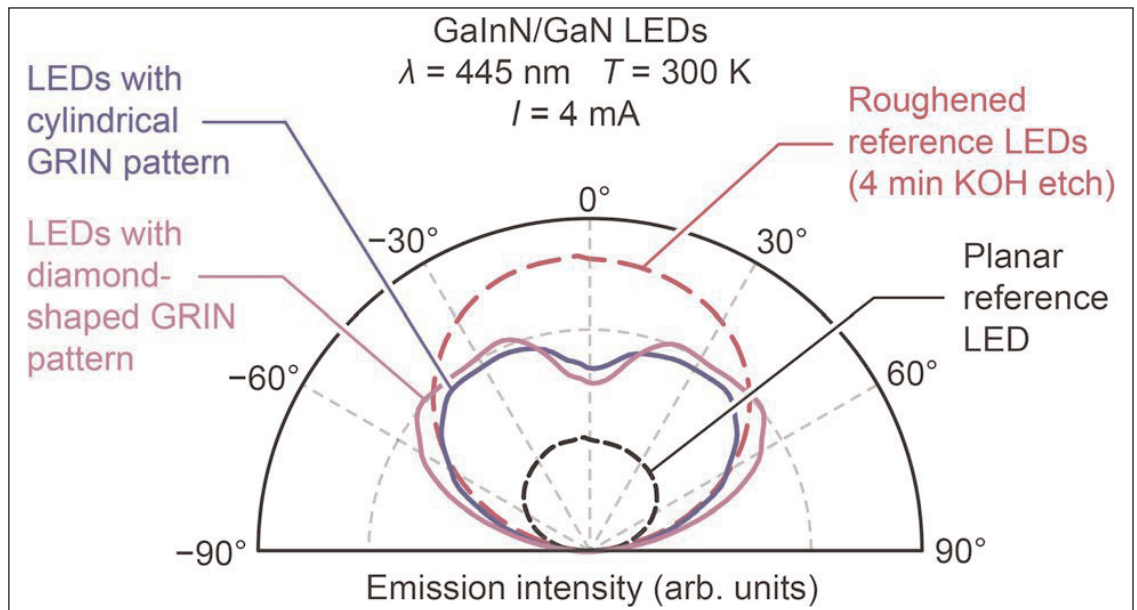
| Layer number | Power applied to target |                | Deposition time | Measured layer thickness | Measured refractive index |
|--------------|-------------------------|----------------|-----------------|--------------------------|---------------------------|
|              | $\text{TiO}_2$          | $\text{SiO}_2$ |                 |                          |                           |
| 1            | 200W                    | 0W             | 240min          | 333nm                    | 2.47                      |
| 2            | 200W                    | 50W            | 180min          | 331nm                    | 2.26                      |
| 3            | 200W                    | 100W           | 120min          | 323nm                    | 1.99                      |
| 4            | 200W                    | 150W           | 90min           | 330nm                    | 1.83                      |
| 5            | 0W                      | 200W           | 120min          | 260nm                    | 1.46                      |

For the devices with GRIN structures, a series of layers with varying thickness and refractive index were applied by sputtering combinations of titanium ( $\text{TiO}_2$ ) and silicon ( $\text{SiO}_2$ ) dioxide (Table 1). The chamber pressure was 2mTorr and was subjected to a 10/0.5 standard cubic centimeter (sccm) flow of argon/oxygen. The substrate plasma was generated at 100V bias.

The GRIN layers were followed by a 127nm layer of indium tin oxide (ITO), which was used as the hard mask for the patterning of the GRIN layers. Photolithography was carried out using a Shipley S1813 photoresist and the pattern transferred to the ITO mask using a methane/hydrogen/chlorine inductively coupled plasma reactive ion etch (ICP-RIE). Having formed the hard mask, the  $\text{TiO}_2$ - $\text{SiO}_2$  layers were patterned with trifluoromethane ( $\text{CHF}_3$ ), again using ICP-RIE. The etch residues were removed using a 30 minute 80°C dip consisting of a photoresist stripper.

The tilt angle of the resulting pillars of dielectric was less than 5°. The patterns were either cylindrical or diamond-shaped pillars (Figure 1). These patterns were designed using theoretical calculations involving ray tracing.

**Although the patterning increased the forward voltage of the devices, improved light output up to 131% was achieved. Patterning of GRIN layers on LEDs could also be used to convert trapped modes of light inside a semiconductor into designable modes with desirable properties, such as preferential direction of emission and polarization of light**



**Figure 2. Far-field emission intensity of planar reference LEDs, KOH-roughened reference LEDs, LEDs with GRIN cylindrical patterns of  $2\mu\text{m}$  diameter, and LEDs with GRIN diamond-shaped patterns with  $4.7\mu\text{m}$  longer diagonal and  $2\mu\text{m}$  shorter diagonal.**

Although the patterning increased the forward voltage of the devices, improved light output up to 131% was achieved (Table 2). The planar and roughened far-field emission patterns are described as 'Lambertian', with peaks at 0°, while the emission for cylindrical and diamond patterned GRIN layers peaks at an off-surface normal direction between 25° and 55° (Figure 2). The researchers comment: "The strong side emission is consistent with our expectations resulting from theoretical calculations."

The researchers suggest that patterning of GRIN layers on LEDs could also be used "to convert trapped modes of light inside a semiconductor into designable modes with desirable properties, such as preferential direction of emission and polarization of light."

Financial support came from a wide range of sources: Samsung LED Co, the Korean Ministry of Knowledge Economy through International Collaborative R&D Program, and the USA's Sandia National Laboratories, National Science Foundation, Department of Energy, Department of Defense, NY State Energy Research and Development Authority (NYSERDA), Magnolia Solar Inc and Raydex Technology Inc. ■

<http://link.aip.org/link/doi/10.1063/1.3632072>

Author: Mike Cooke

**Table 2. Performance results for some of the devices compared at 4mA.**

| Type          | Spacing        | Dimensions                                     | Improvement in light output | Forward voltage |
|---------------|----------------|--|-----------------------------|-----------------|
| Planar        |                |  | 0%                          | 2.64V           |
| Roughened     |                |  | 124%                        | 2.7V            |
| Cylinder GRIN | $2\mu\text{m}$ | $2\mu\text{m}$ diameter                        | 104%                        | 2.67V           |
| Diamond GRIN  | $4\mu\text{m}$ | $2\mu\text{m} \times 4.7\mu\text{m}$ diagonals | 131%                        | 2.67V           |

# Integrating electrostatic discharge handling into nitride LEDs

Chinese research uses silicon delta-doping to increase ESD performance from 1200V to 4000V.

Researchers in China have increased the resilience of nitride semiconductor light-emitting diodes under negative bias from 1200V to 4000V by using four layers of silicon delta-doped (Si DD) material as part of the n-cladding [Zhiyuan Zheng et al, *Appl. Phys. Lett.*, vol99, p111109, 2011]. It is thought that the improvement is due to better current spreading across the device and material quality enhancement. The research was carried out at State Key Laboratory of Optoelectronic Materials and Technologies, Sun Yat-sen University, Guangzhou.

The LED samples were grown on c-plane sapphire using metal-organic chemical vapor deposition

(MOCVD). The active region consisted of a 6-period multi-quantum well (MQW) of indium gallium nitride ( $\text{In}_{0.17}\text{Ga}_{0.83}\text{N}$ ) separated by GaN barriers. A standard device was produced with a 2.3 $\mu\text{m}$ -thick heavily Si-doped n-cladding layer (carrier density  $6 \times 10^{18}/\text{cm}^3$ ), and 200nm magnesium-doped p-GaN layer.

A second device with four Si delta-doped (Si-DD) layers separated with 50nm of GaN between the MQW and n-cladding layers were also produced. The n-cladding was reduced in thickness in the second device to 2.1 $\mu\text{m}$  to maintain the same total thickness of the n-type layer between the devices. The delta doping was achieved by alternatively switching the trimethylgallium and silane ( $\text{SiH}_4$ ) sources on or off, while maintain the ammonia ( $\text{NH}_3$ ) flow.

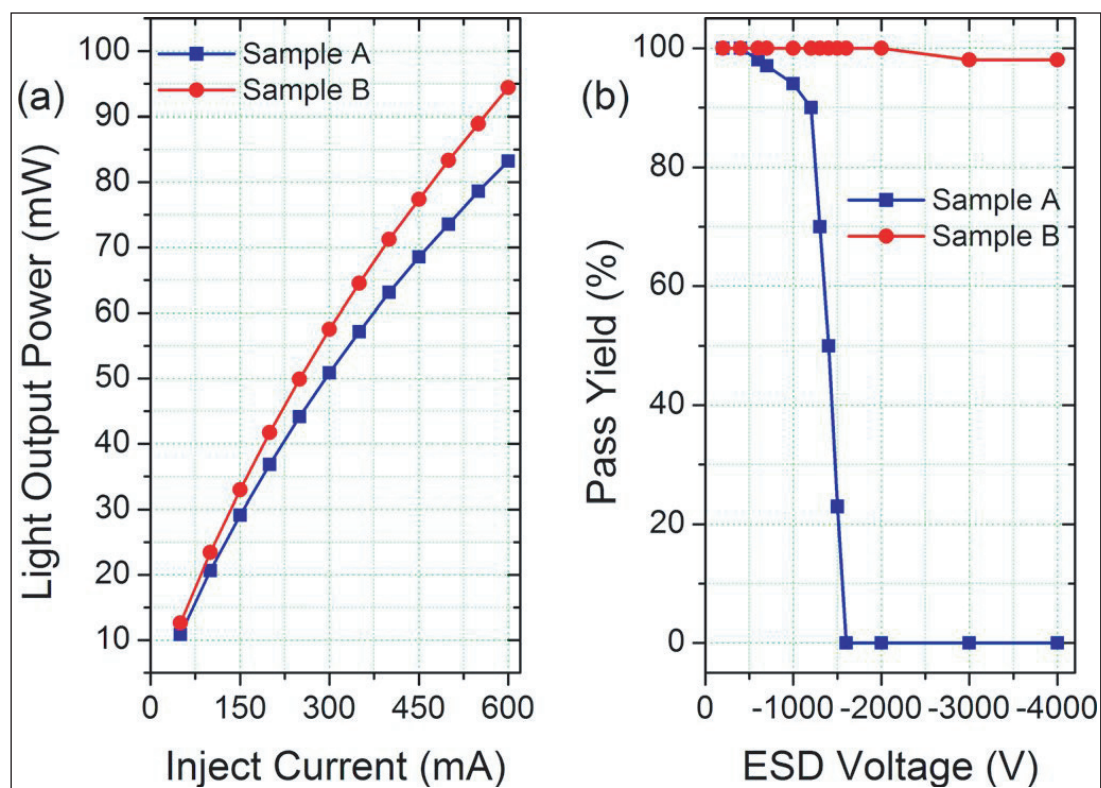


Figure 1. (a) Light output power and (b) ESD properties of devices without and with Si delta-doping layers (samples A and B, respectively).

Mesa structure 1mm x 1mm LEDs were produced from the epitaxial samples. The output power (Figure 1a) of the device with delta-doped n-GaN (sample B) was 64.8mW at 350mA, which is 12.8% higher than that of the standard device (sample A). Since the sapphire substrate is insulating, the electrode contacting with the n-type material of the device is off to the side of the device. This means that the electron current has to flow laterally under the active region before they can ascend to the active region.

The electrostatic discharge performance (Figure 1b) was assessed by applying negative biases up to 4000V and then testing the reverse bias leakage current at 5V. If the leakage current exceeded 5 $\mu\text{A}$ , the device was considered to fail the test. With this criterion,

device A failed at 1200V, but LED-B continued to pass at 4000V. The measurements were made on an IPT 6000 Fit Tech system with a human-body-mode ESD module.

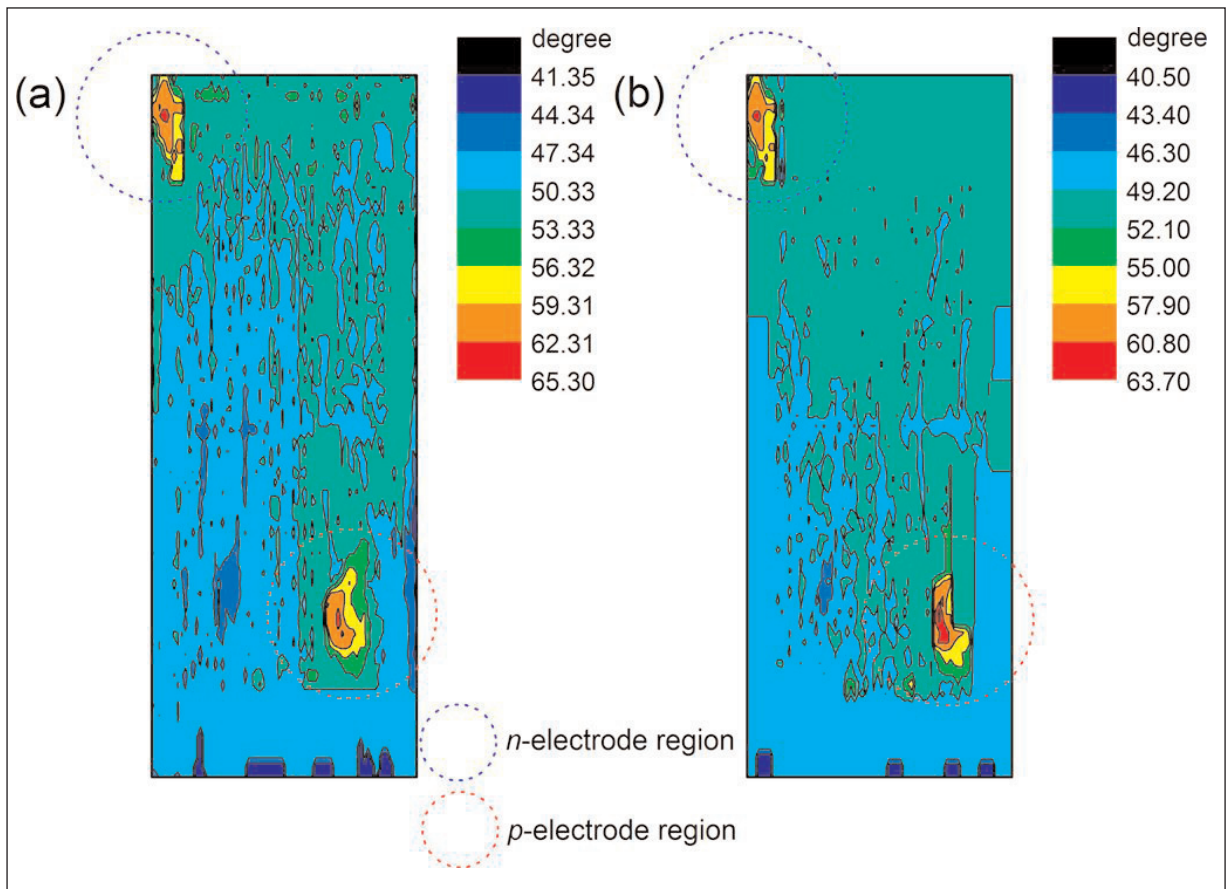
The researchers also wanted to know why their delta-doping technique improved ESD handling by investigating possible explanations such as capacitance modulation, better current spreading and improved material quality.

