

# semiconductor TODAY

COMPOUNDS & ADVANCED SILICON

Vol. 4 • Issue 3 • April/May 2009

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## GaAs industry slumps & recovery Changing horizons in CIGS PVs

GaAs RFIC demand returns • News from OFC 2009  
Bookham and Avanex form Oclaro • JDSU closes VCSEL fab

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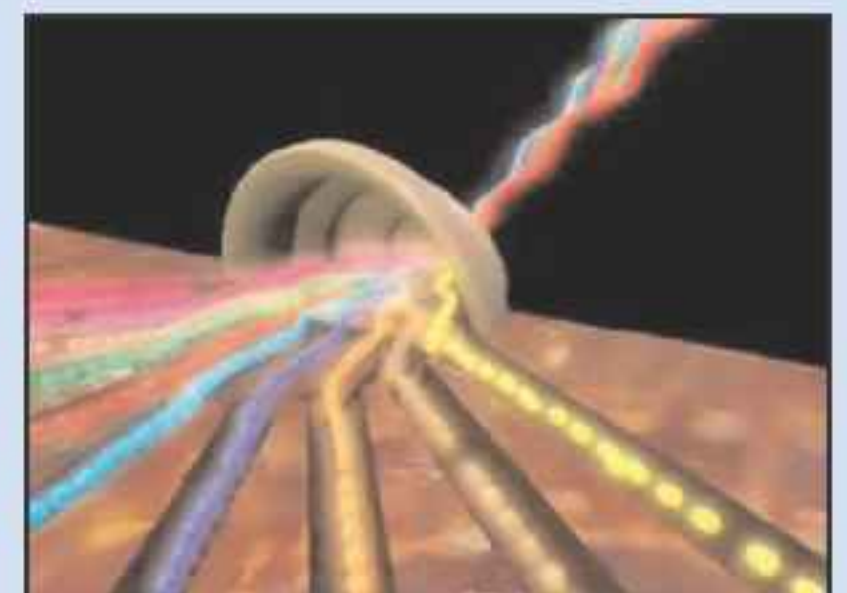
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**p23** EpiWorks' plant, which is being doubled in capacity to 100,000 wafers per year in a Phase II expansion.



**p38** Red and blue LEDs from Seoul Semiconductor used as an artificial light source to boost growth of plants.



**p56** Infinera's latest InP-based photonic integrated circuits integrate ten 40Gb/s channels to achieve 400Gb/s capacity.



**Cover:** View from beneath an array of Solyndra's rooftop-mounted CIGS-based cylindrical solar modules, which can capture sunlight across a 360° surface capable of converting direct, diffuse and reflected sunlight into electricity, as well as allowing wind to pass through the array. **p88**

# Inflection point seen as inventory burns off

This year's CS MANTECH event (18–21 May) comes at a time of rapid change in the fortunes of the compound semiconductor industry (particularly the GaAs RFIC sector): rapid not only because of the speed and severity of the slump in demand that hit in fourth-quarter 2008, but also because of the turnaround that many firms are seeing.

Despite the year-on-year decline in consumer-driven markets such as mobile handsets (see page 6) — some sectors of the compound semiconductor industry are seeing a turnaround and a pickup in demand as inventories of components burn off at their customers.

Both GaAs RFIC makers RF Micro Devices and TriQuint report seeing an 'inflection point' in demand in mid to late first-quarter 2009, while Skyworks also sees increasing demand (boosted by its diversification) and even Anadigics — hit by capacity constraints last year — forecasts a return to growth in Q3/2009 (see pages 8–14). Hence, despite market research firm Strategy Analytics estimating an average 15% quarter-to-quarter drop in compound semiconductor industry revenues in Q4/2008 (see page 4), it foresees a less severe and less prolonged downturn in 2009 than in the previous industry slump of 2001 (see article on pages 80–81), with market contraction of just 5–6% in full-year 2009 versus 25% in 2001.

Meanwhile, in the optical communications sector, consolidation has continued. Not only have Bookham and Avanex completed their merger (forming Oclaro — see page 64), but there have been other, more niche mergers announced in recent weeks. These include Thorlabs' acquisition of Covega from Gemfire, and Ignis' acquisition of Syntune (page 63). In both cases, these involve broader, passive optical component makers adding active optoelectronic component manufacturing capabilities (including photonic integration in indium phosphide).

In the latter case, the aim is to integrate its supply of tunable lasers into manufacturing of components for Gigabit passive optical networks, targeting applications such as fiber-to-the-home (FTTH) for high-speed, high-bandwidth services. However, the acquisition only followed the settling of tunable laser patent disputes that JDSU had filed against Syntune, Bookham and CyOptics (see page 62).

In the case of Bookham, the settlement comes at the cost of a patent license and hefty royalty payments to JDSU concerning a product that has been gaining market share for Bookham. This also comes as JDSU is promoting what it claims is the first monolithically integrated and tunable optical transceiver (see page 61, among other news from the OFC 2009 event on pages 55–67). Nevertheless, Bookham has said that its acquisition of Avanex allows it to boost its level of R&D spending to the levels necessary to compete with JDSU, Finisar and Opnext, especially as the development of 40Gb/s and 100Gb/s technologies for burgeoning high-bandwidth services places greater demands on increased photonic integration.

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

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**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)

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## Compound semiconductor revenue growth to return in second-half '09 after 15% drop in Q4/2008

In fourth-quarter 2008, compound semiconductor industry revenues dropped sequentially by an average of 15%, with individual companies seeing their revenues drop 10–30%, according to the Strategy Analytics GaAs and Compound Semiconductor Technologies service's regular analysis of microelectronic, optoelectronic and materials/equipment markets.

Q4/2008 saw an abrupt drop-off in sales as demand from end markets ground to a halt. A financial performance snapshot of companies offering optoelectronic products, materials and equipment shows a similar story to the RF market, with sequential revenues declining.

"Profitability was also hit," says the market research firm's Asif Anwar. "In some cases, exceptional charges related to merger and acquisition activity over the past 12–18 months compounded the ability of companies to generate positive net income," he adds.

"While the first quarter in 2009 will see further sequential reductions in revenue, Strategy Analytics believes that pockets of recovery will emerge in the second quarter, and current indicators suggest that the industry will start to see growth from the second half of 2009 moving into 2010," Anwar concludes.

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

## Solar panel sales growth to slow from 48% in 2008 to 26% in 2009

Solar energy panel sales rose 48% to 5.6GW in 2008, but a stimulus package is needed to create jobs in the USA, according to a report 'Opportunities in The Solar Cell Market For Thin Film Technology' from market research firm The Information Network.

However, less than 14% of solar panel production (750MW) was produced in the USA. Europe produced more than 25% (1.5GW) and Asia 60% (3.3 GW).

"While the use of renewable energy is lauded, what's worse: buying solar panels from Europe and Asia or oil from OPEC?," asks president Dr Robert Castellano. "The Obama energy stimulus package must include ways to generate jobs here in the USA. The alternative energy program in the USA needs an Energy Czar to enable job production, and I volunteer my services," he adds.

The solar energy industry is also in flux. Capacity utilization is below 50%, an oversupply of polysilicon is pushing prices of crystalline wafers below \$5 (impacting sales of much lower-efficiency amorphous silicon panels), and macroeconomic issues will result in newly installed solar capacity reaching only 7.1GW in 2009 (equivalent to a global growth rate of 26%).

"The solar panel market is expected to pick up again in 2010, growing 48% to 10.5GW of newly installed PV systems," says Castellano. "The thin-film sector, which includes amorphous silicon, cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS), will represent less than 20% of the market in 2010," he adds. "Plagued by low efficiencies of 7–12%, this sector will be compensated by low manufacturing costs."

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

## Market for embedded pico-projector modules to exceed \$1bn within five years

With a potential addressable market numbering billions of units, market research firm In-Stat is forecasting that the pico-projector market will exceed \$1.1bn within five years, according to its report 'Embedded Picoprojectors Ready To Break Out Worldwide' (priced at \$2495).

Companies offering pico-projectors include 3M, Displaytech, Foxxcon, Light Blue Optics, Oculon, Optoma, Microvision, Toshiba, and TI. The report covers products using pico-projector modules, including cell phones, computing devices, personal media players, digital cameras, digital camcorders, and accessory projectors. Cell phones and accessory projectors will lead the market, followed by computing devices and consumer products.

In particular, projector module economies of scale will expand the market for embedded picoprojectors to lower-priced cell phones and media players in the near future, reckons the market research firm. "As mobile devices add more multimedia capabilities, embedded picoprojectors can add a big-screen experience to a very small device," says In-Stat analyst David Chamberlain. "Technological advances in miniaturization, signal processing, and light sources—including green laser—are making pico-projectors a realistic feature for small battery-powered devices like cell phones, media players, computing devices, and other consumer electronics," he adds.

As well as MEMS and liquid crystal on silicon (LCoS) displays, the report analyses developments in competing illumination technologies, with vendors offering both LED and laser technology. The green laser, in particular, is a critical development area.

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# Penetration of LED backlights in notebook PCs doubles to 24% in Q1

Shipments of 120Hz (double frame rate) LCD TV panels of 3.3 million units in fourth-quarter 2008 were flat on Q3/2008, but rose from 15% to 16% of all 32" and above LCD TV panels and from 27% to 31% of all 40" and above LCD TV panels, according to market research firm DisplaySearch's 'Quarterly Large-Area TFT LCD Shipment Report'.

Meanwhile, due to cost reductions and the launches of new notebook PC models, shipments of notebook panels with LED backlights grew by 62%, from 2.3 million to 3.7 million (following 63% growth in Q3). Accentuated by the overall notebook PC market falling 24% (from 36.8 million to 28.1 million), notebook panels with LED backlights rose from a 6.3% share to a 13.4% share of all notebook panels (excluding 10.1" and 10.2" mini-note panels).

LG Display was the leading supplier of notebook LED backlight panels (with 38.3% market share, up from 23% in Q3), followed by fellow Korean firm Samsung (19.2%, up from 12%), Japan's Toshiba Matsushita Display Technology (16.4%, down from a leading 39% in Q3), Taiwan's AU Optronics (12.9%, down from 23%) and Chi Mei Optoelectronics (11.8%, up from just 1%), and Hydis (1.4%, down from 2%).

In fourth-quarter 2008, 12.1" 1280 x 800, 13.3" 1280 x 800, and 15.4" 1280 x 800 and 1440 x 900

were the leading sizes of LED backlight notebook panels. New 16:9 panels will largely adopt LED backlights in 2009.

With the adoption of LED backlights being triggered by lower cost and new LED backlight structures, estimates from notebook panel makers suggest that the penetration of notebook panels with LED backlights will almost double again to 24% in Q1/2009. This is a more rapid increase in penetration than forecast just a quarter ago, accelerated by the slowdown in the overall notebook PC market since late 2008.

Many notebook brands (including HP, Dell and Acer) are planning to launch new LED notebook models in first-half 2009. Consequently, in Q4/2009 most notebook panels shipped will have LED backlights, forecasts DisplaySearch.

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

**Many notebook brands are planning to launch new LED notebook models... In Q4/09 most notebook panels shipped will have LED backlights**

## Industrial laser sales to fall 32% to 2004 levels

If sales stay at current levels, then the industrial laser market will fall 32% in 2009 (to the same level as 2004), forecasts market research firm Strategies Unlimited in its report 'Fiber and Industrial Laser Market Review and Forecast—2009', which includes coverage of thin-disk lasers, diode-pumped solid-state lasers (DPSSL), lamp-pumped solid-state lasers (LPSSLs), and carbon dioxide (CO<sub>2</sub>) lasers.

By 2013, sales will return to 2008 levels, helped by military, biomedical instruments, and energy-related applications. Many materials-processing applications (spanning laser marking to metal cutting and welding) will take longer to recover. In contrast, fiber-laser suppliers will see a shallower decline of 24% to \$230m in

2009, and experience faster recovery than other types of lasers. However, if the recession deepens or if suppliers engage in a desperate price war, 2009 sales will fall further.

While the industrial laser sector is highly fragmented, the top 10 suppliers earn about 86% of revenues (with Coherent Inc of Santa Clara, CA, USA and TRUMPF of Ditzingen, Germany remaining top), while many dozens of small suppliers share less than 5% of the market.

Although IPG Photonics of Oxford, MA, USA continues to dominate the fiber-laser segment, in second-half 2008 more than 30 firms were making complete fiber-laser products, as the market reached almost \$300m for 2008. Although the fiber-laser sector is not one to make rapid changes, many application

trends are becoming clearer during the current period of transition, points out Strategies Unlimited. The recession is so severe that every supplier will be forced to pick and choose the laser businesses in which it wants to continue to compete. Afterward, not only will there be fewer players, but the remaining players will play in fewer niches.

"The recession breaks a nearly unbroken string of growth for both fiber lasers and industrial lasers in general," says Tom Hausken, director of components research at Strategies Unlimited. "For the next several years the business will appear less like a steady, growing, still-young market and more like a cyclic one, more typical of mature capital markets," Hausken concludes.

[www.strategies-u.com](http://www.strategies-u.com)

## Handset shipments fall at a record rate in Q1/2009: year-on-year decline of 13% to see 245 million shipments

Global mobile handset shipments fell a huge 13% from 282 million units a year ago to 245 million units in first-quarter 2009, according to the report 'Q1 2009 Global Handset Market Share Update' from market research firm Strategy Analytics.

Analyst Alex Spektor attributes the fastest ever year-on-year decline in handset shipments since the modern cellphone industry began 27 years ago (in 1983) to the worldwide economic downturn and de-stocking by cautious retailers, as well as consumers delaying purchases because of financial fears.

"The first quarter of 2009 was an exceptionally tough period," says Strategy Analytics director Neil Mawston. "Shipment growth contracted for all the top five major vendors, forcing some of them, such as Nokia, to rein in costs and slash thousands of jobs," he adds.

"However, one bright spot was found among the smart-phone specialists," Mawston notes. "Apple, for

### Handset shipments & market share (top five).

Shipments (millions)	Q1/08	2008	Q1/09
Nokia	115.5	468.4	93.2
Samsung	46.3	196.6	45.8
LG Electronics	24.4	100.8	22.6
Motorola	27.4	100.1	14.7
Sony Ericsson	22.3	96.6	14.5
Others	46.5	214.8	53.7
Total	282.4	1177.3	244.5
Market share (%)	Q1/08	2008	Q1/09
Nokia	40.9%	39.8%	38.1%
Samsung	16.4%	16.7%	18.7%
LG Electronics	8.6%	8.6%	9.2%
Motorola	9.7%	8.5%	6.0%
Sony Ericsson	7.9%	8.2%	5.9%
Others	16.5%	18.2%	22.0%
<b>Growth year-on-year</b>	<b>14.3%</b>	<b>4.9%</b>	<b>-13.4%</b>

example, more than doubled its volumes year-over-year due to healthy demand for its wildly popular 3G iPhone."

Other findings of the report for Q1/2009 include:

123% from 1.7 million units a year ago). This exceeded those of one of its main touchscreen rivals, the Nokia 5800, which recorded slightly lower volumes of 2.6 million units.

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● Samsung was again the top performer among the big five vendors, as its shipments fell only 1% and its market share hit a record 19%. Its success has been driven by an attractive portfolio of handsets for the high-growth touchscreen and QWERTY messaging markets; ● Apple shipped a better-than-expected 3.8 million iPhones (up a healthy

## Handset sales decline of 8% in 2009 to level out in 2010: Asia-Pacific stabilization to lag North America and Europe

Despite forecasts that 2009 will be a bad year for cellular handset sales worldwide, ABI Research's current forecasts for 2010 are cautiously optimistic, i.e. that shipment numbers will stabilize and maintain an essentially flat growth rate rather than falling further, according to the market research firms newly updated report 'Mobile Device Market Share Analysis and Forecasts'.

ABI estimates that handset shipments will fall by at least 8% in 2009. "Flat growth in 2010 is the best the market will deliver," believes practice director Kevin Burden. "We will see neither significant growth nor decline in shipments, and that would actually be a good outcome: the beginning of

the upswing back to a more stable growth pattern."

Even if global shipment numbers hold steady at essentially 2009 levels, there will be regional variations, e.g. the Middle East and Africa will fare comparatively better, but volumes there are quite low.

The Asia-Pacific region will suffer most in 2009, mainly due to its huge volume of shipments — roughly triple the next largest region. Also, stabilization — if it comes — will arrive there a little

**Many handset vendors are replacing component inventories after reducing them to very low levels in recent months**

later than in North America and Europe, resulting in a 2010 forecast that still shows a minimal decline in shipments, while other regions may enjoy a minimal positive growth.

"There are telltale signs that at least some parts of the handset ecosystem may be starting to steady," Burden says. "Many handset vendors are replacing component inventories after reducing them to very low levels in recent months to keep from overextending as the market dropped," he adds. "This doesn't necessarily mean the whole market is doing better, but it is good news at least for the component suppliers, some of which were really suffering."

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# RFMD's fab utilization rebounds after 'inflection point' in demand

For its fiscal fourth-quarter 2009 (to 28 March), RF Micro Devices Inc of Greensboro, NC, USA had revenue of \$172.3m, split 75:25 between its Cellular Products Group (CPG) and Multi-Market Products Group (MPG). Revenue is down 14.7% on \$202m last quarter and 21.9% on \$220.6m a year ago. Nevertheless, 3G-related revenue still grew sequentially, to about 50% of CPG sales.

On a non-GAAP basis, gross margin has fallen from 30.6% a year ago and 22.6% last quarter to just 19.8%, due mainly to unusually low factory utilization of about 25%. Net loss almost doubled from \$12.9m last quarter to \$25.4m, compared to a net profit of \$2.2m a year ago.

"The RFMD team executed extremely well on a number of important company goals," says president & CEO Bob Bruggeworth. "We lowered our requirements for future capital expenditures significantly [to \$4m in fiscal Q4/2009, and \$10–20m for fiscal 2010 — less than a quarter of 2008's \$81m]," he says. "RFMD continued to structure manufacturing costs and operating expenses in a manner that we believe will allow us to achieve our target operating model at reduced revenue levels while still investing in our growth," adds chief financial officer Dean Priddy.

RFMD has cut non-GAAP operating expenses by 31% year-on-year to \$55.5m, and is making progress towards its expense model of 25% of sales. In the past four quarters, RFMD has reduced annualized manufacturing costs and operating expenses by more than \$130m.

Consequently, after \$45.7m last quarter, cash flow from operations was \$29.4m. Over the past three quarters, RFMD has generated over \$85m in free cash flow and reduced net debt by \$125m. During the quarter, cash and short-term investments rose by \$28.3m to \$266.5m.

Regarding cost cutting, in fiscal Q4 RFMD idled its 4" GaAs fab (transitioning production to more efficient 6" fabs) and reduced costs at its 6" fab in Newton Aycliffe, UK. It is also consolidating test & assembly in Shanghai into its Beijing facility by the December quarter. In addition, RFMD has completed qualification of its more cost-efficient die-shrink technology and has been ramping up the first products to use it.

Implementation is now being accelerated across the firm's product portfolio: 35% of revenue is expected to come from reduced-die-size technology in the next 2–4 quarters.

RFMD is also launching products for new markets and refreshing products in existing markets. In the March quarter, CPG launched 14 new products (and plans a record number in fiscal 2010). As well as securing major GSM/GPRS design wins at top-five handset OEMs and leading platform providers, CPG continued to diversify its 3G customer base with multiple multimode design wins. The group also grew its smart-phone customer base as well as its content opportunity across cellular front ends, switches and low-noise amplifiers.

Based on existing design activity, CPG expects near-term market share gains in China, Korea and Taiwan. Also, MPG launched 24 RF components and 59 derivative products (and expects to launch more than 100 new products in fiscal 2010). In particular, the group received its first order to supply highly integrated multi-chip modules into new multi-standard wireless base-stations (which can support 2G, 3G, 4G/LTE and WiMAX air interface standards). MPG also formed its GaN Foundry Services business unit, and expects

increased GaN-based revenue from CATV line amplifiers as well as defense and commercial power applications in fiscal 2010. The group also saw robust design activity across a broad range of markets, including automatic meter reading (AMR), electronic toll collection (ETC), and 3G cellular infrastructure (led by China). "We have increased our share at key accounts while expanding our exposure to large growth markets," says Bruggeworth.

Regarding current trends, Bruggeworth says that the environment began strengthening in mid to late February as excess channel inventories were reduced and customers began to better understand actual levels of real normalized demand. "We saw an inflection point midway through the March quarter in terms of demand at the component level," adds CPG president Steven Creviston. For the June quarter, RFMD is booked for sequential growth (in both CPG and MPG), and expects revenue to outpace the growth rate of its main end-markets.

Due to the improved demand, RFMD has aggressively increased utilization rates in its 6" fabs (to closer to 65–70%, approaching historical levels). By idling its 4" fab, it has reduced its total GaAs capacity by 10% while cutting manufacturing overhead by a much higher percentage. Coupled with the proliferation of new product cycles and a richer mix of inherently higher-margin MPG revenue, gross margin should reach the mid-30s in fiscal 2010. RFMD doesn't rule out reaching its goal of 40% in the next 4–6 quarters.

More immediately, for the June quarter, with CapEx of less than \$5m, RFMD expects roughly break-even operating profitability on a non-GAAP basis. For fiscal 2010, the firm continues to expect \$80–\$120m in free cash flow.

www.rfmd.com

**We saw an inflection point midway through the March quarter**

## RFMD expands integrated configurable component range to cellular repeater and WLAN markets

RF Micro Devices Inc of Greensboro, NC, USA has extended its portfolio of integrated configurable components to include products for the cellular repeater and wireless local-area network (WLAN) markets.

The new RF2057 RF synthesizer with integrated mixers and the RF2059 RF transverter join the RF2051, RF2052 and RF2053, which were introduced in April 2008 and have been adopted in markets as diverse as cellular, defense and broadband cable systems.

By integrating multiple common RF functions into highly integrated, size-reduced packages, the flexibility of the integrated configurable components enables the development of radio systems that operate over a wide dynamic range and across a broad range of frequencies and channel bandwidths, the firm says.

"The unique system partitioning and functional integration of RFMD's integrated configurable components help radio designers shrink circuit board area, reduce risk, simplify implementation and shorten product development time, thereby lowering the cost of implementation," claims Alastair Upton, general manager of RFMD's Broadband Products business unit.

The RF2057 RF synthesizer provides designers of cellular repeaters (which are used to extend network range and provide coverage in 'dead' spots) with an improved level of integration within the performance parameters required to meet the W-CDMA/PCS specifications for pico and mini repeaters.

The RF2057 includes all functions required for frequency downconversion and upconversion, a fractional-N phase locked loop (PLL) synthesizer capable of tuning accuracy of about 1Hz, a wideband monolithic voltage controlled oscillator (VCO) with a tuning range of

1900-2400MHz, local oscillator (LO) drivers, and two double-balanced wideband mixers with a minimum IIP3 of +18dBm.

By integrating the interface between the VCOs and mixers, the RF2057 can deliver highly reliable operation at published specifications, reducing design time and risk in radio implementation. Also, by combining the PLL, VCO, LO path and mixers into a single 5mm x 5mm package, it delivers a size-reduced solution for low- to mid-power cellular repeaters (providing greater flexibility in implementation).

The RF2059 RF transverter provides WLAN system designers with a size-reduced and simplified solution for converting RF signals between the 2.4GHz and 900MHz ISM bands. The transverter is placed between the WLAN chipset and the RF front end, and all functionality necessary for frequency conversion is integrated on-chip.

The RF2059 contains a PLL synthesizer, a VCO capable of meeting WLAN linearity and accuracy requirements, and two double-balanced mixers for receive and transmit paths. By integrating the synthesizer, VCOs and mixers on-chip, combined with the buffer circuits usually required to implement the functions discretely, the RF2059 delivers circuit board space savings and simplicity of implementation compared to typical discrete implementations, RFMD claims, with negligible signal degradation (typically less than 0.8% RMS). The transverter is programmed and controlled through a simple three-wire interface and is housed in a compact 5mm x 5mm package. It can also be used in certain cellular repeater systems.

The RF2057 and RF2059 are priced at \$5.60 in quantities of 1000.

[www.rfmd.com/RF205x](http://www.rfmd.com/RF205x)

### IN BRIEF

## RFMD to supply multi-chip modules for multi-standard wireless base-stations

RF Micro Devices has received its first order to supply highly integrated RVA2007L multi-chip modules (MCMs) into new multi-standard wireless base-stations. The order, received from a leading supplier of wireless base-stations, is RFMD's first ever for MCMs for the wireless infrastructure market.

The RVA2007L is a voltage variable attenuator (VVA) housed in a highly integrated 7mm x 7mm laminate package. It contains an analog attenuator and several die, including the GaAs pHEMT SXE-1089Z and InGaP HBT SPA-1426Z, both of which are high-performance amplifiers originally introduced for the infrastructure market by Sirenza Microdevices Inc of Broomfield, CO, USA (acquired by RFMD in November 2007). The new order illustrates synergies achieved between RFMD's module design and manufacturing and Sirenza's high-performance RF design capabilities, the firm says.

The RVA2007L is the first in a family of products designed for multi-standard wireless base-stations, which can support 2G, 3G, 4G and WiMAX air interface standards. RFMD is scheduled to launch additional MCMs to support various air interface standards and frequencies, each in the same package and pin-out configuration.

RFMD's Wireless Products business unit is part of the firm's Multi-Market Products Group (MPG), which is extending its addressable markets through new product offerings while leveraging the scale advantages, technologies and systems-level knowledge of RFMD's Cellular Product Group (CPG).

# TriQuint sees demand return as handset inventory burns off

For first-quarter 2009, RF product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported revenue up 7% from \$111.1m a year ago to \$118.9m.

Growth was led by handsets being up 24% (up \$25m in 2.5/3G, offset by a \$10m drop in 2G revenue) and defense & aerospace being up 23% (driven by radar, R&D and satellite revenue, and insulated from any economic drag). Reduced demand from wireless LAN, standard handsets, cable and optical products was offset by market strength in smart-phones (driven by TriQuint's highly integrated module products for 3G handsets), the acquisition of WJ Communications in Q2/2008, and positive momentum in major military programs.

More recently, due to the "challenging economic environment of inventory correction" and reduced short-term demand due to the economic weakness, Q1/2009 revenue is down 20% on the last quarter's seasonally strong \$149m (although the decline is at the low end of the forecast 19–26%).

In particular, handset revenue fell a seasonally typical 14% on the last quarter. Defense & aerospace revenue fell 16% (although this was due mainly to a customer program timing that pulled some planned Q1 revenue into Q4/2008). Networks revenue was down 29% (although base-station revenue grew as China's investment in 3G infrastructure offset reduced GSM and CDMA infrastructure spending in other regions).

Of total revenue, 58% was for handsets (up from 54% last quarter), 28% for networks (down from 33%) and 14% for defense & aerospace (up slightly from 13%).

"The global economic downturn prompted lower inventory at our

customers and very low factory utilization in Q1 [35% in the Hillsboro fab, down from 45% in Q4/2008 and 83% in Q3]," says president & CEO Ralph Quinsey. Due to the lower factory utilization and the revenue mix shifting from networks to handsets, gross margin fell from 30.2% last quarter to just 19.6% (offset slightly by the 2G to 3G shift).

On a non-GAAP basis (excluding stock-based compensation charges, impairment charges, and charges associated with the WJ acquisition), operating expenses were cut by 6% (\$2.5m) from last quarter to \$37.3m. This was driven by short-term cost-control measures that included mandatory time off for most staff, no bonus or profit-share payments, and restrictions on hiring, travel and other discretionary expenses.

Compared to a profit of \$6.8m last quarter and \$6.9m a year ago, non-GAAP net loss was \$11m (at the favorable end of expectations). Despite this, cash flow from operations was \$7.1m. After capital spending of \$12.2m, cash, cash equivalents and long-term investments fell only slightly during the quarter (by \$2.9m to \$99m).

"While first quarter sales and factory utilization were low, excess inventory both in the channel and at TriQuint was largely burned off," Quinsey says. "We are now seeing signs of inventory normalization in some of our markets," he adds. In particular, for handsets, this led to what TriQuint calls an inflection point of increasing demand late in the quarter. "This should translate into stronger demand in the coming months," Quinsey says. "The handset inventory adjustment is largely behind us," he reckons.

**The handset inventory adjustment is largely behind us**

"The networks market is reacting more slowly to the down cycle than handsets and will be slower to normalize," Quinsey continues. WLAN channel inventory will remain high well through Q2, suppressing revenue until shipments resume in Q3.

TriQuint says that reduced visibility and greater-than-normal volatility in demand has caused it to be more cautious in translating order backlog into expected revenue. Nevertheless, for Q2/2009, the firm says that it is fully booked to the mid-point of its revenue guidance of \$140–150m (up 18–26% on Q1). Fab utilization should rebound to 50–60% and non-GAAP gross margin to 30–35%, driving a return to profitability.

In particular, TriQuint expects strong handset revenue growth, driven by new products, inventory restocking and the popularity of SmartPhones. Handset mix continues to shift from 2G to 3G (and hence more GaAs content), driving improved margin.

In addition, non-handset revenue is expected to grow modestly, with strength in defense & aerospace and recovery in some other markets (after seeing pull-in activity since early this quarter). In particular, in networking, TriQuint is shipping initial production volumes for the first design win of its TriPower base-station technology (which boosts power efficiency, requiring less energy for power and cooling). In the defense & aerospace market, after generating \$40m of revenue over the last 10 years supporting 180 aircraft in the F-22 program, TriQuint is moving into early-stage production for the F-35 Joint Strike Fighter (involving 3000 aircraft spread over 30 years). Although content per aircraft is lower, the forecasted revenue per year is much higher than for the F22, the firm says.

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

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# Anadigics' revenue falls by a third, driven by WLAN and cable shortfall

For first-quarter 2009, GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported revenue of \$30.5m (down 33% on \$45.2m last quarter and 59% on \$74.4m a year ago). However, this is \$1m above the guidance of a 35% sequential drop, due to stronger revenue from the firm's wireless 3G product line. Customers representing more than 10% of revenue included Korean handset maker LG Electronics and Blackberry maker Research In Motion.

"Our results reflect typical wireless seasonality and the effects of the economic downturn on our cable and WiFi customers," says president & CEO Mario Rivas.

Wireless revenue was \$21.4m, down a less-than-expected 13.9% from last quarter's \$24.8m (considering seasonal trends). However, broadband revenue of \$9.1m was down 55% from \$20.3m, due to lower revenues from wireless local-area networks (WLAN) and cable (reflecting the economy-driven softness experienced by customers).

In particular, WLAN revenue was just \$1m, reflecting ongoing high inventory levels at customers. Cable revenue fell to \$8.1m (although Anadigics maintains a dominant market share with each of its cable customers, claims chief financial officer Tom Shields).

On a non-GAAP basis (excluding charges of \$9.2m), net loss was \$12.8m, up from \$4.9m last quarter. However, this was better than guidance, due partly to slightly better-than-expected gross margin of 11.1% (after a moderate increase in fab utilization) and partly to cost-reduction initiatives driving lower-than-expected operating expenses of \$16.2m.

During the quarter, Anadigics reduced its workforce by 110. Headcount is currently about 550.

Over the past few quarters, the firm has also reduced variable compensation benefits substantially.

Cash, cash equivalents and short- and long-term marketable securities still fell, from \$145.7m to \$132.5m (after capital expenditure of \$3.1m and depreciation expense of \$4.6m). However, the expense controls should allow Anadigics to reduce its quarterly burn rate. "We continue to evaluate our cost structure relative to demand in order to preserve cash," says Rivas.

For second-quarter 2009, despite operating expenses falling another 4.5% (to \$15.5m), Anadigics expects gross margin to fall again, due to a further 8-10% drop in revenue.

Both broadband and wireless revenues are expected to fall equally. However, the main reason for the decline in wireless stems from one customer needing to work down high inventory levels. Anadigics believes there is greater opportunity for an increase in business from other wireless customers, given their short lead times, which have not been forecasted due to continued market uncertainty. This could have a positive impact on revenue guidance. Even so, Anadigics does not expect growth in revenue until Q3/2009.

"While I am not satisfied with our financial guidance for the second quarter, which continues to reflect the impact of the economic downturn on our customers, we are confident that we have the leading technologies to service our end markets and are focused on execution, both strategically and operationally," says Rivas.

"Our differentiated products are a key factor in driving a higher level of engagement in design activity,"

he adds. In Q1/2009, Anadigics secured more than 50 wireless design wins that could enter production in second-half 2009. In particular, its power amplifiers are being designed into 3G smart phones by not only top-tier customers LG, Samsung and Research In Motion but also Palm. After Anadigics' production problems in mid-2008 led to market-share losses with the likes of Korean handset maker Samsung (which had been a 10% customer), if all the design wins turn into sales, then revenue from Samsung should be between one-third and one-half of the prior peak. "We continue to win back business at Samsung, and have further expanded our opportunities in the area of CDMA, EVDO and 3G with LG as well," says Rivas.

Anadigics is also actively engaged with Huawei regarding handsets, plug-in cards and USB dongles. In addition, several Anadigics products are now being specified by 3G chipset reference designs firms and equipment makers for data-cards, USB modems and embedded modules in PCs and netbooks, including products from Qualcomm, Ericsson, Samsung, Huawei, Sierra Wireless, ZTE and Novatel. Anadigics hence reckons it should see a return to revenue growth in second-half 2009.

Regarding its move towards a hybrid manufacturing model, Anadigics has got the first parts back from its new foundry partners and is pleased with the results, says Rivas. He cautions that it takes several months to qualify parts and then to get customers to qualify them. Nevertheless, revenue from foundry-manufactured products is possible in second-half 2009. However, it will be 2010 before the mix between in-house/foundry manufacturing becomes apparent (the targeted long-term split is 80:20).

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

**Anadigics expects gross margin to fall again, due to a further 8-10% drop in revenue**

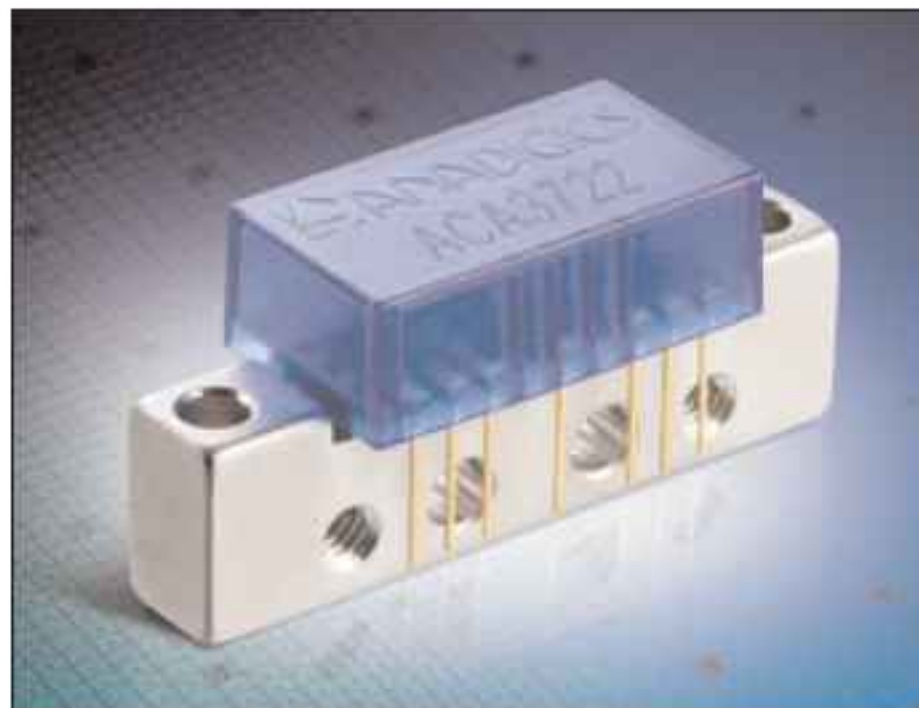
## Anadigics launches 870MHz hybrid line amplifiers for CATV

Anadigics has launched a family of 24V 870MHz hybrid line amplifiers, designed mainly for use in CATV distribution systems.

"Anadigics introduced the first commercially available integrated circuit cable TV line amplifiers," says Ray Aubert, senior product marketing manager. Anadigics has shipped more than 20 million CATV line amplifiers in individual surface-mount packages in the last 15 years.

The new products mark the first time that Anadigics has made its CATV line amplifier technology available in the industry-standard SOT115J hybrid package.

The new hybrid-packaged devices, which deliver high gain, low noise, and superior distortion performance it is claimed, should enable manufacturers to rapidly assimilate Anadigics' solutions into existing CATV distribution nodes and line extenders. "These new hybrid products enable us to address growing markets in Asia and eastern Europe, by harnessing Anadigics' RF technology and design capability to provide customers with a competitively priced, drop-in replacement that outperforms other hybrid line amps," Aubert claims.



**Anadigics' ACA3722 hybrid line amplifier.**

"Extra testing and special circuitry has been added to maximize the ESD performance," says Doug Johnson, VP of CATV Amplifier Products. "This is required to achieve the ruggedness needed for the CATV infrastructure applications."

The new product family includes three power-doubler hybrid line amplifiers (the ACA3742, ACA 3747 and ACA 3753, with 21.5dB, 25dB and 28dB of gain, respectively) and two push-pull hybrid line amplifiers (ACA3722 and ACA3733, with gain of 21.5dB and 34dB, respectively).

The ACA3722 and ACA3742 are sampling in Q2/2009 (followed shortly by the ACA3753) and the ACA3733 and ACA3747 in Q3/2009.

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

## Inducement grant declared for new president & CEO Rivas

Anadigics has announced the granting to president & CEO Mario A. Rivas on 1 February (on replacing interim CEO Delfassy) of options, expiring on 1 February 2019, to purchase 700,000 shares of the firm's common stock at an exercise price of \$2.03 per share (the closing price on 30 January). Of this, options to purchase 250,000 shares vest on 1 February 2011 and options to purchase 450,000 shares vest on 1 February 2012.

If the firm terminates Rivas's employment without cause or if Rivas terminates his employment for good reason, then he is entitled to receive immediate vesting of all such stock options.

The grant, considered an inducement award — as defined by NASDAQ Marketplace Rule 4350(i)(1)(A)(iv) — was granted outside the terms of the firm's existing equity incentive plans and was approved by its compensation committee and board of directors.

### IN BRIEF

#### PAs shipped for global broadband embedded device

Anadigics is shipping production volumes of three of its high-efficiency 3G power amplifiers (PAs) for use in what it calls an "industry leading multi-mode embedded 3G wireless modem", which enables mobile broadband connectivity for notebook users on cellular networks worldwide.

With shipments already reaching 20 million units in 2008, a recent study from market research firm In-Stat predicted strong growth in 3G data services and cellular modem deployments. Two big trends are the move in form factor to USB modems and the growing emphasis on embedded modems, led by Ericsson and Qualcomm. Embedded shipments are expected to overtake external modem shipments by the end of 2011.

"Lack of global connectivity and multi-operator compatibility has been a major barrier to widespread adoption of embedded 3G modules in notebook computers," says Dr Ali Khatibzadeh, senior VP & general manager of RF Products. "The new generation of embedded modules offer a breakthrough solution for global 3G broadband connectivity beyond WiFi for notebook and netbook computers," he adds. "Adoption of the new HELP3 WCDMA/HSPA power amplifiers for these modules expands Anadigics' 3G market share into notebook and net-book computers."

The three WCDMA/HSPA power amplifiers being shipped enable operation in the IMT, PCS, and cellular bands for the embedded module. Each PA incorporates Anadigics' proprietary third-generation high-efficiency-at-low-power (HELP3) technology, which reduces average current consumption by as much as 75% compared to a conventional PA device, it is claimed.

# Skyworks' sales shrink by 18%, but rebound to yield June-quarter profit

For its fiscal second-quarter 2009, Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has reported revenue of \$173m. This is down 14% on \$201.7m a year ago and 18% on \$210.2m last quarter, but up on forecasts of \$168m. Samsung, Sony Ericsson and Motorola were all 10% customers, closely followed by LG and Nokia.

To cut operating expenses by more than \$25m on an annualized basis, on 22 January Skyworks implemented a restructuring plan that reduced headcount by 4% (about 150 jobs, mainly in the transceiver development group). This leaves about 3150 staff overall (including 1600 in assembly & test in Mexico). In particular, Skyworks reckons that its fab-lite hybrid manufacturing model (mixing in-house capacity with using foundry suppliers) is beginning to exhibit meaningful financial results, maintaining internal utilization and hence non-GAAP gross margin (level with last quarter's 40%) on a much broader range of revenues, despite the economic downturn.

Net loss was \$4.6m, compared with net income of \$22m last quarter and \$16.7m a year ago. However, excluding one-time charges (e.g. \$19.4m for the restructuring), non-GAAP net income was \$20m, down from \$27.6m last quarter and \$25.3m a year ago. During the quarter, Skyworks generated \$22m in positive operating cash flow. Cash balance rose from \$250m to \$268m.

Despite the challenging economic backdrop, Skyworks delivered solid financial results, driven by diversification, scale advantages, a fab-lite strategy and an improved cost structure, says president & CEO David J. Aldrich. "Offsetting general market weakness, our performance

was highlighted by strength in energy management and smart grid technologies [e.g. smart meters], China 3G base stations, smart phones and push-to-talk applications."

Skyworks captured energy management design wins in support of Itron, Sensus, and Landis and Gear. With utilities, businesses and consumers all demanding enhanced billing efficiency, usage monitoring, and power control to prevent costly burnouts and potentially catastrophic blackouts, market research firm Gartner expects more than 150 million smart meter readers to be installed worldwide in the next five years, creating an incremental semiconductor opportunity of about \$2bn by 2012. The recent American Recovery and Reinvestment Act has allocated \$4bn for advanced metering projects, adds Skyworks.

Skyworks is also continuing to broaden its analog product catalog business, supporting a wider range of markets including medical, avionics, automotive, broadband, and industrial applications. "We believe our results demonstrate that Skyworks is gaining share in the broader analog semiconductor market and is creating a highly differentiated business model," says Aldrich.

Also during the quarter, Skyworks ramped its suite of infrastructure solutions at telecom network provider Huawei and secured design wins with ZTE, both in support of China's 3G rollout of 3G technologies as well as 4G

base-station solutions. Specifically, Skyworks is delivering mixers, amplifiers and receivers, and is moving from \$3 of addressable content per local-area network (LAN) card to more than \$20 with some of its more highly integrated solutions.

Skyworks says that it is also gaining momentum across several key smart-phone OEMs, particularly as they seek to integrate more bands and modes, as well as WiFi functionality.

In addition, number-one handset supplier Nokia has recently diversified its supply base to base-band chipset makers with which Skyworks is qualified. These include Qualcomm and Broadcom as well as Infineon Technologies (adopted by Nokia for its EDGE platform, which is currently ramping up). Skyworks' components are probably in less than 10% of Nokia's phones currently, but this will grow to at least a third in the next couple of years, reckons Aldrich.

"Although we remain cautious on the macro-economy, Skyworks intends to resume top- and bottom-line growth in the current quarter [fiscal third-quarter 2009] through share gains and participation in new markets," says Donald W. Palette, VP & chief financial officer. The firm expects June-quarter revenue to be up 5% sequentially (to \$182m) and gross margins to be 40-40.5%, driving a return to profitability.

Longer term, while Skyworks currently uses 4-inch GaAs wafers in-house and outsources 6-inch epiwafer processing to the foundries Kopin in Taunton, MA, USA and AWSC in Taiwan (10-15% of wafers), the firm's in-house 6-inch manufacturing line should come on-stream in early 2010, driving further margin improvement, says Aldrich.

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

**Results demonstrate that Skyworks is gaining share in the broader analog semiconductor market and is creating a highly differentiated business model**



## Kopin's III-V sales fall 37% due to wireless handset slump

For first-quarter 2009, Kopin Corp of Taunton, MA, USA, which makes III-V heterojunction bipolar transistor (HBT) epiwafers and CyberDisplay LCDs, has reported revenues of \$21.5m, down 26% on \$29.1m last quarter and \$29.2m a year ago.

III-V product revenues were \$6.9m, down 37% on \$10.9m last quarter and 43% on \$12.1m a year ago. This is attributed to the drop in wireless handset sales and limited sales visibility, which prompted aggressive inventory reduction by customers.

CyberDisplay revenues were \$14.6m, down 20% on \$18.2m last quarter and 14% on \$17.1m a year ago. Military display revenues rose by \$4m year-on-year. However, revenues from video eyewear displays and consumer electronics fell by, respectively, \$1.3m (due to the impact of the economic recession) and \$3.9m (due to Kopin's strategy to transition from lower-margin camcorder and digital camera viewfinders toward military and

industrial applications and higher-margin consumer electronics).

"We have successfully navigated what we anticipate will be the most challenging quarter of 2009," says president & CEO Dr John C.C. Fan. "While the macroeconomic environment contributed to lower overall top-line results in the first quarter, revenue from military display products continued to climb," he adds. "CyberDisplay revenues from military applications, which grew approximately 57% over the first quarter of 2008, were driven primarily by our participation in the US Army's Thermal Weapon Sight programs. We expect these programs to continue to ramp production in 2009."

Reflecting the increased sales of displays for military applications, gross margin rose from 25% a year ago and 27.8% last quarter to 29%.

Including a \$2.6m gain from the sale of patents that are no longer used, net income was \$1.9m, up from \$1.8m last quarter and \$1m a

year ago. During the quarter, cash and marketable securities rose by \$4m to \$104.1m. With no long-term debt, the firm repurchased 481,824 shares for about \$887,000 (as part of its plan — announced in December — to repurchase up to \$15m of common stock).

For full-year 2009, Kopin expects revenue of \$90–110m (down on 2008's \$114.8m, though on a par with 2007's \$98.1m). Although the economic slowdown is expected to result in lower revenues from commercial and industrial products, the firm expects its military display revenues to grow in 2009.

"While this deep economic recession presents unique challenges, we believe that our unyielding commitment to technology innovation and new product development, coupled with our strong financial position, will enable us to extend our leadership in core markets and broaden our reach into new applications," says Fan.

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

## Skyworks wins LG best supplier award for second year

For the second consecutive year, Skyworks Solutions has received LG Electronics' 2008 Best Supplier Award, which is based on technology, quality, product reliability and on-time delivery.

LG (a Skyworks customer since 1995) incorporates the firm's front-end solutions into mobile handsets sold worldwide spanning all key air interfaces, including CDMA, GSM, EDGE and WCDMA for 3G multi-mode applications.

"Skyworks has been an exceedingly valuable business partner and very instrumental in helping us expand our global mobile communications presence," says Gi-seob Shin, executive VP for LG's procurement division.

"This prestigious award underscores our full commitment to LG," says Liam K. Griffin, Skyworks' senior VP of sales & marketing. "We

look forward to strengthening our partnership in support of 3G and 4G wireless technologies as well as

LG's leading consumer products and home networking segments."

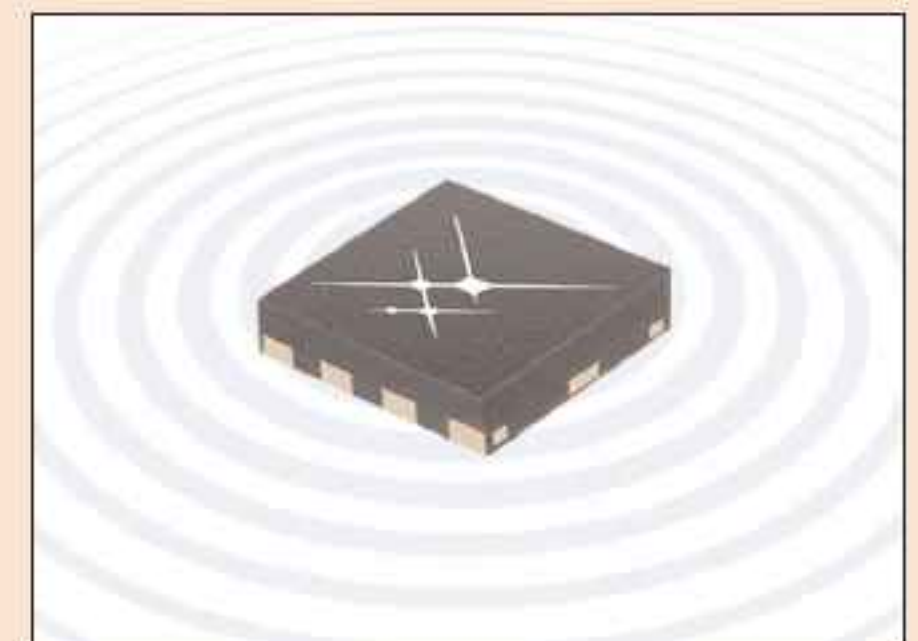
[www.skyworksinc.com](http://www.skyworksinc.com)

### SP3T switch launched for 0.1–6GHz

Skyworks Solutions has made available samples of a pHEMT GaAs IC SP3T switch for frequencies of 0.1–6.0GHz.

The SKY13317-373LF symmetric switch offers low insertion loss and high isolation with a 44% reduction in size compared to the SKY13309-370LF. Featuring higher overall transmit efficiency and linearity, less board space is used with greater design/layout flexibility, equating to a small and thin end-product.

Appropriate for high-volume, consumer products, end-users will also find better linearity and



**Skyworks' SKY13317-373LF.**

a clearer signal. The SKY13317-373LF is currently being used with wireless local-area network (WLAN) and Bluetooth combo chipsets.

## IN BRIEF

## Hittite's revenues fall 18%, but Q2 to show slight rebound

For first-quarter 2009, Hittite Microwave Corp of Chelmsford, MA, USA, which designs and supplies analog and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems, has reported revenue of \$38.2m. This is down 11.8% on \$43.3m a year ago and 17.7% on \$46.4m last quarter but slightly above the forecast \$36–38m.

"Six of our eight markets experienced sequential declines in demand [due to the weak global economic environment], offset by two markets with growth [automotive and space]," says chairman & CEO Stephen Daly. Three (cellular infrastructure, microwave & millimeter-wave communications, and military) accounted for 79% of revenue, although microwave & millimeter-wave communications and military declined the most. The remaining target markets are automotive, broadband, fiber-optic, space, and test & measurement.

Gross margin was 71.5%, down from 72% last quarter. Net income was \$10.2m, down from \$13.6m but at the top end of the forecast range of \$8.3–10.2m.

During the quarter, cash and cash equivalents rose by \$3.7m to \$184.6m, and the firm repurchased about 392,000 shares of its stock for \$10.8m.

For Q2/2009, Hittite expects revenue to rebound slightly to \$38.5–39.5m and net income to be steady at \$9.5–10.5m.

"We maintain a long-term perspective on our business and we are confident our investments in new products and technologies are the foundation for future growth," says Daly. "In 2009 we will focus on expanding sales beyond our current 3000 customers," he adds.

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

## Cobham divests M/A-COM Technology Solutions to Ocampo

UK-based aerospace technology developer Cobham plc has completed its planned divestment of M/A-COM's commercial division, now named M/A-COM Technology Solutions Inc (MTS), for up to \$90m. The transaction excludes cash and the freehold of the Walker Building in Lowell, MA, USA (valued at \$10m).

This follows last May's \$425m agreement for Cobham to acquire both the defense & aerospace and commercial segments of M/A-COM Inc from Bermuda-based Tyco Electronics Ltd. The transaction was completed on 26 September. However, the commercial segment — which provides microwave and RF design solutions and products (silicon, SiGe, GaAs, AlGaAs, InGaAs and InP devices) from facilities in Lowell, MA and Torrance, CA — was deemed non-core to Cobham's aerospace-focused strategy.

RF and semiconductor technology maker M/A-COM was founded in the 1960s, but has not been an independent entity since 1995, when it was acquired by Pennsylvania-based AMP Inc for \$277m, before becoming Tyco Electronics' Wireless Systems Segment after Tyco International Inc acquired AMP in 1999.

Now, through an auction process, Cobham has sold MTS to John Ocampo, co-founder, owner and president of Silicon Valley-based private equity fund GaAs Labs LLC (and co-founder of Sirenza Microdevices Inc). The transaction involves \$30m in cash, \$30m in senior loan notes secured on MTS assets, and \$30m dependent on future revenue in 2010–2012. The loan notes carry a rate of interest of 7.5%, which increases over time, and they are repayable in two equal tranches in December 2011 and 2012.

M/A-COM has over 20 years experience of manufacturing GaAs monolithic microwave integrated circuits (MMICs), including acquiring GaAs MMIC maker ITT GaAsTEK of Roanoke, VA in 2000, where

8000ft<sup>2</sup> of cleanroom space adds to M/A-COM's 24,000ft<sup>2</sup> wafer fab space in Lowell for manufacturing GaAs MESFETs, pHEMTs and silicon LDMOS.

Products include ICs, power transistors and diodes for wireless communications and industrial/military and consumer applications, infrastructure/components for wireless applications such as cellular base-stations and WiMAX infrastructure using RF, microwave and semiconductor-based components, and RFID components for inventory management and asset tracking applications.

In the year to end-September 2007, MTS recorded revenue of \$275m and operating profit of less than \$10m. Given the significant reductions in end-market demand and the fact that Cobham has retained the MTS cash, the business may need work-

**We placed MTS in the hands of owners who are specialists in the industry**

ing capital and, if required, Cobham will make available a 12 month secured credit facility for up to \$12m.

"Cobham has sold MTS in the face of difficult market conditions, and this allows us to focus on our core business," says Cobham's chief financial officer Warren Tucker. "Despite the reduction in valuation multiples and credit availability, we are pleased to have achieved a sensible economic outcome and to have placed MTS in the hands of owners who are specialists in the industry," he adds.

Last July, GaAs Labs also invested \$10m in the fourth round of institutional financing of Mimix Broadband of Houston, TX, USA, which supplies GaAs semiconductors operating from DC to 50GHz for microwave and millimeter-wave applications. GaAs Labs' John Ocampo is chairman of the board of Mimix.

