

# semiconductor TODAY

COMPOUNDS & ADVANCED SILICON

Vol. 8 • Issue 1 • February 2013

[www.semiconductor-today.com](http://www.semiconductor-today.com)

A person wearing a blue cleanroom suit and a white face mask is working in a laboratory. They are holding a small, dark, rectangular object, possibly a semiconductor wafer, and looking at it through a microscope. The background is slightly blurred, showing other laboratory equipment.

## Silicon carbide epitaxy for growing market

## Raytheon Glenrothes opens SiC foundry

Soitec partners with GT & SEI • Solar Junction & Amonix partner  
Management buyout revives Albis • Emcore returns to profit



# Light Up a Brighter World

## Introducing MaxBright MHP MOCVD System



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

### The Best in MOCVD Technology Just Got Better

Veeco, the world's leader in MOCVD equipment, launches another breakthrough in yield performance: the TurboDisc® MaxBright® MHP™ MOCVD System, a high performance, modular version of the best-selling MaxBright. With up to 20% within-wafer wavelength uniformity improvement, 15% increase in footprint efficiency and enhanced serviceability, the MaxBright MHP will accelerate the solid state lighting revolution with the highest productivity and excellent yield. It is part of our entirely new suite of MOCVD systems — which include the new footprint-efficient MaxBright M™ and the high performance K465i HP™ — all engineered to offer you the best solution to drive your LED manufacturing success.

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



Innovation. Performance. Brilliant.



# contents

<b>Editorial</b>	<b>4</b>
<b>News</b>	
<b>Markets News</b>	<b>6</b>
GaN device market to grow at 18% annually • Excess sapphire capacity to trigger consolidation	
<b>Microelectronics</b>	<b>10</b>
RFMD grows 29% sequentially • Peregrine unveils STeP8 process	
<b>Wide-bandgap electronics</b>	<b>24</b>
Raytheon Glenrothes opens SiC foundry • Graphensic wins business development grant for graphene on SiC	
<b>Materials and processing equipment</b>	<b>30</b>
Veeco's orders return to growth • Soitec partners with GT on HVPE GaN template system and with Sumitomo on GaN substrates	
<b>LEDs</b>	<b>48</b>
Cree sets 276lm/W efficacy record for white R&D power LED	
<b>Optoelectronics</b>	<b>52</b>
Versatilis spins out green laser venture VerLASE • German IMOTHEB project to develop high-brilliance IR laser sources	
<b>Optical communications</b>	<b>60</b>
Management buyout from Enablence re-launches Albis • NeoPhotonics acquiring LAPIS' optical components unit	
<b>Photovoltaics</b>	<b>76</b>
Emcore returns to profit • Solar Junction partners with Amonix • First Solar sets 18.7% efficiency record • DayStar sells CIGS assets	
<b>Technology focus: Nitride materials</b>	<b>86</b>
Reducing gallium nitride growth temperature to 500°C	
<b>Technology focus: Nitride LEDs</b>	<b>88</b>
Distributed Bragg reflection in epitaxial nitride layers	
<b>Technology focus: Nitride LEDs</b>	<b>90</b>
Nanocolumns support monolithic multi-wavelength emission	
<b>Technology focus: Nitride LEDs</b>	<b>92</b>
Air-channels & nanoporous structure boost nitride LED output	
<b>Technology focus: Nitride LEDs</b>	<b>94</b>
Polystyrene nanospheres focus effort on photonic crystal	
<b>Technology focus: UV LEDs</b>	<b>96</b>
Self-textured oxide mask enhances UV LED efficiency by 83%	
<b>Technology focus: III-V-on-silicon</b>	<b>98</b>
Step towards integrating GaN HEMTs and CMOS	
<b>Technology focus: III-V-on-silicon</b>	<b>100</b>
HfO <sub>2</sub> for gate insulation and surface passivation in nitride HEMTs	
<b>Technology focus: III-V-on-silicon</b>	<b>102</b>
InGaN-channel HEMT cut-off reaches 260GHz	
<b>Technology focus: Silicon carbide</b>	<b>104</b>
Silicon carbide epitaxy for growing market	
<b>Suppliers' Directory</b>	<b>108</b>
<b>Event Calendar and Advertisers' Index</b>	<b>114</b>

## semiconductor**TODAY**

COMPOUNDS & ADVANCED SILICON

Vol. 8 • Issue 1 • February 2013



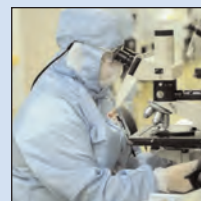
**p55** University of Strathclyde professor Martin Dawson, leader of the new UK-funded project 'Ultra-parallel visible light communications: UP-VLC'.



**p79** First Solar's R&D team in Perryburg, which has set a new record of 18.7% for CdTe solar cell efficiency.



**p82** Flisom has raised funding to ramp up a 15MW flexible CIGS module production plant.



Cover: Interior view of the Raytheon Glenrothes plant in Scotland, which has officially opened a new manufacturing facility for silicon carbide foundry. The SiC foundry is the first of its kind in the UK, and was opened by the Right Honorable Michael Moore (Secretary of State for Scotland). **p24**

# Wide-bandgap market prospects driving equipment and materials developments

In this issue's feature article (pages 104–106) we focus on development trends in silicon carbide epitaxy, including the pending migration to 150mm SiC substrates and market drivers such as the development of SiC-based power semiconductor microelectronic devices and systems.

Indeed, just at the end of January, US defense contractor Raytheon officially opened a new manufacturing facility for silicon carbide foundry at its UK subsidiary's Raytheon Glenrothes site in Scotland (see page 24). Aided by funding from the UK government's Technology Strategy Board, what is reckoned to be the first SiC foundry in the UK, targeting not only smaller and lighter electronics for harsh environments but also demand for energy-efficiency savings in power switching and rectifying components.

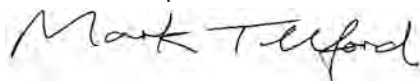
Such wide-bandgap semiconductor properties are also driving developments at France-based silicon-on-insulator (SOI) wafer supplier Soitec, which also produces III-V-based 'engineered substrates'. The firm has signed a licensing and technology-transfer agreement under which compound semiconductor materials provider Sumitomo Electric Industries in Japan will use Soitec's proprietary Smart Cut technology to manufacture engineered gallium nitride substrates, targeting LED-based solid-state lighting (see page 48). In addition, Soitec has also just announced development and licensing agreements allowing US-based GT Advanced Technologies (a provider of sapphire and silicon crystal growth systems and materials) to develop and commercialize a high-volume, multi-wafer hydride vapor phase epitaxy (HVPE) system. The systems will be targeted at producing high-quality GaN epilayers on sapphire substrates to produce GaN template substrates for use in not only LED manufacturing but also sectors including power electronics (see page 46).

Meanwhile, University of California Santa Barbara spin-off Sora Inc, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates, has announced the next generation of its high external quantum efficiency GaN-on-GaN LEDs (see page 49). Other white LED and solid-state lighting products were launched and demonstrated by LED makers including Philips Lumileds and Bridgelux at February's Strategies in Light event in Santa Clara (pages 52 & 54). Regarding performance, Cree has raised its previous industry record of 254 lumen per Watt (announced last April) to 276lm/W for luminous efficacy of a white R&D power LED (page 57).

While such technology and product developments are driven by the prospectively huge markets for wide-bandgap SiC- and GaN-based power semiconductors and lighting-class LEDs, mass market adoption is having a prolonged gestation, which led to a downturn in MOCVD system sales for suppliers Aixtron and Veeco last year. Just as we go to press, Aixtron has reported a loss for 2012 rather than the profitability expected until as late as last October. However, Aixtron believes demand has reached the bottom of the current cycle, and that an LED-driven recovery will occur "at some point during 2013". Full details will be reported next issue.

**Mark Telford, Editor**

[mark@semiconductor-today.com](mailto:mark@semiconductor-today.com)



**semiconductor**TODAY  
COMPOUNDS & ADVANCED SILICON



## Editor

Mark Telford

Tel: +44 (0)1869 811 577

Cell: +44 (0)7944 455 602

Fax: +44 (0)1242 291 482

E-mail: [mark@semiconductor-today.com](mailto:mark@semiconductor-today.com)

## Commercial Director/Assistant Editor

Darren Cummings

Tel: +44 (0)121 288 0779

Cell: +44 (0)7990 623 395

Fax: +44 (0)1242 291 482

E-mail: [darren@semiconductor-today.com](mailto:darren@semiconductor-today.com)

## Advertisement Manager

Jon Craxford

Tel: +44 (0)207 193 9749

Cell: +44 (0)7989 558 168

Fax: +44 (0)1242 291 482

E-mail: [jon@semiconductor-today.com](mailto:jon@semiconductor-today.com)

## Original design

Paul Johnson

[www.higgs-boson.com](http://www.higgs-boson.com)

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

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

## Regular issues contain:

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

**Semiconductor Today (ISSN 1752-2935) is published free of subscription charge**

in a digital format 10 times per year by Juno Publishing and Media Solutions Ltd, Suite no. 133, 20 Winchcombe Street, Cheltenham GL52 2LY, UK. See: [www.semiconductor-today.com/subscribe.htm](http://www.semiconductor-today.com/subscribe.htm)

© 2013 Juno Publishing and Media Solutions Ltd. All rights reserved.

*Semiconductor Today* and the editorial material contained within is the copyright of Juno Publishing and Media Solutions Ltd. Reproduction in whole or in part without permission is forbidden. In most cases, permission will be granted, if the author, magazine and publisher are acknowledged.

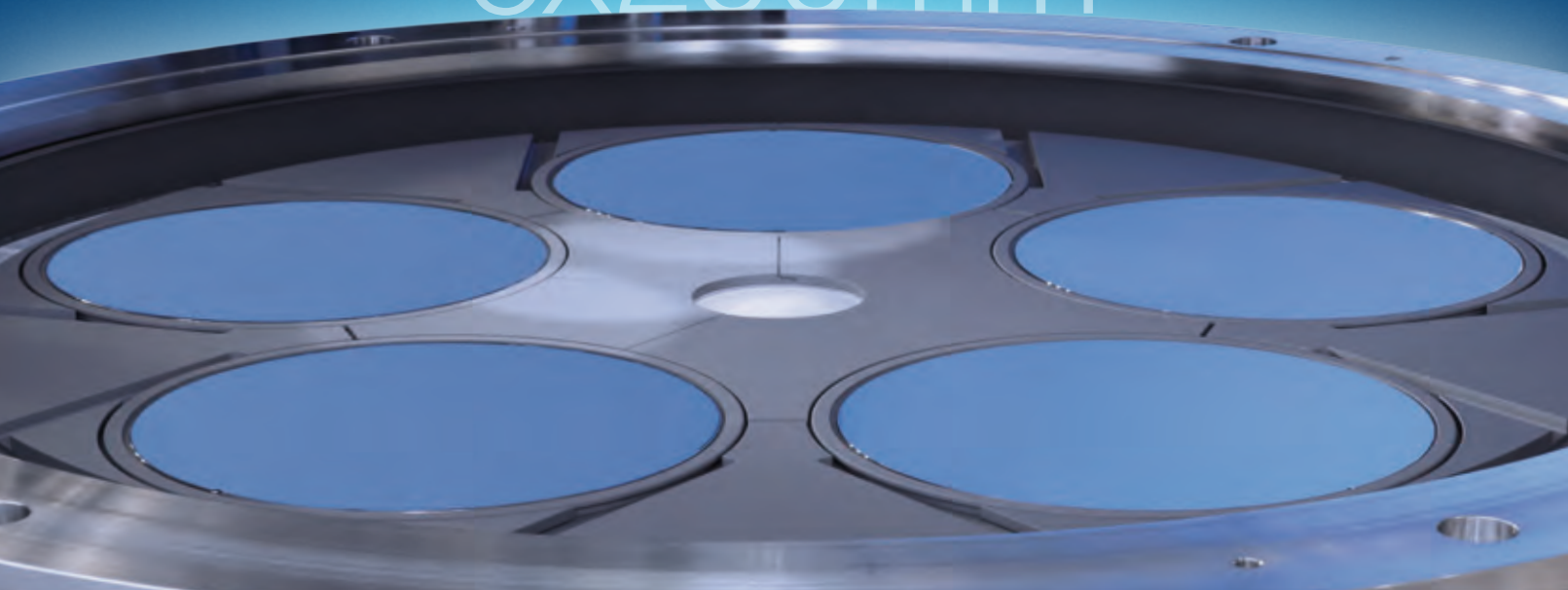
**Disclaimer:** Material published within *Semiconductor Today* does not necessarily reflect the views of the publisher or staff. Juno Publishing and Media Solutions Ltd and its staff accept no responsibility for opinions expressed, editorial errors and damage/injury to property or persons as a result of material published.



**AIXTRON**

# 200mm GaN-on-Si Batch Reactor

5x200mm



## AIX G5+



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

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



## GaN device market to grow at 18% annually through 2016 ...but lack of trained professionals slowing market progress

The global gallium nitride (GaN) semiconductor device market will grow at a compound annual growth rate (CAGR) of 18% over 2012–2016, forecasts a new report from TechNavio (the market research platform of Infiniti Research Ltd).

"The applications of gallium nitride are expanding aggressively across various segments, especially in the Automobile segment," notes an analyst from TechNavio's Hardware team. "The evolution of electric vehicles and hybrid electric vehicles is primarily driving the demand for GaN power semiconductors in the Automobile segment. In addition, the increase in infotainment applications in the Automobile segment is driving the demand for GaN opto-semiconductor devices in the global market," they add. "Further-

more, the increase in applications in the Defense segment is gaining traction in this market."

One of the key factors contributing to this growth is the high thermal conductivity of GaN over other non-silicon substrates such as gallium arsenide (GaAs), says the report. Although GaAs has the required thermal conductivity, it can only operate with a maximum of 14 volts. In order to overcome this, semiconductor firms prefer GaN-on-silicon (GaN-on-Si) wafers and GaN on silicon carbide (SiC) wafers, which have the capability to provide high thermal conductivity and to generate high power.

The GaN device market has therefore witnessed the increasing preference for GaN with different substrates. However, the complex-

ity in matching cost and performance could pose a challenge to the growth of this market, reckons the market research firm.

The report 'Global Gallium Nitride Semiconductor Devices Market 2012-2016' also includes a discussion of the dominant vendors operating in the market, such as NXP Semiconductors NV, RF Micro Devices Inc, and Triquint Semiconductor Inc, as well as Nichia Corp, Osram Optosemiconductors GmbH, Royal Philips Electronics NV, and Toyoda Gosei Co Ltd.

However, the report also concludes that the lack of trained professionals in this field is slowing down market progress.

[www.technavio.com/content/global-gallium-nitride-semiconductor-devices-market-2012-2016](http://www.technavio.com/content/global-gallium-nitride-semiconductor-devices-market-2012-2016)

## Dominant players identified in LEDs & power electronics

LEDs are projected to grow more than six-fold to nearly \$100bn and power conversion electronics to \$15bn over the next ten years as the desire for energy efficiency drives adoption, reckons analyst firm Lux Research in the report 'Winning the Jump Ball: Sorting Winners from Losers in LEDs and Power Electronics'. But while the market opportunity is clear, the winning positions are still very much up for grabs, making wise partnership and investment choices critical.

"A slew of developers are working on innovative materials and system architectures, targeting the primary challenges of cost reduction and manufacturability," says analyst Pallavi Madakasira, lead author of the report. "Many leading lights of the electronics industry are strong in these markets, but start-ups with novel technologies are looking to grab a share for themselves," he adds.

Lux positioned key developers of

LEDs and power electronics materials, devices, and systems on the Lux Innovation Grid based on their technical value and business execution. Firms that are strong on both axes reach the dominant quadrant. Lux also assessed each firm's maturity, and provided an overall view:

● *Silicon carbide (SiC) players are dominant in power electronics.* The dominant power electronics players wager mostly on SiC. Cree is a fully vertically integrated SiC device manufacturer, while other top leaders are experienced players from silicon power electronics like Infineon, Rohm Semiconductor and ST Microelectronics.

**Leading lights of the electronics industry are strong in these markets, but start-ups with novel technologies are looking to grab a share**

● *Cree and II-VI Wide Bandgap lead materials space.* Cree is also dominant in materials, based on its development of SiC substrates. The only other company with a dominant rank is II-VI Wide Bandgap Group, a SiC wafer supplier with established relationships with power electronics and RF device manufacturers.

● *Six vie for dominance in LED.* Cree is the leader in LEDs as well, the only firm that has successfully commercialized SiC-substrate-based LEDs at scale. Among other dominant firms, Nichia holds the most IP, while Samsung, Philips, and Osram Opto Semiconductors have all demonstrated GaN-on-silicon LEDs. GE Lighting does not have its own chip technology but its integration further down the value chain and its recent acquisition of fixture manufacturer Albeo make it a force to reckon with.

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



# Excess capacity in sapphire substrates to trigger 'massive consolidation, attrition'

Significant overcapacity and low LED substrate prices will affect the profitability and viability of many sapphire players in 2013 and beyond, says a new market report 'Sapphire Substrates 2013' from Yole Développement. However, "emerging applications could transform the industry" it concludes.

The report provides an analysis of the sapphire industry, including revenues, volumes and price trends for all major substrate applications. It also includes a list of manufacturers with current and planned capacity, and an analysis of established and emerging manufacturing technologies. The drivers and dynamics of the LED and SoS markets are analyzed, and a preliminary view and plausible scenario are provided on emerging non-substrate applications in cell phones. Report author Eric Virey has a PhD in optoelectronics from France's National Polytechnic Institute of Grenoble and previously worked for Saint-Gobain.

Yole says that the sapphire material shortage experienced from 2010 to early 2011 created "a window of opportunity for new entrants". In the past two years, more than 80 companies announced their intention to enter the industry, bringing the potential number of players to more than 130 — with more than 50 of these potential new entrants located in China.

Coupled with slow demand from LED makers in 2012, this situation created a "very challenging environment", according to the report, with cores and wafers often selling at prices at or below manufacturing cost. Revenues increased 15% in 2011 but are expected to have fallen 9% in 2012 due to lower average selling prices (ASPs), despite volume increases and a favorable product mix — with the percentage of PSS (patterned sapphire substrate) wafers increasing dramatically.

Yole says that these difficult market conditions "will trigger an industry rationalization through consolidation and attrition" that should take place in 2013 and 2014; activities that the Yole Finance business unit will be monitoring closely. In the long-term, as the environment remains extremely competitive, Yole's team expects the [sapphire substrate] industry to evolve toward a more vertically integrated model in order to limit margin stacking. A handful of global tier-1 leaders should emerge from this rationalization, along with smaller tier-2 regional players.

Yole's report presents both historical and future price trends for materials and finished wafers, as well as a detailed supply/demand analysis. Volume forecasts are presented for material, standard and PSS wafers, along with a revenue forecast for finished wafers.

## LED-on-Si: a looming threat

Virey (who is senior analyst, LED, at Yole) commented, "All major LED makers are currently exploring opportunities for transitioning from a sapphire-based technology platform to a silicon-based one ('LED-on-Si'). This interest is driven by a potential cost savings of up to 60% at the die level."

But while significant progress has been made, the technology still faces hurdles, and it remains to be seen whether the leading proponents of LED-on-Si, like Bridgelux/Toshiba and Lattice Power, will be able to tackle all of the remaining challenges and transition to mass manufacturing in a cost-effective manner.

For most other LED companies, LED-on-Si is often a key development axis, but not a necessary milestone on their manufacturing roadmap. The jury is still out. In the meantime investments in the large-diameter sapphire platform are often postponed pending the outcome of LED-on-Si.

Yole also presents an in-depth analysis of the requisite conditions

for the success of LED-on-Si, and reveals how GaN could capture some niche markets due to higher performance and competitive system-level cost of ownership.

Other market-related headlines include "SoS to provide welcome upsides" and "Could cell phone windows be the next killer application?". The silicon-on-sapphire (SoS) application could represent a nice upside for the happy few that enter the supply chain, Yole forecasts. Demand more than doubled in 2012 and could do the same in 2013. For example, leading SoS company Peregrine has developed a compelling antenna switch technology that has already achieved vast success in smart phones.

This company benefits from strong macro trends in the cell-phone market and is developing new components that could further increase not only SoS content per phone, but also wafer demand. Opportunities for these new components (power amplifiers and tunable capacitors), as well as for competing technologies developed by companies such as Paratek (now part of cell phone maker RIM), may bring new volume applications to sapphire wafer manufacturers.

The significant capability and capacity build-up and dramatic cost reduction achieved by the sapphire industry in the past three years could open the door for new applications. Among these, the use of sapphire for small display covers has the potential to be a game-changer and raise the sapphire industry to a new level. Despite significant hurdles in terms of cost and manufacturing technologies, all major cell-phone OEMs are investigating this option. While mass adoption remains uncertain, it is not wholly unrealistic — and, due to the current state of their LED-related business, most sapphire makers are keen to help it materialize.

[www.yole.fr](http://www.yole.fr)

*Matthew Peach, Contributing Editor*



# Mobile phone shipments grow 2% to 1.6 billion in 2012, with Samsung taking 25% share

Global mobile phone shipments grew a modest 2% annually to 1.6 billion units in 2012, according to a report from Strategy Analytics.

"Macroeconomic challenges in mature markets like North America and Western Europe, tighter operator upgrade policies, and shifting consumer tastes were among the key reasons why global mobile phone shipments grew just 2% annually to reach 1.6 billion units in 2012," says senior analyst Neil Shah.

"Fuelled by robust demand for its popular Galaxy models, Samsung was the star performer, shipping a record 396.5 million mobile phones worldwide and capturing 25% market share to solidify its first-place lead," he adds. However, Samsung's total volumes for the year fell just short of the 400-million threshold.

Nokia's mobile phone shipments fell 20% from 417.1 million units in 2011 to 335.6 million in 2012.

"Nokia faced tough competition from Samsung in developing markets like China, while Apple and others ramped up the pressure in developed regions such as Western

**Mobile phone vendor shipments and market share in Q4/12 (total does not include grey phone shipments).**

Vendor	Q4/11	2011	Q4/12	2012
Samsung	95.0	327.4	108.0	396.5
Nokia	113.5	417.1	86.3	335.6
Apple	37.0	93.0	47.8	135.8
ZTE	24.4	78.1	19.5	71.7
Others	169.7	630.4	189.3	635.4
Total	439.6	1546.0	450.9	1575.0
Share	Q4/11	2011	Q4/12	2012
Samsung	21.6%	21.2%	24.0%	25.2%
Nokia	25.8%	27.0%	19.1%	21.3%
Apple	8.4%	6.0%	10.6%	8.6%
ZTE	5.6%	5.1%	4.3%	4.6%
Others	38.6%	40.8%	42.0%	40.3%
<b>Growth y-o-y</b>	<b>9.9%</b>	<b>13.7%</b>	<b>2.6%</b>	<b>1.9%</b>

Europe," notes executive director Neil Mawston. "Nokia's dual-SIM feature phones, Asha touchphones and Lumia handsets have been performing well, but this was not enough to offset a slump in demand for the company's aging Symbian smartphone platform last year."

Apple's shipments grew 46% to a record 135.8 million mobile phones in 2012, bolstered by solid demand

and supply chain challenges cast a slight shadow over the launch," comments analyst Linda Sui.

Also, ZTE captured 5% share of the mobile phone market in 2012, as its shipments fell 8% from 2011. This was partly because of heightened competition from rivals such as Coolpad and Samsung in core markets like China and Western Europe.

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

in North America and Asia. "Apple's launch of the iPhone 5 in Q4/2012 was a success as volumes ramped up in dozens of countries worldwide, but negative media coverage of the model's new integrated maps service

## Smartphone pressure mounts for Samsung and Apple Less costly smartphones gaining momentum entering 2013

Nearly 196 million smartphones and 451 million handsets were shipped during fourth-quarter 2012, according to the latest estimates from ABI Research. This brings 2012 annual totals to 653 million smartphone and 1.6 billion handset shipments, up 36% and 2% year-on-year, respectively. Smartphones accounted for 43% of all handset shipments in Q4, which pushed smartphones to 41% of all shipments in 2012.

Samsung retained its lead position overall by shipping 106 million handsets, of which 60 million were smartphones in Q4 and capturing 31% of total smartphone shipments. In 2012 Samsung grew its handset shipments by 21.6% and its smart-

phone shipments by 123.8%.

Despite missing most analyst estimates in Q4, Apple grew its smartphone shipment market share to 24.5%, up from 16.4% in Q3. Apple shipped 47.8 million iPhones in Q4, bringing its full-year 2012 total to 135.8 million. Apple's 2012 annual shipment growth declined from 96% in 2011 to 46% in 2012.

"It is clear that the iPhone's hyper-growth has ended, and ABI believes that Apple's market share will peak in 2013 at 22%," says mobile devices senior analyst Michael Morgan. "Unless Apple is willing to trade iPhone margins for low-cost iPhone shipments, Apple's handset market share will become

dependent on customer loyalty."

Nokia shipped 86.3 million handsets and 6.6 million smartphones in Q4, while Research In Motion's shipments of smartphones fell to 6.9 million. ZTE had an excellent Q4, with 20.7 million handset shipments and 11.2 million smartphone shipments.

"Samsung and Apple are both under pressure to maintain their market lead as less costly smartphones gain momentum entering 2013," says senior practice director Jeff Orr. "Technology optimization choices and a diverse handset portfolio are critical decisions over the next 6–9 months to come out ahead."

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

# Inverter market to grow from \$45bn to \$71bn by 2020

## SiC making inroads in micro-inverter diodes and JFETs; GaN market introduction due this year

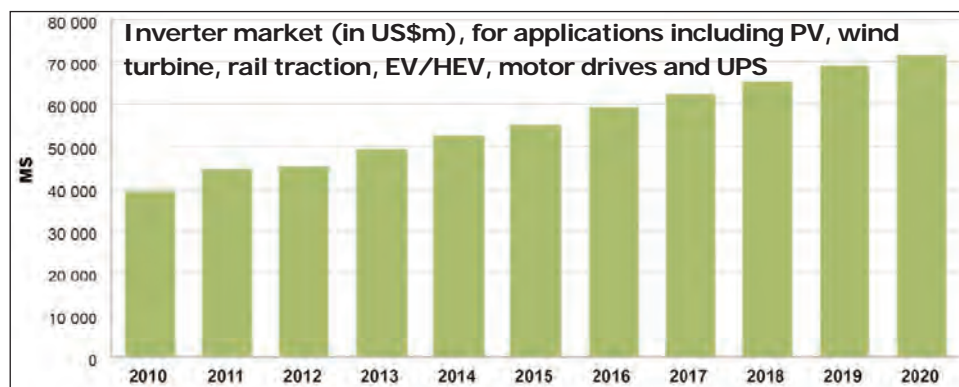
The inverter market grew significantly to \$45bn in 2012, and will reach \$71bn by 2020, according to Yole Développement's report on 'Inverter market trends for 2013–2020 and major technology changes'. "More than 28 million units were shipped in 2012 and we estimate that will grow to 80 million units in 2020," says Brice Le Gouic, activity leader, Power Electronics, at Yole.

The report provides a focus on the six most attractive motion and conversion applications — photovoltaics (PV), wind turbines, electric and hybrid-electric vehicles (EV/HEV), rail traction, motor drives and uninterruptible power supplies (UPS) — and a new analysis on the trends in power stacks from the previous report.

Yole says that energy-related topics (vehicle electrification, renewable energies, electricity transportation) have gained in importance in 2012. The power electronics market has hence risen. This growth is driven by: high-volume and cost-pressure applications such as EV/HEV; and high-added-value markets such as renewable energy and rail traction.

The main components of inverters — passive and semiconductor modules (found in power stacks) — represent enticing industries, says Yole. In 2012, the market was \$1.9bn for power modules and more than \$4bn for passive components, including capacitors, resistors, connectors, bus-bars and — newly added in this updated report — magnetic components (inductors and transformers).

Yole notes that, as expected, wide-bandgap semiconductor devices have also started to penetrate those high-end market segments: in particular, silicon carbide (SiC) is present in PV inverters — a total market size of \$43m, driven mainly by diodes in micro-inverters but also by junction field-effect transistors (JFETs) — and gallium nitride (GaN) should enter the market in 2013.



### Semiconductor technology developments continue to sharpen inverter performance

Yole's 2012 investigation confirmed that improvements in semiconductors have enabled more efficient conversion, lighter systems and more reliable end-products. For example, silicon-based insulated-gate bipolar transistors (IGBTs) have improved (higher current density, thinner and faster), as have SiC- and GaN-based devices.

GaN could be delayed in its market introduction, notes Yole, but SiC is already here and several companies have demonstrated SiC power module capabilities during last year. Hence, in the new report Yole has updated its technology roadmaps for materials and devices.

### Adoption of power stacks driving modular approach

The report also highlights the trend in power stacks that Yole surveyed closely in 2012. The power stack is the innovative sub-system of an inverter that involves the custom design and manufacturing of an inverter's sub-unit, which includes only the core components: power semiconductor module, cooling system, capacitors, resistors, current sensors, busbars and connectors.

Yole remarks that inverter and device makers are becoming power stack makers for several reasons, including: vertical integration; access to several applications (since power stacks are less application-dependent than inverters); internal cost reduc-

tions; access to high-end markets; and maintaining R&D in-house.

Large firms such as Ingeteam, Semikron or ABB are now involved, but power stacks also interest smaller players such as AgileSwitch (former IGBT driver manufacturer), who are part of this \$500m market.

### Major changes happening across the supply chain

Power electronics often requires having knowledge and experience-based expertise in several different sectors, including mechanics, electronics, semiconductors, electrics, fluidics and hydraulics, and connectors. Development can hence be complicated and final products expensive. As a consequence, Yole has observed and analyzed two main trends coming out of the power electronics industry:

- Japanese and Chinese players (especially system makers) tend toward internal vertical integration, and master the manufacturing processes of each sub-system and component. In the case of Japanese firms, this tendency is driven mostly by cost reduction and the absorption of intermediary margins, whereas Chinese companies want to access the technology and show some proof of quality, says Yole.

- On the other hand, EU and US players are diversified, and acquisition of new or complementary competencies or high-end R&D and prototyping services is becoming more common, concludes the market research firm.

[www.yole.fr](http://www.yole.fr)



# RFMD enjoys 29% sequential revenue growth

## Firm to outperform underlying markets in March quarter

For its fiscal third-quarter 2013 (ended 29 December 2012), RF Micro Devices, of Greensboro, NC, USA has reported revenue of \$271.2m, up 29.3% from \$209.7m the prior quarter and up 20.3% on \$225.4m a year ago.

The sequential growth was much more than the 17% forecast, reflecting broad-based growth of 40% in RFMD's Cellular Products Group (to \$222.6m, with increasing content in smartphones and reference designs). Also, there was 28% growth in high-performance WiFi (in support of multiple applications, including smartphones and consumer products) within RFMD's Multi-Market Products Group (which however was flat sequentially, at \$48.6m overall).

"Sequential revenue growth in the December 2012 quarter reflected continued content gains, category expansion, and growth in our addressable markets," said president & CEO Bob Bruggeworth.

On a non-GAAP basis, gross margin has grown from 30.2% a year ago and 35.2% last quarter to 35.5%. Operating income was \$26.8m, nearly tripling from \$9.2m last quarter. Net income was \$21.3m (\$0.08 per diluted share), up from \$7.8m (\$0.03 per diluted share). Cash flow from operations rose from \$1.9m to \$43.3m, nearly offsetting the net cash paid for November's acquisition of Amalfi Semiconductor.

The firm listed several strategic highlights from Q3 including: delivering robust sequential revenue growth across a broad set of products and customers; and the acquisition of RF CMOS technology provider Amalfi to complement its product portfolio for entry-level handsets and smart-phones. Furthermore RFMD's MPG division started shipping high-performance 802.11ac WiFi front-ends in support of a leading smartphone manufacturer.

For the March quarter, RFMD expects to outperform normal seasonality, reflecting continued diver-

sification, category expansion and content gains, combined with the benefit of significant customer product ramps. The firm currently believes the demand environment in its end-markets supports the following expectations and projections: revenue will fall by 6–8% sequentially to \$250–255m; and non-GAAP earnings per share will be \$0.04–0.05.

"We have secured major design wins during the latest quarter, and we are executing on multiple opportunities to increase our content generation-over-generation in the world's leading smartphones and expect to significantly outpace the growth rate of the underlying markets," says Bruggeworth.

"In the coming March quarter, we expect our ability to capture an increasing amount of semiconductor content within smart devices and reference designs will enable RFMD to outperform normal seasonality," adds Dean Priddy, chief financial officer & VP administration.

In the analysts conference that followed announcement of the results, Bruggeworth was upbeat about his firm's market prospects, saying, "You have to look long and hard for an industry already this large which is still expected to grow as fast as the data mobility market over the next five years.

"As more and more devices connect to the Internet, more of them will need to be mobile, and more of them will require high-speed, reliable data connections. For RFMD, the implications are clear. Our products are the critical building blocks in this unwired world, and the problems they solve are at the very center of the mobility revolution."

Bruggeworth also gave three reasons why the company has recently enjoyed strong revenue growth and robust design activity for in the area of 4G LTE devices. "One, the world's carriers are increasingly requiring LTE devices on their net-

work; two, the growth rate for RF content in these devices over the long term will outpace device growth; and three, the increase in frequency band combinations and the increasing demand for new technologies such as antenna tuning, envelope tracking and carrier aggregation," he adds. "RFMD has established clear market leadership in these next-generation RF technologies, and we are broadly engaged with the leading smartphone manufacturers and chipset providers to enable and perhaps accelerate widespread adoption."

Bruggeworth also gave a brief update on RFMD's acquisition of Amalfi and how the integration of that company and its activities were progressing. "We are well into the process of combining their product portfolio and the proprietary RF CMOS and mixed-signal expertise with our sales channels and global supply chain," he says. "We are accelerating the adoption of these products in entry-level smartphones, and we intend to drive our RF CMOS technology and products into new markets and new customers. We anticipate this technology will provide us a path to lower costs and improved margins in entry-level handsets and smartphones."

Considering the issue of likely future business, Priddy was asked by an analyst whether he was expecting "another 10% customer" during the [coming] March quarter. "It's always possible," he replied. "But I think you can expect more customers in the 3–6% revenue range because, as we look at our customer mix now, we're probably the most diversified from a customer standpoint and maybe in the history of RFMD as a public company. So we're becoming very well distributed across the entire customer base. So that provides us, I believe, a great deal of comfort in terms of less revenue volatility."

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



# your partner for EPITAXY

visit [www.iqep.com](http://www.iqep.com)  
to see how you can reduce  
your costs and gain  
competitive advantage  
by partnering with  
the world's No.1 pure-play  
epiwafer specialist  
for all your  
epitaxial wafer needs

## OPTO WIRELESS SOLAR

VCSELs edge-emitting lasers Al-free lasers visible/IR lasers  
Visible LEDs APDs PiN detectors long-wavelength PiNs  
Multi-junction CPV cells  
HBTs pHEMTs BiFET/BiHEMTs



# TriQuint's sequential growth of 16% drives greater-than-expected revenue and income in Q4

## First-half 2013 to be slow, but capacity and R&D investments to drive growth in second half

For full-year 2012, RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported revenue of \$829.2m, down 7% on 2011's \$896.1m due mainly to a decrease in Mobile Devices revenue. Nevertheless, TriQuint achieved record Optical sales, fuelled by the firm's 40G and 100G modulator drivers.

However, fourth-quarter revenue was \$233.6m, up 3% on \$227m a year ago and 16% on \$200.8m on Q3/2012 (and above guidance of \$220–225m).

Revenue was split by end-market as Mobile Devices 64%, Networks 22%, and Defense & Aerospace 14%. Defense & Aerospace revenue was up 36% sequentially on Q3/2012, while Networks revenue grew just 1% sequentially. Mobile Devices revenue grew 19%. The company commented that there was "strong demand" for 5GHz WLAN, which drove 66% sequential growth in connectivity in smart-phones. Also, the firm set an "industry record" for its gallium nitride reliability.

On a non-GAAP basis, gross margin for Q4/2012 was 31.7%, up on 31% a year ago but down from 32.5% last quarter. Sequentially higher revenue was offset by inventory reductions, leaving factory utilization down slightly. Gross margin for the whole of 2012 was 30.7%, down from 37.2% for 2011. Utilization fell as TriQuint completed long-planned capacity additions during the year, had lower revenue, and reduced inventory.

Operating expenses for Q4 were \$66.6m (29% of revenue), up by \$4.6m from last quarter. Operating expenses for full-year 2012 were \$254.4m (31% of revenue), up from \$244.4m in 2011. The increases were due mainly to higher engineering expenses.

Full-year 2012 saw a net loss of \$2.2m (\$0.01 per diluted share), compared with net income of \$87.3m (\$0.51 per diluted share) for 2011. However, although down on \$13.3m (\$0.08 per diluted share) a year ago, net income for Q4 of \$6.2m (\$0.04 per diluted share, above guidance of \$0.01–0.03) was up from \$2.5m (\$0.02 per diluted share) last quarter. During Q4, total cash and investments fell by \$5.6m to \$139m.

### Outlook

For Q1/2013, TriQuint expects revenue to fall to \$180–190m (although the firm is already 98% booked to the midpoint of this guidance). Gross margin should fall to 25–27% due to lower revenue and utilization. Operating expenses are expected to grow further, to \$67–69m. Non-GAAP net loss should be \$0.12–0.14 per share.

"I expect a slow start to the year due to seasonality and customer program timing, and our investments in capacity and R&D will remain a financial headwind during the first half of the year,"

said president & CEO Ralph Quinsey.

"We are continuing to expand capacity specifically for high-performance filters in anticipation of strong demand in the second half of 2013 and beyond," said Quinsey. "We are entering the new fiscal year with one of our healthiest new-product and design-win pipelines in place," he added.

"I believe these investments will lead to improved financial results to

the company in the second half and position us well for 2014 and beyond in what remains an opportunity-rich marketplace."

Considering the mobile technologies marketplace, Quinsey noted, "Our approach to the mobile market is three-fold: We offer a broad suite of RF capabilities to address the complete RF front end, including amplifiers, switches, filters. Secondly, we develop differentiated products that offer our customers improved size, cost and performance... we continue to invest in critical technology such as advance bar and soft filters, wafer-level packaging, flip-chip interconnect, BiHEMT and highly integrated high-performance broadband amplifiers for our solutions," he added. "Lastly, we are investing in capacity for long-term growth, but we'll avoid filling up factories with undifferentiated products that tend to be low margin. Our duplexers and high-performance soft filters have limited suppliers worldwide, and these products are currently the fastest-growing portion of the market. TriQuint's ability to supply hard-to-find advanced filters is binding us closer to our customers."

"Additionally, we are in production with our second generation of gallium nitride," said Quinsey. "This updated technology has best-in-class reliability and has achieved manufacturing yields equivalent to GaAs while delivering top RF performance," he added. "We remain closely involved in a portfolio of contracted R&D programs sponsored predominantly by AFRL (Air Force Research Lab) and the Office of Naval Research (ONR)." Contract awards and funding was up 16% in 2012, due mainly to the development and manufacturing of GaN technologies for future Department of Defense programs. ➤

**I expect a slow start to the year due to seasonality and customer program timing... investments in capacity and R&D will remain a financial headwind**

## ► Scrap issue

Quinsey also drew attention to what he described as a potential scrap issue: "We are currently investigating a potential scrap issue related to the ramp up of new GaAs capacity. This issue impacts a small number of mobile customers, none of which are greater than 10% of revenue. We are dual sourced and have kept capacity to support demand while

we work through this issue. We expect to have resolution in Q1, and we are alerting investors to a potential charge of roughly \$5m that is not included in our guidance."

Concluding, Quinsey said, "Low factory utilization remains the dominant financial headwind to TriQuint's near-term performance. Seasonal swings are getting larger but I see a solid opportunity for profitable

growth in coming quarters. More quadrant spectrum is driving high demand for high-performance filters such as BAW. RF complexity is increasing. As discreet components give way to integrated modules, the list of competitors that are able to fully support this market is shrinking and the value proposition for those that remain if they have the right products, is improving."

## TriQuint launches 802.11ac and WLAN/LTE solutions to enable Gigabit Wi-Fi and 4G coexistence for next-gen smartphones & tablets

TriQuint says that it is enabling next-generation 802.11ac Wi-Fi with the introduction of three WLAN front-end modules and two Wi-Fi/4G coexistence filters.

Supplied in 2.5mm x 2.5mm x 0.4mm modules, the TQP887051 (which contains a 5GHz WLAN power amplifier, a low-noise amplifier with bypass mode, an SP2T switch MMIC, and a directional detector) and the TQP887051 (which contains a 5GHz WLAN power amplifier and an SP2T switch MMIC) both operate in bands 802.11 a, n, ac, while the TQP9046 (which contains a WLAN power amplifier, a low-noise amplifier with bypass mode, an SP3T switch MMIC for Bluetooth path, and a directional detector) operate in bands 802.11 b, g, n.

The firm has captured smartphone design wins with its two 5GHz 802.11ac Wi-Fi RF modules, as well as its new 2.4GHz device. Due to advances in output power technology, all three TriConnect Wi-Fi modules provide extended operating ranges compared with earlier products, providing Wi-Fi users with freedom of wireless connectivity across longer distances.

Rounding out the firm's expanding WLAN product line are two new specialty 4G/Wi-Fi coexistence filters, which serve as electronic traffic guards to keep signals in the crowded 2.4GHz spectrum isolated from each other. Supplied in 1.4mm x 1.2mm x 0.5mm packages and operating at 2.4GHz, the



**TriQuint's WLAN front-end modules and Wi-Fi/4G coexistence filters.**

885032 is a LTE/Wi-Fi coexistence filter with bands 7/41 rejection, and the 885033 is a LTE/Wi-Fi coexistence filter with bands 38/40 rejection. Both devices leverage TriQuint's bulk acoustic wave (BAW) technology to address what are reckoned to be some of the industry's toughest filtering challenges.

"TriQuint is the only RF supplier that is currently delivering all three WLAN device components — the 5GHz and 2.4GHz front-end modules as well as multiple variants of coexistence filters," claims Shane Smith, VP of global marketing for Mobile Devices. "We're enabling 802.11ac gigabit speeds and solving Wi-Fi/LTE coexistence problems simultaneously, for smartphones, tablets and other wireless devices."

As demand for Wi-Fi increases, consumers have developed an ever-growing appetite for faster mobile data rates to support video streaming and other multimedia applications, notes TriQuint. With data rates of up to 1.3Gb/s, the new IEEE 802.11ac standard will

enable transfer rates three to four times faster than current-generation 802.11n Wi-Fi.

"TriQuint introduced the industry's first 802.11ac-ready module for mobile devices last year," Smith says. The dual-band product has been selected by a major manufacturer for its next-generation smartphone and is included on a reference design by a leading chipset supplier. "Our 802.11ac technology expertise also expands our future market opportunity for infotainment applications such as in-home video distribution," Smith adds.

In addition to power amplifier modules that enable faster speeds, demand is surging for high-performance Wi-Fi/LTE coexistence filters, TriQuint says. High-end smartphones contain a growing number of cellular and Wi-Fi bands to support 2G/3G/4G voice and data services, as well as global roaming. At the same time, the global spectrum crunch is leading governments around the world to squeeze new 4G bands next to pre-existing Wi-Fi spectrum, often with minimal guard bands, says the firm, so advanced filter technology is needed to mitigate the resulting interference issues.

All products are sampling now, for production in second-quarter 2013. TriQuint exhibited the new devices at the 2013 Mobile World Congress in Barcelona (25–28 February).

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

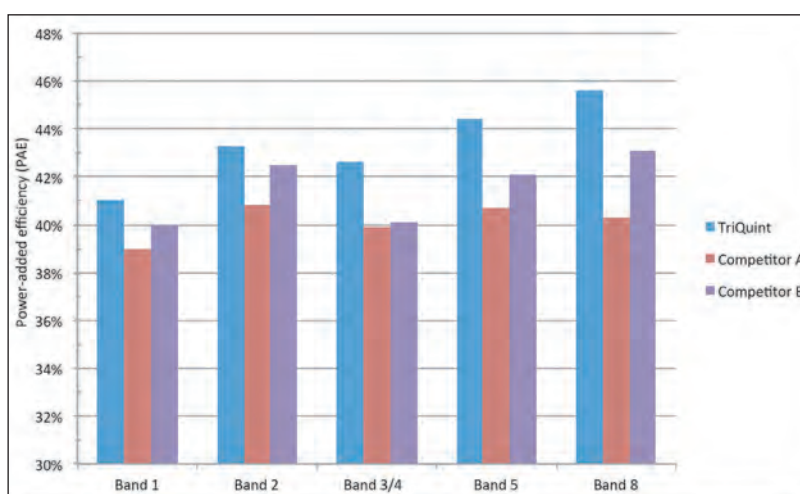


# TriQuint launches high-efficiency multi-band, multi-mode power amplifiers for next-gen global 3G/4G smartphones

RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has launched two multi-band, multi-mode power amplifiers (MMPAs) that extend browsing time while simplifying complex RF design for increasingly sophisticated wireless devices. The highly integrated MMPAs support more frequency bands in 20% less board space than discrete architectures, and have already captured design wins in next-generation 3G/4G smartphones, says the firm.

"Customers have told us they will be migrating to our new MMPAs because these modules deliver longer battery life and extended operating time," says Shane Smith, VP of global marketing for Mobile Devices. "The versatile design of TriQuint's new MMPAs also allows manufacturers to use a common platform to release new products at a faster pace, while controlling design and manufacturing costs."

Aligned with a leading chipset supplier's reference design, the TRIUMF TQM7M9050 supports five 3G/4G bands in addition to quad-band GSM/EDGE. The 3G/4G PA achieves nearly 46% power-added efficiency (PAE), says the firm.



**TriQuint's TRIUMF TQM7M9050 MMPA achieves best-in-class power-added efficiency (PAE) across several popular bands, so it consumes less power, delivering longer battery life and extended operating time for mobile devices. Source: TriQuint lab results.**

The new TRIUMF TQP9058 is almost identical, except that it features a different approach to controlling output power for the 2G PA that is compatible with reference designs from several other major chipset manufacturers. "We've expanded our product portfolio to align with multiple chipset vendors," adds Smith. "In doing so, we've broadened our ability to serve several key customers."

Both MMPAs feature a two-gain-state WCDMA PA with low- and

small data-enabled phones. At 5mm x 7mm, the highly integrated modules provide an ultra-small form factor to shrink overall product footprints while reducing external component count, minimizing assembly costs and speeding time to market.

TRIUMF MMPA TQM7M9050 and TQP9058 are currently sampling. TriQuint exhibited the new products at the 2013 Mobile World Congress in Barcelona, Spain (25–28 February).

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

## TriQuint launches smaller linear EDGE power amplifier module for mobile devices including smartphones

TriQuint has launched a quad-band GSM/EDGE power amplifier module with what is claimed as best-in-class power-added-efficiency (PAE), delivering longer user operating time for mobile devices.

Using TriQuint's GaAs HBT/CuFlip PA technology, the TQM7M5050 module offers high reliability, temperature stability and ruggedness. With input power controlled GMSK and 8PSK (pre-distortion required in EDGE mode), PA output power is controlled by the input power coming from the transceiver in



both GMSK and 8PSK modes. Operation features two modes: high-band mode (HBM) and low-band mode (LBM). The module has a built-in CMOS controller optimized

for 50Ω, and what is claimed to be excellent Rx band noise sensitivity.

Included on a leading chipset supplier's multi-mode reference design for linear EDGE applications, the new TQM7M5050 module suits smartphones, tablets and other mobile devices. The 14-pin 5.0mm x 3.5mm x 0.9mm module is 30% smaller than previous-generation products, saving board space and allowing high levels of integration.

The TQM7M5050 is in production, and samples are available.

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

**SOLARCON®**  
China2013

www.solarconchina.org

**Hall W5**

**25 YEARS**  
**SEMICON®**  
China2013

www.semiconchina.org

**Hall N1-N5**

**10 YEARS**  
**FPD China2013**

www.fpdchina.org

**Hall N1**

## The Largest Pan-semiconductor Industry Platform & Must-attend Events!

### SOLARCON China

- China's No.1 PV technical exhibition
- CPTIC
- Standards
- PV Project Implementation Conference
- ISIS
- PV Tech Training

### SEMICON China

- Celebrating 25 years in China
- CSTIC
- Five Pavilions
- China IC Night
- Industry Gala
- Supplier Search

### FPD China

- China's premier FPD industry event for 10 years
- CFC/ASID 2013
- Three Theme Pavilions
- Eight Technical Sessions
- Short Course

## MORE THAN

- 1500** international exhibitors
- 3000** booths
- 60000** visitors
- 80000** sq.m. exhibiting space
- 180** government delegations

**Register now to win a surprise gift!**

<http://223.4.179.170/semi2013/Default.aspx>



**March 19-21, 2013**

Shanghai New International Expo Centre



Concurrently with



Organized by



SEMI China  
Tel: +86.21.50270909  
FAX: +86.21.50274830  
Email: semichina@semi.org

Beijing Sanda Economic and Technology Center of MIIT  
Tel: +86.10.6871 5396  
FAX: +86.10.6848 9406  
Email: san-da@263.net



**Jing-Jing**  
晶晶



# Anadigics' sales continue recovery, up 6.4% to \$30.5m in Q4

## Ramp-up of WiFi revenue to partially offset cellular's seasonal softness in Q1

For full-year 2012, GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported revenue of \$112.6m, down 26.3% on 2011's \$152.8m. However, although down 16.5% on \$36.5m a year ago, quarterly sales have grown again following the low of \$25.1m in Q2/2012, up 6.4% on Q3's \$28.6m to \$30.5m in Q4. President & CEO Ron Michels attributes this to "continuing to strengthen our relationship with leading customers and targeting high-growth markets".

There were again three greater-than-10% customers (Samsung, Huawei and ZTE), plus three at 5–10% (Cisco and distributors Richardson and World Peace).

Revenue for infrastructure (formerly termed broadband) was \$5.6m (down 9.6% on \$6.2m last quarter). Revenue from legacy WiFi was \$1.1m, down slightly from Q3's \$1.3m. Growth was therefore driven by cellular wireless revenue rising by 12.5% from \$21.1m last quarter to \$23.7m (due mainly to WCDMA, along with some continued sequential growth in LTE). On top of Q3's 17.4% increase, composite growth of Q4 over Q2 is 32% for cellular wireless.

"We continue to execute to our growth strategy," says Michels. "Anadigics' new cellular wireless, WiFi, and infrastructure solutions provide manufacturers with compelling performance and integration advantages," he adds.

"In cellular wireless, we successfully revitalized the product line throughout 2012 and continued to gain design-win momentum," says Michels. In early November, Anadigics said that it was shipping production volumes of LTE, CDMA, and WCDMA power amplifiers to

Samsung Electronics for the new Galaxy Note II smart-phone. During the quarter, the firm launched four new front-end integrated circuits for 802.11n and 802.11ac WiFi applications (now specified on leading reference designs and ramping up production shipments in Q1/2013).

"Our infrastructure solutions continue to support increasing network build-outs," he adds. Also during the quarter, Anadigics expanded its family of small-cell power amplifiers (PAs) by launching a model for Band 8 WCDMA and LTE wireless infrastructure. It also launched four hybrid line amplifier module power doubler modules optimized for CATV networks in Asia (with production shipments expected to start in Q2/2013).

R&D expenses shrank again, by 5.2% from \$10.8m last quarter to \$9.9m, despite the firm continuing to bring more products to market and accelerating new product introductions. Selling & administrative expenses fell just 2%, from \$5m last quarter to \$4.9m. "We have a plan to continue to control and reduce costs and remain diligent in adding to our efficiencies," says VP & chief financial officer Terry Gallagher.

Capacity utilization has risen again, from 45% to about 55% (back above 50% a year ago). Non-GAAP gross margin has recovered further, from just above break-even last quarter to 2.5% (though still down on 16.5% a year ago).

On a non-GAAP basis, full-year net loss has grown from \$31.7m in 2011 to \$62m in 2012. However, although still worse than \$9.5m a year ago, quarterly net loss has been cut from \$15.3m last quarter to \$13.9m. Earnings before interest,

taxes, depreciation and amortization (EBITDA) loss was cut from \$11.3m to \$10.1m (though still almost double the \$5.3m a year ago). "Sequential growth and expense control continued to contribute to improvements in our operational metrics," says Gallagher.

Nevertheless, during the quarter, cash, cash equivalents and short- and long-term marketable securities fell further, from \$62.2m to \$51.5m. Capital expenditure (CapEx) has risen from just \$0.25m last quarter to \$0.4m (though still just a quarter of the \$1.6m a year ago), while depreciation expense fell slightly to \$4m. For the full year, capital spending was \$2.8m while depreciation was \$16.5m.

"By further strengthening our relationships with leading OEMs and reference design icons, we believe that Anadigics is well positioned for continued success in 2013," says Michels. "In commenting on the first quarter, we expect revenue growth in WiFi [to 10% of total revenue] to offset some of the seasonal softness in cellular wireless [normally down 10–15%]," adds Gallagher.

"We expect margin headwinds should ease as revenues grow (particularly in WiFi) and we continue our mix of new product to transition," says Gallagher. "We are receiving positive feedback from customers and are securing design wins in support of revenue growth in 2013." Anadigics continues to target EBITDA breakeven by year-end, boosted by substantially higher utilization and an expected 80% of Anadigics' product portfolio being transitioned by then to the firm's smaller-die (and hence higher-margin) ILD (inter-level dielectric) process.

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

## Anadigics extends frequency band coverage of small-cell power amplifier family

GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has launched the AWB7224 small-cell power amplifier (PA), optimized to deliver a combination of efficiency, linearity, output power and thermal characteristics for WCDMA, HSPA and LTE small-cell base-stations operating in the 728–768MHz frequency band. The firm says that manufacturers can leverage this performance to develop infrastructure solutions that consume less power and provide higher throughput and greater coverage.

"Anadigics continues to expand its family of small-cell power amplifiers to target the 3G and 4G frequency bands most used in dense population areas," says Glenn Eswein, director of product marketing for infrastructure products. "The rapid increase in wireless data



Anadigics' AWB7224 small-cell PA.

consumption, especially in urban and campus settings, places tremendous pressure on existing wireless infrastructure. Our solutions enable the design of high-throughput, reliable and compact small-cell base-stations that offer

service providers an economical and pragmatic path to expand broadband network coverage."

Anadigics' small-cell wireless infrastructure power amplifiers leverage the firm's patented InGaP-Plus technology and design architectures. The AWB7224 offers 13% efficiency to minimize power requirements and provide flexibility in selecting network power systems. With linearity of  $-47\text{dBc}$  ACPR at  $+27\text{dBm}$  output power and  $29\text{dB}$  of RF gain, it enables high-throughput data rates with a wide coverage area.