However, the researchers found "no obvious discrepancy" between their devices A and B in terms of capacitance-voltage performance, so they rejected capacitance modulation as the origin of improved ESD performance.

The researchers looked next at the thermal properties of the devices using infrared microscopy (Figure 2), seeing a more uniform distribution in LED-B that would indicate better current spreading. "We ascribed this improvement to the enhanced electrical conductivity of the Si-DD layers," write the researchers. Hall measurements on the normal (A) and Si-DD (B) n-cladding structures gave mobilities of  $180\text{cm}^2/\text{V}\cdot\text{s}$  and  $218\text{cm}^2/\text{V}\cdot\text{s}$ , respectively. This would give a 17% increase in conductivity for LED-B, enhancing current spreading under the active region and thus lowering the current density across the device. These factors would improve ESD performance.

Current spreading could also improve light output power by reducing the droop effects of high current density (see, e.g., [www.semiconductor-today.com/news\\_items/2011/SEPT/TNCU\\_260911.html](http://www.semiconductor-today.com/news_items/2011/SEPT/TNCU_260911.html)).

Current-voltage measurements show little difference between the devices in forward bias, but in reverse bias, leakage currents are typically reduced by more than one order of magnitude (factor of 10) in LED-B: at 5V, the current in LED-A is  $8 \times 10^{-7}\text{A}$ , compared with  $4 \times 10^{-8}\text{A}$  for LED-B. The researchers suggest that the improvement in LED-B could be due to reduced



**Figure 2. IR camera images of sample A and sample B driven by 350mA injection current.**

dislocation density in LED-B. It is thought that Si-DD can reduce screw-type dislocations by an annihilation effect. Another possibility that may be operating is blocking of pure edge dislocation propagation through formation of silicon nitride complexes.

High threading dislocation densities are created in the growth of nitride semiconductors on sapphire due to the large lattice mismatch ( $\sim 14\%$ ) and differences in thermal expansion between the materials.

X-ray diffraction patterns were little different between the devices. LED-B did have a slightly narrower rocking curve, but not enough to validate improved material quality. The peak intensity in photoluminescence experiments for LED-B was about double that of LED-A. The peak occurred at 470nm wavelength. The much higher emission peak intensity suggests improved quality of the epilayers in the DD structure.

Wet chemical etching also suggests reduced dislocation density with a density of etch pits of  $7 \times 10^7/\text{cm}^2$  for epitaxial sample A and  $3 \times 10^6/\text{cm}^2$  for B. The hexagonal pyramid shape of the pits indicated that the dislocations were mixed- and screw-type. Lowering dislocation densities reduces current leakage paths, enhancing ESD handling and increasing light output. ■

<http://link.aip.org/link/doi/10.1063/1.3637599>

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# Pyramid LED arrays on amorphous glass

**Proof-of-concept for prospect of low cost, high performance for large-substrate production.**

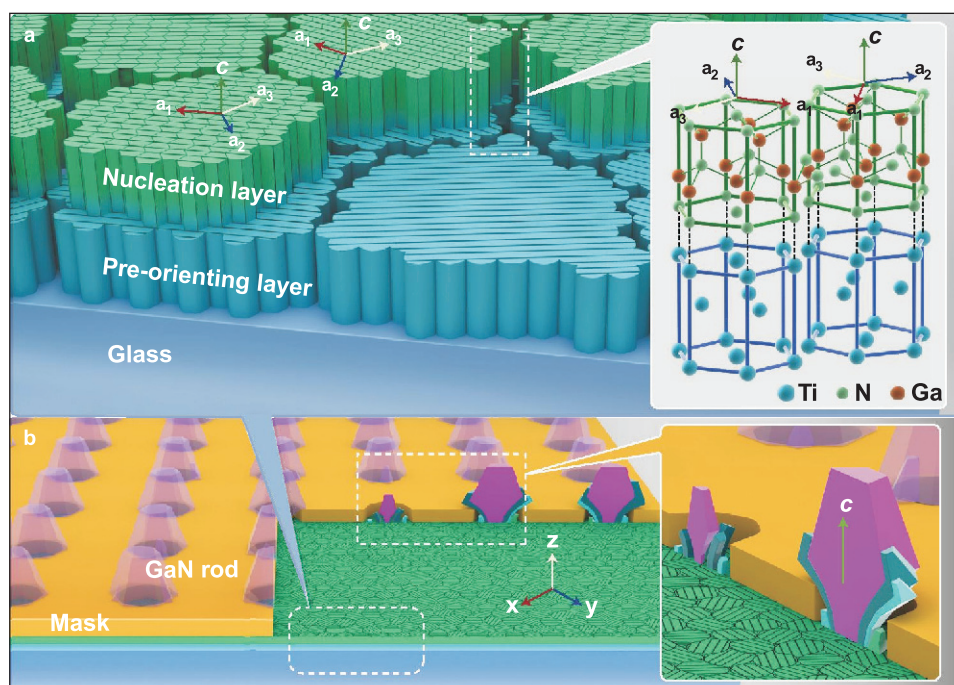
**S**amsung Advanced Institute of Technology and Seoul National University have produced nitride semiconductor LED structures on amorphous glass [Jun Hee Choi et al, *Nature Photonics*, published online 9 October 2011].

The structures consisted of an array of nearly single-crystalline truncated pyramids of gallium nitride (GaN) on which further layers of indium gallium nitride (InGaN) multi-quantum wells, magnesium-doped p-GaN, polymer filling and indium tin oxide (ITO) were deposited.

The researchers see potential applications as including using the pyramids as pixels in displays such as for large-area inorganic LED TVs, concluding: "This method should provide a new and attractive tool for realizing ideal high-performance electroluminescence devices that demonstrate both low cost and high device performance, as well as scalability to large sizes."

The structures were begun with growth of the GaN pyramids on 2-inch fused silica glass wafers. The growth of nearly single-crystalline GaN on these wafers uses a 'pre-orienting layer' of thin-film titanium followed by a GaN nucleation layer (Figure 1a). The titanium is deposited in an evaporation process, and the GaN is deposited in low-temperature (560°C) MOCVD using a Sysnex system with trimethyl-gallium and ammonia sources in hydrogen carrier gas.

Titanium grows with a hexagonal wurzite structure, like GaN, but with a lattice parameter mismatch of 7%. This mismatch is about half that of standard GaN on sapphire growth (~14%). The titanium grains tend to grow in columns, giving crystalline alignment in the vertical, but not lateral directions. Another potential advantage of using titanium in this way is its use as one of the electrodes in electronic devices. Titanium is also stable in ammonia/hydrogen at high temperature, unlike alternatives such as zinc oxide (lattice mismatch



**Figure 1 Schematic for fabricating GaN pyramid arrays. (a) Preferential polycrystalline morphology of titanium pre-orienting layer and LT-GaN nucleation layer. Inset: corresponding atomic arrangement of layers at the grain boundary. (b) GaN pyramid arrays formed during HT-GaN growth on oriented LT-GaN/titanium through patterned holes in SiO<sub>2</sub> mask. Inset: during HT-GaN growth, the GaN pyramid formed from a few crystal islands grown predominantly with preferred c-axes in the z-direction.**

1.9%) or aluminum nitride (-2.4%).

A silicon dioxide (SiO<sub>2</sub>) mask is used to allow local heteroepitaxy where the transfer of crystal orientation from the nucleation layer is constrained to a few orientations, creating near-single-crystal truncated pyramids (Figure 1b). The GaN in this stage is grown at a high temperature of 1040°C to ensure high crystallinity.

The diameters of the holes in the mask were varied between 0.2µm and 2.4µm. At larger sizes, the GaN grew with a central pyramid along with a few small fragments resulting from growth on nucleation sites of differing orientation. At 0.7µm diameter, almost all the smaller fragments disappeared, giving nearly-single-crystal GaN pyramids. One disadvantage of the smaller mask hole is reduced symmetry and order of the pyramid shape; the researchers say that they are still optimizing the process to improve this aspect. ►

The researchers formed five-period InGaN/GaN quantum wells on the pyramid arrays with ultraviolet photoluminescence (PL) peaks at 364nm with 16nm full-width at half maximum (FWHM). This FWHM is similar to that of GaN pyramids on sapphire, but single-crystal GaN films give a typically narrower 10nm. The internal quantum efficiency, estimated from PL measurements at 10–300K, is given as 52%.

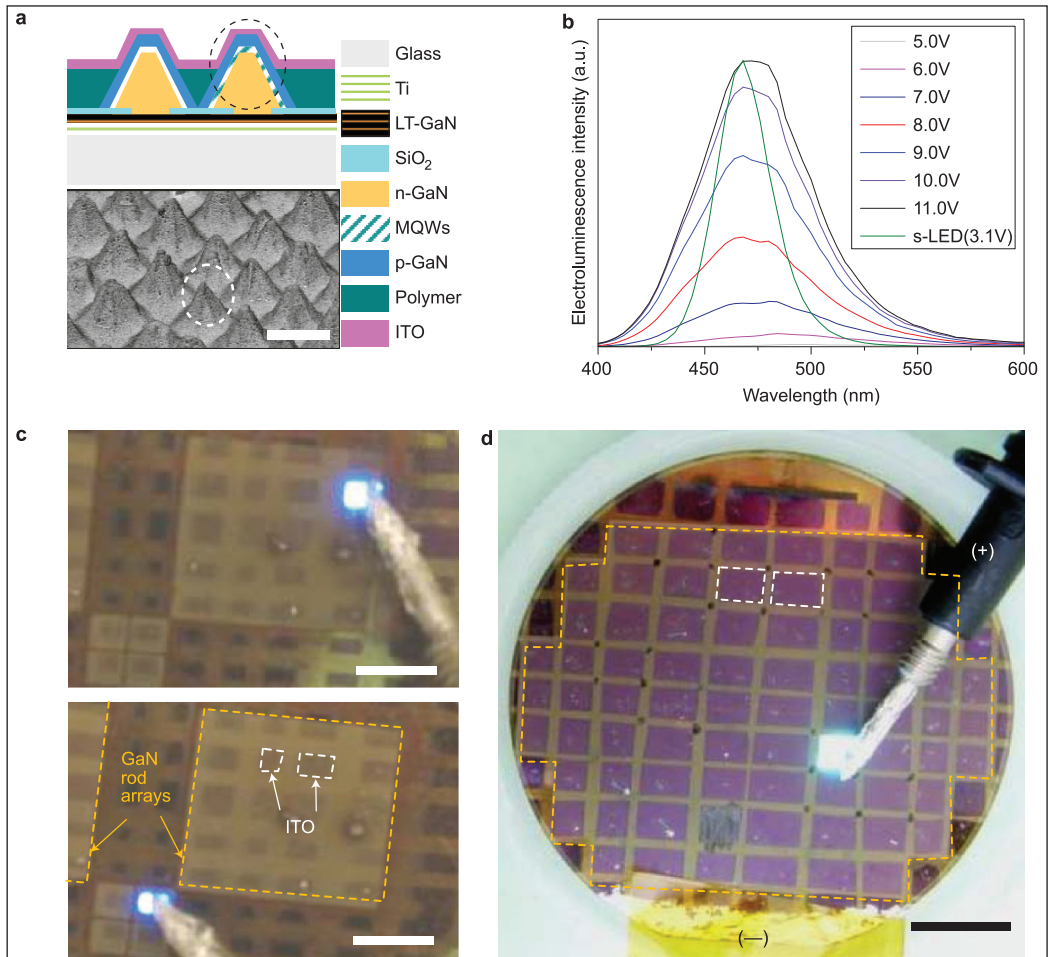
The team comments: "This value of IQE (a typical measure of recombination defect centers) clearly demonstrates the excellent crystalline property of the arrays. The high IQE may be attributed to the reduced quantum-confined Stark effect (QCSE) of the (10 $\bar{1}1$ ) semi-polar facets as well as the high crystallinity in this region, where the MQWs were formed."

The decay time in time-resolved measurements was 2.61ns. The scientists thus attribute 5.02ns (2.61ns/0.52) to radiative decay, and 5.44ns to non-radiative (2.61ns/0.48).

Indium tin oxide (ITO) was used as a transparent conductive layer on top of p-GaN deposited on the multi-quantum well (MQW) pyramids for electroluminescence (EL) measurements, creating LEDs (Figure 2a). The region between pyramids was filled with 3 $\mu$ m spin-coated insulating AZ1512 polymer photoresist before ITO deposition. The n-electrode consisted of the bottom titanium pre-orienting layer, which also acts as a reflector. Although the researchers say the structure are efficient in light extraction, "transmittances of other layers need to be further improved".

The EL spectra were much broader than for single-crystal devices (Figure 2b). Also, the peak wavelength varied across the facets of the pyramids. The peak wavelength was 478nm at the rod apex, decreasing to 448nm towards the pyramid base. These wavelengths are in the 'blue' region (440–490nm) of the visible spectrum. The wavelength decrease is attributed to indium composition and MQW thickness variations.

The researchers add: "On a macroscopic scale, we observed quite uniform and surface-type electroluminescence emission at different locations [Figures 2c, 2d]. To the best of our knowledge, this is the first demon-



**Figure 2. Crystal quality of GaN pyramid arrays and electroluminescence devices fabricated on top of GaN pyramid arrays. (a) Electroluminescence device structure (upper panel) and its corresponding SEM image (bottom panel). (b) Electroluminescence spectra at different voltages and of the s-LED at 3.1V. The peak intensity of the s-LED spectrum was normalized to that of the electroluminescence device spectrum. (c, d) Photos of electroluminescence at different locations, showing bright, surface-type emission. Scale bars, 5mm (a, bottom panel), 0.5cm and 1cm (c and d, respectively).**

stration of such electroluminescence emission from GaN grown on glass."

With the vertical current injection allowed by use of the titanium electrode, the current crowding of the usual lateral injection on insulating substrates like sapphire (and glass) is avoided. Such current crowding tends to degrade LED performance/efficiency.

The maximum luminance was 600cd/m<sup>2</sup>, which is almost half that for the same MQW structure deposited on a single-crystal substrate. "This suggests the possibility of achieving brighter and efficient electroluminescence devices by adopting a standard LED layer structure with an electron-blocking layer," the researchers comment.

