

## SiC power devices market focus: about time for a switch

## Violet-emitting chips for higher- efficiency warm-white LEDs



AXT targets GaP in market • Toshiba's first GaN products  
First short-cavity GaN cw blue laser • Honda selling CIGS PVs



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## semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

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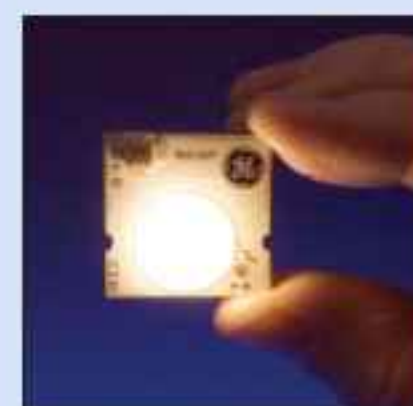
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**p28** UCSB has used low-defect non-polar m-plane GaN to fabricate LEDs with efficiency of 41% up to 200mA.



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**Cover:** Lumination's Vio LED, which combines a 405nm violet-emitting chip (operating at a higher-efficiency wavelength than blue LEDs) with a blend of phosphors to convert the violet light to warm-white light. Color rendering index is 70 at 45lm/W or 85 at 38lm/W. Color shift is less than 100K. **p25**



# GaN applications maturing

Following Motorola's handset division losing market share earlier this year (which led to inventory corrections hitting RFMD and Skyworks in Q1/2007 — see last issue, page 8), Motorola has laid off a further 4000 staff in an attempt to return to profitability (see this issue, page 6).

On a smaller scale, Filtronic has cut 115 jobs at its 6" GaAs pHEMT foundry in Newton Aycliffe, UK. The shortfall in expected demand is partly due to customer RF Micro Devices last year ramping up its in-house production of pHEMT switches as it diversifies from focusing on HBT power amplifiers. Indeed, RFMD also launched pHEMT low-noise amplifiers at June's IEEE MTT-S International Microwave Symposium (IMS 2007) in Hawaii (page 8) and now plans to stop buying from Filtronic in September. Meanwhile, at the same event, fellow RFIC maker TriQuint launched new products as part of its 'RF vision' for wireless connectivity (see page 10), which includes packaging more of its formerly die-level-only chips, aiming to broaden usage.

IMS 2007 also saw both RFMD and Nitronex supplementing their existing ranges of 28V gallium nitride power transistors by launching new families, operating at 48V, of their GaN-on-SiC and GaN-on-Si transistors, respectively, for applications such as 3G and WiMAX infrastructure (see pages 12 and 15). Nitronex, in particular, is also ramping up its production capabilities by appointing a director of product development and a supply chain manager, specifically to address device packaging issues.

Similarly, Cree sampled new GaN-on-SiC HEMTs (including products for WiMAX). But, in addition, it has also complemented the process design kit launched at IMS 2006 for the SiC power device process of its Wide-Bandgap foundry service with a PDK for its GaN MMIC process, again available from electronic design automation tool supplier Applied Wave Research within its Microwave Office software environment (the 2007 version of which — launched just before IMS — now includes WiMAX libraries; see page 13). Toshiba also joined the growing ranks of GaN HEMT suppliers with the launch of its first commercial products. Meanwhile, in the IMS 2007 conference, Sirenza Microdevices reported the use of GaN-on-SiC technology to achieve the first sub-dB, 2W MMIC amplifier (fabricated by Northrop Grumman Space and Technology) — see page 14.

While Filtronic's GaAs business is struggling, it is investigating GaN-based opportunities, not only in microelectronics but also through a consortium funded by £3m from the UK government to develop low-cost GaN LEDs on 6" silicon substrates for solid-state lighting applications (see page 22). Meanwhile, Australia's BluGlass has now succeeded in scaling up its blue light emission from 4"-diameter to 6"-diameter GaN-on-glass substrates.

Regarding materials like copper indium gallium diselenide (CIGS), Honda has now started selling CIGS-based solar cells (page 38). However, a note of caution is flagged by analysis (on page 5) that exhaustion of global raw material reserves (particularly indium) may restrict market development.

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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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- event calendar and event previews;
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## Blue-laser-based optical disk drives to take 20–30% of ODD sales in 2010

This year, blue-laser Blu-ray Disc (BD) and HD DVD will account for just 5% of the global sales volume of all kinds of DVD optical disk drives (ODDs), including players and recorders, but this will rise to 20–30% in 2010, according to Masayuki Kozuka of Matsushita Electric Industrial (Panasonic) in an interview with DigiTimes web-site. Kozuka is general manager of Matsushita's Storage Device Business Strategy Office, which was established to analyse developments and market trends in the light of demand for BD and HD DVD ODDs.