The complete family of small-cell power amplifiers is available in a compact, low-profile  $7\text{mm} \times 7\text{mm} \times 1.3\text{mm}$  surface-mount package with integrated RF matching to reduce PCB space requirements.

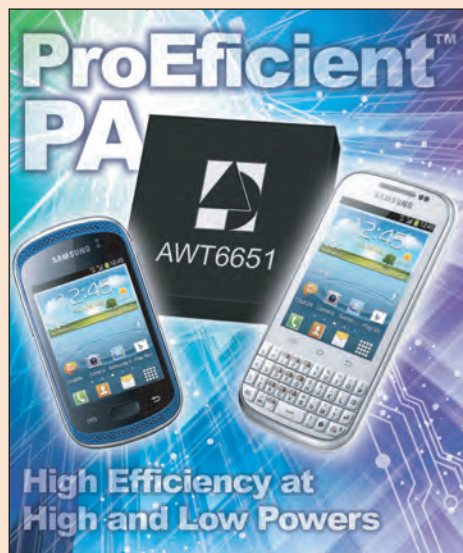
Engineering samples of the AWB7224 are available now for qualified programs.

## ProEfficient PAs power Samsung Galaxy Music Duos and Chat

Anadigics says it is shipping production volumes of its AWT6651 ProEfficient power amplifier (PA) to Samsung Electronics for its Galaxy Music Duos and Chat.

"Anadigics' ProEfficient and ProEfficient-Plus power amplifiers provide the industry's best combination of efficiency, current consumption, and linearity to help extend battery-life and maintain stable, high-throughput 4G connectivity," claims Michael Canonico, senior VP of worldwide sales. "The selection of the AWT6651 for the Galaxy Music Duos and Chat not only exemplifies the tremendous real-world performance advantages offered by our ProEfficient solutions, but also the strength of the relationship that we have forged with Samsung Electronics."

ProEfficient PAs use Anadigics' exclusive InGaP-Plus technology to achieve efficiency at high and low



Anadigics' AWT6651 ProEfficient power amplifier.

power modes to extend 3G and 4G battery-life without the use of a DC–DC converter. The PAs are also optimized for use with average power tracking (APT) to further

increase efficiency and reduce current consumption at medium and low operating powers. ProEfficient power amplifiers also deliver exceptional linearity to ensure a stable connection for clear voice and high-speed data, adds the firm.

ProEfficient's features also include:

- very low quiescent current to extend battery-life;
- a compact  $3\text{mm} \times 3\text{mm}$  package with internal voltage regulation and integrated DC blocks on the RF ports to reduce PCB space requirements;
- what is claimed to be best-in-class linearity to maintain stable, high-throughput 3G/4G connections; and
- RF matching optimized for output power, efficiency and linearity in a  $50\Omega$  system.

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



# Optimistic Skyworks exceeds latest quarter revenue and earnings targets

## Revenue rises 15% year-on-year to \$454m; operating cash flow triples

Analog semiconductor maker Skyworks Solutions Inc of Woburn, MA, USA, has reported improved results for fiscal first-quarter 2013 (ending 28 December 2012). Revenue was \$453.7m, up nearly 8% on last quarter's \$421.1m and 15% on \$393.7m a year ago (and exceeding the company's own forecast of \$450m).

On a non-GAAP basis, operating income was \$114.8m, up from \$103.6m last quarter. This yielded operating margin of 25.3%, up from 24.6%. Net income was \$106.6m (\$0.55 per diluted share, \$0.01 better than guidance), up from \$103.5m (\$0.53 per diluted share). Operating cash flow has almost tripled from \$50m to \$148m. Capital expenditure has been cut from \$31m last quarter (with depreciation of \$17m) to \$26.4m (with depreciation of \$18.5m). Skyworks also invested \$42m to repurchase 1.9 million shares of its common stock. Overall, during the quarter, cash and cash equivalents has grown from \$307m to \$378m.

"We are enabling anytime, anywhere communications across a diverse set of end-markets and applications," commented president & CEO David J. Aldrich. "Skyworks is capitalizing on growing consumer and enterprise demand for ubiquitous connectivity spanning all modes of wireline and wireless communications," he added.

"Our analog semiconductor solutions are increasingly at the heart of everything from smart phones to smart appliances to home security systems to satellites to medical sensors to hybrid vehicles," noted Aldrich. "This market diversity — coupled with Skyworks' leadership scale, product breadth and system IP — is setting the stage for continued market outperformance and shareholder value creation."

Business highlights cited by the

company included: developing high-voltage protection circuits for Boston Scientific heart defibrillators; introducing a 16-channel LED TV backlighting controller at LG and others; starting volume production of radiation-tolerant optocouplers supporting new Iridium satellites; capturing connectivity sockets within the Google Chrome notebook series; enabling the 'world's smallest' 4G LTE data-card with a range of antenna switch modules; and launching camera flash drivers across Samsung's Galaxy platforms.

Looking ahead to the fiscal second quarter, Donald W. Palette, VP & chief financial officer, commented, "Given [our] order visibility and specific product launches, we expect to continue to gain market share and capture additional content per platform in the seasonally low March quarter. "Specifically, for Q2/2013, we anticipate revenue to be up 15% year-on-year with better-than-normal seasonality to approximately \$420m, with non-GAAP diluted earnings per share of \$0.47."

### Extended comments

"One of the overriding themes at this year's Consumer Electronics Show was the Internet of Things, which is comprised of sensors and embedded connectivity deployed across a seemingly endless range

of devices that touch our everyday lives," said Aldrich during the fiscal Q1 conference call for analysts. "We see this trend driving a proliferation of access points from conventional mobile devices, like smart phones, like tablets, to non-traditional devices like home appliances, medical devices, gaming consoles, industrial machinery, home entertainment systems, Smart Energy and security systems, just to name a few," he added.

"Most network devices span a variety of communications protocols, including some mix of cellular, Wi-Fi, Zigbee, peer-to-peer, Bluetooth, and NFC on both licensed and unlicensed spectrum and across multiple operating frequencies. The design challenges within this environment require competencies across mixed-signal, analog and RF, including signal transmission and conditioning, power management, filtering and tuning," Aldrich continued.

"At Skyworks, we are the experts in RF and analog system design, we're leveraging a global force of systems and applications engineers; secondly, we offer an unmatched technology portfolio that includes deep expertise in silicon on insulator or SOI, CMOS, gallium arsenide, BiFET, silicon germanium; and thirdly, we have the leading capability in advanced multichip module integration; and finally, we are the low-cost producer," noted Aldrich.

"So, in closing, we're quite optimistic about our prospects for the remainder of 2013 and beyond. Trends in the broader analog market are moving in our favor and our strategy of continuing to diversify and expand into new verticals, while maintaining a laser focus on operational execution is clearly working."

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

Matthew Peach, Contributing Editor

# Skyworks secures reference design with TI for smart-energy, industrial and networking applications

Skyworks has secured a reference design with Texas Instruments Inc (TI) for smart energy, industrial and networking applications including electric/gas/water meters, street lighting, telematic and tracking systems. Skyworks' front-end solutions are in volume production and compatible with single-chip transceivers for wireless systems requiring high performance at low power and voltage.

"TI is delighted to be collaborating with Skyworks to develop a new reference design using TI's sub-1GHz RF performance line transceiver and Skyworks' front-end solutions," says Terje Lassen, industrial business manager, Wireless Connectivity Solutions, at TI. "With Skyworks, we have created a proven design for customers in a rapid development cycle and removed the guess work in producing high-performance RF designs for a variety of smart energy, industrial and networking applications."

"Skyworks is excited to partner with TI in creating a solution that leverages our newest family of front-end modules with their radio platforms," says David Stasey, general manager of analog solutions.

## Skyworks' front-end solutions

●SKY65313-21 is a transmit/receive (T/R) front-end module (FEM). The device transmit chain features +30dBm output power and 40% power added efficiency (PAE), while the device receive chain contains a low noise amplifier (LNA) with a 1.4dB noise figure (NF) and 16.6dB

gain. The cascaded NF and gain, taking into account the 0.5dB insertion loss T/R antenna switch, are 1.9dB and 16.1dB respectively — making the FEM ideal for medium power microwave links such as 900MHz ISM-band applications. The 28-pin, 6mm x 6mm x 0.9mm device, packaged in a multi-chip module, surface-mounted technology unit, also has a shut-down mode and LNA bypass mode to minimize power consumption — allowing for a highly manufacturable, low-cost solution.

●SKY65364-11 is a T/R, 6mm x 6mm x 0.9mm FEM that provides a complete T/R chain with T/R switches. The device transmit chain on the 28-pin FEM features +30.5dBm output power and 40% power-added efficiency. The device receive chain offers a LNA with a 1.7dB NF and 16.0dB gain. The cascaded NF and gain, taking into account the 0.5dB insertion loss T/R antenna switch, are 2.2dB and 15.5dB, respectively, which makes it ideal for medium power microwave links such as 900MHz ISM-band applications. The module also has a shut-down, power amplifier and LNA bypass mode to minimize power consumption. It is housed in a surface-mounted technology (SMT) package, which allows for a highly manufacturable, low-cost solution.

●SKY65366-11 is a T/R FEM that provides a complete T/R chain with T/R switches. The device transmit chain features +30.2dBm output

power and a 40% PAE. The device receive chain features a LNA with a 1.5dB NF and 22.2dB gain. The cascaded NF and gain, taking into account the 0.3 dB insertion loss T/R antenna switch, are 1.8dB and 21.0dB, respectively. The 400MHz module also has a shut-down, PA and LNA bypass mode to minimize power consumption. It is mounted in a 28-pin, 6mm x 6mm multi-chip module SMT package — allowing for a highly manufacturable, low-cost solution.

●A member of TI's low-power RF performance line, the CC1120 is a fully integrated, single-chip RF transceiver designed for high performance at low power and voltage operation in cost effective wireless narrowband systems. The sub-1GHz RF performance line can be more than 30 times closer to other RF systems and potential connection "interferers" than competitive offerings, allowing streamlined coexistence between various connected devices in one environment. With 65dB adjacent channel rejection at 12.5kHz offset and 90dB blocking, TI delivers the industry's most reliable sub-1GHz connections. With a 139dB link budget, the products' range reaches well beyond 10km and provides maximum indoor penetration. Advanced RF sniff mode also allows systems to listen for RF packets using very low power consumption, with less than 3mA in receive (Rx) sniff mode, while maintaining full RF performance.

## Skyworks launches high-power 50–100W SPDT PIN diode switches

Skyworks has unveiled three high-power single-pole double-throw (SPDT) switches for multiple applications: SKY12207-478LF (0.9–4.0GHz; 50W), SKY12208-306LF (0.02–2.7GHz; 50W) and SKY12210-478LF (0.9–4.0GHz; 100W) deliver transmit/receive

and fail-safe switching functionality for TD-SCDMA and TD-LTE base-stations, and land mobile radios and military communication systems.

The PIN diode switches handle continuous-wave RF input power and provide very low insertion loss in the antenna-to-Rx mode, mini-

mizing the effect on receiver noise figure. They are packaged in small, 4mm x 4mm quad flat no-lead plastic surface-mount technology, which make them suitable for compact system designs with challenging power levels, the firm says.

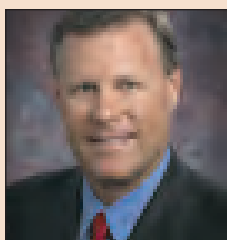
[www.skyworksinc.com](http://www.skyworksinc.com)



## IN BRIEF

### Peregrine adds corporate VP, worldwide sales & applications to boost global sales and support resources

Peregrine Semiconductor Corp of San Diego, CA, USA, a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-sapphire (SOS), has appointed Carl Burrow to the newly created position of corporate VP, worldwide sales & applications.



Burrow has more than 25 years of semiconductor and electronic design automation (EDA) sales experience, having worked at firms including Texas Instruments, Actel Corp, Synopsys, and Magma Design Automation. In his new role, Burrow will manage all aspects of Peregrine's sales and applications functions, worldwide.

"Peregrine Semiconductor has a unique technology in the marketplace," comments Burrow. Peregrine's UltraCMOS technology is an RF silicon-on-insulator (SOI) process, delivering a combination of performance and monolithic integration. "I'm looking forward to further expanding the reach of its products and services worldwide," he adds.

"With the increased demand for our products, this was a natural time to expand our global sales and applications organization," says CEO Jim Cable. "We're fortunate to have found a leader of Carl's caliber, whose wealth of experience and industry knowledge has already made him a key addition to the Peregrine team."

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

## Peregrine unveils STeP8 UltraCMOS process for RF front-end ICs

At the 2013 Mobile World Congress in Barcelona, Spain (25–28 February), Peregrine Semiconductor Corp of San Diego, CA, USA, a fabless provider of radio-frequency (RF) integrated circuits (ICs) based on silicon-on-sapphire (SOS), has unveiled the latest version of its UltraCMOS RF silicon-on-insulator (SOI) process technology: Semiconductor Technology Platform 8 (STeP8).

STeP8 technology shows a 36% improvement in RonCoff performance over STeP5 technology (announced just a year ago), dramatically improving the linearity, insertion loss, and isolation capabilities of Peregrine's RFIC products, the firm says.

Flagship devices using STeP8 include a HaRP-enhanced SP16T (single-pole, 16-throw) RF switch and a highly integrated (single-pole, four-throw) SP4T DuNE enhanced antenna-tuning switch, both of which are available for sampling.

The initial STeP8-based SP16T RF switch demonstrates an almost 40% shrink over the footprint of its STeP-5-based counterpart.

The SP4T antenna-tuning switch has on-resistance of 1.5Ω, and insertion-loss performance of 0.15dB matched at 900MHz — a 66% improvement over the previous version.

"As a fabless semiconductor company, our unique combination of process architecture, circuit designs, and device model-

ing has enabled an accelerated technology roadmap," says Mark Miscione, VP of RF technology solutions. "These results further validate Peregrine's expertise in advanced RF silicon-on-insulator process development and its commitment to integration and high-performance at the RF front-end."

The 4G LTE network has introduced significant challenges to the RF front-end of smart phones, including a fragmented RF spectrum, which causes co-existence issues between bands and other connectivity standards such as GPS, WiFi, and Bluetooth. The lack of global frequency alignment has resulted in more than 40 LTE bands now identified.

"Given the demanding RF conditions in which mobile devices must operate, demonstrating the ability to meet next-generation requirements for high linearity, low loss and optimization is critical for success in the RF components market," comments Francis Sideco, senior principal analyst, consumer electronics and communications technologies, at market analyst firm IHS. "Companies who are able to deliver innovation along those lines are strongly positioned to outpace their competitors."

To ensure consistent, reliable operation within the LTE environment, mobile wireless device designers are required to incorporate high-performance components into the RF front-end while maintaining a small form factor, says Peregrine. Highly integrated RF front-end modules (such as those enabled by UltraCMOS STeP8) address these demands by providing a combination of high linearity and low insertion loss in a single, monolithically integrated device, the firm adds.

Peregrine is sampling the STeP8-based SP16T RF switch and SP4T antenna-tuning switch to select customers.

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

**The 4G LTE network has introduced significant challenges to the RF front-end of smart phones, including a fragmented RF spectrum, which causes co-existence issues between bands and other connectivity standards**

# Breakthrough LTE performance claimed for CMOS PAs

## CMOS PAs plus patented envelope tracking architectures could “signal death of GaAs industry for handset applications”

Fabless semiconductor firm Nujira Ltd of Cambridge, UK has released details of test results that demonstrate how its envelope tracking (ET) technology can unlock the potential of RF CMOS power amplifiers (PAs) for high-end 3G and 4G smartphone applications, it is reckoned. The details of the results are available to download in a white paper on Nujira's web-site.

Traditional silicon CMOS PAs suffer from low inherent linearity, limiting their application to low-cost 2G and 3G devices, says the firm. ET removes this limitation and boosts the linearity, efficiency and output power for CMOS PAs beyond the performance of existing gallium arsenide (GaAs) PAs, even for high-linearity LTE signals, it claims.

Extensive lab testing by Nujira has shown that the combination of its ET power modulators and a prototype CMOS PA device achieves the performance required for 4G, it is reckoned. The key metrics achieved were 57% efficiency, 28dBm average output power, and -38dB adjacent-channel leakage ratio (ACLR), with a high peak-to-average power ratio LTE signal.

Nujira says that the high-end performance results have been made possible by its patented ISOGAIN linearization. ISOGAIN removes the need for digital pre-distortion in CMOS PAs and linearizes the PA at no extra cost, power or complexity, while keeping the device in a highly efficient compressed state across a wide power control range, it is claimed.

The firm says that demonstrating the potential for high-end applications of CMOS PAs opens the door for what is set to be a “hugely disruptive technology shift in the RF market”.

“The exploding complexity of the RF front-end in today's smartphones is driving unprecedented

rates of change in the component industry,” says CEO Tim Haynes. “Our test results are a significant breakthrough, demonstrating that CMOS PAs can also be used in high-end 3G/4G smartphone applications,” he reckons. “The combination of CMOS PAs with Nujira's patented ET architectures

could ultimately signal the death of the GaAs industry for handset applications. In the longer term, these results open the door for further CMOS integration, enabling a highly integrated RF front-end architecture for complex multi-mode, multi-band handsets.”

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



Where do specialty chipmakers find the best solutions?

**Plasma-Therm, of course.**

When you need help overcoming technical hurdles and bringing your latest ideas to fruition, come to Plasma-Therm. Not only will you get solutions custom-tailored to meet your specific needs, but you will also benefit from our breadth of experience, leading-edge technology and innovative thinking. For 35 years we've been enabling Specialty Chipmakers to extend the limits of what is possible. Bring us your challenges and together, we'll redefine the boundaries.

**Plasma-Therm**  
A LEADING SUPPLIER OF PLASMA PROCESS EQUIPMENT

Advanced RIE, CVD, ICP  
for Research & Production

[plasmatherm.com](http://plasmatherm.com)  
[sales@plasmatherm.com](mailto:sales@plasmatherm.com)  
+1 727 577 4999





## IN BRIEF

### M/A-COM Tech launches X-band LNA for V-Sat, radar and microwave

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) has launched an X-band extension to its low-noise amplifier (LNA) family.

The MAAL-010528 is designed to provide a quick LNA solution for V-Sat, radar and microwave applications. The LNA delivers higher gain and linearity performance over the 8–12GHz frequency band than many competing parts, it is claimed, providing system advantages for LNA requirements. Supplied in a small 3mm x 3mm PQFN surface-mount package and having a single, positive bias supply, the device provides a simple LNA solution.

The MAAL-010528 gallium arsenide (GaAs) monolithic microwave integrated circuit (MMIC) LNA provides nominal gain of 20dB, high OIP3 linearity of 26dBm, and a mid-band noise figure supply of 1.6dB. The device features a self-bias architecture that requires the user to apply only a single positive supply. In addition, it is internally matched to 50Ω input/output. Input return loss is 10dB and output return loss is 13dB. Altogether, the MAAL-010528 is suited to multiple radar and communication applications.

"The MAAL-010528 is ideal for customers looking for low noise figure and high linearity for their X-band solutions," reckons product manager Paul Beasley.

Production quantities and samples of the MAAL-010528 are available from stock.

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

### Poongsan partners with SEMATECH on high-pressure anneal processes for advanced silicon and non-Si devices Joint effort to improve device performance and reliability for sub-20nm technology

SEMATECH of Albany, NY, USA (the international research consortium of semiconductor device, equipment, and materials manufacturers) says that South Korean annealing furnace manufacturer Poongsan has joined its Front End Processes (FEP) program, and will work with it to explore high-pressure anneal (HPA) techniques for silicon and non-silicon channel materials to improve device performance and reliability for next-generation technologies.

The solid-state device community is currently investigating non-silicon, high-mobility materials to increase carrier mobility within the device channels and improve overall transistor performance, says SEMATECH. High-mobility channels such as germanium and III-V compounds have the potential to operate at high speeds with low operating power and may be used in mainstream semiconductor CMOS technologies in the future. However, many manufacturing challenges associated with high-mobility channels (such as processes, tools, device test structures and environment, safety and health issues) need to be addressed before these materials-based solutions are brought to manufacturing.

Since 2006, Poongsan and SEMATECH have partnered in tool and process development projects that have demonstrated the technical merits of a high-pressure annealing furnace.

"Working with SEMATECH, we have demonstrated that high-pressure anneals are both effective and manufacturing-worthy approaches to high-k/Si interface defect passivation," says Poongsan's director of sales & marketing Dr Bob Wu.

"From this work, we have gone on to develop and ship production-worthy annealing furnace tools to

worldwide customers," he adds.

"We look forward to continuing our strategic partnership with SEMATECH as we work toward developing emerging technologies and improving products."

As a member of SEMATECH's FEP program, located at the College of Nanoscale Science and Engineering (CNSE) of the University at Albany (State University of New York), Poongsan will collaborate with SEMATECH's engineers and leverage the consortium's activities in advanced test structures, advanced materials and device electrical characterization to improve processing technologies in order to increase mobility and reduce interfacial defects. Specifically, SEMATECH and Poongsan will collaborate on the passivation of silicon and non-silicon gate stacks and other interfaces.

"To achieve better device performance and help shape the next generations of nanoelectronics, it's necessary to partner to share know-how in materials, processing, equipment development and device technologies," says Paul Kirsch, SEMATECH's director of Front End Processes. "Poongsan's proven expertise in high-pressure annealing processes will complement our own device and process expertise," he adds. "We will work together on the technical and manufacturing gaps to address the continued scaling needs of today's aggressive chip manufacturing market."

The goal of SEMATECH's FEP program is to provide novel leading-edge materials, processes, structural modules and electrical and physical characterization methods to support the continued scaling of logic and memory applications.

[www.sematech.org/research/materials](http://www.sematech.org/research/materials)

[www.poongsan.co.kr](http://www.poongsan.co.kr)

## Leti and Agilent present results on millimeter-wave short-range communication integrated systems

At the IEEE's 13th Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF 2013) in Austin, Texas (21–23 January, part of IEEE Radio Wireless Week), French R&D organization CEA-Leti in Grenoble and Agilent Technologies Inc of Santa Clara, CA, USA presented research results on embedded integrated systems.

The low-power monolithic millimeter-wave short-range and high-data-rate communication system was enabled by CEA-Leti's 10 years of experience in ultra-wideband (UWB) and high-frequency links.

To be converted into a functional and market-ready integrated system, the original communication technology also requires specific design methodologies, says Leti. Its solution, which supposes efficient analysis of closely related active, passive and radiation

phenomena, was developed using Agilent's coherent design flow.

"With on-chip high-gain integrated antennas, a real co-design between the receiver/transmitter circuits and the antennas is necessary for a global optimization of the system's performances," said Leti researcher Laurent Dussopt.

"Finding the best trade-off between transmission range and battery life is critical in low-power applications. Since Agilent's

**Leti developed a packaged 60GHz low-power transceiver, with integrated antennas on high-resistive CMOS SOI 65nm process from STMicroelectronics for short-range communication**

Advanced Design System (ADS) and EMPro share the same database, a seamless co-design between circuit simulations and the full 3D finite-element method provides an advantage over classical methods to determine the optimum operating conditions," said Marc Petersen, product manager, EM & Electro-Thermal Solutions at Agilent.

Leti developed a packaged 60GHz low-power transceiver, with integrated antennas on a high-resistive CMOS SOI 65nm process from STMicroelectronics, for short-range communication. The transceiver uses an on-off keying UWB pulse modulation and delivers 2.2Gb/s with less than 100mW in the range of 10cm. The component has potential use in hand-held multi-media applications.

[www.leti.fr](http://www.leti.fr)

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

### How many devices can fit on the tip of a pin?

#### Ask us again tomorrow.

For 35 years, Plasma-Therm has been shrinking the limits of what is possible. Today, our Mask Etcher V® produces at <32nm technology nodes. And our sights are set on 22nm and beyond.

Whether it's new device designs, accelerated productivity goals or innovative material challenges, bring them to us. We will meet them.



Advanced ICP, RIE, DSE™ and PECVD  
for R&D to Production

**plasmatherm.com**  
**sales@plasmatherm.com**  
**+1 727 577 4999**



# Scotland's Raytheon Glenrothes opens SiC foundry

Raytheon of Waltham, MA, USA has officially opened a new manufacturing facility for silicon carbide (SiC) foundry at Raytheon Glenrothes in Scotland (part of subsidiary Raytheon UK, a contractor to the UK Ministry of Defence).

Developed through several years of research into manufacturing processes and materials science, the firm reckons that the application of silicon carbide in electronic systems will place the UK in a leading position to develop next-generation, high-efficiency, smaller, low-weight power conversion products used in harsh environments across the automotive, aerospace, geothermal explorations, oil and gas, and clean-energy sectors.

"The silicon carbide foundry is the first of its kind in the UK and represents the fusion of Raytheon's investment in UK manufacturing technology with university expertise, backed by UK Government funding from the Technology Strategy Board," said the Right Honorable Michael Moore (the Secretary of State for Scotland), who opened the foundry. "This scientific and engineering endeavour born out of Raytheon Glenrothes has placed Scotland in a unique leadership position globally, enhanced by universities across the UK," he added. "The investment has created a team of world-class engineering specialists working in the production of silicon carbide devices and systems designed to operate at high temperatures, specialists who will continue to shape and influence advanced manufacturing processes and technologies."

Raytheon's SiC processing uses high-temperature annealing and high-temperature/ high-voltage ion implantation. The firm says the components provide unique properties in electronics: SiC can operate at higher voltages and greater temperatures than pure silicon, and at a third of the weight and volume — improving operational performance and reducing system operating costs. Raytheon claims that it is the



**Secretary of State for Scotland Michael Moore unveils plaque with Raytheon Glenrothes' MD Jim Trail.**

first firm to have successfully tested SiC circuit devices at temperatures up to 400°C.

"Raytheon's investment in the foundry coupled with support from the Technology Strategy Board exceeds £3.5m to date," notes Raytheon UK's chief executive Bob Delorge. "This places the company at the start of a journey to exploit new global markets for this cost-efficient material, which is estimated to bring significant new business to Raytheon in Scotland in the coming years," he adds. "We have made substantial commitments to develop new engineering talent to maintain our technological edge in high-temperature silicon carbide. We are supporting PhD students and undergraduates, and we are giving apprentices and young graduates the opportunity to develop their careers," he continues.

"What was previously unachievable is now possible with silicon carbide as it allows for smaller and lighter electronics to operate in harsh environments, and addresses a real customer need for significant energy-efficiency savings in the manufacture of power switching and rectifying components (AC/DC converters)," Delorge says.

"We have identified advanced materials as one of the eight new technologies in which Britain has a distinct capability and which are critical to scientific advance," comments UK Universities and Science Minister David Willetts.

"We see Raytheon UK gearing up for future success — through investment, collaboration and diversification," comments Ian Watson, director of the aerospace, defence, security and space trade organisation, ADS Scotland. "One of the main challenges industry faces as it looks to the future is continuing technological discovery to stay ahead

of global competition," he adds.

"To address this challenge, it is vital that industry and academia work together to advance technology and fully explore commercial applications. Raytheon's new facility at Glenrothes is a brilliant example of this."

Raytheon UK says that its R&D into SiC manufacturing processes and technology has been aided by collaborative partnerships between Raytheon Glenrothes, UK academia and specific project funding from the UK government's Technology Strategy Board. Collaborations to date include the following:

- Warwick University has advised on the characterization of SiC.
- University of Strathclyde has worked with Raytheon (funded by the UK Technology Strategy Board) on the High Temperature Silicon Carbide (HiTSiC) program.
- Newcastle University is working as an advisor to Raytheon on the HiTSiC program.
- Heriot Watt University is working with Raytheon to design and build packaging solutions for harsh environments.
- University of Edinburgh has worked with Raytheon to conduct market research on exploiting disruptive technologies.
- Manchester University has partnered with Raytheon to develop SiC technology for the Pro Drive initiative.

[www.raytheon.co.uk](http://www.raytheon.co.uk)

[https://www.gov.uk/](https://www.gov.uk/technology-strategy-board)

[technology-strategy-board](https://www.gov.uk/technology-strategy-board)

## Microsemi expands SiC power module family to industrial and extended temperature ranges

Microsemi Corp of Aliso Viejo, CA, USA (which designs and makes analog and RF devices, mixed-signal integrated circuits and subsystems) has launched a new generation of industrial-temperature silicon carbide (SiC) standard power modules, suited for use in high-power switch mode power supplies (SMPS), motor drives, uninterruptible power supplies (UPS), solar inverters, oil exploration and other high-power, high-voltage industrial applications requiring high performance and reliability. The power module family is also offered with extended temperature ranges to meet next-generation power conversion system requirements for higher power densities, operating frequencies and efficiencies.

Microsemi says that SiC technology delivers higher breakdown field strength and improved thermal conductivity compared to silicon material. This enables improved performance characteristics in parameters including zero reverse recovery, temperature-independent behavior, higher-voltage capability and higher-temperature operation

to achieve new levels of performance, efficiency and reliability.

"We applied our extensive expertise in power semiconductor integration and packaging to deliver a next-generation family of silicon carbide power modules that deliver outstanding levels of performance, reliability and overall quality," claims Philippe Dupin, general manager of Microsemi's Power Module Products group. "Our new modules also allow designers to shrink system size and weight, while reducing total systems costs."

The firm's new industrial-temperature SiC power modules feature multiple circuit topologies and are integrated into low-profile packages. The majority of the new module product family uses aluminium nitride (AlN) substrates to enable isolation from the heat sink, improving heat transfer to the cooling system.

Additional features include high-speed switching, low switching losses, low input capacitance, low drive requirements, low profile and minimum parasitic inductance, enabling high-frequency, high-

performance, high-density and energy-saving power systems.

The new industrial-temperature module family includes the following parameters and devices:

- 1200V boost chopper configuration, rated from 50A to 100A (APT100MC120JCU2 and APT50MC120JCU2);
- 1200V phase leg configuration, rated from 40A to 200A (APTMC120AM08CD3AG, APTMC120AM20CT1AG and APTMC120AM55CT1AG);
- 600V neutral point clamped configuration, dedicated to three level inverters for solar or UPS applications, rated from 20A to 160A (APTMC60TLM14CAG, APTMC60TLM20CT3AG, APTMC60TLM55CT3AG and APTMC60TL11CT3AG); and
- Neutral point clamped configuration, 600V/1200V mixed voltage, rated from 20A to 50A (APTMC120HRM40CT3G and APTMC120HR11CT3G).

Samples of the industrial-temperature SiC standard power modules are available within short lead times.

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

## Sweden's Graphensic granted €60,000 in business support for graphene on SiC

### Funding to boost international development by recruiting

Linköping University spin-off Graphensic AB of Mjärdevi Science Park, Linköping, Sweden says that the Swedish Energy Agency has granted it about €60,000 in financial support for business development. The firm reckons that the funding will give it increased opportunities for international development of its epitaxial graphene on silicon carbide (SiC). Applications of graphene on SiC range from demanding electronics to various approaches for biosensors.

Graphensic was founded in November 2011 by researchers

Rositza Yakimova, Mikael Syväjärvi and Tihomir Iakimov. The firm says that its business development curve during its first year has been evolving internationally with regard to customers, and this is now accelerating. Some of the potential applications are energy related, notes the firm.

Last year Graphensic was selected as one of the 33 hottest technology start-up companies in Sweden. The firm is a member of the LEAD business incubator, which supports start-up companies from university research.

Graphensic says that the new funding will provide the possibility of benefitting from the vision of an experienced entrepreneur. The financing is intended to be used for a chairman of the board, who will also work part-time with sales and marketing, says Mikael Syväjärvi, co-founder and project manager for the Energy Agency.

The firm adds that during 2013 it will be in contact with investors since, with the need for production perhaps increasing rapidly, new equipment may be required.

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



## AWR releases V10.04 upgrade to Design Environment

At IEEE Radio Wireless Week (RWW) in Austin, TX, USA (21–22 January), AWR Corp of El Segundo, CA, USA, a supplier of electronic design automation (EDA) software for designing RF and high-frequency components and systems, demonstrated AWR Design Environment V10.04.

The firm's first new software release in 2013 includes new features and enhancements to Microwave Office/Analog Office circuit design software and Visual System Simulator (VSS) system design software, as well as AXIEM 3D planar electromagnetic (EM) software and Analyst 3D finite-element method (FEM) EM software.

A select subset of new features and enhancements in V10.04 includes:

### Microwave Office/Analog Office Environment

- new MMIC Getting Started Guide;
- new SDELTAM measurement;
- enhancements to optimization algorithms and yield analyses;
- expanded output file support across circuit simulators;
- new scripts to reset the origins for layout.

### Analyst 3D FEM EM Technology

- up to 80% reduction in simulation time;
- up to 85% reduction in memory usage;
- improved error reporting and status update messaging;
- meshing and port type enhancements.

### AXIEM 3D Planar EM Technology

- asynchronous simulation enhancements;
- improved dataset management;
- new solver-suitability algorithms;
- meshing and port type enhancements.

### Visual System Simulator Environment

- additional yield measurements and RF Budget Analysis measurements;
- new frequency planning wizard;
- VSS radar block enhancement/licensing option.

A full list of the more than 120 'What's New' items in AWR V10.04 can be found within the software's online documentation.

[www.awrcorp.com/Analyst](http://www.awrcorp.com/Analyst)

## Richardson RFPD launches GaN website resource

Richardson RFPD Inc (an Arrow Electronics Company) of LaFox, IL, USA has launched a new website resource focused exclusively on gallium nitride (GaN).

Several Richardson RFPD suppliers are driving innovation in the development of GaN discrete devices and modules, says the firm, and the new GaN technology section of

the website offers power transistors, power amplifiers and switches from manufacturers Empower RF Systems, M/A-COM Technology Solutions, Microsemi, Nitronex, TriQuint, and United Monolithic Semiconductors (UMS). The featured GaN products suit a range of broadcast transmission, aerospace and defense, commercial and military avionics and

radar, communications, test & measurement, small cell, and wireless infrastructure applications.

In addition to product and supplier information, the GaN website section offers links to an extensive list of technical resources, from applications notes to brochures, selector guides, videos and white papers.

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

## EPC development board aids design of power systems with 200V eGaN FETs in concert with dedicated TI gate driver

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA has made available the EPC9004 development board, featuring the firm's enhancement-mode gallium nitride on silicon (eGaN) field-effect transistors (FETs) for power management applications. The board aims to demonstrate how recently introduced IC gate drivers, optimized for GaN FETs, make transitioning from silicon power transistors to higher-performance eGaN FETs simple and cost effective.

The EPC9004 development board is a 200V peak voltage, 2A maximum

output current, half-bridge featuring the EPC2012 eGaN FET. The EPC2012 is used in combination with the UCC27611 high-speed gate driver from Texas Instruments, reducing time and complexity for designing high-frequency, high-performance power systems.

The EPC9004 simplifies evaluation of eGaN FETs by including all the critical components, including a dedicated gate driver, on a single 2" x 1.5" board that can be connected into any existing converter. In addition, there are various probe points on the board to facilitate

simple waveform measurement and efficiency calculation. A Quick Start Guide is included for reference and ease of use.

EPC says that the 200V EPC2012 eGaN FET is suited to applications such as wireless charging, magnetic resonance imaging (MRI), and low RF frequency applications such as smart-meter communications.

The EPC9004 development board is priced at \$95, available via Digi-Key.

<http://digkey.com/Suppliers/us/Efficient-Power-Conversion.page>  
[http://epc-co.com/epc/documents/guides/EPC9004\\_qsg.pdf](http://epc-co.com/epc/documents/guides/EPC9004_qsg.pdf)

## Soitec's engineered substrates used in over half of smart phones and tablets

Soitec of Bernin, France, which makes engineered substrates including silicon-on-insulator (SOI) wafers as well as III-V epiwafers, estimates that its engineered substrates (which are used in manufacturing semiconductors for mobile communications) are incorporated in at least 50% of smart phones and internet-connected tablet computers being produced today.

Soitec says that the widespread use of its materials technology in portable communications demonstrates its key role in high-volume, cost-sensitive applications such as cellular phones, tablets and other fast-growing markets involving mobile internet devices.

The firm's wafer shipments for radio-frequency applications have increased by 400% in the last two years. By the end of its current fiscal year, Soitec will have shipped

(between April 2012 and March 2013), more than 200,000 engineered wafers to customers making semiconductors for mobile communications. These wafers will produce about 2.5 billion ICs for front-end module applications, corresponding to half the 600 million smart phones and 100 million tablets expected to be produced this year, according to market projections.

According to market analysts, today most smart phones and tablets rely for their RF circuits on engineered substrates such as bonded silicon-on-sapphire (BSOS), high-resistivity silicon-on-insulator (SOI) and gallium arsenide (GaAs). These engineered substrates are in production to manufacture antenna switches, antenna tuners, power amplifiers and WiFi circuits. Soitec offers all these RF engineered substrates, which meet the requirements of leading-edge smart phone ICs —

such as linearity, high mobility and isolation — at competitive costs.

"Approximately 30% of our micro-electronics business is in the RF-based market," says Soitec's chief operating officer Paul Boudre. "Our technologies' market penetration in smart phones and other RF-based communication devices proves that our engineered substrates are very competitive in price-sensitive consumer applications," he claims.

Soitec's Wave SOI high-resistivity substrates, GaAs epiwafers, BSOS wafers and other layer-transfer technologies offer performance advantages in RF applications, the firm claims. The engineered substrates enable more functionality on smaller chips, lower power usage for longer battery life in portable electronics, and higher performance including faster throughput and wider range, it adds.

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

## Mitsubishi Electric develops multi-wire electrical discharge process for SiC ingot slicing

### Both slicing productivity and effective use of material to be improved

Tokyo-based Mitsubishi Electric Corp says that it has developed a prototype multi-wire electrical discharge processing technology to cut very hard 4" polycrystalline silicon carbide (SiC) ingots into 40 pieces simultaneously.

Up to now, because SiC is the third hardest compound on earth, sliced wafers have been produced by using multi-wire saws with diamond particles. However, this method requires lengthy machining time and large kerf widths.

The new parallel multi-wire electrical discharge machining method uses Mitsubishi Electric's proven electrical discharge technology for difficult-to-cut material, and employs a dedicated power supply specially developed for SiC.

The technology is expected to improve both the productivity of SiC slicing and the effective use of SiC material.

Specifically, 40 wire electrodes (each with a diameter of 0.1mm) aligned at 0.6mm intervals are rotated to cut 40 slices at once, improving productivity. Also, the non-contact, thermal process-wire electrical discharge method slices faster and at closer intervals compared to contact cutting (220µm or less cut at a speed of 80 microns per minute). More wafer slices extracted per SiC ingot for improved efficiency.

Regarding the power supply dedicated to SiC slice processing, Mitsubishi Electric says that simultaneous wire cuts with even energy

enabled by 40 electrically independent power feed contacts to the wire electrodes. Also, there is uninterrupted processing with even very thin (0.1mm) wire electrodes due to a newly developed high-frequency power supply tailored to the characteristics of SiC material, adds the firm.

Pending patents for the technology number 22 in Japan and 10 overseas. Mitsubishi Electric aims to market its multi-wire electrical discharge slicer by 2015.

The firm notes that SiC is expected to be used increasingly in power semiconductors due to its superior energy-saving and CO<sub>2</sub> emissions-reduction properties compared with silicon.

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



# Cree and Eta demonstrate record-efficiency power amplifier for mobile base-stations

## GaN HEMT enables efficiency over 70% under 4G LTE modulation

At the 2013 Mobile World Congress in Barcelona, Spain, Cree Inc of Durham, NC, USA, which makes gallium nitride RF components, and fabless semiconductor firm Eta Devices Inc of Cambridge, MA (which was spun off from MIT, but has an office in Stockholm, Sweden) demonstrated what is claimed to be a record-efficiency power amplifier for mobile base-stations.

Current-generation mobile base-station amplifiers employing silicon LDMOS transistors can provide amplifier efficiencies up to 45%. By contrast, Eta's power amplifiers can deliver efficiencies higher than 70% under a 4G LTE modulation format.

"Eta Devices' next-generation power amplifiers leverage the performance and reliability advantages

of Cree's GaN HEMT RF transistors to realize game-changing efficiency benefits for the mobile-base-station industry," says Jim Milligan, business director, Cree RF. "Our transistors have been instrumental in demonstrating Eta Devices' amplifiers, which perform 50% more efficiently than the best incumbent silicon power amplifiers currently available in the 4G LTE market."

The world's mobile networks consume about 120TWh of electricity per year, and 50–80% of this power is consumed by the networks' power amplifiers and associated components. Implementing Eta's new power amplifier on a global level could save mobile operators 60TWh per year, it is reckoned (equivalent to the amount of power

produced by more than seven average-sized American nuclear power plants). This could also save up to 50% of the \$36.5bn spent to power mobile base-stations each year.

"Mobile operators gain dramatic advantages by adopting our new technology," claims Eta's CEO Mattias Astrom. "In addition to cost savings, our power amplifiers provide operators with a significantly reduced carbon footprint," he adds. "If implemented on a global basis, our solution would reduce carbon emissions by approximately 36 million tons per year, which is equivalent to eliminating the annual greenhouse gas emissions produced by 7 million cars."

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

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

## Acal BFi franchise to boost Cree's GaN RF sales in Europe

Cree and pan-European electronics distributor Acal BFi Ltd have signed a franchise agreement to increase the sale of Cree's RF components in Italy, Spain, Germany, Poland, Czech Republic, the Netherlands, Norway, Sweden, Hungary and Luxembourg.

"GaN is increasingly recognized as a key technology in bringing about improved efficiency and reducing overall systems costs," comments Tom Dekker, world sales & marketing director for RF

Technology at Cree. "We have joined forces with Acal BFi to accelerate bringing this advantage to a wider market," he adds.

"Acal BFi has an excellent reputation with a strong technical team able to support this specialized technology. This agreement further strengthens a sales network that has built a reputation for excellence in customer support. We look forward to accelerating adoption of Cree GaN HEMT as the RF technology of choice throughout Europe," Dekker concludes.

"A partnership with the leading innovator in the key area of GaN RF allows Acal BFi to increase their offer of advanced solutions at the very forefront of technology," says Lee Austin, business development director, Acal BFi communications division. "Acal BFi's experienced engineering team across Europe provides our customers with the design support and product knowledge needed to take advantage of this innovative technology."

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

## Integra launches 100MHz–1GHz broadband transistor

Integra Technologies Inc of El Segundo, CA, USA, which supplies high-power pulsed RF transistors, says its new IGN0110UM100 is a dual-lead packaged gallium nitride on silicon carbide (GaN-on-SiC) high-electron-mobility transistor (HEMT). The device is designed for broadband applications operating

over the 100MHz–1GHz instantaneous frequency band. Under CW conditions it supplies a minimum of 100W of output power with 12dB gain. Specified operation is with Class AB bias. It is also operable under a wide range of pulse widths and duty factors. It operates with spectral purity into all phases of

3:1 output load VSWR (voltage standing wave ratio).

All devices are 100% screened for large-signal RF parameters in a fixed tuned broadband matching circuit/test fixture. The use of external tuners is not allowed during screening.

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

## International Rectifier founder Eric Lidow passes away

Power semiconductor device maker International Rectifier Corp (IR) of El Segundo, CA, USA has announced that co-founder Eric Lidow passed away on 18 January.

Born in Vilnius, Lithuania (then part of Russia) over 100 years ago in 1912, Lidow gained a Masters Degree in electrical engineer at the Technical University of Berlin in 1937, before emigrating to New York that year with just \$14 in his pocket. In 1939 he moved to Los Angeles and in 1940 he co-founded Selenium Corporation of America using borrowed equipment and working in the back of a photographic studio. Selenium Corporation of America supported the war effort with power electronics and was sold to Sperry Corp in 1946.

Together with his father Leon (brought to the USA in 1946), Lidow started up International Rectifier in Inglewood, CA in 1947. He was CEO until 1995, after which he was



**Eric Lidow.**

chairman of the board of directors until his retirement in May 2008.

Lidow played a leading role in the development and commercialization of several

technologies relating to photovoltaic cells, selenium photocells and rectifiers, silicon controlled rectifiers (SCRs), power germanium rectifiers and power MOSFETs. Over the course of more than six decades, Lidow transformed International Rectifier from a start-up company that developed selenium photoelectric cells and selenium rectifiers into firm that now produces thousands of analog, digital and mixed signal integrated circuits and other power management technologies and products. IR says that it retains its

number 1 position in the power MOSFET market. In addition, in late 2008 IR announced its 'GaNpowIR' power device technology platform based on proprietary gallium nitride (GaN)-on-silicon epitaxy.

Lidow was a Life Associate of the California Institute of Technology (Caltech), a Life Member of the Institute of Electrical and Electronics Engineers (IEEE) and a Life Trustee of the Los Angeles County Museum of Art. He also held an Honorary Doctorate from Technion — Israel Institute of Technology.

"Eric was a highly respected pioneer in the power semiconductor industry," comments president & CEO Oleg Khaykin. "The development and growth of International Rectifier was a great source of pride to him and, as we continue to grow as a company, the legacy of Eric's leadership during his 60 years at IR will remain."

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

## Funding round enables Mesuro to relocate and expand overseas sales and RF device characterization

### Office and engineering functions centralized

Mesuro Ltd, a spin-off from Cardiff University's Centre for High Frequency Engineering that provides RF test and device measurement services, says that a £700,000 funding round completed during second-half 2012 to expand its overseas sales and device characterization capabilities has enabled its relocation to the Pencoed Technology Park, within the Sony UK Technology Centre, located just off the M4 near Cardiff, UK.

The facility provides modern office space and facilities, and enables Mesuro for the first time to centralize its office and engineering-based functions under one roof. The newly designated engineering laboratory is available for customer measurement activities, R&D and prototyping work.

"Following the recent investment, these new facilities will enable Mesuro to capitalize on the huge opportunity-base in front of us, in terms of our ability to demonstrate the benefits of Mesuro's Active Harmonic Load Pull technology in conjunction with WaveForm Engineering to potential customers; allow Mesuro to continue developing the product portfolio; and provide enhanced support facilities to our existing customers," says VP of sales Simon Mathias. "We are looking forward to accelerating the growth of the company over the next 12 months."

The funding received during 2012 has enabled Mesuro to refit much of its capabilities, and to offer customers the following measurement capabilities:

- high-power test to 4GHz fundamental — up to 100W CW;
- microwave harmonic capability to X-band fundamental;
- fundamental only facilities to 67GHz; and
- on-wafer capabilities to 40GHz.

The improved load-pull facilities will use the firm's open-loop active harmonic and WaveForm Engineering technology, offering customers the opportunity to obtain the data that they require for improved amplifier designs, says the firm.

The systems will also be capable of extracting the 'Cardiff behavioural Model' formulations, suitable for use within the computer-aided design (CAD) environments employed by many designers.

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



## IN BRIEF

### Riber sells two MBE systems to Asian firm

Molecular beam epitaxy (MBE) system maker Riber says that it has sold two MBE 412 systems to a "leading company in Asia".

The two model 412 orders are repeat business and will enable the customer to further increase its development activities on new material and structures.

Riber says its MBE 412 system (which has capacity for multiple 2" or 4" wafers) was selected because the platform is optimized for this type of application.

As the latest system developed by Riber, the MBE 412 takes into account the increase in complexity of new semiconductor structures, allowing users to design and fabricate structures with 12 different materials.

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

### Brewer Science to add high-volume manufacturing in Missouri

Brewer Science Inc of Rolla, MO, USA, which provides specialty materials, integrated processes and laboratory-scale wafer processing equipment, is to build a high-volume plant in Vichy.

The new plant will be sited at the Rolla National Airport, about 12 miles from the firm's headquarters.

Brewer Science says that the new investment will provide increased capacity for high-volume manufacturing of specialty materials meeting the stringent specifications required for microelectronics.

Under the leadership of founder & president Dr Terry Brewer, the firm has been a major Missouri employer since 1981. The announcement means new jobs and an expansion of the state's technology footprint, the firm says. Brewer Science is part of the emerging I-44 technology corridor, spanning the state from St. Louis to Joplin. "The new

facility will provide the company with multiple manufacturing locations in Missouri," says Dr Brewer.

Utilizing Leadership in Energy and Environmental Design (LEED) guidelines, the new facility will be powered using geothermal energy. Designed to be energy-efficient and environmentally sensitive, the building will have the infrastructure to make high-volume products that meet or exceed International Organization for Standardization (ISO) requirements.

Brewer Science says it appreciates the team effort by the City of Rolla, the Rolla Regional Economic Commission, and the Rolla Community Development Corporation, as well as the involvement of Intercounty Electric Cooperative and the Maries County Commission, in helping to make the development possible.

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

## III/V-Reclaim

GaAs  
InP

### The Cheapest Way to Excellent Quality.

**III/V-Reclaim**

Wald 10

84568 Pleiskirchen / Germany

Telefon: + (49) 8728-911093

Telefax: + (49) 8728-911156

E-Mail: [sales@35reclaim.com](mailto:sales@35reclaim.com)

Internet: [www.35reclaim.com](http://www.35reclaim.com)

- We recycle your GaAs and InP wafer (all formats and sizes)
- One and double side polished wafer
- Best surface quality for direct use in Epitaxy
- Backside thinning of fully structured wafer
- Thin wafer (60  $\mu$ m)
- Single wafer processing possible
- We buy used wafer and sell recycled wafer

# Riber's revenue up 20% year-on-year for Q4/2012

## Fall in OLED-related Sources & Cells revenue offset by research MBE System sales

For full-year 2012, Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported revenue was €27.4m, down 5% on 2011's €29m but up on 2010's €20.7m. At the end of December, the regional breakdown of Riber's revenue was 42% Europe (including Russia), 42% Asia, and 16% the American continent.

Most recently, fourth-quarter 2012 revenue was €10.7m, up only slightly on €10.5m a year ago but up 20% on €7.3m in Q3/2012. Growth was driven by sales of systems to research laboratories.

Full-year sales of Systems rose from 10 invoiced and delivered in 2011 to 17 in 2012 (including a record 15 systems delivered to research laboratories). Systems revenue was hence €19.4m, up

68% on 2011's €11.5m.

The growth in MBE system business has offset a decline in sales of Evaporation sources & Cells of 83%, from €12m in 2011 to just €2.1m in 2012, due to low investments in organic light-emitting diode (OLED) production.

Revenue from Services & Accessories, supported by a commercial recovery plan launched at the end of 2011, are up 9% from €5.4m in 2011 to €5.9m in 2012. Riber says that this confirms the upturn in business during second-half 2012, despite the difficult economic climate.

At the end of 2012, Riber's order book amounted to €12.1m, down 38% on €19.4m a year earlier. Orders for Evaporation sources & Cells are from €0.6m to €0.2m. However, the drop is largely due to Systems orders of €10.1m being

down 42% from €17.4m a year ago. Nevertheless, in fourth-quarter 2012 Riber recorded orders for three systems for research laboratories in the USA and Austria. The order book includes 11 MBE research systems to be delivered in 2013. Services & Accessories business continues to show an upward trend, rising 21% from €1.4m to €1.7m.

Riber says its earnings for full-year 2012 will be released on 4 April.

### ● Riber settles litigation

Riber says parties in the dispute subject to the Pontoise commercial court ruling of 11 December have signed settlement agreements under which they will not appeal against the ruling. Litigation between the parties is now settled.

● Bernard Raboutet has resigned from Riber's supervisory board.

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

1100 Technology Place, Suite 104 - West Palm Beach, FL 33407  
 PHONE: (561) 842-4441 FAX: (561) 842-2677 EMAIL: [sales@waferworld.com](mailto:sales@waferworld.com)



Hello Guest - login  
AS9100:2004/ISO 9001:2008 CERTIFIED

- [Home](#)
- [Our Company](#)
- [Products](#)
- [GaAs + InP RECLAIM](#)
- [Services](#)
- [Latest News](#)
- [Request A Quote](#)
- [Contact Us](#)


**Shopping cart**  
[View your shopping cart.](#)

Special Offers:



Clean Room Products

Our Products

- [Silicon](#)
- [GaAs](#)
- [Germanium](#)
- [Clean Room](#)
- [Other](#)

Product Search

### Our Company



Wafer World, Inc. is a privately held company founded by Sean Quinn in 1997. The 12,000 sq ft facility is situated in Palm Beach County, FL. Wafer World, Inc. is an ISO 9001:2008 and AS9100:2004 certified manufacturing facility for Silicon, Gallium Arsenide, Germanium, Indium Phosphide, Sapphire and Quartz.

Wafer World, Inc. has satisfied customers in 45 countries on 6 continents. Our on-line, fully secured shopping cart is available 24/7 with short lead times. Wafer World has established great relationships with Fortune 100 companies, universities, government labs, and worldwide brokerage houses. Customer Service is our top priority at Wafer World, Inc.

Customers who need 25 wafers once a year and customers who require 1000 wafers/week receive the same high quality service.

[Download the Wafer World Presentation](#)  
[View the Wafer World, Inc. Timeline](#)



# Veeco's bookings rise 10% in Q4/2012, driven by MBE during MOCVD overcapacity

## Revenue and earnings reporting postponed amid accounting review

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA says that, due to its ongoing revenue recognition accounting review announced on 15 November, it is currently unable to report revenue and earnings information for fourth-quarter and full-year 2012. The firm will not be hosting an earnings call at this time, and is providing selected business highlights as follows.

For Q4/2012, unit shipments were in line with expectations. Bookings were \$92.3m, including: MOCVD of \$62.8m, MBE of \$12.6m (LED & Solar together totaling \$75.4m) and Data Storage of \$16.9m. This is up 10.3% from Q3's \$83.7m, which included: MOCVD of \$63m, MBE of \$5m (LED & Solar together totaling \$67.8m) and Data Storage of \$15.9m. Total full-year 2012 bookings were \$392m. At the end of Q4, Veeco took a \$16m adjustment to reduce order backlog across its businesses. Nevertheless, during the quarter the unaudited cash balance rose from \$574m to \$579m.

Veeco says that, amid its ongoing focus on cost controls, Q4 operating costs (unaudited) are expected to

be roughly flat with Q3 (despite higher professional costs associated with the ongoing accounting review).

"While we cannot provide revenue and earnings information at this time, fourth quarter shipments, bookings, and operating expenses are expected to come in about where we planned," comments chairman & CEO John R. Peeler. "Bookings improved a bit sequentially from the third quarter due to some important research wins in our MBE business. We are pleased that the company continued to increase our cash balance in this overall challenging environment," he adds.