Since the research is only at the proof-of-concept stage, there are many possible improvements such as reducing leakage currents through further optimization. ■

[www.nature.com/doi/10.1038/nphoton.2011.253](http://www.nature.com/doi/10.1038/nphoton.2011.253)

[www.sysnex.com/eng](http://www.sysnex.com/eng)

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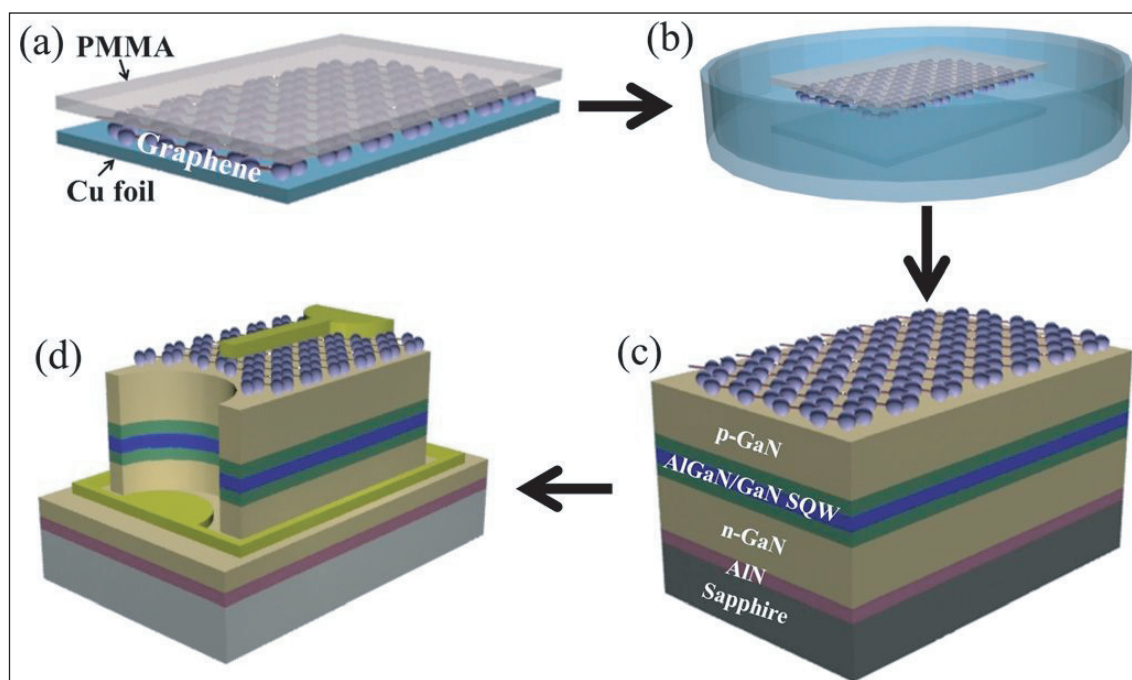
# Graphene as transparent conductor for UV LED current spreading

**Four-layer graphene has been used as a transparent conducting contact for UV LEDs, doubling injection current at 10mA.**

**R**esearchers based in South Korea and USA have been exploring the capabilities of few-layer graphene as a transparent conducting layer for ultraviolet nitride (UV) semiconductor light-emitting diodes (LEDs) [Byung-Jae Kim et al, Appl. Phys. Lett., vol99, p143101, 2011]. The research involved Korea University, Korea Electronics Technology Institute, and the US Naval Research Laboratory.

Since its isolation a few years ago, graphene has been the focus of intense research efforts, and many expectations; however, at present, applications seem far off. Among graphene's useful qualities are high electrical and thermal conductivities. Also, for UV LEDs, the material offers transparency.

The few-layer graphene (FLG) material used for nitride LED contacts was first grown on copper (Cu) foil using chemical vapor deposition (CVD) and coated with Poly(methyl methacrylate) (PMMA) thermoplastic (Figure 1a). The FLG film was then separated with the PMMA layer from the copper using a six-hour wet etch (Figure 1b) in 1%-by-weight ammonium persulfate ((NH<sub>4</sub>)<sub>2</sub>S<sub>2</sub>O<sub>8</sub>) solution. The FLG/PMMA was finally floated onto the top p-contact of UV nitride semiconductor LED structures that had been grown with metal-organic chemical vapor deposition (Figure 1c). The single-quantum-well active light-emitting region



**Figure 1. Schematic of the processes used to fabricate UV LED with a graphene-based transparent conductive electrode. FLG on the Cu foil was grown by CVD. (a) PMMA was coated on the graphene layer. (b) Cu foil on the graphene layer was removed by wet etching in ammonium persulfate. (c) Graphene with PMMA was deposited on p-GaN layer and PMMA was removed. (d) LED chips were fabricated by standard photolithographic processes.**

consisted of 5nm GaN sandwiched between 8nm AlGaIn barriers. The p-GaN consisted of 200nm magnesium-doped material.

The mesa structure of the LED was created after FLG transfer using a plasma etch of boron trichloride and chlorine gas (Figure 1d). The ohmic n-electrode consisted of 750°C annealed titanium-aluminum-nickel gold. Contact pads consisted of titanium-gold for both n- and p-type connections.

One advantage of using graphene over indium tin oxide (ITO) as transparent conductive oxide is its improved transmission in the ultraviolet. At 372nm, the transmittances of bi- (2L) and tetra-layer (4L) graphene were found to be 95% and 89%, respectively. ▶



► By contrast, the value for 150nm ITO was 68%. This advantage for graphene lessens for longer wavelengths and disappears around 600nm.

The survival of the graphene layer from the LED process was confirmed by Raman spectroscopy, which also determined the number of layers by comparing the intensity of the peaks from the G and 2D bands arising from vibration/phonon modes.

The effect of using a 4L-graphene transparent contact was to double the injection current in LEDs: at 10V bias, an LED without graphene p-contact carried 2.3mA, and with the 4L-graphene carrying 5mA (Figure 2a). The main UV emission at 20mA occurs at 372nm (Figure 2b). The broad green-yellow (500–600nm) emission is attributed to “nitrogen vacancy and other growth related defects in the GaN”. Increased light output was also seen for 20mW input power (Figures 2c and d). Without graphene, light is only emitted from the edges of the structure. The 4L-graphene acts to spread the injection current and cause the whole device to emit.

There is a trade-off between the conductivity of graphene and transparency. Thicker layers are more conductive, but transmit less UV.

The FLG contact LED could sustain 10mW input power for an “extended period of time”. However, increasing to 20mW reduced light output. The emission pattern that resulted was similar to that of the LED without FLG transparent conductive layer, suggesting that high-power operation removed the graphene layer. Raman spectroscopy investigation suggested that after a minute, the 4L layer had been reduced to 2L, which is less effective at spreading the injection current due to its lower conductivity.

The researchers conclude: “This study confirms that graphene-based transparent contact to a GaN-based UV LED is superior to an ITO contact based on cost, transparency, and, heat and current spreading. However, critical issues such as reliability and degradation of graphene films require and are the subject of further investigation.”

Funding for the research came from National Research Foundation of Korea (NRF), LG Innotek-Korea University Nano-Photonics Program, and the US Office of Naval Research. ■ [http://apl.aip.org/resource/1/applab/v99/i14/p143101\\_s1](http://apl.aip.org/resource/1/applab/v99/i14/p143101_s1)  
Author: Mike Cooke

**This study confirms that graphene-based transparent contact to a GaN-based UV LED is superior to an ITO contact based on cost, transparency, and, heat and current spreading. However, critical issues such as reliability and degradation of graphene films require and are the subject of further investigation**

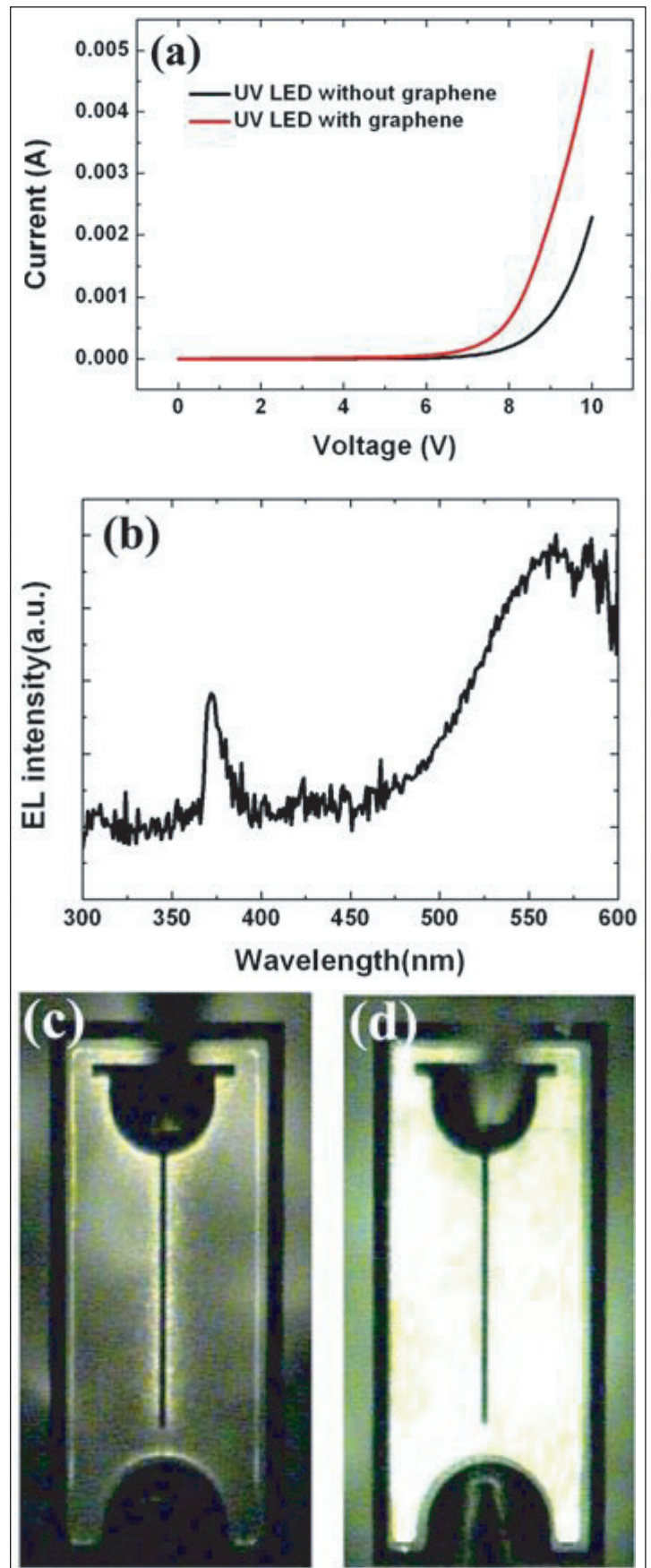


Figure 2. (a) The I–V characteristics of the UV LED with and without FLG-based transparent conductive electrode. (b) The EL spectra of UV LEDs. Optical images of light emission of UV LEDs (c) without and (d) with FLG-based transparent conductive electrode.

# Driving 'on-silicon' solutions in lighting, power electronics & PVs

**Translucent** describes how it grows rare earth oxides using a solid-source epitaxial technique to enable high-quality MOCVD of not only GaN FETs and LEDs but also germanium CPV cells on silicon, leveraging the economies of scale of large-diameter wafers.

**I**n the evolution of today's electronics industry, the demands for lower power, faster performance and more economic solutions continue to exert pressure on materials engineering. Many companies are now exploring how they can more fully utilize mature, robust manufacturing technologies to achieve these goals. 'On-silicon' solutions, which harness standardized technology on low-cost silicon wafers, are now beginning to be not only topical and strategic but also tactical. Indeed, a number of companies have upgraded their R&D programs to full-blown advanced manufacturing programs, targeting production within the next year.

Many of the fast-growing applications such as lighting and power electronics have moved to gallium nitride (GaN) as a vehicle for next-generation devices. In order to keep device costs under control, many major manufacturers are developing GaN-on-silicon (GaN-on-Si) technologies that would be compatible with 200mm wafer fabrication lines that are available in the silicon industry.

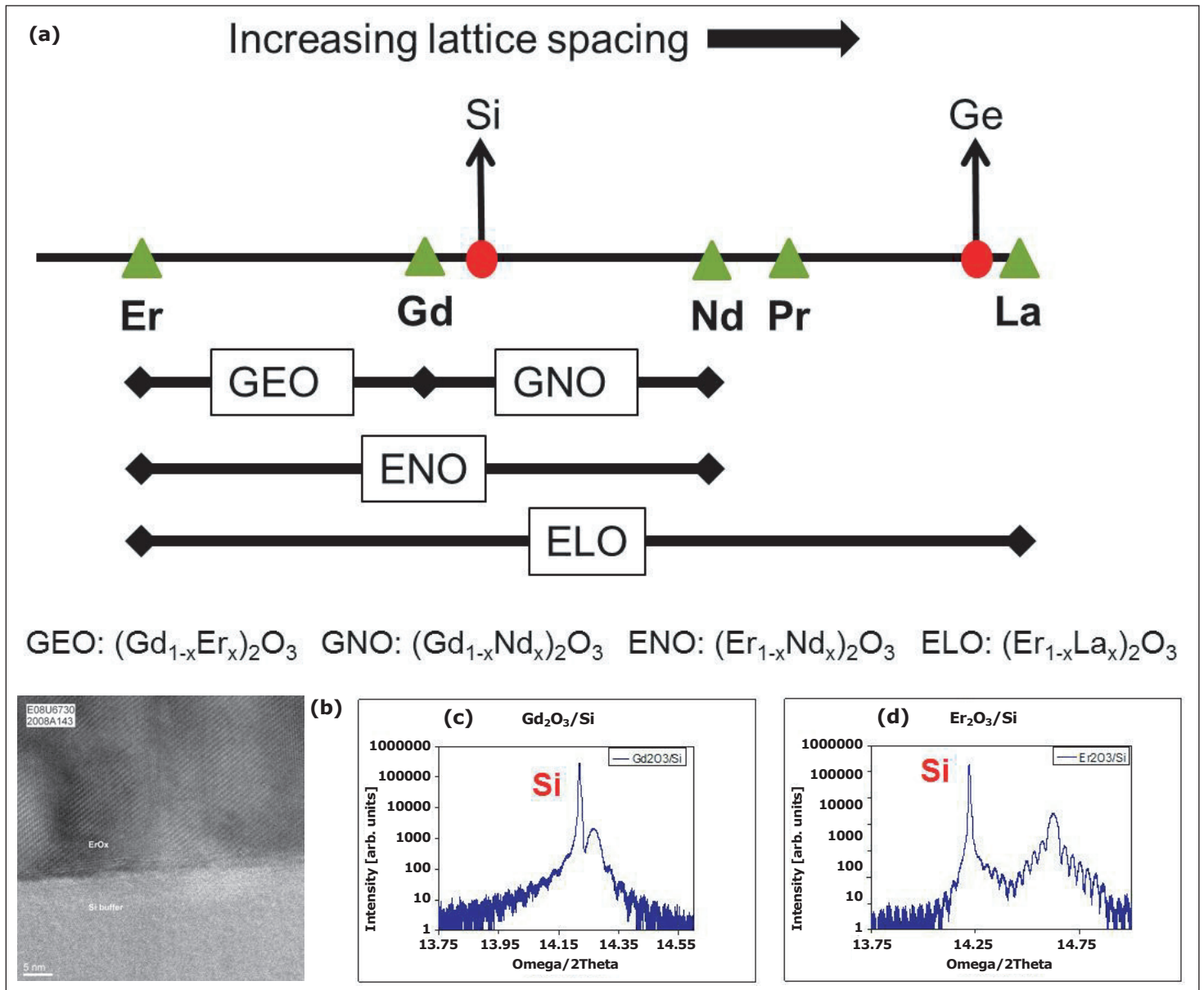
For example, Bridgelux Inc of Livermore, CA, USA recently announced GaN LEDs on silicon substrates with record luminous efficacy of 160lm/W. Conventional LEDs are made using sapphire or silicon carbide (SiC) substrates, both of which are expensive compared with the cost of silicon substrates. Silicon also enjoys the availability of large-diameter wafers and mature processing technology. Combined, these factors yield a cost reduction of 75%, Bridgelux projects.