Also, the shipment volume of desktop and notebook PCs equipped with BD and/or HD DVD burners/drives will reach 35 million units in 2010 (17.5% of the projected 200m units for all PCs), Kozuka adds.

"For DVD standards, the demand began with stand-alone DVD players and then extended to PC-use drives and burners. Today sales volume for the latter is estimated to be five times that for the former. The trend

of development for blue-laser disc drives/players is expected to be the same or similar," Kozuka adds.

●Standard DVD burners will remain the dominant volume product of the optical/removable storage market until 2011, due to commodity prices and almost universal compatibility, according to market research firm IDC's new study 'Worldwide Blue Laser DVD, DVD, CD, and Other Optical/Removable Storage Drive 2007–2011 Forecast and Analysis'. However, blue-laser-based Blu-ray and HD DVD format drives are ramping up. Marketing activities of both the HD DVD and BD camps are accelerating, and more companies are joining either one of the two or both format groups.

"Similar to DVD and DVD burners, blue laser DVD will need a 3–5 year ramp to reach mass-market volume," says Wolfgang Schlichting, research director for Removable Storage.

[www.digitimes.com/news/a20070620PD201.html](http://www.digitimes.com/news/a20070620PD201.html)

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

## Blue-laser ODD sales 52m in 2008

Demand for blue-laser-based optical disc drives (ODDs) — Blu-ray Disc (BD) and HD DVD — will grow from 15m units in 2007 to 52m in 2008, according to a forecast based on Taiwan ODD industry sources by Japanese market research firm BOC, reports DigiTimes. Most growth will come from game consoles such as the PS3 and Xbox 360. In mid-May, BOC said that only 3m blue-laser ODDs and recorders/players were sold worldwide in 2006, but 2m of these were in PS3 game consoles.

In addition, leading movie studios in Hollywood have been releasing BD and/or HD DVD movies in increasing volumes. The leading Japanese ODD brands expect global demand for BD and/or HD DVD ODDs to take off in the second-half 2007, so they are currently making efforts to minimize production costs and expand their production capacities.

[www.digitimes.com/systems/a20070606PD216.html](http://www.digitimes.com/systems/a20070606PD216.html)

## Si and Ge prices rising as substrate demand grows

According to Frost & Sullivan in its report 'World Wafers Markets', shortages of bulk materials have led to steep increases in the price of raw material for both silicon and germanium substrate manufacturing over the last two years.

"Consumer electronic products such as PDAs, notebooks, mobile phones, LCD displays and DVD players are increasingly incorporating silicon, silicon on insulator, and compound semiconductor-based devices in them," says research analyst Jagadeesh Sampath.

The increased buying power of consumers in the Asian region as well as an increased interest in feature-rich products is fueling

demand for consumer electronics products which, together with the move toward larger wafer diameters, is driving wafer markets.

However, Sampath adds, "A key trend in this market is the growth instigated by solar application. Currently, in terms of revenues, the contribution of solar application is very little but, in terms of growth, it has very high potential." Demand for silicon wafers has consequently been rising over the last few years due to growth in solar cell manufacturing.

Due to the consequent shortage of bulk polysilicon, the cost of the raw material has risen from \$20 per kg to \$250 per kg. As a result, sub-

strate manufacturers have increased prices for all diameters. Overall, the silicon wafer market was \$8.61bn in 2006 and should reach \$12.28bn in 2010.

Also, "International pricing of germanium has been the major factor contributing to the very high cost of Ge wafers; from \$570–590 per kg in 2006 it is expected to increase to \$620–650 per kg during the forecast period [to 2010]," says Sampath. "As the raw material price goes up, the pricing of Ge wafers [for photovoltaics applications] is expected to shoot up significantly, thus hindering revenue growth."

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



# Indium supplies to run out in 10 years?

Reserves of indium, hafnium and other such metals could soon be exhausted due to demand for flat screens and other electronic products, reports the 26 May issue of UK magazine New Scientist.

Armin Reller, a materials chemist at Germany's University of Augsburg, forecasts exhaustion of global supplies of indium in 5–10 years time (due to in liquid-crystal displays for flat-screen TVs and PC monitors), hafnium by 2017 (as hafnium compounds replace silicon dioxide as a high-k gate dielectric in CMOS ICs), and zinc in 20–30 years (see table).

The impending scarcity may have already begun to impact prices, with indium rising from about \$60/kg in January 2003 to over \$1000/kg by August 2006.