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



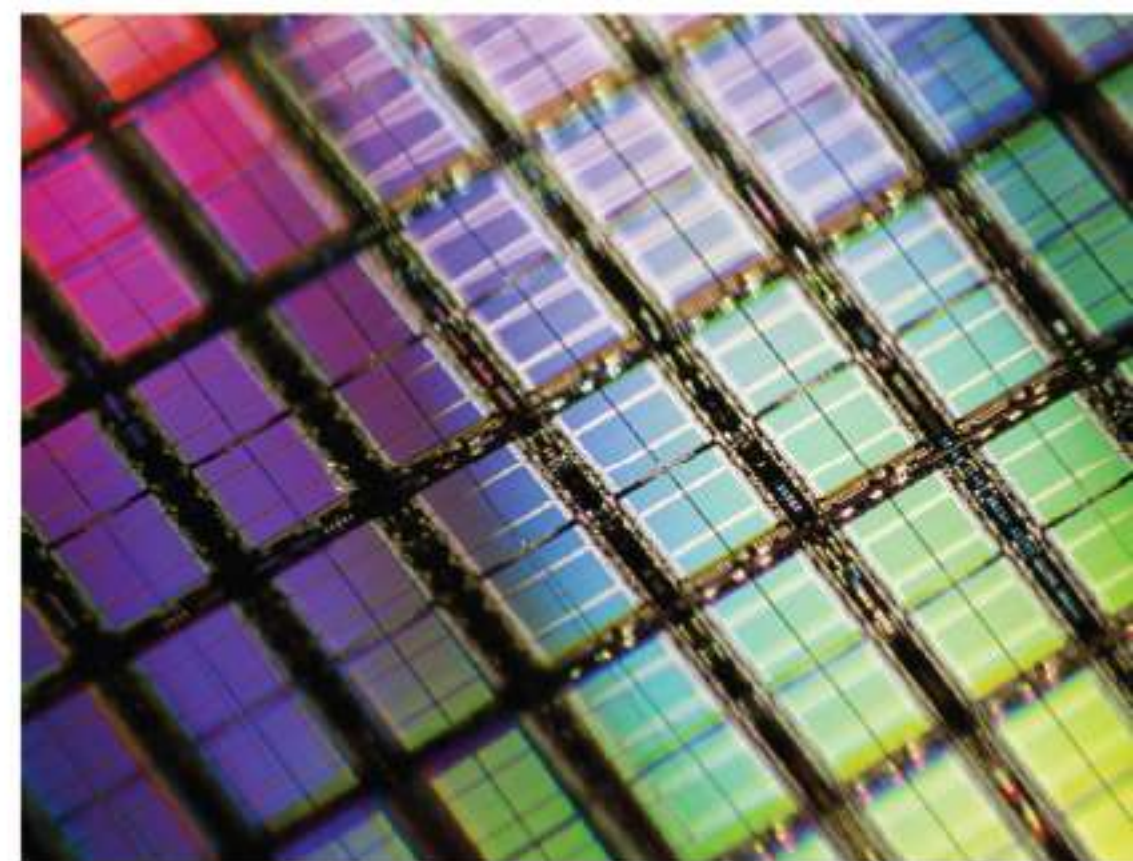
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## BMBF grants €8.1m for DECISIF strained silicon project

The German Federal Ministry of Education and Science (BMBF) has granted €8.1m for the project DECISIF (DEvice and CIRcuit performance boosted through SILicon material Fabrication), which aims to research strained silicon for the manufacturing of more powerful and lower-energy-consumption microprocessor and memory chips for portable devices such as laptops, mobile phones and MP3-players.

Total funding of €14.5m includes another €6.4m contributed by the scientific and industrial project partners GLOBALFOUNDRIES Dresden (the joint venture between microprocessor maker AMD and Advanced Technology Investment Company formed earlier this month), silicon wafer maker Siltronic AG, deposition equipment maker Aixtron AG of Aachen, Germany,

Research Center Jülich, and the Max Planck Institute of Microstructure Physics. There will also be collaboration with French partners (silicon chip maker STMicroelectronics, silicon-on-insulator substrate maker SOITEC and research center LETI) within the scope of the European Union project MEDEA. The DECISIF project is being coordinated by professor Siegfried Mantl of Research Center Jülich.

A technique patented by the Research Center Jülich will be used, amongst others, to fabricate strained silicon, whereby the crystal lattice of silicon is expanded by mechanical strain to change its electrical properties (so that the charge carriers can move much faster through the transistor, the potential switching frequency increases, and power consumption decreases).

This clears the way for more powerful and, at the same time, even smaller transistors. The project aims to combine the properties of (globally) strained silicon with new techniques (involving nano-structuring) to create locally strained silicon, enabling exceptionally high charge carrier mobility within transistors.

DECISIF is intended to build a bridge from fundamental research on strained silicon to an almost production-ready process. Combining the new strained silicon and existing silicon-on-insulator techniques aims to develop a new material generation on industry-compatible 300mm wafers, providing the basis for future device technologies and transistors with a minimum geometry of up to 22nm.

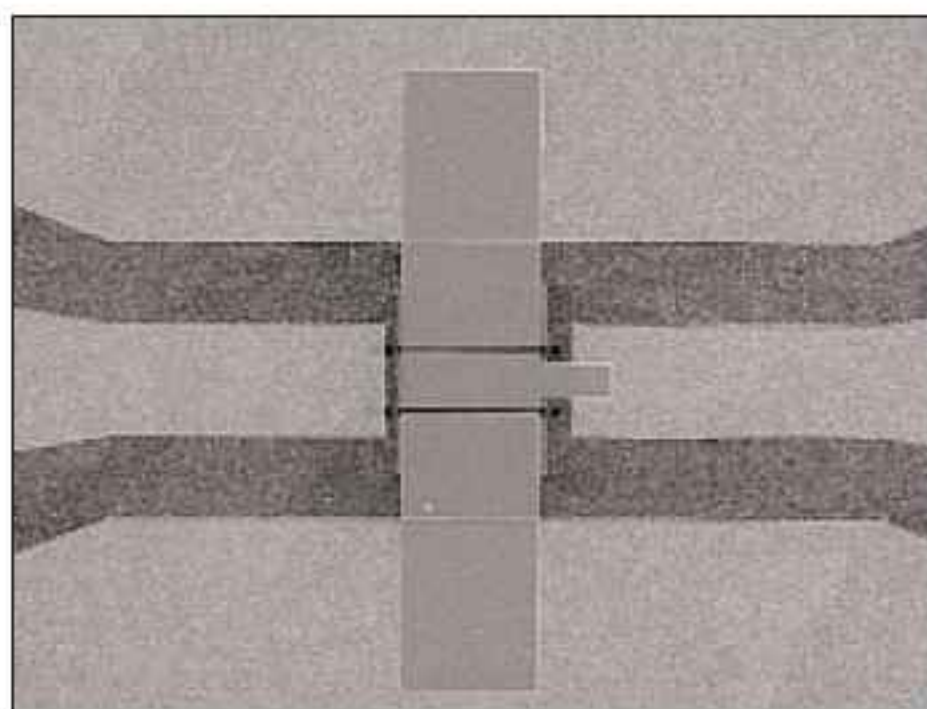
[www.mpi-halle.mpg.de](http://www.mpi-halle.mpg.de)

## Glasgow shrinks diamond transistor to 50nm

Researchers at the University of Glasgow have developed what is claimed to be the world's smallest diamond transistor. Developed by Dr David Moran of the Department of Electronics & Electrical Engineering, the transistor's gate is just 50nm long. This is half the size of the previous smallest diamond transistor, which was developed by Japanese firm NTT.

Due to its unique and highly desirable material properties (such as large bandgap, high intrinsic mobility, and very high thermal conductivity), diamond is regarded as an ideal material for next-generation nanoscale electronic devices and could help the development of nascent technologies such as terahertz imaging and automotive collision detection.

Terahertz imaging uses terahertz radiation (T-rays, with a frequency between that of microwaves and infrared), which can penetrate a range of materials (including clothes and flesh) to create an image. Because it is non-ionizing, it does



**Glasgow's 50nm-gate diamond transistor.**

not damage cells and has potential applications to security scanners (e.g. detecting concealed weapons) as well as safer medical imaging.

The car industry is developing automotive collision detection (or automotive radar) as a safety feature in which a vehicle has an effective radar zone around it that allows it to detect potential collisions (from any side) well in advance and then take avoiding action.

"These applications require a very fast and ideally high-power transistor technology that needs to be

able to operate in adverse weather/temperature conditions," says Moran. "This is where a diamond transistor technology would excel".

The diamond material that was used in the device is made synthetically, using CVD, by Element Six Ltd of Ascot, UK (via its subsidiary Diamond Microwave Devices). Fabrication of the device is part of a five-year project 'Ultra short gate length diamond FETs for high power/high frequency applications' (lasting from October 2007 to September 2012) funded with £0.5m from the UK Engineering & Physical Sciences Research Council (EPSRC). It is also the result of collaborative work between Heriot Watt University and the University of Glasgow, using the extensive fabrication and characterization facilities within the latter's James Watt Nanofabrication Centre (including an ultra-high-resolution Vistec VB6 electron-beam lithography tool).

[www.elec.gla.ac.uk/groups/nano/UFS/nedds.html](http://www.elec.gla.ac.uk/groups/nano/UFS/nedds.html)

## Northrop Grumman settles \$325m false claims lawsuit concerning defective satellite HBTs

In early April the United States Justice Department announced that Northrop Grumman Corp, its subsidiary Northrop Grumman Space and Mission Systems Corp, and its predecessor TRW Inc have agreed to settle for \$325m the False Claims Act allegations that Northrop provided and billed the National Reconnaissance Office (NRO) for defective heterojunction bipolar transistors (HBTs).

The government's investigation (which began in 2003) concluded that TRW failed to properly test and qualify HBTs that it manufactured between 1992 and 2002. As a result, defective HBTs were subsequently integrated into NRO satellite equipment. The investigation further concluded that Northrop and TRW made misrepresentations and concealed certain material facts regarding the reliability of the HBTs.

"The settlement of the HBT case demonstrates that the Department of Justice will investigate even the most complex and challenging allegations," says Michael F. Hertz, acting assistant attorney general for the Justice Department's Civil Division. "The settlement demonstrates that defense contractors will be held accountable and that the government will aggressively pursue all allegations of misconduct in the procurement process."

The settlement resolves a whistleblower lawsuit filed against Northrop in the US District Court in the Central District of California in 2002 (when Northrop Grumman acquired TRW) by Dr Robert Ferro of The Aerospace Corp. The government intervened in the lawsuit in November 2008. Under the agreement, Ferro will receive \$48.75m as his 15-25% share of the recovery in the HBT action stipulated under 'qui tam' provisions of the False Claims Act.

At the same time, the Justice Department (assisted by the Air Force General Counsel's office) also settled a Contract Disputes Act action filed by Northrop in 1996 in the US Court of Federal Claims in Washington concerning the government's decision to terminate (due to cost and schedule overruns) Northrop's contract with the Air Force to develop and produce the Tri-Service Standoff Attack Missile (TSSAM), a low-cost, low-observable, tactical cruise missile. The TSSAM action has been settled for \$325m, resolving Northrop's claims in excess \$1bn and bringing to a close the 12-year litigation. The TSSAM settlement therefore offsets the \$325m false claims settlement, so Northrop Grumman will make no net payment to the US government.

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

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## Nippon Steel starts full-scale production of 4" SiC wafers

Japan's Nippon Steel Corp says that its subsidiary Nippon Steel Materials Co Ltd has started full production and sales of single-crystal n-type silicon carbide (4H-SiC) wafers with diameters of 2" (50mm), 3" (76mm) and 4" (100mm), according to a report by Nikkei Microdevices.

Nippon Steel reckons on being the first Japanese manufacturer to commercialize 100mm SiC wafers. The firm is targeting Japanese manufacturers of SiC power semiconductor devices, initially for use in industrial machines, servers, solar batteries etc, followed by hybrid vehicles and electric cars.

For each diameter of wafer, the firm reduced the micropipe defect density (seen as one of the main causes of yield loss) to 1 per cm<sup>2</sup> or less (comparable to that of Cree's wafers, it is claimed). "To improve the crystal quality of SiC wafers, we leveraged ultra-high-temperature control techniques that have been



**Nippon Steel's 2-4 inch (50-100mm) silicon carbide wafers.**

developed through experience with our blast furnaces for iron making," says Wataru Ohashi, general manager of Nippon Steel's Advanced Technology Research Laboratories.

Until now, Nippon Steel has provided sample wafers for use in prototyping devices. Based at a plant in Yoroi, Saitama Prefecture (owned by Nippon Steel Materials' subsidiary Nippon Micrometal Corp), the firm targets initial production of 200-400 wafers per month and annual sales of several hundreds of millions of yen.

It then aims to scale up production and — driven by start up of the device market — to grow sales several-fold to ¥10bn by 2015 (a 33% share of the global SiC wafer market, which is currently dominated by Cree Inc of Durham, NC, USA). "We can definitely be the second largest manufacturer after Cree Inc," reckons Nippon Steel Materials' president Teruaki Ishiyama.

In addition, the firm says that, while Cree plans to commercialize 6" (150mm) wafers in 2009 or 2010, Nippon Steel Materials aims to ship samples of 6" wafers in 2011.

Regarding epitaxial wafers (with pre-deposited epitaxial films), Nippon Steel owns production equipment and is considering a plan to commercialize them when demand picks up, says Kohei Tatsumi, Nippon Steel Materials' director for the technology management & business development.

[www.nsc.co.jp/nsmat/english](http://www.nsc.co.jp/nsmat/english)

### IN BRIEF

#### GaNpowIR awarded

At April's 2009 Module Power & Power Management Technology Seminar in Shenzhen, China, the GaNpowIR GaN-based power device platform of International Rectifier of El Segundo, CA, USA received the 'Best Innovative Award in Power Components' as part of the Power Products Awards from Electronic Design & Application World-Nikkei Electronics China (EDAW-NEC) magazine.

Based on five years of R&D, GaNpowIR uses proprietary high-throughput, 150mm GaN-on-silicon epitaxial technology and subsequent device fabrication processes that are compatible with IR's silicon manufacturing facilities.

GaNpowIR was launched commercially last September.

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

## Raytheon awarded \$23.9m Phase 3 contract for wide-bandgap program

Raytheon Company of Waltham, MA, USA has been awarded a \$23.9m phase 3 contract from the US Defense Advanced Research Projects Agency (DARPA) to continue work on the agency's Wide Bandgap Semiconductor (WBG) Development program.

This 38-month phase of the program is a collaboration between DARPA and the Missile Defense Agency (MDA). Its objective is to rapidly mature and demonstrate the capabilities of gallium nitride (GaN) to improve the performance of missile defense radars. To accelerate the technology development, it will combine the results of Raytheon's DARPA-funded WBG Phase 2 and the MDA-funded Next-Generation Transmit Receive Integrated Microwave Module programs.

"Our research continues to demonstrate that GaN technology

will improve the capability and performance of current and future military systems," says Michael Del Checcolo, VP of engineering for Raytheon Integrated Defense Systems (IDS) of Tewksbury, MA. "Under the WBG program, we have the

**The 38-month phase 3 of the program is a collaboration between DARPA and the MDA**

opportunity to combine research findings from multiple organizations, allowing us to develop and provide the most advanced technologies."

Work under the new contract will be performed by Raytheon IDS at its Integrated Air Defense Center in Andover and its Surveillance and Sensors Center in Sudbury (both in Massachusetts).

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

## GigOptix re-enters broadband RF market

GigOptix Inc of Palo Alto, CA, USA, which designs optical modulators, drivers and transimpedance amplifier (TIA) ICs based on III-V materials, says it is revitalizing and expanding its range of monolithic microwave integrated circuits (MMICs) and hybrids for military, instrumentation and sensor markets. The performance and scope of its broadband RF amplifiers is a legacy of the portfolio of iTerra Communications (which re-emerged as GigOptix in July 2007) plus two years of extensive new product development since then.

At GigOptix's inception, it focused on realizing the potential of its products in optical transponders and built on its relationship with submarine networks equipment vendors to deliver swift revenue growth. Now, after two years of expansion in the global arena, GigOptix is building on its legacy to

develop a stronger presence in the RF vertical market with the rejuvenation of its portfolio of broadband power amplifiers and limiting amplifiers. The range includes the iT2000 family of ultra-broadband power amplifiers and the iT3000 family of limiting amplifiers.

GigOptix says that the ultra-broadband power devices feature bandwidths from 30kHz to 26.5GHz, good gain linearity, high efficiency, and a low noise figure. The iT2005, iT2008, iT2009 and iT2018 are available as die, with the iT2005F available in a 5mm x 5mm QFN. The GX6155 is also being characterized for use in RF applications.

The limiting amplifiers product line features solutions for 10, 25 and 40Gb/s, high gain and sensitivity (-40dBm), low jitter and good signal integrity. The iT3010E, iT3011E, iT3012E, iT3018E and GX3440 are

currently available in full production.

"Throughout 2008 we continued to support strategic customers who were committed to volume use of our broadband RF products; however, we did not highlight them or promote them in any way," says Julie Tipton, VP of marketing. "Now, in 2009, we are convinced that, with a fresh refocused strategy, more customers will benefit from the best-in-class performance that we can offer for RF, military and instrumentation applications," she adds. "We are now a stronger company and can provide better support and value to our wider customer base. Following our success in securing a lead position in the optical communications market, we intend to extend our portfolio into the RF broadband markets, with more new products in the coming months."

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



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# IQE expects upturn in Q2/2009 as inventory cuts come to an end

Despite difficult economic conditions, in preliminary results for 2008 epi-wafer foundry and substrate maker IQE plc of Cardiff, Wales, UK in late March reported record revenue of £60.5m (up 21% on 2007's £50.1m, and the fourth consecutive year of double-digit revenue growth).

Growth was driven principally by demand for high-speed wireless communications, 3G mobile devices (particularly GaAs-based components for feature-rich mobile devices that require high levels of performance and functionality), and optical products for fiber-optic communications, consumer and office sectors.

Revenue grew quarter-on-quarter well ahead of market expectations for the first three quarters of the year, until the global recession impacted suddenly in Q4/2008.

"Whilst all sectors are currently suffering as a result of the global recession, it is smartphone products which are widely expected to be amongst the first to resume high growth once confidence returns to world markets," says CEO Dr Drew Nelson.

Earnings before interest, tax, depreciation and amortization (EBITDA) more than doubled from £3.9m to £8.4m (before exceptional items). Exceptional charges rose from £0.4m in 2007 to £3.9m: £2.5m from completing relocation of the Singapore business to a new facility last November, plus £1.4m from restructuring operations in Q4/2008 to cut costs and improve efficiencies in preparation for the challenging market conditions ahead (involving a 16% cut in staffing, some short-time working arrangements, and temporary pay cuts).

Underlying operating profit rose almost sevenfold from £0.6m to £4m, reflecting strong operational gearing. Conversion of EBITDA into

cash generated from operations grew more than fourfold from £2m to £8.5m.

This strong financial performance against the gloomy global economic backdrop reflects the strength of IQE's business model, operational gearing and the management's ability to deliver against a robust strategy, the firm reckons.

Compared to 2007's outflow of £7.1m, IQE achieved positive free cash flow of £0.7m,

**The wireless market will resume growth in second-half 2009, driven by the significant roll-out of 3G and other high-speed wireless applications**

even after capital investment of £7.8m (marking the completion of a major capital program). Investment in infrastructure in 2009 is expected to be minimal (falling to maintenance levels), leading to a much higher conversion of operating cash flow into free cash flow.

Net debt rose from £14.2m to £18.1m during 2008. However, the banking facilities negotiated in January 2008 underpin a strong financial position, providing financial resilience in the current economic environment, the firm believes.

IQE is hopeful of returning demand for smart phones, plus a move to the mass production of solar cells for 'multiple customers'.

IQE says that inventory destocking across the supply chain in Q4/2008 continued with slow demand in Q1/2009, but there are signs that this is coming to an end and that demand will start to rise in Q2 as inventories stabilize and customer pulls return to actual consumption levels. However, customers are expected to be cautious about building up inventory. IQE

hence expects that first-half 2009 revenue will be down on second-half 2008. Nevertheless, it expects that the wireless market (particularly the smartphone segment) will resume growth in second-half 2009, driven by the significant roll-out of 3G and other high-speed wireless applications.

Also, new products such as CPV solar cells to address the global focus on energy efficiency are expected to start generating meaningful revenues and contribute strongly in second-half 2009, together with initial revenues from the introduction of products developed over the past couple of years.

The key focus for 2009 will remain on the wireless mobile communications and optoelectronic products. However, advanced solar cells markets and a number of other key high-growth and high-volume opportunities being rapidly developed across IQE will increasingly

**New products such as CPV solar cells are expected to start generating meaningful revenues**

play a role in the firm's core activities, says Nelson.

"Our programme of reducing costs and investing in infrastructure and new product innovation

has strongly positioned IQE to benefit from the upturn in the semiconductor markets," reckons Nelson.

The board remains confident about IQE's ability to increase revenue, profitability and cash generation over the coming years.

"Operational cash generation was strong in 2008 and, having completed our infrastructure investment programme, we expect free cash generation to improve significantly in 2009," says Nelson.

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



## EpiWorks boosts capacity to 100,000 6" wafers per year

EpiWorks Inc of Champaign-Urbana, IL, USA, which manufactures epi-wafers for optical components, wireless devices and high-speed communication systems, has announced its Phase II production plant expansion. The firm completed its Phase I expansion in April 2007, which boosted its 6" HBT production capacity to more than 50,000 wafers per year.

"In 2007, we completed the internal qualification of additional MOCVD equipment. Since then, EpiWorks has successfully added new customers, developed new products and substantially increased its volume," says Dr David Ahmari, executive VP. "EpiWorks is now preparing to meet continued demand beyond 2009."

Phase II involves doubling clean-room space and adding MOCVD capacity to allow for the production of more than 100,000 6" wafers per year. EpiWorks offers 4" and 6" electronic wafer production as well



EpiWorks' epiwafer production facility.

as 2", 3", 4" and 6" optical wafer production.

"EpiWorks has been building capacity, a strong customer base and a profitable business over the past

**By keeping proper balance and perspective, we have afforded ourselves the financial flexibility to judiciously add capacity**

several years," says CEO Quesnell Hartmann. "Despite the current economic conditions, new customers and increased demand for new products are driving our growth and expansion," he adds.

EpiWorks has been profitable for three consecutive years, including Q4/2008 and Q1/2009.

"We have planned

appropriately to maintain our profitability even in the midst of the current global financial crisis," says Hartmann. "By keeping proper balance and perspective in times of extreme bullishness and bearishness, we have afforded ourselves the financial flexibility to judiciously add capacity. This will ensure that EpiWorks is well positioned to meet customer demand during the next upward cycle."

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

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## IN BRIEF

## sp3 engages ATS as sales representative

sp3 Diamond Technologies Inc of Santa Clara, CA, USA, a supplier of chemical vapor deposition (CVD) diamond film products, equipment and services to markets (including electronics, lasers, LEDs, semiconductors and MEMS), has engaged Adams Technical Sales (ATS) as a sales representative, with its president Brent Adams having responsibility for boosting thermal management sales. ATS will target prospective customers in Oregon, Idaho, Washington, Montana and British Columbia, Canada. "ATS brings many years of solid experience in the semiconductor and component packaging markets," says sp3's director of sales William Peifer.

ATS will market sp3's DiaTherm heat spreaders, diamond on silicon (DOS) wafers, silicon on diamond (SOD) wafers, and diamond wafer coating services. sp3 specializes in markets including microwave devices, hermetic packaging, high-power lasers, thick- and thin-film applications, and component packaging for commercial, military and consumer uses.

DiaTherm heat spreaders have high thermal diffusivity and conductivity, suiting mounting structures for laser diodes, laser diode arrays, LEDs and high-power devices (including RF).

DOS wafers provide a uniform deposition of diamond on substrates up to 300mm, leaving an exposed diamond surface for devices (active circuits or MEMS).

SOD wafers allow thermal management via a thin layer of silicon applied on top of diamond, forming a known interface on a high thermally conductive substrate.

sp3's wafer coating services deliver diamond CVD for a range of thermal management and DOS applications for up to 300mm.

[www.sp3diamondtech.com](http://www.sp3diamondtech.com)

# AXT's sales halve as GaAs inventories burn off

For first-quarter 2009, AXT Inc of Fremont, CA, USA has reported revenue of \$7.7m, down 51% on \$15.6m last quarter and 61% on \$19.6m a year ago.

While indium phosphide (InP) substrate revenue was up about 3% from about \$475,000 both a year ago and last quarter to \$490,000, germanium (Ge) substrate revenue was \$622,000, down 9% on \$684,000 last quarter and 56% on \$1.4m a year ago. Gallium arsenide (GaAs) substrate revenue was also down, by 45% on \$9.1m last quarter and 64% on \$13.7m a year ago to \$5m, due mainly to inventory overhang affecting sales of all diameters (particularly 4- and 6-inch). Raw materials sales were \$1.5m, down severely by 72% on \$5.3m last quarter and 62% on \$4m a year ago.

"Our customers continued to utilize their excess inventory and made very good progress in the quarter, but not as quickly as we had hoped," says chief financial officer Wilson Cheung. "We continued to experience push-outs of orders of our highest-value products, particularly 6-inch semi-insulating substrates and 4-inch semi-conducting substrates, into the balance of the year as our customers continue to use excess inventory in a weakened demand environment," he adds.

Gross margin was minus 3.1%, down from last quarter's 4.8% and 31.7% a year ago, due mainly to the low absorption rates (as a result of reduced sales from last quarter) and lower production volume (given the continued weakness at major customers).

In addition, to meet customer supply obligations, AXT's gallium joint venture Ji Ya Semiconductor in China continued to source 99.99%-pure (4N) gallium from an independent third-party supplier, lowering gross margin. Ji Ya had

ceased production for five weeks in fourth-quarter 2008 as a result of a supply shortage of raw materials from the affiliated aluminum plant in which it is housed (which had reduced production and halted operations due to falling aluminum prices in second-half 2008). AXT had expected Ji Ya to get back up to full capacity in Q1/2009, allowing gross margin to bounce back to more normal levels.

Operating expenses have risen from \$4.1m last quarter to \$5m. However, this included \$629,000 severance and stock compensation accrual for former CEO Phil Yin, \$350,000 in legal and professional

**We continued to experience push-outs of orders of our highest-value products, particularly 6" SI substrates and 4" SC substrates**

fees related to March's management change, and a \$507,000 restructuring charge from cutting head-count (from 1120 to 1051, mainly through cutting production staff from 902 to 845).

Net loss has grown from \$2.4m last quarter to \$5.5m, compared with net income of \$2m a year ago. Cash and cash equivalents have fallen from \$13.6m to \$11.5m.

However, for second-quarter 2009, AXT expects revenue to rebound significantly by 30-43% to \$10-11m.

"Our key areas of focus continue to be research and development of advanced products and technologies, customer support, quality control, new customer qualifications and expense management," says Cheung. "We believe that a strong focus in these strategic areas will allow us to emerge in a competitively solid position when the market improves."

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

## SAFC Hitech and AWI extend R&D services collaboration in Japan

SAFC Hitech of St. Louis, MO, USA (a business segment of SAFC within the Sigma-Aldrich Group) has extended its collaborative partnership with Japanese industrial and medical gas producer Air Water Inc (AWI). The firms expect to continue to offer the Japanese chip industry collaborative R&D services in local facilities.

The extended agreement builds on a foundation of providing performance chemicals for both silicon and compound semiconductor markets in Japan, and offers IDMs and OEMs direct access to local R&D facilities for use in developing advanced ICs and the tools to build them.

Customer research programs will be supported at AWI's Matsumoto campus in Japan's Nagano region, which houses laboratories and Class 1000 cleanrooms for a wide range of high-purity gas- and chemical-related research by AWI and SAFC Hitech. A highly collaborative approach is employed to enable research groups in Japan, the USA and the UK to

discuss newly developed data, which can be made available to customers on a confidential basis.

"The innovative, highly competitive nature of Japan's semiconductor market has proven to be a significant driver in pushing the microelectronics industry forward," says SAFC Hitech's R&D director Dr Peter Heys. "Extending our excellent working relationship with AWI provides valuable development resources to this key strategic market, one that we believe will continue to lead advancement of chip technology," he adds. "The highly skilled scientific teams of SAFC Hitech and AWI and the world-class facilities in which they work have attracted a number of Japanese multinational IDMs and OEMs," he claims. "We currently have numerous programs where a customer's research engineers work closely alongside SAFC and AWI researchers to collaborate on projects."

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

[www.awi.co.jp/english](http://www.awi.co.jp/english)

## Huaguang qualifies Veeco GaN and As/P MOCVD systems for HB-LEDs

Veeco Instruments Inc says that Shandong Raysun Huaguang Optoelectronics Co Ltd of Jinan City, China has qualified its GaN and As/P MOCVD systems for the high-volume production of red and blue high-brightness LEDs.

"Huaguang [which was founded in 1999] is one of the first companies dedicated to the R&D and mass production of LEDs in the mainland of China," says general manager Zheng Tiemin. Its plant has a total area of more than 36,000m<sup>2</sup> for manufacturing and R&D, and a monthly production capacity of 1bn LED chips. "In the past several years, we have gained significant expertise on Veeco's MOCVD systems," he adds. The TurboDisc K465 GaN system features Veeco's

most advanced reactor technology and delivers what is claimed to be the industry's highest throughput available for high-volume production of GaN-based blue and green HB-LEDs. The TurboDisc E450 As/P system is engineered for high-volume production of red, orange and yellow HB-LEDs.

"The LED market is growing quickly, and Veeco will be an important supplier as we expand our LED product line," says Zheng Tiemin.

"Veeco's TurboDisc K465 and E450 MOCVD systems were qualified for production in a short period of time, enabling Huaguang to ramp their production quickly," says Bill Miller, senior VP, general manager of Veeco's MOCVD operations.

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

### IN BRIEF

#### Aviza slashes March-quarter guidance

Etch and deposition equipment maker Aviza Technology Inc of Scotts Valley, CA, USA says that, for its fiscal second-quarter 2009 (ended 27 March), it now expects net sales of \$9.5–11m, below its previously announced guidance of \$13–18m. This is also less than half of last quarter's revenue of \$25.2m and a third of \$30.2m a year ago.

The firm also now expects that, excluding restructuring charges of \$9–10m, its adjusted net loss will be \$5–6m, rather than its previous guidance of \$1–5m and compared to last quarter's adjusted net income of \$4.9m.

When Aviza gave its guidance in early February, it said fiscal Q2 would be challenging as it continued to face an unpredictable environment for orders and weakness in customer demand. The firm said that it would continue to institute shut-down days at varying times and locations. US staff were required to take off one Friday every two weeks (amounting to a pay cut of 10%) while similar cuts took place globally. Board members and senior management also accepted a 20% cut in fees and salaries.

Previously, Aviza cut 18% of its staff and contractors last year and about 90–110 more in the December quarter. Of 380–400 staff, about 100 are based in Scotts Valley, with the rest at its manufacturing plant in Wales, UK and support facilities in the UK, Germany, France, Taiwan, China, Japan, Korea, Singapore and Malaysia.

In early January this year, Aviza said it had engaged Needham & Company to assist in evaluating strategic options, including exploring partnering, financing and business development.

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

## IN BRIEF

## Dalian University of Technology orders MOCVD system for R&D on LEDs

Aixtron says that Dalian R&D Center of Optoelectronic Technology at China's Dalian University of Technology (DUT) has ordered a Close-Coupled Showerhead (CCS) MOCVD system. To be supplied in 3x2"-wafer configuration, it will be used for R&D on ultra-high-brightness (UHB) gallium nitride (GaN)-based LEDs and will be delivered in second-quarter 2009.

"We chose an Aixtron system in part because we knew that the Close Coupled Showerhead reactors have particular adaptability to nitride-based UHB-LED process development," says professor Du Guotong, director of the Dalian R&D Center of Optoelectronic Technology. "Other outstanding features include their excellent uniformity of growth while at the same time being easy to operate and maintain. Plus we know we can always call upon the local Aixtron team for support," he adds.

Dalian R&D Center of Optoelectronic Technology was co-constructed by DUT and the Technology Bureau of Dalian City. Its research is focused on semiconductor lighting, laser devices and high-density optical storage technology, fiber-optic active, passive components and modules, scientific research equipment for the optoelectronics industry, and solar cells.

Founded nearly six decades ago, Dalian University of Technology is one of the key universities under the direct leadership of the State Ministry of Education. With the support of 'the 985 Project' and 'the 211 Project', it is engaged in rejuvenating the country's north-eastern industrial base.

[www.dlut.edu.cn/en](http://www.dlut.edu.cn/en)

## Fraunhofer HHI orders Aixtron MOCVD system for InP photonics

Aixtron AG of Aachen of Germany says that in fourth-quarter 2008 the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut (HHI) in Berlin, Germany ordered an AIX 2600G3 IC MOCVD system in 8x4" wafer configuration for the multi-wafer growth of indium phosphide (InP) based optoelectronic devices.

The system will be shipped in third-quarter 2009, and will contribute to further developing the capabilities of the institute's Photonic Components department.

At HHI, research on photonic components covers both telecom & datacom applications and optical sensors and instrumentation, e.g. for medical and environmental monitoring. This involves MOCVD growth of laser diode, detector and modulator structures in the 1200-1900nm spectral range. The new reactor will be used for bulk-InGaAsP-, QW-InGaAsP-, QW-InGaAlAs-, and also self-assembled InAs quantum dot based structures.

"The strong growth of phase-dependent information transmission, together with the demand for WDM optochip solutions at reasonable costs, creates a huge need for

photonic integrated circuits," says Photonic Components department head Norbert Grote. "Soon more than 50% of HHI's wafer area will be some kind of integrated solution," he adds. The AIX 2600G3 IC system should upgrade HHI's MOCVD capabilities to a level sufficient for many years to come, Grote believes.

"We have been doing InP photonics development for more than two decades," says Harald Kuenzel, leader of HHI's epitaxy group. "Our primary research tools have been the AIX 200 and AIX 200/4 horizontal MOVPE reactors, which so far have fulfilled our requirements. Now our program has reached the point where we need to expand our epi capacity and upgrade to the latest technology in terms of area uniformity and multi-wafer capability," he adds. "Our industrial customers are more and more keen on seeing R&D device developments to be compliant with state-of-the-art production tools... It has been our experience that these systems provide excellent reproducibility and uniformity plus a flexibility of configuration that will allow us to rapidly achieve high device quality."

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

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

## PECVD system for Georgia Tech

Aixtron says that in first-quarter 2009 it received a purchase order from Georgia Institute of Technology in Atlanta, GA, USA for a 4" Black Magic combined thermal CVD and plasma-enhanced CVD (PECVD) system, for delivery in second-quarter 2009.

The NEST (Nanoengineered Systems and Transport) Research Group will use the system to process carbon nanotubes (CNTs) for CPU thermal management and for electrode materials in electrochemical energy conversion systems.

The Black Magic system uses unique rapid heating and plasma technologies that have been proven in the field since 2005, and has enabled users to produce various types of nanotubes, including low-temperature, multi-wall, single-wall and super-growth nanotubes.

The new system will be one of the first installed in the 30,000 SF cleanroom in the Marcus Nanotechnology Building, and will be used by several research groups at Georgia Tech.

[www.me.gatech.edu/nest](http://www.me.gatech.edu/nest)

## University of Braunschweig buys LayTec EpiCurve TT for R&D on long-wavelength GaN lasers and LEDs

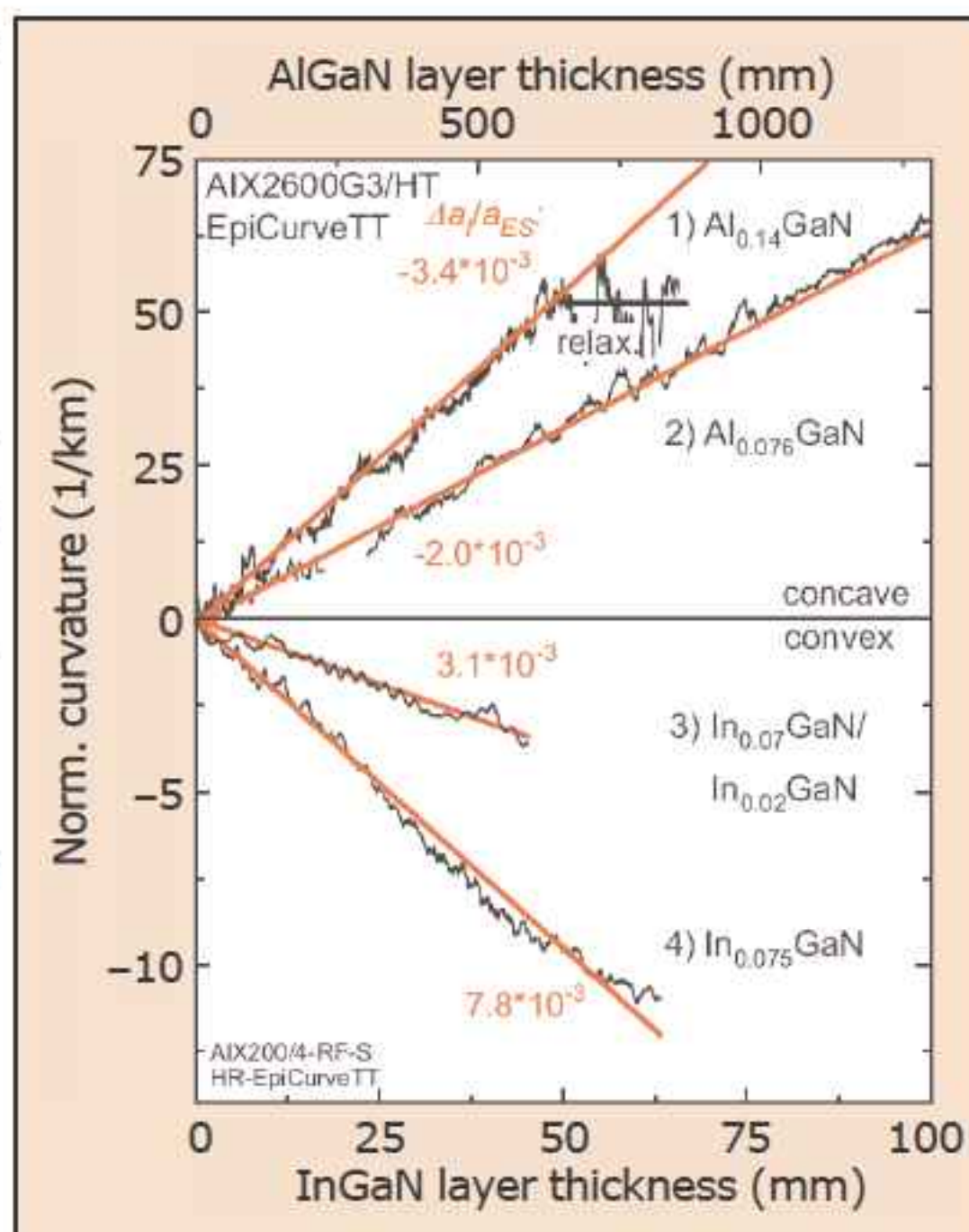
LayTec GmbH of Berlin, Germany, which provides in-situ thin-film monitoring systems, says that it has sold an EpiCurve TT system to the Technical University of Braunschweig, Germany.

The tool will be used by the group of professor A. Hangleiter for R&D on gallium nitride-based long-wavelength emitters (mainly green lasers and LEDs).

Specifically, Dr Uwe Rossow will use the EpiCurve TT to monitor and understand the strain effects and the relaxation process of the underlying cladding and waveguide layers as well as of the layers in the active region of the emitting structures. His team uses indium gallium nitride (InGaN) in the quantum wells.

The EpiCurve TT measures in-situ wafer bowing, temperature and reflectance, which helps to control stress, film composition, surface roughness and wafer temperature.

The Figure shows an example of curvature measurements during the growth of ternary InGaN and AlGaN layers. Both the film composition and strain-induced relaxation can be detected.



**Curvature measurements of ternary layer growth: compressive stress (InGaN) causes convex bow; tensile strain (AlGaN) causes concave bow.**

"Simultaneous curvature and temperature measurements by EpiCurve TT already during the process will help us to control the relaxation process, to achieve better uniformity, to reproduce growth conditions and improve the structure quality," comments Rossow.

### LayTec to hold first Taiwan user meetings

Since its market share in Taiwan is growing rapidly, LayTec says that, in cooperation with Taiwan distributor and service partner Challengtech International Corp, it is organizing two user meetings in Taiwan: one in Hsinchu on 23 June and one in Tainan on 25 June.

At the meetings, LayTec's engineers and customers will present measurement results and share their experience and data analysis for MOCVD process evaluation. LayTec will also report on the latest

developments, answer users' questions and give practical advice.

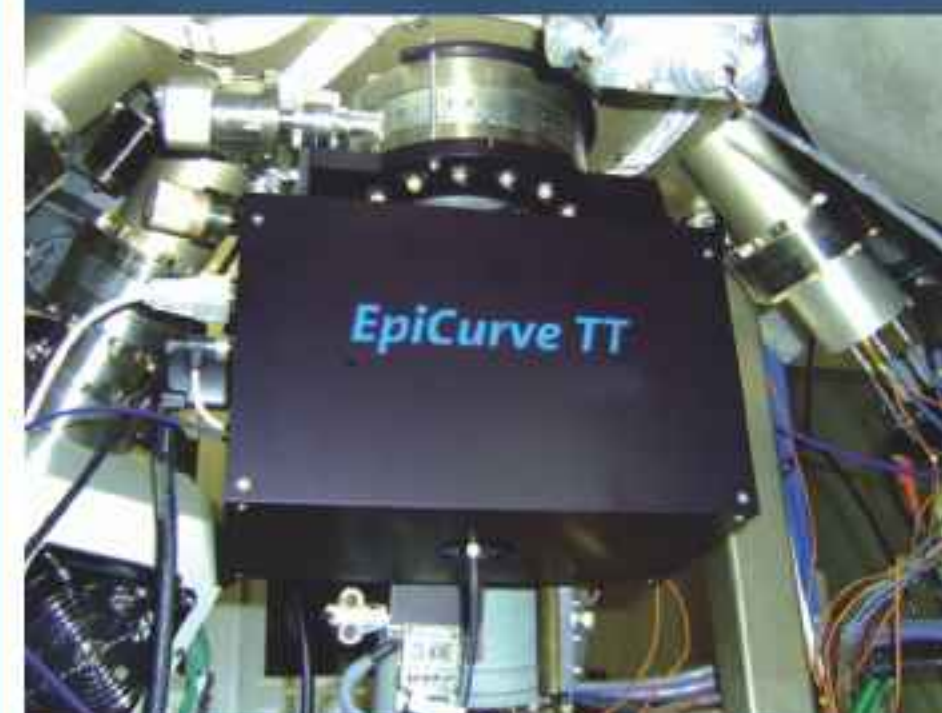
Customers in Taiwan will receive a personal invitation from Taiwan Challengtech International Corp by the end of April.

● In conjunction with the 13th European Workshop on Metalorganic Vapor Phase Epitaxy (EWMOVPE) in Ulm, Germany, LayTec is organizing its 11th in-situ seminar for customers in the Edwin-Schaff Congress Center on 7 June.

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

Some gems  
need a little  
extra help to  
sparkle

For many years LayTec has been providing leadership innovation for in-situ control of compound semiconductor growth.



The EpiCurve<sup>®</sup>TT provides the best temperature control and stress engineering for MOCVD and MBE processes.

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## IN BRIEF

## MiPlaza adds STS CPX cluster tool for multi-purpose etch

Surface Technology Systems plc (STS) of Newport, Wales, UK has installed a CPX cluster tool at Philips Research's MiPlaza (Microsystems Plaza) at its High Tech Campus Eindhoven, The Netherlands. The tool has multiple process chambers capable of etching a wide range of materials. Furthermore, STS and MiPlaza are also to cooperate on process development using the installed equipment.

MiPlaza offers expertise, service and infrastructure to external firms and research institutes. It offers a range of technologies, including MOCVD (for III-V compound semiconductors), CVD, PVD, ion implantation, lithography, inspection, and etch.

"Because MiPlaza is a shared facility, our processing equipment has to be versatile enough to support a wide range of applications," says Frank Dirne, head of MiPlaza's Thin Film facilities. "At the same time, it has to satisfy highly demanding specifications. We need flexibility in the field of standard etching of oxides and nitrides, deep Si etching and etching of a whole variety of metals, all with feature dimensions of excellent quality," he adds.

"Winning this order at a leading European facility, with exposure to a large number of users, was important for us," says STS' CEO Eizo Yasui. "We are confident our CPX provides the ideal combination of flexibility and market-leading process capabilities on a production-proven system, to enable MiPlaza and their clients to transfer their own innovations into new business successes."

[www.stsystems.com](http://www.stsystems.com)  
[www.miplaza.com](http://www.miplaza.com)

## STS receives multi-tool order from Turkey's new Institute of Materials Science and Nanotechnology

Plasma etch and deposition equipment supplier Surface Technology Systems plc (STS) of Newport, Wales, UK has sold two ICP systems to UNAM, a new Institute of Materials Science and Nanotechnology, based at Bilkent University in Turkey. The Inductively Coupled Plasma (ICP) etch tools will be used for a wide range of applications including deep reactive ion etching (DRIE) of silicon, plus dielectric, compound semiconductor and metal etching.

UNAM has been formed as Turkey's first national centre of excellence to lead nano/micro technology research, and will provide facilities for users from all universities and research centres in the country.

"We selected STS tools for our institute because not only are STS acknowledged market-leaders in DRIE of silicon, but their equipment offers very flexible processing capabilities for other materials that our researchers will be working with," says assistant professor Mehmet Bayindir (assistant director of UNAM).

"We are very happy to have placed STS tools in this national centre, giving users from all over Turkey exposure to our technologies and equipment," says STS' CEO Eizo Yasui. "We are looking forward to working with UNAM, as they establish themselves in the international nanotechnology research arena."

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

## Metryx wins follow-on order for mass metrology system

Metryx Ltd of Bristol, UK says that it has shipped a second Mentor OC23 mass metrology system to an unnamed US-based GaAs manufacturer.

The system will be used in the volume production of bulk acoustic wave (BAW) devices, where it will measure both deposition and etch processes on product wafers.

"Once the machine is in the production line, manufacturers can truly evaluate the effectiveness of the technology," says president & CEO Dr Adrian Kiermasz. "To date, 95% of our customers have placed follow-on orders. We see that as an indication of mass metrology's increasing value in the volume production environment," he adds.

Metryx's non-destructive, in-line metrology can be used to monitor product wafers in volume production environments for dielectric and conducting materials in etch,

Metryx's  
OC23.



deposition and CMP process applications. Capable of measuring in the micro-gram range (about one Angstrom of material thickness), the in-line Mentor OC23 tool monitors the mass change of any wafer

following a process step, to determine whether device manufacture process steps are operating consistently and in the expected manner. The mass change response for the process step is managed like other SPC parameters in the process flow.

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

## Lam's revenues fall 38%, but cash reserves fund R&D

For its fiscal third-quarter (to end-March 2009), etch and wafer-cleaning equipment maker Lam Research Corp of Fremont, CA, USA has reported revenue of \$174.4m, down 38% on \$283.4m last quarter and 72% on \$613.8m a year ago.

Due to a combination of factors (including the current economic environment, a sustained decline in the firm's market valuation, and a decline in operating results), Lam has concluded that the fair value of its Clean Product Group has been reduced below its carrying value. The firm has hence recorded a non-cash goodwill impairment charge of \$89.1m.

Excluding this and other charges, ongoing gross margin has fallen from 47.8% a year ago and 38.5% last quarter to 26.8%, due mainly to lower manufacturing and field utilization levels resulting from reduced business activity as well as

product mix. Ongoing net loss is \$89.8m, compared to \$11.7m last quarter and net income of \$109.8m a year ago.

Cash flow from operating activities was -\$24.2m. During the quarter, the firm paid the outstanding principal balance of \$237.5m of its long-term debt. Cash and cash equivalents, short-term investments, and restricted cash and investments balances has fallen from \$1.1bn to \$806.4m.

"We are fortunate to have a strong balance sheet with sufficient cash to continue making investments in

**We are fortunate to have a strong balance sheet with sufficient cash to continue making investments in key R&D programs**

key R&D programs, place next-generation tools at customer sites for joint development projects and evaluations, and deploy inventories to meet short-term shipment requirements as well as respond to any future increases in demand," says president & CEO Steve Newberry. "We are developing next-generation technology solutions alongside our customers and are continuing to win new application tool selection decisions in both etch and clean at the leading-edge technology nodes," he adds.

"Our focus remains on investing in strategic opportunities while aggressively managing the cost structure and cash expenditures... This will enhance our ability to meet the expectations and needs of our customers and strengthen our market position for the next upturn," Newberry concludes.

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

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

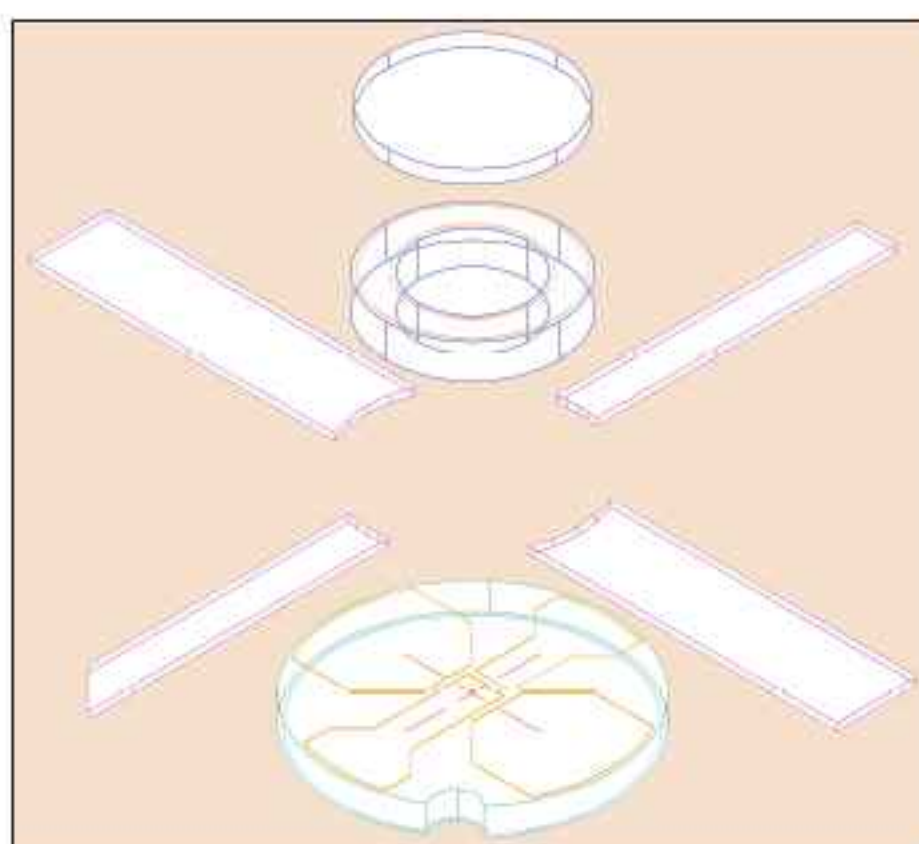
**Focused Innovation. Solid Results.**

## StratEdge introduces BeO low-power, high-power switch package for GaN, SiC, and GaAs devices

StratEdge of San Diego, CA, USA, which designs and produces packages for microwave, millimeter-wave, and high-speed digital devices, has introduced a beryllium oxide (BeO) package and full assembly and testing service for high-power semiconductor switches and small gallium nitride (GaN), silicon carbide (SiC), and gallium arsenide (GaAs) devices. Applications include test & measurement, military radios, and radar.

With a thermal conductivity of 270W/mK, the 0.205" diameter circular package has a BeO disk base to accommodate devices of up to 0.030" by 0.040". The standard hermetic package comes with a circular metal lid with gold tin preform. Designed with four leads, the package accommodates single-pole, three-throw switch (SP3T) devices. The maximum assembled package height, including the lid, is 0.056".

The package's small size and the ability to draw considerable heat



**Diagram of StratEdge's Power Package product family.**

away from high-power devices suits older technology silicon diodes as well as newer SiC and GaN devices, says president & CEO Tim Going. "We have worked with many of our

**Small size and ability to draw considerable heat away from high-power devices suits SiC and GaN devices**

clients who manufacture semiconductor switches to perfect these packages," he adds. For firms looking for a turnkey switch solution, StratEdge says that it can obtain the devices, assemble, test, and deliver them directly to the firm or its customer.

StratEdge's assembly services include eutectic or epoxy die attach, gold or aluminum wedge-to-wedge thermosonic wire bonding, lidding, lead trimming, marking, bulk packaging, and testing.

The BeO packages are available as part of StratEdge's new high-power product family. Materials used in these packages have matched coefficients of expansion to mitigate the inherent stresses of brazing dissimilar materials together.

StratEdge packages are capable of passing MIL-STD 883 fine and gross hermeticity testing and meet RoHS and WEEE compliance standards.