As another example, Nitronex Inc of Raleigh, NC, USA (which was founded in 1999 as a spin-off from North Carolina State University) is producing power transistors using its patented SIGANTIC GaN-on-Si process for power devices in order to address the WiMAX, broadband and cellular markets.

In addition to solid-state lighting and power electronics, another industry that can benefit from 'on-silicon' solutions is the concentrated photovoltaic (CPV) solar industry. The CPV market uses high-efficiency multi-junction (MJ) solar cells, typically grown on germanium (Ge) or gallium arsenide (GaAs) substrates. These cells are then placed at the focal point of optically concentrated sunlight, in either large panels or reflecting dishes. In the case of the reflecting dishes — which have undergone nearly two decades of development by Solar Systems in Australia — the sunlight is focused onto a dense array of these highly efficient solar cells to generate electricity. This industry is also following a similar trend: the drive to bring down the cost of MJ solar cells by creating Ge-on-Si solutions at 150mm (and eventually at 200mm). CPV now demands the combination of superior solar cell efficiencies (>40%) with the economies of scale from silicon.

A need common to both the GaN device industry and the Ge device industry is a novel materials solution that would allow an 'on-silicon' platform for entry into the huge silicon infrastructure. Translucent has spent a decade developing a portfolio of rare earth oxide (REO) materials that are lattice matched to silicon in order to yield excellent crystalline results. The work has all been based in the company's facility in Palo Alto, CA, which houses a number of development and production growth reactors, wafer characterization, and a processing line for 100mm wafers. The growth reactors are solid-source based and can provide a suitable surface for growth by metal-organic chemical vapor deposition (MOCVD).

In the case of GaN high-voltage power field-effect transistors (FETs), full FET structures incorporating REO as both the buffer and a high-K gate dielectric can be manufactured with this technology. Already,



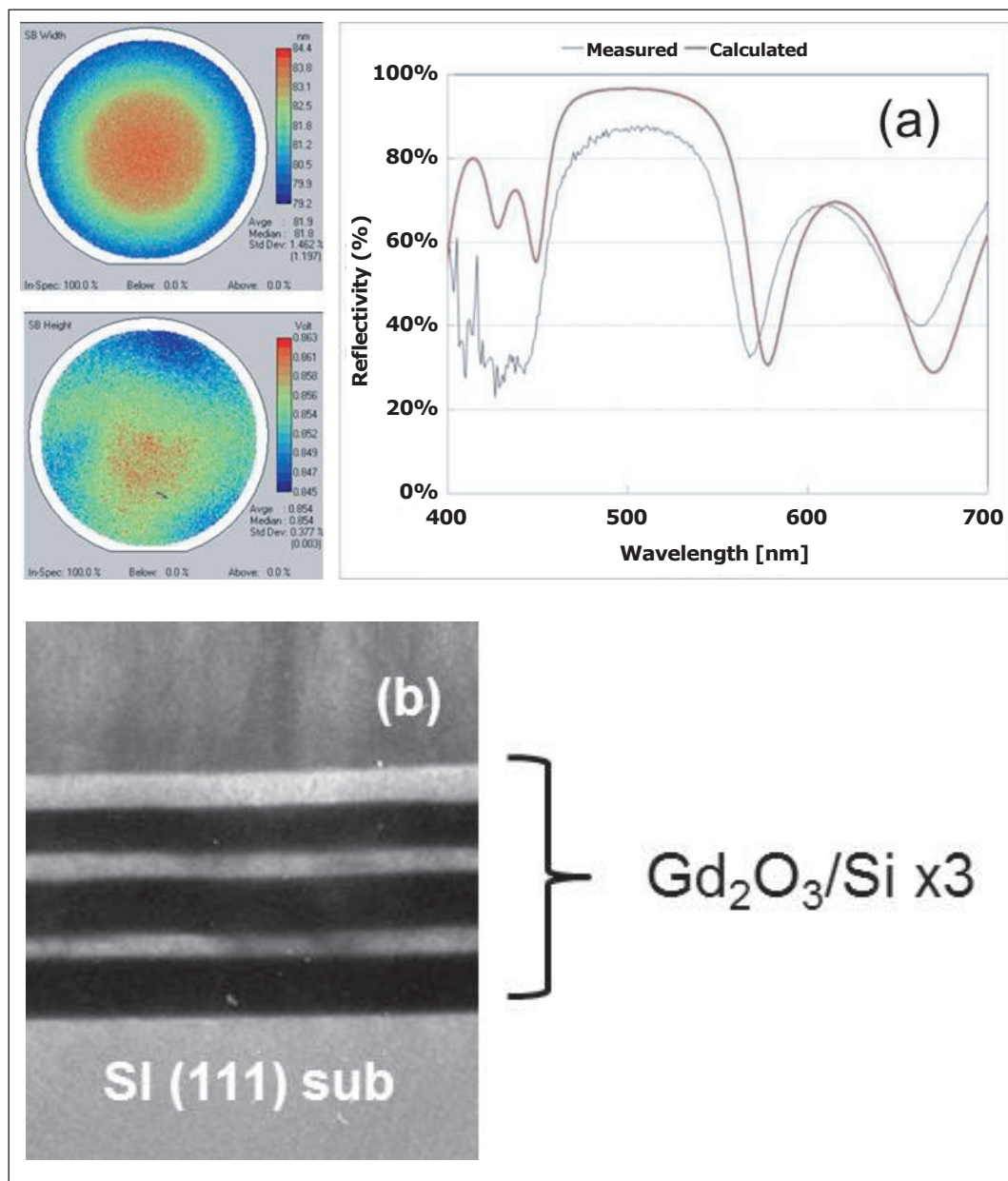
**Figure 1: (a) Comparison of lattice constants of REOs with relevant semiconductors. (b) TEM image showing the abrupt interface between silicon and  $\text{Er}_2\text{O}_3$ . Similarly, growth of other REOs is possible without interfacial layers formed at the interface region. (c) High-resolution x-ray diffraction of  $\text{Gd}_2\text{O}_3$  showing well defined Pendellösung fringe, indicating sharp interfaces between oxide and silicon. (d) Similar XRD pattern for  $\text{Er}_2\text{O}_3$ , showing that oxides with different rare earth elements can be grown on silicon.**

GaN-on-Si templates ready for MOCVD device growth for both FETs and LEDs have been grown by Translucent on 100mm- and 150mm-diameter wafers, and scaling to 200mm is expected in 2012. Ge-on-Si for CPV solar has also been demonstrated at 100mm, and is being scaled to 150mm in late 2011.

Rare earth oxides that are grown epitaxially using solid-source techniques exhibit high-quality crystalline forms. A comparison of the sizes of the crystalline unit cell for the various rare earth oxides relative to the major semiconductor material in use today shows why they are a highly relevant material to the industry. The oxides are in fact 'lattice coincident' — each oxide's crystalline unit cell corresponds to two crystalline unit cells of the underlying semiconductor. Figure 1

shows this relationship, along with x-ray diffraction data from one of the binary oxides epitaxially grown on silicon, showing the quality of the epitaxial oxides on silicon.

The accompanying transmission electron micrograph (TEM) shows just how sharp the interface between oxide and substrate is, and how a well engineered process can avoid the formation of interface silicates. Just like traditional III-V semiconductor epitaxy, the oxides can also be grown as ternary compounds, enabling graded structures to be epitaxially produced on silicon. Some of the ternary oxides developed at Translucent include  $(\text{Gd}_{1-x}\text{Er}_x)_2\text{O}_3$  and  $(\text{Er}_{1-x}\text{Nd}_x)_2\text{O}_3$ . These are also shown in Figure 1 as GEO and ENO, respectively.



**Figure 2 (a) Reflectivity map of DBR structure under white light and reflectivity spectrum of a three-period DBR structure made from oxide/silicon multilayers (black curve), simulation of the experimental data (red curve). (b) TEM image of the DBR mirror on Si(111) consisting of a three-period oxide/silicon stack.**

► Given its proximity to the lattice constant of silicon, almost all oxide structures start with  $Gd_2O_3$ ; what is placed on the upper surface is then chosen according to the application. For example,  $La_2O_3$  would be a good choice if the next layer was to be Ge. This ability to grow a high-quality oxide followed by an epitaxial semiconductor layer is the core building block in the production of compliant/template substrates.

It is also the reason why distributed Bragg reflector (DBR) structures can be produced epitaxially on silicon substrates. With a typical refractive index of  $n=2.0$ , the  $\Delta n$  that results from a pairing with silicon ( $n=4.25$ ) enables large bandwidth reflectors that achieve  $>85\%$  reflectivity after only 3–4 periods of growth. Figure 2 shows some typical DBR data. For a fuller description,

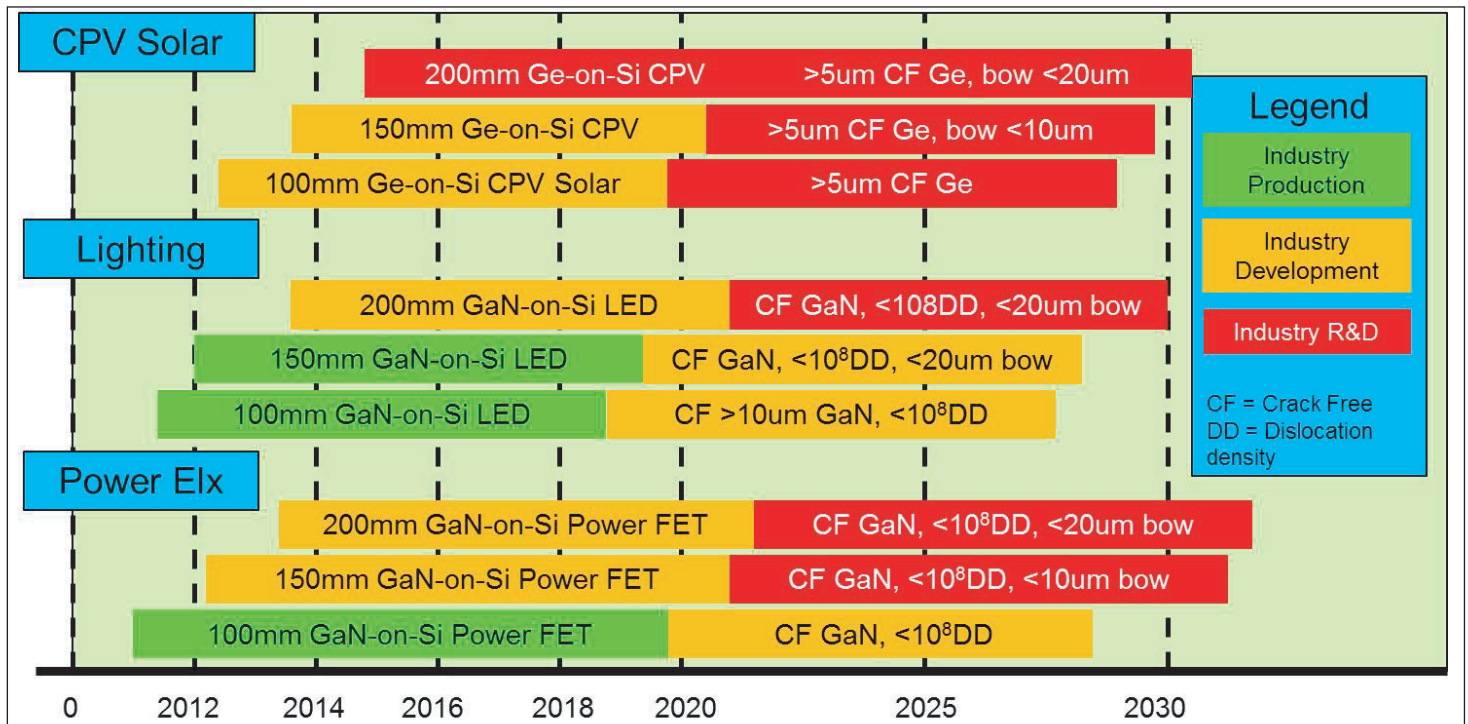
see Translucent's paper from the 9th International Conference on Nitride Semiconductors (ICNS-9), July 2011 (available at [www.translucentinc.com](http://www.translucentinc.com)).

These mechanical attributes, combined with a growth process that enables good control of the compositional aspects of the oxides, enabled the development of a family of 'on-silicon' template wafers with good surface compliancy and stress management. The first of these (silicon-oxide-silicon, cSOI) was developed as an alternative to the traditional two-wafer-bonded approach to SOI. Compatible with a commercial foundry-based silicon reactor, the template supported the growth of 10 $\mu$ m of silicon via a high-temperature trichlorosilane CVD process. The thermal conductivity of the oxide layers are approximately five times better than that of  $SiO_2$ , as verified by the  $3\omega$  method. Even with good epitaxial crystallinity, the SOI industry seems to be comfortable with bonded wafers from companies such as SOITEC of Bernin, France.

More recently, the focus at Translucent has turned to III-N-on-silicon for both the solid-state lighting (SSL) and

power industries, where the economies of scale available through the use of large-diameter silicon are expected to drive the next advance in the adoption of the nitride technology. In this instance, the role of the template is to utilize materials engineering to control the wafer stress and the nucleation of the nitride material such that the growth of the LED by the traditional MOCVD process is made simpler.

Wafer stress can be engineered through the use of binary and ternary rare earth oxides with different lattice constants. Pre-stressing wafers is an important process to reduce wafer bow, especially on larger-diameter silicon wafers (150mm and 200mm). Currently, companies such as Azzurro Semiconductors AG of Magdeburg, Germany manage to control wafer bow



**Figure 3 Industry roadmap for 'on-silicon' solutions showing trends towards 200mm silicon wafer sizes.**

stress through Ge doping of GaN as well as interlaced layers of low-temperature aluminum nitride (AlN).

A pre-stressed wafer with a simple REO layer that has been engineered to minimize lattice mismatch is an attractive option for large-diameter 'on-silicon' technologies. In this case, REOs provide surface compliancy, stress management, and precise crystalline lattice control of the epitaxial layers to provide a very high quality of template that compares favorably with existing wafer technologies on the market. The REO layers, which are grown using a production-grade solid-source epitaxial reactor designed and constructed by Translucent engineers and scientists, are stable and can withstand the high 1100°C temperatures of an MOCVD reactor. A number of experiments have been performed to verify the integrity and performance of capped REOs at 1100°C for MOCVD reactors. The Translucent reactors derive from molecular beam epitaxy (MBE) designs, however they are modified for production fabrication plants.