"Looking at 2013, we do not see any clear signs that the over-capacity in our MOCVD business and weak end-market demand in Data Storage will improve in the near term,"

**The LED industry clearly remains in an equipment digestion period. With few MOCVD deals available, we have also experienced continued competitive pricing pressure**

Peeler notes. "Customers across our markets continue to tightly guard spending and limit capacity expansions, and tight credit policies limit some of our Asian customers' ability to raise capital and buy more equipment. The LED industry clearly remains in an equipment digestion period. With few MOCVD deals available, we have also experienced continued competitive pricing pressure," he adds.

"We are therefore focused on continuing to drive down Veeco's operating expenses and manufacturing costs while maintaining critical investments in new product development," Peeler continues. "Our goal is to be well positioned with competitive products and a strong customer support infrastructure when the market recovers. LEDs are expected to expand from 5% of general lighting to over 30% over the next few years, and continued strong demand for data storage will drive future hard-drive industry investments. While we are confident that demand for our products will improve, we are currently unable to predict the timing of a recovery."

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

## KaiStar places follow-on MOCVD order to ramp LED production

Veeco has received an order for multi- and single-chamber TurboDisc metal-organic chemical vapor deposition (MOCVD) systems, including the new MaxBright M, from KaiStar Lighting Co Ltd of Xiamen, China, a joint venture between Epistar Corp and Shenzhen Kaifa Technology Co Ltd.

KaiStar began LED production in 2012. The systems will be added to its existing fleet of Veeco MOCVD systems as part of its 2013 capacity expansion plan. The firm plans to focus on the lighting market through the production of

green and white LEDs for display and backlighting applications, lamps and automotive products.

"This latest capacity expansion in Xiamen is in keeping with our goal to maximize our position in the China LED backlighting, automotive and general illumination market," says Epistar's president MJ Jou. "Since we originally selected Veeco as our MOCVD equipment supplier for KaiStar a year ago, we have been extremely impressed with the product quality, service and support we have received. A critical deciding factor has been

Veeco's quick process transfer, which is important as we share know-how across our LED manufacturing sites. In addition, the TurboDisc's low cost-of-ownership made it a straight-forward decision to turn to Veeco as we add more tools for KaiStar in 2013."

"We are pleased to support Epistar and Kaifa as they continue to expand their leadership position in the China market through KaiStar and their other joint ventures," says Veeco executive VP Bill Miller. "We will remain focused on helping them to achieve their manufacturing goals."



## Canada's University of Waterloo orders Veeco GEN10 MBE system for Quantum-Nano Centre

Canada's University of Waterloo has ordered a GEN10 molecular beam epitaxy (system from Veeco Instruments Inc of Plainview, NY, USA for its recently opened Quantum-Nano Centre (QNC), which hosts the Waterloo Institute for Nanotechnology (WIN) and the Institute for Quantum Computing (IQC). The system will be installed in the new MBE laboratory being established by professor Zbig Wasilewski, Endowed Nanotechnology chair at WIN.

"MBE technology is rich in its application across several fields of study that we are focusing on here at WIN and IQC," says Wasilewski. "After thorough evaluation, we thought the GEN10 was the best choice due to its flexible cluster architecture, system design details, full automation and relatively small footprint. It ideally fits our needs across many research frontiers. Also, given the importance of effusion cells to our research, we thought Veeco would be a great

choice given their expertise and our history with their cells."

Veeco's GEN10 R&D MBE system allows for up to three configurable, material-specific growth modules, enabling high system utilization with multiple researchers simultaneously performing unattended growths and calibrations.

Opened in fall 2012, the Mike & Ophelia Lazaridis Quantum-Nano Centre is dedicated to allowing faculty and students to pursue quantum information and nanotechnology research. Shared between the Institute of Quantum Computing and the Waterloo Institute of Nanotechnology, the building fosters cross-disciplinary collaboration.

The GEN10 is the first piece of equipment to be installed at the new Quantum-Nano Center, according to Jim Northup, VP, general manager of Veeco's MBE Operations.

<http://uwaterloo.ca>  
[www.veeco.com](http://www.veeco.com)

## KOPTI buys MBE system for GaAs laser R&D

Veeco says that the Korean Photonics Technology Institute (KOPI) has purchased a GEN20 molecular beam epitaxy (MBE) system. The system will be shipped to KOPI's Laser-IT Research Center and Photonics System Lab in Gwangju, South Korea for research on high-power gallium arsenide (GaAs)-based laser diodes.

"We have selected the MBE GEN20 system for our work in development of high-powered GaAs laser diodes because of its process flexibility and Veeco's impressive track record in supplying tools to the III-V laser diode market," says Swook Hann PhD, head of KOPI's Laser-IT Research

Center and Photonics Systems Lab. "These are critical elements for KOPI, since we are developing technologies that can be taken from lab to fab," he adds.

"KOPI is known worldwide for developing pioneering breakthroughs which bridge the gap between pure research and industrial production," comments Jim Northup, VP, general manager of Veeco's MBE Operations. "We are pleased to partner with such an important technology center in Korea, supporting the further commercialization of high-power laser diodes with our GEN20 MBE system."

[www.veeco.com/GEN20](http://www.veeco.com/GEN20)  
[www.kopti.re.kr](http://www.kopti.re.kr)

### IN BRIEF

## Swiss R&D facility École Polytechnique Fédérale de Lausanne orders Veeco ion beam etch system

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA says that Switzerland's École Polytechnique Fédérale de Lausanne (EPFL) has ordered a NEXUS ion beam etch (IBE) system, to be used for R&D projects in micro- and nano-fabrication. Veeco's IBE systems are used to etch precise, complex features for high-yield production of discrete microelectronic devices and components.

"Ion beam etch is important in our micro- and nano-fabrication because we need the ability to accurately etch difficult-to-etch materials and multi-layer stacks used in today's emerging applications," says EPFL's Dr Philippe Flückiger director of operations. "Veeco's technology also provides us a level of precision in defining our structures not available with other dry etching techniques," he adds.

"Given the growing trend of thin-film-based sensors being used in various consumer applications, we are very excited that our IBE technology has been selected by a new customer – EPFL – which is a top European research institution," comments Veeco's VP & general manager Vivek Vohra. "We look forward to supporting their innovative research and industry collaborations." Veeco's IBE and other technologies are used globally for etching/depositing various thin films to produce micro-electro-mechanical systems (MEMS) and magnetic sensors.

[www.epfl.ch](http://www.epfl.ch)

## IN BRIEF

### Aixtron's Holger Jürgensen and Karl-Hermann Kuklies resign from supervisory board

Deposition equipment maker Aixtron SE of Herzogenrath, Germany has announced two changes to its supervisory board.

Dr Holger Jürgensen (deputy chairman of the supervisory board) and Karl-Hermann Kuklies (ordinary member of the supervisory board) have informed the management board of their resignation from office with immediate effect.

After being a research associate at RWTH Aachen University's Institut für Semiconductor Technology from 1981 to 1985 then co-founding Aixtron in 1983, Jürgensen was a member of Aixtron's executive board from 1997 to 2002 (while being president and joint CEO of Aixtron) and became deputy chairman of the supervisory board in 2002.

After teaching at Heinrich-Heine-Gymnasium (Heinrich Heine High School), Botrop secondary school from 1981 to 1997 then being a

managing partner with management firm KAWEK Beteiligungs-GmbH from 1997 to 2008, Kuklies has been a supervisory board member since 1997.

Suitable successors will be proposed for election at the firm's annual general meeting on 23 May.

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



**Holger Jürgensen.**



**Karl-Hermann Kuklies.**

## Martin Goetzeler succeeds outgoing Aixtron president & CEO Hyland

President & CEO Paul Hyland left deposition equipment maker Aixtron SE of Herzogenrath, Germany by mutual agreement on 28 February for personal reasons.

Martin Goetzeler has been appointed to succeed Hyland. He will join Aixtron on 1 March, and will be responsible for strategy, production, purchasing and logistics, investor relations and group communication.

Before joining Aixtron, Goetzeler served on the executive board of Siemens' subsidiary Osram and also held various positions within the Siemens group. Aixtron says that he is an acknowledged LED and lighting industry expert. Goetzeler has also served as president of the European Technology Platform Photonics21, which, among other things, advises the European Commission in determining major strategic research in the area of photonics. Goetzeler's experience in target markets will further strengthen the Aixtron's position in a period of considerable market

change, reckons the firm.

"We have the opportunity to address some of the current social megatrends such as energy efficiency and intelligent networking, which are dominated by LEDs, OLEDs and power electronics," says Goetzeler. "There is substantial growth potential for Aixtron in all of these areas," he adds.

"Mr Goetzeler can build on a solid foundation, and he has both the leadership qualities and experience to take Aixtron successfully onto the next level," comments Hyland.

"Hyland has successfully managed the company during his tenure through many ups and downs in the semiconductor industry," says Kim Schindelhauer, chairman of Aixtron's supervisory board. "We are delighted to have found someone like Mr Goetzeler, a versatile manager with extensive knowledge in the high-tech market and international experience. Mr Hyland will actively support Mr Goetzeler in taking up his office and ensure a smooth transition."

## Aixtron appoints general manager of Korean subsidiary

Aixtron has appointed SukYoung Kim as general manager of its subsidiary Aixtron Korea Co Ltd.

Kim has been working in the international semiconductor industry in Korea and the USA for many years, most recently as regional president & representative director of Novel-lus Systems in Korea.

In his new role, he takes over strategic and operational responsibility from Eun Sook (E.S.) Choi who held this position at Aixtron Korea until now. Ms Choi will further support Aixtron as a consultant.



**SukYoung Kim.**

"Korea is one of the global centers of advanced high-power LED products, with many important key players," says executive VP & chief operating officer Dr Bernd Schulte. SukYoung's appointment demonstrates the strategic importance of Korea's significance as a key market within Aixtron, he adds.

"Aixtron has highly advanced technology not only in compound, but also silicon and organic semiconductors," comments Kim. "Our target is to support our Korean customers' strategies for further development and to provide leadership across the business sector, helping Korea become one of the world's major countries employing MOCVD manufacturing technology."



## Focus Lightings to double capacity with CRIUS II-L systems

In fourth-quarter 2012 Focus Lightings Tech Inc of Suzhou High-tech Industry Park (SIP), Jiangsu province, China ordered multiple Aixtron CRIUS II-L Close Coupled Showerhead (CCS) MOCVD systems — configured to handle up to 69x2" wafers per run — for the mass production of gallium nitride (GaN) white-light LED epitaxial wafers. Shipment started in December.

"With the system's low cost of ownership and high productivity as well as AIXTRON's strong customer service in China, the CRIUS II-L systems will increase our competitiveness in the LED market," comments Focus Lightings Tech's chairman Huarong Pan.

"This new order from Focus Lightings Tech validates the production worthiness of the CRIUS II-L," says Tim Wang, general manager at AIXTRON China Ltd. "Focus Lightings will soon benefit from the large production capacity and high throughput on a proven platform, along with the low cost of ownership," he adds.



CRIUS II-L allows easy process transfer from earlier CRIUS systems. Also, the II-L can be refitted for a new wafer size up to 8" diameter by a simple change of the carrier plate.

Focus Lightings Tech manufactures LED chips, laser diode (LD) laser chips, as well as in semiconductor lighting and IC products. Its new plant houses chip production lines for red, yellow, blue, green, and white LED lights, as well as an R&D center that aims to achieve luminous efficacy of 150lm/W using proprietary technologies for mass production and to transition chip production from 2" to 4" substrates.

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

## Power+Energy ships hydrogen purifier to Chinese InGaN LED epiwafer and chip maker Jiangxi Lianchuang

Power+Energy Inc (P+E) of Ivyland, PA, USA, which provides palladium-membrane-based hydrogen purifiers for the compound semiconductor and energy industries, says that it recently shipped a PE9000C Series purifier to Jiangxi Lianchuang Optoelectronics Science and Technology Co Ltd (Lianovation) to support a process tool at its facility in the Nanchang High-Tech District in Jiangxi, China.

The 9000C Series purifier includes micro-channel palladium membrane technology with automatic operation to provide high-purity

hydrogen from low-quality inlet sources. P+E's regional distributor Wah Lee Industrial will provide customer support in China.

Jiangxi Lianchuang provides indium gallium nitride (InGaN) LED epitaxial wafers and chips, optoelectronic wire cables, relays and communication and information services. The firm is a leading member of the National Torch Program and the research center of Nanchang Semiconductor Lighting Engineering.

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

<http://lianovation.com>

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



For several years, Pyro 400 has been securing top production yields fab-wide at leading HB-LED manufacturers. Now, the next generation has come:

### Pyro 400 Gen 2



- Direct GaN surface temperature control
- Strict LED emission wavelength uniformity
- 24/7 feedback control through automated viewport coating sensing
- Real-time emissivity correction
- 0.5 K AbsoluT on-site calibration
- Main susceptor rotation range: 0–1500 rpm

See what you grow.

LayTec AG | [www.laytec.de](http://www.laytec.de) | [sales@laytec.de](mailto:sales@laytec.de)

**LAYTEC**  
Knowledge is key



## LumaSense launches UV pyrometers for MOCVD processes for LED production

LumaSense Technologies of Santa Clara, CA, USA which makes temperature and gas sensing devices for end-users and original equipment manufacturers (OEMs), has launched the UV 400 and UVR 400 pyrometers, its newest generation of non-contact temperature measurement instrumentation for metal-organic chemical vapor deposition (MOCVD) processes in LED production. The UV 400 and UVR 400 can help manufacturers using MOCVD to improve efficiency and reduce waste in LED manufacturing, it is claimed.

Whereas traditional pyrometers are only able to measure the susceptor/pocket temperature under the wafer, using a center wavelength in the UV spectrum (400nm) the pyrometers make it possible to measure real wafer surface temperature, it is claimed. This allows

accurate and repeatable control of the wafer temperature which, for example, in LED production is critical to the final product wavelength and manufacturing yields.

The wide temperature range of 650–1300°C allows measurement of various applications such as GaN buffer layer growth or multi-quantum well growth. The fast response time of up to 8ms allows measurement of fast processes. True photon-counting instrumentation guarantees the best achievable signal to noise ratio and stability.

In addition to the UV 400 pyrometer, the UVR 400 features a 635nm laser reflectometer, enabling real-time measurement of the thickness and growth rate of the GaN layer during epitaxy growth.

LumaSense has an installed base of 8000+ systems in the semiconductor industry and nearly 2000

MOCVD tools, says Brett Sargent, VP & general manager, Products & Solutions. "The UV 400 and UVR 400 are now setting a new standard for MOCVD measurement all around the world as the instruments have proven to provide temperature measurements with reliable correlation between the measured process temperature and the final product wavelength," he claims. "This will result in unparalleled yield gains and efficiency improvements."

The UV 400 and UVR 400 can also be combined with the PhotriX pyrometer with a concentric lightpipe from LumaSense to additionally control the reactor temperature. Either the UV 400 and UVR 400 alone, or in combination with the PhotriX pyrometer, provide a measuring data and process control solution.

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

## FOREPI orders multiple Aixtron CRIUS II-L systems for GaN-based blue and white UHB-LED production

Deposition equipment maker Aixtron SE of Herzogenrath, Germany says that in Q3/2012 long-term customer Formosa Epitaxy Inc (FOREPI) of Taiwan ordered multiple CRIUS II-L MOCVD production systems in a 69x2"-wafer configuration. All systems will be used for manufacturing ultra-high brightness (UHB) GaN-based blue and white LEDs.

Aixtron's local service team started installing and commissioning the new systems in Q4/012 at FOREPI's new factory in the Pin-Jen industrial zone. Delivery will be completed in Q2/2013. Previously, in May 2012, FOREPI purchased several CRIUS II-XL and AIX G5 HT reactors.

"Aixtron has proven itself as an excellent partner, providing superior customer care by responding to our requests and delivering the needed



**Aixtron's CRIUS II-L MOCVD production system.**

solutions," says FOREPI's chairman Dr Frank Chien. "With short time-to-production, and highest performance and throughput, Aixtron's latest MOCVD generations meet the specific challenges of larger wafers

and maximum chip yields."

All CRIUS II-L systems will be delivered with Aixtron's new ARGUS Topside Temperature Control (TTC) system. The new method eliminates temperature variation within each run and run-to-run, enabling unmatched production yields, claims the firm.

"This latest multiple tool order reflects FOREPI's growth as a top-tier LED chip manufacturer," says Dr Christian Geng, general manager Aixtron Taiwan.

"Besides reactor size and design, we believe that successful in-situ measurement and control offer the greatest optimization potential because they provide a direct impact on yields."

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

# LayTec's Gen 2 UV pyrometry tool enhances GaN surface temperature accuracy during MOCVD growth

Every LED maker wants to know the emission wavelength of its final device during metal-organic chemical vapour deposition (MOCVD) growth, says LayTec AG of Berlin, Germany.

Currently, according to the solid-state lighting (SSL) road map, the wavelength variation across a wafer should be less than 1nm. This equals a <1K variation in gallium nitride (GaN) surface temperature during indium gallium nitride (InGaN) multi-quantum well (MQW) growth. LayTec says its Pyro 400 pyrometry tool is therefore being widely used to enable fab-wide GaN surface temperature uniformity in the production lines of leading LED makers.

Meanwhile, more complex LED structures and tighter cost-reduction targets are demanding even more advanced in-situ metrology. Figure 1 shows such an example: ternary InGaN and AlGaN layers cause changes in emissivity that lead to a 0.7K error in UV pyrometry reading.

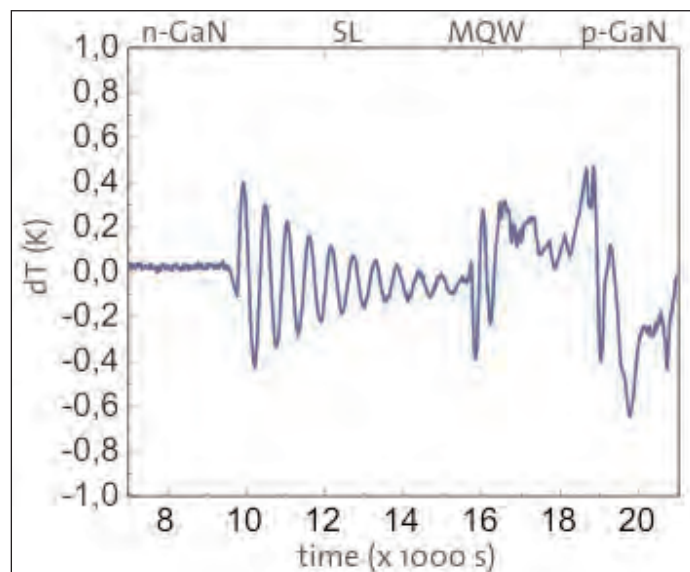
LayTec's answer to this challenge is the Pyro 400 Gen 2. Alongside in-situ UV pyrometry, this new-generation tool includes real-time UV emissivity correction for enhanced accuracy in GaN surface temperature measurement during the growth of more complex LED structures.

A further challenge to reliable GaN temperature control in high-bright-

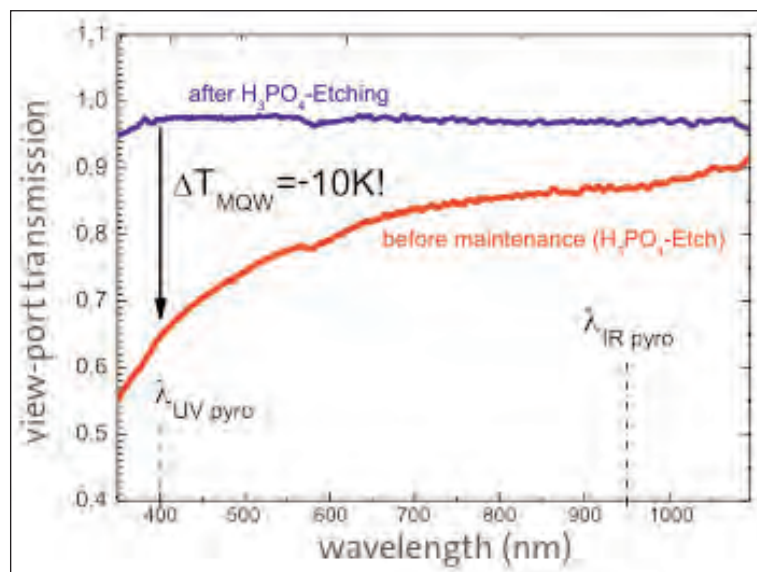
ness (HB)-LED production is the viewport coating. Figure 2 shows its effect just before maintenance: the UV transmission of the viewport is significantly reduced and an uncorrected UV pyrometer would give a -10K temperature artifact. LayTec says that the Pyro 400 Gen 2 can solve this problem by automatically sensing and correcting these coatings, enabling a long-lasting 24/7 accuracy in HB-LED emission wavelength, it is claimed.

Finally, an assisting infrared (IR) pyrometer has been integrated into the Pyro 400 Gen 2 for simultaneous monitoring of wafer pocket temperature throughout the LED growth run.

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



**Figure 1: Effect of changing emissivity to UV pyrometer temperature reading: up to 0.7K, errors show up without emissivity correction during growth of a GaN/AlGaN-GaN-superlattice/InGaNMQW/GaN structure.**



**Figure 2: GaN MOCVD viewport before (red) and after maintenance (blue): transmission at the 400nm detection wavelength of a UV pyrometer is suffering from the window coating (red). The -10K artefact is avoided by Pyro 400 Gen2.**

## Chief customer officer to head Application & Support Department

LayTec's Application and Support Department (A&S) is now headed by new chief customer officer (CCO) Dr Oliver Schulz. Dr Kolja Haberland, who headed both A&S and R&D until the end of 2012, is now focusing fully on his R&D work as chief technology officer (CTO).

As sales manager for Korea in

2010–2012, Schulz is familiar with the needs of LayTec's customers in Asia. In close collaboration with Dr Marcello Binetti, who has headed the support team for several years, he will help to further improve LayTec's service quality in all global technology regions.

With an academic and industrial

background in growing III-nitrides on silicon, Schulz will also strengthen LayTec's Application Engineering to support customers in their technology migration towards larger silicon substrates.

"It is a must to deliver extraordinary after-sales service," says CEO Dr Thomas Zettler.



## IN BRIEF

### Plasma-Therm and Stanford workshop

Plasma-Therm LLC of St Petersburg, FL, USA provided a two-day workshop at Stanford University's Nanofabrication Facility (SNF).

Presentations addressed plasma etching & deposition technologies used mainly in semiconductor device fabrication and materials science research. As part of the US National Nanofabrication Infrastructure Network (NNIN), the Stanford facility provides resources for both academic and industrial users worldwide.

The technology community outreach event attracted researchers involved in projects requiring process capability spanning research topics as diverse as solar energy, nanostructures, data storage, opto-telecommunications, and MEMS.

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

## Oxford Instruments awarded patent for high-density plasma-assisted thin-film deposition

UK-based etch and deposition system maker Oxford Instruments Plasma Technology (OIPT), a division of Oxford Instruments, has been granted European patent EP1889946B1 in relation to high-density plasma-assisted thin-film deposition. The patent cites Thomas, Griffiths and Cooke as inventors, and discloses a method of optimizing uniformity over larger areas using a plasma transmission plate. This technique has been used in more than 25 tools shipped by the firm since the patent application was filed.

"The grant of this patent covering high-density plasma-assisted thin-film deposition is part of a broad platform of intellectual property rights which continue to be developed by our company," said Oxford Instruments Plasma Tech-

nology's chief technology officer Dr Mike Cooke. "Oxford Instruments now has multiple patents, and we believe that this intellectual property reinforces our influential position in the plasma technology field," he added.

Plasma-enhanced deposition processes typically decrease the deposition temperature, compared to chemical vapor deposition (CVD) processes driven by heat alone, says OIPT. Using a high-density plasma source offers a significant decrease in processing temperature for the same quality material, and can deposit silicon dioxide layers below 100°C. This development opens up this style of plasma processing to a new range of substrate materials including polymers, adds the firm.

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

# Instrumental in change

## Leading plasma process innovation

Oxford Instruments Plasma Technology is turning smart science into world class products with its flexible systems for precise and repeatable etching, deposition and growth of micro and nano structures

	Plasma Etch & Deposition
	Atomic Layer Deposition
	Ion Beam Etch & Deposition
	Deep Silicon Etch



For more information, please contact Oxford Instruments Plasma Technology:

Tel: +44 (0)1934 837 000 Email: [plasma@oxinst.com](mailto:plasma@oxinst.com)

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





## Oxford Instruments' Baclet presents on resist-coated GaN etching at Strategies in Light

At the Strategies in Light Conference in Santa Clara, CA, USA (12–14 February), Stephanie Baclet — applications specialist with UK-based etch and deposition system maker Oxford Instruments Plasma Technology (OIPT), a division of Oxford Instruments — gave a presentation 'High throughput for resist coated Gallium Nitride etching'.

High throughput in batch GaN-based LED production is determined principally by batch size, process time and the uptime of the tool in operation, says the firm. As the time of the etch process is often fixed in order to meet selectivity, uniformity and profile specifications, one area where throughput can be significantly improved is by reducing the cleaning cycle thus improving the tool's uptime.



Oxford Instruments' Stephanie Baclet.

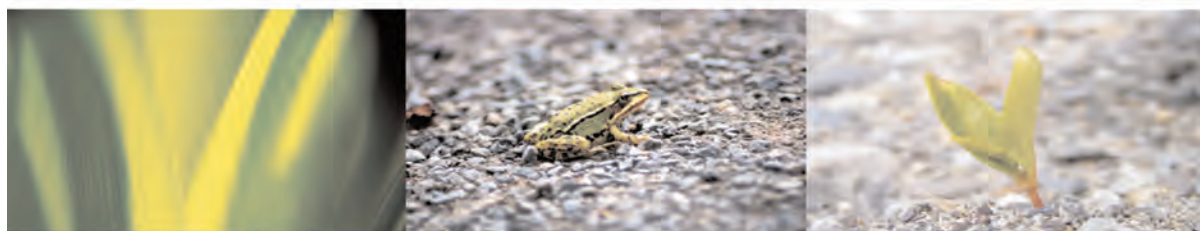
**Throughput can be significantly improved by reducing the cleaning cycle thus improving the tool's uptime**

Baclet's presentation focused on work by Oxford Instruments to improve the plasma cleaning process, by using new chamber hardware for the PlasmaPro 1000 batch etch tool. The new design has been shown to clean the chamber at

up to five times the rate compared with the standard plasma clean, says the firm. As a result, the length of plasma clean can be dramatically reduced, and the mechanical clean interval increased. Both of these factors contribute to gains in the overall throughput of batch processing GaN wafers, driving down the cost per lumen of the finished device.

Capable of etching batch sizes of 55 x 2" and 14 x 4" GaN wafers with high uniformity and selectivity, Oxford Instruments' PlasmaPro1000 systems are used by a number of major HB-LED makers. They are also used in the manufacture of other light-emitting technologies, e.g. OLEDs providing process solutions from R&D to full scale production.

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



CS CLEAN SYSTEMS®

### Safe Abatement of MOCVD Gases



- ▶ Waste gas treatment for MOCVD research and manufacturing
- ▶ Safe, dry chemical conversion of toxic gases to stable solids
- ▶ Proprietary CLEANSORB media specially developed for high MOCVD gas flows
- ▶ Backup column for 100% uptime
- ▶ Integrated capacity endpoint sensor
- ▶ Local refill service worldwide
- ▶ No handling of toxic waste
- ▶ Newly-developed chemisorber for GeH<sub>4</sub> applications

For more information please contact  
CS CLEAN SYSTEMS AG under:  
Phone: +49 (89) 96 24 00-0  
Email: [sales@csclean.com](mailto:sales@csclean.com)

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

## IN BRIEF

### Eagle Stainless eyes growth in semiconductor business

Eagle Stainless Container Inc of Warminster, PA, USA says it is supplying its mirror-polished BTB Type 316L SS series bottles (available 0.5L to 20L) for processing, transport and storage, and its STB Type 316L SS series bottles (available 5mL to 750mL) for transport and sampling to a manufacturer of microcrystalline quantum dot semiconductors.

"Since 1990, Eagle Stainless has developed long term relationships with virtually every pharmaceutical and biotechnology company worldwide," says Charles Lin Ph.D., VP & senior partner at Eagle Stainless. "More recently Eagle Stainless has been providing the semiconductor industry with mirror-polished vessels for processing, transport and storage," he adds.

Eagle Stainless manufactures innovative mirror-polished stainless-steel containers, bottles and process vessels from 1mL to 500L. Its key technologies are CNC machining, electrical discharge machining, orbital welding, automated/mechanical polishing and electro-polishing/passivation.

"Our containers can be used for processing and/or the transport and storage of liquids and powders, and our ASME certified EPV series pressure vessels can be used under positive pressure," adds Dr Lin. "We have become the manufacturer of choice because of our stainless-steel fabrication expertise, focus on quality and support for custom engineered projects," Dr Lin claims.

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

### SEMI-GAS upgrades GSM controller on bulk valve manifold box

SEMI-GAS Systems, a division of Applied Energy Systems Inc of Malvern, PA, USA and a maker of ultra-high-purity gas handling and distribution systems, has updated its GigaGuard GSM (gas safety monitor) controller on its Megaturion Bulk Valve Manifold Box (VMB).

The new controller, which supersedes the GSM 1x4, is PLC based and features a 4.3" color touch screen. Its software features prompts and alarms, which help to reduce operator error and increase safety. Further, operators now have the ability to configure both inputs and outputs as well as adjust set points and limits, making the system more adaptable than the previous GSM 1x4 controller, says the firm.

GigaGuard GSM independently operates ESO valves, monitors both analog and digital process sensors,

displays delivery pressures and continuously monitors the system environment for hazards while maintaining an active alarm log. It also incorporates local and remote system shutdown capabilities in the event of a system trip.

Available in 4-, 6- and 8-stick configurations as well as in customized designs, the semi-automatic Megaturion VMB distributes hazardous process gases from the source to various tools and points of use, as needed, in high-flow semiconductor and LED manufacturing applications.

All Megaturion VMBs meet SEMI S2, SEMI S8 and uniform fire code requirements. Multiple communications protocols, integrated gas and fire detection and Class 1, Division 2 upgrades are available.

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

### Bronkhorst extends range of mini Coriolis MFC flow rates from 30kg/h to 300kg/h

Bronkhorst Cori-Tech B.V. of Ruurlo, The Netherlands has launched a new model in its series of compact Coriolis mass flow meters/controllers (MFCs) for accurate measurement and control of (very) low flow rates.

With the launch of mini CORI-FLOW model M15, the maximum flow range of the product line is extended from 0–30kg/h to 0–300kg/h. The instruments are suitable for both liquid and gas flow applications.

The firm claims that the unique design of the miniature Coriolis sensor features superior response time and high accuracy, irrespective of changing operating conditions with regard to pressure, temperature, density, conductivity and viscosity. The effective turn-down is no less than 1500:1, with the possibility for the user to easily re-range the instrument to their

requirements on-site, guaranteeing the highest process flexibility, it is claimed.

The instruments have a robust IP65 weatherproof housing and are designed to withstand an operating pressure of up to 100 bar. Mini CORI-FLOW also offers integrated PID control and close-coupled control valves or pumps, constituting very compact Coriolis mass flow control loops.

The Mini CORI-FLOW features digital technology, offering standard analog and RS232 communication, optional fieldbus interfaces and additional functions such as alarms, totalizer (to measure fluid consumption) and batch dosing. The instruments also feature fluid temperature and density as secondary digital outputs.

[www.bronkhorst-cori-tech.com](http://www.bronkhorst-cori-tech.com)



## HiCap Cryo Pump

Management System

REDUCE POWER  
CONSUMPTION  
BY UP TO  
**25%**



### REDUCE

Reduce warm up time by more than 75%

### CONTROL

Automatic regeneration control for two cryo pumps simultaneously

### MONITOR

Web-enabled real-time monitoring and control

800-611-8871

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

**Oxford Instruments Austin**

1340 Airport Commerce Dr  
Bldg 1, Suite 175  
Austin, Texas 78741  
[oxford-instruments.com/austin](http://oxford-instruments.com/austin)

**OXFORD**  
INSTRUMENTS

*The Business of Science®*

## Photoresist Flow Meter



- **No Moving Parts**  
High Reliability
- **Unique Sensitivity**  
Highest Speed
- **Non Invasive**  
Straight Tubing Only

### Specifications

Flow Rates	up to 120 ml/min
Repeatability	typical 1-2 %
Speed	response time down to 30 ms
Wetted Materials	PCTFE, Quartz Glass

SENSIRION Inc. Westlake Village  
CA 91361, 805-409-4900  
[www.sensirion.com](http://www.sensirion.com)

**SENSIRION**  
THE SENSOR COMPANY



## IN BRIEF

### Evergreen Enhancement announces free materials measurement service

Metrology system maker Evergreen Enhancement Inc of Canton, MA, USA says that it is offering semiconductor manufacturers an opportunity to sample a variety of characteristics of its products for free.

"For a limited time, semiconductor makers have the opportunity to sample precise thickness, relative shape and local variations of a number of substrate wafers using our unique new metrology technique and equipment — at no cost," says president Bill Kerr.

"Applying the proven consumer marketing technique of 'try-before-you-buy', the accuracy, speed and ease of use of our new approach and equipment can become compelling," Kerr reckons. "Our objective is to leapfrog competitive measurement services and gain traction in this dynamic marketplace," he adds. "Using Evergreen Enhancement for metrology needs frees up a semiconductor manufacturer's valuable engineering staff to continue the development of next-generation processes and products."

Evergreen says that its free measurement service is suited to compound semiconductor, LED, gallium nitride (GaN), silicon and sapphire materials.

The firm adds that its team of engineers has expertise in mechanical, electrical, software and component engineering as well as system integration.

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

## Structured Materials Industries adds updated products for CVD process control systems

Structured Materials Industries Inc (SMI) of Piscataway, NJ, USA, which provides chemical vapor deposition (CVD) systems, components, materials, and process development services, has announced three updated products for process control systems: CVD Computer-PLC Control System Hardware, the CVD PLC/PAC Digital Control System Distribution Box, and the CVD PLC/PAC Analog Control System Distribution Box.

The three instruments, together with SMI's Smart Control System Software, constitute a complete process control system for a wide range of applications, including CVD/MOCVD (metal-organic chemical vapor deposition) systems, atomic layer deposition (ALD) systems, and other thin-film of chemical process systems. The firm says that the hardware provides a simple and direct process control

hardware and cabling interface for any process.

The CVD Computer-PLC Control System Hardware's core consists of an industrial computer and an industrial programmable logic controller (PLC) or programmable automation controller (PAC). The PLC interfaces to SMI's powered ( $\pm 15V_{DC}$ ) Analog Distribution Module and to its Digital Control Distribution Module, both of which are rack-mounted platforms that provide up to 48 channels of analog I/O plus  $24V_{DC}$  power per channel, 64 channels of digital output and 32 channels of digital input distribution in a standard package — both are expandable. Supporting the assembly are an industrial-grade monitor, keyboard with track ball mouse or track pad with pointer, and an industrial power outlet strip. A UPS system is optional.

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

SMI has launched an updated series of components for CVD, MOCVD, ALD, PVD and PLD researchers: the Standard & Custom Filaments & Heating Assemblies for Oxidizing or Reducing CVD, MOCVD and Related Environments. The firm says the components provide an economical solution to diverse heating problems. Designed for oxidizing and reducing environ-

ments, the heating assemblies span the temperature range from room temperature to  $2400^{\circ}C$ . The components can be highly customized and have been used in diverse applications and configurations, the firm adds. The heating elements are suitable for static and rotating disc reactors and have also been configured for tape and in-line type systems.

## SMI launches components for CVD, MOCVD and ALD research

SMI has launched a series of components for researchers: CVD, MOCVD & ALD Completely Dis-Assemble-Able Bubblers and Sublimators. The firm says that the components provide an economical, reusable and self-cleanable all-metal (to atmosphere) precursor reservoir

for use with CVD, MOCVD and ALD systems. The units can easily be taken apart, the firm adds. Also, if an individual component needs to be replaced, this can be done so without throwing away the rest of the assembly. Custom sizes can be fabricated to order.



compact dimensions  
+  
maximum power

unequaled performance

## The Global Space Saver

Take control with Fuji's Global TWIN Series Earth Leakage Circuit Breakers (ELCB). G-Twin ELCBs provide superior performance at the smallest dimensions, with a reduced panel size that optimizes ground fault protection for equipment.

### Featuring:

- **Unique Compact Design:** The built-in ground fault protector makes one compact ELCB unit.
- **Wide Range of Frame Sizes:** 50AF, 100AF, 125AF, 250AF, 400AF & 630AF
- **Safety Device Performance:** Proven performance and protection for commercial & industrial applications.
- **Accessories:** Optional internal & external accessories are available.
- **Global Product:** Conforming to worldwide standards and the RoHS directive.



The next generation of  
low voltage circuit breakers

**Fuji Electric**  
e-Front runners

Fuji Electric Corp. of America Distribution and Control Department

For sales, product and distributor information, please visit: <http://www.americas.fujielectric.com/components/distribution-control>  
or contact: [dcfuji@fecoa.fujielectric.com](mailto:dcfuji@fecoa.fujielectric.com)



# Rubicon's 6" sapphire sales growth for LEDs offsets drop for SoS and low pricing for 2-4" cores

## ...but excess inventory at two main LED and SoS 6" customers to see Q1 plummet before second-half 2013 pick up

For fourth-quarter 2012, 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 \$20m, up slightly on \$19.9m last quarter and \$19.4m a year ago.

In particular, revenue from 6" wafer sales showed another sequential rise, up 7% from \$16.4m last quarter to \$17.5m (88% of total revenue), driven by increased orders from the firm's largest LED customer, partially offset by a sequential decrease in revenue from the silicon-on-sapphire (SoS) market.

"We saw strong demand for 6" polished wafers from the LED market, with 6" wafer revenue from that market increasing to \$10.5m from \$7.7m last quarter," says president & CEO Raja Parvez. 6" revenue from the SoS market fell from \$8.7m last quarter to at \$7m. "We saw only a slight sequential reduction in average pricing for 6" wafers in the quarter," Parvez notes. "We continue to be the largest provider of 6" polished wafers in the market due to our strength in both large-diameter crystal growth and large-diameter polishing, evidenced by the fact that we have now shipped over 400,000 polished 6" wafers to date into the LED and SoS markets," he adds.

Due to low industry pricing for 2-4" core products, the firm decided not to sell those products in the third and fourth quarters, with just a few exceptions, yielding revenue of just \$1.3m in Q3 and \$337,000 in Q4.

However, while the pricing environment has not improved for 2-4" core products, the firm has started taking orders for delivery in Q1 and Q2/2013 in order to begin reducing

inventory levels and maintain customer relationships. Due to resuming sales into this market, pricing has decreased further. "Current pricing of 2-4" core products is now below our carrying cost in finished goods and WIP [work-in-process] inventory for those products," says chief financial officer William Weissman. "As a result, we recorded a \$1.6m adjustment in the period to reflect the value of those products in inventory at the current market price," he adds. "We believe that our competitors are now selling smaller-diameter cores at cash cost in order to reduce inventory or to keep utilization rates high. However, excess capacity in the market is gradually being absorbed and we believe the pricing environment should eventually improve."

Gross margin has fallen from 12.3% last quarter to 5%, due mainly to the decline in smaller-diameter core pricing as well as lower utilization rates and the slightly lower 6" pricing.

Net loss was \$1.1m (\$0.05 per diluted share), compared to net income of \$272,000 (\$0.01 per diluted share) last quarter, due mainly to the lower smaller-diameter core pricing and corresponding inventory adjustment. However, cash and short-term investments were maintained during the quarter at \$44m, with no debt.

"With the accelerating growth of the general lighting sector of the LED market and with the increasing complexity of mobile devices creat-

ing greater opportunity for SoS technology, I am very excited by the longer-term growth potential of the markets we serve," says Parvez. "However, they are evolving markets and we will likely continue to see shorter-term volatility... with cyclicity impacting orders from both our two largest 6" wafer customers," he cautions. "In the first quarter, our 6" wafer orders will be lower. Similar to what we experienced last year, our largest LED customer for 6" wafers has excess inventory and will not likely need additional material until the second quarter. Also, our SoS customer recently announced that their orders are down, based on weaker-than-expected sales by a key end-customer."

For first-quarter 2013, Rubicon hence expects revenue to slump to about \$8m (although 6" should still be more than half of revenue). Utilization rates will be low in both crystal growth and polishing, putting pressure on margins. This will be compounded by the moving remaining polishing operations to Malaysia, causing some temporary redundancy. The firm hence expects a loss per share of \$0.10-0.14.

Most inventory is in raw material and boule inventory. "We continue to refine our new raw material preparation process and are now taking delivery on the equipment needed to expand that capability to support most of our crystal growth operation with internally processed raw material. This will result in a significant reduction in our raw material costs, which is a major component of our crystal growth costs," says Parvez. "Our safety stock of raw material is now more than sufficient and our commitments to purchase additional material are complete. So we will now be drawing down the raw material stock." ➤

➤ Rubicon has also decided to further scale back its crystal growth production temporarily to reduce boule inventory levels. Total inventory levels should hence begin to decline (starting in Q2).

"Projects like our in-house raw material production and the continued move of our polishing operation to Malaysia will significantly reduce our costs once completed this year and further enhance our competitive advantage," reckons Parvez. US staffing has been cut by about a third. "Our vertical integration is a real differentiator in the market and allows us to better control quality and costs and provide assurance to our customers that their orders will be delivered on time and with consistent quality," he adds.

Also, capital expenditure requirements are limited this year, with the exception of investment in patterned sapphire substrate production. CapEx for full-year 2013 is likely to be \$10–15m, with a little over half going towards the PSS (patterned sapphire substrate) initiative.

"We continue to focus on enhancing our existing platform and developing new products," says Parvez. "We will be extending the vertical integration this year by completing the build-out of an internal wafer

patterning capability and will be introducing large-diameter patterned substrate to the LED market," he adds.

"The markets we serve are young, are evolving and will likely continue to see volatility. However, by focusing on reducing costs and evolving our products through technology, we intend to maintain our market leadership role and position the company to capitalize on market conditions when they later change."

Rubicon's SoS customer has expressed confidence in a strong second-half 2013. "Our SoS customers is extremely well-positioned to capture market share for switches in the latest-model more advanced smartphones to be introduced later this year," reckons Parvez. "We believe the markets we serve will strengthen throughout the year, with 6" orders in particular being much stronger in the second half [from both the SoS and LED markets]. In the LED market, the general lighting segment is expected to drive strong growth later in the year," he adds. "Pricing for 2–4" cores will remain weak in the near term, but as the LED market strengthens we believe pricing will eventually improve, as current pricing levels are not sustainable in our opinion."

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

## Rubicon ships 400,000th 6" sapphire wafer

Rubicon says it has shipped a total of 400,000 six-inch sapphire wafers to LED manufacturing and silicon-on-sapphire (SoS)/RFIC (radio-frequency integrated circuit) markets.

"This latest milestone demonstrates Rubicon's continuing leadership in the volume delivery of high-quality large-diameter sapphire wafers," says president & CEO Raja M. Parvez. "Our emphasis on vertical integration — achieving cost efficiencies and control of sapphire production — enables us to scale production and ensures our customers an unparalleled, reliable supply of

high-quality, large-diameter sapphire wafers that meet their unique and exacting specifications," he adds. "Rubicon's capabilities are increasingly important as LED manufacturers seek to reduce costs throughout the manufacturing process to make LED-based lighting more affordable for consumers and encourage adoption worldwide."

Market analyst firm IMS Research forecasts that the overall LED market of nearly \$10.9bn in 2012 (with \$2.9bn in lighting) will grow to \$13.9bn in 2015 (with the lighting market nearly doubling to \$5.8bn in three years).

## IN BRIEF

### ARC continues Trinity partnership; outlines upgrade to CHES performance

Advanced RenewableEnergy Company LLC (ARC Energy) of Nashua, NH, USA, a provider of c-axis sapphire growth technologies and turnkey solutions for the LED solid-state lighting market, says that, after qualifying sapphire substrates at multiple LED chip companies, China-based Jiangsu Trinity Material Co Ltd is continuing to further improve the efficiency of ARC Energy's CHES (Controlled Heat Extraction System) furnaces. ARC is currently working on the upgrades to lower costs and increase equipment productivity.

With two factories (Jiangxi Trinity Material Co Ltd and Jiangsu Trinity Material Co Ltd), Trinity produces 2-8 inch sapphire ingots for LED chip manufacturing.

ARC says that its CHES furnaces allow seamless upgrades without investment in entirely new furnaces. The firm is currently working to further improve sapphire production costs by lowering consumable costs, reducing power consumption, and increasing equipment productivity. Its CHES upgrades are targeted to further reduce costs in mid-2013. Trinity is poised to take advantage of these upgrades as they become available.

"In this challenging LED market, it is important for us to keep innovating, including supplying the latest technology upgrades to our partners such as Trinity Materials," says co-founder & chief technology officer Dr Rick Schwerdtfeger.

"We look forward to offering additional productivity and cost-of-ownership enhancements to CHES products in 2013."

[www.trinity-material.com](http://www.trinity-material.com)  
[www.arc-energy.com](http://www.arc-energy.com)



## NSF awards \$150,000 SBIR grant for low-cost scalable manufacturing of patterned sapphire substrates

In mid-December, the US National Science Foundation (NSF) awarded Sinmat Inc of Gainesville, FL, USA \$150,000 grant for a Small Business Innovation Research (SBIR) Phase I project 'Low Cost Scalable Manufacturing of Patterned Sapphire Substrates (PSS) for High Efficiency LEDs', running from 1 January to end-June 2013.

The NSF program manager is Steven Konsek, IIP Division of Industrial Innovation and Partnerships (ENG Directorate for Engineering), and the principal investigator at Sinmat is Rajiv Singh.

Patterned sapphire substrates have been found to improve the quality of gallium nitride (GaN)

epi-layers and to enhance the light extraction efficiency of LED devices. The project will focus on the development of a novel patterned sapphire substrate by employing a unique planarization technology. Such a substrate is expected to lead to improved film growth and enhanced light extraction efficiency, while at the same time reducing manufacturing costs. The feasibility of the technology will be demonstrated in Phase I, followed by a Phase II focused on scale-up and manufacturability issues for rapid commercialization of the technology.

Sinmat says that the broader impact and commercial potential of the project lie in its ability to

increase the efficiency and reduce the cost of solid-state lighting products. Because of their potentially very high efficiency, LED-based solid-state lighting devices are expected to begin to supplant the inefficient incandescent and fluorescent lamps that currently predominate. Lighting consumes over 20% of the total electricity generated in the USA and nearly 30% of electricity used in commercial and residential buildings.

The technology to be developed aims to boost the efficiency and cut the price of high-brightness LEDs, making them more competitive with fluorescent and incandescent lamps.

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

## GT enters development and licensing agreements with Soitec to commercialize HVPE system for GaN templates

Soitec of Bernin, France, which makes engineered substrates including silicon-on-insulator wafers and III-V epiwafers) has announced development and licensing agreements allowing GT Advanced Technologies Inc of Nashua, NH, USA (a provider of polysilicon production technology as well as sapphire and silicon crystal growth systems and materials) to develop, make and commercialize a high-volume, multi-wafer hydride vapor phase epitaxy (HVPE) system. The systems will be targeted at producing high-quality GaN epilayers on substrates used in the LED and other growth industries such as power electronics.

The higher growth rates and improved material properties enabled by HVPE are expected to greatly reduce process costs while boosting device performance compared with traditional MOCVD. Initial pre-payment of the licensing fees as outlined in the agreement is already underway, but further specific terms were not disclosed.

GT will develop, manufacture and commercialize the HVPE system incorporating proprietary HVPE technology of Soitec Phoenix Labs, including its novel source delivery system that is expected to lower the costs of precursors delivered to the HVPE reactor. The HVPE system should enable the production of GaN template sapphire substrates at scale. The expected target date for commercial availability of the system is second-half 2014.

"We have been working for more than 6 years on GaN epi processes and have created this breakthrough HVPE technology critical in producing high-quality and low-cost GaN layers on sapphire substrates," says Chantal Arena, VP & general manager of Soitec Phoenix Labs.

The development and license agreements build on the agreement announced last year with China's Chongqing Silian Optoelectronics Science & Technology Co Ltd to integrate HVPE-based technology on their sapphire. "This allows Soitec to structure its LED lighting

offer around differentiated technologies and industrial partners that includes materials and equipment," says Arena. Soitec Phoenix Labs' expertise in epitaxy technologies and GaN materials will key to enabling GT to bring an HVPE system to market, it is reckoned.

"GT has a successful track record of delivering innovative equipment that has changed industries such as solar PV and LED," claims GT's president & CEO Tom Gutierrez.

"Our decision to enter into the agreements with Soitec is the result of our extensive search for the right partner with the right technology to complement our equipment business as we diversify into new, high-value technologies that broaden our reach," he adds. "Soitec Phoenix Labs brings a high level of expertise and technical experience in GaN process know-how. When commercially available, we believe the new HVPE system will be a key element to further reduce LED device costs."

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

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

# COMPLETE R&D SOLUTIONS

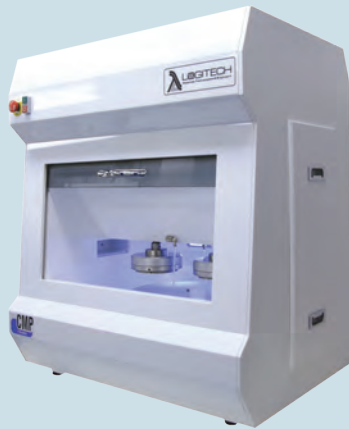
## WHERE APPLICATIONS DEMAND PRECISE TOLERANCES AND OPTIMUM SURFACE FINISH.

Logitech's range of lapping and polishing systems offer low cost solutions for Research & Development applications through reliability, flexibility and cost efficiencies.



### ORBIS Chemical Mechanical Polishing System:

Precision engineered floor standing CMP tool aimed at pilot production testing applications. The system offers optimum planarization and polishing capabilities, in partnership with reliable analytical data collection for materials up to 200mm/8" diameter. This system provides substantial cost savings in areas such as slurry usage, pad flexibility and operator requirements.



### TRIBO Chemical Mechanical Polishing System:

Precision engineered bench top solution designed specifically for researching wafer processes, for samples up to 100mm/4" diameter.

Key applications areas for this system are in the areas of:

- CMP planarization or delayering
- Tribological Science and Research

The Tribo CMP system utilises cutting edge technology with advanced process sensors that monitor parameters such as CoF, pad, slurry, plate and carrier/pad interface temperatures.



### DRIVEN HEAD Polishing Systems:

Designed for semi automated final stage polishing, these systems can process material up to 300mm/12". The 50kg of download on each carrier head provides fast, highly reliable results and epitaxy ready quality surfaces on hard materials such as:

- Sapphire
- Silicon Carbide
- Gallium Nitride

For further information please visit: [www.logitech.uk.com](http://www.logitech.uk.com)



## IN BRIEF

### Lighting PlugFest

Soraa sponsored a Lighting PlugFest in conjunction with Strategies Unlimited's annual Strategies in Light conference in Santa Clara (12–14 February).

Incompatibility between LED lamps and fixtures with existing control gear and dimmers designed for traditional light sources (incandescent, halogen, or fluorescent) is a major hurdle, says Soraa. In December in New York City, Soraa launched the first lighting PlugFest, to give lighting designers and specifiers, manufacturers, and end-users the chance to test products and identify underlying compatibility issues.

"Soraa has been an innovator in solid-state lighting, launching a revolution in everything from substrates to LED chips to lamps," says Strategies Unlimited's Ella Shum, chair of Strategies in Light Conferences. "Lighting PlugFest is a unique opportunity to bring the SSL revolution to be on par with the IT world," she adds. "Today, when we use a smart-phone and a PC, we don't think about how they communicate with each other. It should be the same for SSL lighting."

Soraa managed and ran the testing using a custom-built testing panel consisting of an array of commonly used transformers and dimmers and Soraa's 12V<sub>AC</sub> LED MR16 lamps. The panel also accommodated participating firms' transformers, dimmers, and 12V<sub>AC</sub> or 120V<sub>AC</sub> (E26 only) LED lamps or fixtures.

"Manufacturers benefit because Lighting PlugFest addresses compatibility — an obstacle to widespread LED lamp adoption; designers benefit because they can specify with confidence; and end-users benefit because they will know that a particular product combination works," says Soraa's CEO Eric Kim.

[www.soraa.com/news/SIL-plugfest](http://www.soraa.com/news/SIL-plugfest)

## Soitec and Sumitomo Electric sign Smart Cut licensing agreement Partnership for developing GaN substrates for LED lighting applications targets industrialization

Soitec of Bernin, France, which makes engineered substrates including silicon-on-insulator (SOI) wafers and III-V epiwafers, has signed a licensing and technology-transfer agreement under which compound semiconductor materials provider Sumitomo Electric Industries Ltd of Osaka, Japan will use its proprietary Smart Cut technology to manufacture engineered gallium nitride substrates.

The firms says the announcement is a key step in the ongoing strategic alliance, launched in December 2010 to leverage Sumitomo Electric's expertise in materials technology and Soitec's unique Smart Cut layer-transfer technology, to develop the global market for GaN substrates used in LED lighting applications.

The joint development program between Soitec and Sumitomo Electric has already demonstrated the capability to produce 4" and 6" engineered GaN substrates in a pilot production environment.

High-quality, ultra-thin layers of GaN have been repeatedly transferred from a single-source wafer onto multiple substrates developed by Sumitomo Electric. The engineered wafers have exhibited high functionality at a low production cost, say the firms. Having proven the effectiveness of the technology-transfer process, Sumitomo Electric will now industrialize the product and invest in Smart Cut technology.

"Today's announcement represents a very important step in the material roadmap for the compound semiconductor market, and a first step in our strategy," believes Frédéric Dupont, VP of Soitec's Specialty Electronics business unit. "This is the first licensing agreement of our Smart Cut technology to leverage a reusable, expensive base material to bring an economically viable process to this field. Sumitomo Electric's

proven track record in innovative materials development and their in-house manufacturing expertise are key assets in developing the most cost-effective substrate material for high-quality LEDs," he adds.

"By combining the two innovative technologies — Soitec's Smart Cut technology and our high-quality, large-diameter, free-standing GaN substrates — we are able to offer a high-value proposition to our LED customers," says Yoshiki Miura, general manager of Sumitomo Electric's Compound Semiconductor Materials Division. "Soitec's unique material-transfer technology enables the reuse of GaN wafers several times, achieving a substantial reduction in the cost of high-quality GaN materials to serve high-volume applications."