Given the widespread use already of gallium and indium in both electrical and non-electrical products, New Scientist's own calculations of when materials will run out raise most concern about the massive extra demand for thin-film photovoltaic cells, notably indium gallium arsenide (InGaAs) and copper indium gallium diselenide (CIGS). For the latter, market research firm IDTechEx is tracking over 10 organizations planning major production soon in Japan, Europe and the USA.

But chemist René Kleijn of Leiden University in the Netherlands says that current reserves will not allow a substantial contribution of these cells to future solar power supply,

and that such panels might not get built for lack of gallium and indium. He reckons that they will probably contribute to less than 1% of all solar cells — "a limitation imposed purely by a lack of raw material".

However, estimates of reserves vary widely (compounded by the secrecy of mining companies), so it is difficult to accurately forecast demand, says New Scientist's David Cohen. Also, demand for some metals may plateau. For example, Tom Graedel, a professor of industrial ecology at Yale University, found that per capita consumption of iron leveled off in about 1980, suggesting that people in technologically advanced societies might only need so much of any one metal; perhaps solar cells will be the same. But Graedel cautions that this has not been the case with copper, for which global demand might outstrip mineable supplies by 2100.

If the most dire forecasts are true, recycling of rare metals will be the only way to manufacture some devices as demand grows in the developing world, says New Scientist.

In its report 'Inorganic Printed and Thin Film Electronics' IDTechEx says there should be much more debate about these predictions, and action programs should result. A working group of the OECD (Organisation for Economic Co-operation and Development) was convened in June to come up with answers. Nevertheless, there are huge opportunities for inorganic semi-

conductors and dielectrics, given their superior performance and, in many applications, their modest usage of material (provided that their price does not escalate unacceptably due to imprudent volume use elsewhere).

[www.newscientist.com](http://www.newscientist.com)  
[www.idtechex.com](http://www.idtechex.com)

## US crystals to grow 5.8% a year to \$1.1bn in 2011

The \$845m US market for industrial crystals (excluding silicon) will grow more than 5.8% a year through 2011 and surpass \$1.1bn, according to the report 'Industrial Crystals' from The Freedonia Group. Growth will be driven largely by demand for nonlinear optical materials and compound semiconductor substrates for communications equipment.

While the largest gains will occur in the communications market, the security and defense market will grow slightly faster. Also growing strongly will be medical markets, driven by technological advances.

The fastest-growing materials will be transition-metal oxides (due to growth in nonlinear optical crystals in optical applications), closely followed by semiconducting crystals.

The communications industry is poised for a renewed period of rapid growth as consumers demand bandwidth-intensive multimedia content and services. This will intensify as countries transition to high-definition TV signals, and as high-definition TVs and media players become more widespread.

In wireless applications, continued expansion of the world mobile phone market, along with 4G roll-out, will generate demand for high-power compound semiconductor chips, which are still largely designed and fabricated in the USA.

Strong growth in substrate application demand will also occur due to the rapidly growing solar market, and the use of LEDs in vehicles, as backlights in both flat screen monitors and TVs, and in general lighting. Growth in detector applications will stem largely from demand for medical imaging instruments. Timing applications will weaken as production of consumer mobile communication and wireless network electronics shifts to Asia, and new technologies such as MEMS provide competition.

<http://freedonia.ecnext.com>

**Table. Forecast reserves of key materials.**

Element	Time to run out	Main source
Antimony	15–20 years	China
Hafnium	10 years	Australia
Indium	5–10 years	Canada
Zinc	20–30 years	USA

Sources: Armin Reller (University of Augsburg), Tom Graedel (Yale University), and the US Geological Survey.



# Motorola cuts 4000 more jobs

Motorola, the world's second biggest cell-phone handset maker, is cutting a further 4000 jobs (6% of its workforce) over the next 12 months in an effort to enhance profitability.

According to market research firm Gartner, in Q1/2007 Nokia increased its leading market share to 35.7% while Motorola fell to 18.5% (down from more than 20% a year ago). Also, fueled by price cuts on a grow-

ing inventory of older phone models, Motorola made a loss of nearly \$1bn in Q1/2007, leading to 3500 job cuts (to be completed by end-June), which should save \$400m in 2007.

Now, this second wave of layoffs (bringing the total to 10% of its workforce) plus related moves (including shifting investments to more strategic areas and cutting discretionary spending) will cost

\$300m (mostly in severance payments) over the remainder of 2007. However, it should save the firm a further \$600m in 2008, bringing total annual savings to \$1bn.