The drive towards larger silicon wafers for 'on-silicon' solutions is shown in Figure 3. The industry roadmap shows wafer size trends for three major applications: solid-state lighting, power electronics, and solar CPV. In all applications, the drive to 200mm silicon wafer technology will enable better economies of scale for products.

Key criteria are noted in the roadmap:

- (1) crack-free (CF) GaN growth;
- (2) defect dislocation density (DD); and
- (3) wafer bow.

All these criteria are key merits of success for 'on-silicon' technology. Crack-free GaN implies that the

crystal and thermal stress issues are resolved, while low defect dislocation densities are needed to drive higher device performance. Wafer bow becomes an issue on larger wafer sizes and indeed is a by-product of stress induced by the dissimilar epitaxy. Low wafer bow allows for easier handling in silicon fabrication plants, as well as better photolithography during device processing.

In summary, rare earth oxides have been developed to provide excellent quality crystalline templates for GaN and Ge epitaxial growth. Rare earth oxides can alleviate mechanical (stress, lattice mismatch, bowing), thermal (runaway), optical (mirrors), and electrical (gate dielectric, field suppression) issues as well as, importantly, economic issues involving compound semiconductor devices.

The industries that are looking for 'on-silicon' solutions include solid-state lighting and power electronics in the GaN-on-Si field, and CPV solar in the Ge-on-Si field. Even though these industries seem to be the leaders in driving wafer platform economies of scale, other industries are standing by; for example, the vertical-cavity surface-emitting laser (VCSEL) and GaAs electronics industries are watching very closely as the technology scales to 200mm GaAs wafers. So, as industries and product manufacturers demand more cost-effective solutions to fast-moving applications, the future for rare earth oxides looks bright. ■

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# Compounding energy efficiency and performance

IMEC recently held its annual meeting presenting work to the international press. **Mike Cooke** attended and reports on some of the center's research in relation to compound semiconductors.

**W**ith costs increasing across the main branches and tentacles of the semiconductor industry, sharing research costs has become increasingly important. The IMEC research center in Leuven, Belgium has been at the forefront of this trend since 1984.

Until recently, the center has focused mainly on silicon devices in terms of complementary metal-oxide-semiconductor (CMOS) integrated circuit and micro-electro-mechanical systems (MEMs) processing, electronics design and bioelectronics for medical applications. But now, ever increasing demands for CMOS circuitry performance and higher energy efficiency technologies have shifted the focus to compound semiconductor technology in the past few years. These include nitride semiconductors for high-voltage circuits and light emission, thin-film materials for lower-cost photovoltaic solar energy conversion, and bandgap engineering for high-mobility channels in high-speed/low-power CMOS transistors.

## Energy efficiency

The main work at IMEC concerning nitride semiconductor application centers on energy efficiency. Philip Pieters, business development director energy at IMEC, reported on research around the power efficiency possibilities arising from use of nitride semiconductors, both in the form of high-efficiency power conversion electronics and light emission. In particular, IMEC wants to use its silicon expertise as a platform for producing such devices cost effectively.

The wide bandgap of nitride semiconductors allows for the emission of visible light, and for power components a high critical breakdown voltage can be achieved. For power electronics, this means that high power density can be achieved with low switching losses.

IMEC has a dedicated III-V processing area that can handle 4-inch substrates. However, the center is working towards using larger-scale facilities such as the 6-inch MiPlaza facility (in Eindhoven, The Netherlands)

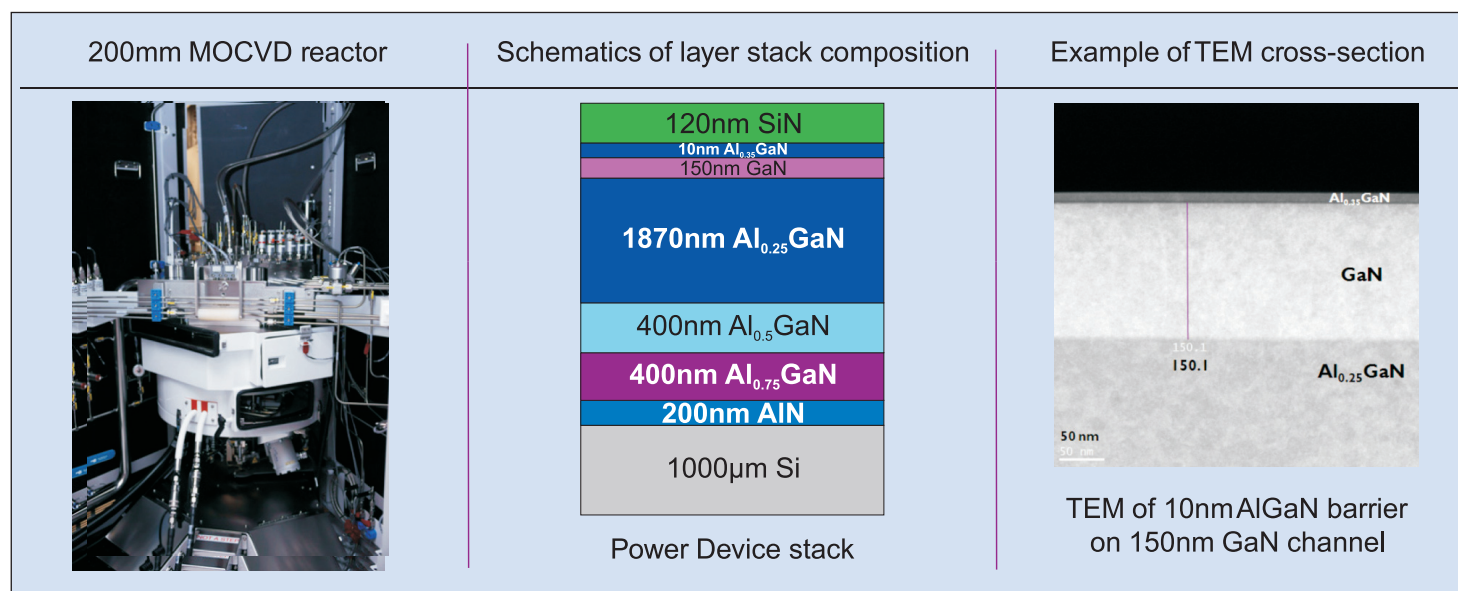
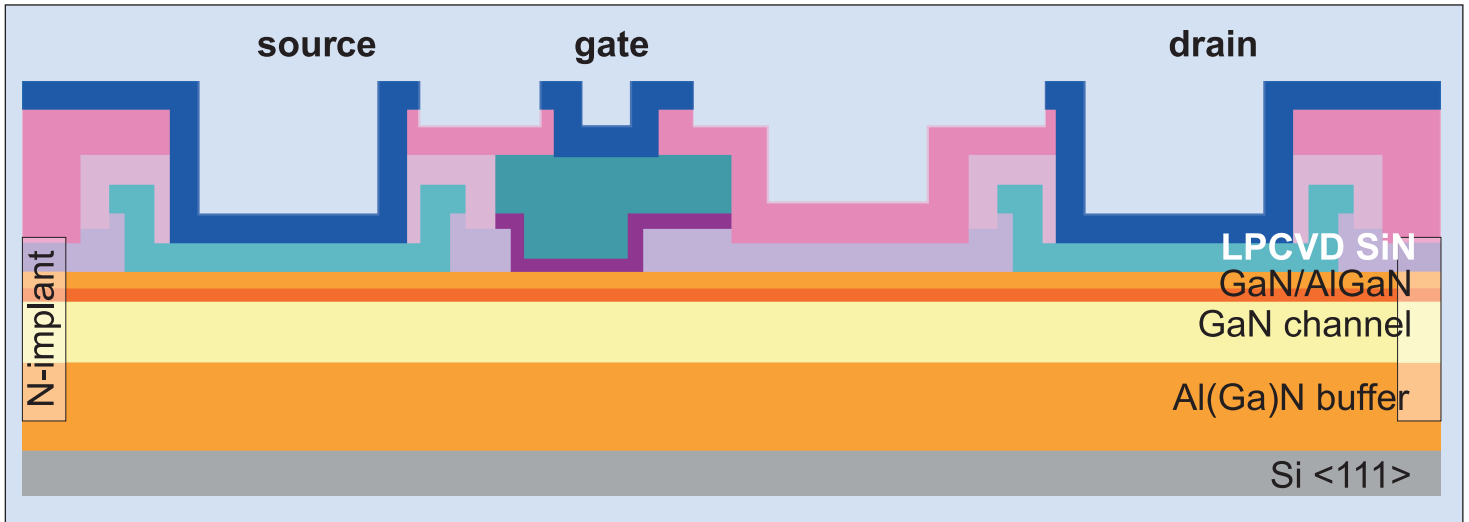


Figure 1. Some IMEC achievements of GaN epitaxial growth on 200mm silicon.



**Figure 2. Structure of power devices from silicon-compatible 200mm process.**

and its own 8-inch (200mm) pilot line. Indeed, IMEC has produced the first GaN layers on 200mm silicon substrates and has an industrial Applied Materials 200mm MOCVD system installed and operational.

Among the 200mm achievements are complex aluminum gallium nitride (AlGaN) layers for power devices such as high resistive buffer, GaN channel, and single/twin barriers; and, for light-emitters, quantum wells, p-type GaN and AlGaN, and n-type GaN (Figure 1).

Such material has been used to create the first 200mm GaN-on Si-power device (Figure 2) with functional transistors found on the first two pathfinder lots. Also, building up the work in the past year, IMEC has recently (in September 2011) produced fully functional GaN LEDs on 200mm silicon (Figure 3).

The IMEC epitaxy process on silicon has buffer layers that can handle 600V and even voltages beyond

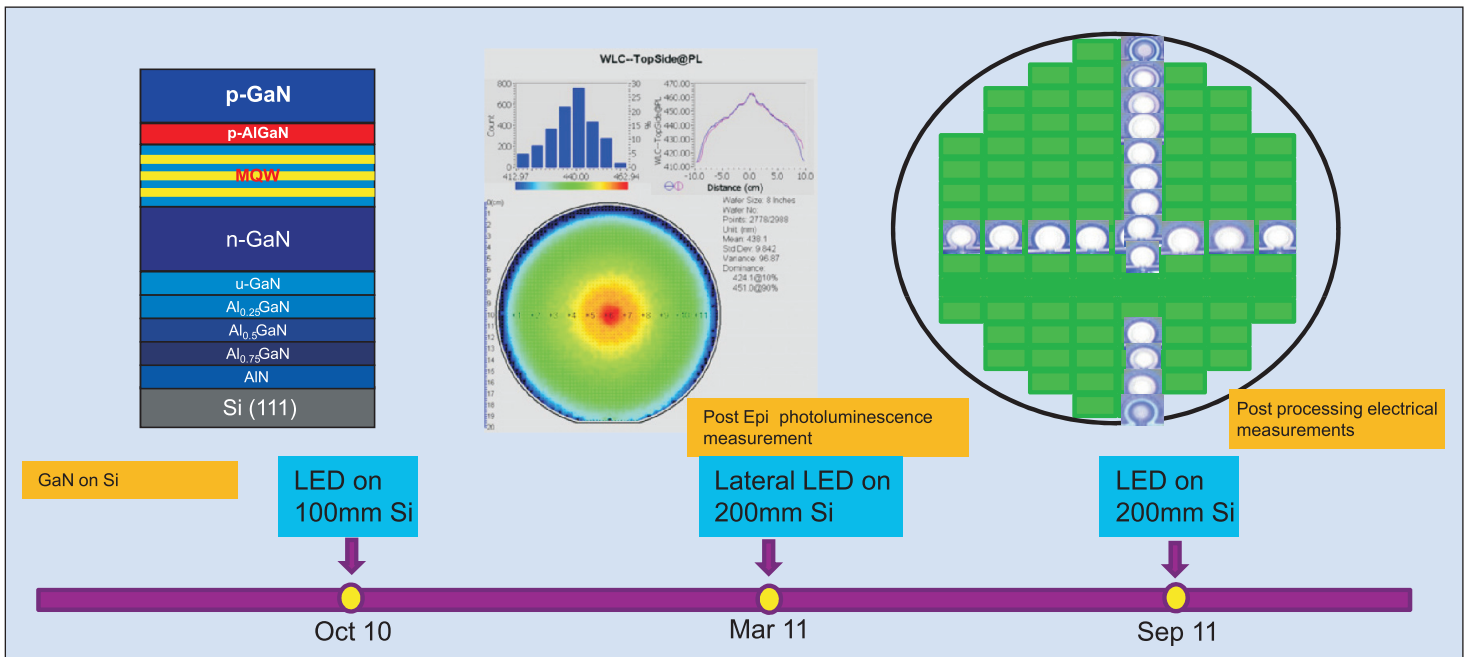
1000V. The center has also previously developed an in-situ nitride passivation that is part of the portfolio of the spin-out company EpiGaN of Hasselt, Belgium, which provides nitride-on-silicon wafers.

In its 4-inch facility, IMEC has developed a process of reference involving 12 masking steps, eight before metal-1. For practical application of the technology, circuit layout and design, simulation, characterization and reliability activities have also been developed.

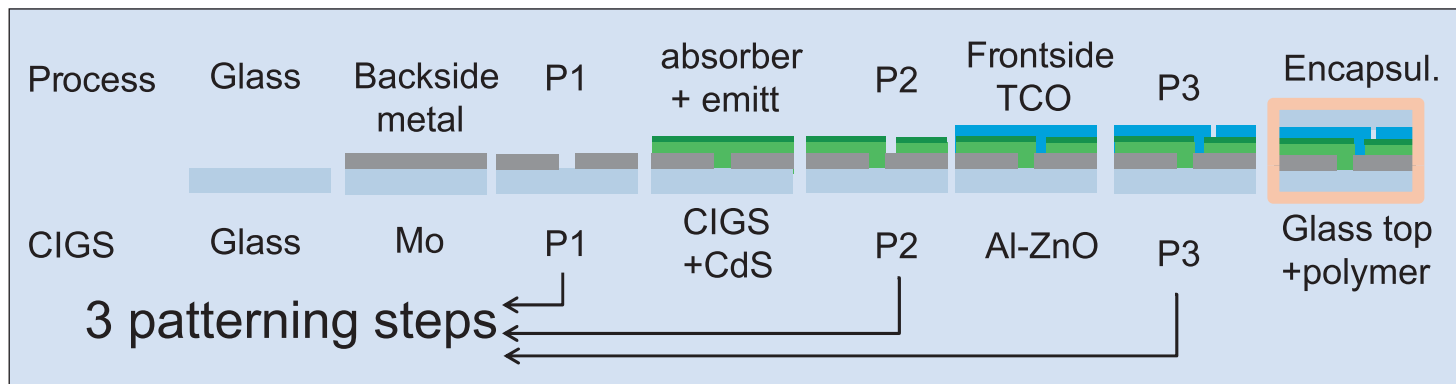
**Solar energy from thin-film photovoltaics**

Although thin-film PV constituted less than 20% of 2010’s \$50–60bn market, this share is expected to increase to 25% in the period up to 2025, according to IMEC’s Marc Meuris, team leader novel materials.