Soitec's Smart Cut technology has been developed in collaboration with microelectronics research laboratories CEA-Leti of Grenoble, France. It uses both implantation of light ions and wafer bonding to respectively define and transfer ultra-thin, single-crystal layers from one substrate to another. It works like an atomic scalpel, allowing active layers to be managed independently from the supporting mechanical substrate. The technology enables the development of new families of standard and custom-engineered wafers. It was made viable for high-volume commercial production by Soitec, and is now protected by over 3000 Soitec-owned or controlled patents worldwide. Soitec leverages Smart Cut technology to manufacture engineered wafers for chipmakers, and holds exclusive rights to use and license the technology to third-party materials and process suppliers.

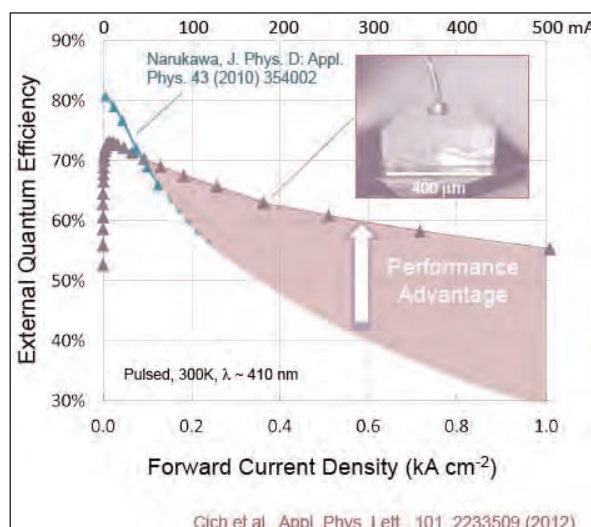
[www.soitec.com](http://www.soitec.com)  
<http://global-sei.com>

## Soraa announces next generation of GaN-on-GaN LEDs

Soraa Inc of Fremont, CA, USA, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates, has announced the next generation of its high external quantum efficiency GaN-on-GaN LEDs. As described in Appl. Phys. Lett. 101, 223509 (2012), the firm's new LED outperforms the best-documented LED laboratory result by Nichia Chemical Co at current densities of 100A/cm<sup>2</sup> and beyond (J. Phys. D: Appl. Phys. 43, 354002).

The record performance is a testament to the vision of company founder and GaN-on-GaN pioneer professor Shuji Nakamura, says chief technology officer Mike Krames. "We have just scratched the surface in terms of performance gains from our GaN-on-GaN LED technology," he reckons.

Soraa reckons that its GaN-on-GaN LEDs handle significantly more current and emit ten times more light per unit area of LED wafer material than conventional LEDs made by depositing GaN layers on cheaper foreign substrates like sapphire, silicon carbide (SiC) or silicon. Its GaN-on-GaN technology



**Soraa's record-performance GaN-on-GaN LED.**

leverages the advantages of the native substrate, including over 1000 times lower crystal defect densities that allow reliable operation at very high current densities (the same principle that enabled Blu-ray laser diodes). In addition to superior crystal quality, the native substrate's optical transparency and high electrical and thermal conductivities enable a very robust, simple LED design that delivers maximum performance, the firm claims. Another advantage of GaN-on-GaN is that it enables consider-

able flexibility in the choice of crystal growth plane.

"We've developed a comprehensive intellectual property program and patent portfolio covering the technology," says Krames.

Soraa leveraged the advantages of its first-generation GaN-on-GaN LEDs by introducing in 2012 what was claimed to be the first true full-visible-spectrum LED MR16 lamps — a superior alternative to 50-Watt halogen MR16 lamps. The firm's LED

MR16 lamps have a color rendering index (CRI) of 95 and R9 of 95 (higher than most halogen lamps) and, compared with halogen lamps, produce no ultraviolet (UV) or infrared (IR); last up to 10 times as long; use 75% less energy; run cooler; produce a much more consistent and efficient beam; and are compatible with existing lamp fixtures and lighting infrastructure.

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

[http://apl.aip.org/resource/1/applab/v101/i22/p223509\\_s1?isAuthorized=no](http://apl.aip.org/resource/1/applab/v101/i22/p223509_s1?isAuthorized=no)

## Soraa receives lighting award from DOE for developing high-efficiency m-plane LEDs on bulk GaN

Soraa has received an award from the US Department of Energy for its work in the development of high-efficiency m-plane LEDs grown on low-defect density bulk GaN substrates. The firm demonstrated a very high peak internal quantum efficiency (IQE of 88%), low efficiency droop (10% from 10A/cm<sup>2</sup> to 100A/cm<sup>2</sup>) and perfect wavelength stability (up to 200A/cm<sup>2</sup>) at a wavelength of 450nm LEDs.

"Research and development of LEDs on bulk GaN substrates is one of the critical approaches to the technological development of Solid State Lighting — a sentiment

recently echoed by the National Academy of Sciences," says Jim Brodrick, manager of the US Department of Energy's Solid State Lighting Program. "We are pleased to recognize Soraa's pioneering work in this area," he adds.

Soraa reckons that its GaN-on-GaN LEDs handle more current and emit substantially more light (about ten times) per area of LED wafer material than the conventional approach of depositing GaN layers on cheaper foreign substrates such as sapphire, silicon carbide (SiC) or silicon. Its GaN-on-GaN technology leverages

the advantages of the native substrate, including lower crystal defect densities (by more than a 1000 times), that allow reliable operation at very high current densities (the same principle that enabled Blu-ray laser diodes). Also, the native substrate advantages of optical transparency and high electrical and thermal conductivities enable a very robust, simple LED design for maximum performance. Another advantage of GaN-on-GaN is the flexible choice of crystal growth plane, which has demonstrated advantages in high peak IQE and low-droop LED performance.



## Luminus ships high-power UV LED in CBT-90 format

At the Photonics West 2013 show in San Francisco (5–7 February), Luminus Devices Inc of Billerica, MA, USA, which makes PhlatLight (photonic lattice) LEDs for solid-state lighting applications, announced that production units of a new high-powered UV Big Chip LED in its CBT-90 form factor are available for immediate delivery.

By providing a high-performance form factor at 405nm, the CBT-90-UV LEDs will help to accelerate the conversion to solid-state UV light sources in industrial markets, the

firm reckons. CBT-90-UV LEDs contain a single monolithic 9mm<sup>2</sup> die that emits directly into air. At a forward current of 13.5A, the LEDs produce a NIST-traceable power output ranging from 7W to 9.1W at 405nm peak-wavelength, suiting UV life science, machine vision and curing applications.

"The CBT-90-UV LED provides all of the traditional advantages of Luminus' Big Chip LED technology, including improved thermal power density and simpler support system architecture, along with delivering

greater wall-plug efficiency than traditional-sized LED dies and arrays," says Mike Lim, director of global industrial and new business. "Luminus engineers designed it to replace traditional UV mercury vapor lamps, and the CBT-90-UV's features provide new high-power LED solutions that also deliver longer lifetimes, greater energy efficiency, the reduction of harmful emissions and the elimination of environmental disposal issues," he adds.

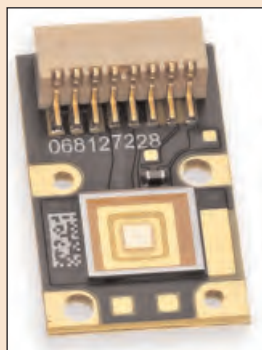
[www.luminus.com](http://www.luminus.com)

## Luminus' PT-39-UV chip brings UV to 3.9mm<sup>2</sup> projection platform

At Photonics West, Luminus introduced engineering samples of a new UV Big Chip LED in its PT-39 form factor (demonstrated driving a 3D printing system).

Containing a single 3.9mm<sup>2</sup> die that maximizes power density by emitting directly into air, the new PT-39-UV LEDs are available in a NIST-traceable power range output of 3.2W in either 385nm or 405nm wavelengths, suiting UV life science, machine-vision and curing applications.

The PT-39-UV enables new UV



The PT-39-UV LED.

applications that had been impractical for mercury UV lamps due to short service life and durability issues, it adds. The new LED solution delivers long lifetimes, robust construction, superior energy-efficiency, plus zero toxic emission

and disposal issues.

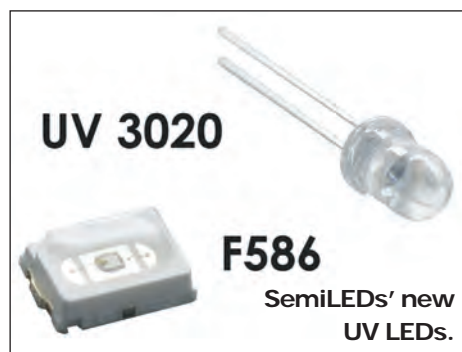
Luminus showcased the PT-39-UV LED's performance by demonstrating a 3D printer, the EnvisionTEC Perfactory Micro desktop rapid prototyping system.

"Luminus' high-power UV-LED platform will accelerate the 3D printing revolution by enabling lower-cost and higher-performance systems that push this exciting technology into new manufacturing markets," reckons Mike Lim, director of global industrial and new business.

## SemiLEDs expands UV LED portfolio with 0.06W series for consumer applications

LED chip and component maker SemiLEDs Corp of Hsinchu Science Park, Taiwan has launched two new 0.06W products to its ultraviolet (UV) LED portfolio. The new series of 3020 PLCC UV LEDs and 5mm through-hole lamp-type UV LEDs incorporate SemiLEDs' patented chip technology to offer what is claimed to be higher performance for cost-sensitive, retail applications.

Both products are available now for sampling and volume production in wavelengths of 365–425nm with typical output power of 5-



15mW at 20mA (power is dependent on wavelength).

SemiLEDs says that the 3020 product series can provide a solution to those looking for an LED

replacement for commercial UV tubes. The 3020 series features what are claimed to be a smaller footprint, excellent thermal properties, and high output power densities in a well distributed light pattern, suiting tube replacement applications.

The 5mm through-hole lamp-type UV LED is designed with a 20–30° beam angle for applications that require more directed and concentrated light in a smaller surface area, such as counterfeit detection and cosmetic retail markets.

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



# Temescal

## The end of the rainbow is closer than you think.

At the heart of every electron beam evaporation system is a vapor cloud—a unique, repeatable flux distribution characteristic of radiation from a point source. But these flux clouds can vary.

With lift-off metallization coating processes on a conventional box coater, an inefficient optimization to the flux cloud typically results in an excessive use of process metals. It's like you're vaporizing money. At Temescal, we have a better way.

At Temescal, we're dedicated to mapping and better understanding the dynamics of the flux cloud. Through extensive testing and research, we have collected hundreds of vapor cloud maps and used these maps to advance and automate the process of lift-off uniformity mask design. We can help you find the pot of gold in your metallization process.

To find out more, visit [www.temescal.net/auratus-gold](http://www.temescal.net/auratus-gold) or call 1-800-552-1215.



**FerroTec**

EMBRACE THE CLOUD

© 2013 Ferrotec (USA) Corporation. All rights reserved. Auratus is a trademark of Ferrotec Corporation.



# Lumileds unveils LUXEON S emitters with 50lm/mm<sup>2</sup> lumen density and high center beam candle power

At the Strategies in Light 2013 conference in Santa Clara (12–14 February), LED maker Philips Lumileds of San Jose, CA, USA launched the second-generation of its LUXEON S illumination-grade multi-chip emitters, offering twice the lumen density of existing solutions — an R9 value that exceeds 80 and 50% better color over angle (COA) variation.

Designed for retail, architectural and entertainment applications, LUXEON S emitters deliver up to 50 lumens per square millimeter and a high light output of up to 8000 lumens in narrow beams with sharp shadows.

Because of the challenges in creating a small footprint with tight beam angles and high lumen density, luminaire designers have had to deal with large optics and limited lumen levels. Lumileds says that, with LUXEON S, luminaire designers have more flexibility and can achieve beam angles in the 8° range in a compact design, with



**LUXEON S1000, S2000, S3000 and S5000 emitters simplify design of compact spotlights and downlights for architectural, retail and entertainment lighting solutions.**

light levels that rival traditional CDM light sources. This flexibility enables unprecedented center beam candle power (CBCP) of over 50,000 candela, compared to other LEDs like chip-on-board (COB) solutions with a larger light-emitting surface (LES) that achieve less than 20,000–25,000 candela, it is claimed.

“With a lumen density that is twice that of available solutions, the LUXEON S can offer light outputs as high as 8000 lumens at half of the optical size, enabling LED approaches to replace traditional ceramic discharge metal-halide (CDM) lamps in spotlight and architectural applications,” says Orson Lo, director of LUXEON S products. “Relative to CDM lamps, LUXEON S-based lamps offer comparable efficacy of 90lm/W but with instant-on operation, better color consistency and four times the expected lifetime at 60,000 hours.”

The new emitters feature correlated color temperatures (CCTs) of 2700K and 3000K with a CRI of 80 or 90, as well as 3500K, 4000K and 5000K at a CRI of 80. In the 90 CRI products, R9 value exceeds 80, making them suitable for applications requiring exceptional color renderings (such as in premium retail and museum applications).

[www.philipslumileds.com/products/luxeon-s](http://www.philipslumileds.com/products/luxeon-s)

## Lumileds launches die-level LUXEON Flip Chip LEDs for greater luminaire design flexibility

Philips Lumileds has launched new LUXEON Flip Chip LED devices (in a 1mm x 1mm format) to provide luminaire manufacturers with more design flexibility. Users can now access Lumileds technology through a robust LUXEON Flip Chip die format, giving them greater design options than previously.

“Now luminaire manufacturers can enjoy the best of both worlds, by either incorporating packaged LEDs as they did in the past, or by starting with the LED die and customizing the phosphor and packaging to best suit their lighting application,” says CEO Pierre-Yves Lesaichere.

While traditional wire bonding limits the packing and power density of LEDs, LUXEON Flip Chip



**Robust design of Flip Chip LED die enables high lumen output per dollar.**

LEDs can be packaged closer and can be driven at a higher current density. This requires fewer emitters to achieve a higher lumen output at higher lumen densities, a capability that is especially advantageous with chip-on-board (COB)



**Large p and n bond pads improve Flip Chip packaging reliability.**

and other high-power applications.

“The end result is that luminaire manufacturers can achieve higher lumens per dollar through higher lumen densities and a straightforward packaging process,” says Lesaichere.



# THE NEW BAK... BECAUSE NOT ALL EVAPORATORS ARE THE SAME!



Raise your performance to a new level with custom sources, cassette to cassette handling and our new '**on line**' reoptimisation mid process to increase yield and reduce costs. To see the new brochure visit the Evatec website or contact your local sales office. [www.evatecnet.com/products/bak-evaporators/](http://www.evatecnet.com/products/bak-evaporators/)

Visit us at booth 3571 at Semicon China. March 19 - 21.



MORE INFO

LEDs • POWER DEVICES • TELECOMS • PHOTOVOLTAICS • MEMS • EVATEC - THE THIN FILM POWERHOUSE

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



## Bridgelux appoints Bradley J. Bullington as CEO; Bill Watkins to become chairman

LED chip and lighting array maker Bridgelux Inc of Livermore, CA, USA says that its board of directors has appointed Bradley J. Bullington — VP, Strategy and Corporate Development & general manager, Technology Solutions — as CEO. William Watkins has moved up to chairman of the board of directors, having served as CEO since January 2010.

Bullington joined Bridgelux from Seagate in 2010 (where he worked with Watkins) and has been responsible for overall business strategy and all corporate and market development activities, including strategic partnerships and joint venture development, technology licensing, capital formation and the legal function. He also ran Bridgelux's Technology Solutions business.



**Bill Watkins.**

"Brad has driven Bridgelux's strategic direction and corporate development initiatives since joining the company when I came aboard," says Watkins. "I look forward to working with him to ensure a smooth transition, as well as going forward as Bridgelux enters its next phase of growth," he adds.

"Bill has restructured and recapitalized the company, nurtured and developed our leadership position in GaN-on-silicon, and significantly strengthened Bridgelux's position in the rapidly growing global lighting market," comments Alan Salzman, CEO & managing partner of VantagePoint Capital Partners.

"Bridgelux will continue to benefit from Bill's tremendous knowledge, expertise, and guidance."

Prior to joining Bridgelux, Bullington held executive strategy, corporate and business development roles at Seagate Technology from 2006 to 2009. He held similar positions at Maxtor Corp, where he was also a founding member of Maxtor's Branded Products Group (BPG), an industry pioneer in the external storage solutions market. Prior to entering the data storage industry, he was a management consultant for A.T. Kearney, where he served a range of clients focused on issues of strategy and operations in the software and technology hardware, aerospace, retail and financial services industries. He began his professional services career at Deloitte & Touche.

## Bridgelux showcases and demos new products at Strategies in Light

At Strategies in Light in Santa Clara (12–14 February), Bridgelux's director of marketing Aaron Merrill led a session on 'Simplified Connectivity and Higher Flux Density LED Packages' during the LED & Lighting Technology Track. Merrill provided insight into the future of LED lighting as manufacturers embed more functionality in their systems while streamlining the design of driver, thermal and optical solutions (which



**VERO LED arrays.**

promise to lead to applications and features such as motion or temperature sensing, architec-

turally integrated lighting and wireless communication as well as lower prices and better performance).

Also, at the Strategies in Light exhibition, Bridgelux demonstrated its new VERO LED array (which — through advances in design flexibility, ease of use and energy efficiency — boosts lumens per watt output by up to 20% over existing Bridgelux LED arrays).

[www.bridgelux.com/products/vero.htm](http://www.bridgelux.com/products/vero.htm)

## Bridgelux celebrates 10th anniversary as ITO power LED surpasses 5.5 years of continuous reliability testing

Bridgelux celebrated its 10th anniversary by announcing that one of its LEDs has completed a record 48,000 consecutive hours (5.5 years) of reliability testing.

The MKO 45mm LED chip — one of the first high-power indium tin oxide (ITO) technology LED chips developed for commercial applications — continues to deliver 97% of its

initial lumen output in the test. The chip is on track to deliver a lifetime performance of over 120,000 hours (nearly 14 years) while still delivering 70% of its initial lumen output at elevated temperature and current.

"This may be the longest continuous reliability test for this ITO power chip generation," believes chief technology officer Steve Lester.

"The industry has always stated that its chips could deliver this kind of performance over the long haul. Bridgelux has empirically demonstrated that its products can deliver on this promise with actual data," he adds. "This evidence is clearly transferable to the reliability of Bridgelux chips used in solid-state lighting."

# Multi-tasking micro-LEDs targeted at Wi-Fi-like communications, while displaying information and illuminating homes

## Four-year £4.6m program funded by UK's EPSRC

With the target of drawing academic and industrial expertise together to address the solid-state lighting/electronics interface and its implications for custom-controlled lighting systems, Scotland's University of Strathclyde is already establishing the Intelligent Lighting Centre (ILC) in its Technology and Innovation Centre (TIC, a £103m research and innovation hub currently under construction). Now, it is also leading a new £4.6m four-year program 'Ultra-parallel visible light communications: UP-VLC', funded by the UK Engineering and Physical Sciences Research Council (EPSRC) from September 2012 to August 2016, which is investigating solid-state lighting for next-generation optical communications. The program aims to pioneer new data communications infrastructure based on solid-state lighting, where lighting components provide both illumination and an ultra-high-bandwidth 'light fidelity (Li-Fi)' technology complementary to traditional radio wave and microwave Wi-Fi wireless communications.

Although the potential possibilities offered by Li-Fi are already being explored globally, a consortium of UK universities is pursuing a distinctive vision that could deliver enormous benefits, it is reckoned.

"Imagine an LED array beside a motorway helping to light the road, displaying the latest traffic updates and transmitting internet information wirelessly to passengers' laptops, netbooks and smartphones," says professor Martin Dawson of the University of Strathclyde's Institute of Photonics. "This is the kind of extraordinary, energy-saving parallelism that we believe our pioneering technology could deliver."

"The Universities of Cambridge, Edinburgh, Oxford and St Andrews are all working with us, bringing



**UP-VLC project leader Martin Dawson, professor at University of Strathclyde.**

specific expertise in complementary areas that will equip the consortium to tackle the many formidable challenges involved — in electronics, computing and materials, for instance — in making this vision a reality," Dawson says. "This is technology that could start to touch every aspect of human life within a decade."

Imperceptibly, LEDs flicker on and off thousands of times a second. By altering the length of the flickers, it is possible to send digital information to specially adapted PCs and other electronic devices. This would make the visible part of the electromagnetic spectrum available for internet communications, easing pressure on the increasingly crowded parts of the spectrum currently being used, it is reckoned.

But rather than developing Li-Fi LEDs around 1mm<sup>2</sup> in size (on

which other research concentrates), the EPSRC-funded team is developing micron-sized gallium nitride (GaN)-based LEDs that potentially offer major advantages, it is reckoned.

First, the LEDs are able to flicker on and off 1000 times quicker than the larger LEDs, so they can transmit data more quickly. Second, 1000 micron-sized LEDs would fit into the space occupied by a single larger 1mm<sup>2</sup> LED, with each LED acting as a separate communication channel. A 1mm<sup>2</sup>-sized array of micron-sized LEDs could therefore communicate 1000 x 1000 (i.e. 1 million) times more information than one 1mm<sup>2</sup> LED.

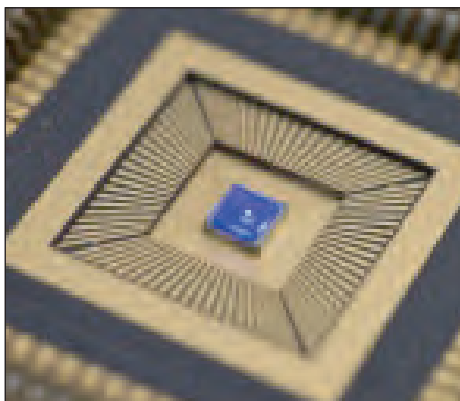
Each micron-sized LED would also act as a minute pixel. So one large LED array display — for example, used to light a living room, a meeting room or the interior of an aircraft — could also be used as a screen displaying information, at the same time as providing internet communications and lighting.

Eventually, it could be possible for the LEDs to incorporate sensing capabilities too, reckon the researchers. For example, a mobile phone could be equipped with a flash that — when pointed at a shop display in which every item has been given an electronic price tag — could display the price of these items.

Spin-out companies related to this research include Glasgow-based mLED Ltd and Edinburgh-based pureVLC Ltd.

For more information, see the audio slide show 'Li-Fi Multi-tasking micro-lights could spark a communications revolution' at:

[www.youtube.com/user/EPSRCvideo?feature=mhum](http://www.youtube.com/user/EPSRCvideo?feature=mhum)  
[www.strath.ac.uk/Departments//Photonics](http://www.strath.ac.uk/Departments//Photonics)  
[www.mled-ltd.com](http://www.mled-ltd.com)  
<http://purevlc.com>



**A GaN microLED array made by mLED.**



# Cree grows quarterly revenue 10% to record \$346m

## Net income rises 69% to \$20.4m

For its fiscal second-quarter 2013 (to end-December 2012), Cree Inc of Durham, NC, USA has reported revenue of \$346.3m, up 10% on last quarter's \$315.8m and up 14% on \$304.1m a year ago. On a non-GAAP basis, net income was \$36.9m (\$0.32 per diluted share), up from \$31.8m (\$0.27 per diluted share) last quarter and \$28.7m (\$0.25 per diluted share) a year ago.

"Fiscal Q2 was another strong quarter with record revenue and earnings per share higher than our target range due to stronger sales in both LEDs and lighting, combined with improved gross margins that more than offset higher operating expenses [up \$2m on last quarter to \$88.4m due to higher sales & marketing spending that supported the higher revenue]," said chairman & CEO Chuck Swoboda.

"Revenue trends in Q2 were as follows: lighting sales increased more than \$14m (or 14%) from Q1 [to \$122.7m], as we saw a better-than-targeted growth for both our indoor and outdoor product lines; LED sales increased more than \$13m (or 7%) from Q1 [to \$201m], which was on the high side of our target for the quarter; power & RF sales increased more than \$2m from Q1 [to \$22.6m], which was slightly higher than our target for the quarter," he added.

Between Q1 and Q2/2013, gross margin on a non-GAAP basis increased from 37.5% to 39.2% (above the targeted 38.5%), driven by factory cost reductions, improved production yields, product mix, lower cost of new products, and higher factory utilization. Cash and investments increased \$69.5m to \$885.8m due to good working capital management, focused capital spending and higher profitability.

Swoboda described the firm's Q2 highlights as: releasing its 200lm/W XLamp MK-R LED; launching the LM16 LED lamp (designed to replace halogen MR16 lamps);

launching XLamp XM-L2 LEDs (said to be the industry's brightest single-die LEDs, delivering 186lm/W); and releasing the industry's first fully qualified, production-ready, all-SiC power module. Notable new installations include over 130 locations of US restaurant chain Sheetz, which now feature LED lighting by Cree.

"Overall company backlog is in line with seasonal trends for our fiscal Q3," notes Swoboda. For fiscal Q3/2013 (to end-March), Cree is targeting revenue of \$325–345m. On a non-GAAP basis, gross margin is expected to rise slightly to about 39.5% (excluding stock-based compensation expense of about \$2.4m), as Cree builds on momentum from the last several quarters while it continues to target incremental gains and factory efficiency and the benefit of higher new product sales to offset price decline. Operating expenses should be similar to Q2. Net income is targeted to be \$35–41m (\$0.30–0.35 per diluted share, excluding expenses related to the amortization of acquired intangibles and stock-based compensation expense of \$0.15 per diluted share).

"Longer term, we remain focused on driving adoption through innovation. We see opportunities to move the market even faster," says Swoboda.

At the announcements of the results, Swoboda gave more information about his objectives and views on likely market conditions. He detailed Cree's four key priorities that the firm is focusing on.

"Firstly, to accelerate adoption of LED lighting and increase sales of our indoor and outdoor lighting products. [Our] lighting product line grew 14% sequentially in Q2 due to strong sales for both indoor and outdoor products. Sales growth is coming from a combination of new products and overall momentum in our sales channels.

"Our second priority is to drive

growth in our LED component product line through innovation by leveraging the SC<sup>3</sup> LED technology into new products. We saw an increase in SC<sup>3</sup> product sales in Q2, and based on the design activity, so we target this product family to continue to increase as a percentage of LED sales over the next few quarters.

"Thirdly, we want to leverage our technology lead in power and RF areas to open a new generation of applications for these products. We released our first all-silicon carbide high-frequency power module, which sets a new standard as the industry's first fully qualified all-silicon carbide module. The new high-frequency module, which is targeted at power converters and high-voltage transportation applications, is rated at 100A current handling and 1200V blocking.

"Cree's fourth priority is our ongoing effort to translate our product innovation into revenue and profit growth. Our new products are driving growth in sales for LED lighting, LED component and our power and RF product line."

In conclusion, Swoboda added, "We remain focused on driving adoption through innovation. Our new products have improved payback and fueled growth in LED lighting. Based on the trends over the last — over the past few quarters, I think it is clear we're on the right track. Despite our success, we are not satisfied with the rate of LED lighting adoption."

"With Cree's broad understanding of the technology levers from materials through systems, we see opportunities to move the market faster. LED lighting is not an incremental improvement for the lighting industry. It is a completely new way to deliver light... we continue to be intensely focused on our long-term goal of 100% upgrade to LED lighting."

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

*Matthew Peach, Contributing Editor*

## Cree sets efficacy record of 276lm/W for white R&D power LED

Cree has claimed an industry first with a record 276 lumen-per-watt white R&D power LED, exceeding its previous industry record of 254lm/W (announced last April).

Cree says that the record R&D result has been enabled by its SC<sup>3</sup> Technology Platform (currently available commercially in its XLamp LEDs), which features advances in LED chip architecture and phosphor as well as a new package design.

Cree says that the LED efficacy was measured at 276lm/W at a correlated color temperature (CCT)

of 4401K using a drive current of 350mA.

"The core of the Cree R&D culture is a relentless focus on innovation that ultimately drives LED adoption," says co-founder & director of advanced optoelectronics John Edmond. "The innovation from our labs is the foundation for our lighting-class XLamp LEDs," he adds. "Higher-performance LEDs can enable new and better LED-based applications and drive down the solution cost of LED designs."

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

## Cree launches CR Series LED troffer family

Cree has introduced the CR Series LED Architectural High-Efficacy (HE) troffer, with 130lm/W and 90 CRI (color rendering index). Furthermore, the firm is increasing the efficacy of the standard CR family to 100lm/W.

Cree is further expanding the CR troffer line with the new CR Series High-Definition (HD) troffer, featuring 80+ CRI with enhanced color spectrum and high R9 values via Cree's proprietary color-mixing and tuning technology. HD technology delivers higher color quality than traditional 80-CRI fluorescent troffers, says Cree.

Cree's CR Series offers a ten-year warranty and is designed to provide a lifetime of up to 100,000 hours. Its thermal management system and room-side heat sink

enable the LEDs to consistently run cooler, providing significant boosts to lifetime, efficacy and color consistency, adds the firm. The CR Series HE troffer consumes nearly 60% less energy than a comparable linear fluorescent 34-W T12 system and nearly 50% less when compared to an existing 32-W T8 system.

The CR Series troffer family is available in three models (the CR14 1x4, the CR22 2x2 and the CR24 2x4) and in a range of correlated color temperatures to match existing fluorescent technologies (3000, 3500 and 4000K), plus a new 5000K for all CR Series LED troffers. Dimming control down to 5% and emergency backup features are also available.

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

## Interim CFO now chief financial officer

Cree has appointed Mike McDevitt as executive VP & chief financial officer (CFO). McDevitt has more than two decades of finance and operations leadership and has been VP & interim CFO since 22 May 2012.

"After conducting an exhaustive national search, we realized Mike is the best candidate for the job," says Cree's chairman & CEO

Chuck Swoboda. "Mike's proven leadership will help Cree drive innovation and accelerated adoption of LED lighting."

Prior to being interim CFO, McDevitt held several key roles at Cree including director of Sales Operations in 2011–2012, director of Financial Planning in 2005–2011, and corporate controller in 2002–2005.

### IN BRIEF

## Cree adds KR4 LED downlight, with higher lumen output, 4" aperture and expanded options

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has extended its KR Series LED downlight portfolio, delivering improved performance at pricing to match incumbent fluorescent downlights. With new lumen packages of up to 2650 delivered lumens, the KR Series replaces 18–42W fluorescents.

Cree is further expanding the range of LED downlight applications by introducing the KR4 downlight, which features a high-lumen, 4-inch aperture, with options similar to the 6-inch KR6 downlight. With new standard 0V to 10V dimming, sloped-ceiling and wall-wash trim options, the KR Series downlights provide aesthetic appeal for numerous commercial and retail applications, the firm reckons.

"The KR Series LED downlights are ideal for new construction applications," says Greg Merritt, vice president, Lighting. "With the increased range of LED options now available at price parity to fluorescent-lighting incumbents, I see no reason to ever specify a CFL [compact fluorescent lamp] downlight," he adds.

Built with Cree TrueWhite Technology, the KR Series downlight family is available in a wide range of color temperatures (2700K, 3000K, 3500K and a new 4000K), all with 90+ color rendering index (CRI). To help facilitate utility rebates, the KR Series is currently in the process of ENERGY STAR qualification.

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

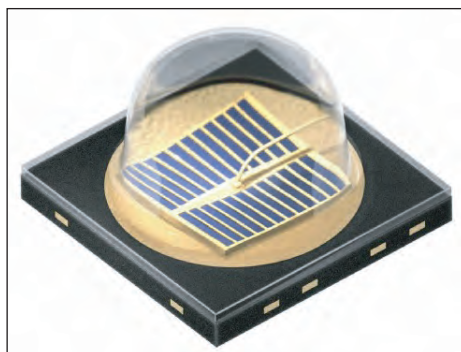


## Osram launches black Oslon 940nm infrared LED for discreet security applications

Osram Opto Semiconductors GmbH of Regensburg, Germany says that, not only does its new infrared Oslon black SFH 4725S emit light at a wavelength of 940nm (making it virtually invisible to the human eye) but its black package reflects almost no ambient light. Together with its high optical output of almost 1 watt, the LED is suitable as a light source for covert surveillance.

Concealed security systems – such as those installed in banks, on machinery and at border controls – need to be designed so they are unobtrusive. This is a major challenge for IR illumination in such applications, because the 850nm LEDs that are most often used appear as weak dots of red light, especially in dark environments, says Osram Opto. The solution is to switch to a wavelength of 940nm, which the human eye is 130 times less likely to notice. Camera sensors, however, can easily detect this invisible radiation.

The compact Oslon black SFH 4725S infrared LED provides 940nm light with high optical out-



**Oslon black SFH 4725S 940nm IR-LED.**

put of 980mW from an operating current of 1A. Behind this high performance lies Nanostack technology, in which Osram has succeeded in providing two emission centers in one chip, almost doubling the light output. The SFH 4725S achieves a radiant intensity of 450mW/sr at an emission angle of 90° and therefore provides what is claimed to be excellent illumination over the area being monitored. Radiant intensity (measured in milliwatts per steradian) indicates the light output within a solid angle segment and hence defines the intensity of the light beam.

The black package ensures that the component is completely concealed behind the camera lens. "The 940nm SFH 4725S is a further addition to our Oslon black series for the security sector, which already includes 850nm versions with standard and Nanostack chips," says Dr Jörg Heerlein, head of product marketing for industrial infrared components.

Osram Opto claims that, in the compact class, the Oslon is currently one of the most powerful versions for both visible and infrared illumination. Measuring only 3.85mm x 3.85mm x 2.29mm, the infrared Oslon components are among the smallest IREDs, with around 1W optical power, the firm adds. Its beam angle is  $\pm 45^\circ$ . "Users with experience in constructing visible lighting units can transfer their know-how and their processes directly to the infrared Oslon," comments Heerlein. The market is also full of lenses that designers can use to shape the beam from the IRED to meet their specific requirements.

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

## DILAS' lightweight, fiber-coupled T-bar module meets critical metrics for defense market

Diode laser maker DILAS of Mainz, Germany says that its new fiber-coupled tailored bar (T-bar) module meets the critical metric of <1kg/kW of overall module weight to optical output power, while maintaining nearly 50% efficiency.

In terms of specifications, the fiber-coupled module produces >300W output power at a wavelength of 976nm from a 200µm-diameter fiber with a numerical aperture (NA) of 0.22 in a total package weight of ~300g. The device is also of suitable brightness to meet the requirements for flyable systems on lightweight aircraft and unmanned aerial vehicle (UAVs).



**DILAS' fiber-coupled laser module.**

DILAS says that the key innovation is the combination of the high-power, high-brightness, tailored diode laser bar and the lightweight, compact, low-thermal-impedance heat sink. In addition, micro-optics

attachment is completely automated, which optimizes the beam quality from the diode laser bar, enabling high-efficiency fiber coupling.

The firm reckons that exceeding this critical weight-to-power ratio of 1kg/kW is a milestone for high-brightness fiber-coupled diode lasers. In addition to defense applications, potential applications in other markets are opened up, including industrial and medical where the overall size, weight reduction, and efficiency can reduce system ownership and operating costs.

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

## Versatilis spins out new venture VerLASE

### Sample direct-emitting green laser products targeted by end-2013

Technology development firm Versatilis LLC of Shelburne, VT, USA has spun out VerLASE Technologies LLC, a new venture in lasers and solid-state lighting that aims to further develop and commercialize technology that it has been developing (in stealth mode) over several years. Using novel materials and processes, surface-emitting laser diodes and novel LEDs are an early product focus, including sources that emit directly at green wavelengths. The initial private investment round was led by Hong Kong-based private investment group Wakley Ltd (which focuses on high-tech ventures with significant intellectual property in high-growth energy markets).

LEDs and laser diodes currently emit light in wavelengths limited by the materials technology used. In the visible spectrum, these are mainly in blue or red colors. In LEDs, phosphors are then used to convert the light into other colors (including white), with associated losses in efficiency and increased costs. In laser diodes, colors such as green are typically achieved by frequency doubling, which limits the efficiency and wavelengths that can be attained.

Versatilis claims that VerLASE's technology circumvents these problems to obtain very high-brightness light sources emitting light directly at novel wavelengths and lower costs.

"We have a different materials approach to laser diodes, for example, that can enable devices emitting directly in green and other colors," says Versatilis' CEO George Powch, who will lead the new firm, together with CTO Ajay Jain (the inventor of the technology) as VerLASE's chief technology officer. VerLASE says that it is working with key partners to demonstrate working devices, and plans to selectively sample its first products by the end of 2013. Early discussions are ongoing with prospective manufacturing partners.

Funded by private investors specializing in technology ventures, Versatilis was founded by Jain and Powch in 2004 to focus on advanced materials and manufacturing processes for specialized applications in industries ranging from defense to flexible displays to solar cells. It works with research universities including Albany's College of Nanoscale Science and Engineering (CNSE), where Versatilis is a member of the iCLEAN Incubator, and with associates and partners worldwide. The firm has won Small Business Innovation Research (SBIR) awards from US Government agencies including the Department of Energy (DOE), the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research (ONR) and the Army Research Laboratory (ARL). It is a 2006 winner of the National Roland Tibbetts Award for SBIR Excellence, and a 2011 Finalist of the New Energy Symposium at the New York Academy of Sciences. The firm has licensed several of its technologies.

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



## Solutions for HIGH BRIGHTNESS

# LED

## Manufacturing

- Optical lithography and resist processing solutions
- Wafer bonding for layer transfer
- Nano Imprint Lithography for patterned sapphire substrates PSS
- Handling and processing of thin and bowed wafers

**EV Group launches  
second-generation  
EVG®620HBL Mask  
Alignment System for  
LED Manufacturing**



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





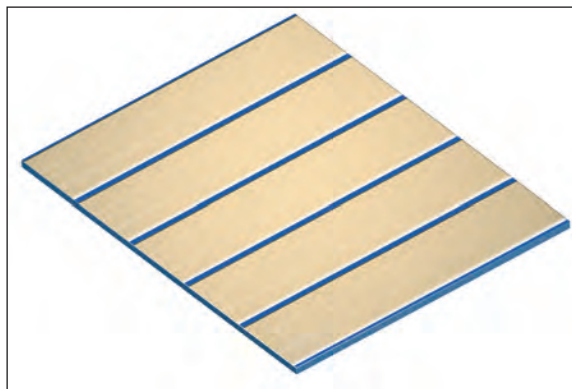
# Osram coordinating BMBF-funded project IMOTHEB to develop high-brilliance IR laser sources

## Goal to boost output by 40% and lower cost of laser systems for materials processing

To help improve the performance of laser systems while reducing production costs, Osram Opto Semiconductors GmbH of Regensburg, Germany is coordinating the project IMOTHEB (Integrated microoptical and microthermal elements for diode lasers of high brilliance) as part of the 'Integrated Microphotonics' initiative. The project partners are DILAS Diode Laser and the non-profit research organization Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI). The project runs from 1 October 2012 to 30 September 2015 and is being supported by the German Federal Ministry for Education and Research (BMBF).

Diode-pumped high-power laser systems for materials processing applications such as cutting and welding are playing an increasingly important role in industry, says Osram Opto. Their advantages over carbon dioxide lasers and lasers pumped with flash lamps include lower operating costs, greater efficiency and smaller size. Fiber lasers and fiber-coupled diode lasers are becoming increasingly important for optical materials processing. But as the lasers become more widespread, the focus is shifting to the issue of cost. Developments that increase the performance of laser systems, and at the same time reduce production costs, are necessary to move this market forward, says the firm. Infrared semiconductor laser diodes that can be used to pump fiber lasers are key components in this area, offering enormous potential for automating production and miniaturizing the systems while reducing the number of semiconductor chips needed thanks to the increased performance they provide, it adds.

The objective of the IMOTHEB project is to investigate new



**Prototype high-power laser bar, developed by Osram Opto in IMOTHEB project.**

approaches and technologies that may ultimately lead to significant reductions in the cost of the pump modules, including the semiconductor lasers and also the cooling elements, optics and sensors. There are also plans over the course of the project to increase the output of semiconductor lasers by 40% while retaining the same high beam quality.

IMOTHEB maps the entire value-added chain from the semiconductor chip to the complete laser system. The project partners bring their own specific areas of expertise:

- Osram Opto Semiconductors is coordinating the project and offering its expertise in semiconductors,

- laser diodes and laser bars (simulations are being sub-contracted to the Fraunhofer Institute for Applied Optics and Precision Engineering);
- diode laser maker DILAS of Mainz, Germany is responsible for the assembly technology (with improved thermal resistance and higher integration in laser modules) as well as for automation in module production; and

- the Max Born Institute is acting as a scientific partner, analyzing and characterizing the chips and modules.

Osram Opto has set the goal of achieving a higher degree of integration at the semiconductor level, increasing the brilliance of infrared laser diodes by integrating micro-optical and microthermal elements directly on the chip. Over the course of the project, the target is to increase output by 40% compared with the current best values while retaining the same high emission quality. If these high outputs are achieved, they will make laser chips suitable for fiber laser pump modules and for fiber-coupled diode lasers.

"We need results that bring not only technical but also economic benefits to strengthen our competitive position," says Dr Alexander Bachmann, project leader at Osram. "Based on results from the project, our brilliant laser diodes should provide more output into the fibers so that fewer chips are needed in the system and the laser systems therefore become more efficient and more cost-effective."

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



**Higher output from laser diodes and new automated assembly processes for laser systems are targeted at industrial applications.**

# HexaTech claims record threshold of 85kW/cm<sup>2</sup> in optically pumped 264 and 280nm lasers

## AlN substrate platform demonstrated for UV-C laser fabrication

In a parallel effort to its development of UV-C light-emitting diodes (LEDs), HexaTech Inc of Morrisville, NC, USA recently demonstrated optically pumped AlGaIn-based lasers grown on single-crystalline aluminium nitride (AlN) substrates.

Laser structures fabricated at HexaTech and tested in collaboration with North Carolina State University (NCSSU) featured lasing thresholds as low as 85kW/cm<sup>2</sup> at wavelengths of 264nm and 280nm. HexaTech says that this not only represents record laser performance but also further validates its AlN substrate platform for UV-C optoelectronic applications.

"Our recent results show convincing evidence of the feasibility of a solid-state UV-C laser," comments Dr Andy Xie. "The tests not only demonstrate lasing at low pump intensities, but we also observed emission peak line widths as narrow as 0.02nm, and further tell-tale signs of a properly operating laser, including spectrally resolved cavity modes, TE-mode polarization, and elliptically shaped far-field patterns."

HexaTech reckons that the observed lasing at low pump intensities is a key milestone toward the development of semiconductor lasers operating at short wavelengths in the UV-C range. Enabled by its low-dislocation-density bulk AlN substrates, the results add to the record UV-C LED and laser performance reported by other groups, the firm comments. The use of high-quality, native AlN substrates that are lattice-matched to the overgrown III-nitride device layers allows the fabrication of optoelectronic devices of superior structural quality and hence previously unachievable performance, HexaTech adds.

There is a growing market opportunity for UV-C lasers used for

chemical, biological, and explosive material detection. "HexaTech's core expertise in AlN crystal growth and wafer fabrication has already led to the development of world-class UV-C LEDs with previously

unachievable device lifetimes," claims CEO Joe Grzyb.

Technical details will be published in the scientific literature in the near future.

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

**Burr-free  
micro drilling**  
*that meets your most  
demanding requirements.*

### Drilling Capabilities

- all drilling and inspection performed under climate-controlled conditions
- micro drilling down to .0020" dia. and 10 times dia. in depth
- drilling of a wide range of materials, from plastics and ceramics to tool steel, aluminum, copper and brass

**RIFF  
COMPANY, Inc.**

1484 Highland Avenue • Cheshire, CT 06410 USA

Tel +1 203 272 4899 • [micro-drilling@riff-co.com](mailto:micro-drilling@riff-co.com)

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



## OPEL completes CDN\$7.2m private placement to fund commercialization of POET technology

### CDN\$1.3m to be spent on acquiring equipment

OPEL Technologies Inc of Toronto, Ontario, Canada has completed a CDN\$7.2m private placement (14,400,000 units at a price of CDN\$0.50 each), which was oversubscribed from the original 11,000,000-unit CDN\$5.5m private placement (announced on 5 February).

Each unit consists of one common share and one common share purchase warrant (allowing the holder to acquire one common share at an exercise price of CDN\$0.75 per share until 14 February 2015). The private placement was conditionally accepted by the TSX Venture Exchange. The securities issued will be subject to a hold period that expires on 15 June.

The firm paid cash commissions of 7% of the funds raised and issued

broker warrants equal to 10% of the units raised (each allowing the holder to acquire one common share of OPEL at a price of CDN\$0.50 until 14 February 2016).

OPEL says that the new funding will provide it with the capital required to complete a CDN\$1.3m equipment acquisition, fund internal and third-party development efforts at US affiliate OPEL Defense Integrated Systems (ODIS Inc) of Storrs, CT, as well as funding general administrative expenses and working capital. With the capital in place, OPEL is in a position to continue development work towards its previously announced milestones and its strategy for monetization of ODIS' POET technology.

The POET process enables monolithic fabrication of gallium arsenide

(GaAs) integrated circuits containing both electronic and optical elements on a single wafer, with potential high-speed and power-efficient applications in devices such as servers, tablet computers and smartphones. III-V semiconductor devices developed by ODIS include infrared sensor arrays and ultra-low-power random access memory.

OPEL's board recognizes its member, executive director Peter Copetti, who collaborated with the firm's agent IBK Capital Corp to complete the fundraising in a rapid time frame. The firm says that Copetti's efforts since joining the board have been instrumental in its return to solid financial health.

[www.opeltechinc.com](http://www.opeltechinc.com)  
[www.odisinc.com](http://www.odisinc.com)

## Management buyout from Enablence re-launches Albis

Following a buyout initiated by local management, coordinated by industry veteran Joerg Wieland and supported by a team of European private investors, Albis Optoelectronics AG of Rüschlikon near Zurich, Switzerland (the name by which the firm was previously known from 2003 to 2008) has re-emerged as a brand for high-speed photodetectors.

Albis was established in 2003 (based on more than 20 years of expertise in technology and product design, following the acquisition of a former Opto Speed business line). However, in March 2007 it was acquired by Enablence Technologies Inc of Ottawa, Canada (which develops fiber-to-the-home transceivers for optical modems), becoming the Active Components Group within its Optical Components and Subsystems Division.

Albis is an ISO-certified designer and manufacturer of high-speed GaAs- and InGaAs-based PIN and

avalanche photodiode (APD) single-channel and array photodetectors for fiber-optic datacom and telecom applications. The product portfolio supports 10G, 40G and 100G communication links as well as analog microwave applications. Fabrication facilities (including a class 100 cleanroom and test and qualification laboratories) offer full in-house production (from front-end to back-end) of products for emerging markets as well as customer-specific modifications.

"During the past 5 years, demand for our photodiode products has grown steadily, with an average growth rate of 35% year over year," says CEO Vincent Grundlehner. "As we see the enormous potential of our technology, we are obviously very excited to be masters again of our own business," he adds.

The firm says that the management buyout allows for the execution of growth initiatives such as an expanded product portfolio, a

higher level of production automation, and a strengthening of customer support functions.

At the Optical Fiber Communication Conference & Exposition and National Fiber Optic Engineers Conference (OFC/NFOEC 2013) in Anaheim, CA (19–21 March), Albis is unveiling a further expansion of its high-speed photodetectors portfolio.

Investors backing the firm bring a broad industry network and share the long-term focus to expand its global reach. "As seasoned technology entrepreneurs, we understand the value of a strong management team combined with a solid balance sheet," says Falk Strasczeg, reckoned to be one of the most experienced private equity investors in Germany. "Considering the operational success of the company throughout the past ten years, we gladly took a substantial stake in Albis."

[www.albisopto.com](http://www.albisopto.com)  
[www.enablence.com](http://www.enablence.com)



# Wafer Technology

## - the universal choice

Wafer Technology's unrivalled range of materials, crystal growth techniques and product forms, provides high quality material solutions, whatever the application.

- Epitaxy Ready Wafers
- Polycrystalline Materials
- As-Cut Wafers
- MBE Source Materials
- Sapphire Wafers
- Speciality Materials

**GaAs InP InAs InSb GaSb** for all your III-V needs



WAFER TECHNOLOGY LTD

Head Office and Manufacturing Plant

34 Maryland Road Tongwell Milton Keynes Bucks MK15 8HJ England United Kingdom

Telephone: +44(0)1908 210444 Facsimile: +44(0)1908 210443

www.wafertech.co.uk sales@wafertech.co.uk



ISO9001:2000, Certificate No.: FM 26963  
ISO14001:2004, Certificate No.: EMS 502245



## Oclaro shrinks red lasers by 75% for 4-beam and 80% for 8-beam while improving printing quality

Optical components, modules and subsystems developer Oclaro Inc of San Jose, CA, USA has announced advances in its red laser diodes that has enabled it to reduce the size of 4-beam red laser diodes by 75% (from TO9.0mm to TO5.6mm) and 8-beam red laser diodes by 80% (from TO16.0 to TO9.0mm).

The firm reckons that the size reductions will enable customers designing laser beam printers (LBPs) and multi-function printers (MFPs) to design smaller and more compact printers or to utilize the extra space for adding more features and functionality. In addition, Oclaro has improved the printing quality of its red laser diodes by modifying their structure to produce what is claimed to be the smallest and most precise laser beam available from any red laser diode in the industry.

"Customers designing LBP and MFP applications are under increas-



ing pressure to improve printing quality and deliver lightweight products to customers," says

Tadayuki

Kanno, president, Oclaro Japan Inc & general manager, Modules & Devices business unit.

Oclaro claims that so far no other firm has achieved such size reductions or has been able to deliver this level of laser beam precision (i.e. low droop and small deviation). As a result, customers can now offer improved printing quality while at the same time providing

more lightweight and compact designs, it is reckoned.

Oclaro says that key features making the red beam laser diodes suited to designing MFPs and LBPs include:

- narrow beam pitch (enabling the optics design of a printing system to be simplified);
- high thermal radiation design for high-temperature operation (enabling high printing quality);
- high-accuracy mounting for junction-down die bonding for low droop (also improving the printing quality of the printing system); and
- tuning laser diode characteristics via a new structure to meet each customer's requirement to optimize their printing system.

Oclaro showcased the 4- and 8-beam red laser diodes at the Photonics West 2013 conference (5–7 February) in San Francisco.

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

## Firecomms expands sales presence in China

Firecomms Ltd of Cork, Ireland, a manufacturer of fiber-optic solutions and optical transceivers, has appointed Weikang Jiang to the newly created role of director of sales & marketing for the Greater China region, operating out of its new sales office in Shanghai. The firm has also signed a distribution agreement with DongTing Technologies Shenzhen Co Ltd to meet increased demand for its products in China.

"Continued investment in public infrastructure and production automation has led to significant growth in China's renewable energy, transportation and industrial automation markets; applications that require a broad array of rugged and reliable fiber-optic solutions," says VP of sales & marketing Hugh Hennessy. "This trend, together with our new LC terminated solutions and RedLink

range of Avago Versatile Link compatible components, requires us to significantly expand our footprint in China to meet the growing demand for our products," he adds.

"Formerly at Avago Technologies' Industrial Fiber Product division, Jiang brings a wealth of experience to the organization and is highly respected in the industrial fiber marketplace," comments Hennessy. Jiang will drive expansion of Firecomms' presence in the wider Chinese marketplace and will serve customers in Greater China through direct sales and regional distributors.

DongTing Technologies has a proven track record in serving industrial customers (a key market for Firecomms fiber-optic transceivers). From its headquarters in Shenzhen, DongTing Technologies serves customers throughout China.

"Offering a perfectly aligned

synergy with our product portfolio and excellent coverage throughout Mainland China, DongTing Technologies is an ideal partner in the fast-growing industrial fiber market," believes Jiang. "DongTing Technologies' extensive experience working with customers in the power, automation and transportation industries is a big advantage as these are key markets for Firecomms fiber optical transceivers."

"DongTing is pleased to leverage our abundant resources in different territories to bring Firecomms optical solutions to our strategic accounts and new customers in our key industrial markets," says DongTing's general manager Fred CAI. "The broad usage of Firecomms products also will enable us to explore new and growing market segments throughout mainland China."

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



## MBE FOUNDRY SERVICE

Your epi-wafer supplier for:

- Infrared thermal imaging FPA wafers: type-II superlattice, InSb, InAs.
- High-speed GaAs, InAs and InSb MMIC
- Thermo-photovoltaics
- Any custom structure from AlGaInAsSb

## MID-INFRARED LASER DIODES

Brolis Semiconductors is a world leader in type-I GaSb laser diode technology:

- Wavelengths covered: 1800 nm – 4000 nm
- Room-temperature operation
- Continuous wave operation
- Ultra low input powers
- Die, bar, TO-can.
- Facet coating on request

**BEYOND STATE-OF-THE-ART TECHNOLOGY  
FOR INFRARED APPLICATIONS**



# Oclaro reports improved quarterly results

## Revenue at top of guidance for first quarter following Opnext merger

Optical component, module and subsystem maker Oclaro of San Jose, CA, USA has announced financial results for its fiscal second-quarter 2013 (ended 29 December 2012), which includes the first full quarter of operating results from Opnext (merged with Oclaro on 23 July). Results for fiscal Q1/2013 include about ten weeks of operating results of Opnext since the closing of the merger. Results for fiscal Q2/2012 a year ago were 'pre-merger' Oclaro and did not include the operating results of Opnext at that time. So, any year-to-year and successive quarter comparisons could not be made with a like-for-like company structure.

Fiscal Q2/2013 revenue was \$159.5m. This compares with fiscal Q1 revenue of \$148.8m (without Opnext's contribution). However, pro forma combined revenue for Q1 (including Opnext for the full quarter)

was \$160.2m.