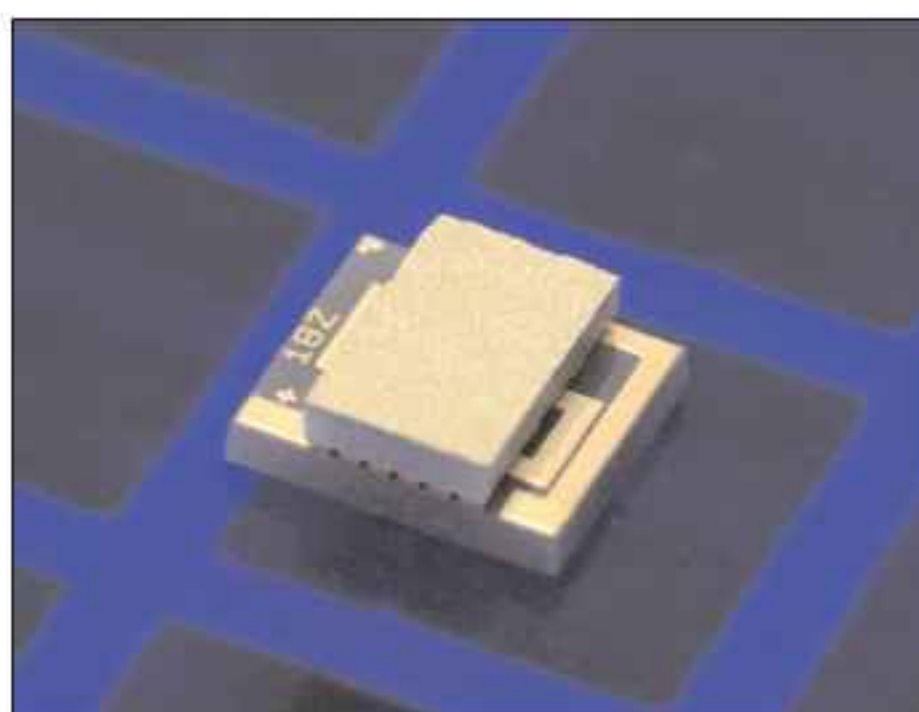
[www.stratedge.com](http://www.stratedge.com)

## Nextreme's OptoCooler breaks 60°C $\Delta T$ barrier

Nextreme Thermal Solutions of Durham, NC, USA says that its OptoCooler HV14 is the first high-voltage, low-current thin-film thermoelectric cooler (TEC) targeted at laser diode cooling for the telecoms market to achieve a 60°C temperature difference ( $\Delta T$ ) between its cold and hot sides, reflecting the device's ability to pump heat efficiently.

The improved performance is the result of recent advances in thin-film technology and reflects Nextreme's response to demand for thermoelectrics with higher  $\Delta T$ s at ambient temperatures.

The OptoCooler HV14 thermoelectric cooler is the first module in a new class of high-voltage and high-heat-pumping thermoelectric coolers that operate at low currents



**Nextreme's OptoCooler HV14, targeted at telecom laser cooling.**

and are optimized for standard circuitry and power requirements, says the firm. The device can pump up to 1.5W of heat at 85°C and operates at a maximum voltage of 2.7V with a maximum current of around 1A. With a footprint of 2.8mm<sup>2</sup>, the module is suited to

the cooling and temperature control of optoelectronic devices such as laser diodes for transmission modules and photodiodes for sensing.

The micro-size and power-pumping capabilities of the HV14 module mean that manufacturers of LEDs and other semiconductor chips can now integrate cooling and temperature control functionality directly into the package during assembly, says Nextreme, resulting in a high-volume, lower-cost thermal management solution.

"Breaking the 60°C  $\Delta T$  barrier raises the bar in terms of improved efficiencies and lower operating costs," says Dave Koester, VP of engineering. "Devices with higher  $\Delta T$ s require less operating power to achieve the desired cooling effect."

[www.nextreme.com/optocooler](http://www.nextreme.com/optocooler)



## Oerlikon completes sale of Esec to BESI

Oerlikon of Pfäffikon, Switzerland has completed the sale of its back-end chip assembly equipment business unit Oerlikon Esec (announced on 26 January) to BE Semiconductor Industries N.V. (BESI) of Duiven, The Netherlands, which manufactures die sorting, flip-chip and multi-chip die bonding, packaging and plating equipment, in exchange for 2.8 million of BESI's ordinary shares.

Founded in 1968, Esec manufactures die bonding equipment for the semiconductor, telecoms and smart-card industries at its headquarters in Cham, Switzerland, and manufactures and services wire bonding systems from its Singapore assembly facility. Esec has an installed base of more than 9000 systems, in fiscal 2008 reported sales of CHF126m (\$111m), and had 515 staff at the end of 2008. However, when the divestment of Esec was announced at the end of January, Oerlikon said that ongoing re-organization measures at Esec would be continued and extended. Of the 280 jobs at the Cham site, about 70 are affected, and another 80 were to be cut from Esec group worldwide.

"The successful completion of this divestiture marks an important milestone for Oerlikon in streamlining its portfolio around the core competencies in applications for

thin-film and coating," says Oerlikon's CEO Dr Uwe Krüger. "The smooth integration of BESI and Esec, with its outstanding products and technologies, will further improve the joined company's competitiveness in the future," he adds. With this move, Oerlikon's exposure to the cyclical semiconductor market is reduced to a low single-digit percentage of sales.

"The purchase of Esec is a complementary product acquisition that fits well with our goal of becoming the world's leading assembly equipment company," says BESI's president & CEO Richard W. Blickman. "In combination with our Datacon product portfolio, the addition of Esec significantly expands our share of the die bonding system market, one of the most rapidly growing segments of the assembly equipment business."

At the end of January, BESI said that it targets synergies from the Esec acquisition by (i) using BESI's Asian manufacturing operations and global supply chain network, (ii) integrating and coordinating R&D activities with BESI's Datacon die handling activities, (iii) leveraging the respective resources of the combined sales and customer support networks, and (iv) sharing and coordinating global IT and general and administrative functions.

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

## JPSA appoints Korean sales & service rep

J.P. Sercel Associates Inc (JPSA) of Manchester, NH, USA, which makes UV laser-based materials processing workstations for wafer processing and micromachining, has appointed BlueON (a fully integrated sales & service company for LEDs and solar industrial equipment and technology) as its laser systems and technology products representative for Korea.

"BlueON is well established in Korea as a professional LEDs and solar products and services provider to a broad and distin-

guished customer base," says JPSA's president Charles E. Cuneo. "Their 14 years of experience in the LED and solar marketplace will be a tremendous asset to JPSA."

As well as sales, BlueON engineers will also service JPSA equipment from their multiple service locations, stock spare parts, assist customers in operation and process development, and provide customer training. BlueON engineers will travel to JPSA's US headquarters for training.

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

## IN BRIEF

### K&S launches automated vertical LED ball bonder

Kulicke & Soffa Industries Inc of Fort Washington, PA, USA has supplemented its Power Series platform for next-generation assembly equipment (which includes the iStackPS, ICONNPS and ConnX) by launching the ConnX-VLEDPS automatic ball bonder, designed specifically for vertical LED applications. The ConnX-VLED was debuted at the SEMICON China 2009 show in Shanghai (17-19 March).

Devices bonded with a vertical orientation of the lead frame include high-brightness and high-power LED lamps, and represent a growing portion of the overall LED market. With the launch of ConnX-VLED, Kulicke & Soffa says that it now offers solutions for the entire spectrum of LED applications.

ConnX-VLED offers the same advantages over competing products as the ConnXPS, including accuracy to  $\pm 3.0\mu\text{m}$ , automatic recovery paths for common production stoppages, and programmable back-up power.

"Recently, the LED market has been one of the bright spots in the semiconductor industry, as interest in energy-saving lighting solutions remains strong even amid the current economic weakness," says chairman & CEO Scott Kulicke. "We expect that this market will continue to grow as the emphasis on energy efficiency becomes common in public policy and private practice." With the launch of ConnX-VLED, Kulicke & Soffa is extending ConnX to cover the full range of LED applications, positioning the firm to grow with the market as energy-efficient LED solutions become commonplace, Kulicke adds.

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

## sp3 launches 2–4” silicon-on-diamond wafers for high-power, high-frequency devices

sp3 Diamond Technologies Inc of Santa Clara, CA, USA is taking orders for 2-inch and 4-inch silicon on diamond (SOD) wafers for use as gallium nitride (GaN) substrates and accelerating development of 6-inch wafers for use as laterally diffused metal oxide semiconductor (LDMOS) substrates.

sp3 claims that, because of improved thermal conductivity over traditional silicon wafers, its SOD wafers deliver higher thermal conductivity at a lower cost than existing silicon carbide (SiC) alternatives for GaN and for higher-performance LDMOS devices.

SOD wafers deliver a high-performance path for devices designed for WiMax base-stations and other commercial and military broadband and high-power switching applications (including radar communications equipment, weather and communications satellite equipment and hybrid power switching devices). sp3 says that its new product offering seeks to address

the current performance limitations of these devices, as they become increasingly impacted by the thermal restrictions of silicon wafers or the extreme cost and lower performance of SiC wafers.

“High-power, high-frequency devices — such as high-power radar and RF amplifiers, and DC-to-DC and AC-to-DC converters — have performance limitations due to the physical structure of standard silicon substrates,” says president & chief operating officer Dwain Aidala. “Military and industrial applications stand to benefit significantly from building devices on a diamond substrate with a device-quality, thin silicon top layer,” he adds. “GaN or LDMOS devices built on such a structured substrate can be driven to significantly higher power levels than current alternatives, thereby maximizing performance.” The SOD wafers are available at a lower cost than alternative diamond-based solutions or traditional SiC substrates, the firm claims.

The wafers are delivered as structured substrates with a top layer of device-quality float-zone silicon. They provide diamond heat spreading directly under the junction and can achieve more than a 100% increase in power levels compared to silicon substrates alone, and a 50–80% increase compared to SiC, at a fixed junction temperature, the company claims. At fixed power, they can reduce the junction temperature by more than 50 degrees compared to GaN on silicon or SiC. GaN growth on SOD yields epitaxial films equivalent to GaN on silicon, and the wafer size can be scaled up to 300mm, sp3 adds.

SOD wafers with diameters of 2-inch and 4-inch and a silicon top layer are currently available for GaN devices, as well as with a GaN epitaxial layer (GaN on SOD wafers) for manufacturers without an in-house epitaxial deposition capability.

[www.sp3diamondtech.com](http://www.sp3diamondtech.com)

## Rubicon grows largest manmade sapphire crystal

Rubicon Technology Inc of Franklin Park, IL, USA, which makes monocrystalline sapphire substrates and products for the LED, RFIC, semiconductor and optical industries, has grown what it believes is the world’s largest sapphire crystal.

Displayed at the SPIE Defense, Security and Sensing Conference and Exhibition in Orlando, FL, USA (14–16 April), the boule weighs 200kg (441lb) and will enable Rubicon to offer high-quality large-size optical windows and next-generation wafer products with dimensions of more than 12 inches.

Currently, Rubicon grows bulk sapphire crystals up to 85kg in production volumes and provides sapphire wafers with a diameter of up to 8 inch and optical windows with dimensions of up to 10 inches.



Rubicon’s 200kg sapphire boule.

Rubicon says that key differentiators are its ability to provide large-size windows and wafers in c-plane orientation as well as all other orientations and to provide robust, high-quality optical parts in thicknesses that meet any requirements. It adds that its proprietary ES2 crystal growth technology and sapphire processing capabilities can also be scaled to produce even larger-size sapphire products in the future.

“This growth capability now opens the door for Rubicon to provide customers with even larger-size, very high-quality, sapphire products,” says CEO Raja Parvez. “The ‘super boule’ growth process will soon be operationalized into production volumes, which will enable new applications for sapphire windows and wafers.”

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

## Monocrystal grows 52%, driven by larger sapphire wafers

Monocrystal Inc of Stavropol, Russia, which supplies sapphire products and metallization pastes to semiconductor, optical, and photovoltaic industries, has reported revenue of \$61m for 2008, up 52% on 2007's \$40.1m. The rise reflects the combination of parent company Energomera Corp's electronic materials business (headed by Monocrystal) and the acquisition in March 2008 of Atlas PCF of Belgorod, Russia, which also manufactures sapphire substrates for HB-LED and RFIC applications (as well as sapphire optics for special application).

Energomera's Electronic Materials business group surpassed 2008 targets, with strong growth supported by each major product segment: sapphire and solar pastes. Growth was driven by higher sales of larger-diameter substrates for LEDs, silicon-on-sapphire wafers, sapphire products for optics, and screen printing pastes for metallizing solar cells.

"We continued expanding our market and technological leadership by innovating premium-quality products aimed at meeting current and future needs of our clients in the sapphire and solar segments," says Andrey Kravchenko, CEO of Monocrystal and the head of Energomera Electronic Materials group. "In 2008, we introduced and started shipments of the next-generation 8" sapphire substrates for LEDs and RFICs, as well as our unique lead-free RoHS-compliant solar pastes for the contact formation of wafer-based solar cells," he adds.

"We have continued integration of Monocrystal and Atlas sapphire operations and also restructured our Electronic Materials group to further improve corporate and managerial effectiveness," says Vladimir Polyakov, president of Energomera and chairman of Monocrystal.

In 2008, net income was \$9.3m, up 73% on 2007's \$5.4m. EBITDA

(earnings before interest, taxes, depreciation and amortization) was \$19.3m, almost double 2007's \$9.8m.

However, though up 15% on a year ago, Q4/2008 revenue of \$14.9m was down 4% on Q3/2008 due to growing market uncertainty.

Continued uncertainty in the global economy makes the projections of Monocrystal's customers extremely short term, mostly not exceeding one-two months ahead, the firm says. This lack of visibility currently makes it difficult for Monocrystal to provide its own guidance for full-year 2009. Management says that it will provide more detailed guidance for 2009 as soon as visibility improves.

"We feel confident about our ability to further develop the group business and continue improving on costs reduction, new product development, and customer service," concludes Kravchenko.

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

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## IN BRIEF

## NanoGan targets GaN wafer launch

NanoGan Ltd of Bath, UK has developed a method of manufacturing free-standing gallium nitride substrates with low dislocation and defect densities (targeting improved efficiency in optoelectronic applications) and is aiming to introduce 2" wafers commercially in June.

NanoGan was founded in February 2008 by CEO professor Wang Nang Wang and chief technology officer Sergei Stepanov with £250,000 in seed funding from the University of Bath's 'Sulis Foundation' commercialization fund. Last June, the firm raised £500,000 more from private investors. Funds were partly spent on a vertical hydride vapor-phase epitaxy (HVPE) reactor, built by a commercial MOCVD equipment maker according to NanoGan's own patented design.

NanoGan's method involves using a multiple bubbler vertical matrix showerhead HVPE reactor configuration for pendeo-epitaxial growth of a buffer layer of GaN nano-pillars, which can accommodate the lattice-mismatch-induced strain between the substrate (SiC, silicon or sapphire) and subsequent growth of bulk GaN. Once a complete boule is grown, individual wafers can be sawn off and polished.

The firm has demonstrated reduced defect densities of  $10^7 \text{cm}^{-2}$  compared to the  $10^{10}$  defects per  $\text{cm}^2$  typical of GaN grown on sapphire substrates, says the University of Bath's Duncan Allsopp, who is acting as a consultant to the firm.

NanoGan has been working with selected partners on characterizing wafers, and is considering ramping up pilot production. The firm adds that its reactor could also scale up to substrate sizes of 4" and larger.

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

## Inlustra starts commercial production of nonpolar GaN wafers

Inlustra Technologies Inc says that it has now developed a scalable production process for manufacturing nonpolar and semipolar gallium nitride (GaN) substrates.

Since GaN has a crystal structure that causes some of its properties to vary strongly with orientation, the nonpolar and semipolar planes of its structure provide alternatives to the conventional polar c-plane of GaN (which faces some fundamental device efficiency limitations), promising much increased device performance, manufacturing yields, and device longevity. However, producing GaN substrates has proven challenging, especially in the nonpolar and semipolar orientations.

With the aim of providing nonpolar GaN substrates to laser, LED and academic customers, Inlustra was founded by Drs Ben Haskell and Paul Fini in 2005 as a spin-off from the GaN research laboratories of the University of California at Santa Barbara (home to professors Shuji Nakamura, Jim Speck, and Steve DenBaars).

While a graduate student and then post-doctoral researcher under Nakamura (specializing in nonpolar GaN thick-film growth and defect reduction), CEO & chief engineer Haskell's research yielded the first planar a-plane and m-plane GaN films grown by HVPE, as well as the first demonstrations of HVPE-based lateral epitaxial overgrowth for microstructural defect reduction in these films.

As a graduate student with DenBaars, chief technology officer Fini studied mechanisms of defect generation in MOCVD GaN films, as well as the use of lateral epitaxial overgrowth for dislocation reduction. He also acted as lead researcher of Nakamura's Nitride Crystal Growth laboratory by overseeing laboratory research activities and equipment design.

Business mentoring is provided by board member Joseph Tumbler,

who has experience as vice chairman of SunAmerica and president & CEO of Providian Capital Management, while Michael Crill of Atlas Accelerator (who has experience as a chief financial officer with high-tech firms) provides the board with start-up-focused finance and operations perspectives. Professor John Bowers (who has founded or co-founded several firms including Calient Networks and Terabit Technologies) is also on the board of directors, providing broad semiconductor fabrication and entrepreneurial expertise.

After winning the New Venture Competition of UCSB's Technology Management Program, in 2006

**Inlustra aims to scale up its process to 2" over the next 9-12 months**

Inlustra raised a Series A financing round, augmented by US government grants from the

National Science Foundation (NSF) and the Department of Defense (DoD). In 2007, after finishing build-out of facilities and construction of its first growth system, the firm began producing bulk GaN. Last year, Inlustra was awarded more DoD funding to further develop nonpolar bulk GaN, and produced the largest wafers reported to date.

The firm is now expanding its GaN production facilities and has recently started to fulfill customer orders. "Our proprietary crystal growth techniques significantly reduce the number of microscopic defects in the substrates, which will enable our customers to realize improved yields in their device production processes," claims Fini.

Inlustra is currently offering nonpolar GaN substrate between 5mm x 10mm and 10mm x 20mm in sizes, and aims to scale up its process to 2" over the next 9-12 months.

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



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## IR LEDs for surveillance and transport applications

Osram Opto Semiconductors of Regensburg, Germany says that, with six powerful thin-film chips and a hemispherical lens, its new infrared OSTAR Lighting LED produces 3.5W of optical output power at an operating current of 1A.

The beam angle and radiant intensity can be varied with standard secondary optics that are readily available on the market. The hexagonal honeycomb shape of the high-power component enables multiple IR LEDs to be combined to form a large space-saving matrix so that the output power can be increased many times.

The IR OSTAR Lighting LED is available in two wavelengths. At 850nm, the SFH4750 is an optimized union of maximum spectral sensitivity for CCD and CMOS cameras with suppressed visibility for the human eye. The SFH4751 is a version with a wavelength of



**Using a variety of optical lenses on the market, the IR OSTAR Lighting LED can be adapted to many illumination requirements.**

940nm (to which the human eye is almost insensitive) for use in applications where visibility of the light source must be eliminated.

"We were able to bring the infrared OSTAR Lighting quickly to market because of the synergies among the various technologies at the product development stage,"

says Harry Feltges, marketing manager for Infrared Components. The package is the same as that of the existing white OSTAR Lighting LED, so users can take advantage of the shared thermal and mechanical designs, he adds.

With their high optical output, both versions of the IR OSTAR Lighting LED suit industrial lighting illumination units for camera-based surveillance systems such as CCTV systems (used to improve public safety on the streets, at railway stations, at airports and in schools, and also to protect museum exhibits against theft).

The LEDs also have a long lifetime, even in pulsed mode applications, and are therefore suitable as light sources for intelligent transportation systems (ITS) such as traffic monitoring, toll systems and automatic number plate recognition (ANTR).

## White Advanced Power TOPLED Plus boosts brightness by 15%

Osram Opto Semiconductors has launched a new optimized LED called Advanced Power TOPLED Plus, designed in particular for architectural and sales lighting applications that call for bright light but offer very small space (e.g. for highlighting edges and contours or illuminating surfaces in a uniform light).

The new LED combines a high luminous flux of up to 27lm (100mA/5700K) with luminous efficacy of up to 90lm/W. As well as being on average 15% brighter than the standard version, it is also available in different white tones from 2700K to 6500K. So, tones from warm white to cold white can be achieved, and all the requirements from linear lighting applications to strip lighting and surface illumination can be met.

The LED suits illuminating the facades and outlines of buildings, as well as applications in retail



**The Advanced Power TOPLED Plus, designed for highlighting contours, lines and surfaces.**

outlets (e.g. freezer cases). It combines high brightness with low

power consumption and small dimensions (enabling light to be mixed in the smallest of spaces). The high-intensity LED has a typical beam angle of 140° and a homogenous white color from every viewing angle, the firm claims. A large number of small LEDs produce a more homogenous light on a surface than a few large LEDs. Designers are therefore free to create new lighting solutions, says Osram Opto.

The Advanced Power TOPLED Plus comes in a robust package and is specified for a connected load of up to 0.5W. Heat is efficiently dissipated via gull-wing connections to the lead frame and the printed-circuit board, so there is no need for expensive thermal management. From this summer, the LED will be the latest addition to Osram's LED portfolio, which includes LEDs with outputs of 0.25–18W.

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

# DOE selects projects for Round 5 SSL Core Technology and Product Development funding

In response to last May's Round 5 'Core Technology' and 'Product Development' funding opportunity announcements (FOAs) for its solid-state lighting (SSL) program, the US Department of Energy's National Energy Technology Laboratory has selected 14 projects for funding.

The selections are expected to contribute to the SSL program's goal of (by 2025) developing solid-state lighting technologies that, compared with conventional lighting technologies, are much more energy efficient, longer lasting, and cost competitive by targeting a product system efficiency of 50% with lighting that accurately reproduces the sunlight spectrum.

Seven selections are in response to the Product Development FOA 'DE-PS26-08NT00291'. The projects are focused on the development or improvement of commercially viable materials, devices, or systems. Technical activities are focused on a targeted market application with fully defined price, efficacy, and other performance parameters necessary for success of the proposed product. Total funding is \$15.6m; the performers will provide an average of 27% as cost-share.

Product Development selections include an award to LED firm Cree Inc of Durham, NC, USA for the project 'SSL Luminaire with Novel Driver Architecture'. This project seeks to develop an 81lm/W solid-state lighting luminaire that is capable of emitting at a color temperature of 2700K with a color rendering index (CRI) of more than 90. The work will involve an integrated development effort tailoring the LED chip characteristics to enable a high-efficiency driver, establishing a technology platform capable of providing high-efficiency components, drivers and luminaires.

Seven of the selections are in response to the Core Technology FOA 'DE-PS26-08NT00290'. These projects are expected to fill key technology gaps, provide enabling knowledge or data, and represent a significant advancement in the SSL technology base. Total funding is \$10.4m; the performers of cooperative agreements will provide an average of 24% as cost-share.

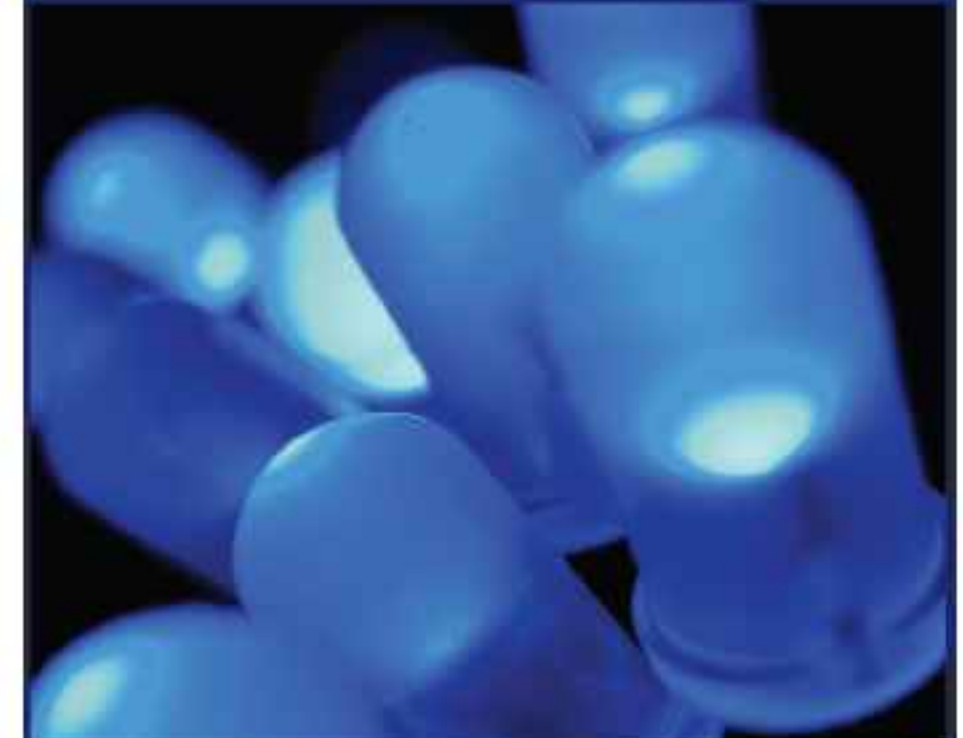
The Core Technology selections include the following awards:

- Kaai Inc for the project 'High Efficiency m-Plane LEDs on Low Defect Density Bulk GaN Substrates', which seeks to develop LEDs on the GaN crystal's nonpolar m-plane orientation, emitting at wavelengths of 400–460nm. Target results are high-performance, temperature- and wavelength-stable nonpolar LEDs with peak internal quantum efficiency (IQE) of more than 90% with minimal IQE roll-over at high current densities ( $>350\text{mA/mm}^2$ ).
- Rensselaer Polytechnic Institute (with wafer-making team member Kyma Technologies of Raleigh, NC) for the project 'High Efficacy Green LEDs by Polarization Controlled Metalorganic Vapor Phase Epitaxy', which aims to tackle poor IQE in deep-green emitters via new approaches to polarization control, including growth along nonpolar orientations, the avoidance of crystalline defects, and new approaches for the quantitative assessment of IQE, to enhance the efficiency at which light is generated in the LED.
- Eastman Kodak Company for the project 'High Efficiency Colloidal Quantum Dot Phosphors', which aims to create white LEDs composed of blue LEDs and colloidal red, green, and blue quantum dot phosphors with dense film quantum efficiencies of over 90%, optical scattering losses of less than 5%, and color stability up to 150°C.

[www1.eere.energy.gov/buildings/ssl](http://www1.eere.energy.gov/buildings/ssl)

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## Showa Denko launches record-output 660nm AlGaInP red LED chips for accelerating plant growth

Showa Denko K.K. (SDK) has started selling samples of aluminum gallium indium phosphide (AlGaInP) LED chips that emit red light at 660nm, which is the optimum wavelength for accelerating the growth of plants.

By developing a new light-emitting layer, SDK has achieved what it reckons is record output for a 660nm LED chip of 11mW at a drive current of 20mA.

In recent years, facilities for growing vegetables in an environment of controlled lighting, temperature, humidity, CO<sub>2</sub> concentration and nourishment have been attracting attention, as they ensure stabilized production regardless of the season or location, realizing multiple cropping. Furthermore, because of the controlled environment, they do not need fungicides or insecticides. Almost 30 facilities of this kind are already in operation in Japan.

It has been found that red light with a wavelength of about 660nm is most effective in increasing the efficiency of photosynthesis, accelerating the growth of plants. Currently, fluorescent lamps, sodium lamps, and conventional red LED lamps are being used at plant growth facilities. However, fluorescent and sodium lamps emit a great deal of light with wavelengths



Lamps using the newly developed 660nm-wavelength red LED chips.

other than around 660nm, and conventional red LED lamps need to use many chips because of their low output, says SDK. As a result, these conventional light sources involve problems of energy loss and high costs. Also, the wavelength of conventional AlGaInP LED chips is 650nm at best, falling short of the ideal wavelength of 660nm.

**SDK has improved the shape and arrangement of electrodes as well as the chip surface treatment method. The external quantum efficiency of LED lamps using the new AlGaInP chips is about three times that of conventional red LED lamps**

In addition to the development of the new 660nm light-emitting layer, SDK says that it has improved the shape and arrangement of electrodes as well as the chip surface treatment method. Thus, the external quantum efficiency of LED lamps using the new AlGaInP chips is about three times that of conventional red LED lamps, it is reckoned. Compared with conventional red LED lamps, the new AlGaInP LED lamps reduce power consumption by 70% at a given level of brightness, resulting in lower cost and energy consumption at plant growth facilities, SDK claims. Also, lower heat emission from light sources should improve the plant growth environment.

SDK says that it will step up marketing activities for the new AlGaInP LED chips, while enhancing their performance to meet diversified needs from customers.

Under its ongoing Passion Extension project, SDK is expanding its ultrabright LED chip operation—consisting of AlGaInP red LED chips and indium gallium nitride (InGaN) blue/green LED chips—as a growth-driver business. The firm says that it is preferentially allocating resources to these areas in an effort to further increase its corporate value.

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

## Seoul Semiconductor supplies LEDs for agricultural lighting in Japan

South Korea's Seoul Semiconductor is supplying its Z-Power red and blue LEDs to an unnamed lighting fixture company in Japan for an 'LED Farming Demonstration Project', coordinated by Japan's Ministry of Economy, Trade & Industry.

The project aims to demonstrate the use of LEDs as an artificial light source for aiding plant growth. Over 300,000 LEDs will be supplied.

By participating in the project, Seoul Semiconductor says it has strengthened its position in the



Red and blue LEDs used as an artificial light source for aiding the growth of plants.

Japanese market, as well as expanding the market for LED lighting for agricultural purposes. In the past, incandescent lamps, fluorescent lamps and sodium lamps have been used as artificial light sources for agriculture, but LEDs are now becoming a popular lighting source because of their high efficiency and long lifespan. Seoul Semiconductor adds that it has already supplied LEDs for agricultural lighting in Canada.

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



## Osram extends patent deal with Everlight to cross-license LED housing patents

Germany's Osram GmbH has extended the existing patent license (dating from September 2003) relating to the manufacturing and sale by Taiwan's Everlight Electronics Co Ltd of white and colored LEDs using conversion technology developed by subsidiary Osram Opto Semiconductors GmbH of Regensburg, Germany.

The conversion technology enables the production of white or coloured LEDs using blue-emitting indium gallium nitride (InGaN) based chips and suitable fluorescent converters.

The latest agreement extends the existing license deal in particular to give Everlight the right to use the Osram intellectual property in all

areas of application without limitations, including automotive and general lighting.

In return, Everlight has granted Osram a cross-license to use its LED housing patents. The latest agreement paves the way for closer cooperation between the two firms.

"Over the years, Osram Opto Semiconductors has built up a very strong patent position," says the company's CEO Dr Rüdiger Müller. The latest agreement is a perfect example of a productive and fair collaboration, he adds. "But we will also continue to vigorously enforce our patent rights against companies making unauthorized use of our intellectual property," comments

Gerd Pokorny, general counsel for Osram GmbH. "The strength of our LED patents has been confirmed by many court rulings in various jurisdictions. Just most recently, the High Court of Appeal in Beijing reconfirmed the decision of the Beijing Second Intermediate Court that LEDs manufactured by the Taiwanese manufacturer Kingbright in China infringe Osram's conversion patents," he adds.

Osram has previously signed royalty-bearing license agreements with various companies, including Rohm, Seoul Semiconductor, Lite-On, Harvatek, Vishay, Samsung Electro-Mechanics, and Avago.

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

## Seoul Semiconductor licenses UV LED patent to M-Vision for portable fluorescent forgery detection

South Korean LED maker Seoul Semiconductor Co Ltd has reached an agreement with industrial optical component developer M-Vision to license patents related to a portable fluorescent forgery detector.

The portable fluorescent forgery detector is widely used for identifying forgery of bank notes, securities, passports, gift coupons, and ID cards by commercial banks and financial companies, as well as transportation firms, self-employed firms and small businesses that mainly transact securities. Demand is expected to grow significantly as counterfeit money raises concerns around the world.

Forgery detection has mainly used ultraviolet (UV) mercury lamps, but UV LEDs provide good lifetime, durability, output power and eco-friendliness, says Seoul Semiconductor. With increasing restrictions on environmentally hazardous materials, UV lamps are being rapidly replaced by UV LED products



**Comparison of fluorescent detecting function between existing UV mercury fluorescent lamp (left) and UV LED lamp (right).**

in the market, says Seoul Semiconductor. Also, unlike existing UV mercury lamps, which can only detect forgery in dark conditions, UV LEDs can easily identify forgery even in bright places.

The technology being licensed was jointly developed by Korea Minting & Security Printing Corp (KOMSCO) and Seoul Semiconductor subsidiary Seoul Optodevice Co Ltd, which was established in 2002. As well as blue- and green-emitting gallium nitride-based LED chips,

Seoul Optodevice has developed and commercialized 310nm, 280nm and short-wavelength 255nm UV LED chips.

Seoul Optodevice claims to have installed the industry's first commercial production facilities for short-wavelength deep UV LEDs, with investment from Sensor Electronic Technology Inc (SETI) of Columbia, SC, USA through a strategic partnership agreed in July 2006. Seoul Optodevice claims to be the only firm to have commercialized short-wavelength deep UV LEDs so far, and reckons that it will be difficult for other firms to develop commercial UV LEDs without recognizing the patent rights of Seoul Semiconductor and Seoul Optodevice.

Seoul Optodevice will receive licensing royalties from M-Vision's sales of the portable fluorescent forgery detector incorporating its technology.

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

# Growth in LED lighting offsets fall for auto, mobile and consumer applications

For fiscal third-quarter 2009 (ended 29 March), Cree Inc of Durham, NC, USA has reported revenue of \$131m, up 5% on \$125m a year ago but down 11% on last quarter (or 8%, excluding one-time licensing revenues last quarter).

LED revenue grew 7% year-on-year but fell 11% sequentially to \$112.4m, driven by lower LED component and chip sales (attributed to a more conservative inventory approach at customers and distributors, a longer Chinese New Year shutdown for a number of customers, and lower sales for automotive, mobile and consumer application). This was partially offset by double-digit growth for LED lighting applications, led by sales of Cree's LR6 downlights and its new LR24 luminaire (despite lower demand for architectural and portable lighting applications). Also, although sales to distributors fell, distributors' sales to customers grew slightly, indicating growing end-customer demand for LED components (led by PC notebook and TV back-lighting).

Non-LED product and contract revenues of \$18.7m were down 4% year-on-year but up 22% sequentially. In particular, revenues for power and RF microelectronic devices grew a greater-than-expected 70% due to spot orders for silicon carbide Schottky diodes. Revenue from materials (SiC substrates) and government contracts were similar to last quarter.

Gross margin was 36.1% (up on 34.8% a year ago and almost level with last quarter's 36.8%, despite the challenging economic environment and lower volumes). This is at the high end of the targeted range due to a favorable product mix and higher yields in LED components plus a lower bill-of-materials cost in LED lighting that more than offset lower factory utilization and the more aggressive pricing environment for LED chips and components.

Net income was \$4m, down on \$5.7m a year ago and \$10.7m last quarter. However, during the quarter, cash and investments grew by \$39.4m to \$404.9m, with cash flow from operations of \$49.9m and (after capital expenditure of \$9.3m) free cash flow of \$40.5m.

For Cree's fiscal fourth-quarter 2009 (ending 28 June), order backlog is up on last quarter and in line with historical booking rates. The firm now targets stronger-than-expected revenue of \$137-143m (up 5-9% sequentially).

The global recession continues to impact near-term demand in mobile automotive and some consumer applications, but this will be offset by positive trends in LED components, says Cree. Although the rate has slowed due to lower spending and new construction, Cree forecasts continued double-digit growth in LED lighting, driven by continued adoption.

"LED lighting is in a position to benefit from the [US] federal government's focus on energy-efficient products as part of the economic stimulus package,"

says chairman & CEO Chuck Swoboda. "We are seeing continued momentum in LED lighting adoption, as evidenced by recent LED street-light projects announced in both Los Angeles and Pittsburgh." Cree's LED component revenue is targeted to rebound, with double-digit growth in both the XLamp and high-brightness LED component product lines, driven by commercial lighting and LED video screens.

However, Swoboda says success in fiscal Q4 will be partially contingent on Cree's ability to ramp production for several targeted high-growth LED component and lighting product areas (after receiving Energy Star qualification in early April for its LR6, LR5, and LR4 families of LED downlights). Hence, to support new product introductions and capacity expansion, during the quarter Cree is planning to increase both R&D spending (by 10%) and capital spending (up to \$10-15m, mainly for capacity increases in China and the continuing transition of LED chip production to 4" SiC wafers). Cree is planning to increase inventories in LED components and lighting products to be able to take advantage of spot business opportunities.

Swoboda says that, to cut product costs further, Cree is continuing to focus on several key activities, including more yield improvements at the LED chip and component level, the introduction of lower-cost LED product designs, and the transition of LED chip production to 4" wafers (on track to account for over half of chips made by the end of fiscal Q4).

To further boost gross margin, Cree is also targeting higher factory utilization and increased off-shore production (in China). This should help to offset a less favorable LED component product mix and a more aggressive pricing environment as competitors try to shift their focus from mobile and automotive to new applications such as LED lighting.

Regarding non-LED products, revenues for power and RF devices are expected to fall by \$2m from the exceptionally high level in fiscal Q3. Nevertheless, Swoboda says that Cree's focus over the next couple of quarters is to continue to build the customer base for SiC power devices as it focuses more on new products, which should improve the operating margins for this sector.

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

**LED lighting is in a position to benefit from the [US] federal government's focus on energy-efficient products as part of the economic stimulus package**

## BlueSpan installs first LED street lights in Portugal using Lumileds' LUXEON Rebel LEDs

LED lighting provider BlueSpan has developed and implemented the first solid-state street lighting solution in Portugal along the Fidalgo Apendiz in Pombal City using LUXEON Rebel LEDs made by Philips Lumileds of San Jose, CA, USA.

The new street lights are about 60% more efficient than the most common high-pressure sodium lamps, which were initially considered to replace the existing mercury vapor lamps. A design based on LUXEON Rebel LEDs that consumes less than 80W of power was selected due to the energy savings, high efficiency, uniform light distribution and long lifetime that could be delivered, says Philips Lumileds. The new street lights will not only reduce energy consumption but will also begin the process of removing



**BlueSpan's new street light, which use LUXEON Rebel LEDs.**

lighting containing mercury from Pombal City, says the mayor, Narciso Mota.

The street lamp's design was the result of a cooperative development effort between Philips Lumileds and optics expert Fraen. Working closely with teams from BlueSpan and LED lighting component dis-

tributor Future Lighting Solutions, the complete system came together in a very short period of time, Philips Lumileds says.

With a new optical solution that ensures uniformity and reduces glare, a correlated color temperature tuned for the environment, and a seven-year warranty, the new street lamp is being considered for broader implementation through the country, it is claimed.

"Implementation in Portugal is being expanded, with new installations in 40 different cities starting in May," confirms BlueSpan's general manager David Marques. "We see national conversion to solid-state technology as a realistic goal over the next several years."

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

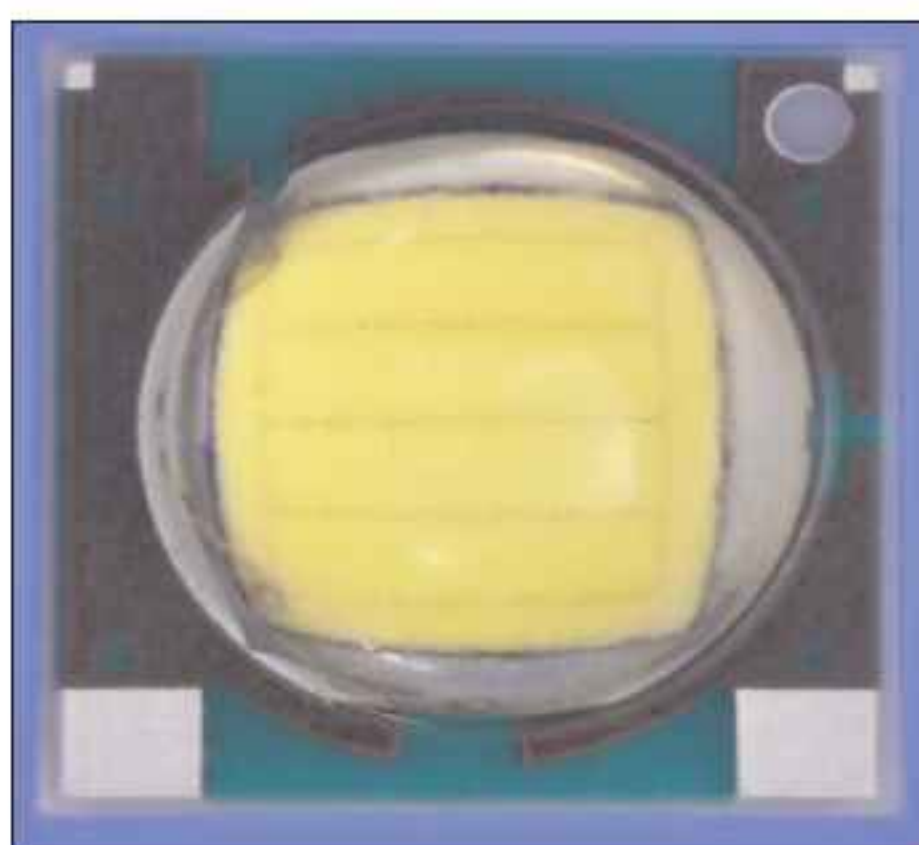
[www.futurelightingsolutions.com](http://www.futurelightingsolutions.com)

## Cree demos record-efficiency 132lm/W cool-white LED, giving 345lm at a drive current of 1 Amp

At LIGHTFAIR International in New York (5-7 May), Cree Inc of Durham, NC, USA demonstrated the newest addition to its lighting-class XLamp LED family.

The cool-white XLamp XP-G provides luminous flux of 139 lumens and efficacy of 132 lumens per Watt at 350mA. Driven at a current of 1A, it produces 345 lumens, which is 37% brighter and 53% more efficient than the brightest of Cree's existing XR-E LEDs. The XP-G has what is claimed to be the highest lumen density of any available lighting-class LED, and is based on the XLamp XP family package.

"The XLamp XP-G again raises the level of performance available from our XLamp LED family," says Paul Thieken, marketing director LED components. "This product is



**Cree's XLamp XP-G LED.**

designed for customers requiring the highest levels of brightness and efficacy," he adds.

Cree is currently taking sample requests for the XP-G, targeting commercial availability in third-quarter 2009.

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

## Mouser and Osram sign agreement

Mouser Electronics Inc of Mansfield, TX, USA has signed a distribution agreement with Osram Opto Semiconductors GmbH of Regensburg, Germany.

Mouser's initial stock of Osram products includes high-powered, mid-powered and standard LEDs, as well as infrared and sensor products.

Specifically, Mouser is stocking Osram's Golden DRAGON Plus family. Available in a full white color spectrum and a broad color portfolio, the 1-3W LEDs can be used for indoor or outdoor lighting applications. Mouser is also stocking Osram's six-lead MULTILED, which enables the driving of each LED chip within a package individually to create any desired color (including white) for a wide range of applications, including full-color video walls, signage, general lighting and backlighting.

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

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

## IN BRIEF

## Cree earns Energy Star qualifications for LED downlights

Cree has been awarded Energy Star qualifications for its LED downlights. The product line (including the LR6, LR5 and LR4) has demonstrated LED lifetime and fixture efficacy that qualifies for the stringent commercial rating, as well as the residential rating.

Energy Star is a joint program of the US Department of Energy and the Environmental Protection Agency to help consumers and organizations save money and protect the environment by promoting energy-efficient products. Products earning the commercial Energy Star qualification must meet extended lifetime criteria, which is 40% longer than residential standards.

"Being rated for both commercial and residential applications is especially significant, since more than three-quarters of the LED lighting we are deploying today is in commercial installations," says Cree LED Lighting president Neal Hunter. "Cree also provides the highest color rendering of any Energy Star-qualified LED downlight," he claims. "In stark contrast to compact fluorescent devices that contain toxic mercury, Cree's non-toxic LED fixtures deliver better efficiency and render colors."

Cree's LR6 is qualified in two color temperatures (2700K and 3500K) and has efficiency of over 54lm/W with lumen output of 650lm — higher than any other qualified recessed downlight, it is claimed. The LR6 was the first recessed downlight to receive the Energy Star commercial qualification.

Cree's LR4 and LR5 recessed downlights are qualified in two color temperatures: 2700K with a CRI of 94; 3500K with a CRI of 91. The LR4 is available in two shield angles: 15° and 30°.

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

## Chapel Hill joins LED City program

The Town of Chapel Hill (home to the University of North Carolina—Chapel Hill) has joined the LED City initiative, an international community of government and industry parties initiated by LED maker Cree Inc of Durham, NC in December 2006 to evaluate, deploy and promote LED lighting for municipal infrastructure. Chapel Hill joins program members Raleigh, NC, Ann Arbor, MI, Austin, TX, Anchorage, AK and Indian Wells, CA in the USA, Toronto and Welland in Canada, Tianjin in China, and Torraca in Italy.

Chapel Hill has installed LED streetlights along the high-profile 100 block of Franklin Street (one of the town's landmarks). Ten high-pressure sodium lights have been replaced to evaluate extending LED street lighting in Chapel Hill. Feedback on lighting quality is being sought from residents during the 12-month pilot program.

"Joining Cree's LED City initiative is an important part of Chapel Hill's commitment to reducing its carbon footprint and becoming a fully sustainable community," said mayor Kevin Foy at a ceremony during Chapel Hill's Earth Action Day 2009. "By replacing low-pressure sodium street lights with LEDs, Chapel Hill can reduce energy consumption for street lighting, which we hope will positively impact our budget as well as our carbon emissions."

In 2006, Chapel Hill became the first US municipality to commit to a 60% cut in carbon dioxide emissions (below 2005 levels) by 2050 through the Carbon Reduction Program. The council authorized the pledge to reduce carbon dioxide emissions from town municipal operations on a per capita basis, beginning with an initial goal of 5% by 2010.

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

## Cree claims smallest ANSI-compliant warm/neutral-white LED bins

Claiming to be the only LED maker to offer lighting-class LEDs in the entire ANSI color space, Cree has announced expanded binning for its XLamp XP LED family.

The firm is sub-binning its entire warm/neutral-white color space for XP-E and XP-C LEDs into what it reckons is the industry's smallest warm-white bins, now available to order with standard lead times. Cree has also standardized two cool-white bins for the XP family covering the ANSI-defined 5700–6500K color space (mainly for outdoor lighting).

"By offering smaller bins (that are more in line with traditional lighting expectations) we can better serve our customers' lighting-class LED needs," says Paul Thielen, marketing director LED components. "These new XLamp XP LED bins are 75% smaller than before, allowing customers better control, color and consistency."

"Noticeable color differences among similar white-light sources could reduce the visual aesthetics

of the lighted environment," says Dr Nadarajah Narendran, director of research at Rensselaer Polytechnic Institute's Lighting Research Center. "Our previous research, sponsored by ASSIST, has shown that smaller bins offer improved color consistency among LED lighting fixtures."

The ANSI C78.377-2008 standard outlines eight quadrangles on the black-body locus, covering the cool-white to warm-white color space. The US Department of Energy cites this standard in its ENERGY STAR Solid State Lighting 1.1 criteria.

Cree adopted the proposed ANSI color space for warm and neutral white in 2007, nearly a year before the C78.377 standard was formally published. Upon publication, Cree offered four sub-bins within each ANSI quadrangle. Now, each warm/neutral ANSI quadrangle is sub-divided into 16 discrete bins—each 75% smaller than previously offered and 94% smaller than the ANSI C78.377-standard.

## Universities of Miami and Alaska join Cree LED University program

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA says that both the University of Miami and the University of Alaska at Anchorage (UAA) are joining the LED University program.

Launched in April 2008, the LED University initiative is an international community of universities working to evaluate, deploy and promote the adoption of energy-efficient LEDs across their campus infrastructures (in areas such as offices, student housing, parking garages, walkways and streets). The aim is to save energy, protect the environment, reduce maintenance costs, and provide better light quality for improved visibility and safety. The University of Miami and UAA join inaugural participant North Carolina State University as well as University of California at Santa Barbara, the University of Arkansas, Marquette University, the University of Notre Dame, University of California, Davis, and Madison Area Technical College (MATC) in the USA, as well as Tianjin Polytechnic University in China.

The University of Miami has already installed 20 BetaLED LED-way pole lights on walkways on the main campus. It is also retrofitting LED lighting at various interior locations such as classrooms. LED lighting pilot installations are already saving as much as 70% on energy used for lighting conference rooms and hallways.

"With new LED lighting on our main campus, we achieve far better area illumination, enhancing visibility and safety at night," says Humberto Speziani, VP business services. "The University of Miami is working toward 'greener' facilities, and we continue to evaluate new technologies, such as LED lighting, for both interior and exterior applications," he adds. "The university intends to monitor the performance of LED lighting and other sustainable technologies as they continue to advance."



Walkway at the University of Miami.

UAA began converting lighting applications to LEDs five years ago, starting with signage, specialty lighting, aisle lighting in lecture halls and theater stairway lighting. It recently completed a parking lot pilot with seven BetaLED fixtures, and is evaluating 14 BetaLED fixtures for parking garages and covered walkways. UAA is cutting its energy consumption for the parking lot and garage by about 60% compared with the high-intensity discharge (HID) lights that were replaced. It is also evaluating LED lighting for recessed lighting in stairwells and mechanical rooms, walkway bollards and parking lot lights for its new Health Science Building.

"We're achieving better visibility and significant energy savings, and anticipate significantly reduced maintenance costs for the life of the LED fixtures, which can be 25 years," says Chris Turletes, associate vice chancellor for facilities and campus services. "We are standardizing on LED lighting in the applications where we can achieve these dramatic benefits," he adds.

"Lighting at UAA is a major focus for visibility and safety, especially during Anchorage's long winter nights," says Deb Lovig, Cree's LED programs manager. "UAA joins a prestigious group of progressive institutions that are promoting and deploying LED lighting as each works toward increasing energy savings, protecting the environment, reducing maintenance costs and providing better light quality."

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

### IN BRIEF

#### Bridgelux promotes Barnby to drive sales of LED light sources

Bridgelux Inc of Sunnyvale, CA, USA has promoted David Barnby to VP of worldwide sales, managing its worldwide sales team and distribution network and reporting directly to CEO Mark Swoboda.

"David's expertise and strategic vision will enable our global sales and distribution network to drive Bridgelux's penetration of the worldwide lighting market," says Swoboda. "Since joining Bridgelux, David has played an instrumental role in increasing the company's sales and customer base in Europe, Middle East and Africa (EMEA)," he adds.

Bridgelux recently expanded its product portfolio beyond power LED chips (based on ITO/InGaN) to include LED arrays — a single LED light source designed specifically for the lighting market. The firm is focusing on driving sales of its LED array product family, targeting fast-growing applications such as replacement lamps (bulbs), street lights, and track and down lights. LED arrays simplify and reduce the cost of lighting design while creating new luminaire design possibilities.

Based in Paris, Barnby has more than 20 years of experience managing and growing business opportunities in Europe for high-tech Silicon Valley firms. Prior to joining Bridgelux, he was the EMEA VP of sales & marketing for Pinnacle Systems (the consumer division of Avid Technology), responsible for managing the consumer IT retail and distribution channels across EMEA. He also held general management, sales and marketing positions at HP, including EMEA and worldwide responsibility for its optoelectronic and RF semiconductor products (Components Group).

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

## IN BRIEF

## Opnext launches miniature red laser for pointing systems

At the SPIE Defense, Security, and Sensing event in Orlando, FL, USA (13–17 April), optical component, module and subsystem maker Opnext Inc of Fremont, CA, USA launched the new 5mW, 639nm visible red SBA635CEL0510 miniature laser module for pointing systems, suitable for industrial, defense and security applications.

The miniature laser module represents a new platform to integrate Opnext's 3.8mm TO-38 laser diodes into a small form factor for incorporation into compact pointing systems.

The 3.8mm diameter by 11mm length of the miniature laser module delivers clean elliptical beams less than 10mm in diameter at a target distance of 10m with high bore sight accuracy, says the firm.

Opnext uses a stainless-steel housing to ensure strength and employs unique telecom-qualified manufacturing processes to assemble the module. The rugged device is



hence capable of sustaining a shock of more than 1500 times gravity. Also, due to a low threshold current, the miniature laser module allows applications that demand long battery lifetime.

"Our new miniature laser module allows our defense and security customers to implement light-weight, battery-efficient, compact aiming devices that can be deployed in tough environments," says Bob Murphy, director of business development North American Sales.

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

## DARPA selects Pranalytica to develop beam combining for QCL arrays

Pranalytica Inc of Santa Monica, CA, USA, which manufactures quantum cascade lasers and laser-based trace gas detection equipment for industrial, environmental, military, and security applications, has been selected by the US Defense Advanced Research Projects Agency (DARPA) Small Business Innovative Research (SBIR) program to participate in Phase I of the Beam Combining of High Power Quantum Cascade Laser (QCL) Arrays project for the US Army Aviation and Missile Command (AMCOM).

The project was created to fill the need of the Department of Defense (DoD) for directional infrared countermeasures (DIRCM), advanced stand-off chemical sensors, and laser radar (LADAR). Potential non-military applications include DIRCM protection of civilian airliners from shoulder-fired missiles, detection of toxic industrial gases, and atmospheric pollution monitoring.

"Pranalytica is committed to providing breakthrough technologies and applications to enhance the capabilities and safety of our troops in today's dynamic and high-tech wartime environments," says founder, president & CEO Dr C. Kumar N. Patel. "Beam combining of high-power quantum cascade laser arrays is a step forward in protecting airborne assets from shoulder-fired missiles (also called man-portable air-defense systems, MANPADS), detecting harmful elements in the field, and creating a virtual picture of the combat area. All these applications help produce a safer and more secure environment," he adds.

The SBIR's first phase aims to demonstrate high-power QCL arrays while maintaining good beam quality. Specifically, Phase I calls for fabricating thermoelectrically cooled lasers with an average power of 200mW and at



**Pranalytica high-power continuous-wave room-temperature quantum cascade laser system.**

least 4% wall-plug efficiency (WPE), and planning for combining them into a 1W module. Phase II calls for extending the approach to average power levels of more than 5W.