While some thin-film PV uses amorphous silicon, it is advantageous in terms of lower material use to employ direct-bandgap material, rather than indirect silicon. ➤



**Figure 3. IMEC timeline for fully processed blue GaN LEDs on 200mm silicon.**



**Figure 4. Process flow for conventional thin-film photovoltaics (TF-PV).**

Thin-film PV materials can be processed for lower cost using less complicated manufacturing process flows (Figure 4).

Presently, these alternative materials are, for example, cadmium telluride (CdTe) and copper indium gallium diselenide (CIGS). Although these materials have performed well (17.3% laboratory efficiency for CdTe; 20.3% for CIGS), both of these options have price concerns, centering on tellurium and indium supply. Also, the cadmium-containing compound raises health concerns.

Low-cost alternatives to CIGS are being sought among 'kesterites' materials such as copper-zinc-tin-sulfide/selenides (CZTS) and sulfosalts (e.g. tin-lead sulfide).  $\text{Cu}_2\text{ZnSnSe}_4$  PV devices have recently achieved 10% efficiency. CZTS covers the bandgap energy range 1.0–1.6eV that is needed to create multi-junction cells that respond to solar radiation with a range of wavelengths.

IMEC is focusing on CIGS and CZTS. For CIGS, the center is developing a solution-based solar cell integration flow, while for CZTS the aim is to build up materials expertise.

For the CZTS work, the researchers want to improve both the composition (stoichiometry) and crystal quality control, along with perfecting contamination (passivation, etc) and dopant technologies. IMEC has a molecular beam epitaxy (MBE) system that is due for installation next year (2012) to be used in the CZTS work. In particular, IMEC is seeking two material compositions that can be used to create multi-junction devices that respond efficiently to different bands of the solar spectrum.

The IMEC work receives funding both from its own funding programs and through the European 'Solliance' of TNO (the Netherlands Organization for Applied Scientific Research in Delft), IMEC, the Holst Center in Eindhoven (a joint research initiative of Imec and TNO), ECN (the energy research institute of The Netherlands) and TU/e (Eindhoven University of Technology) for R&D in thin-film PV, situated in the Eindhoven–Leuven–Aachen triangle (ELAT) region of high-tech development ([www.solliance.eu](http://www.solliance.eu)).

Alongside these direct-bandgap technologies, IMEC is also researching silicon and organic materials for thin-film solar cells.

## CMOS

Aaron Thean, logic program director, presented IMEC's research and aims in the area of logic scaling, including the use of high-mobility channel materials such as indium gallium arsenide (InGaAs, n-channel) and germanium (Ge, p-channel). IMEC has focused in particular on high-mobility-channel integration into CMOS circuitry, and boasts record QWFET performance for SiGe (silicon germanium) p-channel transistors (Figure 5).

Thean comments that "band engineering will be required to enhance transport". IMEC's expectation is that such channels will be used at the 10nm node that is being worked on now (2011) with production expected in 2015 (Figure 6).

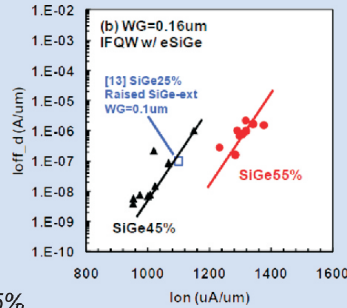
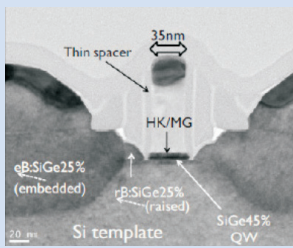
A variety of institutions around the world are bringing their expertise together to realize such high-mobility channels. However, high mobility is not the only characteristic needed, and some researchers [see, for example, Mike Cooke, Semiconductor Today, vol5, issue 5, p78, June/July 2010] have suggested that III-V channels won't cut it in terms of delivering the needed on/off ratios, sub-threshold swing, drain-induced barrier lowering (DIBL) avoidance, etc.

**Band engineering will be required to enhance transport. IMEC's expectation is that such channels will be used at the 10nm node that is being worked on now (2011) with production expected in 2015**

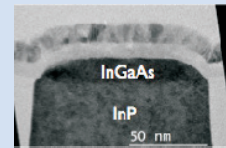
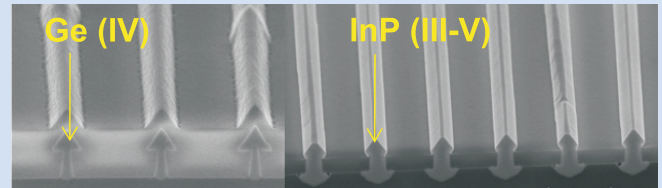
Thean comments on these problems: "There are three fundamental classes of challenges that III-V n-channels need to overcome to be a viable high-mobility successor to the Si channel: (1) epitaxy, material defectivity, and integration; (2) transport impact due to density of states (DOS) limitation with the light effective mass; and (3) channel electrostatics and surface passivation that affect DIBL and swing, respectively.



### Implant-free SiGe quantum well devices



### IV + III-V hybrid channel CMOS



1.3mA/um @ 100nA/um Ioff with 55% Ge, implant-free quantum well and embedded SiGe source/drain

**Figure 5. High-mobility-channel devices for 11nm.**

“Issues (2) and (3) point to a need to implement new materials with device architectures that can provide improvements in channel electrostatics as well. Fully depleted channel devices like multi-gated FinFETs can lower the channel effective field to mitigate the DOS and DIBL/swing issue. The jury is still out and further investigations are on-going,” says Thean.

“Besides the significant work on the material epitaxy and integration,

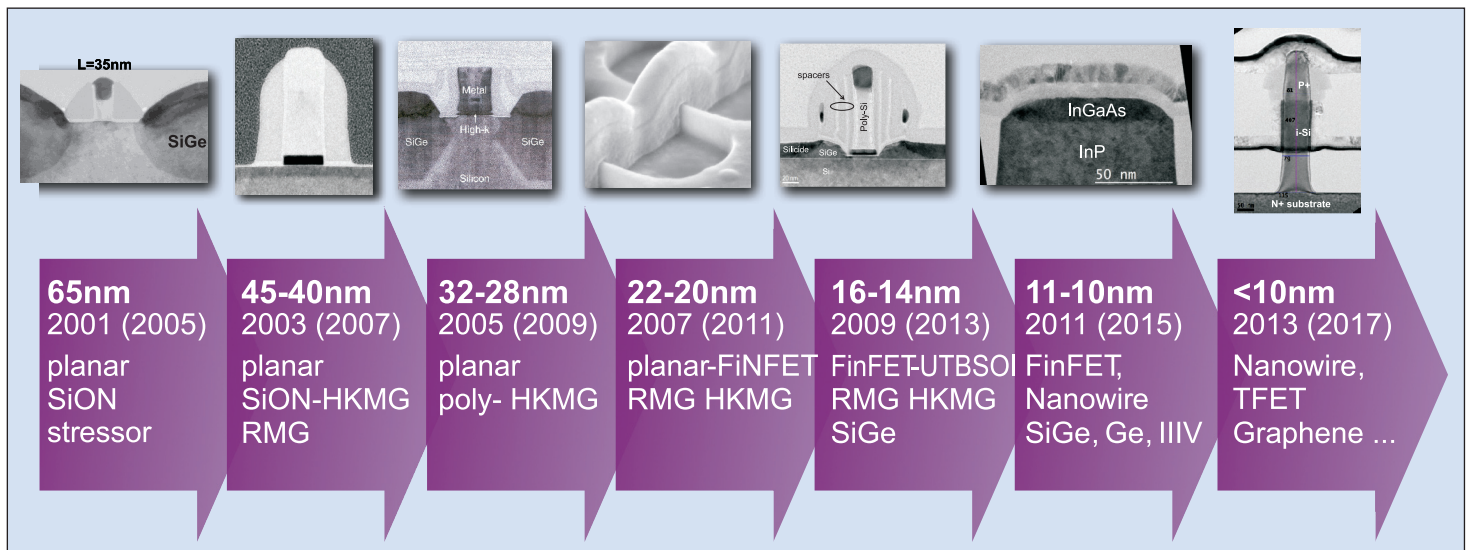
**On the p-channel side, IMEC has been developing quantum well transistors, starting with silicon germanium. We will continue our path to higher Ge composition, on our way to pure Ge channels: this has helped us understand the process and device issues in a progressive manner**

at IMEC much focus is on surface passivation and QW barrier engineering that aligns with the need for further electrostatic improvement. We have gained many insights here and this will help us develop solutions and assess the technology.”

IMEC is also looking at the many alternative possibilities for CMOS channels. “Planar structures are currently being looked at mainly as only a study vehicle, the goal is still to enable a fully depleted channel solution,” says Thean. On the p-channel side, IMEC has been developing quantum well transistors, starting with silicon germanium. “We will continue our path to higher Ge composition, on our way to pure Ge channels: this has helped us understand the process and device issues in a progressive manner,” adds Thean. ■

*The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.*

[www.imec.be](http://www.imec.be)



**Figure 6. IMEC/ASML roadmap for logic scaling and material innovation.**

# Ammonium sulfide vapor passivation for InGaAs

**Researchers in Leuven, Belgium show how ammonium sulfide vapor passivation of III-V surfaces in high-mobility channels can improve the on-current and transconductance in CMOS.**

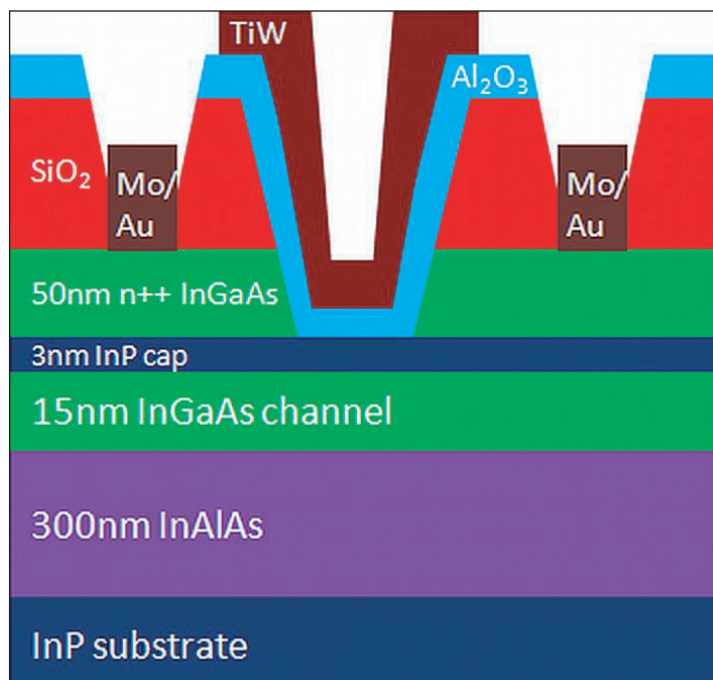
**R**esearchers at European research center IMEC and Katholieke Universiteit Leuven (KU Leuven) in Belgium have been investigating the possible use of ammonium sulfide ((NH<sub>4</sub>)<sub>2</sub>S) vapor (ASV) to passivate surfaces of indium phosphide (InP) and indium gallium arsenide (InGaAs) [Alireza Alian et al, Appl. Phys. Lett., vol99, p112114, 2011]. The researchers say that, based on their work, ASV treatment could be an efficient solution to the passivation of III-V surfaces.

The aim of the research is the attempt to use materials such as InGaAs as high-mobility channels in mainstream complementary metal oxide semiconductor (CMOS) circuits on silicon. At present, such work is impeded by the degradation in performance that occurs when dielectrics are applied as gate oxide insulation. Various new energy levels and charge traps are generated at oxide-semiconductor interfaces that impede transistor performance.

Ammonium sulfide treatment has been proposed as a way to reduce the generation of these interface states. Corresponding author Alireza Alian comments on the advantages of using vapour rather than solution: "One important advantage would be the elimination of the cleaning and drying steps after a wet solution treatment. The cleaning and drying steps are becoming more and more critical as the dimensions are shrinking. The other important advantage would be the cleaner processing; the ammonium sulfide solution is not available in a purity to be applied directly in a CMOS fab. The solution is usually full of all kind of metallic contaminations. You can assume that the contaminations are much less in density in the vapor than in the solution."

Test samples (Figure 1) were grown on (001) indium phosphide (InP) semi-insulating substrates using metal-organic chemical vapor deposition (MOCVD). Patterning was performed with a silicon dioxide hard mask. After mesa isolation etches, the gate recessing was performed using a selective wet etch of the highly doped n-type InGaAs layer down to the InP cap using a sulfuric acid/hydrogen peroxide solution in water.

Buried- and surface-channel devices could be produced by either leaving the InP cap or etching through



**Figure 1. Buried-channel transistor device structure. For the surface-channel device, the 3nm InP cap is removed during recess etch.**

to the InGaAs channel with hydrochloric (HCl) acid solution. The buried-channel devices were treated with dilute HCl solution.

Some of the devices were treated further with ammonium sulfide vapor by holding the samples face down over a beaker containing ammonium sulfide solution

**The doping effect seems insignificant on the In<sub>0.53</sub>Ga<sub>0.47</sub>As surface after ASV treatment, as the change in the subthreshold slope value is less prominent for the ASV-treated surface-channel device**

for 3 minutes before immediate transfer to an atomic layer deposition (ALD) tool where the aluminum oxide (Al<sub>2</sub>O<sub>3</sub>) gate insulation was grown.

The 10nm gate oxide was deposited at 300°C. The gate metal consisted of 40nm of titanium-tungsten (TiW). Annealing was performed for 15 minutes in forming gas (10% hydrogen, 90% nitrogen) at 370°C. ▶

**Table 1. Interface trap density extracted from capacitance–voltage measurements.**

| Type                   | Surface treatment | $D_{it}$ 0.2eV below conduction band     | $D_{it}$ 70meV below conduction band       |
|------------------------|-------------------|--|--|
| InGaAs surface channel | HCl               | $4 \times 10^{12}/\text{cm}^2\text{-eV}$ | $2.5 \times 10^{12}/\text{cm}^2\text{-eV}$ |
|                        | ASV               | $7 \times 10^{12}/\text{cm}^2\text{-eV}$ | $1.5 \times 10^{12}/\text{cm}^2\text{-eV}$ |
| InP capped channel     | HCl               | $8 \times 10^{12}/\text{cm}^2\text{-eV}$ | $7 \times 10^{12}/\text{cm}^2\text{-eV}$   |
|                        | ASV               | $9 \times 10^{12}/\text{cm}^2\text{-eV}$ | $5 \times 10^{12}/\text{cm}^2\text{-eV}$   |

► Interface trap state densities ( $D_{it}$ ) were assessed with capacitance–voltage measurements up to 1MHz on samples before gate oxide deposition (Table 1). Conductance measurements were also carried out at low temperature (77K) to probe  $D_{it}$  closer to the conduction band edge (70meV rather than 0.2eV for room-temperature measurement). While the room-temperature measurements suggest an increase in  $D_{it}$  for the ASV-treated samples, the low-temperature measurements give a lower value with a 30% (buried channel) or 40% (surface channel) reduction.