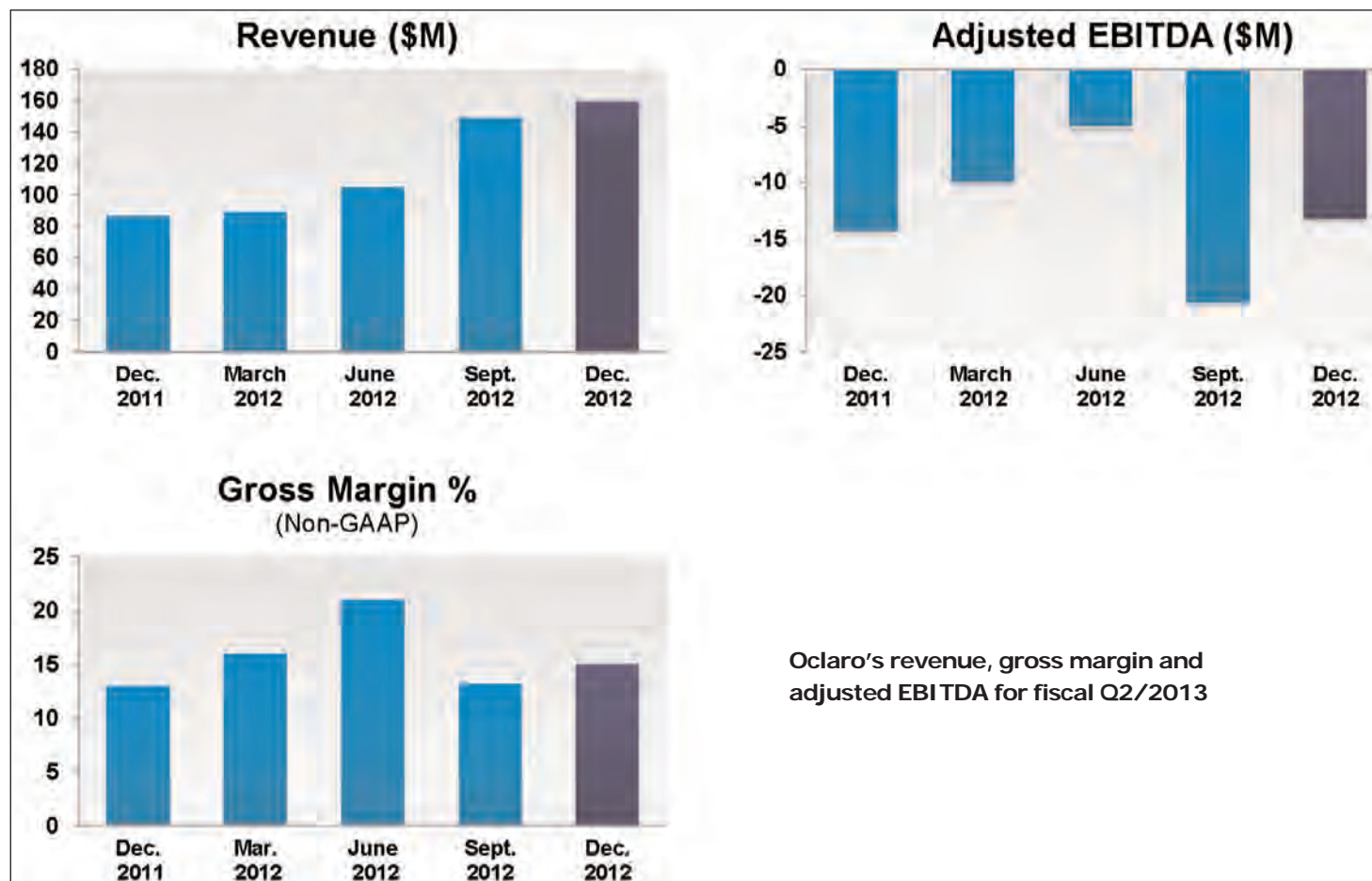
On a non-GAAP basis, gross margin was 15.2%, up from 13.2% in fiscal Q1. Operating loss was \$23.1m, cut by 22% from \$29.4m. Excluding a \$25m gain on the sale of assets related to Oclaro's interleaver product line and thin-film filter business, net loss was \$25.2m. This compares with a net loss of \$31.1m in fiscal Q1 (which excluded a gain on bargain purchase of \$39.5m related to the acquisition of Opnext). Adjusted EBITDA was negative \$13.2m, an improvement on negative \$20.6m. During the quarter, cash, cash equivalents and restricted cash rose slightly, from \$94.4m to \$96m.

"Our financial results for the second quarter of fiscal 2013 demonstrate the progress we are making after the merger," commented chairman & CEO Alain Couder. "Our revenues were at the top-end of guidance

and we have successfully executed to the planned synergies on schedule." Oclaro delivered nearly \$10m in quarterly synergies (\$40m on an annualized basis), ahead of the previous December-quarter target of \$9m.

"We also took action to strengthen our balance sheet," said Couder. On 23 January, Silicon Valley Bank (SVB) and Wells Fargo entered into a joinder agreement, following which SVB agreed to become an additional lender to Oclaro. The lenders agreed to increase Oclaro's revolving credit facility from \$50m to \$80m.

"Looking ahead, market and economic conditions remain uncertain in a typically softer March [2013] quarter," said Couder. For Q3/2013 (to end-March), Oclaro expects revenue of \$140–155m, non-GAAP gross margin of 10–14%, and adjusted EBITDA of negative \$25m



to negative \$13.5m. The midpoint of Oclaro's Q3 forecast range would be somewhat down on performance in fiscal Q2 and approximately equal to that of Q1. "Our efforts will remain focused on reducing operating expenses and improving margin, as well as capitalizing on our new product introductions and strong customer relationships to maximize revenues," Couder stated.

In the analysts' conference, Couder also gave his further thoughts on market conditions as well as an update on the company moving the manufacture of products from its Shenzhen plant to a contract manufacturer in Malaysia.

"Regarding the optical communication market in North America, we have a cautiously optimistic outlook based on the recent pickup," said Couder. "In China, we have a conflicting report from various customers. There is no sign of recovery in Europe, we see a slight decrease in Japan, and in the industrial and consumer market the market is flat. In summary, we are still looking for tangible sign of a system recovery," he added.

"An important part of our strategy is to maintain a growth of our topline

and improve our gross margins, and we do that through product innovation," Couder continued. "Several new products are starting to shift and demonstrate the acceleration of new product line. For instance in 100G coherent, we ship 60 copies of the new 100G coherent module, which [generated] about \$2m in revenue. We accelerated the shipment of the 100G lithium niobate modulator, and that was also something important, and the new generation of 100G CFP is ramping production this quarter," he added.

"We are moving manufacturing from Shenzhen to Malaysia," Couder noted. "The first product was produced in Malaysia, fully qualified by customer and shipped by customer. This means that, in the future, we'll be fully able to rely on two strategic contract manufacturers, Fabrinet and Venture, and this will give us the ability to weather the future cycle of the telecom market."

Also in the analysts' conference, chief financial officer Jerry Turin gave a breakdown of revenue by product category. "Our 40G and 100G module revenues were up

16% in the quarter as we recovered from a shortage of modulators in the prior quarter." Transmission components were down \$5.1m, largely due to a customer previously building up an inventory of one component type. Amplifiers and filters were down \$3.5m, primarily due to the sale of Oclaro's thin-film filter business and the Interlever product line during the December 2012 quarter. Sales of thin-film filters and Interlevers prior to the sale were \$2.5m in that quarter.

Oclaro's other product categories were relatively consistent quarter-on-quarter. From a customer point of view, Cisco, Alcatel-Lucent and Huawei were all in the 10–11% range. "We've not seen a real tangible evidence of a pickup in market conditions, even though there are positive signs like carrier CapEx spend announcements, and order flow in the first four weeks of this quarter was higher than the first four weeks of the prior quarter," said Turin. "We continue to see a degree of uncertainty in the market at this time."

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

*Matthew Peach, Contributing Editor*

## Expanded portfolio of violet, visible and near-infrared laser diodes

At the Photonics West conference (5–7 February) in San Francisco, Oclaro showcased an expanded portfolio of laser diodes that now includes violet, visible and near-infrared lasers.

"By offering one of the industry's most expansive portfolios of laser diode solutions, Oclaro can provide customers with a single-source partner that lowers risks, speeds time to market and reduces development costs," says chief commercial officer Yves LeMaitre. "The combination of violet and visible lasers with our existing infrared high-power diode lasers strengthens our portfolio for many applications in material processing, medical, aesthetics and printing markets. This also enables our customers in

the consumer market to leverage our product leadership, economies of scale, vertical integration and technology expertise."

Oclaro also announced technical advances that improve performance and packaging for its laser diodes used in laser multi-function printers. Also, four technical papers were authored or co-authored by Oclaro:

- 'Optimization of fiber coupling in ultra-high power pump modules at 980nm wavelength' by consulting engineer Boris Sverdlov in SPIE LASE, Session 2: High Power Fiber Coupled Sources II;

- 'Next-generation 9xx/10xx nm high power laser diode bars for multi-kilowatt industrial applications' by senior principal engineer René Todt in SPIE LASE,

Session 7: High Power Laser Diode Reliability II;

- 'Integrated InP based mode-locked lasers and pulse shapers' co-authored by Oclaro representatives in SPIE OPTO, Session 4: On Chip Active Devices; and
- 'High-quality surface micromachining of LiNbO<sub>3</sub> by ion implantation-assisted etching' co-authored by Oclaro representatives in SPIE MOEMS-MEMS, Session 3: Micro-fabrication Technology.

Other Oclaro products on display included a newly qualified 14G VCSEL array for high-speed optical interconnects used in mobile, home, enterprise and data-center applications; red laser diodes for display applications; and various high-power laser diode products.



## Advanced Photonix's quarterly sales rebound by 4% ...but delayed recovery presages flat half-year

After falling 10% last quarter, for fiscal third-quarter 2013 (to 28 December 2012) Advanced Photonix Inc of Ann Arbor, MI, USA (which designs and makes APD, PIN, and FILTRODE photodetectors, HSOR high-speed optical receivers, and T-Ray terahertz instrumentation) has reported sales of \$5.8m, up 4% on last quarter's \$5.6m though still down 10% on \$6.5m a year ago.

Due to a favorable product mix and cost-reduction efforts, gross margin has rebounded from 35.3% last quarter to 42%, up on 41.3% a year ago.

Operating expenses have risen from \$3.2m last quarter (52% of revenue) to \$3.5m (59% of revenue), level with \$3.5m a year ago (55% of revenue).

Adjusted EBITDA (earnings before interest, taxes, depreciation, amortization and stock compensation) has rebounded from negative \$717,000 last quarter to negative \$485,000, although this is still down on just negative \$1000 a year ago.

"We continue to see signs of improving business condition, although further out than we expected," comments CEO Richard Kurtz.

"Because of the continuing supply issues

**We continue to see signs of improving business condition, although further out than we expected. We now expect a flat second half of fiscal 2013**

we have experienced and continue to have in our 100G HSOR product platform, we now expect a flat second half of fiscal 2013 relative to the first half, with growth picking up in subsequent quarters," he adds.

"In anticipation of the drop in revenue in this second half, we have secured an additional \$2.5m in a credit facility to insure we can meet our growth plans this coming year," continues Kurtz. "I would like to thank Partners for Growth for working with us to structure a financing deal that aligns our short-term and long-term debt and minimizes shareholder dilution," he adds. "We plan to give our total revenue guidance for fiscal 2014 in June with our total year fiscal year 2013 results."

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

## VI Systems and UIUC demonstrate 850nm VCSEL for 25Gb/s over 1km of multimode fiber Photonic crystal VCSEL with pattern of holes in top mirror layer allows high modulation bandwidth at low current density

At the 2013 SPIE Photonics West conference in San Francisco (5–7 February), VI Systems GmbH of Berlin, Germany (a fabless spin-off of the Technical University of Berlin and the A. F. Ioffe Physico-Technical Institute in St Petersburg, Russia) and the Department of Electrical and Computer Engineering of the University of Illinois at Urbana-Champaign (UIUC) said that they have jointly demonstrated a novel single-mode photonic crystal vertical-cavity surface-emitting laser (VCSEL) suitable for error-free 25Gb/s data transmission over 1km of multimode fiber at very low received optical power.

The photonic crystal (PC) VCSEL is manufactured from a proprietary VI System's wafer that was processed at the UIUC with a defined pho-

tolithographic pattern of holes in the top mirror layers, allowing high modulation bandwidth at a low current density. The process results in single-mode emission of the VCSEL at a wavelength of 850nm. Single-mode operation of the laser leads to a reduced chromatic dispersion and therefore expands the transmission distance, as was confirmed by measurements at the Technical University of Berlin (TU Berlin).

Operating at a low current density of 5.4kA/cm<sup>2</sup>, the PC VCSEL enables –3dB bandwidth of 18GHz. At TU Berlin's Department of Solid State Physics, error-free optical data transmission at 25Gb/s over 1km of OM4 multi-mode fiber has been realized at very low received power of only 70μW, using a high-speed photoreceiver module from VI Systems.

VI Systems says that single-mode VCSELs extend reach over multimode fiber by eliminating the impact of chromatic dispersion of glass at 850nm wavelength, which is particularly important for ultrahigh transmission bit rates within the next generation of datacom and computercom standards.

Target applications are data transmission inside large data-centers, supercomputer clusters and racks of telecom equipment at ultrahigh bit data rates. The firm says that 1km transmission at very low received power allows cost- and energy-efficient 850nm VCSEL-based links to be extended to longer reach, saving space, cost and energy consumption.

[www.illinois.edu](http://www.illinois.edu)

[www.tu-berlin.de](http://www.tu-berlin.de)

[www.v-i-systems.com](http://www.v-i-systems.com)

## GigOptix lawsuit against M/A-COM set for trial in August

GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical components enabling high-speed end-to-end information streaming over optical fiber and wireless networks) says that in its lawsuit against defendants M/A-COM Technology Solutions Inc of Lowell, MA, USA, MACOM's subsidiary Optomai Inc, and the three former GigOptix employees Vikas Manan, Vivek Rajgarhia and Stefano D'Agostino, the Superior Court of Santa Clara County, California held a trial setting conference on 29 January. At the trial setting conference, the Superior Court scheduled the lawsuit for a two-week jury trial starting 26 August.

M/A-COM Tech manufactures semiconductors, components, and

subassemblies for RF, microwave and millimeter-wave applications. Optomai is a fabless semiconductor company that develops integrated circuits and modules for next-generation 40Gbps and 100Gbps fiber-optic networks. Its product portfolio includes high-speed optoelectronic ICs such as 40G and 100G laser modulator drivers and TIAs for both line-side and client-side applications. Its gallium arsenide (GaAs) and indium phosphide (InP) circuit design complements M/A-COM Tech's CATV/broadcast and point-to-point/infrastructure businesses.

GigOptix filed the lawsuit on 25 April 2011 against Silicon Valley-based firm Optomai Inc and former GigOptix employees. Subsequently, on 26 April, following the announcement of the acquisition of

Optomai by M/A-COM Tech, GigOptix amended the lawsuit to name M/A-COM Tech as an additional defendant. The lawsuit requests damages and injunctive relief based on breach of contract and trade secret misappropriation allegations. According to the lawsuit, the former employees created Optomai in 2009 and began selling products competing directly with GigOptix's products. GigOptix further alleged that its technology and intellectual property were used by Optomai to develop products in violation of California law and that it has been selling its products as the 'Optomai Optoelectronics' product line of MA-COM.

[www.gigoptix.com](http://www.gigoptix.com)  
[www.macomtech.com](http://www.macomtech.com)  
<http://optomai.com>

## GigOptix appoints senior photonic packaging and integration architect for optical and RF transceiver modules

GigOptix has appointed photonics integration veteran Giovanni Delrosso to the newly created role of senior photonic packaging and integration architect. Based at GigOptix's subsidiary GigOptix GmbH in Berlin, Germany, Delrosso will be responsible for leadership of optical and RF advanced packaging and integration initiatives across the organization.

"Giovanni brings nearly 30 years of photonics packaging and integration experience to GigOptix," says Dr Raluca Dinu, general manager & VP of the Optics and RF

product line. "Giovanni will lead the advanced optical integration initiatives we have in place and will help us accelerate our integration of next-generation optical transceivers."

Prior to joining GigOptix, Delrosso held senior packaging technology adviser and product development positions at COGO Optronics in Berlin, where he led packaging design efforts for miniaturized 100Gbps transmit optical sub-assembly (TOSA) modules. Delrosso also worked in R&D project management roles at Pirelli

Labs and Cisco Systems, with a focus on optoelectronic packaging technologies. He is also a visiting researcher at the Fraunhofer Heinrich Hertz Institute in Berlin for GigOptix' terabyte photonic module developments.

Since 1989, Delrosso has volunteered for IMAPS and IEEE-CPMT societies. He held the position of president of IMAPS Europe and European Liaison Committee from 2011 to 2013, and has also co-authored several patents and technical papers.

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

## Daylight Solutions announces passing of Chris Armacost

Daylight Solutions Inc of San Diego, CA, USA, which makes molecular detection and imaging systems based on its mid-infrared and quantum cascade laser (QCL) technology, has announced that Chris Armacost passed away on 21 January after a brief battle with cancer.



As director of scientific sales, Armacost was responsible for Daylight's significant growth into scientific

Chris Armacost.

research markets. "He had a natural and effortless way of connecting with his customers," said the firm.

"He has been an important and contributing member of the photonics community for many years and he will be deeply missed by all who knew him," the firm added.

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



# Kotura grows revenue 40% in 2012

## Data-center performance key driver for future growth

Silicon photonics firm 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 reported revenue growth of 40% in 2012.

"From a product standpoint, 2012 was a turning point for our company," says president & CEO Jean-Louis Malinge. "We exceeded 60,000 channels shipping per month, more than doubling from the previous year. In addition, we launched our 100Gb/s Optical Engine, which is targeted to data centers and high-performance computing applications," he adds. "In 2012, we strengthened our technology position with the addition of seven new patents granted and 22 new patents filed, bringing Kotura's total to 130 filed or granted technology patents – the strongest technology patent position in our industry."

Following a high-growth year, Kotura says that the near future includes high-volume production of its Optical Engine, a low-power, 100Gb/s chip solution that supports the interconnect fabric for next-generation data centers and

high-performance computing.

Pointing to the growing demand for faster, limitless access to digital information as a key driver for future growth, Kotura says that its photonic integrated chips address the pressing bandwidth and performance needs of data centers supporting cloud computing, virtualization and other data-intensive applications.

According to Cisco's Global Cloud Index (released in October), data-center traffic will grow fourfold from 2011 to 6.6 zettabytes (a billion terabytes) by 2016. "Data-center and cloud traffic are global trends driven by the consumer's need for instant access to digital information and the strong desire to access personal and business content anywhere," says Malinge. "The growth of mobility is pushing performance demands on data centers in ways that we couldn't have predicted five years ago."

Kotura says that its Optical Engine addresses the performance demands being placed on data centers and high-performance computing interconnects. An inexpensive, small-form-factor chip solution that reduces power consumption and

provides a high level of integration, the firm's silicon photonics platform supports optical engines using wavelength-division multiplexing (WDM).

"As the only silicon photonics provider to offer WDM, Kotura's Optical Engine offers distinct advantages, including reducing the cost of fiber and associated connectors within the interconnect fabric for 4x25GHz solutions by a factor of four, as well as readily expanding from four channels to eight, 16 or even 40 channels over a single strand of optical fiber," adds Malinge.

For 2013, Kotura anticipates strategic partnerships, technology advances, and sampling of its Optical Engine by year end. "We're optimally positioned for the explosive growth of silicon photonics into more and more markets," reckons Malinge. "Kotura has invested heavily in its team and technology."

Kotura is demonstrating its Optical Engine at the Optical Fiber Communication Conference and Exhibition/National Fiber Optic Engineers Conference (OFC/NFOEC 2013) in Anaheim, CA (19–21 March).

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

## Kotura elects Enevate's president & CEO to board

At its recent board meeting, Kotura elected semiconductor veteran Brian Wong to its board of directors. Currently president & CEO of rechargeable energy storage technology firm Enevate Corp, he has more than 30 years of leadership experience.

"Brian is highly regarded, with a proven track record of growing companies, and his in-depth understanding of the semiconductor business and deep connections in the industry make him a highly valued addition to Kotura," comments chairman Dr Andrew Rickman Obe.



Prior to joining Enevate in 2010, Wong was president & CEO of D2Audio, a developer of digital audio chip and soft-

ware products for the consumer electronics segment. Previously, he served as CEO and in other executive positions with Primarion Inc, an optical datacom and digital power management firm that was acquired by Infineon. Previous positions include a 17-year career at TRW (where he was a senior

manager responsible for the development, manufacturing and marketing of high-performance data converters and digital transceivers) as well as an engineer at Xerox's Microelectronics Center (where he developed MOS digital circuits).

Wong has co-authored textbooks and papers on semiconductor technology and data converters. He holds a master's of science degree in electrical engineering from the University of Southern California and a bachelor's of science degree in electrical engineering from the University of California, Los Angeles.

# Leti to coordinate 4-year EC project PLAT4M

## Complete European supply chain in silicon photonics targeted

Micro/nanotechnology R&D center CEA-Leti of Grenoble, France says that it will coordinate a four-year project aimed at building a European-based supply chain in silicon photonics and speeding industrialization of the technology.

The PLAT4M (Photonic Libraries And Technology for Manufacturing) project will focus on bringing the existing silicon photonics research platform to a level that enables seamless transition to industry, suitable for different application fields and levels of production volume.

Funded by a European Commission (EC) grant of €10.2m, PLAT4M includes 15 leading European R&D institutes and CMOS companies, key industrial and research organizations in design and packaging, as well as end-users in different application fields, to build the complete supply chain.

"Silicon, with its mature integration platform, has brought electronic circuits to mass-market applications — our vision is that silicon photonics will follow this evolution," says PLAT4M coordinator Laurent Fulbert, Integrated Photonics program manager at CEA-Leti. "Upgrading existing platforms to become compatible with industrialization is now essential, and this requires streamlining and stabilizing the design and process flows by taking into account design robustness, process variability and integration constraints," he adds. "The PLAT4M partners bring a critical combination of expertise to the challenge of building a complete supply chain for commercializing silicon photonics in Europe."

A surge in output of silicon photonics research in recent years has significantly boosted the potential for commercial exploitation of the technology, says Leti. However, most of this R&D has been devoted to developing elementary building blocks, rather than fabricating

complete photonic integrated circuits (PICs), which are needed to support large potential markets.

The PLAT4M consortium aims to make technologies and tools mature by building a coherent design flow, demonstrating manufacturability of elementary devices and process integration, and developing a packaging toolkit. The project will validate the complete supply chain through application-driven test vehicles representing various fields, such as telecom and datacom, gas sensing and light detection and ranging (LiDAR), and vibrometry.

It will also focus on preparing the next-generation platform by setting up a roadmap for performance evolution and assessing scalability to high-volume production.

**The aim is to make technologies and tools mature by building a coherent design flow, demonstrating manufacturability of elementary devices and process integration, and developing a packaging toolkit**

The supply chain will be based on the technology platforms of Leti, nanoelectronics research center imec of Leuven, Belgium and semiconductor manufacturer STMicroelectronics (of France and Italy), supported by a unified design environment.

The benefits of PLAT4M for the European photonic industry should include:

- preparing the supply chain for silicon photonics technology, from chip-level technology to packaged circuits;
- making integration technologies accessible to a broad circle of users in a fabless model;
- contributing to the development of a design environment that

facilitates photonics/electronics convergence;

- moving the emphasis from the component to the architecture, and thus concentrating effort on new products or new functionalities rather than the technology level;
- aggregating competencies in photonics/electronics design and fabrication; and
- retaining the key added value in components in Europe through optoelectronic integration, with little added value in offshore assembly.

PLAT4M consortium members consists of technology providers, research institutes, end-users and small-to-medium enterprises (SMEs) with track records in advanced photonics technologies. At the design and process level, CEA and imec have been the most prominent European players in silicon photonics for a decade. Together with University of Paris-Sud, III-V Lab and TNO, they have demonstrated numerous scientific and technical breakthroughs.

For building a complete design flow, electronic design automation (EDA) tool suppliers US-based Mentor Graphics, Netherlands-based PhoeniX BV and Silicon Integration Initiative Inc (Si2) will work together to develop a common reference platform.

STMicroelectronics has been engaged for the past year in developing silicon photonics at the industrial level. Ireland's Tyndall-UCC (University College Cork) and Germany's Aifotec GmbH have expertise in optoelectronic packaging and will work together on implementation packaging technologies developed within PLAT4M in a manufacturing environment.

End-users such as Polytec, Thales Research & Technology and Netherlands-based NXP will drive the demonstrators development and assess the use of silicon photonics in their applications fields.

[www.leti.fr](http://www.leti.fr)



## Infinera grows revenue 14% in Q4 while still cutting losses

For fourth-quarter 2012, Infinera 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 \$128.1m, up 14% on \$112.2m in Q3/2012 and \$112m a year ago. Full-year revenue was \$438.4m, up 8.3% on 2011's \$404.9m.

On a non-GAAP basis, gross margin for Q4 was 36%, down from 39% in Q3 and 42% a year ago. Full-year gross margin has fallen from 43% in 2011 to 38%.

Full-year net loss was \$43.5m, up from \$31.7m in 2011. But quarterly loss was \$6m in Q4, cut from \$7.8m in Q3 and \$6.7m a year ago.

"Our fourth quarter results reflected solid execution of our growth strategy and represented a strong finish to a productive year," says president & CEO Tom Fallon. "Our DTN-X continues to gain traction and, to date, we have purchase commitments from 22 customers, including seven new to Infinera," he adds. "These customers represent a broad cross section of our market segments. Revenue from the DTN-X platform continues to ramp."

During Q4, Infinera announced its first domestic Tier 1 backbone deployment with CenturyLink. "We have also successfully completed the OSMINE certification process, another key milestone in demonstrating our US Tier 1 readiness.

Our ability to fully service global Tier 1 customers essentially doubles our addressable market," Fallon says. "We also added four new DTN customers during the quarter for a total of 111 customers worldwide," he adds.

"We are optimistic about the outlook for 2013," Fallon continues. "Interest in our unique 100G converged DWDM/OTN switching solution remains strong, resulting in significant trial activity, which has helped us build a strong pipeline into 2013. A strong focus on winning footprint and gaining market share, balanced with prudent financial management, remain our priorities for 2013."

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

## Infinera and Telefónica demo first 10Tb/s super-channel capacity

Infinera and Tier-1 network operator Telefónica of Madrid, Spain, have completed a joint Terabit Technology Showcase. Highlights include:

- 10Tb/s of super-channel capacity based on Infinera FlexCoherent technology to realize QPSK and 16 QAM super-channels to extend fiber capacity and signal reach ;
- Telefónica I+D's Flexi-Grid standards-based GMPLS control plane for rapid service deployment and

simplification of network operations; ● Infinera's next-generation PIC-based flexible grid super-channels for improved spectral efficiency and flexibility.

Infinera says the demonstration illustrates capabilities of its PIC-based Digital Optical Network, including transmitting ten 1Tb/s super-channels and demonstrating of flexible grid transmission.

Rapid deployment of services,

robust protection and ease-of-use were demonstrated with Telefónica's prototype Flexi-Grid GMPLS control plane. Telefónica and Infinera, together with other vendors and service providers are standardizing GMPLS-based control plane as one of the key technologies for flexible networks in Internet Engineering Task Force (IETF) standards committees.

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

## OVH deploys Infinera's DTN-X platform for 500Gb/s super-channels on pan-European cloud network

Infinera says that OVH will deploy its DTN-X platform (featuring 500Gb/s super-channels) for its pan-European network. The DTN-X platform will enable OVH to increase its network capacity by potentially up to 10 times that previously offered, connecting data centers throughout 10 major European cities in seven countries, across 10,000 kms of optical fiber.

With the DTN-X platform, OVH will deploy multi-terabit optical transmission capacity across its optical network to support the growing

and dynamic capacity demands of cloud services. The DTN-X delivers the industry's first commercially available 500Gb/s long-haul optical super-channels, says Infinera.

"We continue to be impressed by Infinera's PIC technology and the DTN-X platform – from significantly simplifying our operations and reducing the time to deploy bandwidth to fundamentally lowering our total cost of ownership," says OVH's CEO Octave Klaba.

A key factor in selection of the DTN-X was the combination of

integrated OTN switching with the delivery of 500Gb/s long-haul super-channels based on Infinera's 500Gb/s PIC and second-generation FlexCoherent processor. Integrated OTN switching enables efficient utilization of long-haul capacity while enabling OVH to rapidly deploy large amounts of optical bandwidth for customer services.

The DTN-X will be deployed across routes on OVH's network such as the 1200km Roubaix-Paris-Strasbourg-Frankfurt route, scaling capacity while lowering operational costs.

## NeoPhotonics acquiring LAPIS' optical components unit

NeoPhotonics has agreed to buy the semiconductor optical components business unit (OCU) of LAPIS Semiconductor Co Ltd (a subsidiary of Rohm Co Ltd), together with its portfolio of over 150 patents and patent applications, its campus, and high-speed semiconductor and laser and detector fabrication facility.

OCU is to be bought by Japanese subsidiary NeoPhotonics Semiconductor GK for about \$36.8m in cash (\$21.2m before adjustments for the business unit plus \$15.6m over three years for the associated real estate). NeoPhotonics intends to combine and operate the business as NeoPhotonics Semiconductor GK at its current location near Tokyo.

The acquisition is aimed at speeding development of NeoPhotonics' PIC technology by coupling complex optical devices and analog semiconductor ICs within the same platform. Also, NeoPhotonics' technology portfolio will expand to include

high-speed semiconductor devices for signal generation and amplification (designed to enable advanced modulation methodologies, enhanced performance, and reduced power consumption in communications networks).

LAPIS OCU provides high-speed semiconductor and high-speed laser and photodetector devices for communications networks. Its lasers, photodetectors and analog ICs are key elements of coherent and other high-speed optical transmission devices. OCU produces solutions for the current generation of 100G modules used in accelerating deployments.

OCU had revenue of \$45m for the first nine months to end-September 2012. About 30% was from network equipment manufacturers that are also customers of NeoPhotonics, about 6% was from NeoPhotonics, and the rest was from other optical module manufacturers and test &

measurement customers. OCU should be accretive to NeoPhotonics' adjusted EBITDA within the first year following the transaction.

"The transaction is a natural step in the relationship between NeoPhotonics and LAPIS Semiconductor OCU, as the businesses have been collaborating closely on high-speed coherent technology development for the past four years," says NeoPhotonics' chairman & CEO Tim Jenks. "We plan to leverage our existing sales channels after the acquisition, as the two businesses serve many common customers," he adds. "The transaction will provide NeoPhotonics with revenue from OCU's advanced lasers and drivers used in many of today's 100G client-side data transmission modules."

Each firm's board of directors has approved the transaction, which is expect to close in Q2/2013.

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

## NeoPhotonics reports 22% annual revenue growth to record \$245m; 40/100G grows 300% year-on-year to third of quarterly revenue

For Q4/2012, NeoPhotonics Corp of San Jose, CA, a vertically integrated designer and manufacturer of both indium phosphide (InP) and silica-on-silicon photonic integrated circuit (PIC)-based modules and subsystems, has reported revenue of \$62m, down 6% on \$66.2m last quarter but up 8% on \$57.2m a year ago.

"NeoPhotonics has grown 40/100G product sales to approximately one third of our quarterly revenue as of the fourth quarter of 2012, helping to meet rapidly growing demand for high-speed PIC-based products," says chairman & CEO Tim Jenks. For full-year 2012, revenue was a record \$245.4m, up 22% on 2011's \$201m.

On a non-GAAP basis, gross margin was 24.5%, up on 23.5% a year ago but down from 32.9% last quarter. Gross margin was adversely impacted by about 700 basis points

due to higher yield loss and inventory-related expense relating to one of the firm's high-speed products plus lower wafer fab utilization. However, full-year gross margin was 27%, up from 2011's 25.7%.

Loss from continuing operations was \$0.1m, down from income of \$2.7m last quarter but still a big improvement on a loss of \$6.4m a year ago. Full-year loss has been more than halved, from \$9.6m in 2011 to \$4.7m for 2012.

Adjusted EBITDA was \$3.5m, down from \$6.4m last quarter but an improvement from an adjusted EBITDA loss of \$3m a year ago. Full-year adjusted EBITDA has more than tripled, from \$2.7m in 2011 to \$9.3m for 2012.

Although up from \$86.4m at the end of 2011, total cash, cash equivalents and short-term investments fell during the quarter from \$105.9m to \$101.2m. This was

due mainly to capital expenditure, scheduled repayment of bank debt, and expenses relating to the pending acquisition of the semiconductor optical components business unit (OCU) of LAPIS Semiconductor Co Ltd.

For Q1/2013, NeoPhotonics expects revenue of \$50–\$55m, primarily reflecting seasonally lower business activity and a full quarter impact of changes in product prices negotiated in the fourth quarter. Gross margin should be 22–24%, reflecting the impact of seasonality and pricing changes, related lower wafer fab utilization, and continued higher manufacturing costs relating to the high-speed product.

For full-year 2013, NeoPhotonics expects revenue growth of 8–10% over 2012, and hence profitability on a non-GAAP basis.

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



# JDSU reports quarterly revenue at high end of guidance

## Growth in CommTest offsets drop in Optical Communications

Optical networking and associated semiconductor technology firm JDSU of Milpitas, CA, USA has reported a modest improvement in sales performance during its fiscal second-quarter 2013 (ended 29 December 2012).

On a non-GAAP basis, net revenue was \$429.4m (at the high end of guidance), with net income of \$42.3m (\$0.18 per share). Revenue was up 2% on the prior quarter's \$420.9m, with net income of \$35m (\$0.15 per share). It is also up 4.8% on \$409.6m for fiscal Q2/2012 a year previously, with net income of \$36.3m (\$0.16 per share).

"JDSU delivered a strong fiscal Q2/2013, with revenue at the top of our guidance range and operating margins exceeding expectations across all three business segments," said president & CEO Tom Waechter. "We are pleased with the progress we've made in aligning our product portfolio with customer spending priorities, resulting in a high percentage of revenue from new products and a positive impact on financial results. We are well-positioned for growth opportunities in 2013."

Sales of Communications Test & Measurement equipment for optical and RF networks accounted for nearly half (46%) of overall revenue, at \$195.4m (at the high end of guidance, up 15% on last quarter). Sales of Optical Communications products were \$155.6m (down 4.5% on last quarter, but up 12.7% on a year ago), while sales of Commercial Lasers of \$30.2m were down 5.3% sequentially but up 20.3% on a year ago; together, Communications and Commercial Optical Products (CCOP) totaled \$185.8m, 43% of overall revenue. Sales of Optical Security and Performance (OSP) products were \$48.2m, 12% of overall revenue.

Regarding geographic performance, the Americas, EMEA (Europe, Middle-East and Africa) and Asia-Pacific comprised 49.9%, 23.8% and 26.3% of total revenue, respectively. Operating cash generation was

\$59.4m (the most in eight quarters). Cash and investments totaled \$740.2m at the end of the quarter.

JDSU has adjusted its current and historical consolidated statements of operations and segment financials to reflect the October 2012 sale of its holographic security business (reflected as discontinued operations for the periods reported).

For fiscal third-quarter 2013 (to end-March), the firm expects net revenue to be similar to the latest performance, at \$405–425m.

"Our CommTest division delivered revenue of \$195.4m, at the high end of our guidance, driven by demand for Ethernet, mobility, 100G and cloud solution, all areas of high priority for our customers," says chief financial officer & executive VP Rex Jackson. Revenues from all three major geographic regions grew sequentially. Year-on-year revenue fell by less than 1%, as organic growth and recent acquisitions effectively offset portfolio pruning and the lack of a year-end budget flush, he added.

CommTest delivered gross margin of 64.4%, a record high reflecting a sequential rise of 2.3% and year-on-year improvement of 4.2 points. Gross margin improvement, combined with effective OpEx management, resulted in segment operating profit of \$35.3m (18.1% of revenue, the segment's highest operating margin since December 2010).

CCOP (the Optical Communications and Lasers businesses) delivered revenue of \$185.8m, a gross margin of 30.9% and operating margin of 11.4%. Within the segment, Optical Communications reported revenue of \$155.6m, down by \$7.6m sequentially. Total ROADM (reconfigurable optical add-drop multiplexer) revenue fell by 23% to 20% of Optical revenue compared to 24% last quarter.

"These sequential declines reflect, as expected, the impact of the large optical customers' transition to vendor-managed inventory, which

grew to 46% of optical revenue from 40% last quarter, and to the timing of key customer programs," said Jackson. Tunable XFP revenue was flat on absolute dollars sequentially and represented 14% of Optical revenue. "We recognized a small amount of tunable SFP+ revenue in the quarter," he added.

The Optical Communications division's gross margin improved to 28.3% on lower revenue from 27.5% in the previous quarter, due primarily to cost improvements. "The sequential ASP [average selling price] decline in fiscal Q2 was 1.2%," Jackson said. We expect the sequential ASP decline in fiscal Q3 to be approximately 5%, in line with recent beginning of calendar year ASP declines."

Regarding fiscal third-quarter guidance, Jackson commented, "Based on normal seasonality, particularly in CommTest, we would expect some decline in revenue from our fiscal second to fiscal third quarter. Furthermore, we expect our customers to begin releasing their capital budgets in earnest in March 2013 and thus expect a positive impact of increased network investments in our June quarter.

"With these factors in mind, in CommTest, we expect lighter revenue and corresponding impacts on gross margin and operating margin. In CCOP, we expect a flattish quarter with a slight increase in optical components being offset by a decline in lasers. And for OSP, we expect a slight increase in revenue and consistent performance on profitability.

On a sequential basis, JDSU expects CommTest revenue to be down by 6–10%, CCOP to be flat plus or minus 3%, and OSP to be up 2–6%. Operating expenses are expected to be flat to up \$4m, primarily reflecting continuing investments in R&D and beginning of calendar year payroll impact.

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

Matthew Peach, Contributing Editor



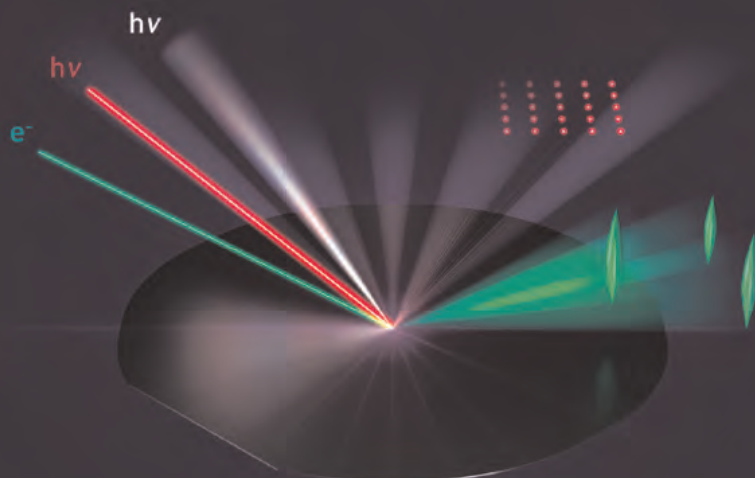
# k-Space Associates, Inc.

[www.k-space.com](http://www.k-space.com)

2182 Bishop Circle East, Dexter, MI 48130 USA | tel: 734-426-7977 | fax: 734-426-7955 | [requestinfo@k-space.com](mailto:requestinfo@k-space.com)

## Control Your Process!

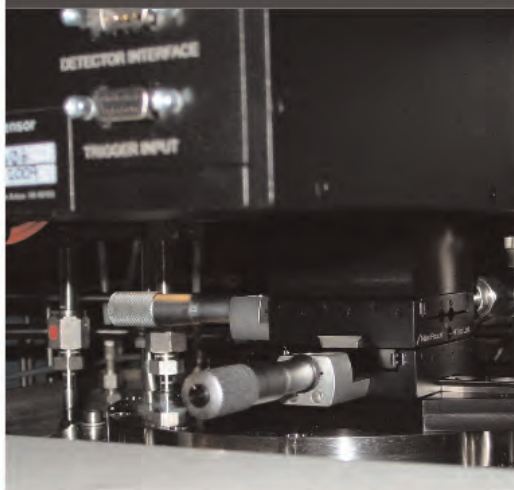
### Real-Time Process Monitoring for MOCVD, MBE, Sputtering, and Thin-Film PV Deposition



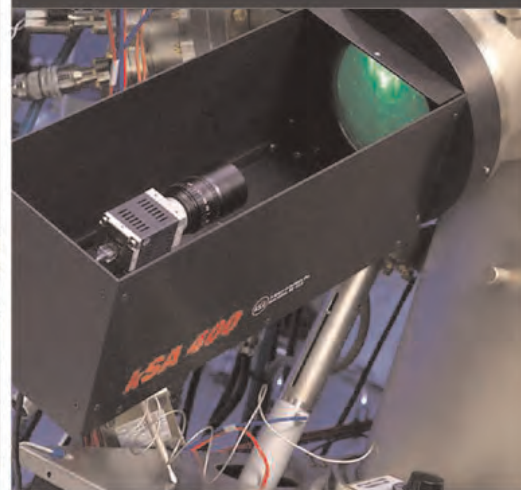
kSA BandiT Wafer Temperature



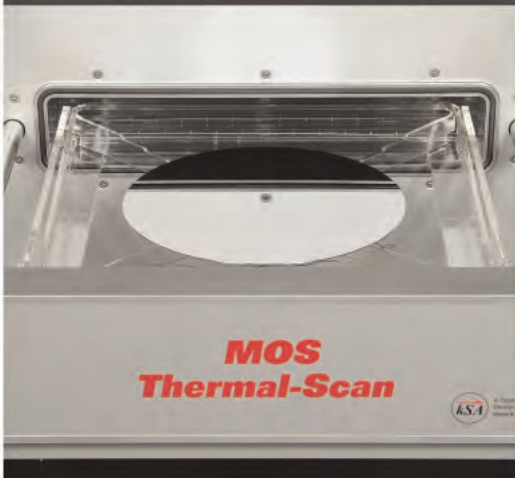
kSA MOS and kSA Mini-MOS Thin-Film Stress



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





# Emcore's increased solar shipments drive return to profit

## March-quarter to be hit by delay in revenue contribution from tunable XFP

Emcore Corp of Albuquerque, NM, USA, which manufactures compound semiconductor-based systems for fiber-optic and solar power applications, has reported generally improved financial results for fiscal first-quarter 2013 (to end-December 2012). Consolidated revenue was \$49.3m, up 31.7% on \$37.5m a year ago and up 3.8% on \$47.5m last quarter, due mainly to higher solar revenue (driven by increased shipments).

Photovoltaics segment revenue was \$19.6m (40% of total revenue), up 2.5% on a year and 12.8% on \$17.4m last quarter. Fiber-optics segment revenue was \$29.7m (60% of total revenue), up 62.1% on a year ago but a drop of 1.4% on \$30.1m last quarter.

Gross margin has risen from 9.3% a year ago and 9.7% last quarter to 22.2%. In particular, Fiber Optics' gross margin was 16.7%, rebounding from 2.4% last quarter and -4.8% a year ago. Photovoltaics' gross margin was 30.5%, up from 22.7% a year ago and 22.2% last quarter, driven by higher revenue and the divesting of the lower-margin terrestrial systems product lines.

Operating income was \$2.8m, improving by \$14.5m on a year ago and by \$9.1m on last quarter. Quarter-over-quarter variance was primarily due to "lower expenses associated with the company's realignment efforts previously announced — and improved results within the business segments."

On a non-GAAP basis, net income was \$0.1m, an improvement on a net loss of \$7.4m a year ago and \$6.3m last quarter.

Photovoltaics order backlog was \$35.3m, an 18% drop from the \$43.3m last quarter. "Order backlog as of 31 December 2012 and 30 September 2012 included

\$3.4m and \$1.9m, respectively, of terrestrial solar cell orders from our Suncore joint venture," the firm noted. "Product sales from our Fiber Optics segment are made pursuant to purchase orders, often with short lead-times".

In the associated analysts' conference, CEO Hong Hou gave more details of the performance and his expectations for the two segments:

"Gross margin for both our solar photovoltaics and broadband fiber

optics business improved [in the latest quarter performance] significantly to approximately 30%, and overall operating expenses were well under control, thanks to the business realignment completed."

Returning a net profit for the quarter demonstrates "the positive outcome of restructuring and the flood recovery that the company has been focusing on over the last year".

Solar photovoltaics revenue demonstrated a substantial

**Gross margin for both our solar photovoltaics and broadband fiber optics business improved significantly to approximately 30%, and overall operating expenses were well under control, thanks to the business realignment... Returning a net profit for the quarter demonstrates the positive outcome of restructuring and the flood recovery that the company has been focusing on over the last year**

sequential increase due to strong demand in space programs, noted Hou. "With some CapEx investment early in the year, manufacturing process was further improved. As a result, the gross profit margin for this division recovered to over 30%."

Order backlog for solar business showed a sequential decline of \$8m to \$35.3m. "We have, however, received a notice of award from an international customer recently, with a total contract value in excess of \$20m, which will significantly add to our order backlog," Hou said. "Several other smaller value new awards are also expected in the near term."

Considering Emcore's market position and business outlook for the Fiber Optics business segment, Hou added, "In the broadband cable TV business, during the September quarter, our revenue recovered to pre-flood levels and the gross margin recovered to the high-20s". The broadband Fiber Optics business generated positive operating income in the December quarter for the first time since the Thailand flooding.

For fiscal Q2/2013 (to end-March), Emcore expects revenue of \$45-49m (including revenue from the Suncore joint venture). The sequential revenue decline is primarily due to seasonal demand softness in cable TV and the delay in revenue contribution from tunable XFP. "However, the impact to the bottom line will be very manageable, as we cut the loss through restructuring and recovering of our Fiber Optics manufacturing to a variable cost basis," believes Hou. "We have worked hard to establish that profitability-focused culture, and we are seeing the benefit of that hard work now."

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

## US Air Force awards Emcore \$7.4m to develop 33%-efficient solar cells

Emcore has been awarded a \$7,364,902 cost-plus-fixed-fee contract (funding announcement FA8650-13-C-5501) by the US Department of Defense (DoD) under the Advanced Multi-Junction Space Cell Producibility Program.

The contracting activity is Air Force Research Laboratory (AFRL) via Wright-Patterson Air Force Base (AFB) in Ohio. Work under the contract is expected to be completed by 13 April 2018.

When the Advanced Multi-Junction Space Cell Producibility Program was announced in September 2011, it was stated that its objec-

tive was to improve manufacturing capabilities, develop improved manufacturing processes, and space qualify air-mass zero (AM0), one-sun, inverted metamorphic multi-junction (IMM) multi-junction solar cells, targeting 33% efficiency. Emcore's existing third-generation triple-junction (ZTJ) solar cells have a quoted minimum average efficiency of 29.5%.

Productization and qualification of high-efficiency, flexible or rigid IMM space solar cells should improve critical performance, mass and volume budgets for small, warfighter-specific satellite payloads.

### Emcore's solar panels power LDCM satellite

Emcore's solar panels are powering the Landsat Data Continuity Mission (LDCM) satellite that was launched on 11 February from Vandenberg Air Force Base in California.

Designed and built by Orbital Sciences Corp for NASA to support the Landsat Earth observation program (which began over four decades ago), the LDCM satellite continues a 40-year legacy of seven previous satellites that have collected data and images of the Earth's surface and environment.

"Emcore is proud to have once again partnered with Orbital on the deployment of critical on-orbit capability," says Brad Clevenger, general manager of Emcore's Photovoltaics Division. "We appreciate the opportunity to contribute to this important mission for NASA and the US Geological Survey."

Emcore's radiation-hard solar cells for space power applications have a beginning-of-life (BOL) conversion efficiency nearing 30% and the option for a patented, onboard monolithic bypass diode. Emcore claims its multi-junction cells provide the highest available power to interplanetary spacecraft and earth orbiting satellites.

NASA and the US Geological Survey (USGS) share responsibility for the LDCM program. NASA's Goddard Space Flight Center oversaw development of the flight systems including the LDCM spacecraft and the onboard instruments, and is responsible for mission operations, launch, and in-orbit checkout. The USGS will operate the satellite and the Landsat ground network, image-processing and archive facilities. The data collected constitutes the longest ongoing record of the Earth's surface seen from space.

LDCM joins Landsat 7 in orbit. Once it completes in-orbit testing and is operated by the USGS, it will be renamed Landsat 8. The satellite has two new spectral bands that will allow it to detect clouds on coastal zones. Also, it will produce over twice as many images per day than Landsat 7. LDCM is about 20 feet tall with a 9-foot diameter at its widest point. The solar array has four Emcore panels that will extend 32 feet from the satellite when deployed and feature high-efficiency BTJ triple-junction cells delivering 3750W of power at end-of-life (EOL).

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

### IN BRIEF

#### Emcore delivers millionth solar cell to Space Systems/Loral

Emcore Corp of Albuquerque, NM, USA, which manufactures compound semiconductor-based systems for fiber-optic and solar power applications, has delivered its 1 millionth high-efficiency, multi-junction solar cell to Space Systems/Loral (SS/L, a subsidiary of Loral Space & Communications), which will ultimately represent over 1MW of power delivered into space.

Emcore and SS/L (which delivers satellites and spacecraft systems for commercial and government customers worldwide) marked the occasion with a special event at Emcore's Albuquerque facilities during the week of 25 February, and with a commemorative award symbolizing the 1 millionth cell.

Emcore has been supplying Space Systems/Loral with multi-junction solar cells for more than 10 years and in May 2009 announced a long-term supply agreement to continue manufacturing and delivering solar cells for their spacecraft programs through 2014. Emcore says that the business relationship has been integral to the development of its photovoltaics division and the growth of its space satellite solar power business. Since its formation in 1998, Emcore Photovoltaics has grown to be the world's leading maker of high-efficiency, multi-junction solar cells for space power applications, it is claimed.

"Delivering 1 million solar cells for more than 50 successful satellite launches by Space Systems/Loral is a tremendous milestone for Emcore and our space satellite solar business," notes CEO Dr Hong Hou. "We look forward to working with Space Systems/Loral to power their satellite missions for many years to come."

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



# Soitec exhibits at World Future Energy Summit in Abu Dhabi

Soitec exhibited its high-efficiency concentrator photovoltaic (CPV) solutions in the French pavilion at the World Future Energy Summit (WFES) 2013 in Abu Dhabi, United Arab Emirates (UAE) on 15–17 January. Soitec's CPV products range from systems using the company's Concentrix technology for utility-scale solar power plants to its Plug&Sun stand-alone unit for smaller scale energy needs in remote locations. The Plug&Sun system was showcased at WFES 2013 for the first time.

"Meeting the world's growing demands for clean, reliable energy will require both large-scale power plants and innovative, self-contained solutions to address the needs of off-grid sites," said Gaetan Borgeres, executive VP of Soitec's Solar energy division. "At Soitec, we are committed to offering the Middle East a full range of CPV solutions."

**Soitec's CPV technology for large-scale solar power plants**  
The company's technology, which is designed for use by large-scale solar power plants in sunny, hot and arid regions, provides the highest efficiency of all solar technologies available. While achieving industry-leading energy-generating efficiency of 30% – twice the performance of conventional photovoltaic technologies – Soitec's systems can withstand high temperatures, and sand storms and do not require any water for cooling, making them well suited to help meet energy needs in sunny, hot and arid locations.

Soitec has installed its first project in Saudi Arabia (Medina). The company's high-concentration, high-efficiency technology, matches day-time peak power load curves, making it an optimal solution for Saudi Arabia and other Middle East countries. In addition, the technology is industrialized for highly automated manufacturing. Soitec's manufacturing process guarantees



**Soitec's Plug & Sun portable mini-tracker systems.**

the resulting product quality, and the technology is perfectly adapted for bringing local content and leveraging local jobs and growth.

## **Soitec's Plug & Sun portable mini-tracker**

At the WFES summit, Soitec displayed its Plug&Sun system, the first portable mini-tracker equipped with 4.2m<sup>2</sup> of CPV modules and a two-axis tracking system. These features enable the system to generate up to 3.4kWp of clean, reliable electricity, allowing it to supplement or replace existing electrification solutions such as diesel- and gasoline-driven power generators or other forms of renewable energy. It is compatible with international electrical standards and comes with an integrated battery system for powering common electrical devices continuously, 24 hours a day.

"Although an estimated 20% of the world's population lacks access to electricity, the vast majority of affected regions has great potential for generating solar energy. The Plug&Sun system that we will showcase at WFES 2013 provides the performance and ease of use to supply electricity to people living and working away from functioning power grids. It is also a way to replace or complement a diesel

generator with solar generated electricity, stored and available 24 hours a day," says Soitec's CEO & founder André-Jacques Auberton-Hervé.

Already a leader in CPV technology for large-scale solar power plants, Soitec is expanding its CPV offerings to meet the needs of additional market segments. The Plug&Sun system is an example of Soitec's creativity in bringing complete solutions to customers. This system is an eco-friendly product offering carbon-free emissions, easy deployment and low-cost operation to help meet sustainable development priorities around the world. Its durable design and tolerance for high temperatures make it ideal for use in sunny regions that have no power grid or unreliable grid connections, including remote communities, mobile sites, water-pumping and desalination systems, eco-lodges, telecommunication antennas and more. The Plug&Sun mini-tracker can supplement or replace existing electrification solutions, such as diesel- and gasoline-driven power generators or other forms of renewable energy. It delivers superior energy-producing efficiency, eliminates any reliance on fuel supplies and needs very little maintenance.

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

## Solar Junction partners with system maker Amonix

### Combining technologies targets increased efficiencies and lower leveled cost of electricity

Solar Junction of San Jose, CA, USA, which makes III-V multi-junction solar cells for concentrated photovoltaics (CPV), has signed a co-development agreement with Amonix Inc of Seal Beach, CA, USA, which manufactures utility-scale CPV solar power systems that use III-V multi-junction solar cells.

Founded in 2007 with investors including New Enterprise Associates, Draper Fisher Jurvetson and Advanced Technology Ventures, Solar Junction says that its cells, which incorporate proprietary adjustable-spectrum lattice-matched (A-SLAM) materials technology, enable it to more optimally partition the solar spectrum for maximum efficiency and greater reliability.

In February 2012, epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK signed a strategic investment agreement and exclusive epiwafer supply agreement with Solar Junction.

Last October, Solar Junction raised its own world record for the energy conversion efficiency of a commercial-ready production solar cell, from 43.5% at a concentration of 418 suns (achieved in April 2011) to 44% at 942 suns.

Previously, in May, Amonix raised its world record for CPV module efficiency from 30.3% to 33.5%.

The US National Renewable Energy Laboratory (NREL) has verified both the Solar Junction cell and Amonix module CPV efficiency records.

The firms say that, together, these

benchmarks for high-concentration photovoltaics confirm that they have a roadmap to reach the forecasted 30% cost reduction compared to existing photovoltaics (according to the report 'Concentrated PV (CPV) — World — 2012' published by PV Market Research.com last September).

"It is our goal, by combining our world record module technology with Solar Junction's world record solar cell, that we can increase efficiencies while driving CPV costs down," says Amonix's CEO Pat McCullough. "The results of this collaboration, and its lower leveled cost of electricity (LCOE), will be revealed soon."