"Pranalytica has already developed a 3 Watt continuous-wave room-temperature laser running at over 10% WPE, which dramatically exceeds Phase I goals, and is in principle already able to satisfy the literal Phase II goals with simple polarization beam combining of only two QCLs," says Patel.

"However, we will fulfill the spirit of the SBIR and combine multiple high-power emitters, thus providing various DoD components with an extensible method of creating very high-power QCL modules, exceeding 10 Watts," he adds.

Pranalytica claims to be the world's only supplier of complete, fully packaged, turnkey high-power QCL systems. As an integrated laser structure and system designer and manufacturer, it offers in-house capabilities to improve and modify its standard systems to meet diverse customer requirements, starting with the fundamental QCL design through to system-level issues.

● Pranalytica exhibited at the 2009 Defense, Security, and Sensing conference in Orlando, FL, USA (13–17 April).

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

## Bookham targets 100W 808nm laser diode bar at defense and security applications

At the SPIE Defense, Security and Sensing event in Orlando, FL, USA (13–17 April), optical component and module maker Bookham Inc of San Jose, CA, USA launched a high-power 808nm laser diode bar that can enable direct energy laser systems and range-guided imaging for defense and security applications. The 100W bar also supports diode-pumped solid-state (DPSS) laser systems, including rod and slab lasers, as well as direct diode systems for flat-panel displays and silicon annealing.

The bar on microchannel cooler provides a rated power of 100W in continuous-wave (CW) and hard-pulse on/off operation. A wall-plug efficiency of 59% and a 50% fill factor enable higher power output from a larger emitter area. The



**Bookham's 100W 808nm laser bar.**

extended wavelength range also includes 793nm, which is important for 'eye safe' applications based on thulium laser systems.

"This new 100W laser diode bar, together with the 60W conductive-

cooled bar released at Photonics West 2009, continues our strength in 808nm products and enhances our offering to high-value markets such as defense and security," says senior product line manager Christian Naumer. "We work closely with our customers to identify new applications for their laser systems and ensure that our products meet their requirements," he adds.

Like all Bookham high-power laser products, the front facet of the bar is protected against catastrophic optical damage by the E2 mirror passivation process. Also, the use of telecom-grade AuSn (gold tin) hard solder suits demanding industrial and defense applications in CW and hard-pulse operation mode.

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

## Alight and ULM partner on volume VCSEL production

Alight Technologies ApS of Copenhagen, Denmark says that Philips Technologie GmbH U-L-M Photonics (Philips U-L-M Photonics) is to provide contract volume manufacturing for its 1300nm photonic bandgap vertical-cavity surface-emitting lasers (PBG-VCSELs).

Via its own prototyping facilities, Alight currently has a high-speed 1300nm PBG-VCSEL under development (for limited sampling from Q3/2009). The firm presented its latest results at the Optical Fiber Communication conference (OFC 2009) in San Diego, where Alight and U-L-M co-exhibited.

Alight acquired Infineon Technologies' dilute-nitride 1300nm VCSEL platform in September 2005, with the aim of meeting the increasing demand for high-power and high-speed single-mode VCSELs operating at 1300nm. The combination of a qualified material platform and the add-on PGB technology creates unique opportunities not only for Alight but also for the firm's partners, it reckons.

Alight initially targets applications such as 10 Gigabit Ethernet LR/LRM and up to 10km links for 8Gb/s Fiber Channel, claiming that its PBG VCSEL technology enables an increase in the single-mode output power or improvement in the characteristics of high-speed VCSELs.

"We are targeting excellent high-temperature performance whilst offering lower power consumption and module flexibility, and expect that this will make our 1300nm PBG VCSEL a candidate to replace edge-emitting lasers in next-generation modules for datacom and telecom applications," says CEO Dirk Jessen. Working with U-L-M as a foundry partner gives proven volume manufacturing capability, he adds, as well as shortening the time from prototyping to products.

"Alight's VCSEL technology platform in combination with the photonic bandgap structures will enable 1300nm VCSELs as a complementary solution to edge-emitting lasers," adds general manager Dr Martin Grabherr.

U-L-M is already a volume manufacturer of a complete portfolio of high-speed multi-mode VCSELs emitting at a wavelength of 850nm for the datacom market (presented at OFC 2009) and has delivered short-wavelength single-mode VCSELs for non-communications applications such as sensing since 2002.

Now, as well as contract manufacturing of Alight's 1300nm PBG-VCSEL, U-L-M will also participate in the reliability testing. "We know that reliability is key to the success of 1300nm VCSELs, and we have set-up a reliability testing program together with Philips U-L-M Photonics," says Alight's CTO Dr Dan Birkedal.

"We have already demonstrated good reliability of our 2.5Gb/s PBG-VCSELs [for which initial results were presented at OFC 2006] due to the large oxide operation, and we expect that we will maintain the good reliability also in our 10Gb/s PBG-VCSELs," he adds.

[www.alight.dk](http://www.alight.dk)

[www.ulm-photonics.com](http://www.ulm-photonics.com)

## Firecomms joins OPASTCO to advocate POF for IPTV

In order to advocate the use of plastic optical fiber (POF) as a low-cost, high-margin medium for IPTV home networks and other enhanced service offerings, Firecomms Ltd of Cork, Ireland, which makes POF transceivers and visible-wavelength vertical-cavity surface-emitting lasers (VCSELs), has become a member of OPASTCO (Organization for the Promotion and Advancement of Small Telecommunications Companies).

OPASTCO provides its members with the regulatory, legislative and technical expertise necessary to navigate the telecom world by covering rural telecom policy, technical issues, member-run committees, education, knowledge-sharing, and networking.

"As rural telcos look to expand their service offerings into advanced areas such as IPTV, these companies face connectivity and resource challenges that are unique to smaller companies," says Lawrence Thorne, Firecomms' VP of

sales & marketing for the Americas.

According to Firecomms, as a low-cost optical alternative to copper cabling, POF offers the advantages of optical fiber without the challenges. Due to its ease of use, large core tolerances, and low costs, POF is enjoying significant growth in a wide range of applications, says the firm. According to market research by Information Gatekeepers, the market is estimated to be worth over \$1bn per year by the end of 2009.

POF was created for consumer, industrial, and automotive applications in which plastic fiber can be used more easily and at lower cost than copper or glass fiber, and is now used in millions of small-area networks, such as those in use in many car models, and is rapidly gaining ground in home network and point-to-point interconnection.

With data rates of up to 1 Gigabit, POF is a robust technology for 100Mb/s optical Ethernet and 250Mb/s optical FireWire in the

home. Its advantages over other home network transmission media (including small size, simple connectivity, quick troubleshooting, and immunity to electrical noise) means that telcos of any size can benefit from quicker, more flexible and cost-effective installations.

As a member of OPASTCO, Firecomms will be able to promote the use of POF in IPTV and home networking to other member firms. "Firecomms will be a resource to help these companies reduce installation time, maximize profits in installations with advanced services, and contribute to the reduction in service truck rolls," says Thorne.

"The company's POF solutions to in-home wiring provide OPASTCO members, who are now offering in-home networking services, a new option for the connection of home network components," says OPASTCO technical director John McHugh.

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

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

## Optical Ethernet transceiver demonstrated in IPTV set-top box

At the IPTV World Forum in London, Firecomms gave the first live demonstration of its Optical Ethernet OptoLock transceiver integrated into STMicroelectronics' newest HD IPTV STi7105 set-top box (STB) reference design.

OptoLock suits Fast Ethernet applications with stringent quality-of-service requirements such as residential IPTV gateways, set-top boxes, and hubs, Firecomms says.

The firm says that OptoLock is an easy-to-use, low-cost transceiver housing for instant termination of bare POF. The plugless connector enables the optical fiber to be cut and terminated to the exact required length on site, allowing consumers to quickly and easily connect POF ports directly into the STB.

"Although we have seen many thousands of POF connections installed with external network adapters, this integration step and

demonstration illustrates to set-top box manufacturers the level of maturity that POF has reached within the IPTV home network," says Hugh Hennessy, VP of sales & marketing. "With this increased level of interest in this low-cost embedded solution, we are hopeful to announce first platform releases by leading set-top box manufacturers in the coming months," he adds.

"The STi7105 is a new, advanced decoding system-on-chip targeted at next-generation high-definition cable, terrestrial, satellite, DSL, IP, and hybrid set-top boxes," says Jean-Michel Goiran, IP-STB business development at STMicroelectronics. "The integration of OptoLock into our STi7105 reference design further expands the flexibility of the chip in facilitating developments in next-generation home network and set-top box solutions."

● Firecomms also announced the compatibility of OptoLock with the Ethernet PHY (physical layer chip) integrated into Broadcom's BCM7405 IP set-top box system-on-a-chip.

"This announcement is a significant milestone in our efforts to enable integration of our OptoLock transceivers across set-top box platforms," says chief technology officer John Lambkin. "Integration of POF ports directly into the set-top box enables reductions in bill of material costs as compared to external network adapters."

"With an integrated PHY capable of driving both copper and optical ports, our collaborated solution enables deployment efficiencies that allow set-top box manufacturers, service providers and consumers in Europe to quickly realize the benefits of home networking," says Aidan O'Rourke, Broadcom's senior director of Product Marketing.



# QD Laser launching 10Gb/s 1310nm quantum dot laser

QD Laser Inc of Tokyo, Japan, which was founded in April 2006 with funding from Fujitsu Ltd and Mitsui Ventures, is to launch what it claims will be the world's first commercial quantum dot Fabry-Perot (QD-FP type) laser operable at 10Gb/s, available from early June.

Currently, in view of environmental concerns, the telecoms industry requires products that feature low power consumption and small form factor, in keeping with the trend towards increasingly faster transmission speeds (resulting in higher power consumption).

Given these circumstances, optical module and system vendors are experiencing difficulties in controlling temperature in products that feature continually smaller form factors and faster data transmission rates.

By employing proprietary quantum dot laser technologies developed in collaboration between Fujitsu Laboratories Ltd and the University of Tokyo, QD Laser claims to be first to develop and commercialize temperature-insensitive 1310nm QD lasers operating at 2.5Gb/s (Figure 1) in a TO-CAN package as well as the QLF-13 series 10Gb/s high-speed version, for applications such as fiber-to-the-home (FTTH), optical local-area networks (LANs), and Fiber Channel for fiber-optic communications.

Compared to conventional lasers, QD Laser has reduced power consumption by about 30% for lasers used in optical modules at 85°C. Furthermore, the firm's realization of high-temperature operation at 100°C enables high-density packaging, resulting in a reduction of the overall power consumption of optical telecoms systems.

By leveraging the temperature-insensitivity characteristics, QD lasers have the potential to eliminate the need for automatic power control (APC) features, while also being able to function at temperatures ranging from room temperature to 100°C without complex bias current adjustments. This hence

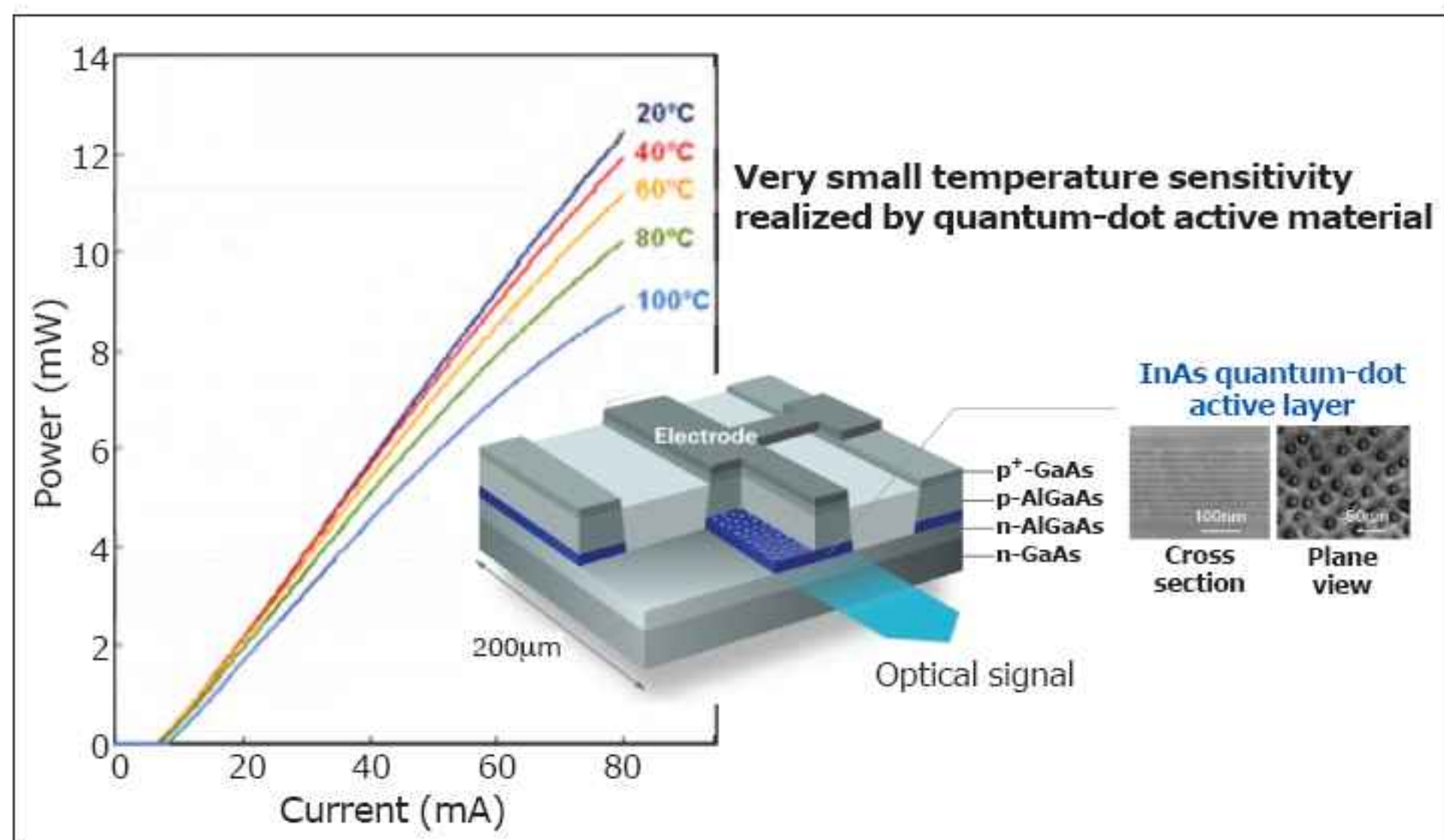


Figure 1: Structure of QD FP laser and LI curve in 10Gb/s operation.

enables cost reductions through fewer components and fewer adjustment processes.

Regarding temperature insensitivity, Figure 2 shows characteristic temperatures ( $T_0$ ) of the 10Gb/s QD-FP, which achieved a characteristic temperature of 500K at 20–100°C, a world record for a commercialized 1310nm semiconductor laser and approximately ten times higher insensitivity to temperature compared to conventional lasers.

At the Optical Fiber Communication conference (OFC) in San Diego, CA in late March, QD Laser presented two papers:

- 'Temperature-stable 10.3Gb/s operation of 1.3µm quantum dot FP lasers with GaInP/GaAs gratings' (on 10Gb/s QD-FP lasers);

- 'High-speed and temperature-insensitive operation in 1.3µm InAs/GaAs high-density quantum dot lasers' (on 2.5Gb/s QD-DFB lasers).

Engineering samples of temperature-insensitive QD-DFB (distributed feedback) lasers — operable at 2.5Gb/s for long-reach transmissions — will be available from early June, and commercial products from early 2010.

The research was conducted as part of the following projects:

- the Special Coordination Funds for Promoting Science and Technology of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan;

- the 'Photonic Network Technology Project' contracted to the Opto-electronic Industry and Technology Development Association

(OITDA) by the New Energy and Industrial Technology Development Organization (NEDO) of Japan; and

- the 'NEDO Grant for Technological Development by R&D Venture Businesses'.

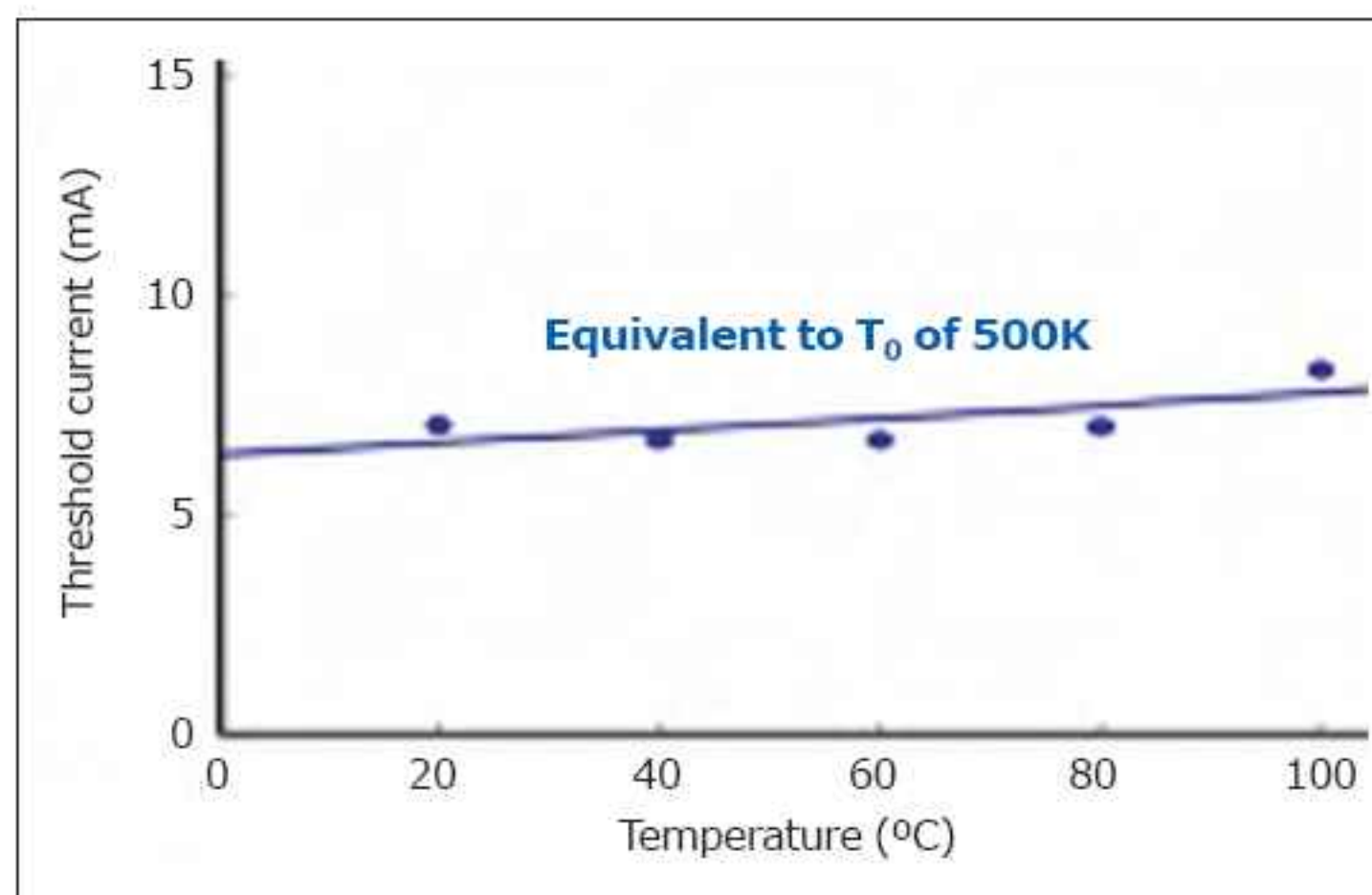


Figure 2: Eye diagram of QD-FP laser at 10Gb/s.

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

## IN BRIEF

## 45Gb/s differential limiting amplifier

GigOptix has announced the availability of a 45Gb/s differential limiting amplifier developed in partnership with a leading Japanese ROSA (receive optical sub-assembly) manufacturer. The GX3440 is being sampled by the development partner and will be available to open sampling later in second-quarter 2009.

GigOptix says that it was chosen to design the 45G/s amplifier because of its capability of providing high-speed Rx amplifier designs that optimize high sensitivity, low power consumption, wide bandwidth, and output voltage. The GX3440 operates with DC coupled differential input and 700mVpp differential output.

Applications include 45Gb/s DPSK (differential phase-shift keying) receivers, 45Gb/s DQPSK (differential quadrature phase-shift keying) receivers, and high-speed test & measurement.

"There is nothing quite like the GX3440 available in today's market and that makes this development partnership a big win for GigOptix," reckons chief technology officer Andrea Betti-Berutto. "We met our commitment to turn this design around in record time and delivered new devices to meet a very tight market schedule," he adds. "By working with a leader in this segment, we are optimistic about the potential of this product, as the GX3440 is targeted for applications which are gaining a lot of traction in the market."

Ovum's most recent market forecast ('WAN optical components unit volume, revenue, and ASP history and forecast, 1998-2013', August 2008) projects that the volume of 40G receivers shipped will grow at a compound annual growth rate (CAGR) of 74%, from 20,000 units in 2009 to 183,000 in 2013.

## GigOptix cuts salaries to save \$900,000 annually

GigOptix Inc of Palo Alto, CA, USA, a fabless provider of III-V-based modulator and laser drivers for telecom, datacom, Infiniband and consumer optical systems, has implemented a company-wide salary reduction plan as part of its ongoing efforts to reduce operating expenses.

Operating expenses for 2008 were \$13.2m, up from \$7.7m for 2007, due mainly to December's merger with Lumera Corp of Bothell, WA (which makes polymer electro-optic modulators) and the acquisition in January 2008 of Helix Semiconductors AG of Zurich, Switzerland (which makes transimpedance amplifiers, limiting amplifiers, and VCSEL drivers).

**By preserving personnel instrumental to our organization and asking everyone to take less, we can continue to focus on meeting our financial goals**

The salary reduction plan is designed to reduce labor costs and improve the firm's financial performance in the face of an uncertain economic environment.

To make expense savings of \$900,000 on an annualized basis, salaries have been cut by 18% for CEO Dr Avi Katz, 15% for the other executive officers, and 10% for other employees. In recognition of their foregone salary, each employee will receive a special grant of stock options equal to 10% of their outstanding options.

"Fiscal responsibility is an important key to our ongoing success, and cost reduction is imperative in today's climate to ensure that we maintain the strongest financial position possible for our shareholders," says Katz. "By preserving the personnel who are instrumental to our organization and asking everyone to take less, starting at the top, we can continue to focus on meeting our short- and long-term financial goals," he adds.

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

## GigOptix doubles Q1 revenue year-on-year

For first-quarter 2009 (ended 5 April), GigOptix Inc of Palo Alto, CA, USA, which designs optical modulators, drivers and transimpedance amplifier (TIA) ICs based on III-V materials, expects to report revenues of about \$4.4m, up 162% on \$1.68m a year ago.

On an unaudited non-GAAP basis, as if the results of Lumera Corp of Bothell, WA (which makes polymer electro-optic modulators, and was acquired on 9 December) were included from the start of 2008, Q1/2009 revenue would still be up 103% on \$2.17m a year ago.

The increase is a direct result of the continuing consolidation and integration of GigOptix's acquisitions in 2008 (including Helix

Semiconductors AG of Zurich, Switzerland, which makes transimpedance amplifiers, limiting amplifiers, and VCSEL drivers, in January) as well as growth of the GX, HX, LX, and iT product lines.

"The growth was initiated through the transactions we successfully completed in 2008 and the continued organic growth of our product lines," says chairman & CEO Dr Avi Katz. The first-quarter 2009 revenue reflects GigOptix's skill in combining synergistic businesses, he adds.

"Our mission is to continue to build top-line growth, while remaining focused on controlling our expenses," says Katz.

The firm expects to report full Q1/2009 results by 14 May.

# Thorlabs acquires opto component maker Covega from Gemfire

Photonics component maker Thorlabs Inc of Newton, NJ, USA has acquired optoelectronic component and subsystem maker Covega Corp of Jessup, MD from Gemfire Corp.

Founded in 1999 as Codeon Corp before changing its name in 2003, Covega is a vertically integrated maker of proprietary gain chips, semiconductor optical amplifiers (SOAs) and other indium phosphide (InP) based components and modules as well as lithium niobate (LiNbO<sub>3</sub>) technology.

Gemfire acquired Covega in February 2008. However, Gemfire says that it now wants to focus more on its integrated optical components and sub-systems (based on photonic lightwave circuits) for telecom and defense-related applications, which it makes at its headquarters in Fremont, CA, USA and in Livingston, Scotland, UK (formerly silica-on-silicon firm Kymata).

Also, last November, Gemfire ran short of cash in the wake of the stock market crash after a new investor decided against providing funding and a couple of large customers pushed out their orders (leading it to close its plants temporarily for two weeks).

"Covega comes to the Thorlabs family with a new suite of optical technologies that Thorlabs looks forward to offering to its diverse customer base," says Thorlabs' president & founder Alex Cable.

Covega's management team consists of industry veterans with experience from Lucent Technologies, Nortel Networks, Newport Corp, the US Naval Research Laboratory, Motorola, Honeywell, Bosch Telecom, and Optelecom. The firm's technology team includes pioneers in high-power lasers, optical amplifiers, and LiNbO<sub>3</sub> modulators, and expertise includes materials, device design, wafer growth and fabrication, processing, advanced E/O

device packaging, manufacturing, and system engineering. Covega has a 40,000ft<sup>2</sup> facility in central Maryland (including 18,000ft<sup>2</sup> of class 100 and 10,000 cleanroom facilities)

**Covega comes to the Thorlabs family with a new suite of optical technologies that Thorlabs looks forward to offering to its diverse customer base, says Thorlabs' founder Alex Cable**

10Gb/s and 40Gb/s zero-chirp and fixed-chirp intensity modulators, 10Gb/s modulators integrated with variable optical attenuators (VOAs), modulators integrated with drivers, and chirp-controlled phase modulators). Intensity modulators are based on Mach-Zehnder interferometers and are fabricated using titanium-indiffused LiNbO<sub>3</sub> substrates fabricated in-house. Modulators for emerging telecom applications, such as dual quadrature phase shift key modulation (DQPSK), are in development, and early samples are available.

Covega's single angle facet (SAF) gain chip solution is a high-power InP active waveguide gain element for external-cavity tunable lasers that provides broad bandwidth, high power, and stable operation.

Based on highly efficient multi-quantum well structures and proven six-sigma-based chip fabrication processes, the firm's

InP-based SOA products offer high-saturation power, high gain over a broad spectral bandwidth, and low noise figure (suited use in communication systems, instrumentation, photonics sensors, scientific applications, and fiber-optic gyros).

InP products — including booster optical amplifiers (BOAs), Fabry-Perot Lasers, broad-area lasers, and superluminescent diodes (SLD) — are designed for use in the 1050–1850nm spectral range, typically for telecoms, medical instrumentation, and sensor applications.

Consequently, after Covega's early focus on the telecom, datacom, and cable TV industries, more than a third of revenues now come from the defense, medical, industrial, sensing, test & measurement, and instrumentation industries.

**After Covega's early focus on the telecom, datacom, and cable TV industries, more than a third of revenues now come from the defense, medical, industrial, sensing, test & measurement, and instrumentation industries**

and E/O device packaging.

"We are committed to ensuring continued access to the broad array of products that Covega currently manufactures," promises Thorlabs' president Alex Cable.

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

Covega also provides fab-lite and fabless customers with turnkey vertically integrated InP and LiNbO<sub>3</sub> foundry services, including device design and modeling, wafer growth, chip and module fabrication,

# Advanced Photonix joins Georgia Institute of Technology 100G Optical Networking Consortium

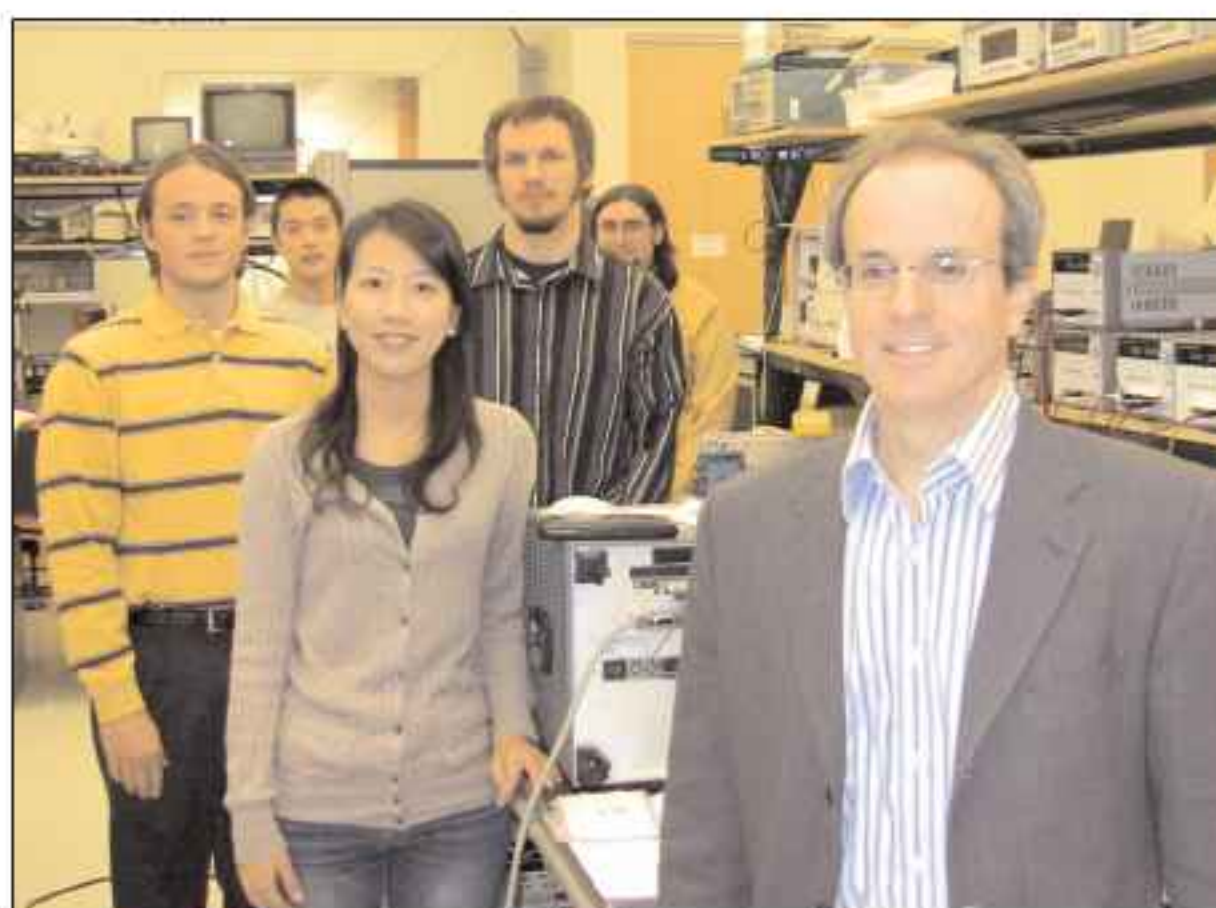
Through its subsidiary Picometrix LLC of Ann Arbor, MI, USA, Advanced Photonix Inc (which designs and makes silicon, InP- and GaAs-based photodetectors, subsystems, and terahertz instrumentation) says it has become a supporting member of the Georgia Institute of Technology 100G Optical Networking Consortium, which was formed in March.

In total, more than \$2.2m in support has been designated for the facility by the consortium's founding research members ADVA Optical Networking, Ciena, OFS, and Verizon and by supporting members Avanex, IBM, Narda Microwave East, Nistica, Picometrix, and RSoft Design Group. Advanced Photonix, via Picometrix, already manufactures 40G high-speed optical receivers.

The consortium will conduct research including 100G fundamental transmission studies and component assessments for high-speed network infrastructure. The facility will use the complementary capabilities of industry personnel to support the facility and to conduct research. A variety of network architectures will be studied in support of the upcoming IEEE 100G standards for short-reach, client-side transport in the local-area network and future IEEE standards for short-reach transmission over laser-optimized, multi-mode fiber in data centers.

Located in Georgia Tech's Technology Square Research Building, the facility's new 100G test bed and supporting simulation capabilities enable independent evaluation of optical and electronic signal processing strategies, new modulation formats and receiver technologies, high-speed silicon CMOS-based electronics, and classical/modern forward error correction, all in realistic optical fiber transport and electronic transceiver environments.

Construction on the consortium's 100G test bed started last July and



**100G Optical Networking Consortium co-director professor Stephen E. Ralph (foreground) together with Andrew Stark, Cheng Lin, Yu-Ting Hsueh, Ben Clarke, and Patrick Decker of his research group.**

was enabled by additional support from the Georgia Tech Office of the senior vice provost for Research and Innovation and the Georgia Research Alliance. The first test bed link, which will allow testing of new modulation concepts within a point-to-point link engineered for 10Gb/s systems, became fully functional last November.

Two additional milestones, including the creation of a long-haul DWDM mesh network environment exceeding 1000km, are scheduled to be met by this July, when the facility will be fully functional.

"The creation of this consortium at Georgia Tech enhances the competitiveness of our member companies, creating job growth in this critical area of communications and networking," says Stephen E. Ralph, the consortium's director and a professor in Georgia Tech's School of Electrical and Computer Engineering (ECE). "The faculty of Georgia Tech is uniquely able to advance under-

standing in signal processing, high-speed circuits, and optical components and systems," he adds. "This combination, together with the expertise of our industry researchers, will enable member companies to develop and demonstrate technical advantages and accelerate deployment of next-generation systems and services while simultaneously influencing the next-generation standards."

Historically, networking infrastructure has

migrated to systems with increased transmission capacity, allowing increased efficiency and the delivery of content-rich services, says Ralph. Advanced Photonix adds that a benefit of the consortium includes having industry leaders working together to support standards that may be implementable over the existing fiber infrastructure, leading to faster deployment of the new technology.

"This consortium is an excellent example of the industry and university collaboration necessary to develop and test the next-generation component technologies that will enable 100G optical transport on both the line side and client side," says Picometrix's president & general manager Robin Risser. "Close collaboration with consortium members will help accelerate our development and deployment of advanced 100G optical receivers," he adds.

"We are also a principle member of the Optical Internetworking Forum (OIF), which promotes the development and deployment of interoperable networking solutions and services and provides feedback to worldwide standards organizations," says API's CEO Richard (Rick) Kurtz.

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

**Consortium members will help accelerate our development and deployment of advanced 100G optical receivers**

## First all-optical silicon-based signal processing for transmission data rates above 100Gb/s

A collaboration between the University of Karlsruhe, Germany, IMEC in Leuven, Belgium, Lehigh University in the USA, and ETH Zürich in Switzerland has resulted in the first experimental proof of all-optical ultra-fast communication signal processing with silicon-based devices for transmission speeds above 100Gb/s (C. Koos et al, *Nature Photonics*, April 2009, vol 3, issue 4, p216). The achievement is claimed as a key step towards the development of complex silicon-based photonic integrated circuits (PICs).

All-optical signal processing is of particular interest for telecoms applications, where speed, power and cost are crucial. A key element is an optical waveguide with highly nonlinear and ultra-fast performance. Researchers from the University of Karlsruhe, IMEC (and its associated laboratory INTEC at Ghent University), Lehigh University, and ETH Zürich fabricated an optical waveguide structure by combining deep-ultraviolet lithography, standard CMOS processing and organic molecular beam deposition. This 'silicon-organic hybrid' (SOH) approach enables the fabrication of waveguides that pave the way towards all-optical processing.

A 4mm long SOH waveguide with a record nonlinearity coefficient of about  $105(\text{Wkm})^{-1}$  in the  $1.55\mu\text{m}$  telecom window proved the capability of the SOH concept. Record values predicted by theory have hence been confirmed experimentally for the first time. Based on these waveguides, all-optical demultiplexing of a 170.8Gb/s telecom signal to 42.7Gb/s was performed using four-wave mixing. This is claimed to be the fastest silicon photonic optical signal processing demonstrated to date. This experiment hence proved the viability of the SOH waveguides for all-optical processing of broadband telecom signals.

With the SOH approach, some inherent limitations of silicon could be overcome, say the researchers. Silicon-based technology, in particular silicon-on-insulator (SOI) technology, has already proven very successful for the fabrication of various passive linear optical devices such as filters. The development of ultra-fast active Si-based functionalities, such as all-optical switching, remained challenging due to the slow dynamics caused by unwanted non-linear effects in silicon. So far, the data rate achieved by using bare silicon waveguides was limited to only 40Gb/s.

The SOH approach overcomes this intrinsic limitation — thus enabling data rates above 100Gb/s — by combining the best of two worlds: mature CMOS processing is used to fabricate the waveguide, and organic molecular beam deposition is used to cover it with organic molecules.

These molecules efficiently transfer all-optical interaction without introducing significant absorption. The ability of the organic material to homogeneously fill the slot between the waveguides is a key feature of the deposition process.

The silicon circuits were designed by researchers at the University of Karlsruhe in a fabless way, and were fabricated through the ePIXfab service on IMEC's 200mm silicon photonics platform. ePIXfab is a European-funded initiative coordinated by IMEC to allow cost-effective fabless prototyping in wafer-scale silicon photonics technology for R&D. The service runs multi-project wafer shuttles in which designs from users worldwide share mask and processing costs.

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

[www.epixfab.eu](http://www.epixfab.eu)

[www.nature.com/nphoton/journal/v3/n4/abs/nphoton.2009.25.html](http://www.nature.com/nphoton/journal/v3/n4/abs/nphoton.2009.25.html)

## First 10Gb/s parallel optic module with 120Gb/s throughput

Avago Technologies of San Jose, CA, USA has launched a 10Gb/s parallel optics transmitter and receiver pair that can reach data throughput levels of up to 120Gb/s.

The AFBR-810BxxZ transmitter and AFBR-820BxxZ receiver high-density modules both leverage 12 independent channels and offer 10Gb/s per channel for an aggregate of 120Gb/s per link, and can support distances of up to 50m. Additionally, with minimal power consumption needs, they require only 2.4W per module.



**Avago's 10Gb/s parallel optics AFBR-810BxxZ transmitter and AFBR-820BxxZ receiver pair.**

Avago says that the high-speed parallel optic modules are based on a 'SNAP 12-like' pluggable form factor with an upgraded pin-out configuration to deliver what is claimed to be superior signal integrity with support for the new P-POD pin-out standard.

Both modules are also keyed to prevent mis-plugging with existing parallel optic modules.

Pricing for the AFBR-810BxxZ and AFBR-820BxxZ begins at less than \$1000 per pair in volume quantities.

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

## Eudyna launches next-gen PON and DWDM components

Eudyna Devices Inc of Yokohama, Japan is launching a range of new products for next-generation passive optical networks (PONs) and advanced DWDM applications.

Eudyna has long used its in-house technologies to provide components for next-generation broadband networks, such as 10Gb/s electro-absorption modulated lasers (EMLs), high-sensitivity PIN and APD (avalanche photodiode) receivers, as well as burst-mode trans-impedance amplifiers (TIAs) for PON applications.

Now, for high-end DWDM applications, Eudyna has applied its device technology to a unique coaxial-style 10Gb/s APD receiver employing a TIA plus integrated automatic gain control (AGC) that offers high gain and linearity. The integrated AGC functionality provides for a very robust optical signal-to-noise ratio (OSNR) performance across a wide range of input powers, Eudyna says. The

coaxial 10Gb/s APD receiver offers equivalent performance to that of existing coplanar packaged receivers but in a more compact and cost-effective form-factor, the firm claims.

On the transmitter side, Eudyna has developed a full-C-band tunable laser that has now been taken into production. Among its unique features is its capability to deliver output powers of up to 17dBm, which can be advantageous for advanced 40 and 100Gb/s transmission modulation formats such as DQPSK and DP-QPSK. The tunable laser will be offered in an OIF-compliant integrable tunable laser assembly (ITLA) module.

For next-generation PON applications, Eudyna is introducing the ELD5403QK/BH-V/W, which is a high-power 10Gb/s EML laser that fully meets with the emerging IEEE 802.3av 10GBASE-PR-D1,D3 or 10/1GBASE-PRX-D1,D3 standards. The output power is +4dBm minimum, the emission wavelength is

1575–1580nm, and the dispersion tolerance is up to 350ps/nm (corresponding to 20km for single-mode fiber). The generally available laser is provided in an XMD-MSA package with either an LC receptacle (ELD5403QK-V/W) or a fiber pigtail (ELD5403BH-V/W). The temperature range is 0–75°C for the -V version and –40°C to +90°C for the -W version.

Additionally, Eudyna is introducing a TO-can APD receiver for the GPON ITU-T G.984.2 Class C+ application, which builds on the firm's expertise in high-sensitivity APD receivers and burst-mode TIAs. The APD receiver for Class C+ is available for immediate sampling.

"By working closely with our key customers, Eudyna has been able to introduce a range of unique products that address new market needs," says Jane Li, general manager & executive VP of subsidiary Eudyna USA in San Jose, CA.

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

## SFF transponder with electronic dispersion compensation

Optical component and module maker Bookham Inc of San Jose, CA, USA has launched the TL9000M, a 300-pin small-form-factor (SFF) transponder with electronic dispersion compensation (EDC) that should enable increased deployment flexibility and simplification of network design rules, delivering cost savings for network equipment makers.

The 10Gb/s TL9000M combines the size and performance benefits of Bookham's existing SFF 300-pin transponder with MLSD-based (maximum likelihood sequence detection) EDC to provide significant tolerance to chromatic dispersion (CD), polarization mode dispersion (PMD) and nonlinearities inherent in telecom networks. This should enable product deployment over a greater proportion of installed fiber routes, including those that will not currently support required spans of 80km at 10Gb/s without equaliza-



**TL9000M**  
300-pin SFF  
transponder

tion. The transponder should also eliminate the need for expensive pre-characterizing of fiber paths for poor PMD performance.

The inclusion of MLSD-based EDC into Bookham's small-form-factor transponder should allow network engineers to use the technology for all deployments, says Chris Clarke, VP strategy & chief engineer of the Telecom Division. "Our InP building blocks within the transponder allow the real estate to incorporate electronics that give our products a significant advantage in terms of performance," he claims. "Combining

this with the cost, size, and unrivalled power dissipation elements, Bookham will bring this technology from a niche application to potential industry-wide deployment."

The transponder incorporates the ClariPhy CL1012 clock and data recovery (CDR) integrated circuit with EDC. The IC uses MLSD technology in a low-cost, low-power CMOS process. The transponder is smaller than competing EDC-enabled offerings and offers lower power dissipation, the firm claims.

Bookham's existing TL9000 (launched in 2007) is much smaller than competing large-form-factor tunable 300-pin transponders; the new transponder retains this small-form-factor transponder footprint, enabled through the combination of Bookham's InP modulator technology and the ClariPhy low-power-dissipation single-chip EDC solution.

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

## First SMT device for 40Gb/s networks

Coinciding with March's Optical Fiber Communication (OFC 2009) event in San Diego, CA, RF product maker and foundry services provider TriQuint Semiconductor of Hillsboro, OR, USA has launched two new driver amplifiers, including what it claims is the first surface-mount technology (SMT) device for next-generation 40Gb/s optical networks, plus a smaller surface-mount driver amplifier with improved performance for the 10Gb/s optical communications market.

The TGA4943-SL is first to combine multiple amplifiers and filters within a surface-mount package, providing designers easier assembly for 40Gb/s optical networks.

Optimized to work with major optical modulators, TriQuint's new driver amplifier provides high output drive capability, superior edge rates and excellent signal-to-noise ratio, the firm claims.

"Power consumption is appreciably better," says Optical Networks Product marketing manager Mike Tessaro. "It consumes only 2.1W — about 50% of comparable optical network solutions."

Based on the heritage of established driver amplifiers including the TGA4953 and TGA4954 for 10Gb/s optical networks, the new driver amplifier module was developed in cooperation with major transceiver and modulator manufacturers specifically to meet the performance requirements of the DQPSK (differential quadrature phase shift keying) modulation standard, which enables high-speed 40Gb/s optical networks. Higher-speed networks with greater bandwidth will allow operators to more cost-effectively meet growing bandwidth demands, says Tessaro.

Market research firm Strategy Analytics has noted that, despite global economic concerns, the continuing expansion of consumer demand for bandwidth, driven by growing social networking and other data-intensive applications,

will move telecom companies toward faster, more efficient high-bandwidth systems.

"Telecom companies can't afford to stop investing in the rollout of 10Gb/s and 40Gb/s networks," says Asif Anwar, director of Strategy Analytics' GaAs and Compound Semiconductor Technologies Service. "The long-haul market in particular uses LiNbO<sub>3</sub> (lithium niobate) modulators, for which GaAs-based drivers offer the best performance. Being able to improve the performance of these drivers while reducing power dissipation and improving the thermal operation of the core components will be an important element to maintaining the momentum behind network rollouts," he adds.

"Strategy Analytics projects the overall growth for GaAs drivers will be 7% through 2012—growth in the 40Gb/s market will be even greater as the need for wider bandwidth on existing fiber networks promotes more efficient pulse transmissions schemes like DQPSK," says Anwar. "Based on our evaluation of the market, we believe TriQuint is a leader in developing optical driver amplifier technology."

TriQuint's new 8mm x 8mm surface-mount driver amplifier (TGA4956-SM) for 10Gb/s optical networks is smaller than previous generations and also offers enhanced performance, including lower power dissipation for less waste heat within a system and lower overall power consumption. The amplifier provides for both low drive voltage (3Vpp) and for high-voltage (6Vpp) drive capability with scalable power supply voltage as well as easier and more economical surface-mount assembly, suiting upgrades to 10Gb/s networks, TriQuint says.

Samples and evaluation boards are now available for both the TGA4943-SL (40Gb/s) and the TGA4956-SM (10Gb/s).

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

### IN BRIEF

#### Opnext cutting staffing by 10%

Optical module and component maker Opnext Inc is reducing its cost structure and operating expenses. Key initiatives include:

- a cut of 10% in global staffing;
- a 10% cut in executive salaries and directors' cash compensation;
- a 5% salary cut for other staff;
- the elimination of cash bonuses for fiscal 2009 and salary rises in the current fiscal year; and
- suspension of the firm's matching contribution to the 401(k) plan.

When fully implemented by year-end, the above actions, together with R&D and SG&A (sales, general & administration) synergies and expense reductions, are expected to contribute total annualized savings of \$25m. Most of the actions will be implemented in the current quarter. The compensation-related reductions are temporary and will be re-evaluated during the second half of the current fiscal year.

For its fiscal third-quarter 2009 (to end-December 2008), Opnext reported an operating loss of \$15.5m, compared to an operating profit of \$0.1m last quarter and \$1.8m a year ago.

"In this difficult economic environment and in order to position Opnext for future success, these actions are critical to right-size the company's fixed cost structure," says president & CEO Gilles Bouchard. "As part of the overall effort, we also continue to manage our variable costs as we streamline our manufacturing operations and supply chain," he adds.

"Our intent is to emerge from this downturn as a stronger company both financially and operationally," concludes Bouchard.

Also, Opnext's has switched its headquarters from Eatontown, NJ to Fremont, CA.

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

## UK awards £1.85m for R&D to extend uncooled devices

As part of the its Collaborative R&D programme, the UK's Technology Strategy Board has invested £1.85m (\$2.8m) in the follow-on three-year project ETOE II (Extended Temperature OptoElectronics) to develop integrated InP-based photonic devices and new active materials.

ETOE II will continue the £1.7m (\$3m), 2.5-year ETOE I collaboration (begun in 2006) between consortium partners CIP Technologies (which makes photonic hybrid integrated circuits and InP-based optoelectronic chips, devices, arrays and modules), optical component, module and subsystem maker Bookham Technology, chemical firm SAFC Hitech, Loughborough Surface Analysis Ltd (LSA), the University of Sheffield and the University of Surrey.

A number of telecoms network operators have recently announced plans to cut their carbon footprints, and this is placing demands on equipment suppliers to develop energy efficient solutions.

But, for each watt consumed by a device on a card, another 2W can be required to remove the heat it

produces from the building. This is most for components such as lasers and amplifiers, since their operating temperatures need to be controlled by local thermoelectric cooling, wasting more power. ETOE II aims to tackle this efficiency problem by raising the allowable operating temperature range of optoelectronic components, and reducing or eliminating the need for cooling.

ETOE II hence has two main thrusts. The first is to develop reliable aluminum-containing active photonic devices, in order to support the high-temperature operation of functions such as integrated semiconductor optical amplifiers and electro-absorption modulators (SOA-EAMs), and widely tunable lasers with integrated MZ modulators (a digital supermode distributed Bragg reflector with a Mach-Zehnder interferometer). A second, longer-range thrust is to look at alternative active-layer materials for InP and GaAs devices, including nitrogen, antimony and bismuth.

Results from the project are expected to lead to high-speed,

high-power integrated devices that can operate uncooled, enabling drastic reductions in power consumption and closer stacking of optical interfaces.

The consortium partners' expertise includes the development of new MOVPE growth processes from novel precursor technologies for the in-situ etching of aluminum-containing materials (SAFC Hitech), layer growth (Bookham, CIP and Sheffield), structural design and modelling (Bookham, CIP and Surrey) and device fabrication (Bookham, CIP), with comprehensive characterization at all stages to assess progress (LSA, Sheffield and Surrey).

"This project builds on successful technology developed under ETOE I, and I confidently expect it will result in advanced monolithic photonic devices offering higher-speed operation, wider temperature performance and greater tenability," says project manager Ian Lealman of CIP.

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

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

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

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

## Hybrid SOA/MZI dual-channel 2R regenerator for 100G

CIP Technologies has launched a new 100Gb/s version of its all-optical 2R (reamplification and reshaping) regenerator for optical networking.

Based on its HyBoard hybrid platform, the new device is fabricated from an integrated combination of an array of the firm's InP-based high-speed nonlinear semiconductor optical amplifiers (SOA-XN) and planar silica Mach-Zehnder interferometers (MZIs). The combination extends the signal regeneration properties of the firm's hybrid 2R device from 40Gb/s to 100Gb/s, and retains multi-channel capability.

Measuring just 9cm x 3cm x 1cm, the 100GXN-2R2-ORP device delivers a compact and practical dual-channel building block for configuring advanced optical networking systems. It may be used

for inline 2R regeneration of RZ (return to zero) signals in high-speed, optical network applications. The device's intrinsic ability to perform additional functions, including wavelength conversion, extends the flexibility for network system developers, the firm claims. Optical logic functions can be implemented by combining components.

The 100GXN-2R2-ORP employs a combination of planar silica and InP component technologies to achieve optimal performance. The two types of component functions used are planar single-mode waveguides with splitter/combiner elements configured to create a balanced MZI, and a monolithically integrated array of four nonlinear SOA-XNs. Hybrid integration, using the best technologies for each function,

ensures low intra-device excess losses and high optical gain, CIP says.

Special interface characteristics on both component types, combined with a unique precision alignment technique, also allow the 2R regenerator devices to be assembled without active alignment. CIP says that this makes the finished component suited to economic volume production.

The low-loss assembly technique, coupled with the improved performance of the SOA-XN, also allows the device to be switched with lower input optical powers than were possible previously, facilitating simpler high-speed experimentation. CIP can also provide custom versions of the device, including with integrated push-pull time delays and all-optical XOR logic gates.



## 3S selected for France's EPOD project for FTTH & metro

3S Photonics of Nozay, France (which makes laser chips, optical discrete modules and components for telecom networks), together with its partners, have won a competitive bid from France's National Research Agency (ANR) for the 2-year industrial research project EPOD — Enhanced PON (passive optical networks) using OFDM (orthogonal frequency division multiplexing) modulation format — which began in early February. EPOD is the French equivalent of the European project ALPHA (launched in January) in which 3S is also involved.

EPOD is led by Orange Labs (the R&D division of the French telecom provider) and also gathers 3S and academic partners including LISIF (Laboratories of Electronics and Electromagnetism — L2E) and a team from XLIM (a research institute held jointly between University of Limoges and CNRS).

EPOD is dedicated mainly to access (fiber-to-the-home, FTTH) and metropolitan telecom markets (urban connections of 200–300km).

Such networks will face increased customer demand for faster and higher-speed broadband access due to the emergence of new services such as triple-play bundles or ultra-high-definition video (UHDV),

HD video-on-demand, video conferencing, interactive online gaming etc. According to the EPOD project's forecast, FTTH is due to reach 12% of total broadband connections in France by the end of 2012 (versus less than 1% at the end of 2007).

"The EPOD project is part of the theme VERSO — Future Networks and Services — of the National Research Agency," says 3S board member & chief technology officer Didier Sauvage. "Its mission is to design next-generation telecom networks based on optical fiber by associating new-generation optical components with new frequency modulation formats." It aims to generate low-cost, ultra-high-capacity broadband access for future needs, he explains.

This performance can be enabled by implementing network architectures like time division multiplexing (TDM) or wavelength division multiplexing (WDM) PON, combining new optical components using the OFDM modulation format derived from radio transmission to increase optical telecom network bit rates.

OFDM enhances the spectral efficiency of transmitted signals, which become more resistant to chromatic dispersion. This enables significant cost reduction by using

optoelectronic components that can provide data rates of more than 40Gb/s with an intrinsic bandwidth of just 10GHz.

Orange Labs and 3S will be in charge of working on the system architecture. In particular, 3S will supply optical transmitter modules (lasers) and receivers (photodiodes) with good linearity for avoiding noise distortion. The components will be tested by Orange Labs on target architectures based on TDM or WDM.

The EPOD project will also benefit from LISIF's expertise in trans-impedance amplifiers (TIAs). The XLIM team will be in charge of system modeling with the OFDM modulation format.

The project involves three phases:

- analysis of market requirements and specifications;
- two prototype runs, to be tested by Orange Labs; and
- validation of the components' compatibilities with future networks.