In terms of transistor performance (Figure 2), the ASV indeed improves on-state current (1.5V overdrive voltage) and transconductance (0.1V drain voltage). The on-state current is increased by about a factor of 3. The researchers comment that their ASV process is “as efficient as the aqueous  $(\text{NH}_4)_2\text{S}$  in gaining a high drive current”.

Despite the higher  $D_{it}$  in the midgap region, “as the nature of these states is donor-like, they will be electrically neutral during the ON-state operation of the device and will not influence the performance. The portion of the  $D_{it}$  located close to and above the surface Fermi-level position during the device operation is affecting the ON-state performance as these traps are electrically active.”

The researchers believe the effect of the higher  $D_{it}$  deeper into the bandgap may be seen in a poorer subthreshold slope behavior, particularly in the buried channel device, which may also suffer from surface doping effects caused by the ASV treatment of the InP cap. Such surface doping can increase depletion capacitance.

The researchers comment: “Comparing the buried-channel and the surface-channel devices, the doping effect seems insignificant on the  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  surface after ASV treatment, as the change in the subthresh-

old slope value is less prominent for the ASV-treated surface-channel device compared to the HCl treatment.”

The threshold voltage of the ASV-treated devices also shifted downward, more for the buried-channel device, due, it is thought, to “fixed charges formed at the interface of  $\text{InP}/\text{Al}_2\text{O}_3$  resulting from the surface doping effect of ASV on the InP surface”. The researchers estimate a reduction in the oxide charge density after ASV treatment on the  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$  surface of about  $2.2 \times 10^{18}/\text{cm}^3$ . Further, “The estimated fixed charge density as a result of the InP surface doping effect of ASV is about  $1 \times 10^{12}/\text{cm}^2$  at the  $\text{Al}_2\text{O}_3/\text{InP}$  interface.”

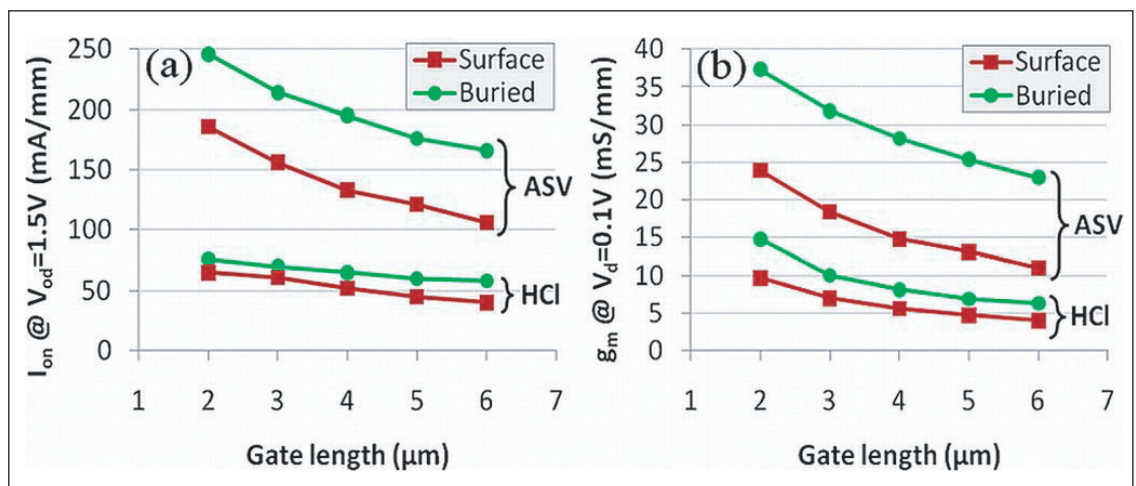
X-ray photoelectron spectroscopy (XPS) examination of the indium 3d core levels suggested reduced concentrations of indium oxide in ASV-treated samples that were capped with 30 minute air exposure and 2nm  $\text{Al}_2\text{O}_3$  from solid-source molecular beam epitaxy (SS-MBE) deposition.

The researchers comment: “These results indicate that indium or its oxides might be responsible for the drive current degradation. This can occur either due to the diffusion of In into the high-k layer creating border traps or the formation of interface states with an energy above the conduction band edge of  $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ , which would degrade the carrier mobility.”

Financial support for the work came from the European Commission’s DualLogic project. ■

<http://link.aip.org/link/doi/10.1063/1.3638492>

Author: Mike Cooke



**Figure 2. (a) Drive current ( $I_{on}$ ) and (b) peak transconductance ( $g_m$ ) as functions of gate length for ASV- and HCl-treated surface-channel and buried-channel devices.**

# Back-barrier boosts nitride HEMT cut-off frequency

**InGaN layer controls short-channel effects and allows record current-gain cut-off frequency  $f_T$  of 300GHz.**

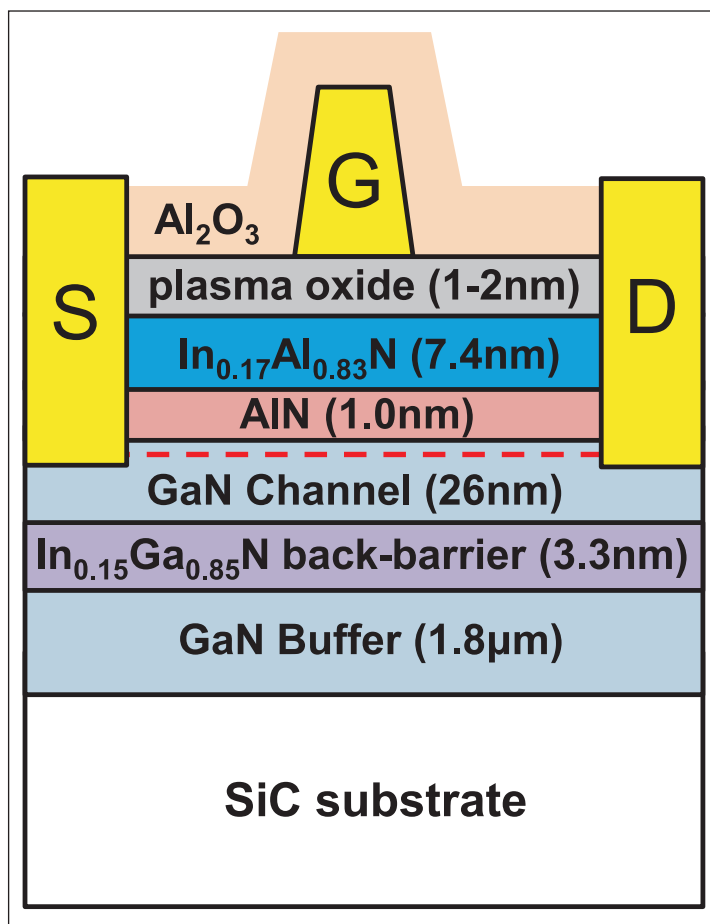
**M**assachusetts Institute of Technology, IQE RF LLC and University of Notre Dame have used an indium gallium nitride (InGaN) back-barrier to control short-channel effects (SCEs) in indium aluminum nitride/gallium nitride (InAlN/GaN) high-electron-mobility transistors (HEMTs) "for the first time" [Dong Seup Lee et al, IEEE Electron Device Letters, published online 19 September 2011].

The researchers used the back-barrier structure to achieve a record current-gain cut-off frequency ( $f_T$ ) of 300GHz for lattice-matched InAlN/GaN HEMTs with 30nm gate length. The group expects that "improved suppression of SCEs at this gate length in combination with reduced access resistance will enable even better performance in the future". The team compares its result with the achievement of 225GHz  $f_T$  for AlGaIn/GaN HEMTs.

The MIT/IQE/Notre Dame devices (Figure 1) were grown on silicon carbide (SiC) substrates, using metal-organic chemical vapor deposition (MOCVD). The InGaN back-barrier has a polarization-induced electric field that creates an effective conduction-band offset. Hall measurements give a two-dimensional electron gas (2DEG) carrier density of  $1.65 \times 10^{13}/\text{cm}^2$  and electron mobility of  $1581 \text{cm}^2/\text{V}\cdot\text{s}$ . By contrast, an AlGaIn back-barrier creates a polarization-induced electric field in the GaN channel layer.

The device processing consisted of mesa isolation through boron trichloride-chlorine plasma etch, silicon-germanium-titanium-aluminum-nickel-gold ohmic contact deposition and  $820^\circ\text{C}$  annealing, oxygen plasma treatment of the top InAlN epitaxial layer to reduce gate leakage and improve RF performance, deposition of a rectangular nickel-gold gate and, finally, aluminum oxide passivation.

One disadvantage of a rectangular gate, as opposed to the more usual mushroom/T-gate, is higher gate resistance that results in poor power-gain. On the other hand, parasitic gate capacitance of the device is reduced, allowing the researchers to push the current-gain to its limit. The poor power-gain is presumably one reason why the power-gain cut-off ( $f_{\text{max}}$ ) is not reported. In AlGaIn/GaN and AlN/GaN  $f_{\text{max}}$  values have been reported up to 400GHz.



**Figure 1. Schematic of MIT/IQE/University of Notre Dame InAlN/GaN high-electron-mobility transistor with a lattice-matched InGaN back-barrier.**

The source-drain distance of the MIT/IQE/Notre Dame devices was  $1\mu\text{m}$ . The gate length was varied between 30nm and 230nm.

In terms of DC performance, the devices showed more evident short-channel effects (SCEs) below 50nm gate length: for example, the threshold voltage rolled-off in a more negative direction for devices below this point. The drain current of a 30nm-gate device at 0V gate potential can reach  $1.8\text{A}/\text{mm}$ ; the on-resistance was  $1.2\Omega\cdot\text{mm}$ . The peak extrinsic transconductance was  $529\text{mS}/\text{mm}$  with drain bias 3V. The researchers extracted a threshold voltage of  $-4.21\text{V}$  at the same bias. ➤

Above 70nm, the researchers see effective suppression of SCEs due to the combination of a back-barrier and a thin GaN channel, despite the relatively thick top AlN/InAlN/plasma oxide barrier of about 10nm.

The RF performance was tested between 110MHz and 110GHz (Figure 2). Parasitic pad capacitances and inductances were de-embedded using off-wafer line reflect match calibration standards and on-wafer open and short structures.

The  $f_T$  of the 30nm device of 300GHz is described as "the highest value reported in GaN-based transistors so far", according to the researchers' knowledge. Figure 2 suggests an  $f_{max}$  value of tens of GHz.

Despite this record result, the product of

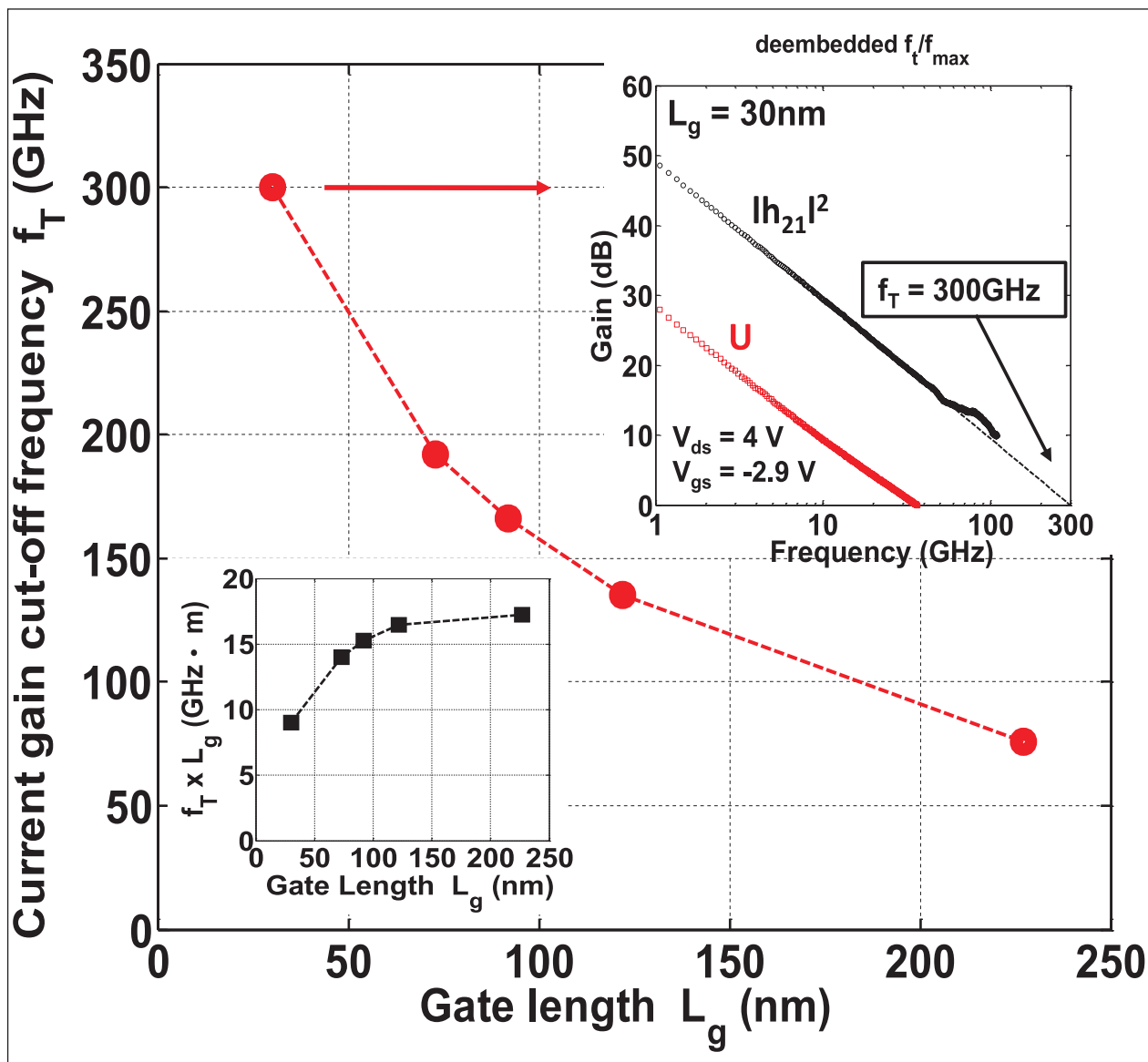


Figure 2. Current-gain cutoff frequency ( $f_T$ ) vs gate length ( $L_g$ ). Top inset, RF performance of 30nm gate-length device with 300GHz  $f_T$ . Bottom inset,  $f_T \times L_g$  dependence on  $L_g$ .