The extra cuts are the result of a push to find ways to "drive out additional costs," says chief financial officer Tom Meredith. Motorola's top priority is "long-term, sustainable profitability", he adds.

## Filtronic cuts 115 jobs; RFMD sales to cease in September

Microwave subsystem and component maker Filtronic plc of Shipley, UK is cutting staffing levels, blaming "continuing uncertainty in the mobile handset market", reported The Northern Echo newspaper in north-east England in May.

Early last year, Filtronic announced a £45m capital expenditure program to triple capacity at its compound semiconductors division in Newton Aycliffe, County Durham UK, which makes GaAs RFICs including pHEMT switches for mobile phone handsets. However, last June, after weaker-than-expected demand for its products (due in part to main customer RFMD increasing in-house pHEMT switch production) and half-year losses of £6.7m, this was reduced to £15m, then again, in January, to 'not exceeding £10m' (including

contract cancellation charges of £7m). However, it pledged not to make cuts to its existing operation.

But now, following a review of its business, Filtronic said it needed to assess its operation to gain a "more considered understanding of what is needed at the plant".

● As we closed for press, on 25 June Filtronic said that RFMD has decided to in-source all production of switches and will cease buying from Filtronic in September. Filtronic is therefore cutting 115 jobs. Options being considered include sale of the Compound Semiconductor business.

● In a trading update, Filtronic says that on 23 July, for its second-half fiscal 2006/7 (to end May), despite making a loss overall (as forecast) it will report operating performance that is better than market expecta-

tions. This reflects another good half year in Point to Point, sound performance in the Defence business, and margin and overhead control in Compound Semiconductors (which will have traded close to breakeven).

For the Newton Aycliffe plant, capital expenditure has been within the £10m limit. Excluding this, the underlying Filtronic Group cash performance in the fiscal second half will have been positive.

As reported in April, the remaining Powerwave shares (acquired last October in selling the Wireless Infrastructure business) have been sold. This raises total net proceeds from all Powerwave shares to £53.4m (making a total of £150.3m, including the £96.9m in cash that Powerwave paid Filtronic for the business).

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

## Sirenza expands Nuremberg facility for CATV demand

Sirenza Microdevices of Broomfield, CO, USA has expanded the capacity of its production facility in Nuremberg, Germany (inherited in its acquisition of Premier Devices) with additional assembly and test equipment to support the growing demand for GaAs-based RF power amplifier modules for cable TV (CATV) and other applications.

By adding high-speed surface-mount and aluminum wire bonding equipment, the expansion has increased surface-mount assembly

capacity by about 25% and wire bonding capacity by up to 50%. The electrical test capacity has also been expanded through the implementation of additional RF-amplifier test stations required for complex RF tests of 1GHz CATV amplifiers.

"This expansion is in response to the growing demand for Sirenza's 1GHz CATV amplifiers and for other applications such as RF-driven light sources for commercial video and TV applications," says Jerry Quinnell, interim president of Sirenza's

subsidiary Premier Devices Inc (PDI) in San Jose, CA (acquired in April 2006).

"In addition to our broad portfolio of 1GHz CATV forward and return path amplifiers, we currently market a complete family of CATV amplifiers in all the required frequency bands to support world-wide transmission network standards; additionally, we currently market optical receivers for CATV applications up to 1GHz frequency."

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



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## IN BRIEF

**RFMD launches pHEMT LNAs**

At the IEEE MTT-S 2007 event, RF Micro Devices launched its new RF386X family of broadband GaAs pHEMT low-noise amplifiers, which operate at 700–3800MHz.

The RF386X family is designed for first-stage low-noise and linear driver amplification targeting CDMA, PCS, DCS, UMTS, WLAN and WiMAX wireless network infrastructure. They are offered in single-stage, dual-stage and dual-channel configurations and each is internally matched, maximizing network designer flexibility with minimal external biasing, simplifying design requirements and accelerating time-to-market. Each LNA is contained in a low-cost, industry-standard QFN package.

"Our new RF386X family of LNAs covers multiple octaves in frequency while delivering excellent noise performance and linearity, resulting in a single component which delivers enhanced signal quality to the customer for multiple radio applications," claims Jeff Shealy, VP of the infrastructure product group.

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

**Anadigics expands in Eastern Canada**

RFIC maker Anadigics Inc of Warren, NJ, USA has appointed Electronic Sales Professionals Inc (ESP) as its representative for the Eastern Canadian Region (representing its complete line of wireless and broadband products).

"Developing strategic sales agreements with leading representatives provides Anadigics with the opportunity to engage new customers in the growing broadband and wireless communications market," said Carl Lump, senior sales director for wireless products.