3S says that its goal is to provide high-quality optical products, ready to equip telecom networks. In addition, in future these applications developed for EPOD could be extended to long-haul terrestrial and submarine optical networks, the firm adds.

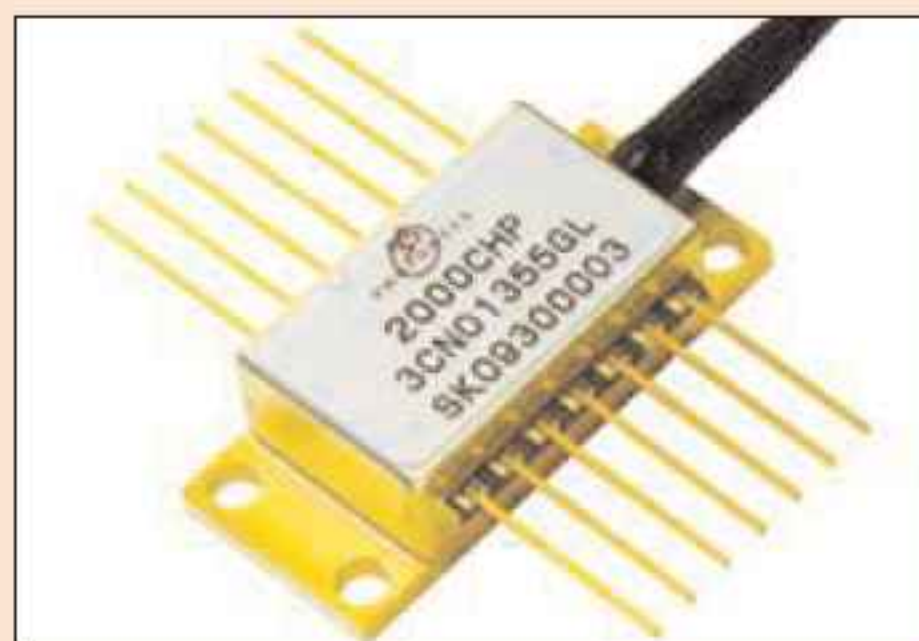
[www.3Sphotonics.com](http://www.3Sphotonics.com)

## 3S launches high-efficiency and high-power 980nm pump lasers

At March's Optical Fiber Communication conference (OFC 2009), 3S Photonics unveiled samples of its new series of 1999 HEP 980nm high-efficiency pump laser modules.

The new modules are claimed to be the most powerful of their kind for telecom applications in erbium-doped fiber amplifier (EDFA) environments with stringent power requirements. The 1999 HEP delivers ex-fiber output power of up to 500mW.

The 1999 HEP has been fully qualified according to Telcordia GR-468-CORE requirements. Volume shipment is expected by June.



3S' new 2000 CHP pump module.

3S is also sampling its 2000 CHP Series cooled high-power 980nm pump module. Incorporating a new GaAs laser chip using 3S' submarine-qualified technology, this is

claimed to be the most powerful 980nm single-mode pump laser module for telecom applications, delivering ex-fiber output power of up to 820mW, while keeping operating current low for network amplifier applications.

3S claims that, for EDFAs, the 2000 CHP offers higher output power, reduced component count, and lower cost and power dissipation, while allowing extended spans and improved noise-figure performance.

The 2000 CHP is compliant with RoHS and Telcordia GR-468-CORE requirements, and will reach full qualification by the end of June.

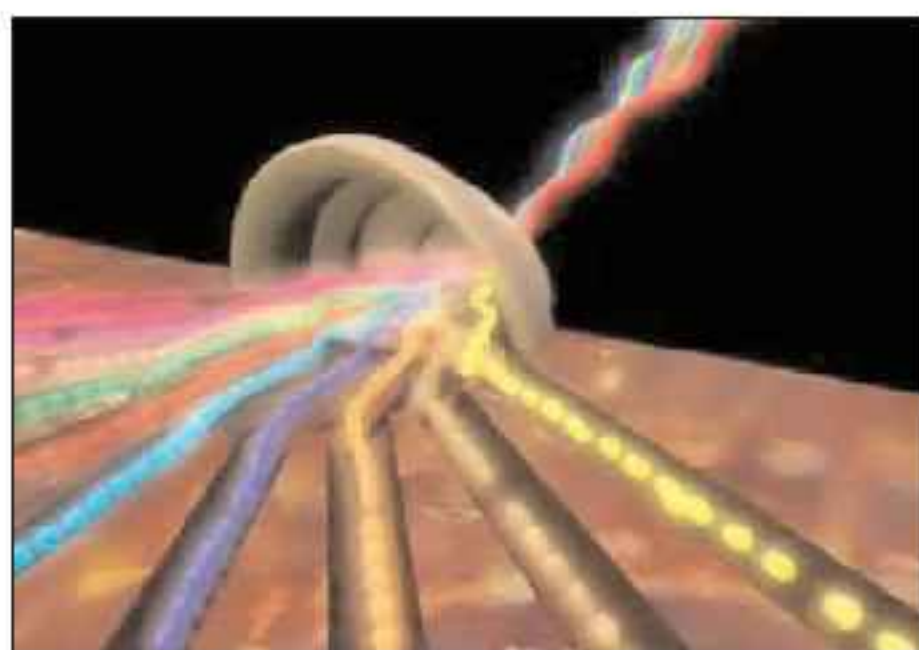
# Infinera's 400Gb/s PIC sets record for photonic integration

Digital optical network system maker Infinera Corp of Sunnyvale, CA, USA has demonstrated working indium phosphide-based photonic integrated circuits (PICs) delivering 400Gb/s of optical capacity in a single pair of chips using complex modulation formats.

The 400G PIC will enable Infinera's next-generation optics to deliver up to 80% power savings over competitor 40Gb/s wavelength optics based on conventional discrete optical components, reckons the firm. It will operate over Infinera's ILS2 line system with 25GHz channel spacing, delivering double the spectral density of competitor systems that operate over 50GHz spacing.

The 400Gb/s transmit PIC, currently running in Infinera's labs, integrates more than 300 optical functions and enables a reduction in optical component packages from about 70 to just one. The 400G PIC pair marks a landmark in Infinera's PIC roadmap, representing a four-fold increase in 'bits per chip' over the firm's existing 100Gb/s PICs, and a forty-fold increase over chips in competitor systems, it is claimed. Infinera introduced its industry roadmap for the progress of photonic integration a year ago, targeting a 400Gb/s PIC in 2009 and a doubling of bandwidth capacity or bits per chip every three years.

The 400Gb/s PIC will be at the heart of Infinera's next-generation systems. It integrates ten lasers to deliver ten optical channels, each operating at 40Gb/s. Data is encoded using polarization-multiplexed differential quadrature phase-shift keying (PM-DQPSK) modulation, which enables optical performance equivalent to 10Gb/s systems on today's fiber plant. The PM-DQPSK modulation format delivers benefits in terms of lower



**Integration of 10 optical channels.**

power consumption, greater spectral efficiency, improved optical reach compared to other complex modulation techniques, and greater resistance to impairments like dispersion. Infinera says that its modulation approach will enable systems based on 400G PICs to be compatible with its 25GHz-spaced ILS2 line system. The firm's next-generation systems will be designed to enable network operators to scale total fiber capacity to 6.4Tb/s in the C-band (twice what is possible using conventional 40G WDM systems).

With bandwidth demand continuing to grow at about 50% a year according to many estimates, service providers need systems that can deliver increased fiber capacity and spectral efficiency, while simultaneously increasing reliability and reducing space, and power consumption per bit. Traditional discrete-component-based optical systems are challenged to drive down space and power per bit because the complex modulation techniques required for higher fiber capacity require a large number of optical and electronic components. The new 400Gb/s PIC eliminates a large number of optical components and complex electronic signal processing, achieving greater network reliability and the fiber capacity benefits of complex modulation while consuming much less space and power than traditional systems.

Power consumption and access to cost-effective energy in conjunction with the continued expansion of the Internet is becoming one of the most critical issues facing the communications industry today, says Infinera. With the price of energy rising and becoming more volatile, power use has become a more significant factor in service providers' costs. In the next several years, the technology industry will be driven to increase its energy efficiency at several levels, including the data center and the network, says the firm. Photonic integration will make a significant contribution to reducing energy consumption per bit for these applications, it believes.

Lab demonstrations show that Infinera's 400Gb/s PICs consume about half the power (on a per Gb/s basis) of its existing 100Gb/s PICs deployed in networks worldwide. The 400Gb/s PICs consume 80% less power per Gb/s compared to existing 40Gb/s optics based on discrete solutions. PICs' power efficiencies are achieved because PICs can implement thermal control more efficiently with many devices integrated into a single package and there is less optical loss with devices much closer together on the chip.

"Complex modulation is an important tool in the drive for ever-greater fiber capacity. But complex modulation with conventional technologies comes at the price of more complex optical structures," says chief marketing & strategy officer Dave Welch. "Because Infinera is able to integrate these structures monolithically, with over 300 individual optical functions on a single chip, the benefits of photonic integration are becoming more powerful than ever before," he adds.

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

## PIC-based system doubles bandwidth over 4000km subsea network

Infinera has demonstrated its PIC-based DTN system transmitting data over a 4000km third-party subsea network (discussed by Infinera fellow Steve Grubb in the Market Watch session 'More Wavelengths, Higher Bit Rates, More Spectrum...The Path to Harnessing Maximum Fiber Capacity at the Lowest Cost' at March's Optical Fiber Communications conference in San Diego, CA, USA).

The DTN is a digital reconfigurable optical add-drop multiplexer (ROADM) for long-haul and metro core networks, combining high-capacity dense wavelength division multiplexing (DWDM) transport, integrated digital bandwidth management, and GMPLS-powered service intelligence in one platform.

Compared to 50GHz on the pre-existing equipment, the DTN's

25GHz channel spacing doubled the subsea network's bandwidth capacity. "The ability of the Infinera DTN to transmit data undersea for 4000km, and over a foreign amplifier chain, is a path-breaking demonstration, which holds out the opportunity of a new, innovative, and cost-effective way to increase capacity on subsea networks," reckons Grubb.

Submarine optical networks include chains of subsea optical amplifiers (designed for the demands of operation on the ocean floor) and submarine line terminating equipment (SLTE) located in terrestrial landing stations and connected to either end of the amplifier chain. In the demonstration, Infinera DTNs replaced the pre-existing SLTE systems and transmitted DWDM optical signals across the pre-existing subsea amplifier chain.

## Infinera's revenue falls 23%, but gains two tier-1 European customers

For first-quarter 2009, Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has reported revenue of \$66.6m. This is down 23% from \$86.2m on an adjusted GAAP basis last quarter and down 30% from \$95.5m on an invoiced shipment basis a year ago.

On a non-GAAP basis, gross margin was 31%, down from 36% last quarter and 45% a year ago.

Net loss was \$17.6m compared to \$9m last quarter and net income of \$12.6m a year ago. During the quarter, cash and cash equivalents fell from \$166.8m to \$153.4m.

"The combination of macroeconomic effects and timing associated with some large deployments put downward pressure on our revenue and gross margins for the first quarter," says president &

CEO Jagdeep Singh. "However, we saw continued momentum with tier-one carriers, as Infinera was selected by two additional European PTTs [postal, telegraph and telephone carriers]," he adds.

"In addition, we continue to experience a robust level of DWDM [dense wavelength division multiplexing] activity with carriers worldwide, and see additional evidence that our unique PIC-based value proposition is resonating with existing customers and prospects," says Singh. Enabled by its new ILS2 line system, in Q1/2009 the firm also won new deals including submarine network routes (an important growth segment in DWDM).

"We believe that we are well-positioned to resume top-line growth and improved bottom-line performance as the macroeconomic environment improves," concludes Singh.

### IN BRIEF

## Ex-Alcatel-Lucent Japan head made president of Infinera Japan

Infinera has made Satoshi Fujita president of Infinera Japan, focused on expanding sales and marketing in Japan.

Fujita brings extensive experience in the Japanese telecoms industry, working for both service providers and system vendors. He spent 30 years at NTT (Japan's incumbent telecom service provider and one of the world's top five telecom carriers) including as head of NTT Communications' global services business, which he grew from launch to a billion dollar business. Fujita was subsequently president of Lucent Technologies Japan and then president of Alcatel-Lucent Japan.

"Infinera has a great opportunity in the Japanese market, a market that is very open to innovation and new technologies such as Infinera's unique photonic integration," believes Fujita.

Infinera has several customers operating networks in Japan. Last year, Global Access Limited (GAL) carried out the first publicly announced demonstration of 100 Gigabit Ethernet (GbE) services over a live network in Japan, using Infinera's 100 GbE module to send 100GbE traffic over GAL's network.

"Infinera has achieved a leadership position in the North American long-haul optical networking market, and our goal is to reach similar positions in other important markets," states CEO Jagdeep Singh. "With his experience, contacts, and knowledge of the challenges of building a service provider business as well as a systems vendor business, Satoshi Fujita will play a key role for Infinera in Japan," he adds.

# Santur announces EPIC 10x10Gb/s InP PIC-based 100Gb/s transceiver platform

Santur Corp of Fremont, CA, USA, a vertically integrated manufacturer of tunable lasers for metro and long-haul WDM systems, has announced its Enhanced Photonic Integration Circuit (EPIC), based on its laser array PIC platform.

The new product family represents an extension of the firm's parallel array architecture, yielding what is claimed to be a breakthrough approach to 100Gb/s optical transceivers. Santur's approach to coupling its parallel laser array with a planar lightwave circuit (PLC) creates what is described as an unprecedented level of photonic integration for client optical connectivity and delivers 100Gb/s up to 10km on a single-mode fiber.

Unlike 10x10Gb/s technology based on ribbons of multi-mode fiber, Santur's solution operates on a single conventional single-mode fiber (SMF) enabling extended reach. Compared with other 100Gb/s implementations for single-mode fiber optical links, this approach does not require 25Gb/s electronics such as gearbox ICs to convert 10Gb/s data streams to intermediate 25Gb/s lanes, says the firm.

"The growth and popularity of digital media has created a whole new set of challenges and opportunities for communication systems tasked to deliver large files at high bit rates from content libraries," says CEO Paul Meissner. "Next-generation systems must deliver far more bandwidth with much lower cost per bit than traditional approaches."

Traditional solutions to this optical connectivity challenge rely on discrete components (e.g. solutions delivering more than 10Gb/s need a four-fold increase in component count to deliver a four-fold increase in bandwidth).

Santur says that EPIC can address the simultaneous scaling factors of bandwidth and cost for optical transceivers.

"The need for higher bandwidth on a single fiber is best addressed by innovative integration at the chip and package level compared with discrete implementations," says

Milind Gokhale, VP of technology & development. "Our 100Gb/s architecture for transmission over single-mode fiber is based on high-yielding 10x10Gb/s laser arrays, PLC integration, and robust 10Gb/s driver and receiver electronics, enabling the delivery of 10 times increase in bandwidth at a significantly lower cost per bit," he adds.

Early developers of 100Gb/s systems have relied on Santur's platform. Last September's European Conference on Optical Communications (ECOC 2008) in Brussels, Belgium saw the first demonstration of 100Gb/s transmission over 10km SMF. At March's Optical Fiber Communication conference (OFC 2009) in San Diego, CA, USA, Santur and its partners demonstrated EPIC running over 40km SMF. Santur also showcased EPIC-based pluggable transceivers delivering 100Gb/s and 40Gb/s over 10km SMF.

The first transceiver product based on EPIC is shipping this spring to early-access partners, with production units scheduled for the end of the year.

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

**This approach does not require 25Gb/s electronics such as gearbox ICs**

## Tunable lasers with integrated InP modulators for up to 12Gb/s

For applications up to 12Gb/s, Santur has announced the general availability of full C-band tunable transmitters (TLMZ), which contain the firm's distributed feedback (DFB) laser array coupled with its indium phosphide-based Mach-Zehnder modulator through Santur's proven MEMS technology. Telcordia qualification has been completed and production has begun. The transmitter's scalable design enables the rapid migration of traditional designs based on continuous wave (CW) lasers and discrete lithium niobate modulators to the smaller and more cost-effective TLMZ, says Santur.

With a focus on integration, the TLMZ offers 45% less footprint and 30% lower power dissipation while delivering performance equivalent to discrete solutions based on tunable CW lasers and discrete small-form-factor lithium niobate modulators, says Santur. Commercial deployment of the modulator integrated with the firm's flagship tunable laser represents a milestone on Santur's product roadmap to deliver compact tunable transmitters to the market, says Milind Gokhale, VP of technology & development.

Santur is supplying devices rated up to 4dBm optical power with

both zero and negative chirp modulators and available in either butterfly or module form factors. "These devices enable rapid adoption of tunability in metro markets," says Santur's CEO Paul Meissner, "In addition to providing the standard pre-calibrated modules with electronics, the simplicity of our tunable laser technology also allows our customers to buy at the lower-cost butterfly level."

The solutions enable system integrators to increase density while maintaining the performance needs of the network, the firm claims.

# Oplink's revenues fall 18%, but cuts generate cash

For fiscal Q3/2009 (to end March), photonic component, module and subsystem maker Oplink Communications Inc of Fremont, CA, USA has reported revenue of \$30.8m (including \$500,000 deferred from last quarter, related mainly to one of Nortel's contract manufacturers). This is down 18% on \$37.6m last quarter and 25% on \$40.8m a year ago, but at the higher end of the expected range.

Complementing passive optical products, which included \$4.6m from reconfigurable optical add-drop multiplexers (ROADMs), active products contributed \$9m (30% of revenue).

Most revenue came from metro core and metro edge projects, which is believed to be the fastest-growing market segment for the next-generation network upgrade.

Oplink's 10% customers were again Tellabs and Huawei (17% and 18% respectively), with Alcatel-Lucent, Nortel, Cisco, and Fujitsu also contributing significantly.

On a non-GAAP basis (excluding \$1.3m in stock-based compensation and \$950,000 in amortization of intangibles), gross margin was 30.3% (up on 25.2% last quarter). This was due to product mix and lower manufacturing expenses through reducing headcount by almost 400 (to 2150), a temporary reduction in compensation for staff in North America, and other cost-cutting measures (related to temporary staff). Overall, operating expenses were cut by \$840,000.

Non-GAAP net income was \$2.1m, down from \$2.6m last quarter, but ahead of the expected range.

"We continue to place a high emphasis on generating positive cash flow," says president & CEO Joe Liu. "Despite the decline in revenue, we were able to generate cash from operations [of \$13m] during the quarter, due to our ability

to scale our cost structure to respond to changes in demand," he adds. Cash, cash equivalents and short and long-term investments rose by \$10.3m to \$157.1m. The firm repurchased \$1.1m of its common stock during the quarter.

"Looking forward, design-in activity with customers remains high, and we believe that revenue may be stabilizing at current levels," says Liu. For fiscal Q4/2009 (to end June), order activity is improving from certain customers and product lines, so Oplink expects revenue to be \$28-32m and non-GAAP gross margin to also be roughly level on Q1. "We have a little bit more confidence, but we have less visibility than before," Liu adds. "We have not seen enough solid purchase orders and therefore we have given flat guidance [for the June quarter]."

In addition, Oplink is consolidating its plant in Calabasas, CA (formerly Optical Communication Products Inc, acquired in October 2007) into its headquarters in Fremont, so operating expenses are expected to fall again slightly in fiscal Q4.

Also, Liu believes that the current industry downturn will be much shorter than that of 2001. For telecoms in particular, Oplink has quickly stopped the free fall, as indicated by revenue bottoming even in the March quarter. Some of the order push-outs announced since the beginning of the year have probably already expired, Liu reckons. Oplink should benefit, if not in the June quarter, then in the September quarter "for sure".

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

## IN BRIEF

### AT&T veteran joins Opnext's board

Optical component, module and subsystem maker Opnext Inc of Fremont, CA, USA has elected Bill Smith, president of local network operations for AT&T, to its board.

"Bill has 30 years of experience in the communications industry," says chairman Harry Bosco. "His understanding of networks and their associated technologies will be extremely valuable in helping to guide Opnext's future."

Smith is responsible for all local network-related operations across AT&T's domestic footprint, including construction and engineering, installation and maintenance, U-verse field operations, mobility construction and maintenance, and operations planning. Previously, he was executive VP-shared services, in charge of mass market and enterprise operations, corporate real estate, procurement, regional wireline planning, and business planning and integration.

Smith began his career at the former BellSouth Corp in 1979, with posts in technology, operations, marketing and public policy. He was involved in BellSouth's advanced technology efforts and was responsible for its DSL, Internet and wholesale business units. Most recently, he was BellSouth's chief technology officer, setting the overall technology direction for its core infrastructure, including network and operations technology, Internet Protocol applications, next-generation strategy, and BellSouth Entertainment LLC.

Smith graduated from North Carolina State University at Raleigh in 1979, where he now serves on the board of advisors for the Graduate School. He is ex-chairman of the board of the Make a Wish Foundation of Georgia and Alabama and has served on several other non-profit boards.

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

# JDSU consolidating VCSEL fab into San Jose as part of cost cutting

For its fiscal third-quarter 2009 (ended 28 March 2008), JDSU of Milpitas, CA, USA has reported revenue of \$280.6m, down 21% on \$357m last quarter and 27% on \$383.9m a year ago. The drop is due mainly to the Communication & Commercial Optical Products and Communications Test & Measurement segments, as North American network equipment makers continued to reduce their inventory due to declining demand from their service provider customers. Consequently, the Americas represented just 42% of revenue (down from 47% last quarter), Europe 34% (up from 30%) and Asia-Pacific 24% (up slightly from 23%).

Communications Test & Measurement segment revenue has fallen 26.7% from \$176.2m last quarter to \$129.2m (46% of total revenue, versus 49% last quarter).

Communication & Commercial Optical Products (CCOP) revenue has fallen 36.9% from \$159.1m a year ago and 21.4% from \$127.9m last quarter to \$100.5m (36% of revenue, level with last quarter).

Specifically, including recovering \$3.4m out of \$10m in deferred revenue after Nortel's bankruptcy, Optical Communications revenue was \$89m, down 18.7% on \$109.5m last quarter and 34.6% on \$136.1m a year ago. Nevertheless, CCOP gross margin still improved (from 17.4% to 20.7%, boosted by the Nortel revenue recovery).

Total non-GAAP gross margin has fallen from 43.5% last quarter to 41.8% due to lower factory absorption, an unfavorable product mix in Test & Measurement, and costs associated with transferring production to contract manufacturers.

JDSU's operating expenses have been reduced for the third quarter in a row, by nearly \$12m from last quarter to \$125.2m. This reflects continued company-wide efforts to

lower the cost structure (discretionary spending, office consolidation, workweek shutdowns, and reductions in headcount from 6714 to 4244, including 2272 through transfer to contract manufacturers).

Excluding a \$45m goodwill impairment charge due to the impact of the macro-economic environment on JDSU's market capitalization (following a \$700m charge last quarter), the non-GAAP net loss was \$6.9m, compared with net income of \$24.8m last quarter and \$31.2m a year ago.

Yet, after being free cash flow negative by \$4.6m last quarter, JDSU was free cash flow positive by \$15.3m in fiscal Q3. Cash balance rose by \$34.5m to \$673.5m after reducing inventory by \$40.4m and reducing outstanding debt by \$50m (resulting in a gain of \$20m from the repurchase of convertible debt).

"We fortified our balance sheet during these challenging economic times," says president & CEO Tom Waechter.

JDSU's initiatives to improve gross margins include moving to a more variable cost model, pruning products that don't meet profitability targets, and executing against lean initiatives, with which the firm has already made progress, says chief financial officer Dave Vellequette.

The transfer of ownership of JDSU's Optical Communications assembly & test plant in Shenzhen, China to contract manufacturer Sanmina-SCI Corp (announced in February) was completed in April. "We were able to maintain the skilled workforce and expertise in manufacturing our product, lower our fixed-cost structures, and leverage Sanmina's strength and operational expertise in raw material

sourcing, all without re-qualifying our product," says Waechter.

Also in April, JDSU decided to close its fab in Louisville, CO (acquired with Picolight in 2007) by the end of September, consolidating its GaAs chip manufacturing — including its vertical-cavity surface-emitting lasers (VCSELs) — under one roof in JDSU's Rose Orchard GaAs and InP fab in San Jose, CA. JDSU also has two other separate Optical Communications plants: a silicon oxide fab in San Jose and a lithium niobate fab in Bloomfield, CT.

Compared to previous estimates, the fab closure should boost JDSU's savings in manufacturing overhead from \$28m to over \$35m per year and savings in operating expenses from \$110m to over \$120m per year (relative to fiscal Q4/2008 levels). The quarterly revenue rate for free cash flow breakeven has hence now been lowered from \$290–295m to \$275–285m for fiscal Q4/2009 (ending 27 June).

After bookings in March and April rose across all business segments (significantly in the case of test & measurement and optical communications), for fiscal Q4 JDSU expects revenue of \$265–285m (down only slightly on fiscal Q3 at the mid-point of this guidance). Test & Measurement should rebound slightly better than Optical Communications, says Waechter. Nevertheless, for Optical Communications, the goal is for a sustainable gross margin of 25–30% near term (compared to 20.7% in fiscal Q3) and in excess of 30% longer term.

"We remain confident in our long-term market opportunities and will continue to focus on innovation and our lean initiative activities to position JDSU for future growth," says Waechter. The firm remains committed to its sustainable model of overall gross margin of 43–47%."

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

**The fab closure should boost JDSU's savings in manufacturing overhead**

# JDSU claims first monolithically integrated and tunable optical transceiver

At the Optical Fiber Communication Conference and Exposition (OFC) and National Fiber Optic Engineers Conference (NFOEC) in San Diego, CA (24–26 March), JDSU of Milpitas, CA, USA demonstrated what it claims is the industry's first monolithically integrated and tunable optical transceiver.

The tunable XFP transceiver is 85% smaller than previous tunable products, allowing network equipment manufacturers (NEMs) to pack more transceiver interfaces onto a system's line card or to deploy smaller systems within a network node. This in turn opens up valuable real estate for service providers in network central offices.

The much smaller size of the transceiver can also reduce power dissipation by 60%, reducing electrical and cooling costs within network central offices, says JDSU.

In addition, as increased consumer use of online video, voice and data applications continues to put demands on network capacity, NEMs and service providers are under pressure to add optical solutions that can manage increased bandwidth flexibly and cost effectively. Correspondingly, the tunable XFP transceiver will be the first pluggable solution that service providers can deploy without fully populating line cards, says JDSU, so technicians can easily provision more transceivers to the line card in the field only as needed in a



**JDSU's tunable XFP transceiver.**

'pay-as-you-grow' fashion as network bandwidth demands increase, without affecting network performance.

"The tunable transceiver market had not yet transitioned to pluggable solutions because the technology breakthroughs hadn't happened—until now," says Alan Lowe, president of JDSU's Communications and Commercial Optical Products business segment.

JDSU says that it achieved the dramatically smaller size of the new tunable XFP by leveraging its functional integration product approach at the chip and module level, meaning that size, cost, power efficiency and performance were all factored into its design. In particular, it contains key technology, as follows:

- JDSU's photonic integrated circuit (PIC) technology (announced in 2007), which was used to develop

the Integrated Laser Mach-Zehnder (ILMZ) tunable transmitter—the engine of the tunable XFP (monolithically integrating a tunable laser, amplifier, and optical modulator on a single chip small enough to fit on a tip of a finger).

- The ILMZ was then housed in what JDSU claims is the world's smallest tunable transmitter optical subassembly (TOSA) package (announced in 2008), which JDSU plans to make available to the open market.

"It is quite an accomplishment that JDSU was able to create a tunable solution and get all of the functionality into an XFP form factor," says Daryl Inniss, VP & practice leader of Communications Components at market research firm Ovum. "The new JDSU tunable XFP transceiver could help system vendors realize a wide range of benefits, including increased density, lower costs, and more flexible deployment options," he adds.

JDSU began sampling the transceiver with customers in 2008. "We are engaged in 12 designs with nine customers and have received very positive feedback," Lowe says. "Many of our top customers are already designing the JDSU tunable XFP transceiver into their next-generation systems," he adds. JDSU expects to ship the tunable XFP transceiver in volume this summer.

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

## Executives and management present at OFC sessions

During OFC/NFOEC 2009, JDSU contributed to several panel sessions, including:

- 'Optical Components: Technology for New Business Strategies' at the OSA Executive Committee Forum, in which Alan Lowe, president of JDSU's Commercial and Communications Optical Products

business segment, discussed strategies on how to maneuver through the current challenging business environment;

- 'Optical Switching and Reconfigurable Networks: Balancing Agility, Reliability, and Economy as Networks Evolve' in the Market-Watch Panel session, in which

Doug Alteen, product line manager in JDSU's Commercial and Communications Optical Products business segment, discussed how reconfigurable optical add-drop multiplexers (ROADMs) and other optical switching technology can help network operators evolve networks while managing costs.

# JDSU settles tunable laser lawsuits with Bookham, Syntune and CyOptics

Optical component and module maker Bookham Inc of San Jose, CA, USA has entered into an out-of-court settlement and license agreement with rival JDS Uniphase Corp of Milpitas, CA, USA regarding tunable laser patents. The agreement settles all disputes between the firms relating to the following US patents (filed in July 2000 and issued in December 2003–February 2004 to tunable laser maker Agility Communications Inc of Goleta, CA, which was acquired by JDSU in 2005):

- 6,654,400 ('Method of Making a Tunable Laser Source with Integrated Optical Amplifier');
- 6,658,035 ('Tunable Laser Source with Integrated Optical Amplifier'); and
- 6,687,278 ('Method of Generating an Optical Signal with a Tunable Laser Source with Integrated Optical Amplifier').

In March 2008, JDSU warned Bookham that its products allegedly infringed the patents. In response, Bookham filed a complaint against JDSU in the US District Court for the Northern District of California (San Jose Division) seeking declaratory judgments that its tunable laser products did not infringe any valid, enforceable claim of the patents, and that all claims of the patents were invalid and unenforceable. Bookham also claimed relief for statutory unfair competition and intentional interference with economic advantage. Last July, JDSU countersued Bookham for patent infringement (focusing on its tunable laser product line), seeking compensatory damages as well as an order barring Bookham from future infringement.

Then, last November, JDSU filed a complaint with the US International Trade Commission (ITC) alleging infringement of patents 6,658,035

and 6,687,278 by not only Bookham but also tunable laser maker Syntune AB of Kista, Sweden as well as CyOptics Inc of Breinigsville, PA, USA (which integrates chips from Syntune into products). The lawsuit also sought to ban the rival firms' tunable laser products. JDSU's complaint also named network equipment making customers Tellabs Inc of Naperville, IL, USA, Ciena Corp of Linthicum, MD, USA and Nortel Networks Ltd of Toronto, Canada, plus metro equipment maker ADVA Optical Networking of Munich, Germany, regarding their alleged use and importation of the accused Bookham tunable chips.

According to a filing with the US Securities and Exchange Commission (SEC), the agreement between Bookham and JDSU announced last week provides that:

1. Bookham will pay JDSU \$3m in two equal installments (the first on or about 15 April and the second on or about 15 April 2010) for settlement of all claims in the lawsuits;
2. each party will refrain from instituting any patent litigation against the other party for a period of four years;
3. each party releases the other from any claim or counterclaim asserted in or arising from the lawsuits;
4. JDSU provides both Bookham and customers for certain of its products with a license for the patents, plus related patents; and
5. from 10 April 2010, Bookham will pay JDSU a royalty of up to \$1m per year for up to five years. Adding up to \$5m to the above \$3m payment, Bookham will hence pay JDSU up to \$8m in total.

Bookham and JDSU have also agreed that they will enter into an order of dismissal, and that JDSU will file a motion to terminate the lawsuits.

● The acquisition of tunable laser manufacturer Syntune AB of Kista, Sweden by Ignis ASA of Oslo, Norway, which makes passive optical components for fiber-to-the-home

**Bookham will pay JDSU \$3m plus a royalty of up to \$1m per year for up to five years.**

**Bookham and JDSU have also agreed that they will enter into an order of dismissal, and that JDSU will file a motion to terminate the lawsuits**

As well as settling the ITC complaint with Syntune and CyOptics, JDSU had also sued Syntune separately last July in the US District Court for the Northern District of California. This case has also now

**In the case of Syntune, the settlement follows what is said to be a redesign by the firm of its tunable laser**

JDSU accepts that Syntune's redesigned tunable laser does not infringe its patents.

[www.jdsu.com](http://www.jdsu.com)  
[www.bookham.com](http://www.bookham.com)  
[www.syntune.com](http://www.syntune.com)  
[www.cyoptics.com](http://www.cyoptics.com)

(FTTH) infrastructure (see facing page), was preceded on 20 March by settlement of the complaint filed last November with the US International Trade Commission (ITC) by JDS Uniphase against not only Bookham but also both Syntune and CyOptics.

been dismissed as a result of the out-of-court settlement.

In the case of Syntune, the settlement follows what is said to be a redesign by the firm of its tunable laser.



# Ignis agrees to acquire Syntune

After signing a non-binding letter of intent early this month, the board of Ignis ASA of Oslo, Norway, which makes passive optical components for fiber-to-the-home (FTTH) infrastructure, has approved the acquisition of indium phosphide-based tunable laser manufacturer Syntune AB of Kista (near Stockholm), Sweden.

Syntune's founders and investors InnovationsKapital, Teknoinvest and Vision Capital will receive 8.05 million Ignis shares (worth about \$4.6m). The deal is subject to approval by an ordinary general meeting of Ignis shareholders (brought forward from 20 May to 15 May).

Prior to the acquisition, Syntune will raise SEK25m (Swedish Krone) through an equity issue directed at the current owners. The firm's current interest bearing debt amounts to about SEK41.8m (mainly a €4m venture lease and loan facility entered into with Kreos Capital in 2008). So, Ignis will assume net interest bearing debt of SEK16.8m. However, the deal includes Syntune securing an additional loan facility of SEK25m (€2.3m) from Kreos Capital III, so that its cash position is sufficient to fund its activities until break-even in 2010.

Syntune was founded in January 2003, when it acquired an exclusive worldwide license to a patent on the 'modulated grating Y-branch' (MG-Y) tunable laser design, jointly owned by Leuven-based IMEC and Ghent University in Belgium and UK-based Gayton Photonics Ltd. MG-Y technology was developed as part of the EU-funded project NEWTON (New Widely Tunable Lasers for Optical Networks), in which Stockholm-based tunable laser manufacturer Altitun/ADC was a partner. Syntune's founders had previously helped to establish Altitun (sold to ADC in 2000 for \$872m).

The MG-Y design provides a wide tuning range, high output power, a high side-mode suppression ratio, low power consumption, and fast

tuning. Syntune's indium phosphide-based technology platform provides single-chip tunable lasers and transmitters that are claimed to be the industry's smallest and lowest cost, for applications from sensor systems to fiber-optic communications. The technology is Telcordia certified. Syntune completed the qualification of its first generation of products in 2007.

In 2008, Syntune established a chip packaging supplier relationship with CyOptics Inc of Breinigsville, PA, USA (which specializes in InP optical chip and component technologies). That April it acquired a majority stake in Svedice AB of nearby Järfälla, Sweden, which provides InP-based wafer foundry services. Syntune had previously partnered with Svedice to fabricate its products, including what was claimed to be the first commercially available, widely tunable transmitter on a single chip.

The tunable laser market is still in an early commercial phase but is growing fast, says Ignis. The ramp-up of Syntune's revenue began at the end of 2007, and shipments grew five-fold from first-quarter to fourth quarter 2008. For full-year 2008, prod-

uct sales amounted to SEK18m. Including subsidiary Svedice, Syntune now has 40 staff. In

2009, Syntune is expected to grow with the tunable laser market, as well as through the qualification and launch of new products, and through broader market reach via the Ignis distribution network.

Acquisition means that Syntune's active components (specifically, tunable laser technology) will supplement Ignis' existing portfolio of passive components, offering a broader range of optical compo-

nents to network operators. In particular, tunability is becoming one of the most critical elements of the optical industry, as wavelength agility offers increased flexibility and cost reductions in metro and long-haul, as well as in the access networks that Ignis currently supports. Syntune gives Ignis access to technologies and expertise that will be crucial to compete in future integrated optics markets, says Ignis ASA's CEO Thomas Ramm.

Syntune's CEO Patrik Evaldsson reckons that, as a subsidiary, it will benefit from Ignis' geographically broader sales and distribution structure. Also, the combination of the firms' technology platforms should create highly cost-efficient products for high-bandwidth networks such as passive optical networks using wavelength division multiplexing (WDM-PON), he adds.

Last September, Syntune announced its participation in GigaWaM, a three-year project running from April 2008 until March 2011 funded by a €3m (\$3.8m) grant from the European Commission (EC) to develop Gigabit access WDM-PON for fiber-to-the-home (FTTH), enabling high-bandwidth services including high-definition TV and video on demand. A major goal is to provide a lower cost per user for Gigabit PON (GPON) systems, while increasing the bandwidth per user by more than a factor of ten through developing low-cost application-specific optical components with a high level of integration and improved manufacturing processes. Currently, even the cheapest WDM PON solution costs two to three times as much as GPON.

The GigaWaM project was initiated by the subsidiary Ignis Photonyx A/S of Birkerød, Denmark, which makes silica-on-silicon and polymer-based optical components including switches and arrayed waveguides (AWGs), and is led technically by the its photonic lightwave circuit (PLC) fab.

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

**Syntune gives Ignis access to technologies and expertise crucial to compete in future integrated optics markets**

# Bookham and Avanex form Oclaro

Bookham Inc of San Jose, CA and Avanex Corp of Fremont, CA have closed their merger (announced in late January), creating San Jose-based Oclaro Inc (split 46.75:53.25 in ownership between Avanex and Bookham shareholders).

President & CEO is Alain Couder, chief operating officer is Jim Haynes and chief financial officer is Jerry Turin (all from Bookham). Couder is joined on the board by three Bookham directors (Edward Collins, Lori Holland and Bernard Couillaud, who will be chairman), as well as Avanex's president & CEO Giovanni Barbarossa plus two Avanex directors (Greg Dougherty and Joel Smith).

"By uniting the best components expertise of Bookham with the best modules and subsystems expertise of Avanex, Oclaro has the necessary products and technologies under one roof to become a market setter in the future of the fiber-optic market," claims Couder. The merger makes Oclaro one of the largest suppliers of optical components, modules and subsystems to the long-haul and metro telecom markets, as well as the fourth-largest tier 1 supplier to the fiber-optics market (after Finisar and JDSU, and on a par with Opnext).

The firm is structured around three customer-facing operating units:

- Transmission (under executive VP Adrian Meldrum, formerly general manager of Bookham's Telecom Division) focused on 10 and 40Gb/s optical components, transponders, and tunable transceivers;

- Regeneration and Optical Routing (under executive VP Richard Smart, formerly Avanex's VP of Product Management) focused on amplification (components, gain blocks, controlled amplifier modules, subsystems), dispersion (fixed and tunable dispersion compensation), wavelength routing (Wavelength Selective Switch, passives, interleavers, and subsystems); and

- Advanced Photonics Solutions (under executive VP Yves LeMaitre, formerly Avanex's chief marketing officer then Bookham's VP of Telecoms Sales) focused on high-power lasers and VCSELs, photonics tools and filters.

Oclaro reckons it now has the core technologies to capitalize on the expected growth in fast-growing telecoms markets where new applications such as video streaming, social networking, and cloud computing are driving increasing Internet traffic, with strong demand for more throughput and performance. It also aims to leverage its core technologies to expand into adja-

cent markets, including industrial, defense, life sciences, semiconductor, and scientific, with diversification providing both the potential for new revenue streams and strategic technological advantages.

The firm has about 2500 staff at 13 sites, with technology development and component manufacturing in the USA and Europe (including Bookham's chip fabs in the UK and Switzerland and Avanex's in Italy), R&D support centers in Asia, and assembly & test and contract manufacturing capabilities in Asia (China and Thailand).

"Completion of this transaction is a big step forward for the optical components industry, and one we believe will produce a company capable of thriving in a rapidly consolidating industry," comments Andrew Schmitt, directing analyst, Optical, at Infonetics Research.

"The combined in-house and outsourced manufacturing operations are expected to give Oclaro significant production flexibility, which in turn is expected to drive gross margin improvement," says Couder. "With substantial combined cash and no outstanding debt, Oclaro has a strong balance sheet from day one," he adds.

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

For Bookham's fiscal Q3/2009 (ended 28 March), Oclaro has reported revenue of \$47m (including \$1.9m out of a total \$5.4m deferred from shipments made to Nortel Networks and a related contract manufacturer last quarter). This is down 6% on \$50.2m last quarter and 21% on \$59.7m a year ago.

On a non-GAAP basis, gross margin was 24%, up from 19% last quarter and 23% a year ago. Adjusted earnings before interest, taxes, depreciation and amortization (EBITDA) was -\$0.7m, an improvement on -\$3.3m last quarter and -\$1.1m a year ago. Cash, cash equivalents, short-term

investments and restricted cash has fallen from \$44.7m to \$38.3m.

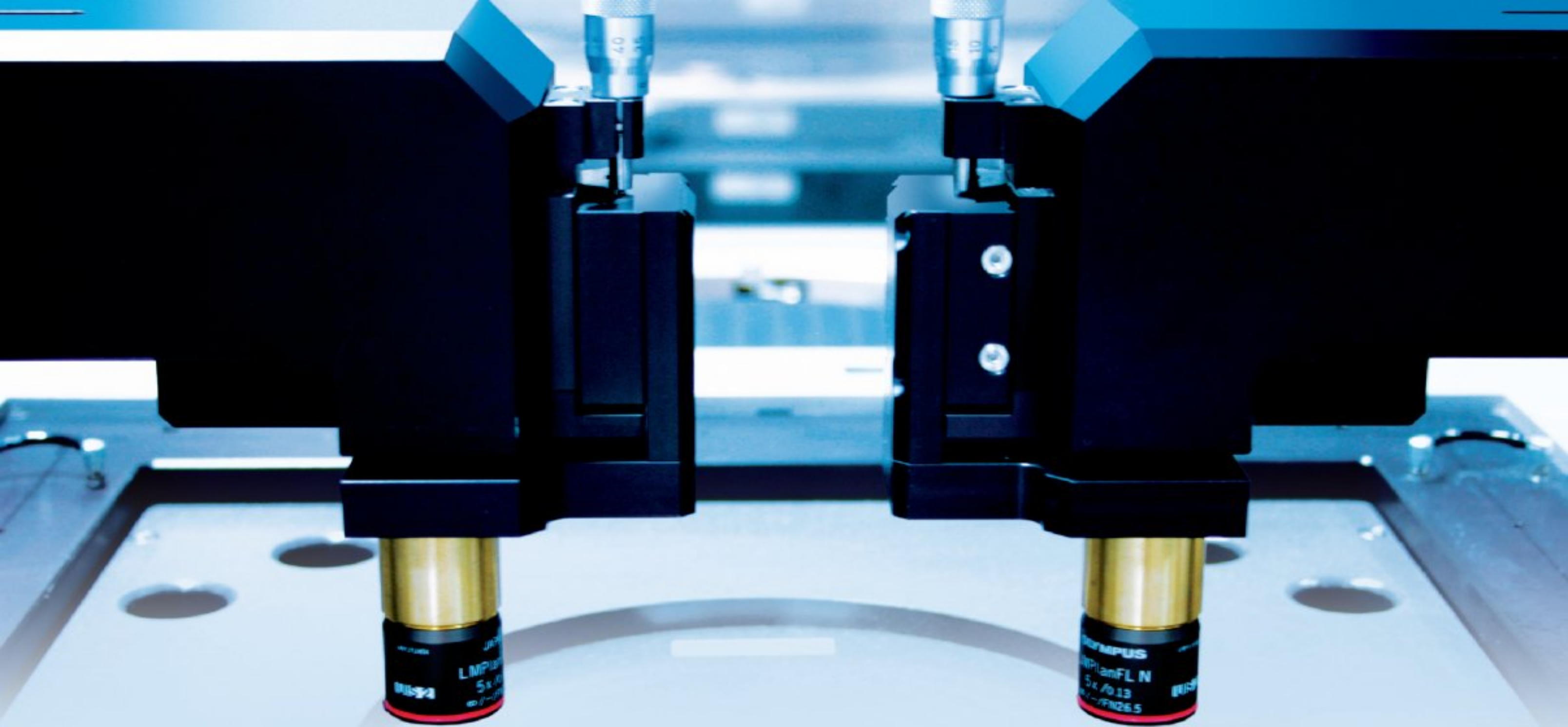
"Despite the lower third-quarter revenues that were driven by the economic downturn, we held our adjusted EBITDA close to breakeven," says CEO Alain Couder. "We continued to execute throughout our business as we positioned ourselves towards achieving our goal of profitability," he adds.

Couder expects the merger with Avanex to further accelerate progress towards profitability. "Our combined companies are well positioned to leverage our complementary product portfolios, operational synergies and strong balance

sheet to accelerate our progress to our long-term financial model."

For fiscal Q4/2009 (ending 27 June) — which includes Bookham's results for the full quarter and Avanex's results from 28 April through 27 June — Oclaro expects revenue of \$67–75m, non-GAAP gross margin of 17–23%, and adjusted EBITDA between -\$5m and breakeven.

Oclaro expects to be adjusted EBITDA positive in the September quarter (the first full quarter after the close of the merger) and to generate at least \$7m of quarterly cost savings by the end of the fourth full quarter post-close.



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## Finisar, Opnext and SEI launch CFP 40–100Gb/s optical transceiver multi-source agreement

Optical module, component and subsystem makers Finisar Corp of Sunnyvale, CA, USA, Opnext Inc of Eatontown, NJ, USA and Sumitomo Electric Industries Ltd (SEI) of Tokyo, Japan (together with subsidiary ExceLight Communications Inc of Durham, NC, USA) have announced the CFP multi-source agreement (MSA), which aims to define a hot-pluggable optical transceiver form factor to enable 40Gb/s and 100Gb/s applications, including next-generation High Speed Ethernet (40GbE and 100GbE). Pluggable CFP transceivers will support the ultra-high bandwidth requirements of data-com and telecom networks that form the backbone of the internet.

According to industry analysts, IP traffic is expected to nearly double every two years through 2012, potentially resulting in core network bandwidth shortages. The IP

traffic volume will be driven by high-quality video services like VOD (video on demand) and IPTV as well as the availability of high-speed and high-capacity access networks such as FTTx and WiFi.

To prevent these shortages, carriers and service providers are already planning the deployment of next-generation high-speed network protocols. The Institute of Electrical and Electronics Engineers (IEEE) is currently working on the standardization of 40Gb/s and 100Gb/s Ethernet under its P802.3ba Task Force. In addition to the existing 40Gb/s telecom standards, both the OIF (Optical Internetworking Forum) and the ITU-T (the International Telecommunications Union's Telecommunication Standardization Sector) are working on standardizing SDH/OTN telecom interfaces for the long-haul transmission of 100 Gigabit Ethernet.

Pluggable transceiver modules compliant to the CFP MSA will be used on these 40Gb/s and 100Gb/s interfaces. The CFP MSA is defining the specifications required to support multiple applications using the same form factor. These applications include various protocols (such as 40GbE, 100GbE, OC-768/STM-256, OTU3), media types (multi-mode and single-mode fiber optics) and link distances. The CFP MSA uses numerous innovative features like advanced thermal management, electromagnetic interference (EMI) management and 10Gb/s signal integrity design to define the transceiver mechanical form factor, the optical connector, the 10x10Gb/s electrical connector with its pin assignments, the MDIO-based transceiver management interface and the hardware required on the system host board.

[www.cfp-msa.org](http://www.cfp-msa.org)

## Continuously Optimized DPSK for 40Gb/s metro, regional and long/ultra-long-haul transmission

At OFC/NFOEC 2009, Opnext announced sampling of its latest 40Gb/s transmission technology, available in an industry-standard 300-pin MSA module (for volume shipment in Q3/2009).

Continuously Optimized DPSK (CO-DPSK) offers what is claimed to be the industry's best performance across all applications, including metro, regional and long-haul, regardless of network configuration, network channel spacing or the number of reconfigurable optical add/drop multiplexers (ROADMs).

Opnext says that CO-DPSK further extends the capabilities of DPSK technology by continuously optimizing the communications link performance based on chromatic dispersion, nonlinear effects and real-time filtering conditions in the network. The CO-DPSK modulation

scheme optimizes for all filtering conditions and provides better performance than standard DPSK, partial bit delay DPSK (P-DPSK), or Switchable FSR in 50GHz channel spacing and offers equivalent performance in the 100GHz channel spacing, the firm claims. It adds that the technology simplifies network design, improves link performance and lowers manufacturing costs and inventory management, enabling simpler, higher-volume deployment of 40Gb/s products.

"Telecom equipment vendors are introducing multi-haul DWDM flexible platforms, enabling their carrier customers to configure for different applications," says Shri Dodani, president of Opnext's subsystems business unit. "Opnext's fourth-generation 40G solution CO-DPSK MSA module allows them to integ-

rate a single DPSK module at 40Gb/s and support all of their applications without requiring manual configuration or complicated design rules, ultimately simplifying network design and lowering costs."

"NSN's hiT7300 and hiT7500 Optical Transport systems are designed and deployed as multi-haul systems with flexible configuration and reach in metro-regional and core network long-haul applications," says Dr Marc Bohn, project manager Optical Components at Nokia Siemens Networks. "Technologies like Opnext's CO-DPSK that are adaptive in nature allow us to support all these applications across different networks with a single product while simplifying splicing, enabling volume deployment and improving overall performance."

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

# Opnext unveils CFP-compliant transceiver for 100GbE and demos 10km SMF transmission

At the Optical Fiber Communication conference and exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC 2009) in San Diego, optical module and component maker Opnext Inc of Eatontown, NJ, USA and former parent company Hitachi Ltd of Japan announced the development of a highly sensitive high-speed 25Gb/s receiver for the 100 Gigabit Ethernet (100GbE) standard. Focusing on practicality and cost-effectiveness, the module uses a coaxial package and achieves both high speed and high responsivity by using a back-illuminated photodiode (PD) with a highly reflective reflector.

Hitachi and Opnext demonstrated 100Gb/s 10km SMF (single-mode fiber) transmission using the newly developed receiver in combination with a 1.3 $\mu$ m-range 4-channel 25Gb/s EA-DFB (electro-absorption modulator integrated distribution feedback) laser developed based on Hitachi's and Opnext's technology as the light source. This transmission achieves the sensitivity requirements of the IEEE P802.3ba 100GBASE-LR4 standard.

A recent study by the IEEE 802.3 High Speed Study Group (HSSG) showed that, by the year 2010, the bandwidth required in core networking will be best satisfied by 100Gb/s interfaces. In preparation, the IEEE 802.3ba 40Gb/s and 100Gb/s Ethernet taskforce is currently discussing specifications for 100GbE, for which 1.3 $\mu$ m-range 4-channel 25Gb/s WDM (wavelength division multiplexing) 10km SMF transmission has been decided by the task force as the most attractive technology. This represents a ten-fold increase in speed from the current 10Gb/s Ethernet standard. The receiver that has been developed is therefore expected to become a key component in this international standard

and support next-generation high-speed interface technology.

"The first step to achieving a 1.3 $\mu$ m-range 25Gb/s WDM optical transceiver was the announcement of a 25Gb/s EA-DFB (electro-absorption modulator with integrated distributed feedback laser) suitable for 100 Gigabit Ethernet, and verification of 12km optical transmission, which Hitachi and Opnext introduced at OFC/NFOEC 2008," says Dr Masahiro Aoki, manager of the Nanoelectronics Research Department at Hitachi's Central Research Laboratory.

"This year, Hitachi and Opnext announced the development of a cost-effective 25Gb/s optical receiver for 100GbE, overcoming several technical issues," he adds.

Consequently, at OFC/NFOEC 2009, Opnext also unveiled what it claims is the first 100GbE optical transceiver for 10km transmission over standard single-mode fiber (SMF). Verification tests using the experimental transceiver, based on the newly developed receiver in combination with the EA-DFB laser developed previously, not only satisfied signal levels

**By the year 2010, the bandwidth required in core networking will be best satisfied by 100Gb/s interfaces**

required for 100 Gigabit Ethernet but also confirmed 25Gb/s 10km SMF transmission. The transceiver is compliant with the IEEE P802.3ba 100GBASE-LR4 standard and with the CFP multi-source agreement (MSA) — launched at OFC, by Opnext, Finisar and Sumitomo Electric Industries — which is the first industry standard to support next-generation high-speed interfaces including 100 Gigabit Ethernet (100GbE) transmission.

Opnext's 100GbE transceiver uses its in-house 1310nm 25Gb/s EA-DFB TOSA (transmission optical sub-assembly) and in-house PIN photodiode ROSA (receive optical sub-assembly). Both the TOSA and ROSA were developed in collaboration with Hitachi's Central Research Laboratories.

The transceiver's low power consumption was achieved by using a high-temperature-operation EA-DFB laser based on Opnext's and Hitachi's technologies of using semiconductor material with a

**The availability of the 100GbE 10km client-side optical transceiver is key for widespread 100GbE applications**

temperature-tolerant bandgap structure. In addition, the transceiver's cost-effective structure and compact size was achieved by using non-coaxial 25Gb/s connections between the TOSA, ROSA and

GearBox IC.

"The availability of the 100GbE 10km client-side optical transceiver is key for widespread 100GbE applications," says Opnext Japan's president Kei Oki.

The transceiver is hot pluggable and is the same length but double the width of the 10 Gigabit Ethernet industry-standard XENPAK module. It has an SC duplex receptacle optical connector and a 148-pin electrical connector with CAUI 10x10Gb/s signals. The transceiver requires a single 3.3V power supply.

Opnext says that samples of the 100GbE transceiver will be available in mid 2009, with mass production targeting general availability in mid 2010.