**Despite this record result, the product of this value with the gate-length ( $L_g$ ) was 9GHz- $\mu$ m, about half the value for a 230nm device (17.3GHz- $\mu$ m). In the absence of SCEs, one would expect the value of  $f_T \times L_g$  to remain relatively constant as the gate length is reduced. The researchers comment: "This decrease is mainly due to the total delay becoming dominated by extrinsic and parasitic components."**

this value with the gate-length ( $L_g$ ) was 9GHz- $\mu$ m, about half the value for a 230nm device (17.3GHz- $\mu$ m). In the absence of SCEs, one would expect the value of  $f_T \times L_g$  to remain relatively constant as the gate length is reduced. The researchers comment: "This decrease is mainly due to the total delay becoming dominated by extrinsic and parasitic components."

Electron velocity determinations were made based on parasitic charging delay and intrinsic gate capacitance variation with  $L_g$ , both extracted at the effective bias condition, giving values of  $1.37 \times 10^7$  cm/s and  $1.45 \times 10^7$  cm/s, respectively.

Funding for the research came from the US military research funds for the DARPA NEXT and ONR DURIP programs. ■

<http://dx.doi.org/10.1109/LED.2011.2164613>

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

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USA  
Tel: +1 408 875 3000  
Fax: +1 408 875 4144  
[www.kla-tencor.com](http://www.kla-tencor.com)

## **LayTec AG**

Seesener Str.  
10-13,  
10709 Berlin,  
Germany  
Tel: +49 30 39 800 80 0  
Fax: +49 30 3180 8237  
[www.laytec.de](http://www.laytec.de)



LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

## **Optical Reference Systems Ltd**

OpTIC Technium,  
St Asaph Business Park,  
St Asaph, LL17 0JD,  
UK  
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Fax: +44 (0)1745 535 186  
[www.ors-ltd.com](http://www.ors-ltd.com)

## **WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)**

Bregstrasse 90, D-78120  
Furtwangen im Schwarzwald,  
Germany  
Tel: +49 7723 9197 0  
Fax: +49 7723 9197 22  
[www.wepcontrol.com](http://www.wepcontrol.com)

## 12 Inspection equipment

### **Bruker AXS GmbH**

Oestliche Rheinbrueckenstrasse 49,  
Karlsruhe, 76187, Germany  
Tel: +49 (0)721 595 2888  
Fax: +49 (0)721 595 4587  
[www.bruker-axs.de](http://www.bruker-axs.de)

## 13 Characterization equipment

### **J.A. Woollam Co. Inc.**

645 M Street Suite 102,  
Lincoln, NE 68508,  
USA  
Tel: +1 402 477 7501  
Fax: +1 402 477 8214  
[www.jawoollam.com](http://www.jawoollam.com)

### **Lake Shore Cryotronics Inc**

575 McCorkle Boulevard,  
Westerville, OH 43082,  
USA  
Tel: +1 614 891 2244  
Fax: +1 614 818 1600  
[www.lakeshore.com](http://www.lakeshore.com)

## 14 Chip test equipment

### **Keithley Instruments Inc**

28775 Aurora Road,  
Cleveland, OH 44139,  
USA  
Tel: +1 440.248.0400  
Fax: +1 440.248.6168  
[www.keithley.com](http://www.keithley.com)

### **SUSS MicroTec Test Systems**

228 Suss Drive,  
Waterbury Center, VT 05677,  
USA  
Tel: +1 800 685 7877  
Fax: +1 802 244 7853  
[www.suss.com](http://www.suss.com)

## 15 Assembly/packaging materials

### **ePAK International Inc**

4926 Spicewood Springs Road,  
Austin, TX 78759, USA  
Tel: +1 512 231 8083  
Fax: +1 512 231 8183  
[www.epak.com](http://www.epak.com)

### **Gel-Pak**

31398 Huntwood Avenue,  
Hayward,  
CA 94544,  
USA  
Tel: +1 510 576 2220  
Fax: +1 510 576 2282  
[www.gelpak.com](http://www.gelpak.com)

### **Wafer World Inc**

(see section 3 for full contact details)

### **Williams Advanced Materials**

2978 Main Street,  
Buffalo, NY 14214,  
USA  
Tel: +1 716 837 1000  
Fax: +1 716 833 2926  
[www.williams-adv.com](http://www.williams-adv.com)

## 16 Assembly/packaging equipment

### **Ismeca Europe Semiconductor SA**

Helvetie 283,  
La Chaux-de-Fonds, 2301,  
Switzerland  
Tel: +41 329257111  
Fax: +41 329257115  
[www.ismeca.com](http://www.ismeca.com)

### **Kulicke & Soffa Industries**

1005 Virginia Drive,  
Fort Washington,  
PA 19034,  
USA  
Tel: +1 215 784 6000  
Fax: +1 215 784 6001  
[www.kns.com](http://www.kns.com)

### **Palomar Technologies Inc**

2728 Loker Avenue West,  
Carlsbad,  
CA 92010,  
USA  
Tel: +1 760 931 3600  
Fax: +1 760 931 5191  
[www.PalomarTechnologies.com](http://www.PalomarTechnologies.com)

### **TECDIA Inc**

2700 Augustine Drive, Suite 110,  
Santa Clara,  
CA 95054,  
USA  
Tel: +1 408 748 0100  
Fax: +1 408 748 0111  
[www.tecdia.com](http://www.tecdia.com)

Tecdia is a **TECDIA** manufacturer of single-layer chip capacitors, chip resistors, DC boards, bias-Ts, diamond scribing tools and dispensing nozzles.

## 17 Assembly/packaging foundry

### Quik-Pak

10987 Via Frontera,  
San Diego, CA 92127, USA  
Tel: +1 858 674 4676  
Fax: +1 8586 74 4681  
[www.quikicpak.com](http://www.quikicpak.com)

## 18 Chip foundry

### Compound Semiconductor Technologies Ltd

Block 7, Kelvin Campus,  
West of Scotland, Glasgow,  
Scotland G20 0TH,  
UK  
Tel: +44 141 579 3000  
Fax: +44 141 579 3040  
[www.compoundsemi.co.uk](http://www.compoundsemi.co.uk)

### United Monolithic Semiconductors

Route departementale 128,  
BP46, Orsay, 91401,  
France  
Tel: +33 1 69 33 04 72  
Fax: +33 169 33 02 92  
[www.ums-gaas.com](http://www.ums-gaas.com)

## 19 Facility equipment

### MEI, LLC

3474 18th Avenue SE,  
Albany, OR 97322-7014, USA  
Tel: +1 541 917 3626

Fax: +1 541 917 3623  
[www.marlerenterprises.net](http://www.marlerenterprises.net)

## 20 Facility consumables

### W.L. Gore & Associates

401 Airport Rd,  
Elkton, MD 21921-4236, USA  
Tel: +1 410 392 4440  
Fax: +1 410 506 8749  
[www.gore.com](http://www.gore.com)

## 21 Computer hardware & software

### Ansoft Corp

4 Station Square, Suite 200,  
Pittsburgh, PA 15219, USA  
Tel: +1 412 261 3200  
Fax: +1 412 471 9427  
[www.ansoft.com](http://www.ansoft.com)

### Crosslight Software Inc

121-3989 Henning Dr.,  
Burnaby, BC, V5C 6P8, Canada  
Tel: +1 604 320 1704  
Fax: +1 604 320 1734  
[www.crosslight.com](http://www.crosslight.com)

### Semiconductor Technology Research Inc

10404 Patterson Ave., Suite 108,  
Richmond, VA 23238, USA  
Tel: +1 804 740 8314  
Fax: +1 804 740 3814  
[www.semitech.us](http://www.semitech.us)

## 22 Used equipment

### Class One Equipment Inc

5302 Snapfinger Woods Drive,  
Decatur, GA 30035, USA  
Tel: +1 770 808 8708  
Fax: +1 770 808 8308  
[www.ClassOneEquipment.com](http://www.ClassOneEquipment.com)

## 23 Services

### Henry Butcher International

Brownlow House, 50-51  
High Holborn,  
London WC1V 6EG, UK  
Tel: +44 (0)20 7405 8411  
Fax: +44 (0)20 7405 9772  
[www.henrybutcher.com](http://www.henrybutcher.com)

### M+W Zander Holding AG

Lotterbergstrasse 30,  
Stuttgart, Germany  
Tel: +49 711 8804 1141  
Fax: +49 711 8804 1950  
[www.mw-zander.com](http://www.mw-zander.com)

### TECDIA Inc

(see section 16 for full contact details)

## 24 Consulting

### Fishbone Consulting SARL

8 Rue de la Grange aux Moines,  
78460 Choisel, France  
Tel: + 33 (0)1 30 47 29 03  
E-mail: jean-luc.ledys@neuf.fr

## 25 Resources

### SEMI Global Headquarters

3081 Zanker Road,  
San Jose, CA 95134, USA  
Tel: +1 408 943 6900  
Fax: +1 408 428 9600  
[www.semi.org](http://www.semi.org)

### Yole Développement

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**8–9 December 2011**

## 26th Workshop of the DGKK: 'Epitaxy of III/V Semiconductors'

Stuttgart, Germany

**E-mail:** [dgkk2011@ihfg.uni-stuttgart.de](mailto:dgkk2011@ihfg.uni-stuttgart.de)

[www.uni-stuttgart.de/dgkk](http://www.uni-stuttgart.de/dgkk)

**18–20 January 2012**

## Theory, Modelling and Computational Methods for Semiconductors (TMCS-III)

University of Leeds, UK

**E-mail:** [registration@tmcsuk.org](mailto:registration@tmcsuk.org)

[www.tmcsuk.org](http://www.tmcsuk.org)

**21–26 January 2012**

## SPIE Photonics West 2012

Moscone Center San Francisco, CA, USA

**E-mail:** [customerservice@spie.org](mailto:customerservice@spie.org)

<http://spie.org/photonics-west.xml>

**7–9 February 2012**

## Strategies in Light 2012 Conference & Expo

Santa Clara Convention Center, CA, USA

**E-mail:** [LubaH@pennwell.com](mailto:LubaH@pennwell.com)

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

**7–9 February 2012**

## LED/SEMICON Korea 2012

COEX, Seoul, Korea

**E-mail:** [semiconkorea@semi.org](mailto:semiconkorea@semi.org)

[www.led-korea.org/en](http://www.led-korea.org/en) [eshim@semi.org](mailto:eshim@semi.org)

**12–16 February 2012**

## SPIE Advanced Lithography 2012

San Jose, CA, USA

**E-mail:** [customerservice@spie.org](mailto:customerservice@spie.org)

<http://spie.org/advanced-lithography.xml>

**4–8 March 2012**

## OFC/NFOEC 2012

(Optical Fiber Communication Conference and Exhibition/National Fiber Optic Engineers Conference)

Los Angeles Convention Center, CA, USA

**E-mail:** [info@ofcconference.org](mailto:info@ofcconference.org)

[www.ofcnfoec.org](http://www.ofcnfoec.org)

**18–19 March 2012**

## China Semiconductor Technology International Conference (CSTIC 2012)

Kerry Hotel Pudong, Shanghai, China

**E-mail:** [cstic@semi.org.cn](mailto:cstic@semi.org.cn)

<http://semiconchina.semi.org/cstic>

**20–22 March 2012**

## SEMICON China 2012

Shanghai New International Expo Centre, China

**E-mail:** [semichina@semi.org](mailto:semichina@semi.org)

[www.semiconchina.org](http://www.semiconchina.org)

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**20–22 March 2012****LASER World of PHOTONICS CHINA**

Shanghai New International Expo Centre (SNIIEC), China

**E-mail:** laser@mami-shanghai.com**www.world-of-photonics.net/en/laser-china/start****21–23 March 2012****7th Asia Solar Photovoltaic Industry Exhibition**

Shanghai Expo Theme Pavilion, China

**E-mail:** info@aieppo.com.cn**www.asiasolar.cc/en****25–30 March 2012****8th conference on Porous Semiconductors - Science and Technology (PSST-2012)**

Hotel Monte Malaga, Spain

Abstract deadline: 25 December 2011

**E-mail:** info@the-psst.com**www.the-psst.com****2–4 April 2012****Semiconductor and Integrated Opto-Electronics Conference (SIOE'12)**

Cardiff University, Wales, UK

**E-mail:** K.A.Shore@bangor.ac.uk**www.astro.cardiff.ac.uk/research/pm/events/?page=sioe****9–13 April 2012****2012 MRS Spring Meeting**

San Francisco, CA, USA

**E-mail:** info@mrs.org**www.mrs.org/spring2012****15–19 April 2012****IEEE International Reliability Physics Symposium (IRPS-2012)**

Hyatt Regency Orange County, Anaheim, CA, USA

**E-mail:** yuan.chen@nasa.gov**www.irps.org****15–20 April 2012****Light+Building 2012**

Frankfurt am Main, Germany

**http://light-building.messefrankfurt.com****16–18 April 2012****CPV-8 International Conference on Concentrating Photovoltaic Systems**

Toledo, Spain

**E-mail:** iinfo@cpv-8.org**www.cpv-8.org/cms****16–20 April 2012****SPIE Photonics Europe 2012**

The Square Conference Center, Brussels, Belgium

**E-mail:** customerservice@spie.org**http://spie.org/photonics-europe.xml****18–20 April 2012****16th European Conference on Integrated Optics (ECIO 2012)**

Hotel Melia Sitges, Barcelona, Spain

**E-mail:** ecio2012@icfo.es**www.ecio2012.com****19–20 April 2012****4th Photovoltaics Thin-Film Week, including 4th Thin-Film Industry Forum (TIF 2012)**

Berlin, Germany

**E-mail:** info@solarpraxis.de**www.solarpraxis.de/en/conferences****23–26 April 2012****2012 CS MANTECH (International Conference on Compound Semiconductor Manufacturing Technology)**

The Boston Park Plaza Hotel, Boston, MA, USA

**E-mail:** csmantech@csmantech.org**www.csmantech.org****23–27 April 2012****SPIE Defense, Security, and Sensing 2012**

Baltimore, MD, USA

**E-mail:** customerservice@spie.org**http://spie.org/defense-security.xml****28 April – 3 May 2012****55th Society of Vacuum Coaters Annual Technical Conference (2012 SVC TechCon)**

Santa Clara Convention Center, CA, USA

**E-mail:** svcinfo@svc.org**www.svc.org/ConferencesExhibits/Future-Meetings.cfm****6–11 May 2012****221st Electrochemical Society (ECS) Meeting**

Seattle, Washington

**E-mail:** meetings@electrochem.org**www.electrochem.org/meetings/biannual/fut\_mtgs.htm****14–18 May 2012****E-MRS 2012 Spring Meeting**

Congress Center, Strasbourg, France

Abstract deadline: 12 January 2012

**E-mail:** emrs@emrs-strasbourg.com**www.emrs-strasbourg.com****15–16 May 2012****SEMICON Russia 2011**

ExpoCenter Moscow, Russia

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