[www.sj-solar.com](http://www.sj-solar.com)

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

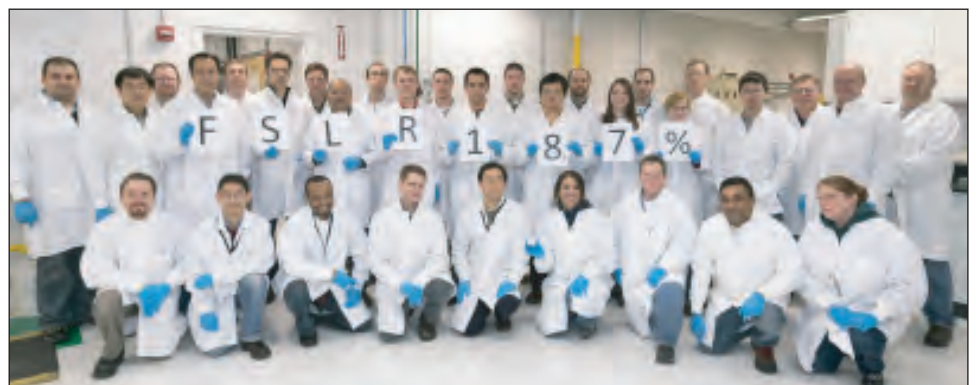
## First Solar sets 18.7% record for CdTe solar cell efficiency

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe), has set a new record for CdTe solar cell conversion efficiency, reaching 18.7% in tests confirmed by the US Department of Energy's National Renewable Energy Laboratory (NREL).

The firm set its last record of 17.3% in July 2011, although that was recently beaten by GE Research achieving 18.3% efficiency with its CdTe solar cells.

The latest record cell was constructed at the firm's Perrysburg, Ohio factory and R&D center using processes and materials — including the glass substrate — that are designed for commercial-scale manufacturing.

"This achievement showcases the huge potential of CdTe compared to other PV technologies and highlights the performance gains we continue to achieve thanks to our consistent and strong investment in R&D," claims chief technology officer Raffi



**First Solar's R&D team in Perrysburg, which has set a new record of 18.7% for CdTe solar cell efficiency (certified by NREL).**

Garabedian. "We are confident the advanced technologies and processes we developed for this record-setting cell will further enhance the performance of our future production modules and power plants."

First Solar says it has continued to transfer its success in the R&D lab into its commercial modules, raising its average production module efficiency from 12.2% in fourth-quarter 2011 to 12.9% in Q4/012. The firm's lead line was producing modules

with 13.1% efficiency during Q4, up from 12.6% a year previously.

Since beginning commercial production in 2002, First Solar has produced more than 90 million modules with a cumulative capacity of more than 7GW (enough to provide electricity for about 3.5 million homes and displace 4.7 million metric tons of CO<sub>2</sub> annually, based on world averages).

[www.firstsolar.com/Innovation/Advanced-Thin-Film-Modules](http://www.firstsolar.com/Innovation/Advanced-Thin-Film-Modules)



## AV Solar Ranch One plant achieves 100MW milestone; to reach 230MW this year

First Solar Inc of Tempe, AZ, USA, which makes cadmium telluride (CdTe) thin-film photovoltaic (PV) modules as well as providing engineering, procurement and construction (EPC) services, says the Antelope Valley Solar Ranch One project has reached a peak generating capacity of 100MW<sub>AC</sub> connected to the grid. The project, being constructed in northern Los Angeles County, will have a generating capacity of 230MW<sub>AC</sub> upon completion (expected later this year).

Initial construction on the project began in September 2011 and module installation started in June 2012, providing an average of 400 jobs during construction. Power from the plant is being purchased by Pacific Gas and Electric Company under a 25-year contract.

"We especially appreciate the support of LA County's Fifth Supervisorial District staff and the departments of Regional Planning and Public Works for their contributions to making this project a success," says Lou Moore, senior VP of EPC.



AV Solar Ranch One, under construction in LA County.

"Unlike traditional power plants, the modular nature of PV power projects enables us to quickly add substantial volumes of clean energy to the grid throughout the construction process. This shorter 'time to energy' is another key advantage of PV solar electricity."

When fully operational, the facility will generate enough power for 75,000 average California homes and will displace about 140,000 tons of carbon dioxide per year (equivalent to taking 30,000 cars off the road on an annual basis).

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

## First Solar acquires 50MW<sub>AC</sub> Macho Springs project from Element Power Solar

First Solar has acquired the 50MW<sub>AC</sub> Macho Springs solar project that Element Power Solar has developed in Luna County, NM on land leased from the New Mexico State Land Office.

Owned by Hudson Clean Energy Partners (a private equity firm that invests in renewable power, alternative fuels, and energy efficiency and storage), Element Power develops, acquires, builds and operates utility-scale solar and wind power projects.

"Element Power is pleased to once again work with the State of New Mexico, Luna County, the town of Deming and El Paso Electric to bring renewable energy and economic development to the region,"

says Element Power's chief operating officer Raimund Grube. "The sale of Macho Springs Solar to First Solar is the result of a strong working relationship that draws on each company's strengths," he adds.

First Solar will construct the facility using its CdTe PV modules. The project should provide up to 400 construction jobs. When completed (in 2014), it is expected to be the state's largest solar power project, producing enough renewable energy to power over 18,000 homes while displacing 40,000 tons of CO<sub>2</sub> per year (equivalent to taking 8000 cars off the road).

Electricity from the facility will be purchased by El Paso Electric under

a power purchase agreement (PPA) subject to regulatory approvals (expected in first-half 2013). The Macho Springs project was the result of a Request for Proposal (RFP) by El Paso Electric to include additional electric peaking resources in its current energy mix.

Previously, in 2011, First Solar completed New Mexico's 30MW Cimarron Solar facility, which is owned by Southern Company and Turner Renewable Energy. The same year it also completed 22MW of solar projects in the state for PNM Resources Inc. The firm has also been selected to build another 21.5MW for PNM, for completion in late 2013.

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

## First Solar adds VP of business development Middle East

First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe) as well as providing engineering, procurement and construction (EPC) services, says that Ahmed Nada will join it as VP of business development for the Middle East, reporting to Christopher Burghardt, VP of business development for Europe, Middle East and Africa (EMEA). In this new role, Ahmed will be based in the firm's Dubai office and will lead business development activities in the region outside of Saudi Arabia, where the company is also establishing operations.

Ahmed has 20 years of experience throughout the Middle East, concentrated in the energy and power industries. He joins First Solar after 14 years with General Electric. Most recently, he was the business exec-

utive and regional general manager of GE Oil & Gas Global Services in the Middle East.

"The Middle East is just beginning to tap its immense potential solar power generation, and Ahmed's many years of experience working with the region's leading energy companies will help us to meet the growing demand for renewable energy in the region," says Christopher Burghardt.

"Utility-scale solar power offers a compelling solution to the region's growing energy needs, and this is a great opportunity to leverage First Solar's proven technology and global experience," comments Ahmed Nada.

Ahmed holds a Master's of Science degree in international management from HEC Lausanne University in Switzerland.

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

## First Solar stockholders urged to reject TRC Capital mini-tender offer

On 25 January, First Solar said it had been notified of an unsolicited 'mini-tender' offer by TRC Capital Corp to purchase up to 2 million shares (about 2.3%) of the outstanding First Solar common stock at a price of \$30 per share in cash.

First Solar said that it did not endorse TRC's mini-tender offer and recommended that stockholders did not tender their shares in response to the offer because TRC's offer price was about 5% less than the \$31.58 market closing price of First Solar's common stock on 22 January (the day before the mini-tender offer commenced). According to TRC's offer documents, First Solar stockholders that had already tendered their shares could withdraw their shares at any time before noon, New York City time, 22 February.

First Solar urged stockholders to

obtain market quotes for their shares, and to exercise caution with respect to the offer. According to First Solar, mini-tender offers are designed to acquire less than 5% of a company's outstanding shares, avoiding many disclosure and procedural requirements of the US Securities and Exchange Commission (SEC) that apply to offers exceeding 5%. Mini-tender offers hence do not provide investors with the same level of protections as provided by larger tender offers under US securities laws. The SEC has cautioned investors about these offers, saying that "some bidders make mini-tender offers at below-market prices, hoping that they will catch investors off guard if the investors do not compare the offer price to the current market price."

[www.sec.gov/investor/pubs/minitend.htm](http://www.sec.gov/investor/pubs/minitend.htm)

### IN BRIEF

#### Indian space agency contract for Sofradir

Sofradir has a 2.5 year contract from ISRO/SAC (the Indian Space Research Organization's Space Applications Center in Ahmedabad) to develop large-format infrared detector prototypes for testing and will deliver numerous flight models.

ISRO focuses on developing capabilities in India to build and launch communication satellites for TV broadcast and telecoms, meteorological satellites, as well as remote sensing satellites for managing natural resources.

"This is Sofradir's first contract for flight models with the Space Applications Center," says chairman & CEO Philippe Bensussan. "It is the outcome of several years' close cooperation with the IR team at SAC that included delivering IR detectors for ground testing," he adds.

ISRO/SAC will receive flight models of the large-format 1000x256 Saturn SWIR (short-wave infrared) detector (Sofradir's best-selling IR detector for space applications, having delivered ten flight models in the last four years). ISRO/SAC will use Saturn SWIR for projects within India's hyperspectral Earth observation satellite development.

Compared to Saturn SWIR detectors deployed in space instruments such as PRISMA and TROPOMI, Sofradir will integrate: a new longer-life high-power active cooler (designed to extend operating lifetime from one to four years, as a single robust element); and an integrated custom optical filter (cutting the complexity of optics in front of the detector). "With this new contract, we'll be expanding our offer in space applications to include longer-life cooled IR detectors optimized for size, weight and power," says Bensussan.

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



# Flisom raises funding to ramp up 15MW flexible CIGS module production plant

## Empa's 20.4%-efficient cells to be scaled up for large-area solar modules

Flisom AG of Duebendorf, Zurich, which was spun off from the Laboratory of Solid State Physics of the Swiss Federal Institute of Technology Zurich (ETH Zurich) in 2005 to develop technologies for industrial roll-to-roll manufacturing of flexible thin-film copper indium gallium (di)selenide (CIGS) solar modules, says that it has raised substantial funding to further develop its technology and build a production plant with an annual capacity of 15MW in Switzerland. The firm has also signed an agreement with the interdisciplinary research institute Empa (the Swiss Federal Laboratories for Materials Science and Technology) to provide R&D support on high-efficiency flexible CIGS solar cell technology.

Flisom's third funding round was completed with participation from a Swiss investor along with existing strategic investor Tata, India's largest company.

"This new investment marks investors' satisfaction with Flisom's progress towards the development of industrial manufacturing technology for roll-to-roll production of flexible solar modules," says Flisom's interim CEO Marc Kaelin. "The 15MW plant will serve as a blueprint towards the establishment of larger-scale plants to manufacture flexible solar modules at low cost," he adds.

"We admire the team and technology, based on a record setting efficiency of over 20% for CIGS from Empa, which we hope will be scaled up successfully," comments Tata Industries' executive director K.R.S. Jamwal. "The funding will enable Flisom to purchase equipment and hire more experts to convert an innovative Swiss technology into an industrial reality."

Flisom reckons that its products, processes and systems could lower



Flisom's flexible CIGS solar cell.

the price of solar electricity through low material usage, economic production technology, and reduced storage, transportation and installation costs. Markets addressable by the flexible solar module manufacturing technology include utility-scale solar farms, building-integrated photovoltaics (BIPV), building-applied photovoltaics (BAPV), transportation, portable power and electronics.

The roll-to-roll manufacturing of flexible solar modules involves deposition of CIGS thin films onto polymer foil. Since being spun off by ETH Zurich, Flisom has developed proprietary manufacturing tools and processes. After moving to Empa's Dübendorf campus, Flisom has been collaborating with Empa's Laboratory for Thin Films and Photovoltaics, led by Ayodhya Nath Tiwari, through various projects. On 17 January, Empa announced that its CIGS flexible solar cells had achieved photovoltaic conversion efficiency of 20.4% — a record for CIGS technology that equals the record efficiency of polycrystalline

silicon wafer solar cells.

"Scale-up for large-area solar modules and adapting these complex innovative processes for industrial manufacturability is quite a challenge and requires close collaboration between research labs and industrial partner," notes Pierangelo Groening, head of the Department of Advanced Materials and Surfaces and member of Empa's board of directors.

"Therefore, Empa and Flisom have signed a collaboration agreement on certain topics of flexible CIGS technology, and Empa has deputed Tiwari for a part-time involvement as senior strategic officer to support Flisom's further development, a move that is instrumental to Empa's long-term strategy to support early-stage companies with global market ambitions," says Empa's CEO Gian-Luca Bona. "This is a very special way of technology transfer — by way of sharing highly experienced staff... I see it as sort of a kick-start for the company's new phase of development," he adds.

"We are very impressed by the high photovoltaic conversion efficiency attained by our scientific partners at Empa," comments Flisom's interim CEO Kaelin. "We look forward to benefitting from the insights of Empa to further raise the efficiency of flexible solar modules produced using Flisom's industrial roll-to-roll vacuum deposition technology."

[www.flisom.ch](http://www.flisom.ch)

[www.empa.ch](http://www.empa.ch)

# TSMC's commercial-sized CIGS solar modules set 15.1% efficiency record for monolithic thin-film PVs

## Champion module performance comparable to mainstream multi-crystalline silicon modules

TSMC Solar Ltd, which was founded in May 2009 as a subsidiary of the world's biggest silicon wafer foundry Taiwan Semiconductor Manufacturing Co Inc (TSMC), has announced confirmation by both TUV SUD and Underwriters Laboratories (UL) that its commercial-sized (1.09m<sup>2</sup>) champion CIGS (copper indium gallium diselenide) photovoltaic module has achieved 15.1% module total area efficiency. The champion module sets a new

record for monolithic thin-film efficiency, and was produced using the existing manufacturing equipment and materials at the firm's manufacturing facility in Taichung, Taiwan.

"In just one year, our process technology has made great progress," says president Ying-Chen Chao. "Our champion modules now have comparable module efficiency to mainstream multi-crystalline silicon modules, demonstrating TSMC Solar's ability to realize the

high-efficiency potential of our CIGS technology. Our technology's superior competitiveness comes from its high efficiency, excellent high-temperature performance and intrinsic cost-structure advantages," he reckons.

"TS CIGS Series modules deliver up to 5% additional energy yield over crystalline silicon in high-temperature regions," notes TSMC Solar's worldwide sales head Stephen McKenry.

[www.tsmc-solar.com](http://www.tsmc-solar.com)

## SEMI and PVMC sign memorandum of understanding

SEMI and the US Photovoltaic Manufacturing Consortium (PVMC) have signed a memorandum of understanding (MOU) to enhance their cooperation on standards and roadmap activities for the solar thin-film industry.

As a global industry association and standards development organization (SDO), SEMI serves the manufacturing supply chain for the micro- and nano-electronics industries, including photovoltaics (PV), through consensus-based, collaborative activities such as PV manufacturing standards via the SEMI International Standards program, as well as technology roadmap development via the International Technology Roadmap for PV (ITRPV).

PVMC, a national industry-led consortium headquartered in New York State at the College of Nanoscale Science and Engineering's (CNSE) Albany NanoTech Complex, is a partnership between international semiconductor manufacturers' research consortium SEMATECH of Albany, NY, USA and CNSE. PVMC was created as part of the US Department of Energy's (DOE) SunShot initiative (which is designed to reduce the cost of photovoltaic solar energy systems by about

75% over the next decade) and brings together the solar community — including industry, academia and government — in cooperative R&D to accelerate the development, commercialization and manufacturing of next-generation solar photovoltaic (PV) systems.

Through PVMC, CNSE and SEMATECH are spearheading a unique research, development and commercialization partnership in which industry, academia and government are working together to drive advances in next-generation solar cell technologies, beginning with copper indium gallium selenide (CIGS) thin-film PV manufacturing solutions — increasing performance while driving down the cost and risk of bringing them to market.

"By joining forces with PVMC and by leveraging lessons learned from SEMI's ITRPV [International Technology Roadmap for Photovoltaic] roadmap and PV standards activity, we intend to create synergies along the PV thin-film manufacturing supply chain, enabling cost reductions and efficiency gains that will benefit the entire global solar industry," says Bettina Weiss, SEMI's VP, business development.

"In accordance with Governor

Andrew Cuomo's innovative green energy initiatives, including the NY-SUN and Energy Superhighway programs, PVMC is delighted to partner with SEMI to drive the development of standards and roadmaps that will guide next-generation PV research and advanced manufacturing," says Dr Pradeep Halder, PVMC's chief operating and technical officer and CNSE's VP for Clean Energy Programs. "This collaboration further highlights the ability of public-private partnerships to enable leading-edge technologies while supporting the critical needs of industry," he adds.

"A critical objective of PVMC is to build on earlier PV roadmap initiatives and support cooperative standards activities for thin-film PV manufacturing and applications," notes Joe Hudgins, PVMC's senior VP of business development and strategic alliances. "This partnership demonstrates PVMC's and SEMI's strong commitment to coalesce industry direction by tackling top industry concerns on the technical barriers for advanced solar PV-related manufacturing processes and BOS (balance of systems) applications and product certifications."

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

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



## Solar Frontier forming joint investment firm with Development Bank of Japan to fund utility-scale plants

In mid-January, Tokyo-based Solar Frontier — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — reached a basic agreement with the Development Bank of Japan Inc (DBJ) to establish a joint investment company that will provide funding for utility-scale solar power plants.

The company will begin operating in February and initially target investments in projects totaling 100MW annually. The firm will become an independent power producer (IPP) and will invest in utility-scale solar projects throughout Japan. Of total capital, Solar Frontier will contribute 60% and DBJ 40%.

The company will invest in not only large-scale projects but also a wide range of projects, including those that have a suitable land plot to develop but have not progressed in terms of finding power producers or financing sources, as well as those less than 2MW (for which it is generally difficult to source project finance).

By providing integrated processes along the value chain from financing to construction and IPP operations, the new firm aims to respond speedily to demand for utility-scale projects in the Japanese market. It also aims to be more competitive in the downstream business by using a new business model to sell already up-and-running projects to

IPPs and investors.

While adding value in the downstream area of solar projects, Solar Frontier says it will support a wide range of customers looking to enter the IPP business by accumulating expertise from the development and operation of IPP projects.

Solar Frontier says that its CIS thin-film photovoltaic modules are being adopted in utility-scale projects both in Japan and abroad. The firm intends to contribute further to the widespread use of renewable energy in Japan by not only supplying solar panels but also providing a full range of services for solar power generation projects.

[www.solar-frontier.com](http://www.solar-frontier.com)

## XsunX begins processing CIS films with CIGSolar evaporation system

XsunX Inc of Irvine, CA, USA, which is developing hybrid copper indium gallium (di)selenide thin-film (CIGS) photovoltaic (TFPV) cell technologies and 'CIGSolar' manufacturing processes, has begun processing CIS films with its recently completed CIGSolar TFPV solar cell evaporation system. The firm has been testing and calibrating the deposition source technology in its new evaporation system so that it can transition to processing CIGS films.

"Recently we initiated the last phase necessary for preparing our CIGSolar TFPV solar cell evaporation system for customer demonstrations with the initiation of CIS (copper indium and selenium) film processing," said CEO Tom Djokovich. "This represents a major step forward and allows us to then transition to CIGS (copper indium gallium and selenium) films and the completion of the system's readiness for demonstrations."

XsunX's technology uses multi-

small-area thermal co-evaporation to deposit the CIGS solar absorber onto thin stainless-steel substrates, which can then be sized to match silicon solar cells for use as a low-cost alternative to silicon solar cells. The flexible aspect of the stainless-steel substrate could also be used in applications where flexibility is required, such as building-integrated PV (BIPV) applications, opening up new market opportunities.

"There was a lot of buzz over CIGS PV that began to develop in 2009 and grew into 2010," says Djokovich. "But with the rapid decline in silicon pricing, many companies focused on producing products to compete with silicon module assemblers have either closed or sold out," he adds.

"XsunX took a different approach with CIGSolar. Rather than develop a product that attempts to compete with assemblers of silicon solar modules, which is a business path that has seen the demise of numer-

ous thin film companies such as Solyndra, XsunX's CIGSolar is designed to offer pre-existing silicon module assemblers a lower-cost replacement to silicon. Our business objective is to leverage the many GW of existing assembly capacity in the market — not compete with it. Now it appears that the flexibility of our stainless-steel substrates may also offer an alternative cell for BIPV assemblers as well."

According to analysts, markets for BIPV installations are predicted to grow by \$5bn over the next two years. The flexibility of CIGSolar cells could offer BIPV manufacturers the potential to use cells manufactured using the CIGSolar process in their products. With the closure of some thin film manufacturers and scaling back of production with others, the company has begun to receive inquiries related to BIPV applications for CIGSolar cells.

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

## DayStar agrees sale of CIGS solar technology line and patents to PacWest Equities

DayStar Technologies Inc (DSTI) of Kelowna, BC, Canada, which was founded in California in 1998 to make copper indium gallium diselenide (CIGS) thin-film photovoltaic modules, has agreed the sale of its CIGS solar technology line to PacWest Equities Inc (PWEI), which uses solar energy to naturally grow animal bio-feed and organic foods on mobile units.

The deal is subject to completion of due diligence (which has been on-going since December) and DayStar's board approval of the transaction.

The transaction includes ownership of all of DayStar's solar assets, including its proprietary manufacturing process to produce low-cost, monolithically integrated, silicon-free, CIGS-on-glass modules addressing the grid-tied, ground-

based PV market as well as the building-integrated photovoltaic (BIPV) market.

DayStar developed its CIGS PV module based on its proprietary one-step CIGS deposition process. The CIGS module addresses the construction market's need to be compatible with solar's largest growth area, i.e. building integration and the most rapidly growing market for thin-film solar (BIPV).

The technology is also of interest to PacWest Equities' subsidiary World EcoSource, a technology-based firm that has developed the MobileFeed and MobileFood systems, which help to offset deficient worldwide food production for both animals and humans.

"This strategy fits well with the company's go forward plan as disclosed in our PRE 14A," says

DayStar's president Lorne Roseborough. In the preliminary proxy statement (filed with the US Securities and Exchange Commission on 21 January), DayStar said that the transition would benefit it financially from PacWest's revenue-generating opportunities using DayStar's technology. The deal was expected to generate proceeds of up to \$10m from an equity deal and royalty revenue streams from a sinking fund worth a total of \$27m. DayStar now says some analysts value the deal in excess of \$50m.

DayStar said that the transition would not only relieve it from further needed investment towards completion of its facility, but also provide it with funding to support its new growth strategy.

[www.worldecosource.com](http://www.worldecosource.com)  
[www.daystartech.com](http://www.daystartech.com)

## DayStar acquires 20% stake in Premier Global Photosynthesis technology integrates energy generation & storage

DayStar's board of directors has approved the acquisition of a 20% equity ownership in Canadian firm Premier Global Holdings Corp.

DayStar is issuing \$12m in preferred stock in return for the 20% stake in privately held Premier. The preferred stock can be converted to common stock at \$1.60 per share, and will pay an in-kind dividend of 5% per annum.

Developed at the University of British Columbia (UBC), Premier's technology integrates photosynthesis into the PV system, permitting simultaneous generation and storage in a single solar cell for the first time, it is claimed. Each battery-like cell comes complete with two electrodes and an electrolyte. Light is absorbed by harvesting light molecules in the electrolyte. Charges are then transferred between the excited light-harvesting molecules and mediator molecules that are also in the electrolyte with nearly perfect

quantum efficiency. The mediators store the harvested energy, which can be extracted at the electrodes on demand. The system therefore addresses the natural intermittency of solar power and can make it available under low or no direct-sun conditions. The result is a built-in solution for reducing total demand on the local electrical grid.

"Premier's photosynthesis photovoltaic (PV) system promises significantly lower total solar energy costs, good performance in low lighting conditions, along with a significantly reduced footprint, and a wide range of possible form factors," says Premier's president John Crawford, who was previously director of strategic ventures for Energizer Holdings (ENR).

DayStar's president Lorne Roseborough said the new technology represents a "fundamental change" in the business model for solar energy, and will provide

Daystar with "a significant competitive advantage in its efforts to facilitate utilities and their customers in designing more cost-effective and profitable renewable energy projects," he reckons. "The technology will enable the deployment of units that could be built into apartments, offices, homes, and industrial sites, providing power during utility system outages and natural disasters."

"Having assembled a team of world-class engineers and system designers, and developed or co-developed projects now or soon to be underway around the world using today's technology, we are very well aware the critical role new technology will play in the expansion of the solar market," says Roseborough. "By investing in Premier we gain access to an important piece of that future without committing the company to fund and manage its own R&D team."



# Reducing gallium nitride growth temperature to 500°C

The pre-deposition of a thin layer of indium can improve the quality of GaN, and may help to extend nitride applications to solar cells.

**S**eoul National University and Ritsumeikan

University in Korea have developed a new technique for growing higher-quality gallium nitride (GaN) layers at temperatures as low as 500°C [In-Su Shin et al, Appl. Phys. Express, vol5, p125503, 2012]. The work developed from the group's previous observations in research directed towards higher-quality indium nitride (InN) and indium gallium nitride (InGaN) growth.

The new growth technique uses a pre-deposition of a thin layer of indium that improves the quality of the subsequent GaN. The indium apparently allows the Ga atoms to migrate more easily on the growth front and to become incorporated into the crystal structure. The indium is not incorporated, but rather is swept upward as the GaN layer develops.

The researchers see their technique as having potential application for growing large-bandgap GaN layers on narrower-bandgap InGaN. Such structures would be useful in multi-junction solar cells, for example. High-temperature growth on InGaN surfaces is difficult because the indium content then tends to evaporate due to its lower binding energy with nitrogen compared with gallium.

The growth temperatures for InN and GaN reflect this: for GaN molecular beam epitaxy (MBE) the nor-

mal growth temperature is around 750°C, while the maximum values for InN are 570°C (N-polar) and 470°C (In-polar). Growth of GaN at temperatures consistent with InN tends to result in low-quality polycrystalline layers with large numbers of misfit defects.

The researchers used MBE rather than metal-organic chemical vapor deposition (MOCVD), since MBE allows lower-temperature growth in general. Radio-frequency MBE was performed on 3µm semi-insulating GaN templates previously grown on sapphire substrates using MOCVD.

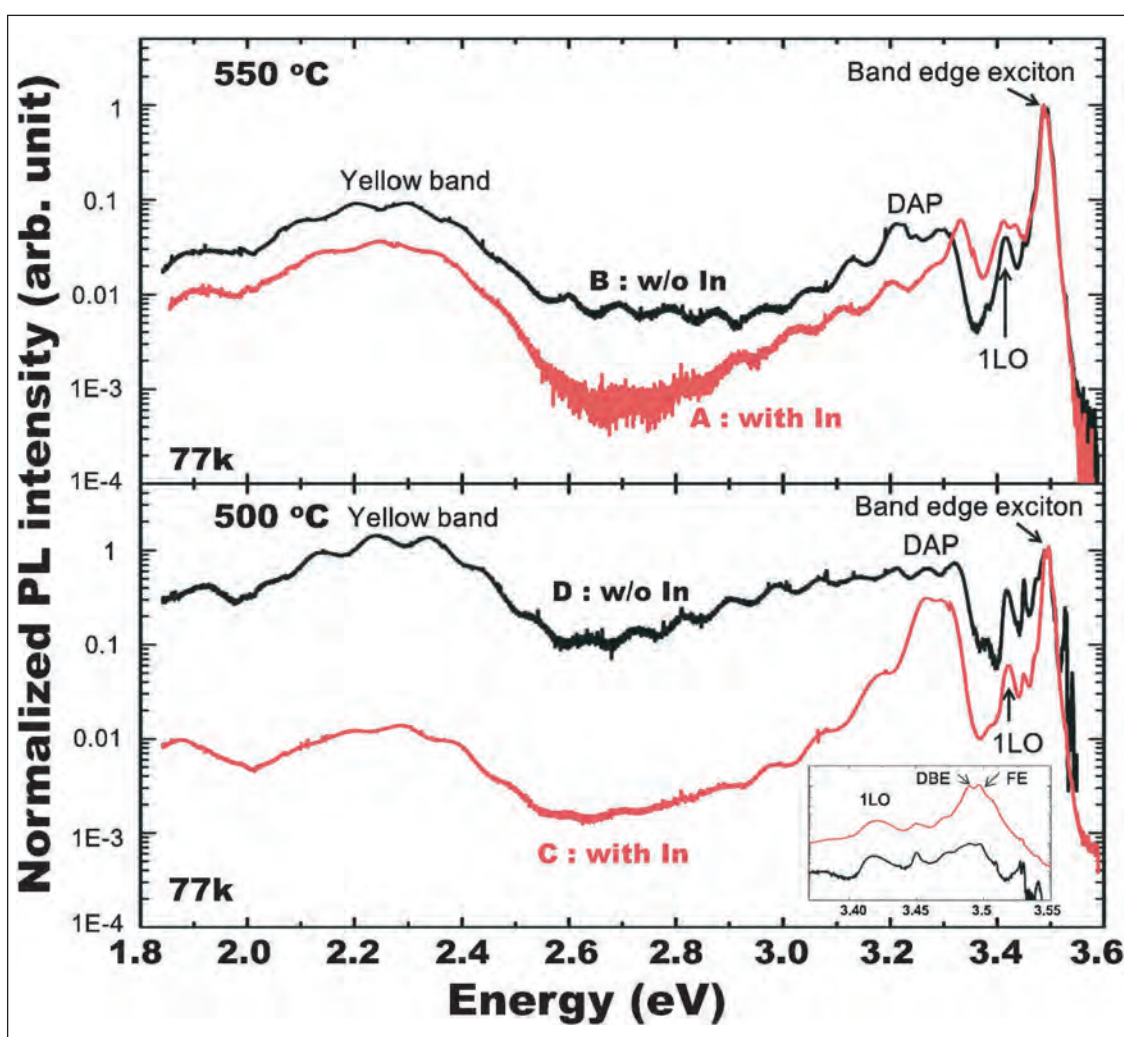


Figure 1. 77K PL spectra of LT GaN grown at (a) 550°C and (b) 500°C. (DAP: donor acceptor pair transition; LO: longitudinal optical phonon; DBE: donor bound exciton; FE: free exciton).

Table 1. Summary of experimental samples and results.

Sample	Growth temperature (°C)	In coverage	Hall mobility (cm <sup>2</sup> /V-s)	Hall electron concentration (/cm <sup>3</sup> )	Intensity ratio of yellow emission to band-edge 77K PL	FWHM of band-edge 77K PL (meV)	RMS AFM surface roughness (nm)
A	550	Yes	200	2:2x10 <sup>17</sup>	0.011	14	1.2
B	550	No	160	1:2x10 <sup>18</sup>	0.030	16	1.4
C	500	Yes	152	9:8x10 <sup>17</sup>	0.0044	14	1.3
D	500	No	149	1:1x10 <sup>18</sup>	0.427	21	2.2

The researchers began RF-MBE with a thin layer of 700°C GaN to suppress surface oxidation effects. The temperature of the system was then lowered to 500°C or 550°C. The low-temperature (LT) 300nm GaN growth was preceded by a thin layer of metallic indium (In). After the LT GaN growth, the surface of the sample was cleaned of In residue with a hydrochloric acid treatment. Comparison samples without In pre-deposition were also made.

The growth of GaN rather than InGaN is due to the preferential incorporation of gallium rather than indium in the GaN crystal when a Ga-rich growth condition is used (N/Ga < 1). By contrast, in nitrogen-rich conditions (N/Ga > 1), x-ray diffraction scans reveal peaks for both GaN and InGaN crystal regions. Scanning electron micrographs taken after the growth showed the presence of In droplets on the surface of the samples, indicating that the In-layer is swept out to the surface throughout the growth so long as Ga-rich growth is maintained.

The samples were also subjected to photo-luminescence (PL) excitation with a 325nm He-Cd laser at 77K (Figure 1). A strong band-edge signal at 3.48eV indicated again that the In was not incorporated into the crystal structure. Further, the samples with In pre-deposition show reduced 'yellow band' emission that has been associated with donor-acceptor transitions due to defects and impurities. By contrast, the yellow band for the lowest-growth-temperature GaN (500°C)

without In pre-deposition (sample D) is higher intensity than the weak band-edge emission. The In pre-deposition (sample C) increases the band-edge by about 120 times, effectively suppressing the yellow band by about two orders of magnitude.

Another effect of In pre-deposition is to narrow the band-edge peak full-width at half maximum (FWHM) from 21meV to 14meV. On closer examination, the band-edge peak in sample C consists of two types of exciton – one is donor bound (DBE) and the other is free (FE). This structure of the band-edge is not clear in sample D.

The higher-growth-temperature GaN (550°C) also shows improvement in performance with In pre-deposition, although the yellow-band suppression is only a factor of 2.7 and the band-edge excitation is increased by 1.4x. The band-edge linewidth FWHM narrowing is also less impressive from 16meV to 14meV.

Hall measurements reveal almost an order of magnitude reduction in residual electron concentration and a modest increase in mobility with In treatment for the 550°C GaN (Table 1). The changes for the 500°C GaN are in the same direction, but not as dramatic.

The surface texture of the samples was studied with atomic force microscopy (AFM). All the samples indicated that most of the growth proceeded in the '3D island mode'. However, with In treatment the samples were smoother and some regions showed evidence of 2D growth sporadically between the 3D islands. "These results demonstrate that the reduced surface migration at low temperatures was compensated by using the pre-deposited In," the researchers comment.

Increased surface migration in GaN grown at higher temperatures leads to better crystal quality. The researchers point out that their material was not expected to have the performance of high-temperature GaN. They add: "However, our results, namely the improved structural, electrical, optical and surface properties of LT GaN epilayers with pre-deposited In, thoroughly indicate that this growth method can be employed to overcome the difficulties in obtaining good-quality LT GaN by the conventional growth methods." ■

<http://apex.jsap.jp/link?APEX/5/125503>

Author: Mike Cooke

**These results demonstrate that the reduced surface migration at low temperatures was compensated by using the pre-deposited In... Our results, namely the improved structural, electrical, optical and surface properties of LT GaN epilayers with pre-deposited In, thoroughly indicate that this growth method can be employed to overcome the difficulties in obtaining good-quality LT GaN by the conventional growth methods**



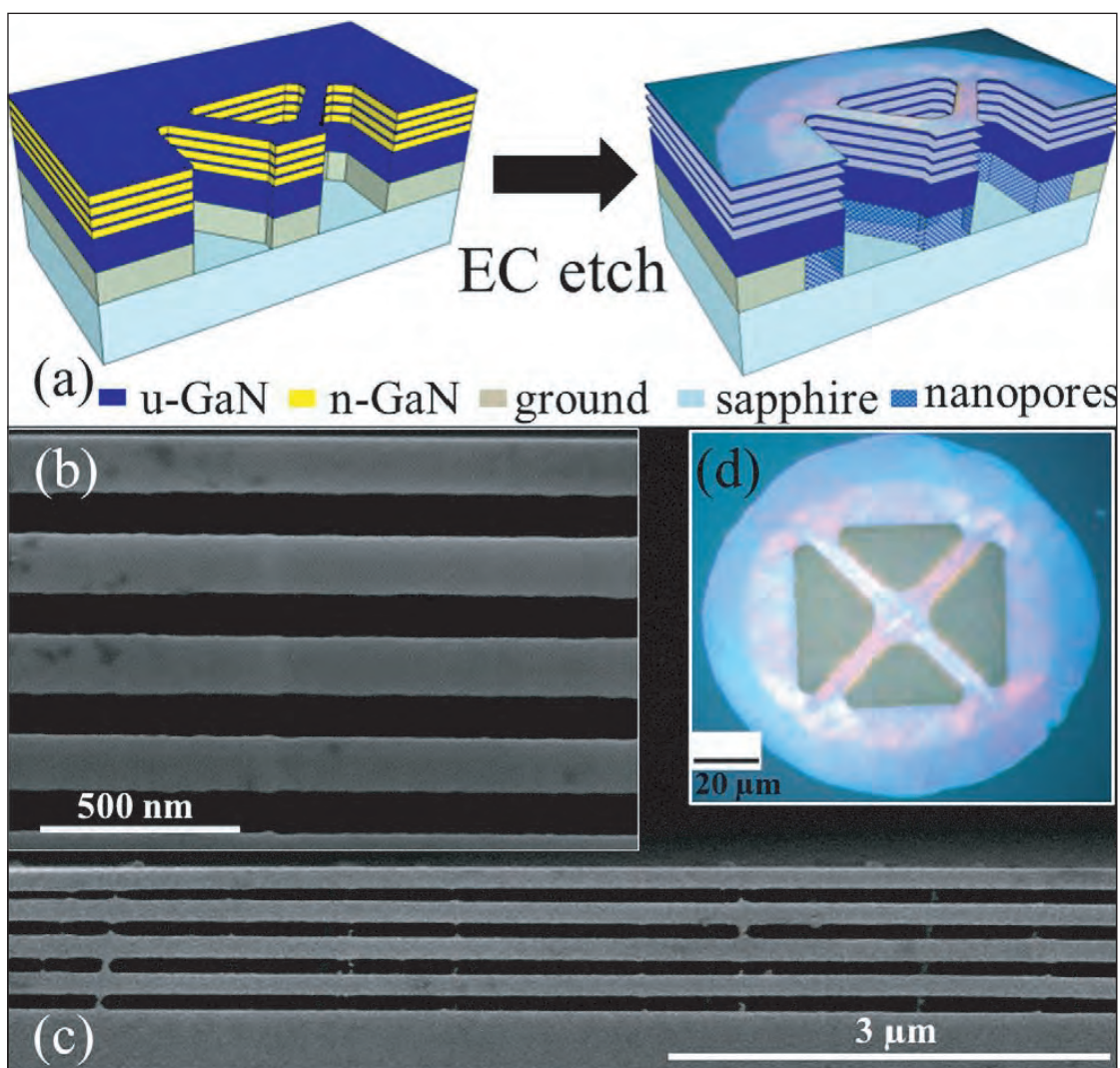
# Distributed Bragg reflection in epitaxial nitride layers

**Yale researchers have developed DBR mirrors for nitride VCSELs with reflectivity of more than 98%, 3–5x that of other epitaxial approaches.**

**T**wo Yale University researchers have developed epitaxial distributed Bragg reflectors (DBRs) in nitride semiconductors with reflectivities of more than 98% [Danti Chen and Jung Han, Appl. Phys. Lett., vol101, p221104, 2012]. Further, the structure used consisted of just four periods of gallium nitride (GaN) and air gaps produced using electrochemical (EC) etching.

Epitaxial DBRs consist of layers of semiconductor with different refractive indices that create interference effects that reflect light back from the structure. With arsenide-based semiconductors, these structures can be used to confine light in vertical-cavity surface emitting lasers (VCSELs), due to the large variation in the refractive index of aluminium gallium arsenide (AlGaAs) with aluminium fraction. DBRs are also used in spontaneous emission devices (resonant-cavity light-emitting diodes, or RCLEDs).

For nitride-based VCSELs, the refractive index variation in AlGaAs is much smaller, meaning that, for high reflectivity, one needs 20–40 different layers of semiconductor. Because of the difficulty in producing such structures with the required quality, recent developments of nitride-based VCSEL have used separately grown dielectric stacks for the DBR sections of these



**Figure 1. (a) Schematic of DBR fabrication process; (b) and (c) cross-sectional SEMs of GaN membrane DBRs confirming clear air gaps are formed; (d) differential interference contrast microscopy (DIC) image of DBRs after electrochemical etching. Formation of air gaps results in a circular pattern. The outer circle is the air gap of the DBR; inner circle is the unintentional porosification of the ground-plane layer.**

devices. Separate processing adds to manufacturing complexity, increasing production costs.

The Yale DBR is based on the large difference in refractive index between GaN (~2.5) and air (1). The structures for the DBR were grown using a standard two-step metal-organic chemical vapor deposition (MOCVD). The epitaxial material consisted of four pairs of undoped and n-type silicon-doped GaN layers.

These were grown on a 500nm u-GaN spacer/etch-stop layer. The ground-plane underneath the structure consisted of 500nm n-GaN that was designed to ensure uniform distribution of the anode bias across the sample.

Due to the higher conductivity of the n-GaN, the electrochemical etch proceeds selectively into these layers, giving air gaps between the unetched u-GaN layers. The thicknesses of the u-GaN were quarter or three-quarter wavelengths, where the target wavelength was ~500nm. The thickness of the n-GaN layer was quarter-wavelength with a view to mechanical stability of the eventual air gap.

The etching was carried out by first applying a vertical inductively coupled plasma reactive-ion etch (ICP-RIE) to expose the side walls of the structure for the subsequent lateral wet EC under-etch. The plasma etch was performed with a nickel mask. The electrolyte for the electrochemical etch consisted of ethanol/glycerol in hydrofluoric acid.

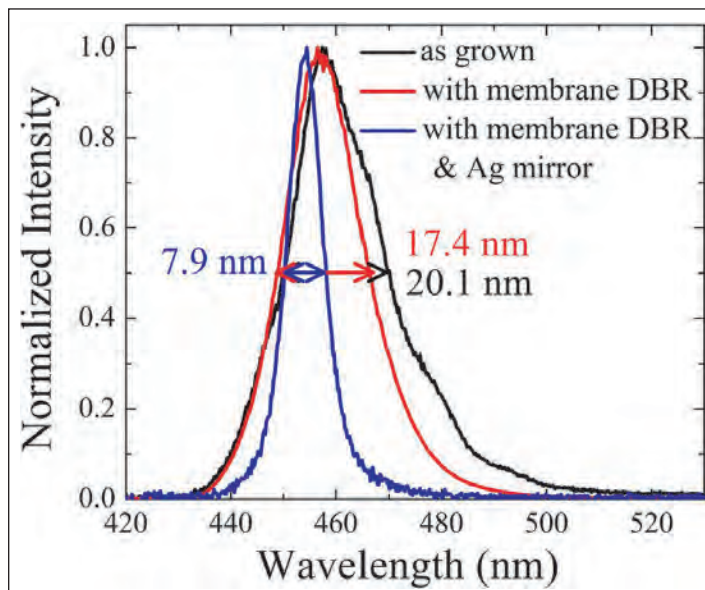
The quality of the structures was affected by both ICP-RIE and EC processes. In particular, the ICP-RIE needed to result in side-walls with minimal corrugation. For the EC etch, anode potentials below 15V result in smoother surfaces at the cost of a lower etch rate. At 12V, the surface roughness was less than 5nm root mean square over a 5µm x 5µm area.

The four-pair quarter-wavelength membrane structure achieved a peak reflectance of 98% at 503nm wavelength. The stop-band width was around 150nm. The researchers point out that the width of the stop-band was three to five times that of other reported epitaxy-based DBR mirrors. A simulation of the system suggests that fluctuation of the air-gap thickness degrades the performance somewhat.

The researchers also grew multi-quantum-well (MQW) superlattice structures on the DBRs and made photoluminescence measurements. The aim was to create a microcavity, as used in RCLEDs and VCSELs. The superlattice consisted of 30 pairs of  $\text{In}_{0.06}\text{Ga}_{0.94}\text{N}/\text{GaN}$  (2nm/2nm) and 10 periods of  $\text{In}_{0.17}\text{Ga}_{0.83}\text{N}/\text{GaN}$  (3nm/8nm) grown on a three-quarter-wavelength DBR designed for 460nm emission.

Photoluminescence on an excitation spot of diameter about 2µm showed significant line-width narrowing with a DBR, compared with the superlattice before EC etch (Figure 2). The full-width at half-maximum (FWHM) for the superlattice was 20nm without DBR and 17nm with DBR. Further, the emission intensity increased five to ten times with the DBR. The interference fringes also disappeared with the reduction in estimated cavity length to around 0.38µm.

Although the reduction in FWHM is rather small, the researchers point out that this is due to the low reflectivity of the upper 'mirror' of the cavity (i.e. the top surface) of around 18%. By applying 50nm of silver to



**Figure 2. Emission spectra of MQW samples (1) without DBRs, (2) with bottom DBRs, and (3) with bottom DBRs and silver capping layer.**

the top surface with reflectance of 70% at 460nm, the FWHM is reduced to less than 8nm.

The researchers carried out simulations with varying qualities of the bottom and top mirrors. Comparison of the results with the experimental FWHMs for 18% (bare top surface) and 70% (50nm silver) top mirror reflectivity suggests that the bottom mirror is highly reflective and compares favorably with the simulation involving a 95% reflective bottom mirror.

"The good agreement between the experimental and simulated FWHM with highly reflective bottom DBR indicates that the high-reflectance membrane DBR can be used to control the modes of spontaneous emission," the researchers write.

By moving the position of the excitation spot from the unetched region of the structure across a strut to the central freely suspended region and out along an adjacent strut, the researchers were able to explore shifts in the peak frequency. The central, freely suspended region was blue-shifted some 35–40meV relative to the response in the edge regions. The researchers believe the shift could be due to a reduction in strain leading to reduced piezoelectric fields in the MQW superlattice of the freely suspended region.

The strain relief was 0.104%, according to Raman shift measurements that are affected by differences in sound wave/phonon propagation with strain. The researchers used the change in strain/piezoelectricity to predict a peak wavelength shift of 34meV. "The good agreement between experimental and theoretical results suggests that the piezoelectric effect is the dominant factor responsible for the observed emission shift," the researchers comment. ■

<http://link.aip.org/link/doi/10.1063/1.4768806>

Author: Mike Cooke



# Nanocolumns support monolithic multi-wavelength emission

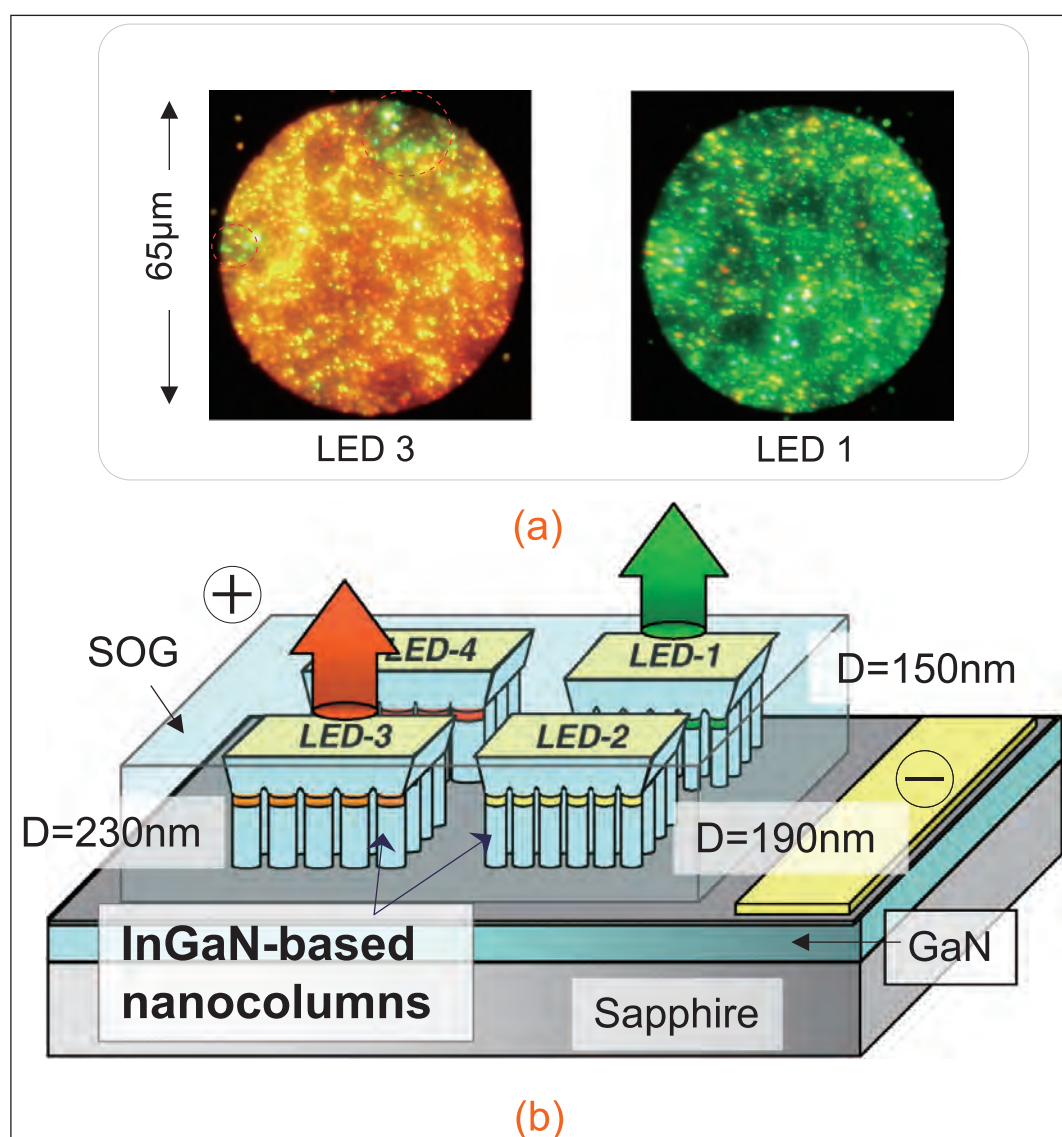
**Orange and green nitride LEDs have been produced in a single growth process for the first time, claims Japan's Sophia University.**

**S**ophia University in Tokyo, Japan, has used nanocolumns of nitride semiconductor to produce different emission color LEDs in a single growth process for what is claimed to be the first time [Katsumi Kishino et al, Appl. Phys. Express, vol6, p012101, 2013].

The researchers have been developing a titanium-mask selective-area growth (SAG) technique of indium gallium nitride (InGaN) nanocolumns by rf-plasma-assisted molecular beam epitaxy (rf-MBE). Previous work has demonstrated strong red photoluminescence comparable with green emission.

The diameter of the nanocolumn was found to influence the peak wavelength, with increasing diameter leading to a wavelength shift from blue to red. This shift apparently arises from the beam-shadowing effects where less gallium is incorporated into the crystal structure, creating high-indium-content InGaN wells with narrower bandgap and hence longer-wavelength emission towards the tops of the columns.

In the latest work, the team produced monolithically four regions of nanocolumns with different emission wavelengths (Figure 1). The rf-MBE growth was performed on gallium nitride templates produced on sapphire using metal-organic chemical vapor deposition



**Figure 1. Monolithic integration of InGaN-based nanocolumn LEDs with different emission colors: (a) near-field emission images of green and orange emissions for LEDs 1 and 3, respectively, and (b) schematic diagram of monolithically integrated nanocolumn LEDs on GaN template on sapphire substrate.**

(MOCVD). The nanocolumns were arranged in triangular arrays with a lattice constant of 400nm. LEDs 1–3 emitted visible light with DC current injection at wavelengths of 544nm (green), 583nm and 597nm (orange),

respectively. The wavelengths from previous PL measurements with the same diameter nanocolumns were 520nm, 570nm, 600nm and (for LED 4) 630nm.

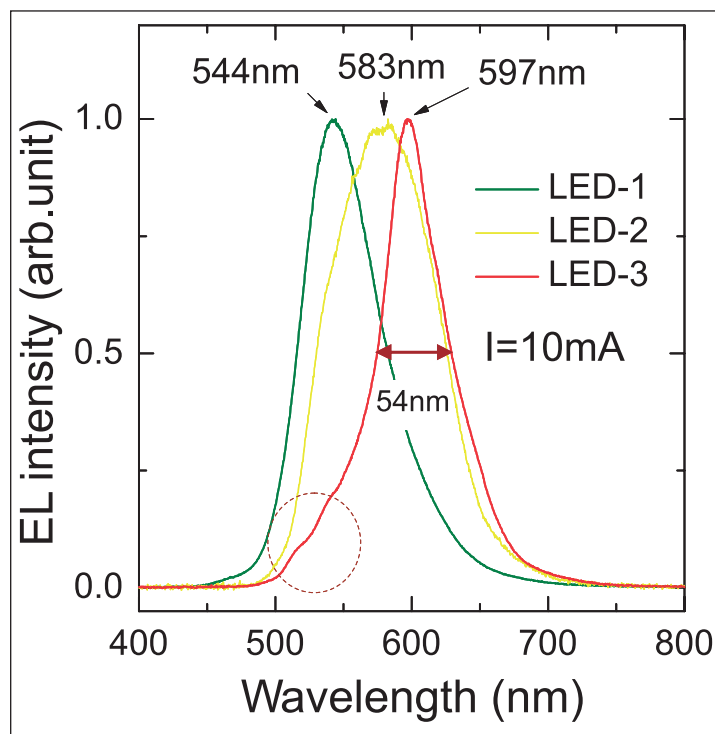
The width of the electroluminescence spectrum for LED 2 was broad, at 96nm full-width at half-maximum (FWHM), which was blamed on deficiencies in the SAG process for this region. The other LEDs had narrower emission spectra, with LEDs 1 and 3 having FWHMs of 67nm and 54nm, respectively.

Further imperfections were noted for LED 1 with 'long-tail' emission in the yellow region being caused by 'growth singularities', and other imperfections such as surface gaps and depressions of the nanocolumn structures that lead to current leakage and other performance degradation. The kink in the green region of the LED 3 is attributed to green emission due to irregular SAG processing, as seen in the near-field image in Figure 1.

Although blue emission is possible in principle, the researchers decided not to produce nanocolumn LEDs for the respective wavelength due to concerns about increased current leakage. The wider spacing between narrower nanocolumns will need sidewall-passivation to suppress such leakage, according to the researchers.

The growth of the nanocolumns proceeded in the order Si-doped n-GaN (3hours at 890°C), InGaN/GaN (1.5nm/1.5nm) short-period superlattice (635–645°C from this point in the process), 3-period InGaN/GaN multi-quantum well (3nm/12nm MQW), 20nm GaN intermediate layer, 10nm p-AlGaIn electron blocking, 250nm GaN cladding, and finally a 50nm p-InGaIn contact layer.

The space between the nanocolumns was filled with spin-on glass (SOG). The p-contact electrodes were formed by etching 70µm-diameter openings in the SOG at the centers of the nanocolumn arrays, depositing indium tin oxide (ITO) transparent conducting material,



**Figure 2. Electroluminescence spectra of LEDs 1–3 under DC current injection of 10mA.**

and titanium/palladium/gold metal electrode layers. Emission windows of 65µm diameter were etched in the p-contact metal. The n-side electrode metals were titanium/aluminium/titanium/gold.