[www.opnext.com](http://www.opnext.com)  
[www.ieee802.org/3/hssg](http://www.ieee802.org/3/hssg)  
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## GreenVolts' delays GV1 plant to develop CPV system as founder & CEO becomes executive chairman

Concentrating photovoltaic (CPV) system maker GreenVolts Inc of San Francisco, CA, USA says that its CEO Bob Cart has moved to a full-time role as executive chairman. He will also serve as chairman of the board of directors.

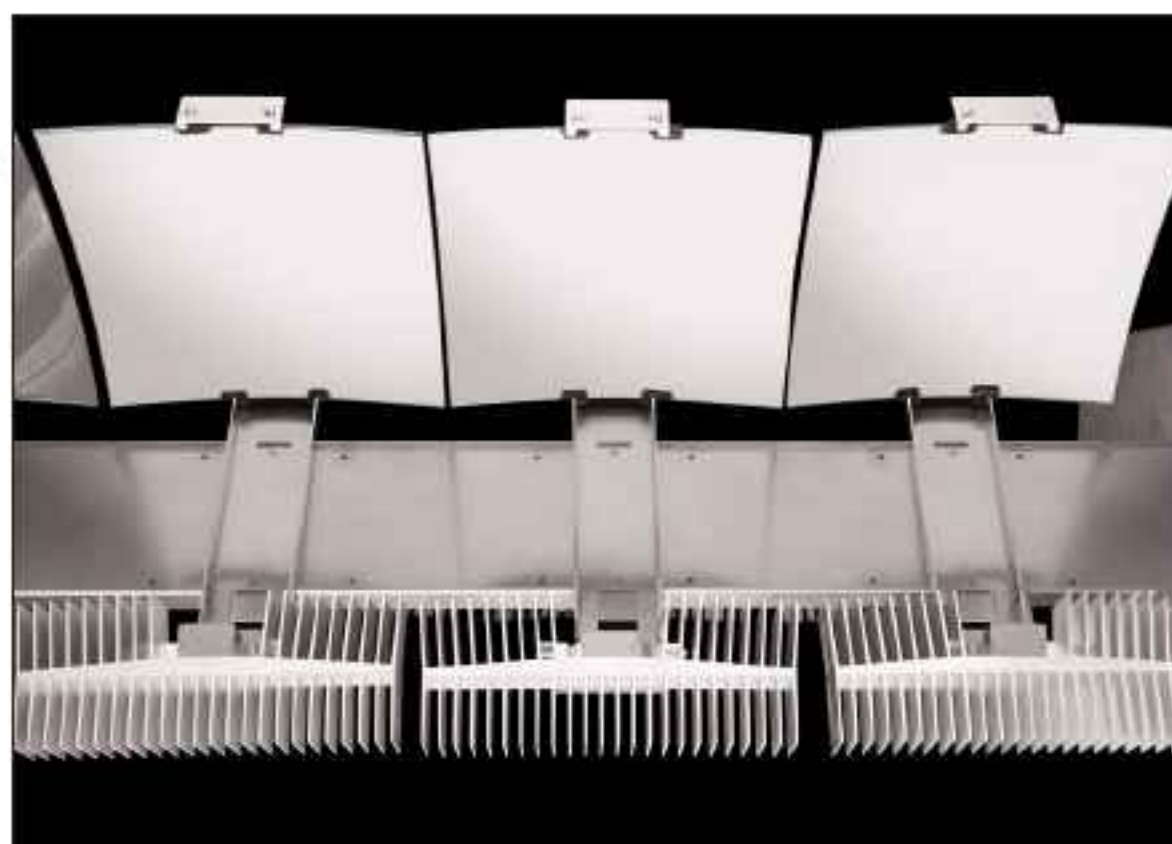
After being founder & CEO of several other ventures, entrepreneur Cart founded GreenVolts in 2005. GreenVolts has since raised \$44m in funding to date.

Cart will now focus on the firm's strategic vision and direction, including work on government relations and strategic alliances.

Gary Beasley (who has been GreenVolts' chief financial officer for the past year) has assumed the additional responsibilities of president & CEO on an interim basis.

"We are at a natural evolution point in the maturation of this company, and it made sense to allow others to focus on the day-to-day operations of the company so that I could keep my eyes trained on the broader vision and future for GreenVolts," Cart says.

In 2007, GreenVolts announced a 20-year power purchase agreement



Reflector (top) and receiver (bottom) of GreenVolts' CarouSol CPV array power unit.

to build the 2MW 'GV1' pilot facility in Tracy, CA (50 miles east of San Francisco) and sell the electricity to Pacific Gas and Electric Company (PG&E), aiming to complete the project by the end of 2009. When GreenVolts raised \$30m in a series B round of financing last September, it was still aiming to finish the first half of the project by the end of 2008. However, the deadline for completing the entire project has since been delayed to mid-2010. The firm decided that, instead of using its first-generation technol-

ogy, it would instead work on improving its CPV system's design in order to boost its performance and lower its cost, and put in place a next-generation system at GV1.

GreenVolts is making changes to several parts, including the mirrors and receiver (including the lens and solar cell). Until now, GreenVolts has bought solar cells from other firms. In March it entered into a two-year development relationship with the National Renewable Energy Laboratory (NREL) of Golden,

CO, USA, licensing patents to commercialize its inverted metamorphic (IMM) multi-junction solar cells. Last August this technology reached record conversion efficiency of 40.8% at 326x concentration (since exceeded by Fraunhofer ISE's 41.1%, although NREL reckons that its IMM technology promises further substantial increases).

GreenVolts will remain focused on making improvements to its technology and advancing its solar cell initiative with NREL, says Beasley.

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

## NREL awards Spire \$3.7m to develop 42%-efficient CPVs

Spire Corp of Bedford, MA, USA, which provides turnkey production lines and capital equipment for making photovoltaic modules, cells and wafers, says that its epiwafer foundry subsidiary Spire Semiconductor LLC has been awarded an 18-month, \$3.7m program by the US Department of Energy's National Renewable Energy Laboratory (NREL), consisting of \$2.96m in government funding and a \$745,000 cost share.

Under the contract, Spire Semiconductor of Hudson, NH, USA aims to develop next-generation manufacturing technology to produce III-V triple-junction tandem concentrator solar cells with an effi-

ciency of 42% by growing differentiated bi-facial cells on a GaAs substrate. This approach should allow Spire to optimize the optical properties of the device layers to better match the solar spectrum, the firm says.

The goal of the Photovoltaic (PV) Technology Incubator program is to shorten the timeline for companies to transition prototype and pre-commercial PV technologies into pilot and full-scale manufacture, says Spire Semiconductor's general manager Edward D. Gagnon.

"Our new growth technique has the potential for producing concentrator cells with record-level efficiencies with lower manufacturing costs and

higher reliability," he reckons.

"Spire has been involved in the solar energy market for over 25 years," says Spire Corp's chairman & CEO Roger G. Little. "Development of this cell will put us in an excellent position to capitalize on the growing market opportunity for custom GaAs-based solar cells for concentrator photovoltaic (CPV) systems. Our Spire Semiconductor facility has state-of-the-art capabilities for producing these devices," he adds. "We plan to offer our new series of triple-junction Triathlon concentrator solar cells to system integrators around the world."

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

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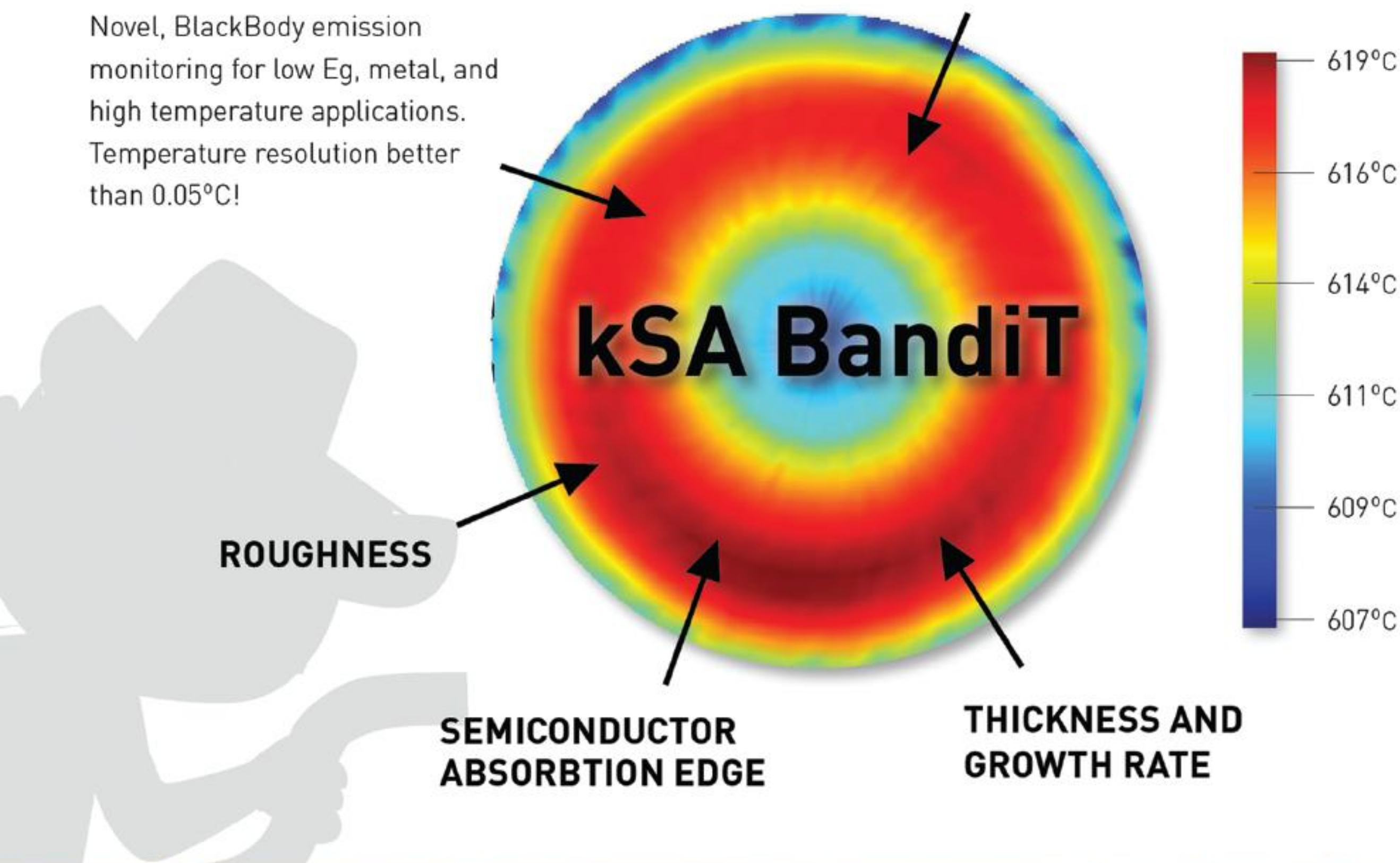
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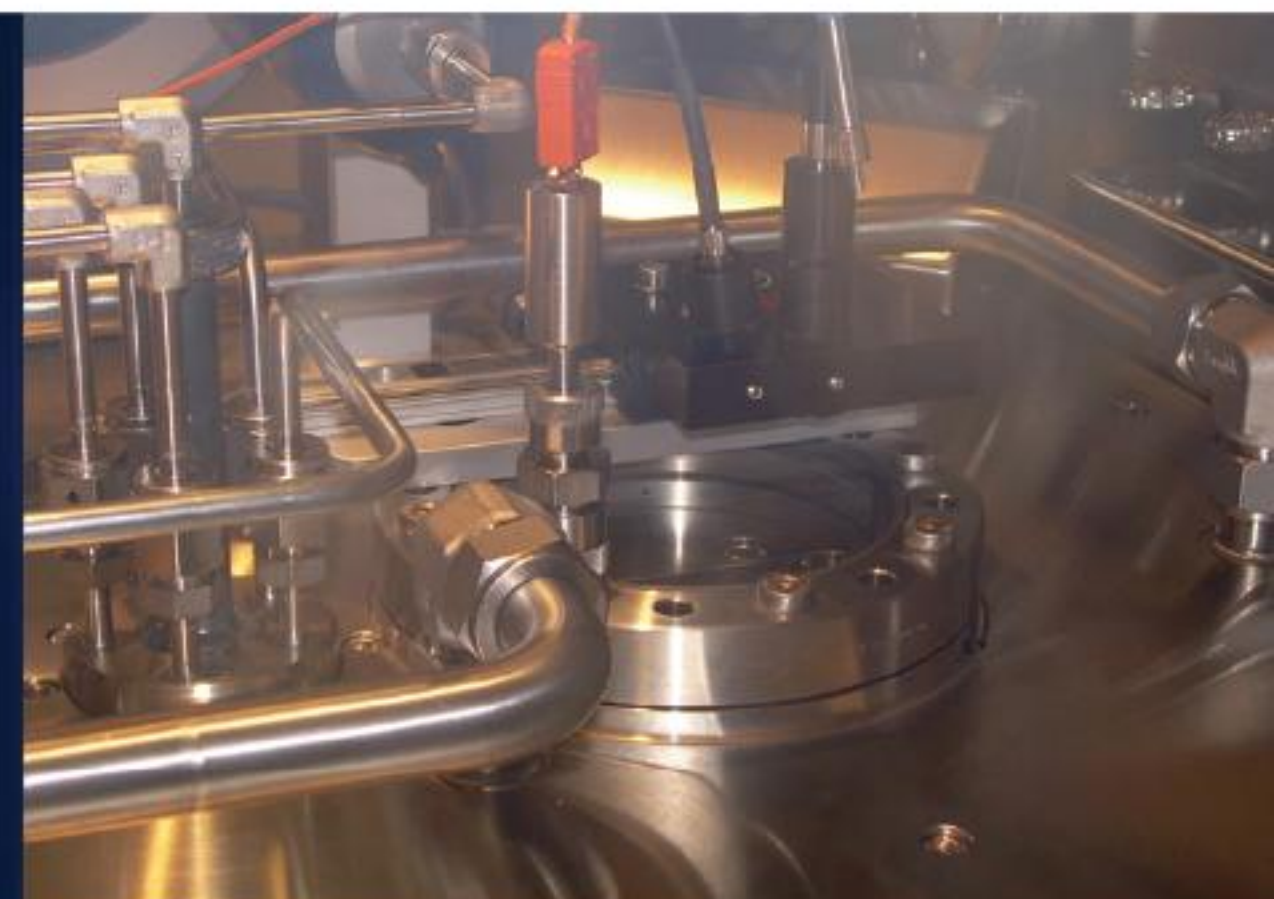
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# CPV panel maker OPEL forms subsidiary to partner with European solar project developers

In late March, OPEL International Inc of Toronto, Canada, which makes high-concentration photovoltaic (HCPV) panels (as well as both roof- and ground-based dual- and single-axis solar trackers for mounting them), formed a limited liability company OPL Solar Europe (OSE) based in Brussels, Belgium. The aim is to open up solar markets and projects for OPEL's products throughout Europe and the Mediterranean basin.

OSE is a financial holding company that allows subsidiary firms to form limited joint ventures and partnerships with solar developers so that utility-grade solar farms can be financed and installed featuring OPEL technology. The solar farms will be sold to subsequent investor firms acting as power suppliers. "OSE functions as the hub of all OPEL solar projects, partnerships, and joint ventures on the European continent," says Eric Vanbutsele, a senior OPEL executive and European managing director.

OPEL International was founded in 2000 by Daniel Upp (formerly of ITT Corp's Advanced Technology Center then TranSwitch Corp), originally to develop integrated DSL circuits for telecoms, before refocusing on PVs after the telecom bubble burst. Products are based on technology developed in cooperation with Canada's National Research Council in Ottawa and the University of Connecticut, where OPEL has a lab (via its US subsidiary OPEL Inc of Shelton, CT). OPEL International has been awarded 31 patents and has 15 more patents pending. The firm (which has 26 staff) started production of HCPV panels and tracker systems last December.



OPEL's Mk-I HCPV panels.

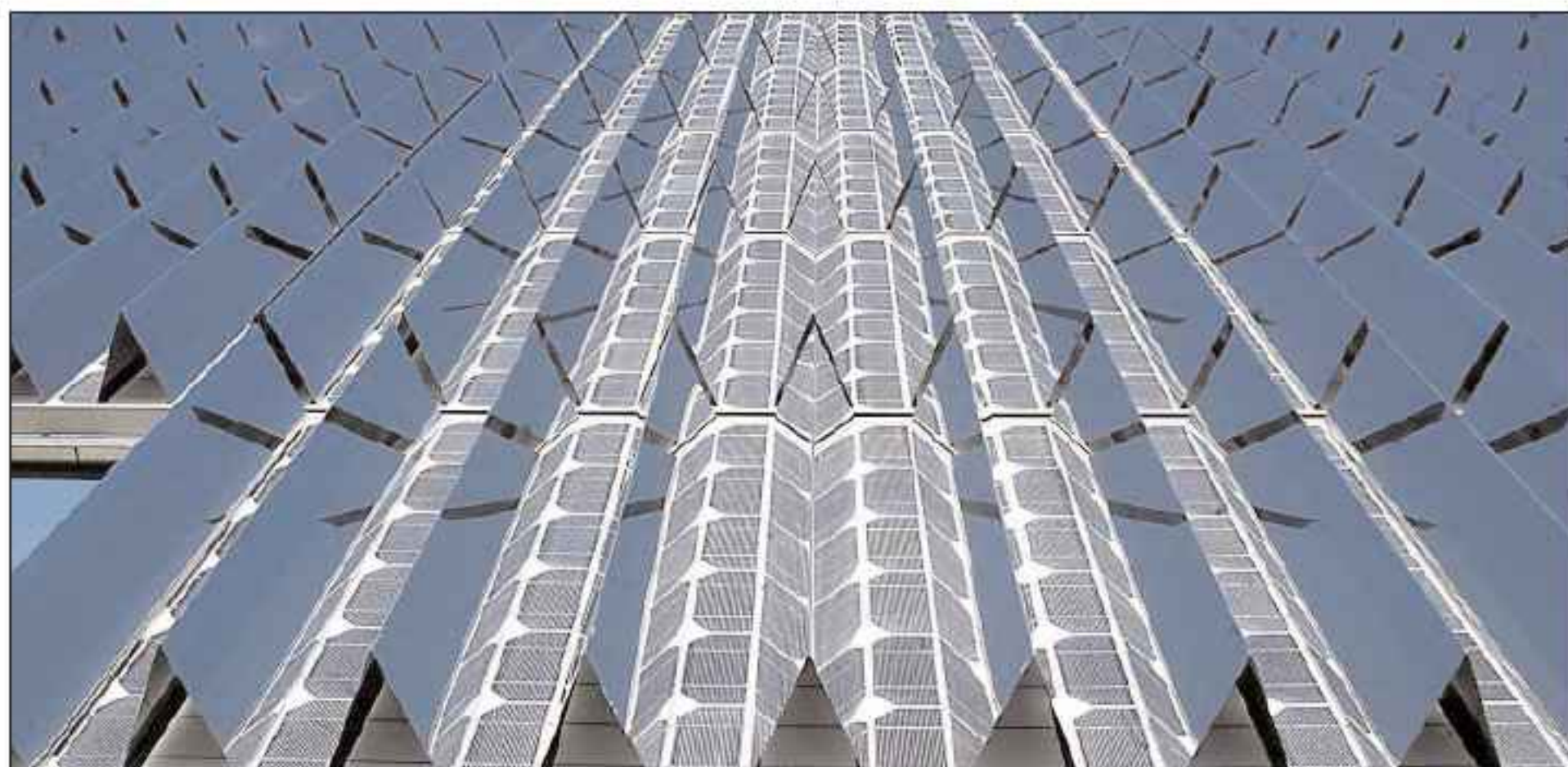
OPEL aims to supply grid farm installations featuring its dual-axis trackers and Mk-I HCPV panels, which are designed for grid-connected systems and medium to high solar irradiance. Each module uses a dual-element refractive concentrator to concentrate sunlight more than 500 times. GaAs-based triple-junction solar cells from Boeing-Spectrolab yield a conversion efficiency up to twice that of silicon solar panels and up to three

times that of thin-film solar panels, it is claimed. The Mk-I (which is made in Mexico) obtained CE qualification for Europe last September.

OSE's formation is key to OPEL's global strategy, says OPEL International's president & CEO Robert Pico (also formerly of ITT and TranSwitch). "OSE's mission encourages its subsidiary companies and solar developers to launch projects to build solar farms using OPEL technology and products," he adds. "Europe has taken a leadership position in promoting solar power."

OSE inherits two existing OPEL International joint ventures announced last November and this January, respectively: with Alcapi Solarwent Management GmbH (ASM), a German limited liability company, for a 700kW project in Spain; and with Spain's BETASOL for a 440kW utility-grade solar power plant that is expected to supply to more than 500 households. OPEL began supplying Mk-I HCPV panels to BETASOL in December (for completion in first-quarter 2009), and will soon begin delivery to its first project with Alcapi Solarwent.

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



OPEL's Mk-III low-concentration photovoltaic (LCPV) panels.



# Connecticut's first rooftop tracking PV system goes live

OPEL Inc's rooftop PV installation at the Linden Street School in Plainville, CT (the first combined rooftop solar panel and tracker system in the state of Connecticut) went live in late March.

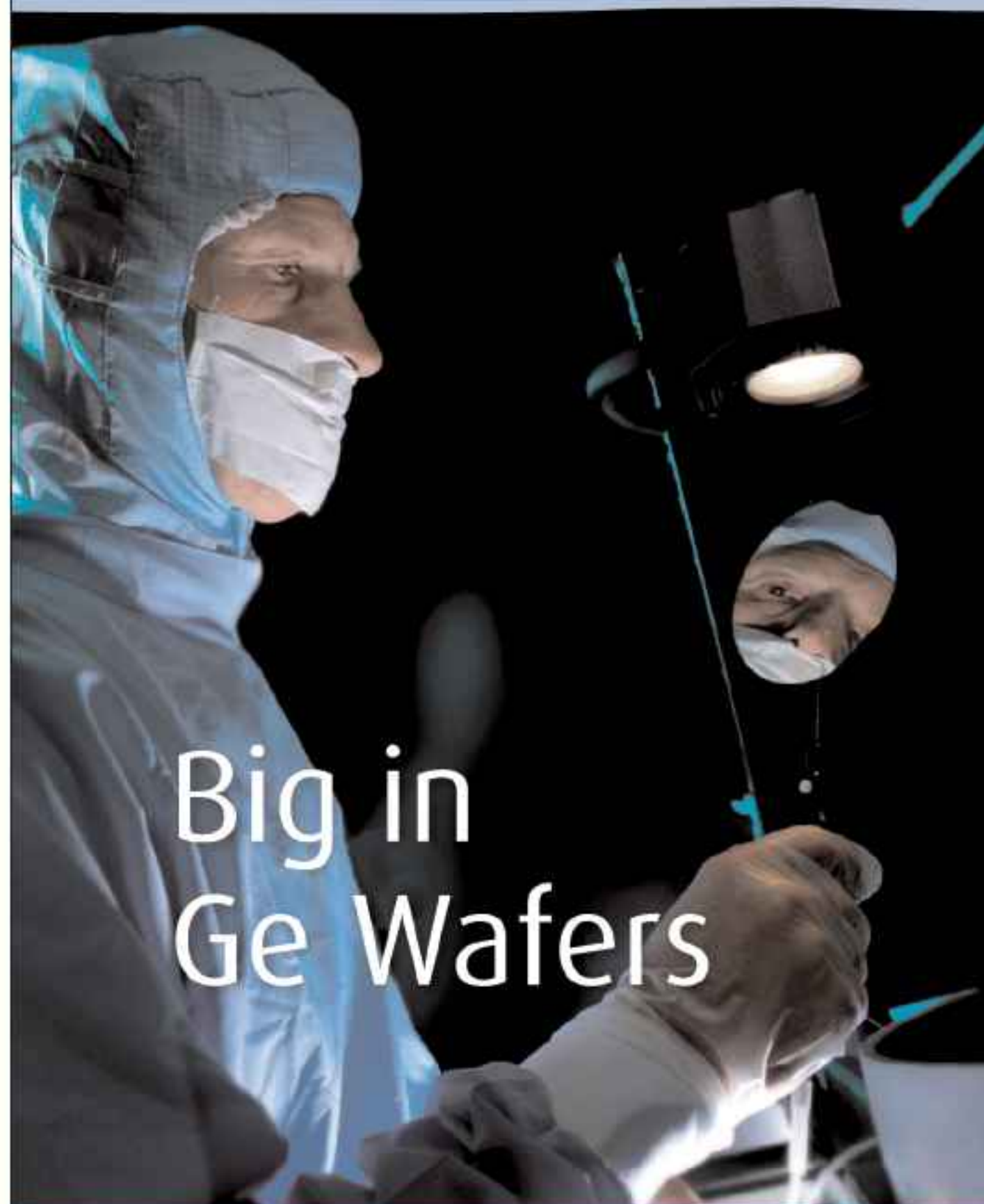
The Plainville installation features OPEL's patent-pending Sequoia tracker system, which includes 210 trackers and 770 panels generating 170W each. The Sequoia design (inspired by the root system of the Sequoia tree) is a non-penetrating roof design that allows simple installation and easy disassembly for any required maintenance.

The 131kW installation is a partnership agreed last June with the Town of Plainville and the Connecticut Clean Energy Fund (CCEF), which provides grants and rebates and contributed to funding the project. OPEL will own and operate the installation and sell electricity to the Town of Plainville at rates below those currently being paid. Annual savings of at least \$7000 in electricity costs are projected. "OPEL's rooftop solar tracker system will generate up to 30% more kilowatt-hours than conventional fixed flat-plate silicon solar panels," claims Robert Pico, president & CEO of OPEL International.

The system will supply energy for up to 20% of the 130,000ft<sup>2</sup> elementary school's total electrical bill, eliminating 79 tons of carbon emissions, it is reckoned. "The Linden Street School solar power program reinforces Plainville's position as a leader in clean energy initiatives with the help of valuable funding from CCEF," says Plainville town manager Robert Lee.

The project highlights CCEF's focus on providing support for clean energy initiatives at Connecticut educational institutions, which now total 32 installations statewide, says CCEF president Lise Dondy. "We hope to continue developing and implementing these valuable renewable energy programs throughout the state for many years to come," she adds. "This innovative solar power initiative not only promotes a cleaner environment, but also offers a unique educational opportunity for our students at the Linden Street School to see solar energy in action firsthand," comments Plainville's Superintendent of Schools Dr Kathleen Binkowski.

Previously, last November, OPEL installed a 9.5kW grid-tied solar plant at The Sports Zone in Trumbull, CT, consisting of Mk-I HCPV panels along with its Mk-III low-concentration photovoltaic (LCPV) panels (designed for medium to low solar irradiance, using a V trough of highly reflective, weather-resistant materials to enhance conversion while reducing system costs — see photo on previous page), all mounted on SF-20 dual-axis tracker systems.



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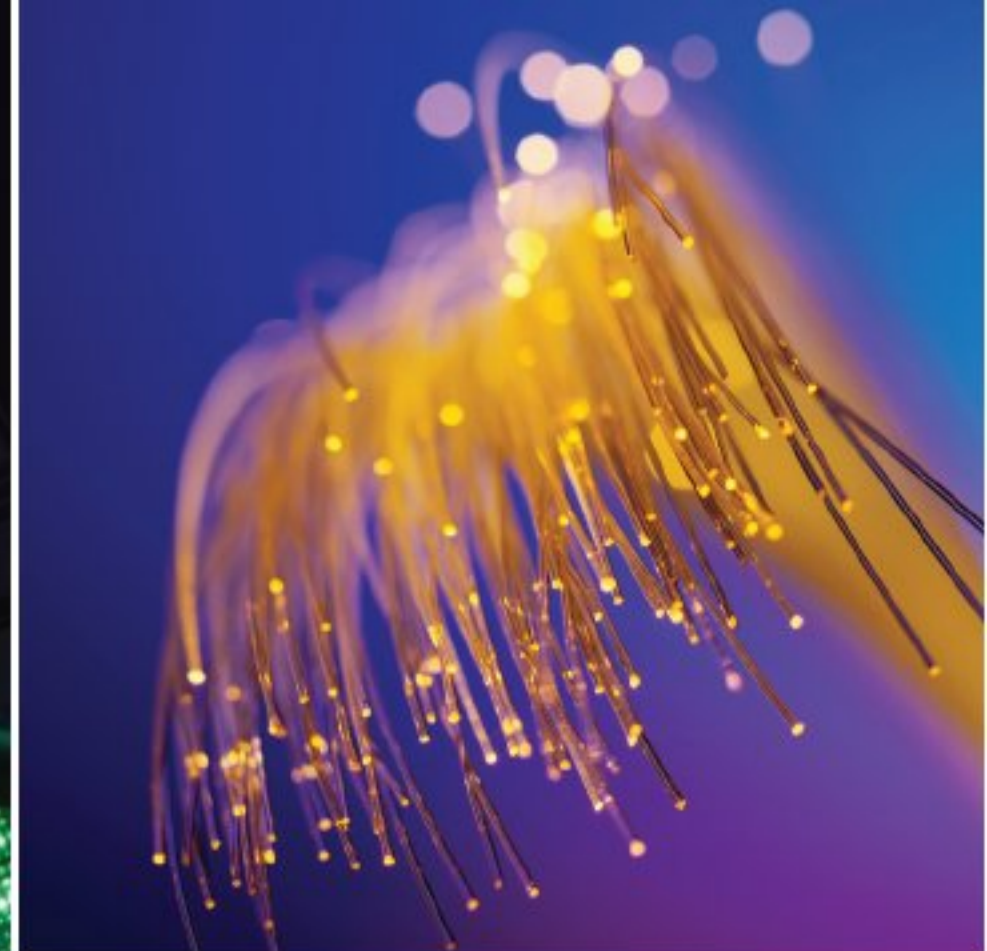
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# Juwi and First Solar secure funds for 53MW German plant

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe), and German renewable energy firm Juwi Holding AG have secured financing for a 53MW DC photovoltaic (PV) power plant near the German city of Cottbus.

More than 80% of the required project capital is financed through non-recourse debt from a consortium of banks. First Solar and Juwi intend to sell the majority of the project after its completion. Construction began in January, and the first 15MW has been completed.

The remaining 38MW is scheduled for completion by the end of 2009.

The project is being constructed on 162 hectares of land that is part of the 26,000 hectare former Soviet Army Lieberose training area north of Cottbus in eastern Germany. The firms say that its low cost enables the required return to fund an attractive land lease for the

State of Brandenburg. This, in turn, finances the environmental cleanup of the former military zone, which is littered with tons of land mines and grenades as well as other munitions.

The project is a model for the conversion of former military land to productive use, according to Matthias Platzeck, minister president of the German state government of Brandenburg. "This kind of project helps us heal the scars of the Cold War and meet our ambitious targets for renewable energy production at the same time," he says.

This project alone is expected to displace about 35,000 tons of CO<sub>2</sub> emissions a year, comments Stephan Hansen, managing director of First Solar GmbH in Mainz, Germany. "Not only will the project produce clean electricity, but it will also result in the removal of hazardous munitions from this project site," he adds.

Upon completion, the PV power plant will consist of about 700,000 modules and is projected to be the largest in Germany (producing enough power to provide for the annual electricity needs of more than 14,000 homes) and the second largest worldwide. "The sheer size of the project helps us achieve economies of scale that are a significant factor in helping PV energy become competitive with fossil fuels and to be able to provide an increasing contribution to national renewable energy targets," says Hansen.

"Large projects like this one demonstrate that solar power is already capable of making significant contributions to addressing climate change," claims Juwi's chief executive Matthias Willenbacher. "With this project, Juwi, using First Solar modules, has developed the three largest PV power plants in Germany," he adds.

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

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

## Modules to be supplied for Australia's largest PV installation

First Solar Inc of Tempe, AZ, USA is to supply its cadmium telluride (CdTe) thin-film photovoltaic (PV) modules to Solar Shop Australia Pty Ltd for a 1MW DC rooftop project commissioned by the Royal Agricultural and Horticultural Society of South Australia.

The solar power system, installed on six separate buildings at the Adelaide Showground, will be the largest PV installation in the country.

Solar Shop is the largest provider of grid-connected solar systems in Australia, having installed 25% of all systems in 2008. In partnership with building and engineering company Build Environs Pty Ltd, it will design and construct the 1MW

installation, which is expected to displace about 1500 tons of CO<sub>2</sub> per year. Construction is expected to begin immediately and to be completed by third-quarter 2009. The power produced will be used predominantly at the Adelaide Showground site, displacing power generated from conventional sources.

"Solar Shop determined First Solar's modules offered the best option for the Showground after considering a number of other solar technologies and the client's specific requirements," says Solar Shop's managing director Adrian Ferraretto.

As the world's largest manufacturer of thin-film solar modules,

in March First Solar announced that it had produced 1GW of PV modules since starting commercial production in early 2002. The firm also claims the PV industry's lowest manufacturing cost, having broken the \$1 per watt price barrier by reducing its manufacturing cost to 98 cents.

"This project marks the beginning of what we expect to be a very promising future for solar energy in Australia," says John Carrington, First Solar's executive VP of marketing & business development. "Australia's policy initiatives have set the stage for the growth of affordable renewable energy," he adds.

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

# First Solar to build 48MW extension to Sempra's plant

Sempra Generation (a subsidiary of Sempra Energy of San Diego, CA) has contracted First Solar Inc of Tempe, AZ, which makes thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe), to build a ground-mounted PV power-generation plant with a capacity of 48MW AC (enough to supply more than 30,000 homes).

The 'Copper Mountain Solar' project will expand an existing \$40m, 10MW PV power plant constructed by First Solar last July–December, adjacent to Sempra Generation's existing 480MW El Dorado Energy combined-cycle natural gas power plant near Boulder City, NV (about 40 miles southeast of Las Vegas). The new plant will boost the number of PV panels at the site from 167,000 to nearly 1 million.

As with the first plant, First Solar will design, engineer and construct



Sempra Energy's El Dorado plant.

the new plant; Sempra Generation will own and operate it. Construction is expected to begin in 2009 (conditional upon applicable state and local regulatory approvals, as well as Sempra Generation executing a power purchase agreement with a utility customer for the electricity generated). Once completed in 2010, the combined 58MW project is expected to be the largest PV power plant in North America.

"This would be our largest renewable energy project thus far, and move us closer to our stated goal of becoming the first US company to own 500MW of solar power," says Sempra Generation's president & CEO Michael W. Allman.

"We are pleased to have the opportunity to expand this 10MW project to 58MW — more than five times its original size, advancing our mission of providing clean, affordable solar electricity," says First Solar's executive VP of marketing & business development John Carrington.

"Sempra Generation's decision to use First Solar in expanding the El Dorado solar plant demonstrates our ability to provide a cost-effective energy solution for utility-scale projects," Carrington adds.

[www.semprageneration.com](http://www.semprageneration.com)  
[www.firstsolar.com](http://www.firstsolar.com)

## VP of federal affairs appointed to lead government relations

First Solar has appointed Dennis Fitzgibbons as VP federal affairs, responsible for leading the firm's federal government affairs activities in the USA.

"He has a wealth of experience in dealing with climate change and renewable energy issues that impact the company, and his efforts

will support our mission of providing clean, affordable solar electricity," says CEO Michael Ahearn.

Most recently, Fitzgibbons was chief of staff for the Committee on Energy and Commerce in the US House of Representatives, where he participated in major legislative policy debates and development

relating to energy. Previously, he served as director of public policy for Daimler Chrysler (developing, coordinating, implementing and communicating the firm's positions on major public policy issues, ensuring consistency across major markets, and aligning positions within business strategies).

## Acquisition of OptiSolar's PV project pipeline completed

First Solar has completed its acquisition of the photovoltaic project development business of OptiSolar Inc of Hayward, CA (which makes thin-film PV modules and produces power from its own large-scale solar farms). First Solar expects to construct the solar power plants developed under OptiSolar's project development pipeline over the next several years and sell them to a

combination of regulated utilities, diversified energy companies and other independent power producers.

In addition, the core development team responsible for assembling and executing on the solar project pipeline has joined the First Solar development team. First Solar acquired all of OptiSolar's project development business in an all-stock transaction valued at about \$400m.

As a result of the deal closing, First Solar will issue about 3 million shares of common stock, representing a dilution of about 3.5%. This is less than the dilution of about 5% that was expected when the acquisition was announced, due to recent appreciation in the price of shares of First Solar's common stock.

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

# Abound Solar opens full-scale CdTe PV production facility

In March, AVA Solar Inc unveiled its new brand name, Abound Solar, after having manufactured cadmium telluride (CdTe) thin-film photovoltaic (PV) modules on an initial 3MW pilot-production line at its headquarters and R&D lab in Fort Collins, CO, USA since late 2007.

Now, in the presence of Colorado Governor Bill Ritter, Robert F. Kennedy Jr and EUROSOLAR president Hermann Scheer, Abound has unveiled its fully automated commercial-scale manufacturing plant in Longmont, CO, after breaking ground in April 2008. Annual capacity is 65MW from the first production line, and 200MW ultimately. "Abound Solar proves that we have the capability here in the United States to cost-effectively meet our energy needs, while protecting our climate," said Kennedy. Ritter described Abound as a "true Colorado success story of how renewable energy technologies can move from the lab to the marketplace."

Based on 15 years of research led by professor W.S. Sampath, director of Colorado State University's Material Engineering Laboratory (with the support of the National Renewable Energy Laboratory in Golden, CO), AVA was founded in January 2007 to commercialize a proprietary process for manufacturing CdTe thin-film PV modules. A seed round of funding in February 2007 led to construction of the initial 3MW pilot-production line, followed that June by a second round of funding plus \$3m over 18 months from the Photovoltaic Technology Incubator Program of the US Department of Energy's Solar America Initiative.

AVA has since developed an automated process in which its proprietary continuous in-line equipment converts sheets of glass into solar panels in less than 2 hours at a cost



From left to right: CFO Stephen Abely; chairman John Hill; US Congressman Jared Polis; CEO Dr Pascal Noronha; Colorado Governor Bill Ritter; Robert F. Kennedy Jr; Dr Herman Scheer; and NREL director Dr Dan Arvizu.

of less than \$1/watt, it is claimed. Initial PV efficiencies were 11–13%. Last August, AVA completed a \$104m second institutional equity financing round, led by Doll Capital Management and joined by new investors Technology Partners, GLG Partners and Bohemian Companies LLC as well as previous investors including Invus LP. This raised total funding from private investors and institutions to nearly \$150m, enabling the firm to complete the Longmont plant and create more than 300 further jobs. AVA reckons on employing 500 staff in total by the end of 2009.

"We are trying to get the cost of solar power down to be competitive with fossil fuels [i.e. grid parity]," says marketing director Mark Chen. "Larger-scale projects are more likely to accomplish this in the near term." Chen added that Abound's manufacturing costs will be competitive with the industry leader — First Solar says it cut its CdTe PV manufacturing cost in fourth quarter 2008 to 98 cents per watt.

"Our new brand identity represents a change in the company's look, as well as our focus," says president & CEO Pascal Noronha. "We are well-positioned to address the growing demand for solar power, and we are focused on scaling to create a source of renewable, abundant and

universally affordable energy."

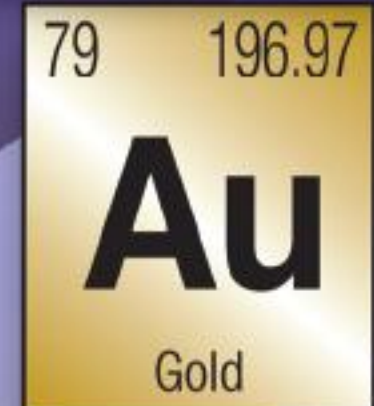
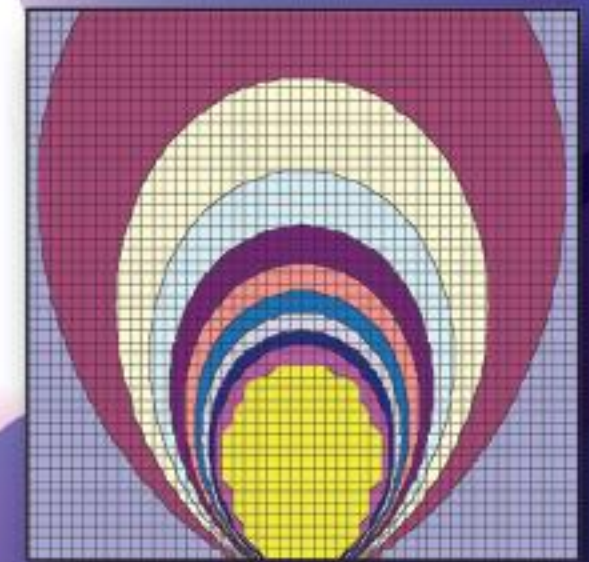
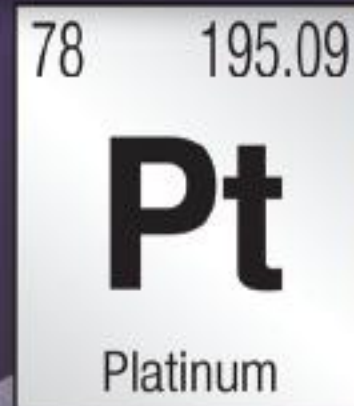
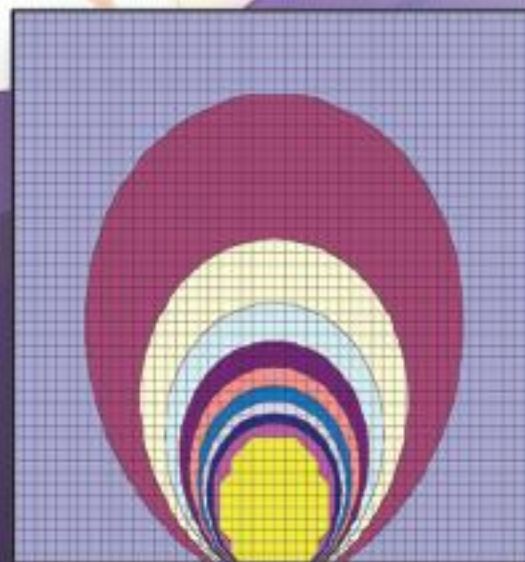
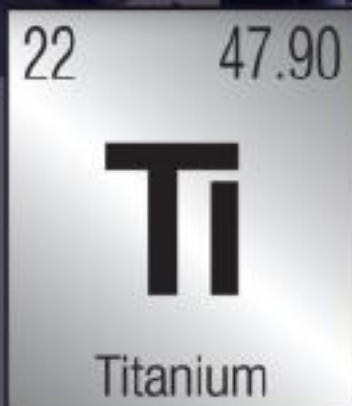
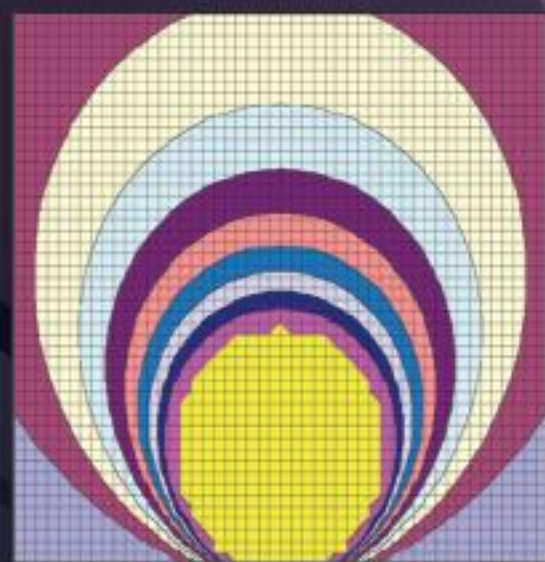
Fueled in part by enhanced federal support for renewable energy (including tax credits and loan guarantees), the global solar industry is expected to continue to grow 30% annually for the foreseeable future, driving increased demand for cost-effective solar modules. Abound Solar reckons that it is well positioned to accelerate its evolution from an R&D firm commercializing a new manufacturing process to a high-volume manufacturer of low-cost PV panels.

Even prior to officially entering commercial production, Abound Solar says that it has long-term supply contracts in place with vendors and customers globally to support multiple gigawatts of production.

Abound is seeking further funds to demonstrate scalability. In February, to expand its Longmont plant's capacity by about 50% and to begin construction of a larger second plant in the USA, the firm applied for a loan guarantee from the US Department of Energy (DOE), which recently financed its first loan (\$535m) under a three-year-old program to Solyndra Inc of Fremont, CA, which manufactures copper indium gallium diselenide (CIGS) thin-film PV modules.

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

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## FastLine glass coating systems launched for CIGS PVs

Veeco Instruments has launched its FastLine platform of glass coating systems, which leverages the firm's PV-Series Thermal Deposition Sources and is designed for high-throughput, low-cost-of-ownership production of copper indium gallium diselenide (CIGS) thin-film photovoltaic cells.

"Veeco is now the only equipment company offering integrated production-scale solutions for CIGS manufacturing on glass using thermal evaporation sources for the CIGS/absorber layer," claims Piero Sferlazzo, senior VP of Veeco's Solar Equipment business. "Customers can now choose Veeco to provide comprehensive, fully integrated equipment to manufacture CIGS solar cells, whether they



Veeco's FastLine platform.

choose to use our FastLine systems for glass or our FastFlex systems for flexible substrates."

According to the firm, compared with other deposition methods, thermal evaporation produces the highest-efficiency thin-film solar cells and has the lowest materials cost, with high material utilization

driving down the manufacturing cost per watt. FastLine systems can handle up to thirty 1.1m x 1.4m glass panels/hour, and the modular architecture allows users to scale output according to their needs.

The US Department of Energy's National Renewable Energy Laboratory (NREL) has claimed a world record for CIGS thin-film solar cell conversion efficiency of 19.9%. The conversion efficiency for CIGS is now close to that of multi-crystalline silicon-based solar cells, it reckons. This achievement has been hailed as an important milestone, because the efficiency of thin-film solar cells is now achieving its goal of matching silicon in performance.

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

## Veeco supplying CIGS PV manufacturing equipment to Daiyang

In March, Veeco Instruments entered into a strategic partnership to supply equipment for manufacturing CIGS solar cells to Daiyang Metal Co Ltd of Seoul, Korea, which produces cold rolled stainless steel but is entering the CIGS solar cell market.

As a first milestone in the relationship, in order to build a thin-film CIGS solar cell production line in Yesan, Korea, Daiyang has placed an initial multi-million dollar purchase order with Veeco for its complement of FastFlex Web Coating Systems, consisting of one Mo (molybdenum) deposition system, one TCO (transparent conductive oxide) deposition system, and two CIGS deposition systems. Veeco expects to ship the systems in fourth-quarter 2009, after which it expects to firm up a follow-on order with Daiyang.

Veeco says that its FastFlex platform has a flexible architecture with high uptime that can be configured to specific needs, with a choice of rotary or planar magnetrons for high-throughput, high-temperature effusion sources, and

substrate sizes up to 1m wide.

"Daiyang Metal has an aggressive multi-year, multi-site plan to become a leading worldwide manufacturer of CIGS solar cells," says Daiyang's CEO Chan Ku Kang.

"Our short-term goal is to aggressively ramp to 200MW capacity during 2010 and 2011, which will entail the purchase of additional Veeco systems. Ultimately it is our goal to achieve 1 gigawatt of CIGS production capacity by 2013," he adds.

"This partnership is especially important to us because together, with Daiyang as the substrate manufacturer and Veeco as the production equipment supplier, we can accelerate the solar industry's efficiency roadmap," says Veeco's

**With Daiyang as the substrate manufacturer and Veeco as the production equipment supplier, we can accelerate the solar industry's efficiency roadmap**

CEO John R. Peeler. "CIGS is emerging as the next-generation solar technology, offering combined benefits of higher efficiencies and lower costs when compared with silicon."

Market research firm Nanomarkets estimates that CIGS production capacity will reach 1.4GW in 2012 and 4.9GW in 2015 (a 30-fold increase over 2008's 152MW). CIGS solar cells offer the broadest range of applications of any thin-film solar technology, including solar farms, building-integrated PVs (BIPVs), flat and pitched roofs, rooftop shingles, and portable devices.

"Daiyang's selection of Veeco is confirmation of our leadership in thermal evaporation sources," claims Piero Sferlazzo, senior VP of Veeco's Solar Equipment business. "Thermal source technology is quickly becoming the preferred CIGS deposition method because it provides customers with high-volume, low-cost manufacturing solutions that drive down the manufacturing cost per watt."

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



## Ascent Solar opens expanded headquarters in Colorado

Ascent Solar Technologies Inc has expanded from its existing facility in Littleton, CO, USA, where its 1.5MW capacity manufacturing line produces fully integrated lightweight copper indium gallium diselenide (CIGS) thin-film photovoltaic modules using a flexible plastic substrate, with the opening of its new headquarters in Thornton, CO, just north of Denver. The opening was attended by Colorado governor Bill Ritter Jr, City of Thornton mayor Erik Hansen, and Adams County commissioner Larry Pace.

Ascent renovated an existing 120,000ft<sup>2</sup> building in Thornton to 145,000ft<sup>2</sup>, expanding it to house its new headquarters and planned 30MW capacity solar module manufacturing lines. Initial equipment installation has started and module production should begin late this



**Senior VP of operations & Thornton Plant general manager Ashutosh Misra with new equipment.**

year. Ascent aims to add 180–200 jobs there over the next two years.

"Thanks to companies such as Ascent Solar, all across Colorado, we're creating a sustainable energy future, sustainable opportunities for new businesses, and sustainable jobs," said Governor Ritter. "The New Energy Economy is leading Colorado forward and will be

one of the keys to bringing us out of this recession. Colorado and Ascent Solar's success are a model for how America can and must re-tool our entire economy," he adds.

"Ascent Solar's flexible, thin-film technology has been in development in Colorado for more than 15 years, so it is a great milestone to open a large-scale facility here that will help bring talented employees and a unique enabling solar technology to the market at a time when the economy and environment are creating great demand," says chairman & CEO Dr Mohan Misra.

The firm says that it is working with its partners to develop products that include building-integrated photovoltaics (BIPV), which can be incorporated in rooftops, awnings and siding, for example.

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

## HelioVolt raises \$17.5m as part of \$32m funding round

As part of an anticipated \$32m round of financing, in March HelioVolt Corp of Austin, TX, USA raised \$17.5m in the form of debt securities and stock options from 17 investors including Sequel Venture Partners, New Enterprise Associates, Noventi, Morgan Stanley Private Equity and Credit Suisse Private Equity.

HelioVolt was founded in 2001 by Dr Billy J. Stanbery based on his proprietary FASST manufacturing process for printing thin-film copper indium gallium diselenide (CIGS) photovoltaic (PV) material, either directly onto glass substrates for solar modules or onto flexible plastic substrate for embedding in building-integrated photovoltaic (BIPV) products (e.g. architectural glass and roofing tiles).

In 2005, HelioVolt raised \$8m in a Series A venture capital funding round, followed in October 2007 by a \$101m Series B round. The firm's aim was to optimize FASST for further efficiency gains and to scale up the process into volume produc-

tion. Subsequently, in April 2008, HelioVolt was awarded \$1m from the Texas Enterprise Fund, as well as \$600,000 in tax subsidies from the City of Austin, as part of a deal to construct its 122,400ft<sup>2</sup> manufacturing plant in the Expo Business Park in Southeast Austin.

Last October, HelioVolt opened its first \$80m, 20MW commercial production line. The firm had originally intended to start mass production in first-quarter 2009 and ramp up from 160 to 300 staff and a capacity of 20MW by the end of 2009.

However, in February the firm said that it now expects to start shipping sample panels to customers only in second-half 2009, for mass production starting in early 2010. In a report in the Austin American-Statesman, Stanbery said that the firm faces technical challenges in getting the plant ready for manufacturing, and that the new round of financing reflects its continuing efforts to move into commercial production. The funds will be used to further develop the plant.

In January, HelioVolt laid off nearly 15% of its staff due to shifting away from development toward manufacturing, as well as needing to "re-balance our workforce in a tough economic environment, where we need to be careful with our cash", said Stanbery. The new funding is part of an ongoing program to maintain capital reserves.

Also, in February, Sequel Ventures partner Ron Bernal (a board member since 2007) was appointed interim CEO, replacing Stanbery, who became chief strategy officer & chairman. Bernal will direct the firm as it transitions from development to commercial production.

"We are preparing for additional capacity expansion next year once market conditions have improved," said Stanbery to the Austin Business Journal. "We are currently exploring all options for raising the funds to support our planned growth, and as such are continually engaged in discussions with both current and potentially new investors."

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

# GaAs industry downturns: 2001 versus 2009

**Asif Anwar** of Strategy Analytics explains that there are a number of differences between the 2001 and 2009 downturns in the gallium arsenide industry which justify the market research firm's expectation of a 5–6% contraction in revenues versus the 25% contraction observed in 2001.

**T**he gallium arsenide industry hit a wall in the last quarter of 2008, with the effects of a global economic slowdown finally catching up with the mobile handset market and other end markets in which GaAs technology is used.

While the first quarter of 2009 saw further sequential reductions in revenue, Strategy Analytics believes that pockets of recovery will emerge in the second quarter, and current indicators suggest that the industry will start to see growth from the second half of 2009 moving into 2010.

There are a lot of comparisons being made with previous slowdowns, with many regarding the current downturn as worse than previous downturns experienced by the general semiconductor industry. These observations generally take into account the difficulties being encountered by mainstream silicon-based markets including the DRAM and flash memory sectors.