Photoluminescence (PL) of the structures was carried out using a 405nm laser diode excitation. The peak wavelengths were 559nm, 580nm and 590nm for LEDs 1–3, respectively. LED 4 produced little PL. The researchers believe this was due to coalescence of the n-side nanocolumns and the resultant introduction of threading dislocations into the InGaN MQW active region. ■

<http://apex.jsap.jp/link?APEX/6/012101>

Author: Mike Cooke

**REGISTER**  
for *Semiconductor Today*  
free at  
**[www.semiconductor-today.com](http://www.semiconductor-today.com)**



# Air-channels and nanoporous structure boost output from nitride LEDs

**Researchers in Taiwan have increased the light output power of nitride LEDs by 1.75x over standard devices due to improved light scattering.**

Taiwan's National Chung Hsing University has used nitride semiconductor growth on gallium nitride nanocolumns and nano-porosity achieved with photoelectrochemical etching to boost the light output power of light-emitting diodes (LEDs) by up to 1.75x [Ren-Hao Jiang et al, Appl. Phys. Express, vol6, p012103, 2013].

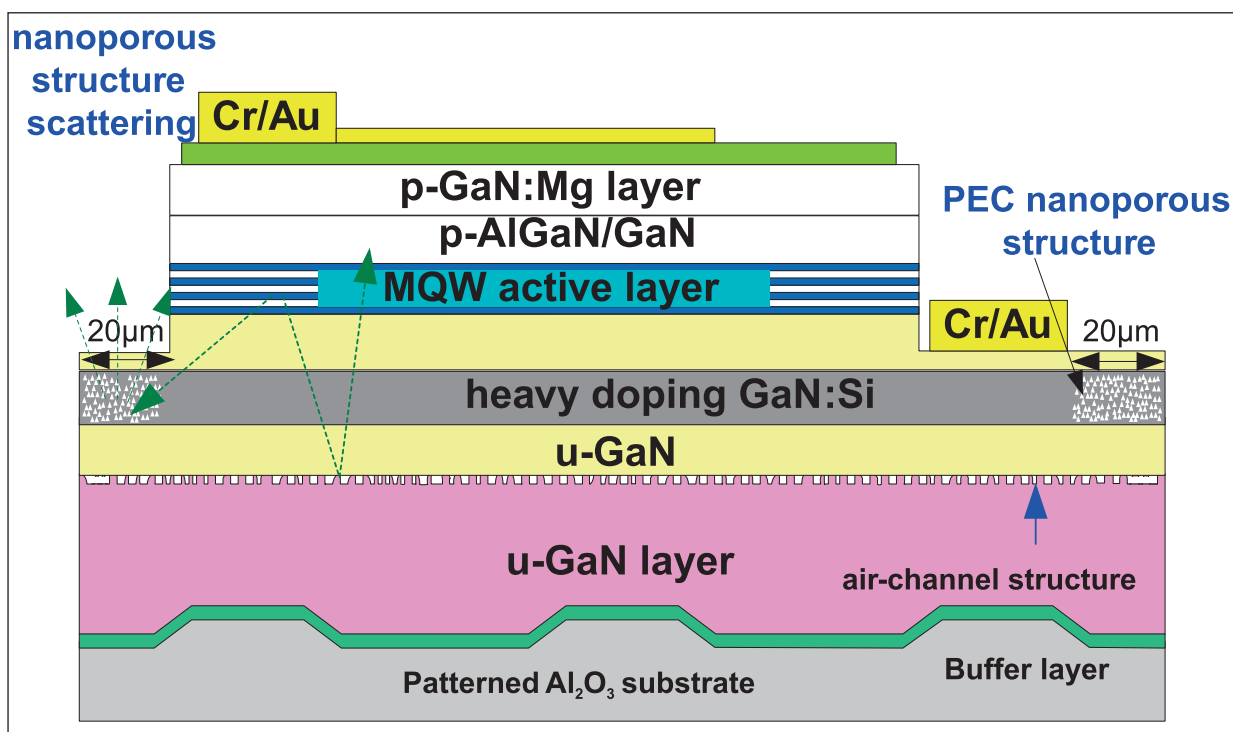
The researchers used metal-organic chemical vapor deposition (MOCVD) on patterned sapphire to grow the epitaxial material for the LEDs (Figure 1). The first two layers consisted of 30nm of low-temperature GaN (550°C) as a buffer, followed by 6µm of high-temperature undoped (u-)GaN (1150°C) as template.

The nanorod layer was formed using a 75Å-thick layer of nickel that was self-assembled into clusters by a rapid thermal anneal at 850°C in nitrogen for 90 seconds. The exposed GaN surface was reactive-ion etched. The nickel was removed by nitric acid solution, leaving nanorods that were 200–400nm in diameter and 0.5µm high.

The MOCVD process was then continued with 2µm of undoped GaN (1150°C), 2µm of heavily doped n-GaN, 0.5µm of lightly doped n-GaN, a nine-period multi-quantum well layer ( $\text{In}_{0.2}\text{Ga}_{0.8}\text{N}/\text{In}_{0.01}\text{Ga}_{0.99}\text{N}$ , 3/13nm, 830°C), a six-period electron-blocking layer ( $\text{Al}_{0.3}\text{Ga}_{0.7}\text{N}/\text{GaN}$ , 2/2nm, 950°C), and, finally, 0.13µm of p-GaN.

The photoelectrochemical (PEC) process was preceded by cleaving the 2-inch wafer into two halves, and isolation using a triple-frequency ultraviolet Nd:yttrium aluminium garnet (355nm) laser. The PEC etch process was performed with 0.5M oxalic acid, 0.5V DC bias, and illumination by a 400W mercury lamp. The PEC etch mainly attacked the heavily doped n-GaN layer, giving a nanoporous structure of ~0.1µm-diameter triangular holes. This region extended laterally about 20µm into the n-GaN layer from the laser scribe line. The PEC etch also reduced the diameters of the nanorods in the air-channel region.

Various LEDs were produced with/without air-channels from the nanorods, and with/without nanoporous regions from the PEC. The p-GaN layer was covered with 250nm of indium tin oxide (ITO) transparent conductor. The n- and p-type metal contacts consisted of chromium/gold.



**Figure 1. Schematic structure of LED with nanoporous and air-channel regions (NA-LED).**

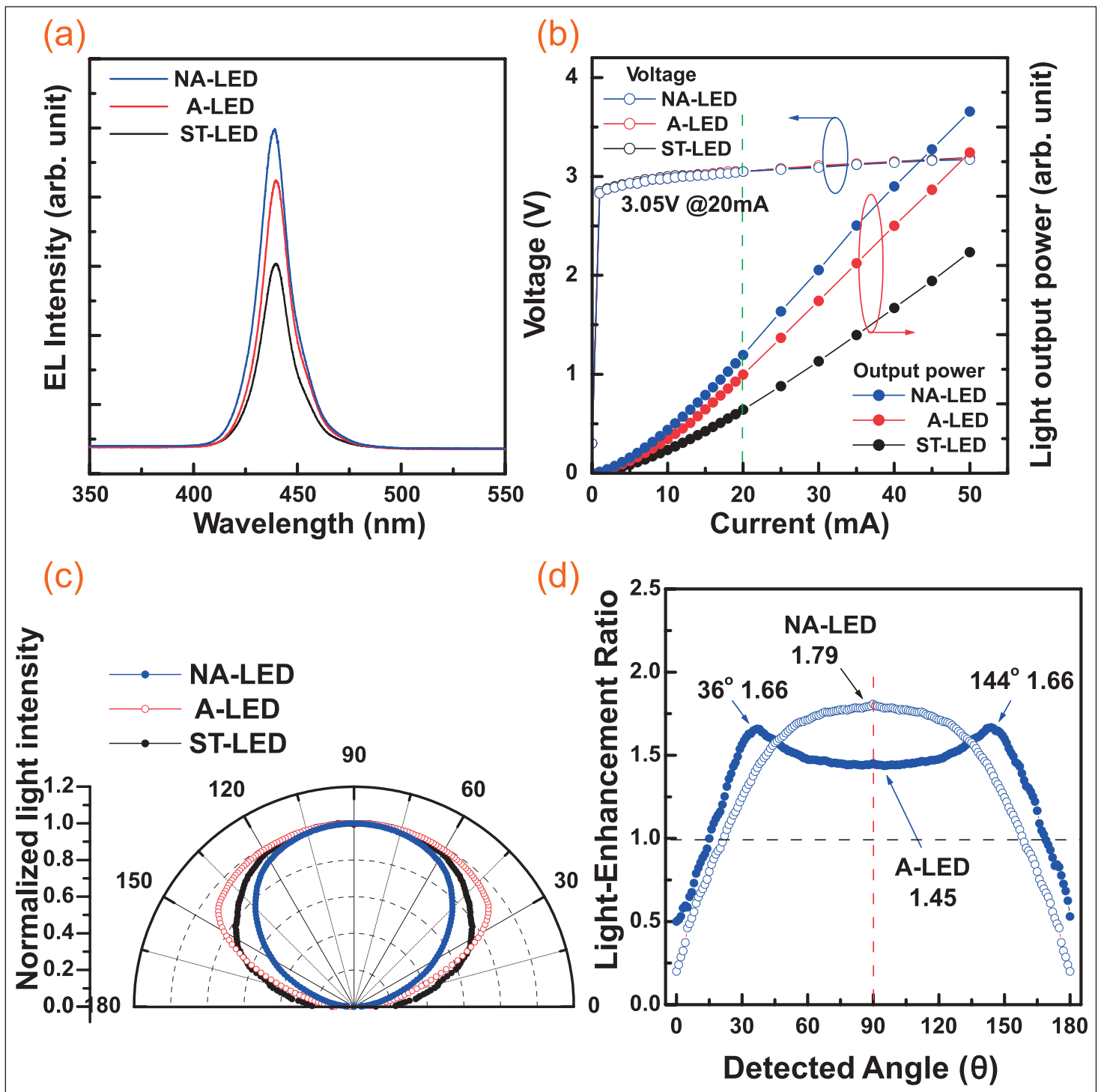


Figure 2. EL emission-peak wavelengths of LEDs measured at 20mA. (b) Operation voltage and light output power versus injection current. (c) Far-field radiation patterns of the LED structures at 20mA. (d) Light-enhancement ratios of A-LED and NA-LED measured by varying detection angle.

The peak emission wavelength at 20mA for the LED with air-channels and nanoporous regions (NA-LED) was 438.7nm (Figure 2a). The peaks for standard (ST-LED) and air-channel (A-LED) LEDs were both at 439.5nm. The line-widths for all LEDs were around 16nm.

The operating voltage at 20mA was also the same over the devices at 3.05V (Figure 2b). However, the NA- and A-LEDs had 1.75x and 1.48x the output power of the ST-LED. The researchers attribute the improve-

ments to better light scattering leading to increased light extraction from the devices.

The air-channels and nanoporosity also led to narrower light beams, with a divergence angle of 122° for the NA-LED, compared with 138° for the A-LED and 146° for the ST-LED (Figure 2c). ■

<http://apex.jsap.jp/link?APEX/6/012103>

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.



# Polystyrene nanospheres focus effort on photonic crystal for nitride LED

**Silicon dioxide or air-voids in the p-type GaN contact layer of nitride LEDs have enhanced light output power by up to 84%.**

Researchers in China have developed a low-cost, high-throughput photonic crystal (PhC) process for nitride semiconductor light-emitting diodes (LEDs) [Tongbo Wei et al, Appl. Phys. Lett., vol101, p211111, 2012]. The process used nanospherical-lens photolithography (NLP) and re-growth of gallium nitride to improve light extraction from and generation in the LEDs.

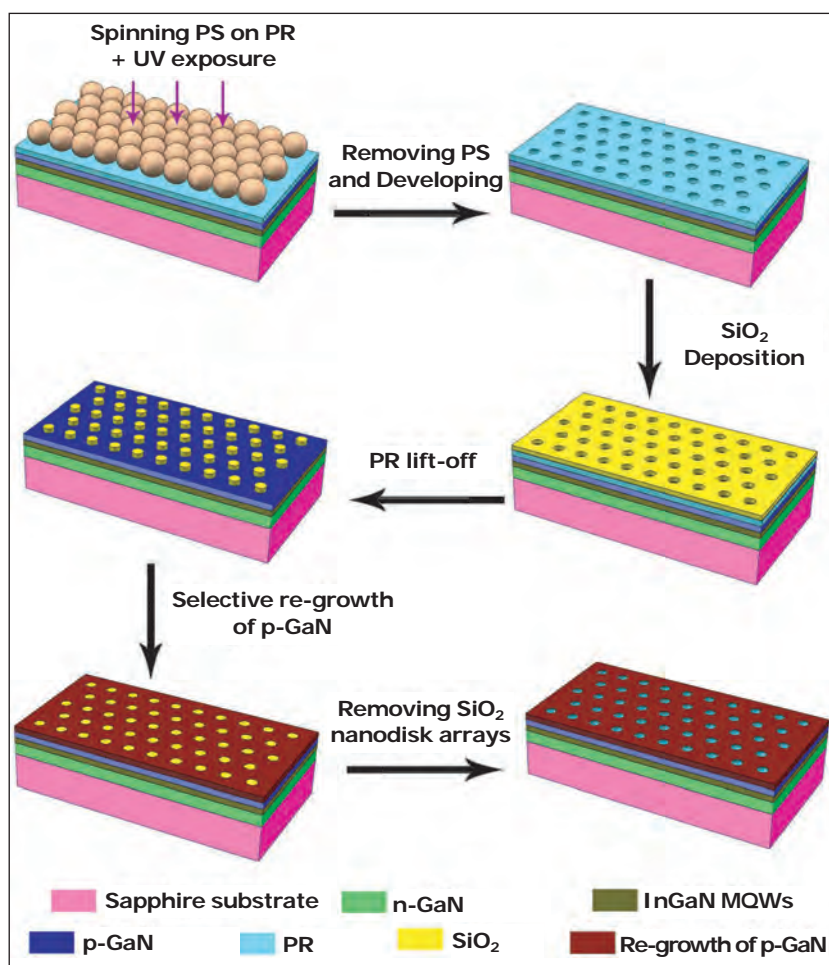
The nanospheres consisted of polystyrene. Some of the same researchers have previously used polystyrene nano-spheres to create surface texturing of nitride LEDs for improved light extraction [e.g. [www.semiconductor-today.com/news\\_items/2012/MAY/CAS\\_240512.html](http://www.semiconductor-today.com/news_items/2012/MAY/CAS_240512.html)]. The researchers of the latest work were based at Chinese Academy of Sciences' institutes of Semiconductors and of Mechanics, and Tsinghua University.

'Photonic crystals' are periodic structural arrays that can alter optical properties of materials such as light extraction through interfaces. The interface between flat gallium nitride (GaN) and the air suffers from a particularly small escape cone of  $\sim 24^\circ$  due to a large ratio of refractive indices ( $\sim 2.5:1$ ).

Proposed processes for creating PhCs tend to be time consuming/low throughput. The new process uses self-assembled arrays of nanospheres to focus light rather than a lithographic technique using masks (Figure 1).

Blue indium gallium nitride (InGaN) LED structures were grown on c-plane sapphire using metal-organic chemical vapor deposition (MOCVD). The active region consisted of 8-period multi-quantum wells (MQWs) with  $\text{In}_{0.2}\text{Ga}_{0.8}$  wells and GaN barriers. The PhC was formed on the 100nm p-GaN top layer (Figure 1) using NLP.

The NLP process consists of using the hexagonally close-packed array of polystyrene nanospheres as lenses to selectively expose underlying AR-P 3120 photoresist (PR) to UV radiation. The nanosphere layer was then removed through ultrasound exposure in

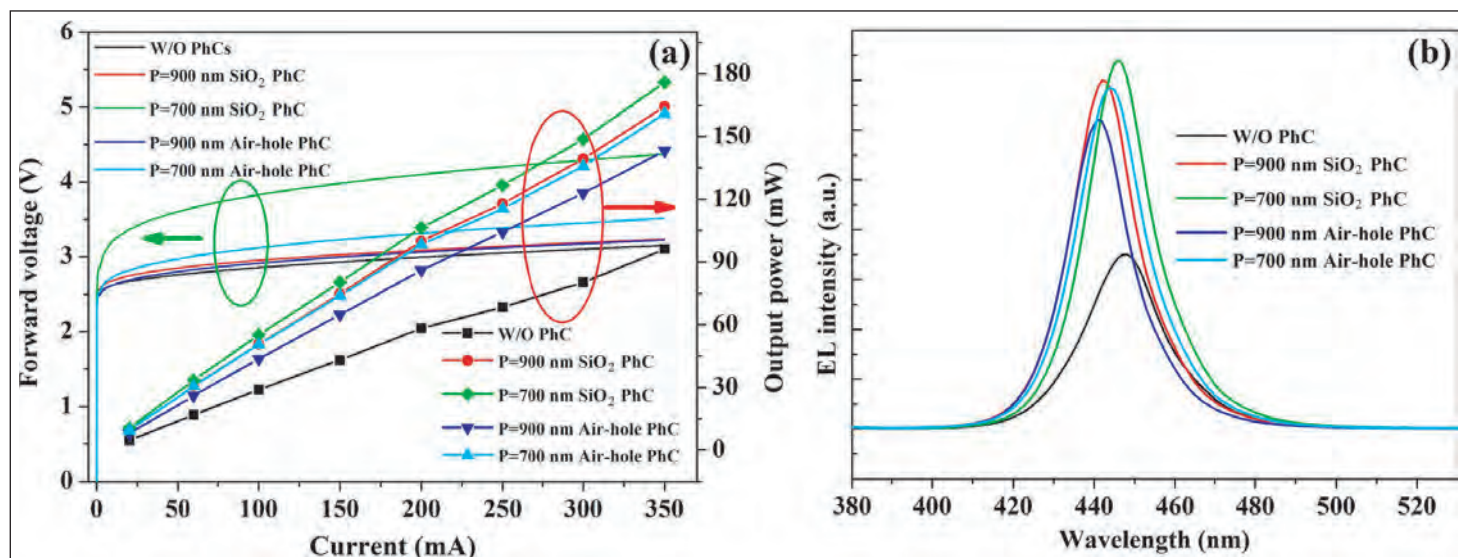


**Figure 1. Process schematic for fabricating  $\text{SiO}_2$  PhC LEDs and air-hole PhC LEDs by NLP method.**

deionized water.

The PR pattern was developed and used as a mask for ion-beam sputtering deposition of 150nm silicon dioxide ( $\text{SiO}_2$ ). The size of the holes in the PR pattern could be controlled by varying the development time. The 900nm or 700nm periodicity of the holes was determined by the nanosphere size.

The lift-off process consisted of dissolving the PR in acetone, leaving an array of  $\sim 450\text{nm}$ -diameter  $\text{SiO}_2$  nanodisks. The gaps between the nanodisks were filled by further growth ('re-growth') of 150nm p-GaN.



**Figure 2. (a) Forward voltages and light output powers of LEDs with and without PhC structures as functions of injection current. (b) Peak wavelengths of electroluminescence spectra of LEDs at driving current of 350mA.**

An air-hole PhC LED was also produced by wet etch of the SiO<sub>2</sub>, using hydrofluoric acid. The epitaxial material was formed into conventional 1mm x 1mm mesa nitride semiconductor LEDs with a 200nm indium tin oxide (ITO) current-spreading

layer, and chromium/platinum/gold n- and p-electrodes.

The flatness of the p-GaN was affected by the periodicity of the nanodisks. The larger periodicity resulted in a flat surface, while the 700nm periodicity resulted in bowl-shaped p-GaN around the disks due to the smaller space between nanodisks leading to faster growth. This is reflected in the height of re-grown p-GaN being higher (220nm) with 700nm periodicity, compared with 150nm for the 900nm sample.

The forward voltage at 350mA was higher for 700nm periodicity due to non-ohmic contact between the bowl-shaped p-GaN and ITO layers. By contrast, the 900nm periodicity resulted in negligible degradation in electrical performance, showing the high quality of the flat re-grown p-GaN.

The higher light output enhancement of SiO<sub>2</sub> PhC compared with air-hole PhC LEDs was attributed to the bigger incident angle of the PhC Bragg diffraction, introducing SiO<sub>2</sub>'s refractive index between the p-GaN and air ambient. The additional enhancement of the 700nm periodicity was related to diffused light scattering from the bowl-shaped GaN with inclined facets.

The emission peaks were blue-shifted compared with conventional LEDs (i.e. without PhC), due to partial compression strain release in the InGaN active region

**Table 1. LED performance characteristics at 350mA injection current, except for angular divergence measured at 200mA.**

PhC	Periodicity	Forward voltage	Light output power enhancement	Wall-plug efficiency enhancement	Peak wave-length	Angular divergence (FWHM)
None	0	3.15V	0% (reference)	0% (reference)	447.6nm	151.3°
SiO <sub>2</sub>	900nm	3.23V	71.3%	67.1%	442.4nm	137.8°
SiO <sub>2</sub>	700nm	4.37V	83.8%	32.2%	445.9nm	132.5°
Air	900nm	3.21V	49.3%	46.4%	441.3nm	143.2°
Air	700nm	3.51V	67.7%	50.5%	444.1nm	138.6°

as a result of the selective area epitaxial (SAE) re-growth of p-GaN. The compression strain is somewhat higher with 700nm periodicity due to the high growth rate within the constricted space between nanodisks. Removing the nanodisks to give air-holes releases some further strain within the structure.

The angular divergence of the light was also measured on devices on aluminium-leaded chip carrier with gold-wire bonding but without epoxy encapsulation. The larger divergent angle seen for conventional devices was attributed to multiple scattering events. The longer that light is trapped in the device, the more likely it is to be reabsorbed. The presence of the PhC is thought to effectively re-direct light into the top escape cone of the LED through the nanodisks.

The 700nm SiO<sub>2</sub> PhC has the best performance in terms of concentrating the light into a smaller angle. The researchers attribute this to the combination of the PhC and the bowl-shaped GaN top surface.

"Unlike the random scattering of surface roughness, the bowl-shaped p-GaN helps to confine the light to radiate in the vertical direction, effectively reducing the energy confined in the LED slab," the researchers comment. ■

<http://link.aip.org/link/doi/10.1063/1.4767334>

Author: Mike Cooke



# Self-textured oxide mask enhances UV LED external quantum efficiency by 83%

**Researchers in Taiwan show how using an STOM template reduces threading dislocations and improves light extraction for UV LEDs.**

Taiwan researchers have used a self-textured oxide mask (STOM) as a template to enhance the external quantum efficiency (EQE) of nitride 380nm ultraviolet (UV) light-emitting diodes (LEDs) by up to 83% [Kun-Ching Shen et al, IEEE Electron Device Letters, published online 02 January 2013]. The researchers are variously associated with National Chung Hsing University, Da-Yeh University, Formosa Epitaxy Inc, and National Cheng Kung University

The nitride semiconductor layers began with a layer of undoped gallium nitride (HT u-GaN) on sapphire substrate grown at high temperature. Next, a textured surface was created with a low-temperature (LT, less than 800°C) growth step.

Construction of the STOM began with inductively coupled plasma chemical vapor deposition (ICP CVD) of silicon dioxide (SiO<sub>2</sub>). The SiO<sub>2</sub> was patterned in a hexagonal arrangement using photolithography and

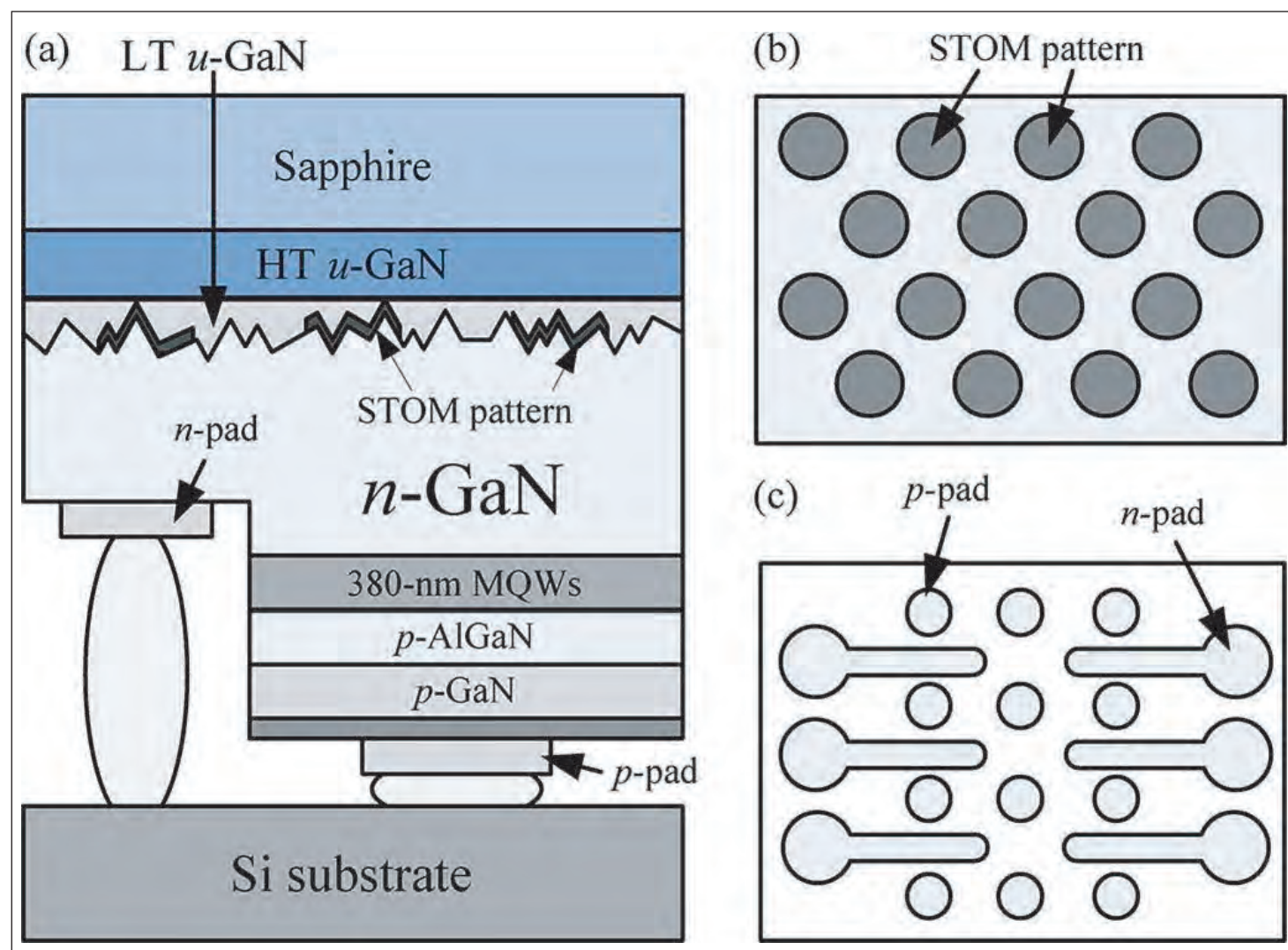


Figure. 1. (a) Schematic of 380nm InGaN UV STOM-FCLED. (b) Hexagonal STOM pattern. (c) Metal contact pad.

carbon tetrafluoride plasma etch.

New nitride semiconductor growth was started with a thin layer of aluminium nitride (AlN, less than 100nm), followed by 3µm of n-GaN, a 380nm-wavelength multi-quantum well (MQW) active region, 20nm of p-AlGaIn cladding, and a p-GaN contact. The MQW consisted of ten periods of  $\text{In}_{0.02}\text{Ga}_{0.98}\text{N}/\text{Al}_{0.08}\text{Ga}_{0.92}\text{N}$ .

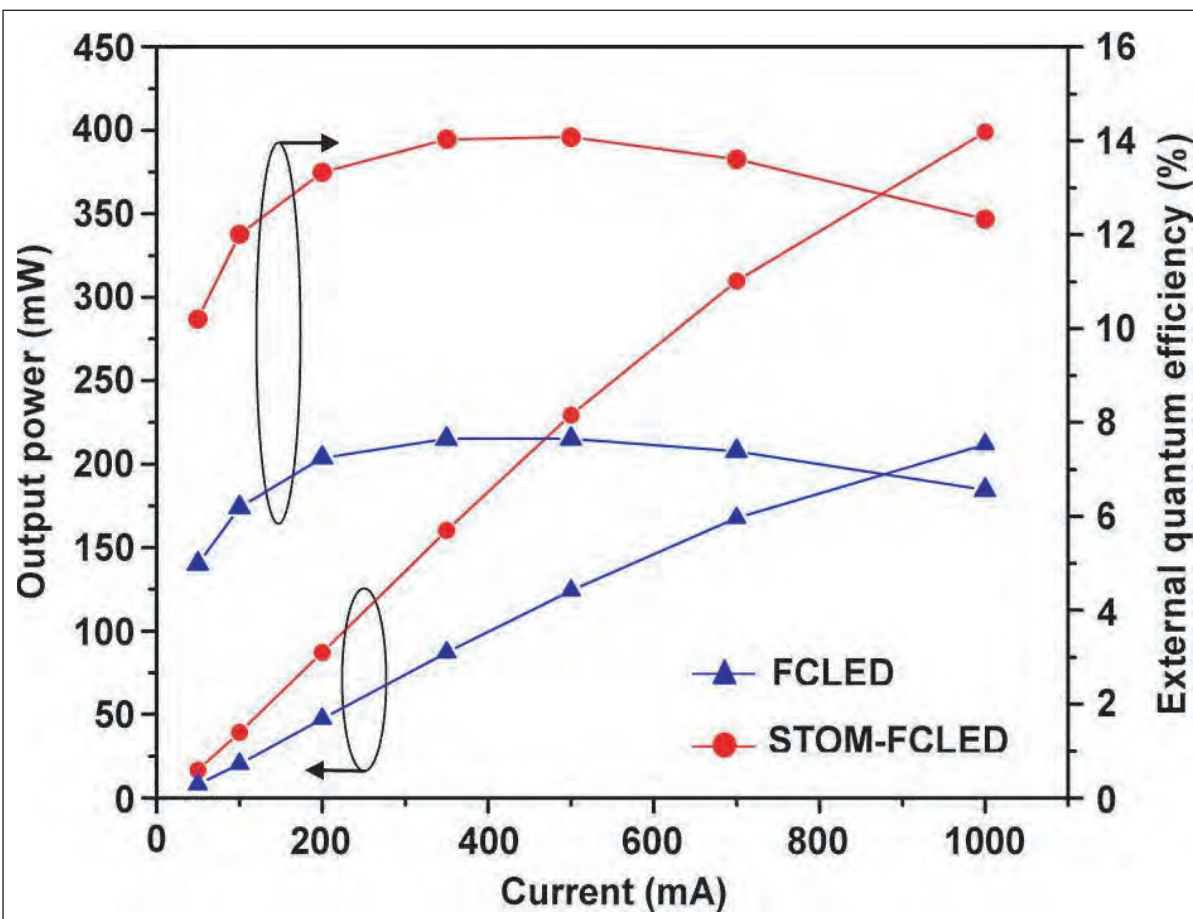
The material was used in a flip-chip LED (FCLED) configuration (Figure 1) with a square chip with 1125µm sides bonded to a silicon substrate.

A highly reflective mirror coating was used to increase light output through the sapphire substrate.

One effect of using the STOM template is that it stops some of the threading dislocations (TDs) from the earlier GaN layers from propagating into the n-GaN and later layers of the LED. An expected benefit of this is a reduction in non-radiative recombination, resulting in higher internal quantum efficiency (IQE). The measured density of TDs in the LED layers on STOM template was  $3.2 \times 10^6/\text{cm}^2$  compared with  $4.9 \times 10^7/\text{cm}^2$  in epitaxial structures grown on templates without STOM. Also, the IQE, as determined using temperature-dependent photoluminescence, was 27% for STOM-FCLED material as opposed to 16% for the standard FCLED.

Electroluminescence measurements were made on encapsulated chips without lens. Despite the encapsulation, which can cause performance degradation from self-heating, the output of the FCLEDs with and without STOM showed a linear increase in power output up to 1000mA (Figure 2). The researchers attributed this linearity to "good thermal management via the FC configuration design".

The 350mA powers were 87.3mW for the FCLED and 160.4mW for the STOM-FCLED. The respective external quantum efficiencies were 7.65% and 14.03%.



**Figure 2. Output power and EQE as a function of the injection current for the FCLED and the STOM-FCLED.**

The STOM-FCLED had nearly 400mW output at 1000mA.

The beam divergence from the STOM-FCLED was also narrower at  $131.7^\circ$ , compared with  $138.2^\circ$  for the standard FCLED. The researchers comment: "For the FCLED, the larger viewing angle implies that the confined light in the LED chip was extracted from the edge of the chip or of the sapphire substrate after multiple scattering or reflection events. The STOM-FCLED exhibited a smaller divergence angle than the FCLED, indicating that the embedded STOM array serves as a light-scattering center and re-directs light to the top of the LED, resulting in a boost in LED light extraction."

The researchers also examined the luminescence in detail, finding that away from the electrodes the light intensity peaked in a hexagonal array of dots with diameter 3µm and spacing 2µm that matched the pattern of the STOM. The researchers write: "This result strongly supports the argument that the STOM array can decrease the degree of total internal reflection and aid the escape of the confined light from the STOM-FCLED device to the sapphire surface, further boosting the LED light extraction." ■

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6400284>

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

Author: Mike Cooke



# Step towards integrating GaN HEMTs and CMOS

**Singapore researchers have used a gold-free metallization scheme with low contact resistance to claim the first DC and microwave measurements of sub-micron-gate AlGaN/GaN HEMTs on silicon.**

Researchers in Singapore claim the first DC and microwave performance measurements for 0.15µm-gate aluminium gallium nitride (AlGaN) on gallium nitride high-electron-mobility transistors (HEMTs) on silicon substrates with gold-free metallization [Subramaniam Arulkumaran et al, Appl. Phys. Express, vol6, p016501, 2013].

The development of gold-free source, drain, gate and interconnects is important for the easy transfer of GaN-based devices onto an integrated complementary metal-oxide-semiconductor (CMOS) transistor platform. Gold contamination poisons silicon semiconductor performance. Gold-free processing is also relevant where manufacturers may want to run separate GaN transistor fabrication wafers alongside traditional silicon device wafers.

The research is therefore of interest in developing GaN device production on large-diameter silicon (up to 12-inch diameter versus ~2-4-inch on sapphire and silicon carbide) for economies of scale. GaN devices can achieve high-frequency performance (up to 370GHz cut-off) and large power density (~2.5W/mm at 40GHz) due to the wide bandgap and high critical electric field for breakdown.

Researchers based at Temasek Laboratories and Nanyang Technological University (NTU) in Singapore developed the gold-free process with low contact resistance (Table 1). In fact, the Temasek facility is also sited at the Nanyang campus. The heterostructure for the HEMT consisted of a 4-inch high-resistivity silicon substrate (resistivity greater than 6000Ω-cm),

1.4µm GaN transition layer, 800nm GaN buffer, 18nm Al<sub>0.26</sub>Ga<sub>0.74</sub>N barrier, and 2nm GaN cap. The researchers used metal-organic chemical vapor deposition (MOCVD) as the nitride semiconductor heterostructure growth process. The resulting electron transport properties were 1450cm<sup>2</sup>/V-second mobility and 1.1x10<sup>13</sup>/cm<sup>2</sup> sheet carrier density.

The transistors were fabricated using mesa isolation, ohmic metal deposition and gate fabrication. The ohmic metal stack was tantalum/silicon/titanium/aluminium/nickel/tantalum. After annealing in nitrogen at 800°C for 30 seconds, the typical contact resistance was 0.24Ω-mm (standard deviation 0.07Ω-mm). Three separate runs of the ohmic metal process were performed. The average specific contact resistivity was 1.5x10<sup>-6</sup>Ω-cm<sup>2</sup>.

The researchers comment: "The achieved contact resistance is believed to be the lowest ever reported for non-gold ohmic contacts for conventional AlGaN/GaN HEMTs on Si and it is also lower than that of recessed ohmic contacts." (See Table 1.)

Recessing is used to reduce contact resistance, but tends to increase process complexity and hence production costs.

The T-gate formation process consisted of a 30

**Table 1. Contact resistance values for different GaN HEMT structures on silicon substrate using conventional III–V gold- and CMOS-compatible non-gold-based ohmic stacks.**

Research group	HEMT on Si	Metal stack	Annealing temp. (°C)	R <sub>c</sub> (Ω-mm)
<u>Gold-based</u>				
Nitronex	AlGaN/GaN	Ti/Al/Ni/Au	825	0.45 (Rough surface)
NTU	AlGaN/GaN	Ti/Al/Ni/Au	825	0.18 (Rough surface)
ETH-Z	AlGaN/GaN	Ti/Al/Ni/Au	850	0.45 (Rough surface)
IEMN	AlGaN/GaN	Ti/Al/Ni/Au	900	0.50 (Rough surface)
<u>Non-gold</u>				
IMEC	AlGaN/GaN/AlGaN	Ti/Al/W	800	0.65
IMEC	AlGaN/GaN/AlGaN	Ti/Al/Ti/TiN	550 (Recess)	1.25
MIT	AlGaN/GaN	Ti/Al/W	870 (Recess)	0.49 (Smooth surface)
Temasek/NTU new work	AlGaN/GaN	Ta/Si/Ti/Al/Ni/Ta	800	0.24 (Smooth surface)

minute ammonium sulfide pre-treatment, 120nm silicon nitride plasma-enhanced chemical vapor deposition (PECVD), 0.15 $\mu\text{m}$ -gate footprint opening by patterned etch, and nickel/aluminium/tantalum (100/400/30nm) gate head formation. The gate dimensions were: source–gate distance of 0.8 $\mu\text{m}$ , gate–length of 0.15 $\mu\text{m}$  and gate–drain distance of 1.7 $\mu\text{m}$ . The width of the gate was 2 $\mu\text{m}$  x 75 $\mu\text{m}$ .

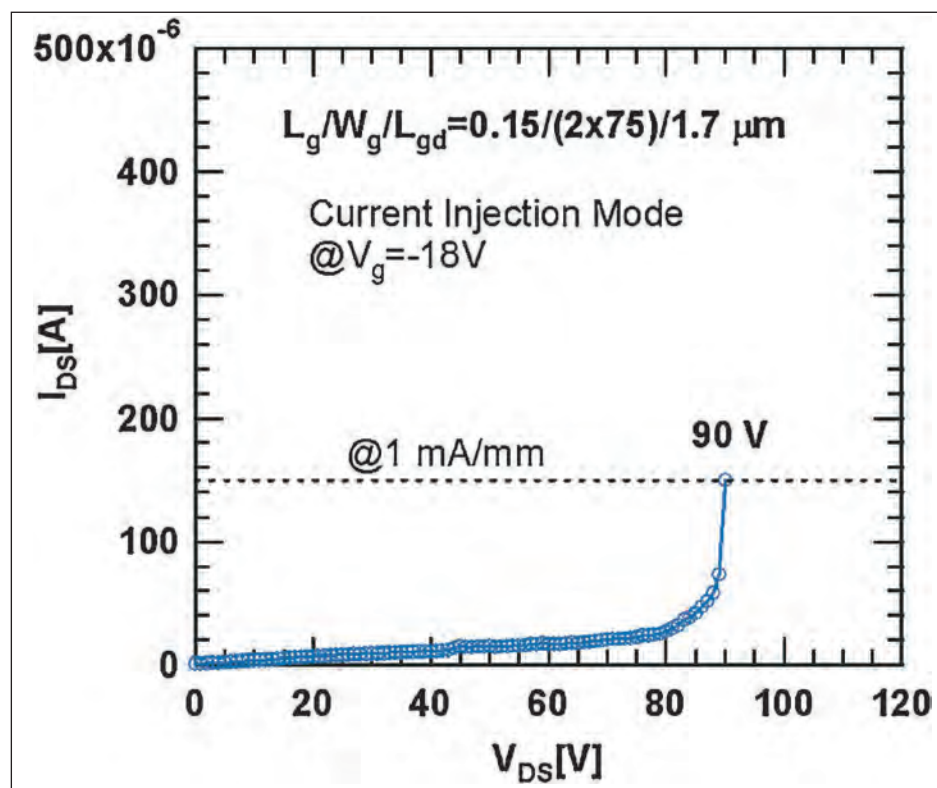
The fabrication was completed with a titanium/aluminium/tantalum (50/800/30nm) interconnect metal stack and final passivation with a further 120nm of silicon nitride.

The metals chosen for use “are commonly used in the silicon fabrication process line and, hence, they will not introduce any cross-contamination in the manufacturing lines.”

The maximum drain current was 830mA/mm and the peak extrinsic transconductance was 250mS/mm. The threshold voltage was negative (depletion-mode, normally-on) at –3.75V. The reverse-biased gate leakage current was  $3.8 \times 10^{-3}$ mA/mm at –20V.

The small-signal gain frequency performance was measured between 6GHz and 40GHz. The cut-off frequency ( $f_T$ ) was 39GHz and the maximum oscillation ( $f_{\text{max}}$ ) was also 39GHz. The researchers believe this to be “the first reported microwave performance of sub-micron AlGaIn/GaN HEMTs using CMOS-compatible non-gold metal stacks”.

Current collapse with pulsed currents was less than 10%. The three-terminal OFF-state breakdown voltage ( $BV_{\text{gd}}$ ) was 90V (Figure 1). The Johnson figure of merit of  $f_T \times BV_{\text{gd}}$  was 3.51–3.83THz-V for gate–drain spac-



**Figure 1.** Three-terminal OFF-state breakdown voltage characteristics of HEMT with CMOS-compatible non-gold metal stack and 1.7 $\mu\text{m}$  gate–drain spacing.

ings in the range 1.7–3.5 $\mu\text{m}$ .

The researchers comment: “The obtained values are comparable to that of the 0.15 $\mu\text{m}$  gate-length GaN HEMTs (3.3THz-V) on Si(111) fabricated using a conventional III–V gold-based metal stack.”

The team concludes: “These results demonstrate the feasibility of non-gold metallization process to achieve submicron-gate AlGaIn/GaN HEMTs on Si substrate for high-frequency applications.” ■

<http://apex.jsap.jp/link?APEX/6/016501>

<http://www3.ntu.edu.sg/temasek-labs>

Author: Mike Cooke

**REGISTER**  
for *Semiconductor Today*  
free at  
**[www.semiconductor-today.com](http://www.semiconductor-today.com)**



# Hafnium dioxide for gate insulation and surface passivation in nitride HEMTs

**An on/off current ratio of ten orders of magnitude and a breakdown voltage of 1524V have been achieved using  $\text{HfO}_2$  in AlGaN MOSHEMTs.**

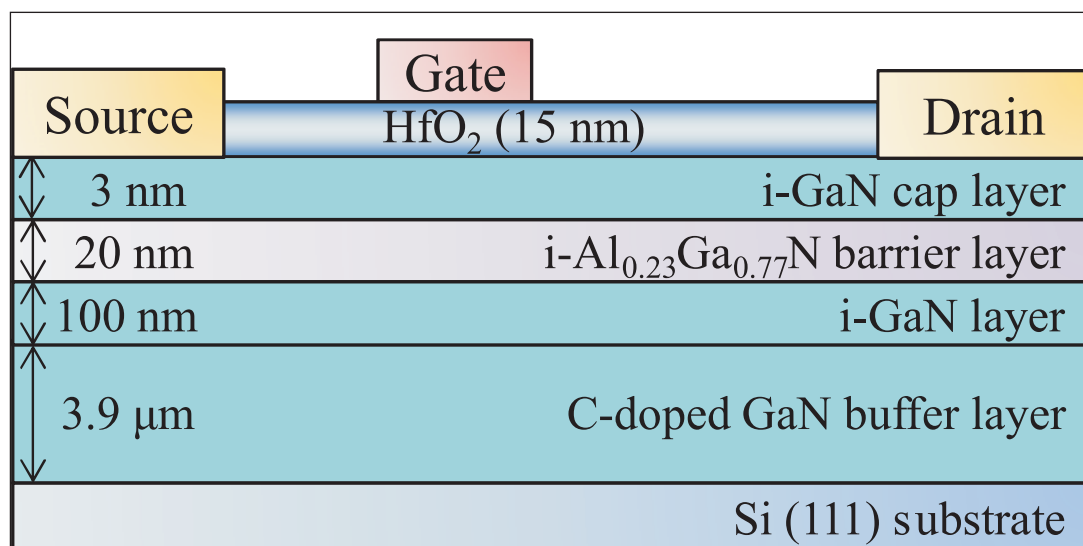
**S**eoul National University and Korea Electronics Technology Institute have been developing hafnium dioxide ( $\text{HfO}_2$ ) as a gate insulator for aluminium gallium nitride (AlGaN) metal-oxide-semiconductor high-electron-mobility transistors (MOSHEMTs) [Ogyun Seok et al, Semicond. Sci. Technol., vol28, p025001, 2013]. The researchers found that  $\text{HfO}_2$  has superior blocking characteristics, surface passivation properties and causes a smaller shift of

threshold voltage compared with alternatives. A further attraction is that it has been demonstrated 'for the first time' that the material can be deposited using simple RF-sputtering.

The nitride semiconductor layers were grown on (111) silicon substrates using metal-organic chemical vapor deposition (Figure 1). The buffer was carbon-doped to increase its resistivity. The structure resulted in a channel with electron mobility of  $1740\text{cm}^2/\text{V}\cdot\text{s}$ , sheet carrier density of  $6.81 \times 10^{12}/\text{cm}^2$ , and sheet resistance of  $528\Omega/\text{square}$ .

The transistors were formed with mesa isolation, titanium/aluminium/nickel/gold ohmic source/drain electrodes, RF-sputtered  $\text{HfO}_2$  gate insulation, and nickel/gold Schottky gate. The sputtering was performed at low power and at room temperature under an argon gas flow. The aim of using low-power sputtering was to minimize damage to the underlying nitride semiconductor materials. The sputtering was preceded with a buffered oxide etch to remove any native oxide. The resulting  $\text{HfO}_2$  is found by x-ray analysis to be weakly crystalline.

The effect of the  $\text{HfO}_2$  insulator was to reduce the



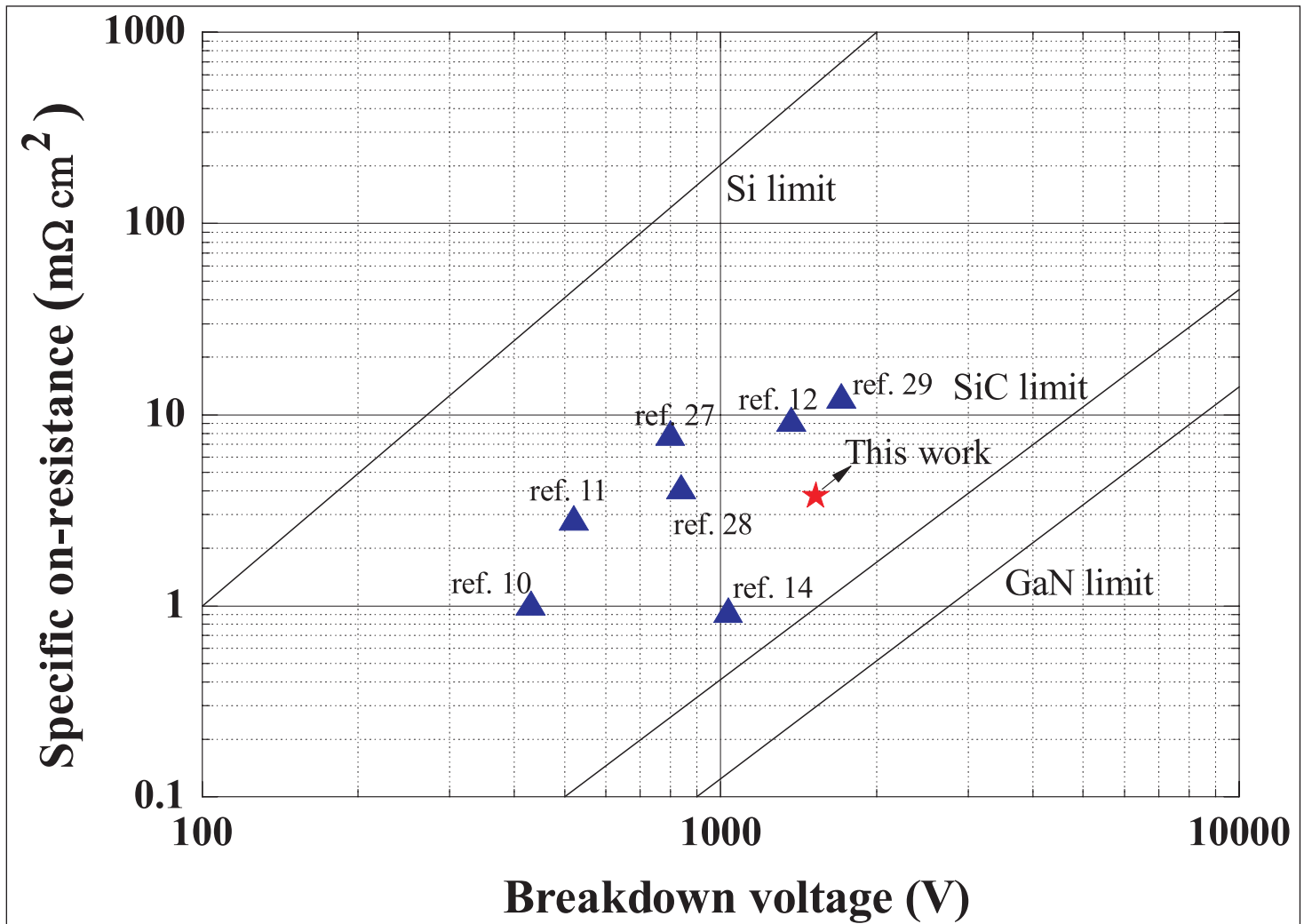
**Figure 1. Cross-sectional view of AlGaN/GaN MOS-HEMT with  $\text{HfO}_2$  gate insulator.**

gate leakage to  $-67\text{pA}/\text{mm}$  at  $-10\text{V}$  gate-source potential and  $100\text{V}$  drain bias, compared with  $-47\mu\text{A}/\text{mm}$  for a conventional HEMT without insulator. The reduction is some six orders of magnitude. The drain leakage under the same 'off-state' conditions was also not degraded by 100s of sustained DC stress, while for the conventional device the leakage increased from  $57.5\mu\text{A}/\text{mm}$  to  $496\mu\text{A}/\text{mm}$ .

The devices had  $3\mu\text{m}$  gate-length and gate-source distance, and  $20\mu\text{m}$  gate-drain distance. The researchers attribute the improved leakage performance for the transistor with  $\text{HfO}_2$  to the effective suppression of surface trap states for electrons from the gate electrode.

The  $\text{HfO}_2$  also blocked leakage under a forward gate-drain bias of  $+3\text{V}$  with a gate current of  $11\text{nA}/\text{mm}$ , while the conventional device current was  $56\text{mA}/\text{mm}$ . The leakage under a reverse bias of  $-10\text{V}$  was  $-33\text{pA}/\text{mm}$  for the MOSHEMT and  $-9.7\mu\text{A}/\text{mm}$  for the HEMT. The  $\text{HfO}_2$  continues to block current up to  $+10\text{V}$ , after which the gate current quickly rises to around  $1000\text{A}/\text{mm}$ .

Further tests indicated that the  $\text{HfO}_2$  layer also has a passivating effect on the GaN surface layer, reducing



**Figure 2. Summarized breakdown voltage and specific on-resistance for AlGaN/GaN HEMTs and MOS-HEMTs with various gate insulator materials.**

surface leakage currents and electron trapping effects. The researchers measured a three-terminal breakdown voltage (BV, when leakage current reaches 1mA/mm at a gate-source potential of -10V) of 1524V for the MOSHEMT (470V for the HEMT). The breakdown mechanism for the HEMT was electron runaway current from the gate through surface states.

The researchers comment: "In the proposed MOS-HEMT, the trap-assisted Schottky tunneling current and the surface leakage current caused by electron trapping are successfully suppressed by the HfO<sub>2</sub> gate insulator such that the device with HfO<sub>2</sub> sustains a high breakdown voltage."

Another common problem with HEMTs is current collapse under pulsed gate and drain biases. The researchers found some amelioration of this in their MOSHEMTs, which they attribute to suppression of surface traps by the HfO<sub>2</sub> layer.

The on/off ratio was determined using the currents at 0V and -10V gate-source potential. The MOSHEMT achieved a ratio of  $2.37 \times 10^{10}$  (191mA/mm on-current, 8.01pA/mm off-current), compared with  $7.61 \times 10^3$  (175mA/mm, 23μA/mm) for the conventional HEMT.

"The high on/off current ratio indicates that the HfO<sub>2</sub>

successfully suppresses the gate leakage current as well as the isolation leakage current from the drain to the source," the researchers write.

The threshold voltages of the devices were -2.3V for the HEMT and -4.2V for the HfO<sub>2</sub> MOSHEMT. A SiO<sub>2</sub> MOSHEMT produced by the researchers had a threshold of -15.8V due to the low-k value of the dielectric. A more positive threshold is desired. Indeed, many research groups are seeking devices with a positive threshold voltage that would have its off-current at 0V gate potential (normally-off, enhancement-mode), rather than -10V as used in the HfO<sub>2</sub> MOSHEMTs.

The specific on-resistance was 3.77mΩ-cm² which, combined with the breakdown voltage, gives a BV²/R<sub>on</sub> figure of merit of  $6.2 \times 10^5 \text{V}^2/\text{m}\Omega\text{-cm}^2$ . The researchers compared these results with those of a number of other groups (Figure 2).

Funding for the work came from a 'Power Generation and Electricity Delivery' grant of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) government organization. ■

<http://dx.doi.org/10.1088/0268-1242/28/2/025001>

Author: Mike Cooke



# InGaN-channel HEMT cut-off reaches 260GHz

**As well as a cut-off frequency of 260GHz, researchers at Notre Dame and Kopin also achieve a maximum oscillation frequency of 220GHz.**

**R**esearchers at University of Notre Dame and Kopin Corp have developed high-performance nitride semiconductor high-electron-mobility transistors (HEMTs) with indium gallium nitride (InGaN) channels [Ronghua Wang et al, Appl. Phys. Express, vol6, p016503, 2013]. The performance of the devices is approaching that of GaN-channel HEMTs.

Incorporation of indium in GaN is expected to improve frequency performance in a similar way that indium gallium arsenide (InGaAs) is used to boost device speeds over pure-GaAs devices. The peak cut-off frequency for GaN HEMTs is presently more than 300GHz. The UND/Kopin InGaN device has a cut-off of 260GHz and a record-breaking square root of the product of the cut-off and maximum oscillation frequencies of 239GHz.