However, if we focus exclusively on the GaAs industry, then we see a number of differences between the two cycles. Strategy Analytics believes that the contrast between the 2001 and 2009 downturns justifies the expectation of a 5–6% contraction versus the 25% contraction observed in 2001:

- In 2001, there was a lot of talk about 3G technologies and wireline broadband services that were going to drive demand for bandwidth. However, it was clear that 3G technology was not ready for the market and there were no services available to the consumer that required 40Gb/s fiber-optic services.
- 2001 also saw extremely high excessive inventory build-up in the cellular handset supply chain that extended from operator and cellular handset distribution channels through to the GaAs device and material suppliers.
- In 2009, broadband is an integral part of the consumer's portfolio of products, both on wireless and wireline platforms. Moving forwards, the demand for bandwidth will increase as the viewing of streaming content becomes increasingly commonplace, with internet content now extending to the living room via the TV.

- Inventory build-up in 2009 is not at the same level as 2001 levels and, while there will be a general slowdown in demand for GaAs devices and materials, inventories were being cleared in first quarter 2009. Major handset OEMs such as Nokia have previously indicated that they expect to resume placing orders with their suppliers from the second quarter of 2009 onwards.

This viewpoint appears to be upheld by more recent announcements from major silicon fabs, including the foundries TSMC and UMC, who are seeing renewed orders from major customers involved in the wireless sector such as Qualcomm. Admittedly, the upturn in orders may in itself be a temporary inventory restocking exercise, and we do not expect to see a real return to growth before

late 2009 moving into 2010.

However, the pockets of growth that we will see in the second quarter of 2009 do support our assertion that inventory levels are not at the excessive levels that were seen by the industry in 2001. The excessive inventory in 2001 resulted in severe disruptions through the complete GaAs industry supply chain, with inventory levels not returning to normality for almost 24 months.

Importantly for the GaAs industry, we do not expect the interim slowdown to result in any major paradigm shift in cellular handset radio technology, with GaAs continuing to dominate the front-end and benefiting from multi-mode and multi-band trends that will result in multiple insertions per handset. Augmenting this demand from cellular handsets will be the uptake of wireless broadband based on cellular radio technology implemented in notebook computers, USB dongles and other platforms. The early roll-out of long-term evolution

**Excessive inventory in 2001 resulted in severe disruptions through the complete GaAs industry supply chain, with inventory levels not returning to normality for almost 24 months**

(LTE) platforms in particular will be for devices enabling wireless broadband as opposed to simply providing a new generation of cellular handsets for voice-centric communications.

Looking at some of the other end markets for GaAs:

- Strategy Analytics maintains earlier projections that Wi-Fi will become the second largest market for GaAs devices, driven by the near 100% penetration of Wi-Fi in notebook computers, as well as banking on emerging opportunities based around 802.11n architectures.

- While infrastructure markets are expected to show some slowdown in 2009 as carriers offset certain projects to a later date, we believe that global carriers

will not want to lose momentum in the roll-out of 3.5G and 4G technologies, which will result in GaAs demand coming from base-station markets, with a potential emerging opportunity coming from femtocells, as well as related demand from backhaul roll-out.

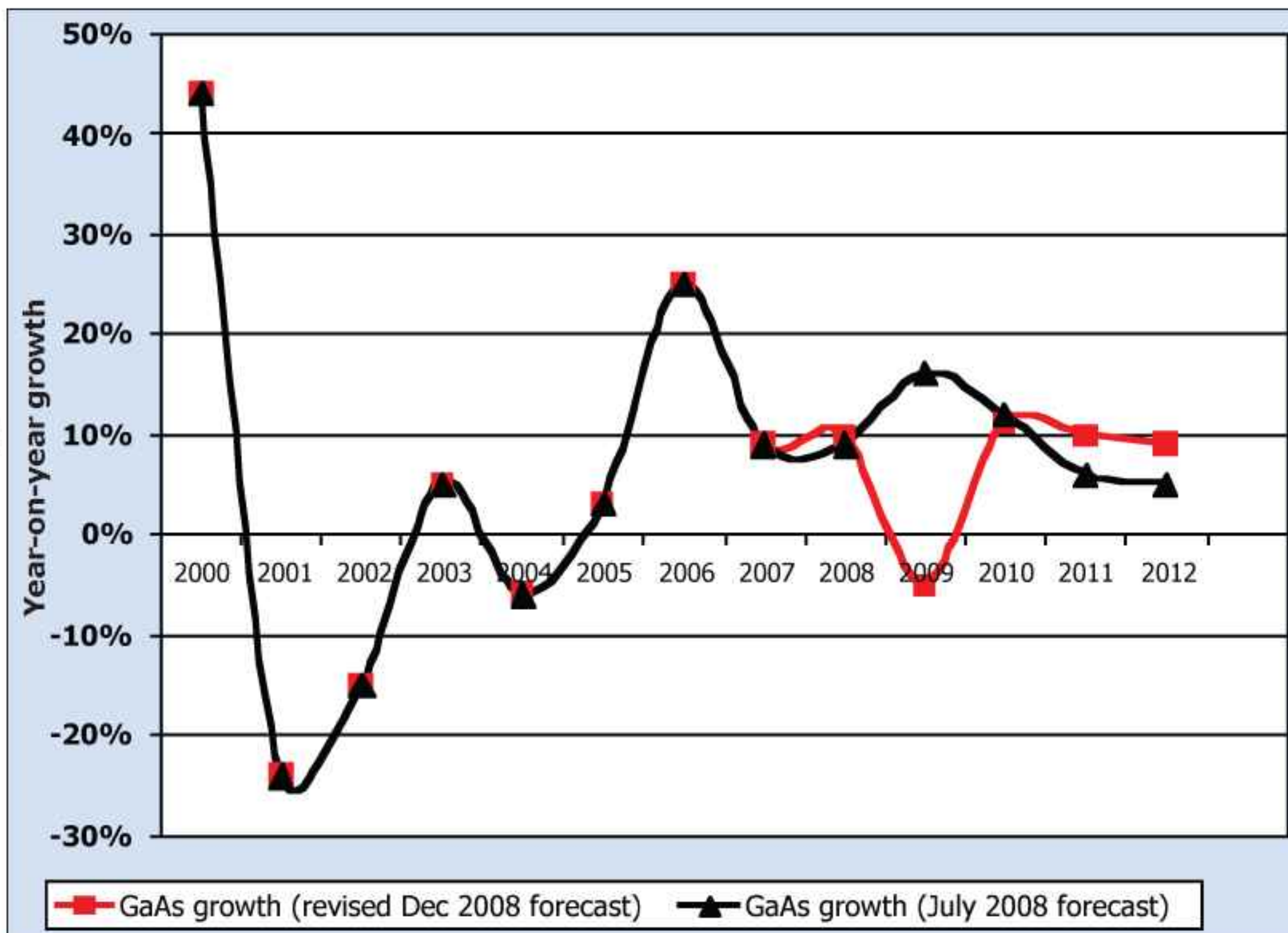
- GaAs will also remain an important technology for fiber-optic network roll-outs, especially for 10Gb/s and 40Gb/s long-haul.

- The satellite industry remains robust, with demand from both the space segment and ground terminals driving demand for GaAs discretes and MMICs, respectively. Satellite-based applications such as environmental

monitoring, radio astronomy and surveillance require a mix of high-frequency, low-noise capabilities that present an additional high-value opportunity for GaAs components from the satellite industry.

- GaAs technology will continue to dominate network infrastructure roll-out in CATV networks and remain the primary technology used in the LNBS (low-noise blocks) of digital satellite receive dishes.

- Automotive radar will be affected by the global downturn in vehicle production. However, a mixed blessing is that the insertion of collision mitigation technologies is still at an early stage of deployment, which will help maintain previously forecast trends related to GaAs penetration in this market.



Year-on-year growth in the gallium arsenide industry.

- GaAs demand from the defense sector will remain strong, with annual growth continuing at 5–10% levels based on strong industry backlog and growing trends towards active electronically scanned array (AESA) radar technology that utilizes greater GaAs content.

None of the markets listed above is immune to challenges from silicon technologies, and the GaAs industry will need to continue to demonstrate that GaAs technologies not only provide the prerequisite performance, but also remain the most cost-effective solution for both mainstream and niche applications.

### Implications

Strategy Analytics maintained its 9% growth forecast for 2008 with the market growing to \$3.9bn from \$3.5bn in 2007. However, with a global recession impacting unit growth across nearly all the major end markets for GaAs, the previous forecast of growth in 2009 has been replaced by the forecast that the market will shrink 5% year-on-year.

However, due to the differences between the 2001 and 2009 downturns that led to this expectation of moderate contraction (versus the 25% seen in 2001), Strategy Analytics believes growth will return in 2010, with the market growing at a reduced compound annual average growth rate (CAGR) of 7% through 2012 versus the previously forecasted 9%. ■

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

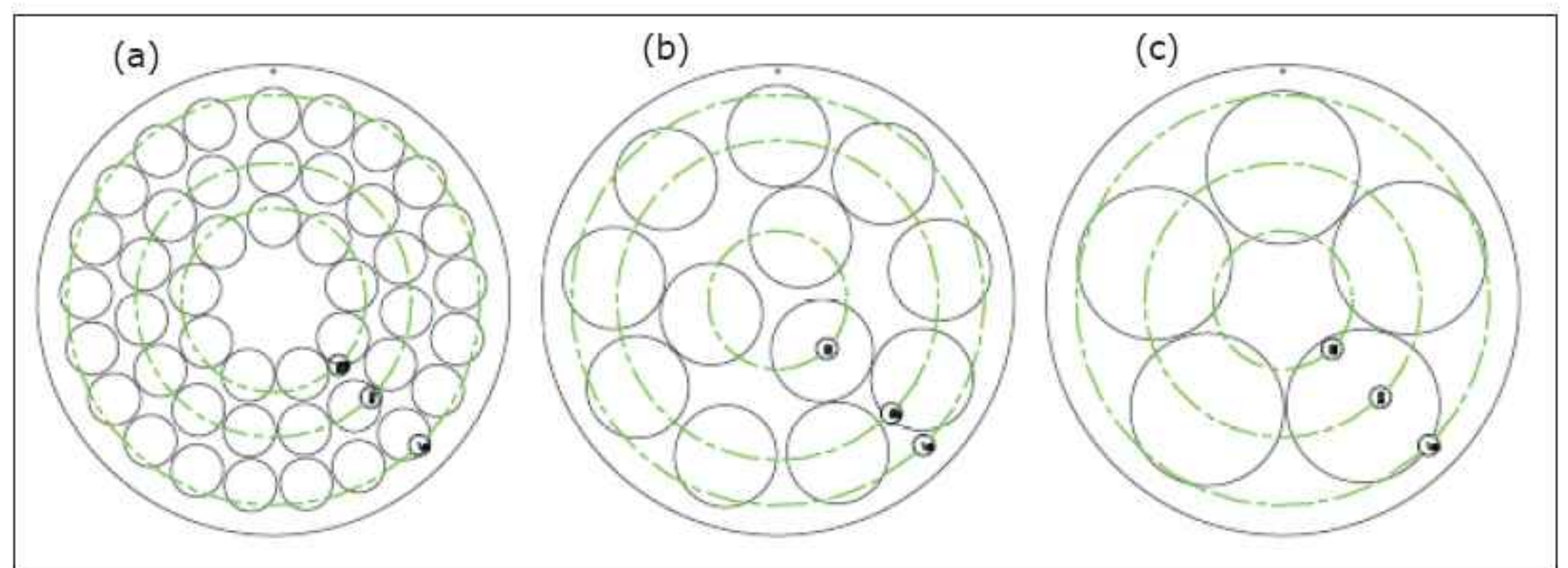
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# LED growth compatibility between 2", 4" and 6" sapphire

Sapphire substrate diameters of 2", 4" and 6" with different thicknesses have been investigated by **Veeco Instruments Inc** for GaN-based blue LED (460nm) MOCVD epitaxy. Growth processes equivalent to standard 2" growths have been achieved for 4" wafers with thicknesses of 650 and 900 $\mu$ m as well as 6" wafers with a thickness of 900–1300 $\mu$ m. However, the quality of the 6" processes has shown a strong dependence on wafer thickness. By understanding the factors affecting the thickness and wafer bow dependence during epitaxial growth, process conditions can be modified to provide equivalent performance on 4" and 6" wafers.

**T**he LED industry is aggressively reducing manufacturing costs to compete economically with existing lighting technologies. One approach currently being pursued is to produce LED epitaxial growth on larger-diameter wafers such as 4" and 6" sapphire substrates. Epitaxy on 4" substrates is in pilot production, and 6" wafer sizes are being explored, as they are compatible with existing silicon fabrication line equipment. Unlike the 2" to 4" transition, epitaxial growth on 6" has proven to be more challenging, primarily due to the large thermal and lattice mismatches that occur between the sapphire and gallium nitride (GaN) layers, which result in large bowing of the wafers throughout the process.

We have developed a simple standard LED process in our 465mm chamber, and have used it to compare differences in 2", 4" and 6" wafer configurations. The 2" and 4" processes exhibit good compatibility, but 6" processes require additional work to adjust wafer curvatures, especially when working with thinner substrates. In this paper, we briefly cover the compatibility of 2" and 4" processes, and then focus on the more recent 6" process development. In all cases, the growth environment (laminar flow conditions, temperature and pressure ramps) remain constant across all wafer sizes; the primary difference between experiments is the wafer carrier pocket geometry.



**Figure 1:** Typical wafer configurations on a K465 reactor for (a) 45 x 2" sapphire substrates, (b) 12 x 4" substrates, and (c) 5 x 6" substrates, along with viewport positions for in-situ sensors.

## Experiment

All growths conducted in this study are on Veeco's TurboDisc® K-465 MOCVD reactors (465mm diameter disc) utilizing 'rimmed' pockets machined in graphite wafer carriers coated with silicon carbide (SiC). The typical packing configuration for 2", 4" and 6" wafers are illustrated in Figure 1. For this study, the 2" sapphire substrates had a thickness of 430 $\mu$ m, the 4" substrate thicknesses were 650 $\mu$ m and 900 $\mu$ m, and 6" substrate thicknesses ranged from 900 $\mu$ m to 1300 $\mu$ m. All sapphire substrates were single-side polished with etched backsides.

In-situ curvature measurements were conducted using a Veeco DRT™-210 integrated pyrometer/reflectometer/deflectometer unit which measures along a fixed radial position within the spinning wafer carrier in the reactor, as shown in Figure 2. For curvature measurements with this device, the two-dimensional position of a reflected laser signal is measured as a wafer passes underneath the

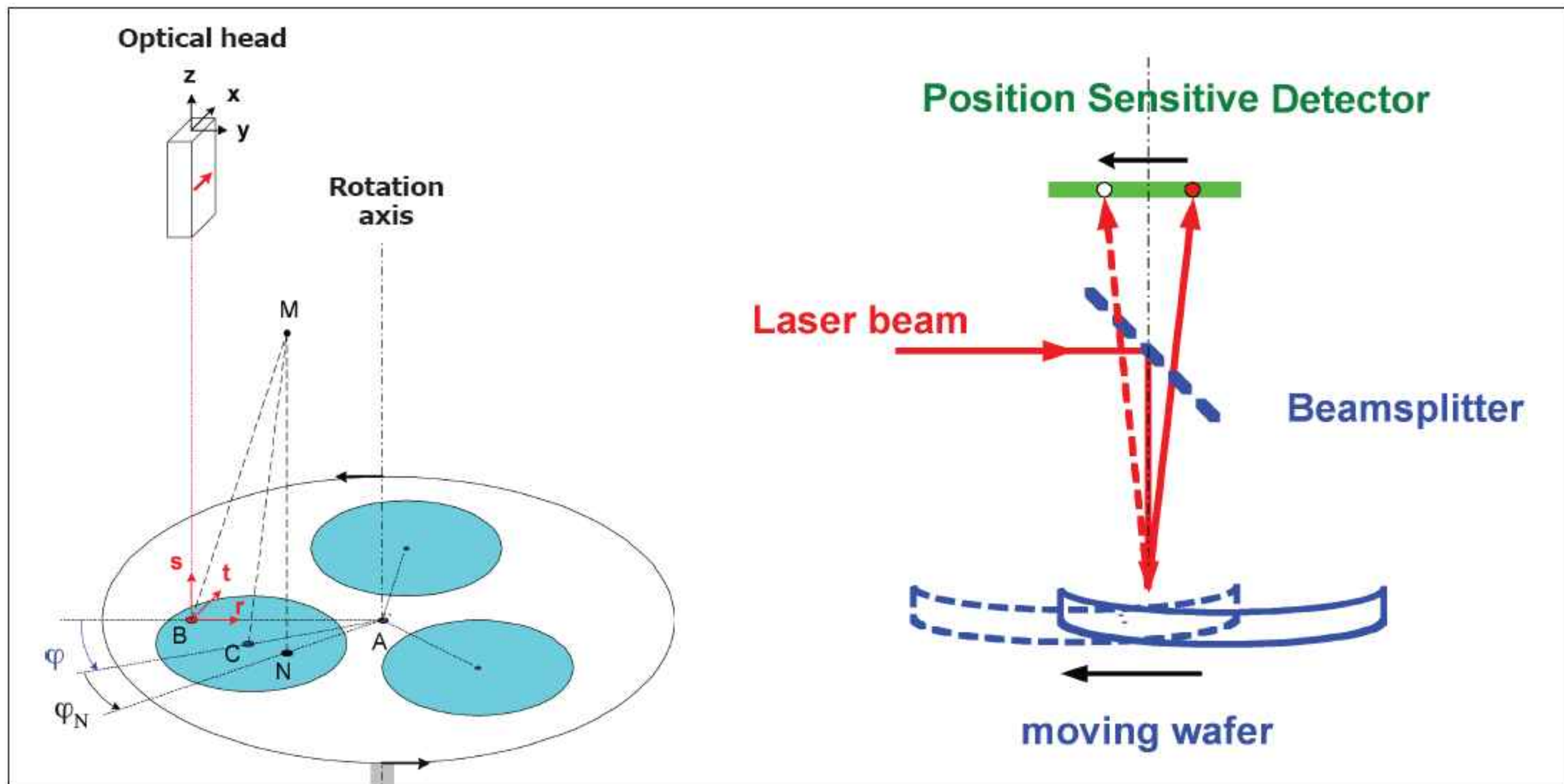


Figure 2: Schematic of single-beam deflectometer operation.

beam (normal to the wafer carrier) using a high-speed position sensitive detector. The position of the reflected beam at the plane of the detector depends on the surface local tilt angle of the wafer. As the wafer moves through the beam-path, the angle profile as a function of wafer displacement is measured, allowing the wafer curvature to be calculated. Since the single-beam deflectometer has a triangulation base determined by the wafer diameter, not the view port diameter, it has a higher resolution in curvature compared to a multi-beam deflectometer.

### Curvature Evolution during LED growth

In Figure 3, we show the typical temperature, reflectance and curvature evolution of a simple 2" LED growth as a

function of elapsed time. Out-of-the-box sapphire wafers are usually slightly concave. During the initial high-temperature annealing step in a hydrogen gas ambient, the wafers become more concave in shape, as their top surface expands less than that of the bottom surface, which is in thermal contact with the hot wafer carrier. Next follows either a thin (250Å), low-temperature GaN nucleation (LT-GaN, ~550°C), where the wafers become flatter, or a high-temperature AlN nucleation layer (not shown, ~800°C), where they remain fairly concave. After the nucleation step, thick (3–7µm) undoped and n-type GaN layers are grown, where the wafers become considerably concave, due mainly to tensile strain induced by the GaN on the wafer.

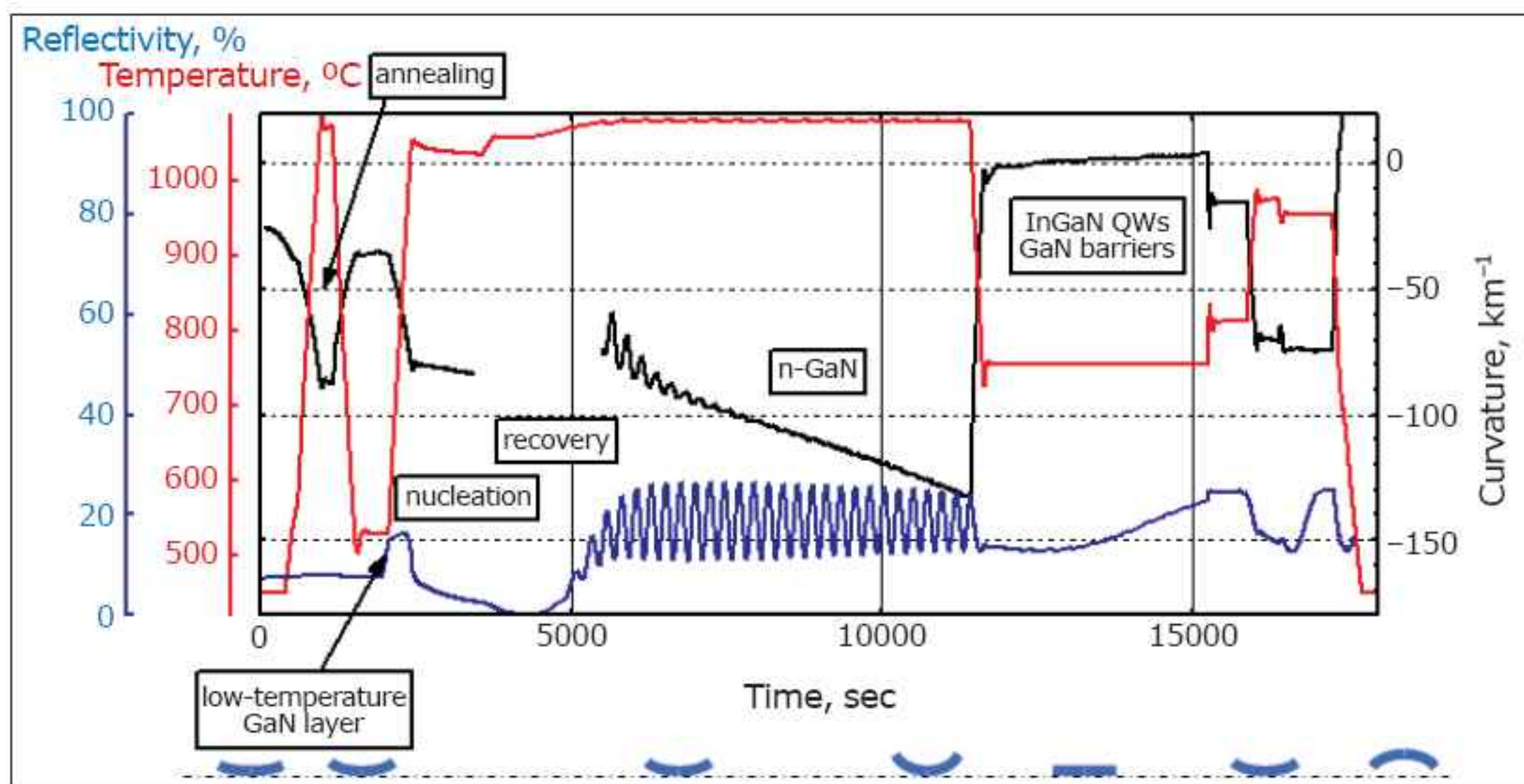
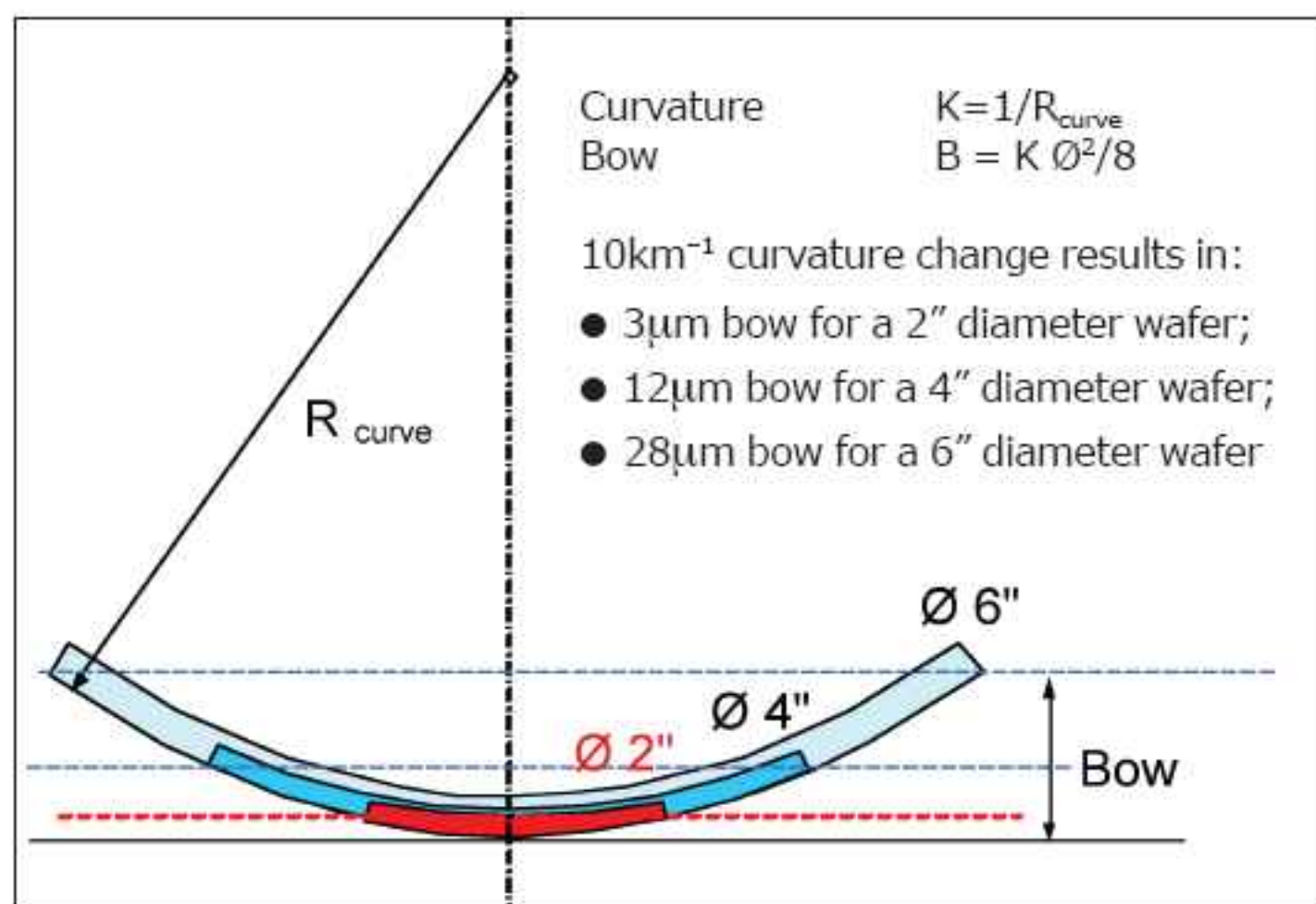


Figure 3: Growth temperature (red), reflectivity (blue) and curvature (black) as a function of elapsed time during MOCVD growth of simple LED structure.

Fortunately, during the following 25Å InGaN/130Å GaN multi-quantum-well (MQW, 5 periods) active region, the wafers flatten so that they are mildly concave or even slightly convex, due mainly to the colder deposition temperature (~750°C) and nitrogen-only gas ambient necessary during this step. After the MQW growth, the hotter (~900°C) p-AlGaIn and p-GaN growth steps result in a concave profile, which is inverted to a convex profile when the wafers are cooled to ambient temperature.



**Figure 4:** The relationship between the wafer curvature and bow. The bow varies as the square of the substrate diameter, Ø.

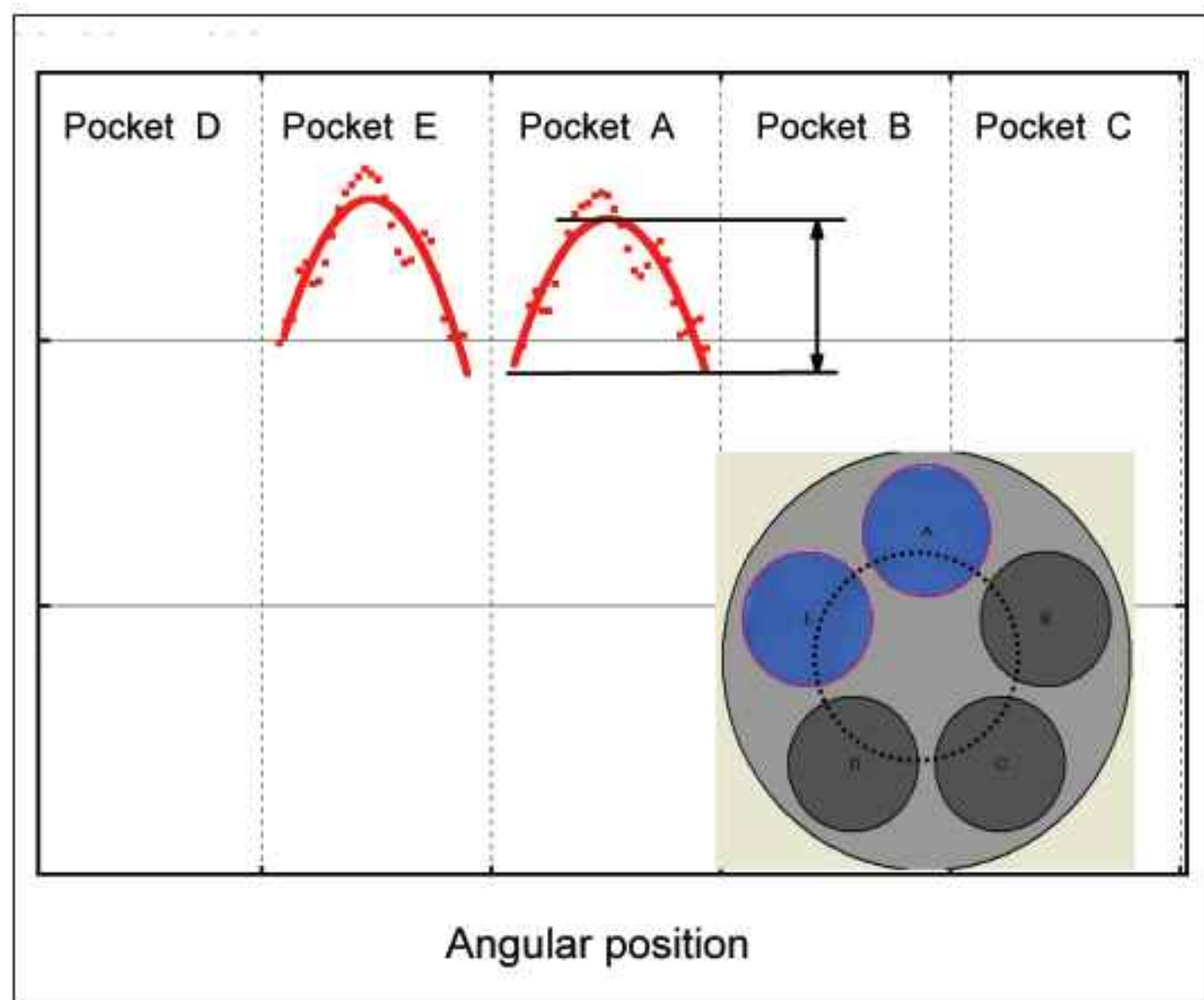
**Relationship between curvature and bow**

The DRT-210 determines the radius of curvature of the wafer by fitting the measured profile to a parabolic curve, as shown in Figure 4.

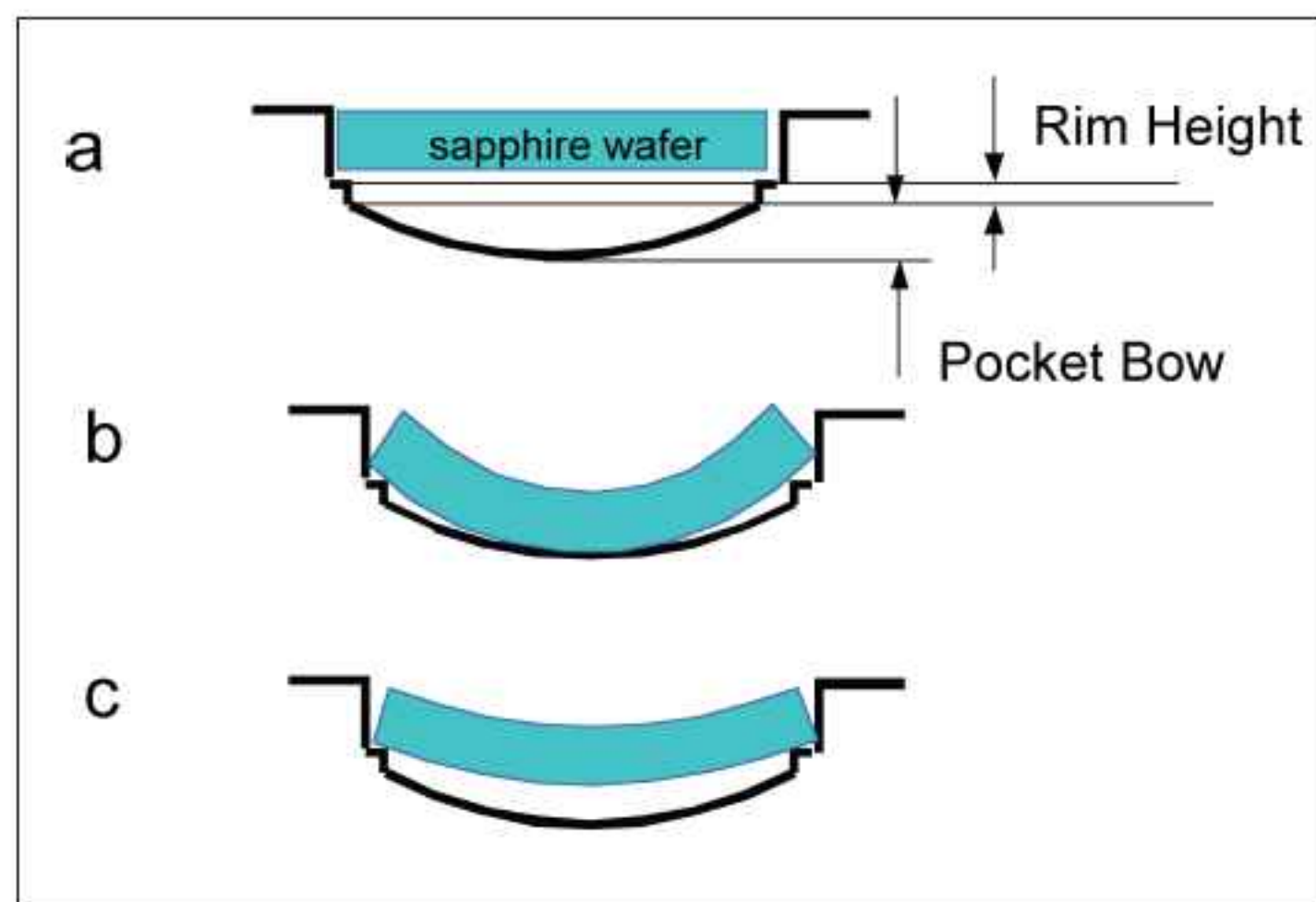
However, a more convenient metric is the wafer bow, which is the amount of deflection of the outer radius of the wafer compared to the center.

For a given curvature, the bow varies as the square of the diameter, and thus a 4" wafer will bow four times more than a 2" wafer, and a 6" wafer will bow nine times more.

This has important consequences, which will be described in the following sections.



**Figure 6:** Temperature distribution under a sapphire wafer. The center of the pocket covered by the wafer is 6°C hotter than the periphery for a 6" wafer, as measured by in-situ emissivity-compensated pyrometry. The difference is about 2°C in a 4" wafer, and is not accurately measurable for a 2" diameter wafer.



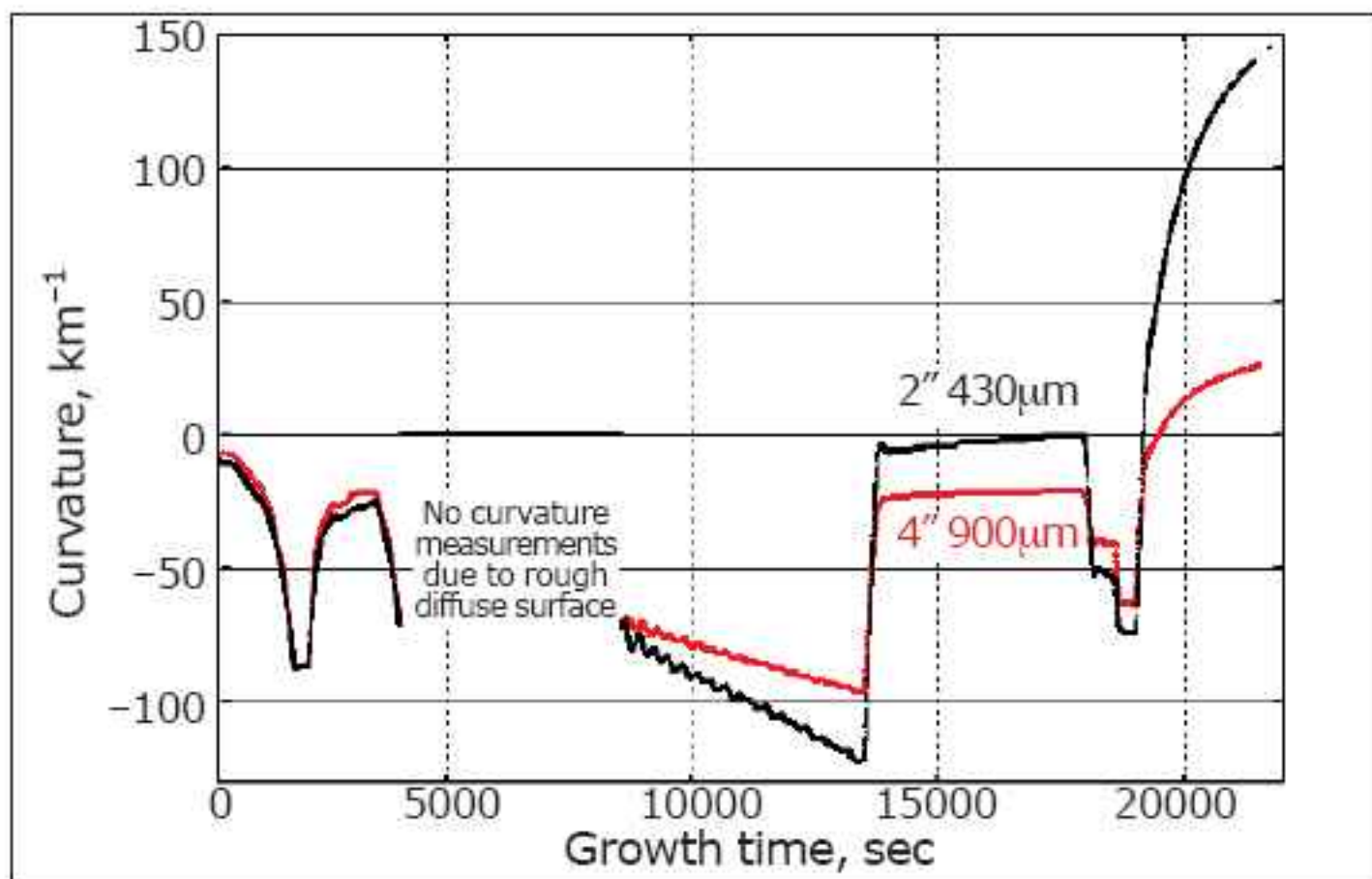
**Figure 5:** Rimmed pocket design geometry. Rim height and pocket bow can be independently optimized to accommodate wafer bow at end of bulk GaN layer (b), and wafer profile at InGaN MQW growth conditions (c).

**Rim pocket design**

Thermal uniformity within a wafer is extremely important during InGaN MQW growth, as the alloy composition is a strong function of surface temperature. The temperature dependence results from evaporation of indium from the growth surface due to the weak In-Ga bond strength. As an approximation, a 1°C change from a nominal 750°C growth temperature results in a 1.8nm wavelength shift for a 460nm MQW. However, this value depends upon numerous factors such as growth rate, quantum well thickness and InGaN composition, growth pressure, V/III ratio, and of course growth temperature. The heating of the wafer growth surface is primarily driven by thermal conductance within the gas ambient. Consequently, small changes in wafer bottom to pocket floor gap on the order of 10µm or more can have large effects on the thermal distribution across the wafer. Thus, it is important to tailor the pocket geometry to match the wafer shape during the active layer.

As is evident in Figure 3, the wafer curvature changes significantly during the GaN and InGaN growth layers. To compensate for these differences, we have developed a rim pocket design that allows independent optimization of the rim height and floor geometry, as illustrated in Figure 5. The pocket rim height is chosen to accommodate the large concave bow that occurs during GaN growth, whereas the pocket floor shape (concave, convex, or flat) is profiled to give uniform temperature distribution within-wafer during the critical InGaN MQW growth.

Another effect that must be taken into account when optimizing within-wafer thermal uniformity is the difference in temperature between the center and the outer radius of the wafers, as shown in Figure 6. The thermal delta is due to a blanketing effect of the wafer located on the top surface of the hot pocket surface.



**Figure 7: Wafer curvature as a function of elapsed time during MOCVD growth of equivalent simple LED structures on 2" 430 $\mu\text{m}$ -thick and 4" 900 $\mu\text{m}$ -thick sapphire substrates.**

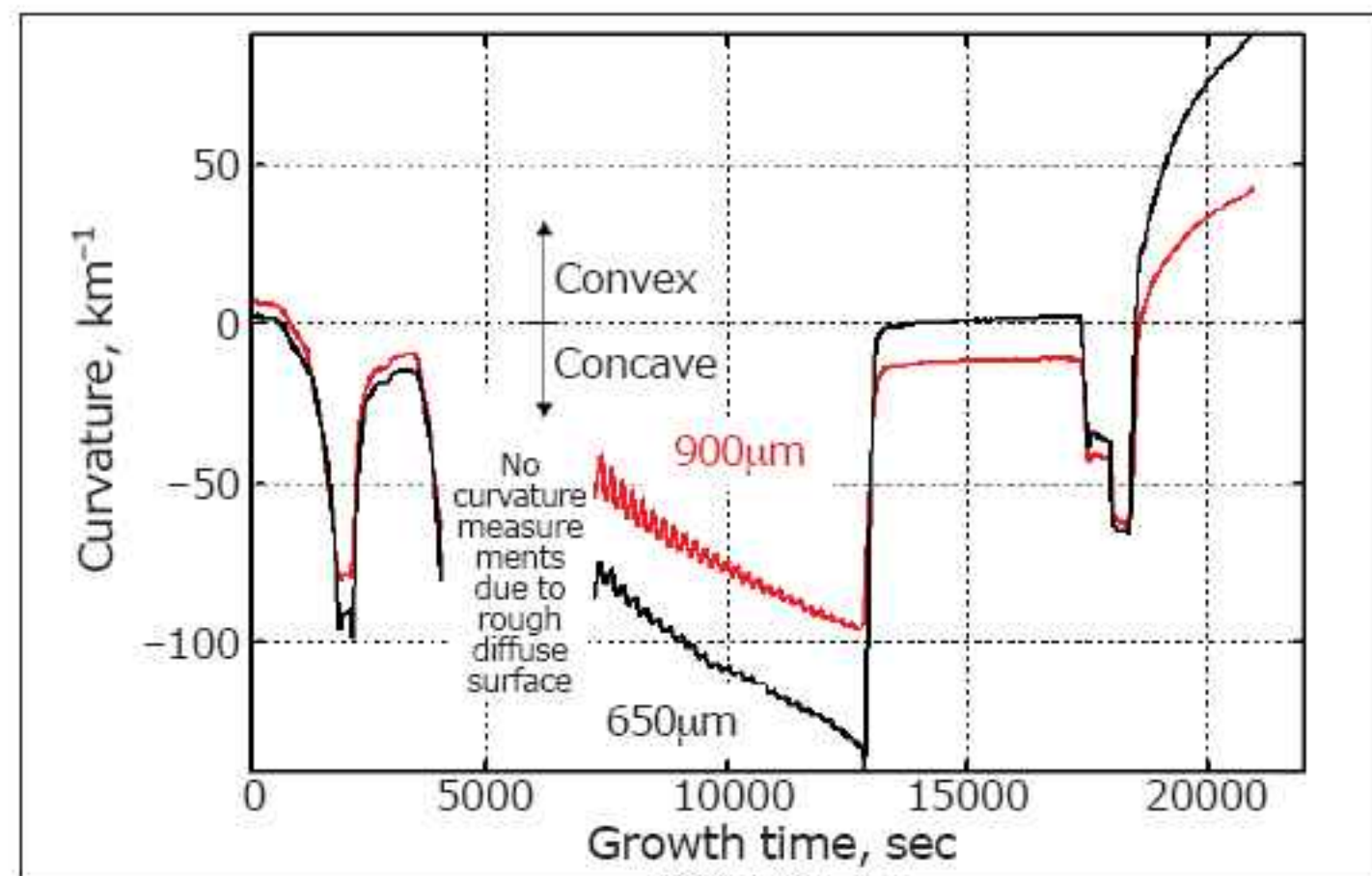
This phenomenon becomes more dominant as the area-to-circumference ratio becomes larger, as is the case with larger wafer sizes.

### 2" and 4" LED growth

In Figure 7, LED growths on 430 $\mu\text{m}$ -thick 2" and 900 $\mu\text{m}$ -thick 4" wafers are compared. The resulting slope in the bulk n-GaN layers towards increasing curvature is related to the thickness of the substrates. At the end of the 3.5 $\mu\text{m}$  n-GaN layers, the 2" wafer curvature is  $-110\text{km}^{-1}$ , corresponding to a concavity of 34 $\mu\text{m}$ , whereas the 4" wafer curvature is less at  $-95\text{km}^{-1}$ , but corresponding to a larger concavity of 118 $\mu\text{m}$ . Even though the curvature is greater for the 2" wafers in the GaN layers, at the InGaN growth conditions the wafer becomes nominally flat (curvature  $\sim 0\text{km}^{-1}$ ), such that a flat pocket floor profile will give a uniform temperature distribution across the wafer. Conversely, the 4" wafer remains concave at  $-25\text{km}^{-1}$ , corresponding to a concavity of 31 $\mu\text{m}$  at the active layer. Thus, for this 4" growth, a relatively concave pocket floor is needed to thermally compensate the 4" curvature combined with the 2 $^{\circ}\text{C}$  difference induced by the thermal blanketing effect.

The curvature evolution for 4" MQWs and LEDs with 650 $\mu\text{m}$  and 900 $\mu\text{m}$  sapphire substrates using the same recipe are shown in Figure 8. As expected, during the high-temperature GaN layers, the difference in curvature profiles start to diverge drastically. At the end of 4 $\mu\text{m}$  of n-GaN, the 650 $\mu\text{m}$  sapphire substrate has a curvature of  $-133\text{km}^{-1}$  (black), whereas the 900 $\mu\text{m}$  sapphire substrate ends at  $-95\text{km}^{-1}$  (red), corresponding to bow values of 165 $\mu\text{m}$  and 118 $\mu\text{m}$ , respectively.

This difference in film strain from the thick GaN makes a large difference in thermal uniformity when the wafers are cooled to the active layer growth conditions. The 650 $\mu\text{m}$  sapphire substrate is nominally flat at the start of the MQW growth, whereas the 900 $\mu\text{m}$

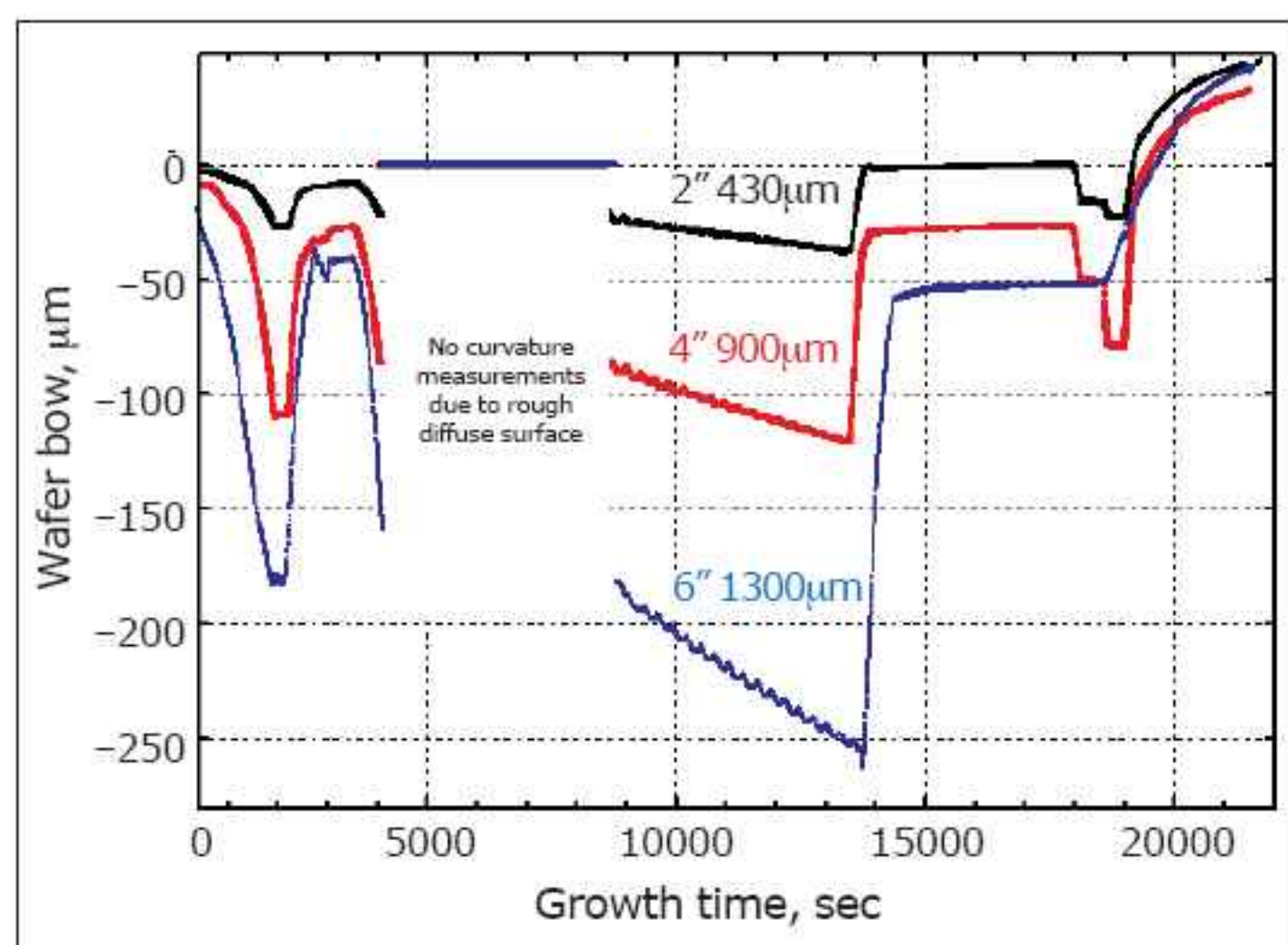


**Figure 8: Comparison of curvature for 4" LED structures with 650 $\mu\text{m}$ - (black) and 900 $\mu\text{m}$ - (red) thick substrates utilizing an equivalent growth recipe.**

sapphire substrate has a  $-13\text{km}^{-1}$  curvature, corresponding to a 16 $\mu\text{m}$  concave bow. In order to achieve optimal within-wafer wavelength uniformity for these different substrate thicknesses with this particular recipe, rim pockets with a 175 $\mu\text{m}$  rim depth and a flat floor profile are necessary for the 650 $\mu\text{m}$  substrates, however a floor profile of  $\sim 25\mu\text{m}$  concavity is optimal for the 900 $\mu\text{m}$ -thick substrates.