Although InGaN has a higher predicted steady-state drift velocity (highest with InN) than GaN (based on the lower electron effective mass), there are a number of factors that presently hinder real-world performance. For example, electron mobility is reduced due to alloy scattering effects. Further problems arise from the instability of InGaN during high-temperature growth, creating material inhomogeneity and rough

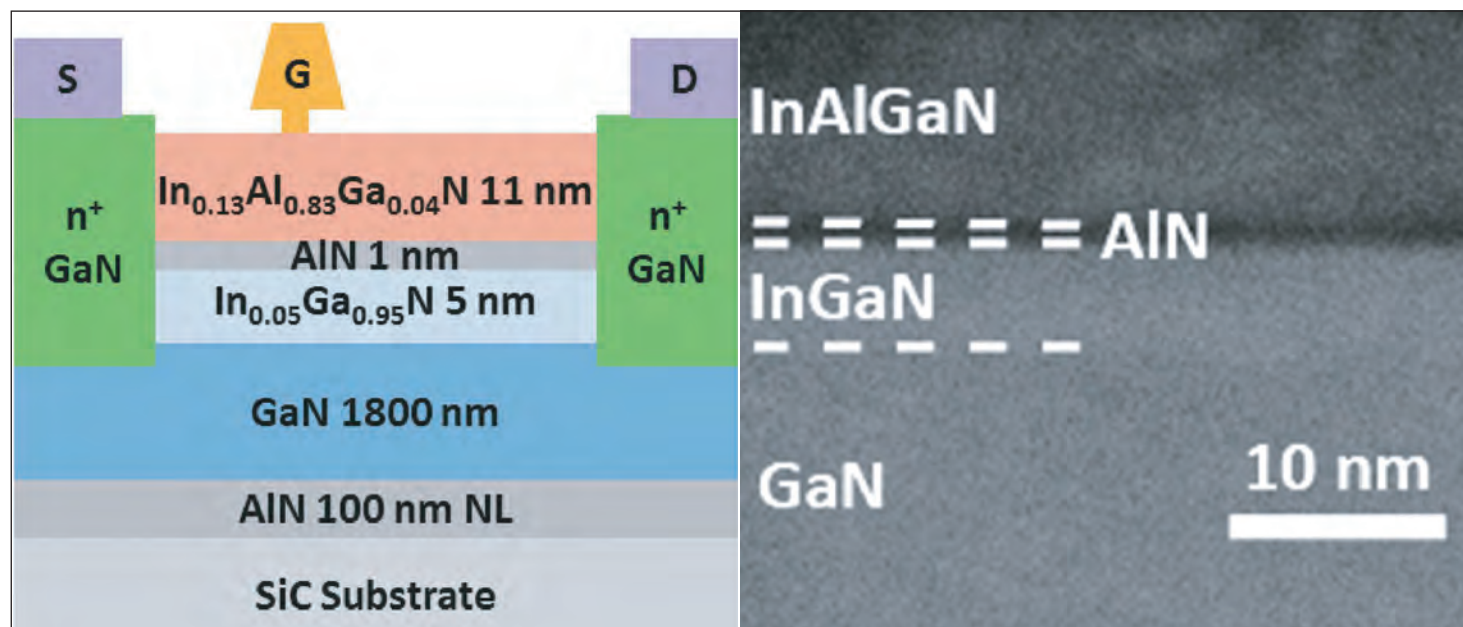
interfaces that reduce electron response to electric fields.

The InAlGaN/InGaN barrier/channel heterostructure was grown using metal-organic chemical vapor deposition (MOCVD) on silicon carbide (SiC) substrates (Figure 1). The quaternary InAlGaN barrier was chosen over ternary InAlN with a view to the higher-mobility channel that can be obtained. The GaN buffer layer also acts as a back barrier that confines the electron channel, reducing short-channel effects.

The n<sup>+</sup>-GaN source-drain regions were re-grown using molecular-beam epitaxy (MBE). The re-growth was followed by mesa isolation, ohmic metallization with titanium/gold, and nickel-gold T-gate formation using electron-beam lithography and lift-off. There was no passivation.

The resulting device had a contact resistance of 0.2Ω-mm. The channel had a sheet resistance of 264Ω/square, carrier density of 2.08×10<sup>13</sup>/cm<sup>2</sup>, and mobility of 1140cm<sup>2</sup>/V-second. The source-drain spacing was 1.6μm. The gate footprint was 50nm long and 2μm x 25μm wide. The mushroom-head of the T-gate was 150nm.

The maximum current density of the device was



**Figure 1. Schematic cross section of InAlGaN/AlN/InGaN/GaN HEMT epitaxial layer structure with T-gates and non-alloyed MBE re-grown ohmic contacts; cross-sectional STEM image confirming InGaN channel thickness.**

2.0A/mm at 1V gate potential. The researchers point out that the current performance is comparable with conventional quaternary-barrier InAlGaN HEMTs with GaN channels, since the channel charge density and mobility are similar. The on-resistance was  $0.88\Omega\text{-mm}$ . Three-terminal off-state breakdown occurred at  $\sim 15\text{V}$  with  $-8\text{V}$  gate bias (breakdown defined as off-current density exceeding  $1\text{mA/mm}$ ).

The peak extrinsic transconductance was  $660\text{--}690\text{mS/mm}$ , achieved near pinch-off at around  $-4\text{V}$  gate bias. The threshold voltage was  $-4\text{V}$  at  $0.1\text{V}$  drain and  $-4.4\text{V}$  at  $6\text{V}$  (depletion-mode/normally-off). A comparable GaN-channel device produced and reported in 2012 by the UND/Kopin group had a threshold of  $-3.5\text{V}$  at  $0.1\text{V}$  and  $-4.0\text{V}$  at  $6.6\text{V}$ .

The researchers comment: "The more negative threshold voltage of the InGaN-channel HEMT is likely due to the slightly higher charge in the channel besides the inevitable variations in epitaxy and device fabrication."

The frequency performance was measured between  $100\text{MHz}$  and  $110\text{GHz}$ . De-embedded values for the cut-off ( $f_T$ ) and maximum oscillation ( $f_{\text{max}}$ ) frequencies were  $260\text{GHz}$  and  $220\text{GHz}$ , respectively (embedded values  $140/186\text{GHz}$ ). These results compare with a previous University of Illinois InGaN-channel HEMT (2004) with  $0.18\mu\text{m}$  gate that had  $f_T/f_{\text{max}}$  of  $65/94\text{GHz}$ .

The geometric mean of the de-embedded values (square root of  $f_T \times f_{\text{max}}$ ) was  $239\text{GHz}$ , claimed as a record for InGaN-channel HEMTs. Increasing the mushroom-head of the T-gate is expected to increase the  $f_{\text{max}}/f_T$  ratio.

The UND/Kopin work was supported partly by finance from the US Defense Advanced Research Projects Agency (DARPA), the US Air Force Office of Scientific Research, and the US Air Force Research Laboratory/Missile Defense Agency (AFRL/MDA).■

<http://apex.jsap.jp/link?APEX/6/016503>

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

Author: Mike Cooke

**REGISTER**  
for *Semiconductor Today*  
free at  
**[www.semiconductor-today.com](http://www.semiconductor-today.com)**

# Silicon carbide epitaxy for growing market

A move to 6-inch substrates and emerging markets is driving expansion for SiC. **Mike Cooke** reports.

**S**ilicon carbide (SiC) is a semiconductor that is very hard to create and work. Despite this, market analyst firm Yole Développement believes that SiC devices will net a billion dollars in revenue within a decade.

The interest in SiC as a device medium comes from its wide bandgap, which generally means that the material should be able to withstand larger electric fields and hence potential differences before breakdown. High breakdown voltages are of interest in electric power generation, distribution and heavy-duty application.

Another potential benefit of the wideband gap is higher-temperature operation that could allow reduced cooling requirements for SiC-based power systems. Also, the chemical inertness of SiC that makes it so difficult to work means that, once fabricated, SiC devices can operate in harsh environments.

Research has been carried out over many years with military, state, and industrial funding sources. A wide range of device types have been suggested for the range of applications in which SiC may find profitable application: Schottky diodes, metal oxide semiconductor field-effect transistors (MOSFETs), junction field-effect transistors (JFETs), bipolar junction transistors (BJTs), thyristors, gate-turn-off devices (GTOs) and insulated-gate bipolar transistors (IGBTs). These are generally produced from wafers with SiC epitaxial layers grown on SiC or silicon substrates.

In the past year, renewed interest in SiC device technology has been indicated with a number of orders for the tools needed to produce SiC epiwafers. Here, we look at some of the developments and the companies behind them.

## Toolshop

Aixtron is the company that is most often mentioned for SiC chemical vapor deposition (CVD) epitaxy tools. The firm's latest AIX G5 WW Planetary Reactor is designed to reach the extreme temperatures needed for SiC growth on substrates up to 150mm. The G5 can handle 6x150mm wafers per run (or 10x100mm). The company sees opportunities in supporting producers of power rectifiers and switches for power conversion and distribution applications.



**Figure 1. An Aixtron AIX G5 Planetary Reactor.**

The Aixtron G5 is based on its fifth-generation system that is also used for GaN epitaxy. Both materials need higher-temperature processes than arsenic- or phosphorus-based compound semiconductors — the range for GaN tools is given as 1200–1300°C, as opposed to 1500–1700°C for SiC. These figures compare with the cooler 850°C needed for As/P-based materials.

Veeco, the main competitor with Aixtron in the metal-organic CVD market, does not appear to offer SiC epitaxy products. Other firms do market more general CVD tools for this challenging application, but one must distinguish between SiC epitaxy and coating. (SiC CVD coating is used as a material able to withstand high temperature and chemically reactive environments, for example, in semiconductor processing chambers.)

In Italy, the company LPE produces the ACiS range of SiC epitaxial reactors based on hot-wall CVD. The firm quotes power consumption figures of the induction heating system for both 1550°C (20kW) and 2000°C (36kW), giving an indication of the temperature range of the tools. The smaller M8 machine is capable of handling batch loads of 6x2-inch, 3x3-inch or 1x4-inch substrates. The larger M10 can handle batches of 9x2-inch, 5x3-inch or 3x4-inch.

LPE reported in July 2012 that it had installed a 6-inch (150mm) SiC epitaxy tool at E.T.C. (Epitaxial Technology Center) in Catania, Italy. The tool is being used in the context of the ENIAC-LASTPOWER Project of the



European Union. LASTPOWER began in April 2010 and is due to complete this October. The budget was €16.3m.

ETC has two further LPE SiC epitaxial reactors (ACiS M8 and ACiS M10) for R&D and volume production. ETC also has SiC-on-silicon capability up to 200mm diameter.

In Japan, Tokyo Electron Limited (TEL) has the Probus CVD system for SiC epitaxy on substrates up to 6-inch diameter. The system can be configured with two process chambers. An auto-loader can also be added. Infineon bought a TEL tool in early 2012 for mass production of advanced SiC power devices.

### Epitaxy and substrate producer

In any discussion of SiC epitaxy one must look at Cree in the USA. The company produces SiC substrates, SiC/SiC epitaxial wafers, SiC/III-nitride epitaxial wafers, along with LED and power and RF electronics devices.

The firm's most recent announcements in SiC epitaxy have concerned low-basal plane defect density 100mm epiwafers and the development of larger 6-inch (150mm) diameter products.

Basal-plane defects (BPDs) can cause forward voltage drifting that adversely affects the long-term reliability of SiC components. Cree's new wafers have reduced BPD density to less than  $1/\text{cm}^2$ . In addition, the particular type of BPD that causes voltage drift has been reduced to less than  $0.1/\text{cm}^2$ .

John Palmour, chief technology officer of Cree's Power & RF division reports: "This low-BPD material enables very high-voltage bipolar devices such as IGBTs (insulated-gate bipolar transistors) and GTOs (gate turn-off thyristors) to have improved stability over time. This recent development helps remove roadblocks to commercialization of these extremely high-power devices."

The increased-diameter products are expected to lead to significant product cost reductions and increased throughput.

Cree offers SiC and III-nitride epitaxy on n-, p-type and high-purity semi-insulating (HPSI) substrates. The firm sees applications for SiC/SiC epiwafers as being optoelectronics, power factor correction (PFC), solar inverters, and industrial motor drives. III-nitride epitaxy on SiC is seen as being more suited to high-power RF, graphene, and terahertz development.

Other companies have announced 150mm epiwafers in the last year.

Dow Corning, which is also US-based, has a range of SiC wafer products. In the middle of last year, the company expanded production by ordering two extra Aixtron AIX 2800G4 WW Planetary Reactors. The platforms installed at Dow Corning are able to handle 10x100mm or 6x150mm SiC substrates. Dow Corning also offers 4H n+ conductive SiC wafers in test grades for research, in commercial grade for high-volume



**Figure 2. Tokyo Electron's Probus CVD system.**

production, or 'prime' for top-end wafer specifications. The firm also supplies epiwafers with  $n^+$  and  $n^-$  conductivity with layer thicknesses up to  $20\mu\text{m}$ .

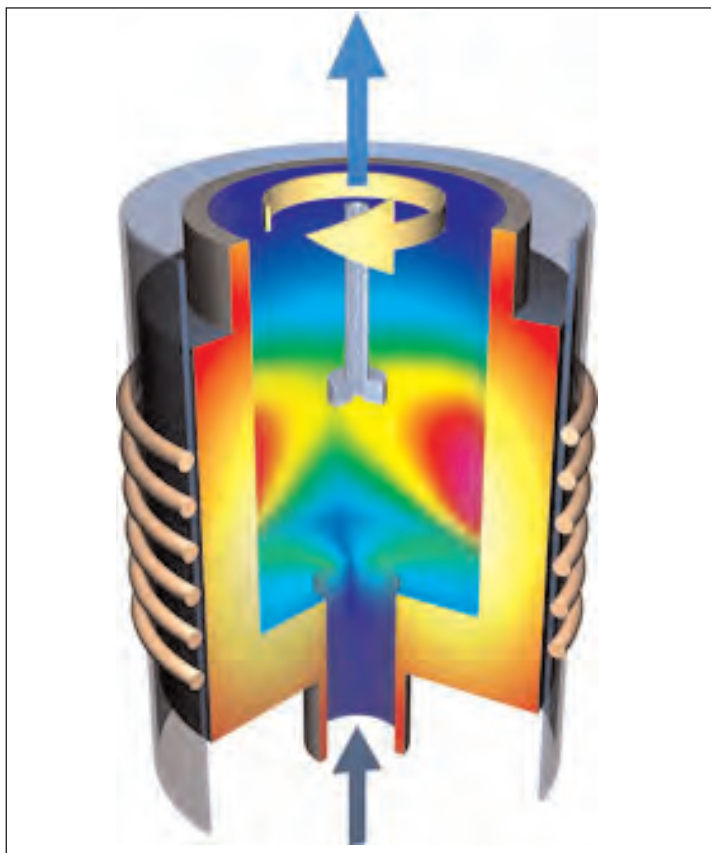
Showa Denko produces SiC epitaxial wafers at its Chichibu facility in Japan. Last year, the company prepared an expansion of its product line to 150mm-diameter wafers with the purchase of a SiC Warm-Wall Planetary Reactor system from Aixtron. The new system is capable of handling ten 100mm or six 150mm wafers. The firm already offers 4-inch (100mm) SiC epitaxy products for power device application.

### Complete portfolio

Sweden's Norstel has more than 15 years experience in SiC epitaxy and crystal growth using its patented High Temperature Chemical Vapor Deposition (HTCVD) technique. The company claims to be the only SiC supplier besides Cree with a complete product portfolio of conductive substrates, semi-insulating substrates and SiC epi capability.

Norstel's epitaxial capability has been at 100mm diameter for almost two years. The firm operates two Aixtron machines for industrial (Aixtron/Epigress VP-2400HW) and R&D (Aixtron/Epigress VP-508) epitaxy. Both these machines use 'hot-wall' techniques pioneered at Linköping University and further refined by Norstel. The firm developed out of a collaboration on SiC epitaxy between Swiss power company ABB and Linköping in 1993.

Norstel will soon be releasing 100mm conductive substrates for sale after extensive pre-release customer testing. The 100mm substrates were developed using low-stress crystal growth techniques with defect-free



**Figure 3. Norstel's HTCVD furnace.**

expansion, giving wafers with a micropipe density less than  $1/\text{cm}^2$  and a basal plane dislocation density of less than  $5000/\text{cm}^2$ . The research team at Norstel now has its sights set on even lower defect densities and 150mm diameters.

To meet expected demand for its new products, Norstel is installing new manufacturing capacity to ramp up production during second-half 2013.

A further development is 100mm semi-insulating substrates, as preferred for RF devices. The first batch is due to ship soon for testing and device manufacturing as part of the European Defense Agency sponsored program 'MANGA — Manufacturable GaN'. Norstel has been involved in MANGA since 2010.

"We expect to start selling these 100mm semi-insulating wafers during the second quarter, and we will then have a full 100mm diameter product portfolio," comments Norstel's director of sales & marketing Niklas Henelius.

### Emerging market

In China, companies have announced competing claims to be first in the SiC epitaxy arena.

Dongguan Tianyu Semiconductor Technology Co Ltd, claimed to be the first manufacturer of silicon carbide (SiC) epitaxial wafers in China, has been expanding its capacity. The expansion will include an increase in the maximum substrate diameter to 6 inches.

The company produces n-type epitaxial 4H SiC with silicon face on wafers up to 4 inches (100mm)

diameter. On the largest wafers the non-uniformity of carrier concentration ( $5 \times 10^{15}$ – $2 \times 10^{18}/\text{cm}^3$ ) is less than 20% and typically is about 15%. Better uniformity is achieved over smaller areas. The thickness range is 5–15 $\mu\text{m}$  with non-uniformity less than 10% and typically 5% on 4-inch substrate.

The present equipment base (according to the firm's website) consists of an Aixtron 2800G4 WW production system (10x4-inch substrate per run) and two R&D tools (6x2-inch and 7x3-inch). Power+Energy Inc of the USA reported last year that it was to supply a second hydrogen purifier system. Such purifiers are designed for use with Aixtron MOCVD systems, suggesting that Tianyu may already have a second such system, presumably 6-inch capable, on order or even installed.

Tianyu was founded at the beginning of 2009 and is based at Songshan Lake National High-tech Industrial Development Zone of Dongguan City, Guangdong province. The technical team includes six Chinese Academy of Sciences researchers. The engineering staff consists of 30 SiC growth technologists. The 20,000m<sup>2</sup> plant area and 10,000m<sup>2</sup> workshop has the claimed capacity to ship 10,000 wafers per month.

EpiWorld International in Xiamen, China also claimed the first commercial availability of and orders in China for 3-inch and 4-inch 4H-SiC epitaxial wafers in March 2012. The company is a joint venture with investors from the USA, Japan and China. The equipment base is described as "multiple most advanced epitaxial systems for 3", 4", and 6" SiC epitaxy, auto defect identification and mapping system in a class-100 cleanroom".

A photo on the firm's website shows an Aixtron Planetary Reactor.

### Silicon carbide on silicon

Although most development of SiC epitaxy uses SiC substrates, some researchers have sought to create SiC epitaxial layers on silicon. In July 2012, Griffith University's Queensland Micro- and Nanotechnology Centre in Brisbane, Australia, was awarded AUS\$1m in research funding by the Queensland Government for such work, with the aim of production processes for LED, micro-electro-mechanical systems (MEMS) and power electronics. The center has enlisted the help of UK company SPTS for plasma etch, deposition and thermal processing expertise.

SiC epitaxy on silicon generally creates 3C polytype crystals, as opposed to the 4H (or more rarely 6H) polytype generally offered on SiC substrate. Griffith has used silicon substrate epitaxy to create SiC-based memory with charge retention times at 85°C in excess of 10 years. The group's further achievements include low-temperature epitaxy of 3C SiC on Si, and MOS purity oxides to enable quality MOS devices in SiC. ■

*Author: Mike Cooke*





# **Compound Semiconductor Mantech**

May 13 - May 16, 2013  
Hilton New Orleans Riverside  
New Orleans, LA, USA

**[www.csmantech.org](http://www.csmantech.org)**





# Index

- |  |   |
|--|---|
| 1 Bulk crystal source materials <b>p108</b>    | 14 Chip test equipment <b>p112</b>          |
| 2 Bulk crystal growth equipment <b>p108</b>    | 15 Assembly/packaging materials <b>p112</b> |
| 3 Substrates <b>p108</b>                       | 16 Assembly/packaging equipment <b>p112</b> |
| 4 Epiwafer foundry <b>p109</b>                 | 17 Assembly/packaging foundry <b>p112</b>   |
| 5 Deposition materials <b>p109</b>             | 18 Chip foundry <b>p113</b>                 |
| 6 Deposition equipment <b>p110</b>             | 19 Facility equipment <b>p113</b>           |
| 7 Wafer processing materials <b>p111</b>       | 20 Facility consumables <b>p113</b>         |
| 8 Wafer processing equipment <b>p111</b>       | 21 Computer hardware & software <b>p113</b> |
| 9 Materials and metals <b>p111</b>             | 22 Used equipment <b>p113</b>               |
| 10 Gas & liquid handling equipment <b>p111</b> | 23 Services <b>p113</b>                     |
| 11 Process monitoring and control <b>p111</b>  | 24 Consulting <b>p113</b>                   |
| 12 Inspection equipment <b>p112</b>            | 25 Resources <b>p113</b>                    |
| 13 Characterization equipment <b>p112</b>      |   |

To have your company listed in this directory, e-mail details (including categories) to [mark@semiconductor-today.com](mailto:mark@semiconductor-today.com)

Note: advertisers receive a free listing. For all other companies, a charge is applicable.

## 1 Bulk crystal source materials

### Mining & Chemical Products Ltd (part of 5N Plus, Inc)

1-4, Nielson Road,  
Finedon Road Industrial Estate,  
Wellingborough,  
Northants NN8 4PE,  
UK

Tel: +44 1933 220626  
Fax: +44 1933 227814

[www.MCP-group.com](http://www.MCP-group.com)

### Umicore Indium Products

50 Simms Avenue,  
Providence, RI 02902,  
USA

Tel: +1 401 456 0800  
Fax: +1 401 421 2419

[www.thinfilmpproducts.umicore.com](http://www.thinfilmpproducts.umicore.com)

### United Mineral & Chemical Corp

1100 Valley Brook Avenue,  
Lyndhurst, NJ 07071,  
USA

Tel: +1 201 507 3300  
Fax: +1 201 507 1506

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

## 2 Bulk crystal growth equipment

### MR Semicon Inc

PO Box 91687,  
Albuquerque,  
NM 87199-1687,  
USA

Tel: +1 505 899 8183  
Fax: +1 505 899 8172

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

## 3 Substrates

### AXT Inc

4281 Technology Drive  
Fremont,  
CA 94538,  
USA

Tel: +1 510 438 4700  
Fax: +1 510 683 5901

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

Supplies GaAs, InP, and Ge wafers using VGF technology with manufacturing facilities in Beijing and five joint ventures in China producing raw materials, including Ga, As, Ge, pBN, B<sub>2</sub>O<sub>3</sub>.



### CrystAl-N GmbH

Dr.-Mack-Straße 77,  
D-90762  
Fürth,  
Germany

Tel: +49 (0)911 650 78 650 90  
Fax: +49 (0)911 650 78 650 93  
E-mail: [info@crystal-n.com](mailto:info@crystal-n.com)

[www.crystal-n.com](http://www.crystal-n.com)

### Crystal IS Inc

70 Cohoes Avenue  
Green Island, NY 12183, USA

Tel: +1 518 271 7375  
Fax: +1 518 271 7394

[www.crystal-is.com](http://www.crystal-is.com)

### The Fox Group Inc

200 Voyageur Drive, Montreal,  
Quebec H9R 6A8, Canada

Tel: +1 925 980 5645  
Fax: +1 514 630 0227

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

### Freiberger Compound Materials

Am Junger Loewe Schacht 5,  
Freiberg, 09599, Germany

Tel: +49 3731 280 0  
Fax: +49 3731 280 106

[www.fcm-germany.com](http://www.fcm-germany.com)

**Kyma Technologies Inc**

8829 Midway West Road,  
Raleigh, NC, USA  
Tel: +1 919 789 8880  
Fax: +1 919 789 8881  
[www.kymatech.com](http://www.kymatech.com)

**Nikko Materials**

125 North Price Road,  
Chandler, AZ, USA  
Tel: +1 480 732 9857  
Fax: +1 480 899 0779  
[www.nikkomaterials.com](http://www.nikkomaterials.com)

**SiCrystal AG**

Guenther-Scharowsky-Str. 1  
D-91058 Erlangen, Germany  
Tel: +49 (0) 9131 / 73 33 97  
Fax: +49 (0) 9131 / 73 22 37  
[www.sicrystal.de](http://www.sicrystal.de)

**sp3 Diamond Technologies**

2220 Martin Avenue,  
Santa Clara, CA 95050, USA  
Tel: +1 877 773 9940  
Fax: +1 408 492 0633  
[www.sp3inc.com](http://www.sp3inc.com)

**Sumitomo Electric  
Semiconductor Materials Inc**

7230 NW Evergreen Parkway,  
Hillsboro, OR 97124, USA  
Tel: +1 503 693 3100 x207  
Fax: +1 503 693 8275  
[www.sesmi.com](http://www.sesmi.com)

**III/V-Reclaim**

Wald 10,   
84568 Pleiskirchen,  
Germany  
Tel: +49 8728 911 093  
Fax: +49 8728 911 156  
[www.35reclaim.de](http://www.35reclaim.de)  
III/V-Reclaim offers reclaim  
(recycling) of GaAs and InP wafers,  
removing all kinds of layers and  
structures from customers' wafers.  
All formats and sizes can be  
handled. The firm offers single-side  
and double-side-polishing and  
ready-to-use surface treatment.

**Umicore Electro-Optic Materials**

Watertorenstraat 33,  
B-2250 Olen, Belgium  
Tel: +32-14 24 53 67  
Fax: +32-14 24 58 00  
[www.substrates.umicore.com](http://www.substrates.umicore.com)

**Wafer Technology Ltd**

34 Maryland Road, Tongwell,  
Milton Keynes, Bucks, MK15 8HJ,  
UK  
Tel: +44 (0)1908 210444  
Fax: +44 (0)1908 210443  
[www.wafertech.co.uk](http://www.wafertech.co.uk)  
Wafer Technology Ltd  
is a UK-based  
producer of III-V  
materials and epitaxy-  
ready substrates  
offering the widest product range in  
the business.

**Wafer World Inc**

1100 Technology Place, Suite 104,  
West Palm Beach, FL 33407, USA  
Tel: +1-561-842-4441  
Fax: +1-561-842-2677  
E-mail: [sales@waferworld.com](mailto:sales@waferworld.com)  
[www.waferworld.com](http://www.waferworld.com)



World's leading supplier of small-  
diameter (25.4–150.0mm) silicon,  
germanium, GaAs & InP reclaim,  
cleanroom packaging and 50 other  
materials!

## 4 Epiwafer foundry

**Spire Semiconductor LLC**

25 Sagamore Park Drive,  
Hudson, NH 03051, USA  
Tel: +1 603 595 8900  
Fax: +1 603 595 0975  
[www.spirecorp.com](http://www.spirecorp.com)

**Cambridge Chemical Company Ltd**

Unit 5 Chesterton Mills,  
French's Road, Cambridge CB4 3NP,  
UK  
Tel: +44 (0)1223 352244  
Fax: +44 (0)1223 352444  
[www.camchem.co.uk](http://www.camchem.co.uk)

**The Fox Group Inc**

(see section 3 for full contact details)

**Intelligent Epitaxy Technology Inc**

1250 E Collins Blvd, Richardson,  
TX 75081-2401, USA  
Tel: +1 972 234 0068  
Fax: +1 972 234 0069  
[www.intelliepi.com](http://www.intelliepi.com)

**IQE**

Cypress Drive,  
St Mellons, Cardiff  
CF3 0EG,  
UK  
Tel: +44 29 2083 9400  
Fax: +44 29 2083 9401  
[www.iqep.com](http://www.iqep.com)  
IQE is a leading global supplier of  
advanced epiwafers, with products  
covering a diverse range of  
applications within the wireless,  
optoelectronic, photovoltaic and  
electronic markets.

**OMMIC**

2, Chemin du Moulin B.P. 11,  
Limeil-Brevannes, 94453, France  
Tel: +33 1 45 10 67 31  
Fax: +33 1 45 10 69 53  
[www.ommic.fr](http://www.ommic.fr)

**Picogiga International S.A.S.**

Place Marcel Rebuffat, Parc de  
Villejust, 91971 Courtabouef, France  
Tel: +33 (0)1 69 31 61 30  
Fax: +33 (0)1 69 31 61 79  
[www.picogiga.com](http://www.picogiga.com)

**SemiSouth Laboratories Inc**

201 Research Boulevard,  
Starkville, MS 39759, USA  
Tel: +1 662 324 7607  
Fax: +1 662 324 7997  
[www.semisouth.com](http://www.semisouth.com)

## 5 Deposition materials

**Akzo Nobel  
High Purity  
Metalorganics**

AkzoNobel HPMP is a global leading  
supplier of high-purity metalorganics  
serving the semiconductor industry.  
MO sources include Trimethylgallium  
(TMGa), Triethylgallium (TEGa),  
Trimethylindium (TMIIn), Trimethyl-  
aluminum (TMAI), Dimethylzinc  
(DMZn) and Bis(cyclopentadienyl)  
magnesium (Cp<sub>2</sub>Mg). In addition,  
we offer specific grades of  
Diethylzinc (DEZn TCO) and  
Trimethylaluminum (TMAI SOLAR)  
to serve the needs of the solar  
industry. Visit us at  
[www.akzonobel.com/hpmp](http://www.akzonobel.com/hpmp)

## Asia Pacific:

Akzo Nobel (Asia) Co Ltd,  
Shanghai, China  
Tel: +86 21 2216 3600  
Fax: +86 21 3360 7739  
metalorganicsAP@akzonobel.com

## Americas:

AkzoNobel Functional Chemicals,  
Chicago, USA  
Tel: +31 800 828 7929 (US only)  
Tel: +1 312 544 7000  
Fax: +1 312 544 7188  
metalorganicsNA@akzonobel.com

## Europe, Middle East and Africa:

AkzoNobel Functional Chemicals,  
Amersfoort, The Netherlands  
Tel: +31 33 467 6656  
Fax: +31 33 467 6101  
metalorganicsEU@akzonobel.com

## Cambridge Chemical Company Ltd

Unit 5 Chesterton Mills,  
French's Road,  
Cambridge CB4 3NP,  
UK  
Tel: +44 (0)1223 352244  
Fax: +44 (0)1223 352444  
[www.camchem.co.uk](http://www.camchem.co.uk)

## Dow Electronic Materials

60 Willow Street,  
North Andover, MA 01845,  
USA  
Tel: +1 978 557 1700  
Fax: +1 978 557 1701  
[www.metalorganics.com](http://www.metalorganics.com)

## Matheson Tri-Gas

6775 Central Avenue,  
Newark, CA 94560,  
USA  
Tel: +1 510 793 2559  
Fax: +1 510 790 6241  
[www.mathesontrigas.com](http://www.mathesontrigas.com)

## Mining & Chemical Products Ltd (see section 1 for full contact details)

## Power + Energy Inc

(see section 10 for full contact details)

## Praxair Electronics

542 Route 303, Orangeburg,  
NY 10962,  
USA  
Tel: +1 845 398 8242  
Fax: +1 845 398 8304  
[www.praxair.com/electronics](http://www.praxair.com/electronics)

## SAFC Hitech

Power Road, Bromborough,  
Wirral, Merseyside CH62 3QF, UK  
Tel: +44 151 334 2774  
Fax: +44 151 334 6422  
[www.safchitech.com](http://www.safchitech.com)

## Williams Advanced Materials

2978 Main Street,  
Buffalo, NY 14214,  
USA  
Tel: +1 716 837 1000  
Fax: +1 716 833 2926  
[www.williams-adv.com](http://www.williams-adv.com)

## 6 Deposition equipment

### AIXTRON SE

Kaiserstrasse 98,  
52134 Herzogenrath,  
Germany  
Tel: +49 241 89 09 0  
Fax: +49 241 89 09 40  
[www.aixtron.com](http://www.aixtron.com)

**AIXTRON**

AIXTRON is a leading provider of deposition equipment to the semiconductor industry. The company's technology solutions are used by a diverse range of customers worldwide to build advanced components for electronic and optoelectronic applications (photonic) based on compound, silicon, or organic semiconductor materials and, more recently, carbon nanotubes (CNT), graphene and other nanomaterials.

### Oxford Instruments Plasma Technology

North End, Yatton,  
Bristol, Avon BS49 4AP,  
UK  
Tel: +44 1934 837 000  
Fax: +44 1934 837 001

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

We provide  
flexible tools  
and processes



for precise materials deposition, etching and controlled nanostructure growth. Core technologies include plasma and ion-beam deposition and etch and ALD.

## Plasma-Therm LLC

10050 16th Street North,  
St. Petersburg, FL 33716,  
USA  
Tel: +1 727 577 4999  
Fax: +1 727 577 7035  
[www.plasmatherm.com](http://www.plasmatherm.com)



Plasma-Therm, LLC is an established leading provider of advanced plasma processing equipment for the semiconductor industry and related specialty markets.

## Riber

31 rue Casimir Périer, BP 70083,  
95873 Bezons Cedex,  
France  
Tel: +33 (0) 1 39 96 65 00  
Fax: +33 (0) 1 39 47 45 62  
[www.riber.com](http://www.riber.com)

## SVT Associates Inc

7620 Executive Drive,  
Eden Prairie, MN 55344,  
USA  
Tel: +1 952 934 2100  
Fax: +1 952 934 2737  
[www.svta.com](http://www.svta.com)

## Temescal, a part of Ferrotec

4569-C Las  
Positas Rd,  
Livermore,  
CA 94551,  
USA  
Tel: +1 925 245 5817  
Fax: +1 925 449-4096  
[www.temescal.net](http://www.temescal.net)



Temescal, the expert in metallization systems for the processing of compound semiconductor-based substrates, provides the finest evaporation systems available. Multi-layer coatings of materials such as Ti, Pt, Au, Pd, Ag, NiCr, Al, Cr, Cu, Mo, Nb, SiO<sub>2</sub>, with high uniformity are guaranteed. Today the world's most sophisticated handsets, optical, wireless and telecom systems rely on millions of devices that are made using Temescal deposition systems and components.



**Veeco Instruments Inc**

100 Sunnyside Blvd.,  
Woodbury, NY 11797,  
USA

Tel: +1 516 677 0200

Fax: +1 516 714 1231

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



Veeco is a world-leading supplier of compound semiconductor equipment, and the only company offering both MOCVD and MBE solutions. With complementary AFM technology and the industry's most advanced Process Integration Center, Veeco tools help grow and measure nanoscale devices in worldwide LED/wireless, data storage, semiconductor and scientific research markets—offering important choices, delivering ideal solutions.

## 7 Wafer processing materials

**Air Products and Chemicals Inc**

7201 Hamilton Blvd.,  
Allentown, PA 18195,  
USA

Tel: +1 610 481 4911

[www.airproducts.com/compound](http://www.airproducts.com/compound)

**MicroChem Corp**

1254 Chestnut St. Newton,  
MA 02464,  
USA

Tel: +1 617 965 5511

Fax: +1 617 965 5818

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

**Power + Energy Inc**

(see section 10 for full contact details)

**Praxair Electronics**

(see section 5 for full contact details)

## 8 Wafer processing equipment

**EV Group**

DI Erich Thallner Strasse 1,  
St. Florian/Inn, 4782,  
Austria

Tel: +43 7712 5311 0

Fax: +43 7712 5311 4600

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

Technology and  
market leader for  
wafer processing  
equipment.



Worldwide industry standards for aligned wafer bonding, resist processing for the MEMS, nano and semiconductor industry.

**Logitech Ltd**

Erskine Ferry  
Road,  
Old Kilpatrick,  
near Glasgow G60 5EU,  
Scotland, UK

Tel: +44 (0) 1389 875 444

Fax: +44 (0) 1389 879 042

[www.logitech.uk.com](http://www.logitech.uk.com)

Logitech Ltd is a leading designer and manufacturer of high-precision cutting, lapping, polishing and CMP equipment enabling high-specification surface finishes to be prepared with precise geometric accuracy.

**Oxford Instruments Plasma Technology**

(see section 6 for full contact details)

**Plasma-Therm LLC**

(see section 6 for full contact details)

**Power + Energy Inc**

(see section 10 for full contact details)

**SAMCO International Inc**

532 Weddell Drive,  
Sunnyvale, CA, USA

Tel: +1 408 734 0459

Fax: +1 408 734 0961

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

**SPP Process Technology Systems Ltd**

Imperial Park, Newport NP10 8UJ,  
Wales, UK

Tel: +44 (0)1633 652400

Fax: +44 (0)1633 652405

[www.spp-pts.com](http://www.spp-pts.com)

**Veeco Instruments Inc**

(see section 6 for full contact details)

## 9 Materials & metals

**Goodfellow Cambridge Ltd**

Ermine Business Park, Huntingdon,  
Cambridgeshire PE29 6WR, UK

Tel: +44 (0) 1480 424800

Fax: +44 (0) 1480 424900

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



Goodfellow supplies small quantities of metals and materials for research, development, prototyping and specialised manufacturing operations.

## 10 Gas and liquid handling equipment

**Air Products and Chemicals Inc**

(see section 7 for full contact details)

**Cambridge Fluid Systems**

12 Trafalgar Way, Bar Hill,  
Cambridge CB3 8SQ, UK

Tel: +44 (0)1954 786800

Fax: +44 (0)1954 786818

[www.cambridge-fluid.com](http://www.cambridge-fluid.com)

**CS CLEAN SYSTEMS AG**

Fraunhoferstrasse 4,  
Ismaning, 85737,  
Germany

Tel: +49 89 96 24 00 0

Fax: +49 89 96 24 00 122

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

**Power + Energy Inc**

106 Railroad Drive,  
Ivyland, PA 18974, USA

Tel: +1 215 942-4600

Fax: +1 215 942-9300

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

**SAES Pure Gas Inc**

4175 Santa Fe Road,  
San Luis Obispo, CA 93401,  
USA

Tel: +1 805 541 9299

Fax: +1 805 541 9399

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

## 11 Process monitoring and control

**k-Space Associates Inc**

2182 Bishop Circle  
East, Dexter,  
MI 48130, USA

Tel: +1 734 426 7977

Fax: +1 734 426 7955

[www.k-space.com](http://www.k-space.com)



k-Space Associates Inc specializes in in-situ, real-time thin-film process monitoring tools for MBE, MOCVD, PVD, and thermal evaporation. Applications and materials include the research and production line monitoring of compound semiconductor-based electronic, optoelectronic, and photovoltaic devices.

## KLA-Tencor

One Technology Dr,  
1-22211, Milpitas,  
CA 95035,  
USA  
Tel: +1 408 875 3000  
Fax: +1 408 875 4144  
[www.kla-tencor.com](http://www.kla-tencor.com)

## LayTec AG

Seesener Str.  
10-13,  
10709 Berlin,  
Germany  
Tel: +49 30 39 800 80 0  
Fax: +49 30 3180 8237  
[www.laytec.de](http://www.laytec.de)



LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

## Optical Reference Systems Ltd

OpTIC Technium,  
St Asaph Business Park,  
St Asaph, LL17 0JD,  
UK  
Tel: +44 (0)1745 535 188  
Fax: +44 (0)1745 535 186  
[www.ors-ltd.com](http://www.ors-ltd.com)

## WEP

(Ingenieurbüro Wolff  
für Elektronik- und  
Programmentwicklungen)  
Bregstrasse 90, D-78120  
Furtwangen im Schwarzwald,  
Germany  
Tel: +49 7723 9197 0  
Fax: +49 7723 9197 22  
[www.wepcontrol.com](http://www.wepcontrol.com)

## 12 Inspection equipment

### Bruker AXS GmbH

Oestliche Rheinbrueckenstrasse 49,  
Karlsruhe, 76187,  
Germany  
Tel: +49 (0)721 595 2888  
Fax: +49 (0)721 595 4587  
[www.bruker-axs.de](http://www.bruker-axs.de)

## 13 Characterization equipment

### J.A. Woollam Co. Inc.

645 M Street Suite 102,  
Lincoln, NE 68508, USA  
Tel: +1 402 477 7501  
Fax: +1 402 477 8214  
[www.jawoollam.com](http://www.jawoollam.com)

### Lake Shore Cryotronics Inc

575 McCorkle Boulevard,  
Westerville, OH 43082,  
USA  
Tel: +1 614 891 2244  
Fax: +1 614 818 1600  
[www.lakeshore.com](http://www.lakeshore.com)

## 14 Chip test equipment

### Keithley Instruments Inc

28775 Aurora Road,  
Cleveland, OH 44139,  
USA  
Tel: +1 440.248.0400  
Fax: +1 440.248.6168  
[www.keithley.com](http://www.keithley.com)

### SUSS MicroTec Test Systems

228 Suss Drive,  
Waterbury Center, VT 05677,  
USA  
Tel: +1 800 685 7877  
Fax: +1 802 244 7853  
[www.suss.com](http://www.suss.com)

## 15 Assembly/packaging materials

### ePAK International Inc

4926 Spicewood Springs Road,  
Austin, TX 78759, USA  
Tel: +1 512 231 8083  
Fax: +1 512 231 8183  
[www.epak.com](http://www.epak.com)

## Gel-Pak

31398 Huntwood Avenue,  
Hayward, CA 94544, USA  
Tel: +1 510 576 2220  
Fax: +1 510 576 2282  
[www.gelpak.com](http://www.gelpak.com)

## Wafer World Inc

(see section 3 for full contact details)

## Williams Advanced Materials

2978 Main Street,  
Buffalo, NY 14214, USA  
Tel: +1 716 837 1000  
Fax: +1 716 833 2926  
[www.williams-adv.com](http://www.williams-adv.com)

## 16 Assembly/packaging equipment

### Ismeca Europe Semiconductor SA

Helvetie 283, La Chaux-de-Fonds,  
2301, Switzerland  
Tel: +41 329257111  
Fax: +41 329257115  
[www.ismeca.com](http://www.ismeca.com)

### Kulicke & Soffa Industries

1005 Virginia Drive,  
Fort Washington, PA 19034, USA  
Tel: +1 215 784 6000  
Fax: +1 215 784 6001  
[www.kns.com](http://www.kns.com)

### Palomar Technologies Inc

2728 Loker Avenue West,  
Carlsbad, CA 92010, USA  
Tel: +1 760 931 3600  
Fax: +1 760 931 5191  
[www.PalomarTechnologies.com](http://www.PalomarTechnologies.com)

### TECDIA Inc

2700 Augustine Drive, Suite 110,  
Santa Clara, CA 95054, USA  
Tel: +1 408 748 0100  
Fax: +1 408 748 0111  
[www.tecdia.com](http://www.tecdia.com)

## 17 Assembly/packaging foundry

### Quik-Pak

10987 Via Frontera,  
San Diego, CA 92127, USA  
Tel: +1 858 674 4676  
Fax: +1 8586 74 4681  
[www.quikicpak.com](http://www.quikicpak.com)

## 18 Chip foundry

### Compound Semiconductor Technologies Ltd

Block 7, Kelvin Campus,  
West of Scotland, Glasgow,  
Scotland G20 0TH,  
UK

Tel: +44 141 579 3000

Fax: +44 141 579 3040

[www.compoundsemi.co.uk](http://www.compoundsemi.co.uk)

### United Monolithic Semiconductors

Route departementale 128,  
BP46, Orsay, 91401,  
France

Tel: +33 1 69 33 04 72

Fax: +33 169 33 02 92

[www.ums-gaas.com](http://www.ums-gaas.com)

## 19 Facility equipment

### MEI, LLC

3474 18th Avenue SE,  
Albany, OR 97322-7014,  
USA

Tel: +1 541 917 3626

Fax: +1 541 917 3623

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

## 20 Facility consumables

### W.L. Gore & Associates

401 Airport Rd,  
Elkton, MD 21921-4236,  
USA

Tel: +1 410 392 4440

Fax: +1 410 506 8749

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

## 21 Computer hardware & software

### Ansoft Corp

4 Station Square, Suite 200,  
Pittsburgh, PA 15219,  
USA

Tel: +1 412 261 3200

Fax: +1 412 471 9427

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

### Crosslight Software Inc

121-3989 Henning Dr.,  
Burnaby, BC, V5C 6P8,  
Canada

Tel: +1 604 320 1704

Fax: +1 604 320 1734

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

### Semiconductor Technology Research Inc

10404 Patterson Ave., Suite 108,  
Richmond, VA 23238,  
USA

Tel: +1 804 740 8314

Fax: +1 804 740 3814

[www.semitech.us](http://www.semitech.us)

## 22 Used equipment

### Class One Equipment Inc

5302 Snapfinger Woods Drive,  
Decatur, GA 30035,  
USA

Tel: +1 770 808 8708

Fax: +1 770 808 8308

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

### Brumley South Inc

422 North Broad Street,  
Mooresville,  
NC 28115,  
USA

Tel: +1 704 664 9251

Fax: +1 704 664 9246

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

As an ISO 9001 registered global leader in the remanufacturing of wafer inspection systems, Brumley South Inc specializes in designing, installing and supporting upgrades for ADE, Nanometrics, Dryden and KLA-Tencor Surfscan tools, polysterene



latex sphere calibration standards, particle deposition systems, and semiconductor parts and service.

## 23 Services

### Henry Butcher International

Brownlow House, 50-51

High Holborn,  
London WC1V 6EG,  
UK

Tel: +44 (0)20 7405 8411

Fax: +44 (0)20 7405 9772

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

### M+W Zander Holding AG

Lotterbergstrasse 30,  
Stuttgart,  
Germany

Tel: +49 711 8804 1141

Fax: +49 711 8804 1950

[www.mw-zander.com](http://www.mw-zander.com)

## 24 Consulting

### Fishbone Consulting SARL

8 Rue de la Grange aux Moines,  
78460 Choisel,  
France

Tel: + 33 (0)1 30 47 29 03

E-mail: [jean-luc.ledys@neuf.fr](mailto:jean-luc.ledys@neuf.fr)

## 25 Resources

### SEMI Global Headquarters

3081 Zanker Road,  
San Jose, CA 95134, USA

Tel: +1 408 943 6900

Fax: +1 408 428 9600

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

### Yole Développement

45 rue Sainte Geneviève,  
69006 Lyon,  
France

Tel: +33 472 83 01 86

[www.yole.fr](http://www.yole.fr)

**REGISTER**  
for *Semiconductor Today* free at  
[www.semiconductor-today.com](http://www.semiconductor-today.com)



# event calendar

If you would like your event listed in *Semiconductor Today's* Event Calendar, then please e-mail all details to the Editor at [mark@semiconductor-today.com](mailto:mark@semiconductor-today.com)

**10–13 March 2013**

## **17th European Molecular Beam Epitaxy Workshop (Euro MBE 2013)**

Levi, Finland

**E-mail:** [eurombe@tut.fi](mailto:eurombe@tut.fi)

[www.eurombe.eu](http://www.eurombe.eu)

**17–23 March 2013**

## **Optical Fiber Communications (OFC 2013)**

Anaheim, CA, USA

**E-mail:** [info@ofcconference.org](mailto:info@ofcconference.org)

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

**17–21 March 2013**

## **Applied Power Electronics Conference and Exposition (APEC 2013)**

Long Beach Convention Center, CA, USA

**E-mail:** [apec@apec-conf.org](mailto:apec@apec-conf.org)

[www.apec-conf.org](http://www.apec-conf.org)

**17–18 March 2013**

## **China Semiconductor Technology International Conference (CSTIC 2013)**

Kerry Hotel Pudong, Shanghai, China

**E-mail:** [kwu@semi.org](mailto:kwu@semi.org)

<http://semiconchina.semi.org/cstic>

**19–21 March 2013**

## **SEMI CON China 2013**

Shanghai New International Expo Centre (SNIEC), China

**E-mail:** [semichina@semi.org](mailto:semichina@semi.org)

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

**19–21 March 2013**

## **LASER World of PHOTONICS CHINA**

Shanghai New International Expo Centre (SNIEC), China

**E-mail:** [laser@mmi-shanghai.com](mailto:laser@mmi-shanghai.com)

[www.world-of-photonics.net/en/laser-china/start](http://www.world-of-photonics.net/en/laser-china/start)

**21–22 March 2013**

## **CPV International 2013**

### **(4th Annual Concentrated Photovoltaics Conference & Expo)**

Madrid, Spain

**E-mail:** [lthomas@pv-insider.com](mailto:lthomas@pv-insider.com)

[www.pv-insider.com/cpv-international](http://www.pv-insider.com/cpv-international)

**15–17 April 2013**

## **9th International Conference on Concentrator Photovoltaic Systems (CPV-9)**

Phoenix Seagaia Resort, Miyazaki, Japan

**E-mail:** [info@cpv-9.org](mailto:info@cpv-9.org)

[www.cpv-9.org](http://www.cpv-9.org)

# advertisers' index

Advertiser	Page no.	Advertiser	Page no.
Aixtron SE	5	Logitech	47
Brolis	65	Oxford Instruments Austin	41
CS Clean Systems	39	Oxford Instruments Plasma Technology	38
CS Mantech	107	Plasma-Therm	21 & 23
EV Group	59	RIFF Company	61
Evatec	53	SEMI China	15
Fuji Electric	43	Sensirion	41
Hilco	76	Temescal	51
III/V-Reclaim	30	Veeco Instruments — MOCVD	2
IQE	11	Wafer Technology	63
k-Space	75	Wafer World	31
LayTec	35		

**29 April – 3 May 2013**

**SPIE Defense, Security, and Sensing 2013**

Baltimore Convention Center, Maryland, USA

**E-mail:** [customerservice@spie.org](mailto:customerservice@spie.org)

<http://spie.org/defense-security-sensing.xml>

**5–8 May 2013**

**IEEE Optical Interconnects Conference (OI Conference 2013)**

Eldorado Hotel & Spa, Santa Fe, NM, USA

**E-mail:** [m.figueroa@ieee.org](mailto:m.figueroa@ieee.org)

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

**12–16 May 2013**

**World of Photonics Congress, incorporating European Conference on Lasers and Electro-Optics and International Quantum Electronics Conference (CLEO/Europe-IQEC 2013)**

International Congress Centre Munich (ICM), Germany

**E-mail:** [info@photonics-congress.com](mailto:info@photonics-congress.com)

[www.world-of-photonics.net/en/photonics-congress/start](http://www.world-of-photonics.net/en/photonics-congress/start)

**13–16 May 2013**

**21st LASER World of Photonics**

Messe München, Munich, Germany

**E-mail:** [info@world-of-photonics.net](mailto:info@world-of-photonics.net)

[www.world-of-photonics.net](http://www.world-of-photonics.net)

**12–17 May 2013**

**223rd Electrochemical Society (ECS) Meeting**

Toronto, Ontario, Canada

**E-mail:** [meetings@electrochem.org](mailto:meetings@electrochem.org)

[www.electrochem.org/meetings/biannual/fut\\_mtgs.htm](http://www.electrochem.org/meetings/biannual/fut_mtgs.htm)

**13 May 2013**

**JEDEC's 28th Annual ROCS (Reliability of Compound Semiconductors) Workshop**

Hilton New Orleans Riverside, New Orleans, LA, USA

**E-mail:** [ptanner@jedec.org](mailto:ptanner@jedec.org)

[www.jedec.org/home/gaas](http://www.jedec.org/home/gaas)

**13–16 May 2013**

**2013 CS MANTECH: International Conference on Compound Semiconductor Manufacturing Technology**

Hilton New Orleans Riverside, New Orleans, LA, USA

**E-mail:** [csmantech@csmantech.org](mailto:csmantech@csmantech.org)

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

**2–5 June 2013**

**15th European Workshop on Metalorganic Vapour Phase Epitaxy (EWMOVPE 2013)**

Technology Centre in Aachen, Germany

**E-mail:** [ewmovpe2013@jara.org](mailto:ewmovpe2013@jara.org)

[www.jara.org/index.php?id=606](http://www.jara.org/index.php?id=606)

**5–6 June 2013**

**SEMI CON Russia 2013**

Moscow, Russia

**E-mail:** [eweller@semi.org](mailto:eweller@semi.org)

[www.semiconrussia.org/en](http://www.semiconrussia.org/en)

**17–20 June 2013**

**LASER World of PHOTONICS 2013**

Munich, Germany

**E-mail:** [info@world-of-photonics.net](mailto:info@world-of-photonics.net)

[www.world-of-photonics.net/en](http://www.world-of-photonics.net/en)

**24–25 June 2013**

**euroLED 2013**

The ICC, Birmingham, UK

**E-mail:** [info@euroled](mailto:info@euroled)

[www.euroLED.org.uk](http://www.euroLED.org.uk)

**1–2 July 2013**

**SolarTech Expo China 2013**

Shanghai, China

**E-mail:** [ds@greenworldconferences.com](mailto:ds@greenworldconferences.com)

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

**9–11 July 2013**

**SEMI CON West 2013**

San Francisco, CA, USA

**E-mail:** [semiconwest@xpressreg.net](mailto:semiconwest@xpressreg.net)

<http://semiconwest.org>

**22–23 July 2013**

**SolarTech Expo India 2013**

New Delhi, India

**E-mail:** [ds@greenworldconferences.com](mailto:ds@greenworldconferences.com)

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

**4–10 August 2013**

**15th Summer School on Crystal Growth (ISSCG-15)**

Gdansk, Poland

[www.ptwk.org.pl/pol/documents/ISSCG-15-1.pdf](http://www.ptwk.org.pl/pol/documents/ISSCG-15-1.pdf)

<http://science24.com/event/isscg15>

**5–6 August 2013**

**SolarTech Expo Spain 2013**

Valencia, Spain

**E-mail:** [ds@greenworldconferences.com](mailto:ds@greenworldconferences.com)

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

**11–16 August 2013**

**17th International Conference on Crystal Growth and Epitaxy (ICCGE-17)**

Warsaw, Poland

**E-mail:** [sarzyn@unipress.waw.pl](mailto:sarzyn@unipress.waw.pl)

[www.ptwk.org.pl/pol/documents/ICCGE-17-1.pdf](http://www.ptwk.org.pl/pol/documents/ICCGE-17-1.pdf)

<http://science24.com/event/iccge17>

# semiconductor**TODAY**

COMPOUNDS & ADVANCED SILICON

Advertisers choose *Semiconductor Today* for its...

- Accurate, timely editorial coverage of key issues
- Highly targeted 32,000+ international circulation
- Highly competitive rates
- Magazine, website and E-brief package options
- Direct, rapid delivery by e-mail and RSS feeds

Register now  
for your FREE subscription  
at

**[www.semiconductor-today.com](http://www.semiconductor-today.com)**