### 6" LED growth

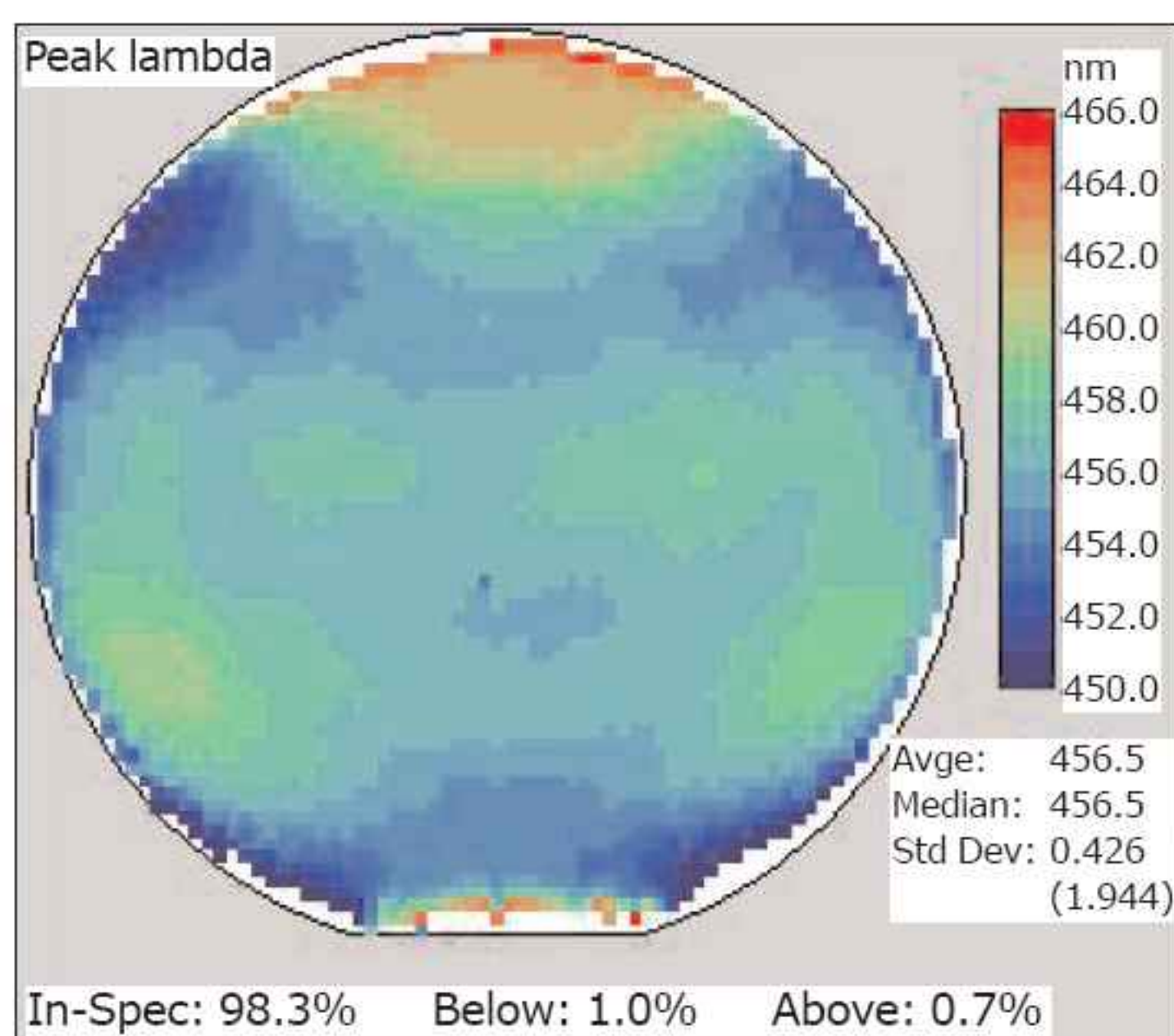
We initially started with the equivalent LED growth process on 6" wafers that worked well for the 2" and 4" diameter substrates. However, we found that thin 6" substrates ( $< 1000\mu\text{m}$ ) caused problems, primarily due to extensive wafer bow occurring during the initial low-temperature GaN nucleation and subsequent GaN buffer steps. We observed that, if the wafers incur a concave bow of greater than about 300 $\mu\text{m}$ , a huge thermal gradient is created between the center and the outer radius of the pockets, which often results in wafer cracking. In order to resolve this issue, we reduced the amount of film stress within the wafer by nucleating with high-temperature AlN instead of the low-temperature GaN. In addition, to minimize thermal gradients across the wafer created by non-equilibrium heating or cooling, slower temperature ramps were utilized for the 6" growths during the highly concave GaN layers. As a result, 900 $\mu\text{m}$ - and 1mm-thick substrates can be used with this kind of approach without cracking. However, the within-wafer uniformity results tended to be irreproducible, possibly due to subtle differences in the thickness control of the substrates or differences in sapphire internal stress or flexural strength. Regardless of the growth technique or film structure, obtaining repeatable MQW wavelength uniformity proved considerably more challenging for these thin wafers due to the extreme curvature generated between the GaN and MQW growth conditions. ▶



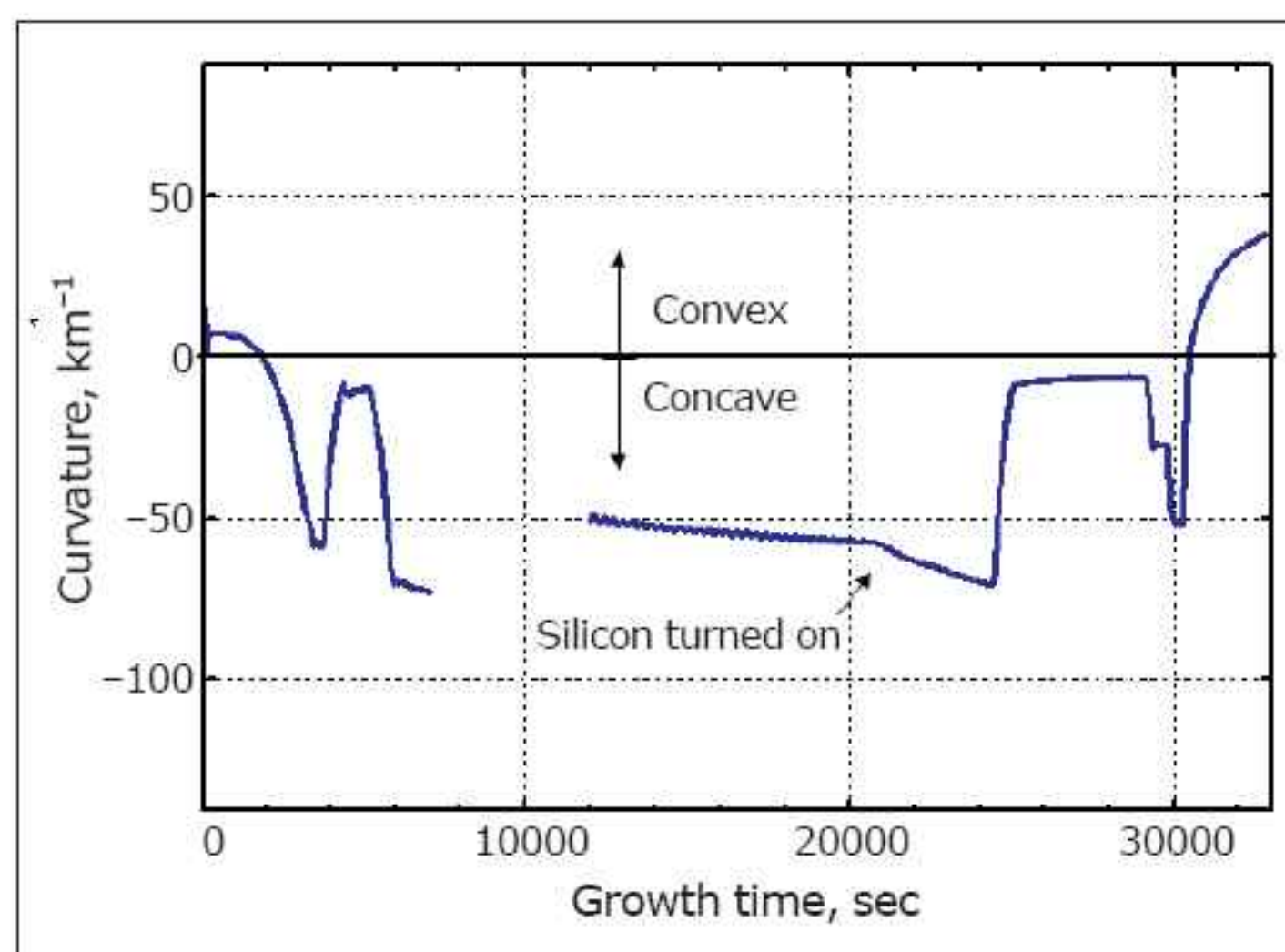
**Figure 9: Comparison of wafer bow for 2", 4" and 6" wafers in equivalent growth recipes. All bows in this example are concave in shape.**

Unlike their thinner counterparts, 1.1mm- and 1.3mm-thick 6" diameter substrates exhibited much more rigidity and gave much more reproducible run-to-run curvature profiles. At a thickness of 1.3mm, growth processes similar to the 4" diameter wafers could be implemented without the need to precisely bin individual wafer thicknesses. In Figure 9, we compare the wafer bow evolution for the 2", 4" and thicker 6" wafers in the study. Note that, even with the 1.3mm-thick 6" wafers, the bow is still about 270 $\mu\text{m}$  at the end of a 3.5 $\mu\text{m}$ -thick n-GaN layer when a LT-GaN nucleation method is used.

Figure 10 shows the reflectance and wafer curvature profile for a 6" LED growth on a 1.3mm-thick substrate, with AlGaIn nucleation and a thick undoped GaN buffer, which gives less curvature than GaN nucleation and a



**Figure 11: PL map of 1.3mm-thick, 6" sapphire substrate showing within-wafer wavelength uniformity (1mm edge exclusion) for five-period MQW with 6 $\mu\text{m}$  GaN buffer.**



**Figure 10: Curvature evolution of a simple blue LED on 1.3mm thick 6" sapphire using AlGaIn nucleation, and thick undoped GaN layer before n-GaN layer growth.**

thick n-GaN buffer. As the silicon dopant is introduced to the GaN layers at a time of 21,000s, the curvature slope becomes more negative. At the end of the 6 $\mu\text{m}$ -thick bulk GaN layer, the curvature is  $-70\text{km}^{-1}$ , which is much less than for 2" and 4". However, even though the curvature is less, the actual concavity is still about 195 $\mu\text{m}$ .

Using our in-situ curvature measurements, we have developed wafer carrier pocket profiles that allow for the large bows during the GaN growth while optimizing bottom pocket shapes that conform to the curvature of the 6" wafers during the InGaIn MQW growth. By understanding these dynamics, good within-wafer wavelength uniformity of  $\sigma < 2\text{nm}$  can be achieved on 6" wafers, as shown in Figure 11, which is similar to what can be achieved on 2" and 4" diameter wafers.

## Summary

Understanding the dynamics of wafer curvature is required for process development of LED epitaxy, especially for larger wafer sizes. Subtle changes in nucleation, bulk GaN thickness and doping as well as growth temperature can have strong effects on the curvature of the wafers during the growth process. A standard growth process can be used for wafer sizes from 2" to 6", provided that the 6" wafers are at least 1.1mm thick. The use of thinner 6" wafers will need additional research and development, both at the MOCVD epitaxy and substrate quality level.

The concepts learned in the 6" development process can be adapted to even larger wafer sizes, such as 8". Our Veeco K-465 reactor has a common chamber configuration for all different size wafers, from 2" to 8", so continued increases in wafer size for research and production can be realized quite easily in the future. ■

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## 2009 International Conference on Compound Semiconductor Manufacturing Technology May 18 - 21, 2009, Marriott – Waterside, Tampa, Florida

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# CIGS solar: a new investment landscape

**Mike Cooke surveys recent developments in the commercialization and financing of the production of solar photovoltaic panels based on copper indium gallium diselenide (CIGS) solar cells. Driven by concerns over silicon shortages, CIGS developers have proliferated in recent years, but the success of turning research performance into manufacturability has been varied, and funding has tightened.**

**S**olar power based on photovoltaic (PV) materials is one of the leading desiderata for moving beyond limited resources, such as oil, to an era of sustainable human life. A wide variety of materials can be used, including ubiquitous silicon. However, in recent years suitable supplies of high-quality silicon wafers became tight, so low-cost, thin-film alternatives have been sought. Among the material systems applied in a thin-film format, copper indium gallium diselenide (CIGS) is attractive in being generally higher efficiency compared with thin-film cadmium telluride (CdTe) and amorphous silicon. It is even hoped that, in the near future, the technology could go below \$1/Watt in terms of investment cost, heralding the technology's competitiveness against fossil fuels.

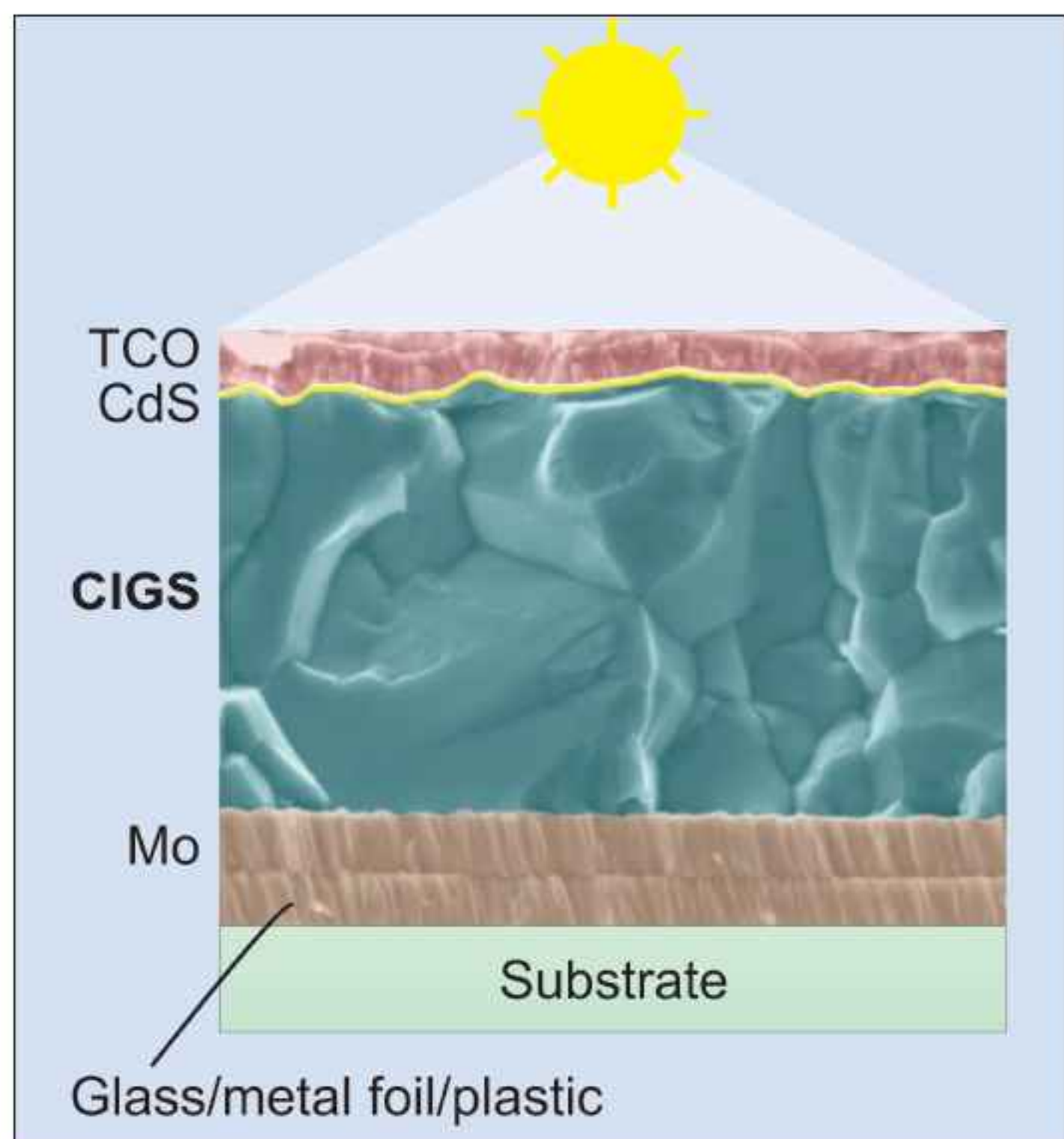
Analysts from Greentech Media and Prometheus Institute estimate that, by 2012, CIGS producers could make 12%, or nearly 3 GigaWatts, of the worldwide supply of solar panels [1].

The report puts the other technologies in 2012 at CdTe 6%, amorphous silicon 15% and crystalline silicon still dominating with 66%.

The reports' authors also believe that CIGS' cost per Watt will reach \$0.75 compared with crystalline silicon's \$1.40 by 2015.

However, the credit crunch may make it more difficult to raise funds for development of solar products. Some

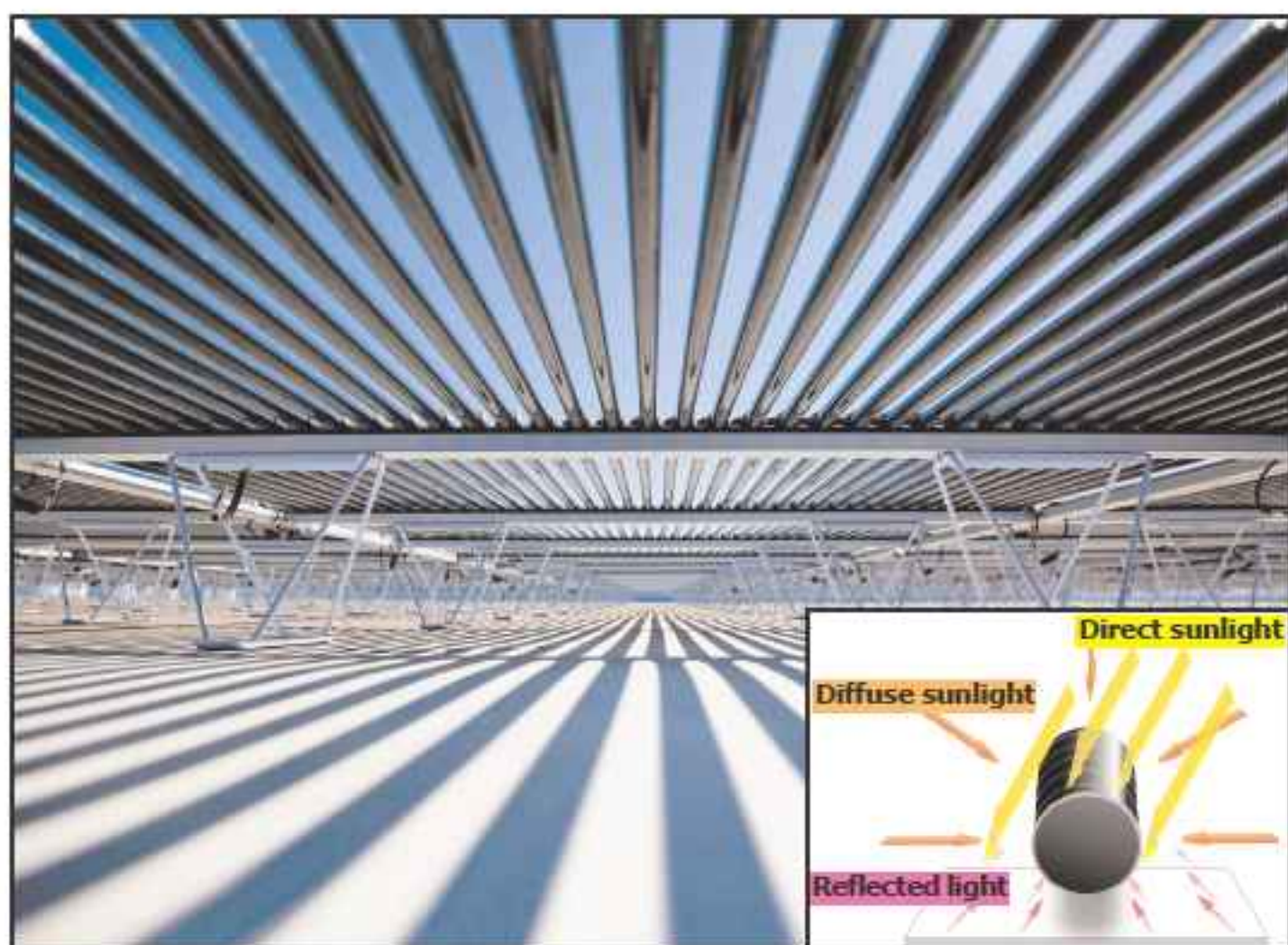
**By 2012, CIGS producers could make 12%, or nearly 3 GigaWatts, of the worldwide supply of solar panels, reckon analysts**



**Cross section of DayStar's CIGS solar cell structure, showing CIGS active layer and substrate.**

companies are already feeling the pressure. The recent 10-K annual report submission to the US Securities and Exchange Commission by DayStar Technology Inc of Santa Clara, CA, USA contains repeated reference to its independent auditor's doubts as to the company's ability to continue as a going concern, which could squash attempts to raise further capital. The auditor, Hein & Associates, bases its opinion on the company's need for "substantial funds beyond its current cash on hand to fully continue its development efforts, build-out its initial manufacturing line, and commence commercial shipments". Such vicious circles will no doubt multiply as the economic consequences of the credit crunch play out. One can also expect that the good bits of failing companies will be bought up by the more successful in consolidation efforts.

DayStar's present CIGS technology involves depositing the materials on low-cost glass. The company has also developed techniques to produce CIGS cells on flexible foil substrates (TerraFoil). The latter technology is aimed at applications such as building-integrated photovoltaics (BIPV).



Solyndra's cylindrical solar modules, which capture sunlight across a 360° surface capable of converting direct, diffuse and reflected sunlight into electricity.

### Guarantees

All is not gloom and doom for CIGS financing, however. One must remember that funding development of renewable energy sources has been specifically highlighted as part of US President Obama's economic rescue package.

Solyndra says that it is the first company to receive an offer for a US Department of Energy (DOE) loan guarantee under Title XVII of the Energy Policy Act of 2005. As can be seen from the date of the legislation, this is not a direct result of the new US administration's plans. Use of the legislation in this way had been in a logjam for some time. Solyndra CEO and founder, Dr Chris Gronet says: "The leadership and actions of President Barack Obama, Energy Secretary Steven Chu and the US Congress were instrumental in concluding this offer for a loan guarantee." The company plans to use a \$535m loan from the US Treasury's Federal Financing Bank to expand manufacturing capacity.

Solyndra manufactures a new cylindrical-format photovoltaic module based on a thin-film CIGS active layer, designed to capture direct, diffuse and reflected sunlight over 360° of its surface. The modules are intended for rooftop installation on commercial, industrial and institutional buildings. Optimal performance comes when the cylinders are mounted horizontally and packed closely together. Solyndra claims that this covers significantly more of typical roof areas and produces more electricity per rooftop on an annual basis than conventional panels. Solyndra's panels have been shipping commercially since July 2008.

The guaranteed loan is planned to provide debt financing for 73% of the project costs, allowing Solyndra to construct a second module fabrication plant (Fab 2) with an annual manufacturing capacity of 500MW/year. Documentation and conditions need to be finalized before completion of the transaction. Solyndra esti-



Solyndra's PV system design allows maximum coverage and easy installation on commercial low-slope rooftops.

mates that Fab 2 will produce 15GW of solar panels, giving power outputs equivalent to about 300 million metric tons of carbon dioxide emissions.

Solyndra also reports the completion and full operation of a 132kWp system using its CIGS technology by SPG Solar on the rooftop of Cinema West's building in Livermore, CA. Installation took less than four days. Solyndra's PV system does not need roof-penetrating mounts or ballast to hold the panels in place, allowing speedy set-up. The Livermore project involved covering a complex roof shape with many areas not aligned in the north/south direction, which is a problem for traditional PV technologies. Solyndra says that the orientation of its panels has minimal impact on the overall energy yield.

### Material concerns

The Solyndra financing moves have not gone without criticism. Jack Lifton, writing on the Resource Inventory website [2], is concerned about the supply of the rare elements — gallium (Ga), indium (In) and selenium (Se) — that go into making CIGS. Both Ga and In are almost completely imported into the USA (99% and 100%, respectively),

**Lifton points out that gallium use has tripled in the last four years and is concerned about a new major consumer of this element coming into play**

according to the US Geological Survey (USGS) government organization. The USA produced a significant proportion of its gallium needs up to 2001, but thereafter abandoned extraction due to imports coming in at about half the price of domestic

material. Lifton points out that gallium use has tripled in the last four years and is concerned about a new major consumer of this element coming into play. ▶

The USGS notes that gallium demand has been driven by the need for GaAs components in "high-speed, feature-rich, third-generation, cellular handsets and other high-speed wireless applications". LEDs based on gallium nitride (GaN) technology are another major consumer of the material. USGS estimates that 95 metric tons of fresh gallium were produced. Total gallium refining, including scrap processing, came to around 135 metric tons. The USGS estimate for world gallium production capacity is 184 metric tons, with refinery capacity at 167 metric tons and recycling 78 metric tons. For indium, the USGS estimates world refinery production at 568 metric tons.

Greater supplies of these materials depend on the delicate balance between the desire of producers to charge as much as possible for their product and the willingness/ability to create new production to meet new demands. Gallium comes mainly as a by-product of bauxite/aluminum production at ~50 parts/million; indium is a by-product of sphalerite/zinc production (which also produces some gallium) at 1–100ppm.

Ironically, CIGS is often sold as a solution to the supply problem for ultra-high purity silicon, which has in recent years become very tight due to increased solar cell production on crystalline wafers (despite silicon making up 25% of the Earth's crust by mass).

The power rating of CIGS cells is usually derived from irradiation with  $1\text{kW}/\text{m}^2$  sources with air mass (AM) 1.5 spectral characteristics to simulate solar conditions that are believed to cover general use (e.g. in the northern hemisphere, irradiance and spectrum of sunlight on clear day upon a sun-facing  $37^\circ$ -tilted surface with the sun at an angle of  $42^\circ$  above the horizon). Champion efficiencies are about 20% for CIGS, with hopes that this might be increased by up to three percentage points. At this level, one could expect power generation of about  $200\text{W}/\text{m}^2$ .

To hit Greentech Media's prediction of 3GW in 2012, 15 million square meters of CIGS material operating at the top efficiency of 20% is needed. A  $1\mu\text{m}$  CIGS layer with this area would have a volume of  $15\text{m}^3$ . About a quarter of this would be the indium-gallium component. The density of gallium is about  $6\text{gm}/\text{cm}^3$  (indium is denser, at over  $7\text{gm}/\text{cm}^3$ ). This results in estimated gallium consumption of more than 20 metric tons at a bare minimum. In fact, efficiencies from commercial processes are often less than half the champion value, and the thicknesses of CIGS material can be up to  $6\mu\text{m}$ .

**To hit Greentech Media's prediction of 3GW in 2012, 15 million square meters of CIGS material operating at the top efficiency of 20% is needed... This results in estimated gallium consumption of more than 20 metric tons at a bare minimum**

## Production developments

Despite such concerns, companies are moving ahead. Ascent Solar Technologies Inc of Littleton, CO, USA announced in March that it had successfully begun regular production of monolithically integrated flexible CIGS modules. Ascent Solar claims that it is the first company to produce fully integrated lightweight thin-film CIGS modules on a high-temperature plastic substrate. The manufacturing line is to initially work one shift, moving to 1.5MW-rated capacity from three manufacturing shifts per day.

Ascent Solar is aiming at a system-level solution for space, near-space, and commercial and residential applications. The high-temperature plastics that are used have been chosen for their ability to survive the manufacturing temperatures associated with thin-film CIGS processing (back contact, CIGS active layer, CdS window, isolation and via, etc.). The material is designed to stay flexible and electrically insulating to make it possible to connect individual cells into modules during processing. The company has also worked to reduce the weight, cost and complexity of PV products for high-volume production. Among the aims is building-integrated PV (BIPV) on rooftop and siding areas.

Ascent Solar was created by ITN Energy Systems in October 2005 to commercialize its CIGS technology. ITN developed the technology to be producible in a roll-to-roll process.

Some CIGS companies are preparing for improved market conditions. HelioVolt Corp of Austin, TX, USA has more than half the \$32m it plans to raise to help it to add capacity. The company uses a printing process to deposit its thin-film solar cells with a CIGS active layer. HelioVolt says that it can print directly onto multiple construction materials — glass, steel, metal, composites and some polymers — in a range of shapes and sizes. Such solar materials are planned for incorporation into building materials, architectural modules and BIPV products. In October 2008, HelioVolt 'cut the ribbon' on its first factory — a  $122,400\text{ft}^2$  plant.

"We are currently installing and qualifying our factory production tools as part of our plans for ramping up our commercial manufacturing capabilities in 2009, and preparing for additional capacity expansion next year once market conditions have improved," says founder & CEO BJ Stanbery. "We are currently exploring all options for raising the funds to support our planned growth, and as such are continually engaged in discussions with both current and potentially new investors," he comments. "We continue to work with our diverse roster of strategic investors as both the solar and financial markets develop in the coming year to ensure our business trajectory and capital reserves are in line with the market need and potential for our thin-film solar photovoltaic products in 2010."

## Capacity round-up

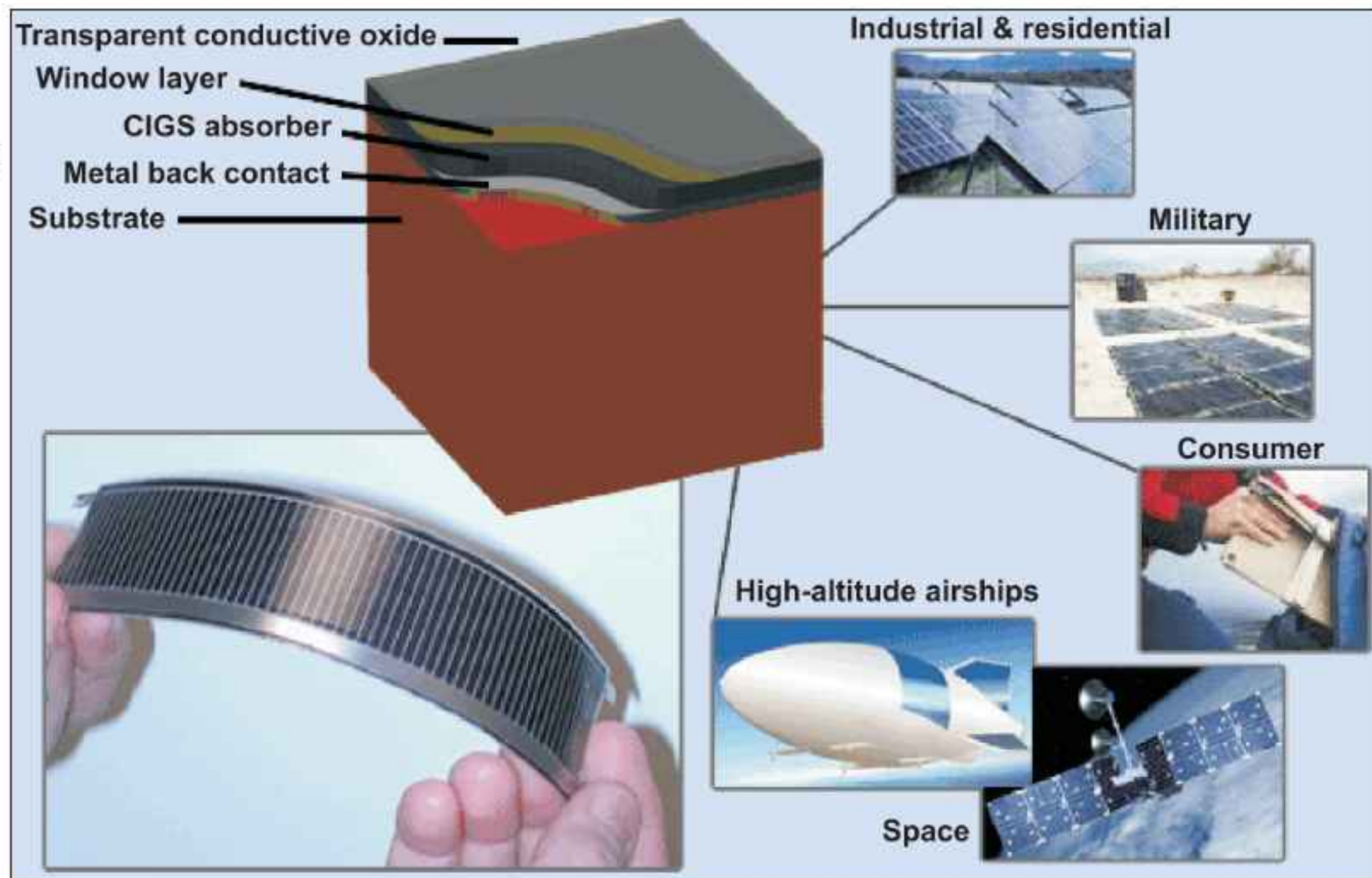
A number of companies announced new production and marketing in second-half 2008, just as the credit crunch was building to its crescendo.

Last June, Martin Roscheisen, CEO of Nanosolar Inc in Palo Alto, CA, USA, claimed that his firm had achieved manufacturing throughput of 1 GigaWatt (430MW in San Jose, CA and 620MW in Berlin, Germany) compared with 10–30MW standard among its competitors. The company has a roll-to-roll process where deposition is a printing process of a proprietary nanoparticle ink. Nanosolar claims 14% efficiency for its cells. The speed of its roll-to-roll process is currently 100ft per minute, but Roscheisen claims that it could run at 1000ft or even 2000ft per minute, and that faster speeds are advantageous in terms of coating quality.

Nanosolar has also been raising an extra \$300m in capital, bringing the total to nearly half a billion dollars. The aim is to accelerate its business implementation with product supply agreements, strategic collaboration and equity investments.

Last October, Honda Soltec Co Ltd began selling CIGS thin-film solar cells for public and industrial use in Japan. This adds to its products available for the domestic Japanese market since October 2007. The aim of its new products is high-capacity electrical generation, as demanded for public and industrial facilities. Honda claims that its cells are environmentally responsible both in their manufacturing process and in their use.

The company says that it has installed such systems at a number of its own facilities, in both Japan and the US, and on an automobile transport ship operated by one of its affiliates. Honda has also installed systems at three kindergartens in Japan, selected by the Solar Bear Fund non-profit organization for environmental education.



**Ascent Solar is targeting a system-level CIGS solution for space, near-space, and commercial and residential applications.**

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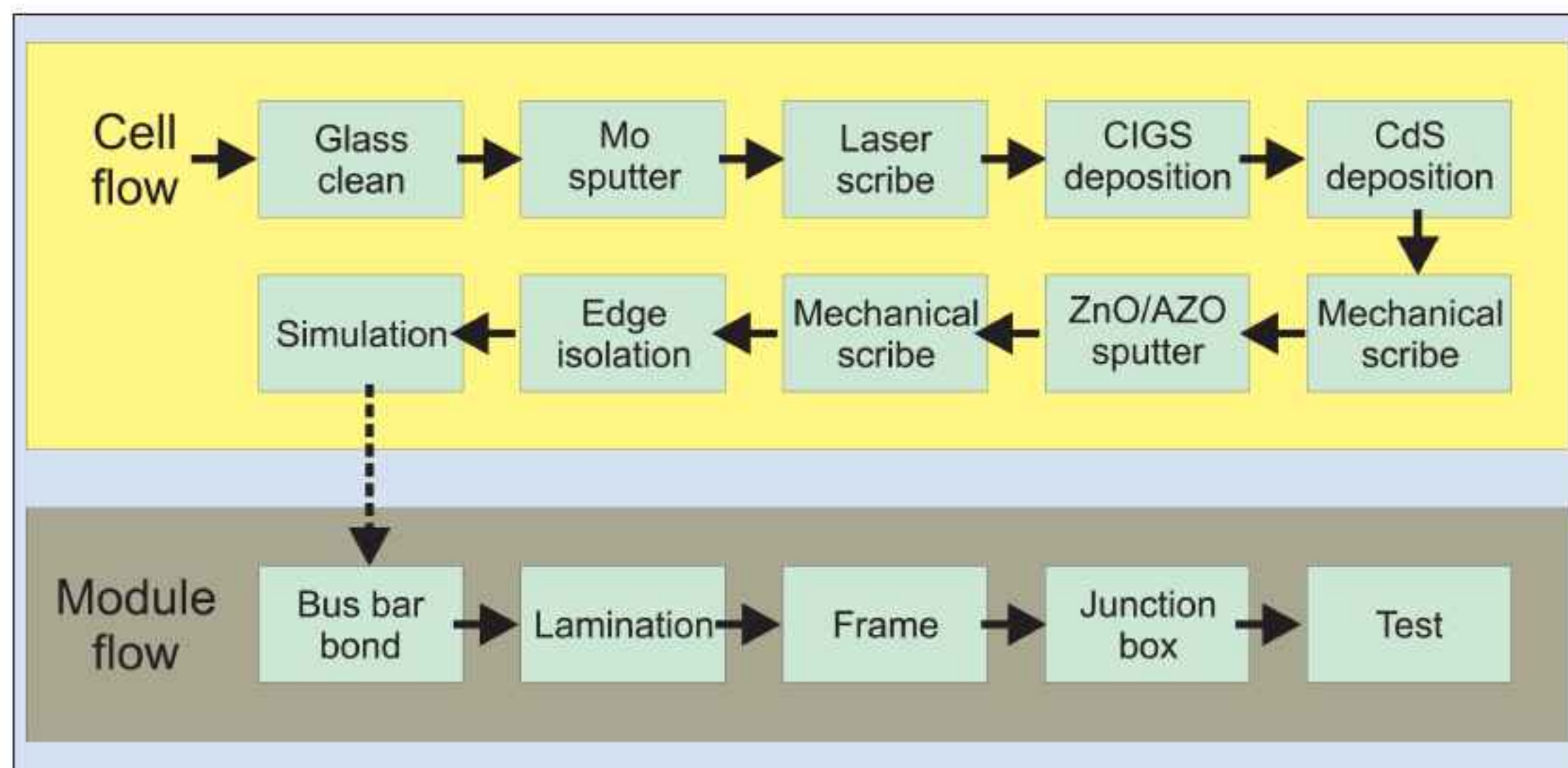
The main difference between the 'industrial use' products as opposed to 'home use' products seems to be a lower nominal open-circuit voltage — about 90V compared with about 280V. The power outputs of the 1.4m x 0.8m panels are around 120W under standard AM1.5 conditions (1kW/m<sup>2</sup>, 25°C).

In July 2008, results from testing by the USA's National Renewable Energy Laboratory (NREL) of CIGS modules made by Miasolé of Santa Clara, CA showed efficiency of 10.2%. The modules that were tested contained Miasolé's flexible cells encapsulated in a glass/glass construction. All of the CIGS material in the modules was manufactured on the company's continuous, roll-to-roll production line.

"Manufacturing high-efficiency CIGS material on a flexible substrate has proven to be difficult, and we applaud Miasolé on its ability to produce 10% modules," says Lawrence Kazmerski, director of the National Center for Photovoltaics at NREL.

Miasolé's deposition method is physical vapor deposition (PVD). The process deposits CIGS on a 2 mile long, 3 foot wide roll of stainless-steel foil in a continuous, roll-to-roll process, aimed at low cost and high volume. Miasolé has installed two 20MW production lines.

Shell has two projects around CIS (i.e. no gallium). Firstly, its Avancis joint venture with Saint-Gobain celebrated the start of production at its facility in Germany last October. The plant has an annual capacity of 20MW. An efficiency of 11% is claimed for the resulting modules. Shell Solar previously had a 3MW production facility in Camarillo, CA. Saint-Gobain contributed its expertise in glass processing and production. Avancis says that its production process consists of



Process flow for Telio's CIGS solar cell manufacturing.

just 30 steps between substrate delivery and module labeling.

Secondly, in 2008, Showa Shell Solar in Japan opened a CIS solar research centre and began collaborative research on mass-production technology of the solar modules with Ulvac. Showa Shell Solar's first plant in Miyazaki started commercial production in 2007 with an annual production capacity of 20MW; a second 60MW plant is currently under construction and is planned to start commercial production in 2009.

Showa Shell is looking to boost its mass-production capability using Ulvac's expertise in vacuum components for the semiconductor and display industries. The solar cell producer wants to squeeze production costs at a new 1GW plant starting in 2011. Shell divested its silicon solar business in 2006, selling up to SolarWorld in Germany.

Telio Solar is a new CIGS company, launched in second-half 2008. Its founders come from South Korea but have based the company in the USA. Telio's approach is to apply techniques from the displays (LCD, organic LEDs) industry (pictured above), in addition to semiconductors.

The company has established a branch office in South Korea to put it in touch with the country's highly developed infrastructure in these industries. Telio is developing a process to co-deposit the CIGS components on glass at 520°C using a top-down linear evaporation source on glass without causing substrate curvature. The company has successfully used the technique on 200mm x 200mm glass panels. Scale-ups to substrates measuring 300mm x 300mm and then 600mm x 1200mm are part of the plan.

The process performs laser patterning on the molybdenum (Mo) layer, and then a needle is used to mechanically scribe the ZnO/CdS/CIGS and TCO/ZnO/CdS/CIGS layers. The needle doing the patterning must not damage the Mo layer.

Johanna Solar Technology GmbH of Brandenburg an der Havel, Germany said last November that it had started production just a year after installing process equipment. The site has a nominal capacity of 30MW. The firm adds sulfur to its CIGS, giving CIGS<sub>Se</sub> devices. Johanna Solar produces modules that are black in color; this has both technical and aesthetic advantages.

The products made by Johanna Solar will be distributed via aleo solar AG of Oldenburg, Germany from early summer onwards. aleo targets high demand from roof installations in Germany, Italy, and France.

Solibro, the CIGS producing subsidiary of Germany's Q-Cells, began module shipments in September 2008 and announced plans for further expansion. The company expects to be at a capacity of 135MW peak per year by the end of 2009, producing from two facilities in Bitterfeld-Wolfen, Germany.

### Shell divested its silicon solar business in 2006, selling up to SolarWorld in Germany

Infrastructure firms are also looking to supply beyond the mainstream silicon business. BioSolar plans to extend its patent-pending BioBacksheet technology to CIGS and cadmium telluride (CdTe) thin-film modules from its traditional crystalline silicon (c-Si) PV base. The silicon version of the technology is in the pre-production phase. For CIGS/CdTe, the backsheet needs improved moisture barrier properties. BioSolar is working towards a composite film consisting of bio-based and 100% recyclable materials that are much lighter than glass as well as lower cost.

BioSolar aims to replace petroleum-based components (e.g. plastic) with renewable plant sources. BioBacksheet consists of a cellulose film combined with a highly water-resistant and high-dielectric-strength nylon film made from castor beans. The firm claims its technology can cut backsheet costs by 50% on traditional materials. ■

### Infrastructure firms are also looking to supply beyond the mainstream silicon business

### References

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2. <http://www.resourceinvestor.com/pebble.asp?reid=49262>

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**Power + Energy Inc**  
(see section 8 for full contact details)

**SAMCO International Inc**  
532 Weddell Drive, Sunnyvale, CA,  
USA  
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Fax: +1 408 734 0961  
[www.samcointl.com](http://www.samcointl.com)

**Surface Technology Systems plc**  
Imperial Park, Newport NP10 8UJ,  
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Fax: +44 (0)1633 652405  
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Fax: +41 21 694 35 01  
[www.synova.ch](http://www.synova.ch)

**TECDIA Inc**  
(see section 16 for full contact details)

**Tegal Corp**  
2201 S McDowell Boulevard,  
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CA 94954,  
USA  
Tel: +1 707 763 5600  
[www.tegal.com](http://www.tegal.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  
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Fax: +44 (0) 1480 424900  
[www.goodfellow.com](http://www.goodfellow.com)



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**TECDIA Inc**  
(see section 16 for full contact details)

## 10 Gas and liquid handling equipment

**Air Products and Chemicals Inc**  
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**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)

**EMF Semiconductor Systems Ltd**  
(see section 6 for full contact details)

**IEM Technologies Ltd**  
Fothergill House, Colley Lane,  
Bridgwater, Somerset TA6 5JJ,  
UK  
Tel: +44 (0)1278 420555  
Fax: +44 (0)1278 420666  
[www.iemtec.com](http://www.iemtec.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

**EMF Semiconductor Systems Ltd**  
(see section 6 for full contact details)

**k-Space Associates Inc**  
3626 W. Liberty Rd.,  
Ann Arbor,  
MI 48103,  
USA  
Tel: +1 734 668 4644  
Fax: +1 734 668 4663  
[www.k-space.com](http://www.k-space.com)

**LayTec GmbH**  
Helmholtzstr. 13-14,  
Berlin, 10587  
Germany  
Tel: +49 30 39 800 80 0  
Fax: +49 30 3180 8237  
[www.laytec.de](http://www.laytec.de)

**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)

**KLA-Tencor**  
160 Rio Robles, Suite 103D,  
San Jose, CA 94538-7306,  
USA  
Tel: +1 408 875 3000  
Fax: +1 510 456 2498  
[www.kla-tencor.com](http://www.kla-tencor.com)

## 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)

**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)

**J P Sercel Associates Inc**  
220 Hackett Hill Road,  
Manchester,  
NH 03102,  
USA  
Tel: +1 603 518 3200  
Fax: +1 603 518 3298  
[www.jpsalaser.com](http://www.jpsalaser.com)

**Kulicke & Soffa Industries**

1005 Virginia Drive,  
Fort Washington,  
PA 19034,  
USA  
Tel: +1 215 784 6000  
Fax: +1 215 784 6001  
[www.kns.com](http://www.kns.com)

**Palomar Technologies Inc**

2728 Loker Avenue West,  
Carlsbad,  
CA 92010,  
USA  
Tel: +1 760 931 3600  
Fax: +1 760 931 5191  
[www.PalomarTechnologies.com](http://www.PalomarTechnologies.com)

**TECDIA Inc**

2700 Augustine Drive, Suite 110,  
Santa Clara,  
CA 95054,  
USA  
Tel: +1 408 748 0100  
Fax: +1 408 748 0111  
[www.tecdia.com](http://www.tecdia.com)

Tecdia is a **TECDIA**  
manufacturer of  
single-layer chip capacitors,  
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**17 Assembly/packaging  
foundry****Quik-Pak**

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San Diego,  
CA 92127,  
USA  
Tel: +1 858 674 4676  
Fax: +1 8586 74 4681  
[www.quikicpak.com](http://www.quikicpak.com)

**18 Chip foundry****Compound Semiconductor  
Technologies Ltd**

Block 7, Kelvin Campus,  
West of Scotland, Glasgow,  
Scotland G20 0TH,  
UK  
Tel: +44 141 579 3000  
Fax: +44 141 579 3040  
[www.compoundsemi.co.uk](http://www.compoundsemi.co.uk)

**United Monolithic  
Semiconductors**

Route departementale 128,  
BP46, Orsay, 91401,  
France  
Tel: +33 1 69 33 04 72  
Fax: +33 169 33 02 92  
[www.ums-gaas.com](http://www.ums-gaas.com)

**19 Facility equipment****MEI, LLC**

3474 18th Avenue SE,  
Albany, OR 97322-7014,  
USA  
Tel: +1 541 917 3626  
Fax: +1 541 917 3623  
[www.marlerenterprises.net](http://www.marlerenterprises.net)

**20 Facility consumables****W.L. Gore & Associates**

401 Airport Rd,  
Elkton, MD 21921-4236,  
USA  
Tel: +1 410 392 4440  
Fax: +1 410 506 8749  
[www.gore.com](http://www.gore.com)

**21 Computer hardware  
& software****Ansoft Corp**

4 Station Square, Suite 200,  
Pittsburgh, PA 15219,  
USA  
Tel: +1 412 261 3200  
Fax: +1 412 471 9427  
[www.ansoft.com](http://www.ansoft.com)

**Crosslight Software Inc**

121-3989 Henning Dr.,  
Burnaby, BC, V5C 6P8,  
Canada  
Tel: +1 604 320 1704  
Fax: +1 604 320 1734  
[www.crosslight.com](http://www.crosslight.com)

**Semiconductor Technology  
Research Inc**

10404 Patterson Ave., Suite 108,  
Richmond, VA 23238,  
USA  
Tel: +1 804 740 8314  
Fax: +1 804 740 3814  
[www.semitech.us](http://www.semitech.us)

**22 Used equipment****Class One Equipment Inc**

5302 Snapfinger Woods Drive,  
Decatur, GA 30035,  
USA  
Tel: +1 770 808 8708  
Fax: +1 770 808 8308  
[www.ClassOneEquipment.com](http://www.ClassOneEquipment.com)

**23 Services****Henry Butcher International**

Brownlow House,  
50-51 High Holborn,  
London WC1V 6EG,  
UK  
Tel: +44 (0)20 7405 8411  
Fax: +44 (0)20 7405 9772  
[www.henrybutcher.com](http://www.henrybutcher.com)

**M+W Zander Holding AG**

Lotterbergstrasse 30, Stuttgart,  
Germany  
Tel: +49 711 8804 1141  
Fax: +49 711 8804 1950  
[www.mw-zander.com](http://www.mw-zander.com)

**TECDIA Inc**

(see section 16 for full contact details)

**24 Consulting****WSR Optical Device Solutions**

P.O. Box 248, Flemington,  
NJ 08822, USA  
Tel: +1 908 428 4986  
[www.wsr-ods.com](http://www.wsr-ods.com)

**25 Resources****SEMI Global Headquarters**

3081 Zanker Road,  
San Jose, CA 95134,  
USA  
Tel: +1 408 943 6900  
Fax: +1 408 428 9600  
[www.semi.org](http://www.semi.org)

**Yole Développement**

45 rue Sainte Geneviève,  
69006 Lyon,  
France  
Tel: +33 472 83 01 86  
[www.yole.fr](http://www.yole.fr)

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**18–21 May 2009**

## CS MANTECH (2009 International Conference on Compound Semiconductor Manufacturing Technology)

Tampa, FL, USA

**E-mail:** [csmantech@csmantech.org](mailto:csmantech@csmantech.org)

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

**19–20 May 2009**

## The Thin Film Solar Summit Europe

Berlin, Germany

**E-mail:** [josh@thinfilmtoday.com](mailto:josh@thinfilmtoday.com)

[www.thinfilmtoday.com/eu](http://www.thinfilmtoday.com/eu)

**20–23 May 2009**

## LED & Solid State Lighting EXPO 2009

KINTEX, Seoul, South Korea

**E-mail:** [led@exponu.com](mailto:led@exponu.com)

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

**24–28 May 2009**

## APWS 2009: 4th Asia-Pacific Workshop on Wide gap Semiconductors

Zhang Jia Jie, Hunan, China

**E-mail:** [Apws2009@pku.edu.cn](mailto:Apws2009@pku.edu.cn)

[www.apws2009.com.cn](http://www.apws2009.com.cn)

**24–29 May 2009**

## 215th Electrochemical Society Conference (Spring 2009 ECS)

San Francisco, CA, USA

[www.electrochem.org/meetings/biannual/215/215.htm](http://www.electrochem.org/meetings/biannual/215/215.htm)

**27–29 May 2009**

## PHOTON's 5th Photovoltaic Technology Show 2009 Asia

Shenzhen, China

**E-mail:** [ticket@photon-expo.com](mailto:ticket@photon-expo.com)

[www.photon-expo.com/en/pts\\_2009\\_asia/pts\\_2009.htm](http://www.photon-expo.com/en/pts_2009_asia/pts_2009.htm)

**31 May – 5 June 2009**

## CLEO/IQEC '09: 29th Conference on Lasers and Electro-Optics and 27th International Quantum Electronics Conference

Baltimore, MD, USA

**E-mail:** [custserv@osa.org](mailto:custserv@osa.org)

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

**1–3 June 2009**

## Photovoltaics Summit 2009

Hotel Kabuki, San Francisco, CA, USA

**E-mail:** [jeremy.powell@pira-international.com](mailto:jeremy.powell@pira-international.com)

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

**1–3 June 2009**

## SEMICON Russia 2009

Moscow, Russia

**E-mail:** [ovyshkvarkov@semi.org](mailto:ovyshkvarkov@semi.org)

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

**2–4 June 2009**

## eurolED 2009

Ricoh Arena, West Midlands, UK

**E-mail:** [eveg@astonsciencepark.co.uk](mailto:eveg@astonsciencepark.co.uk)

[www.euroled.org.uk](http://www.euroled.org.uk)

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semiconductor conference and networking  
exhibition**

City Hall, Cardiff, Wales, UK

**E-mail:** jemi-enquiries@see.ed.ac.uk**www.semiconductor2k.com****7–10 June 2009****13th European Workshop on Metalorganic  
Vapor Phase Epitaxy (EWMOVPE XIII)**

Neu-Ulm, Germany

**E-mail:** ewmovpe2009@uni-ulm.de**www.uni-ulm.de/opto/EWMOVPE2009****7–12 June 2009****IEEE Microwave Theory and Techniques  
Society (MTT-S) International Microwave  
Symposium 2009 (IMS 2009)**

Boston, MA, USA

Paper submission deadline: 8 December 2008

**www.ims2009.org****7–12 June 2009****34th IEEE Photovoltaic Specialists  
Conference (PVSC)**

Philadelphia, PA, USA

**E-mail:** wendy\_larsen@nrel.gov**www.34pvsc.org****8–9 June 2009****Blue 2009 (The 7th International Industry  
Review)**

Ambassador Hotel, Hsinchu, Taiwan

**E-mail:** Blue-2009@solidstatelighting.net**www.solidstatelighting.net/conferences/blue2009****8–10 June 2009****PV America**

Philadelphia, PA, USA

**E-mail:** swatson@seia.org**http://events.jspargo.com/seia09****8–11 June 2009****NXTcomm '09**

Chicago, IL, USA

**E-mail:** jwilliams@NXTcommShow.com**www.nxtcommshow.com****10–13 June 2009****Photonics Festival in Taiwan:  
Opto Taiwan, LED Taiwan, Solar Taiwan,  
Optics Taiwan**

Taipei World Trade Center, Taiwan

**E-mail:** exhibit@mail.pida.org.tw**www.optotaiwan.com/en/****14–19 June 2009****21st International Symposium on Power  
Semiconductor Devices and ICs**

Barcelona, Spain

**E-mail:** ispsd2009@reunionsciencia.es**www.ispsd09.com****16–18 June 2009****Solar Economics Forum — Towards Grid Parity**

London, UK

**E-mail:** victoria.adair@greenpowerconferences.com**www2.greenpowerconferences.co.uk****24–26 June 2009****PVJapan 2009**

Makuhari Messe, Tokyo, Japan

**E-mail:** pvj@semi.org**www.pvjapan.org****1–2 July 2009****UK Semiconductors 2009**

University of Sheffield, UK

**E-mail:** registration@uksemiconductors.com**www.uksemiconductors.com****13–17 July 2009****14th International Conference on Narrow  
Gap Semiconductors and Systems (NGS2)**

Tohoku University, Sendai, Japan

**E-mail:** nitta@material.tohoku.ac.jp**www.material.tohoku.ac.jp/~kotaib/NGS14front.html****14–16 July 2009****SEMICON West/Intersolar USA**

Moscone Center, San Francisco, CA, USA

**E-mail:** ktorres@semi.org**www.semiconwest.org****19–22 July 2009****9th International Conference on Atomic  
Layer Deposition (ALD 2009)**

Monterey, CA, USA

**E-mail:** della@avs.org**www2.avs.org/conferences/ALD2009****2–6 August 2009****SPIE Optics + Photonics 2009**

San Diego Convention Center, CA, USA

**E-mail:** CustomerService@SPIE.org**http://spie.org/optics-photonics.xml****9–12 August 2009****26th North American Conference on  
Molecular Beam Epitaxy (NAMBE)**

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