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

**WJ enters technology license and foundry agreement and sells fab gear**

WJ Communications Inc of San Jose, CA, which designs and supplies wireless infrastructure RFICs and multi-chip modules as well as RFID reader modules, has sold the wafer manufacturing equipment of its 4" GaAs wafer fabrication plant in Milpitas, CA, USA for about \$1.87m in cash (plus other considerations) to electronic assembly manufacturing firm AmpTech Inc of Free Soil, MI, USA. AmpTech, which is developing compound semiconductor processes and products for RF mobile applications, has also entered into a technology license and foundry agreement with WJ.

WJ completed its transition to a fabless model with the closure of its fab at the end of March (plans for which were first announced last November). WJ acquired the fab in June 2004 along with EiC Corp's wireless infrastructure business, but it was considerably under-utilized.

As part of the deal, AmpTech has entered into a lease agreement with the owner of the fab building. AmpTech has also offered employ-

ment to certain WJ employees, and plans to start production ramp-up in the near term.

"Our specialized Milpitas wafer fab has served us well for many years, and we look forward to partnering with AmpTech to ensure a steady flow of wafers in the future," said WJ's president and CEO Bruce Diamond. "The foundry agreements with AmpTech and GCS [of Torrance, CA] provide WJ a dual-source strategy with qualified foundries and ensure capacity flexibility to meet the future needs of our customers." WJ agreed in March 2006 to use III-V wafer foundry GCS as a second source of GaAs and InGaP HBT wafers (starting last July).

AmpTech's CEO Ray Milano added: "The purchase of WJ's Milpitas fabrication equipment, combined with the license agreement, accelerates our technology roadmap and allows us to instantly leverage WJ's expertise in advanced proprietary process technologies."

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

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

**GCS & RFIC Solutions ally on design**

III-V wafer foundry Global Communication Semiconductors Inc (GCS) of Torrance, CA and third-party intellectual properties and design services provider RFIC Solutions Inc of San Jose, CA, USA have announced a strategic alliance to provide a broad range of services, from product design to finished parts.

The alliance combines GCS' portfolio of foundry technologies (HBT, pHEMT, InP) and RFIC Solutions' expertise in IP, RFIC and module design to provide low-cost custom RF solutions quickly and efficiently.

GCS aims to provide 'one-stop solutions', says its VP of sales & marketing Simon Yu. The partnership should provide design capabilities and low-cost RF design solutions that enable customers to

enhance product performance and competitiveness and shorten their product time to market, he adds.

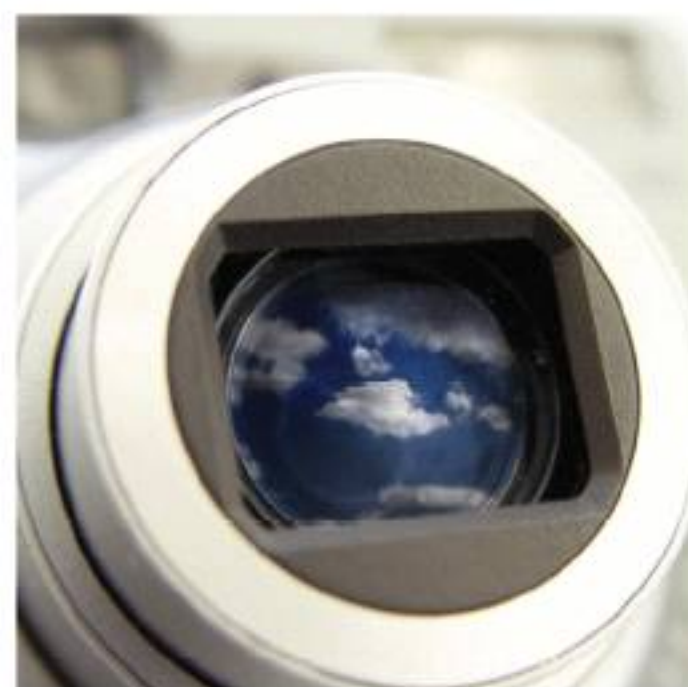
"We have designed many of our IP blocks using GCS' GaAs HBT and other processes," says RFIC Solutions' president and CEO Sanjay Moghe. "We are designing power amplifiers, low-noise amplifiers, mixers, synthesizers, and transceivers for cellular, WiFi, WiMax, UWB [ultra-wideband], and cable TV markets," he adds.

"Many of these markets require advanced GaAs and pHEMT processes... By partnering with GCS we offer one-stop shop, high-performance, low-cost RFIC and module design services."

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

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





## Advanced CVD and ALD Precursors

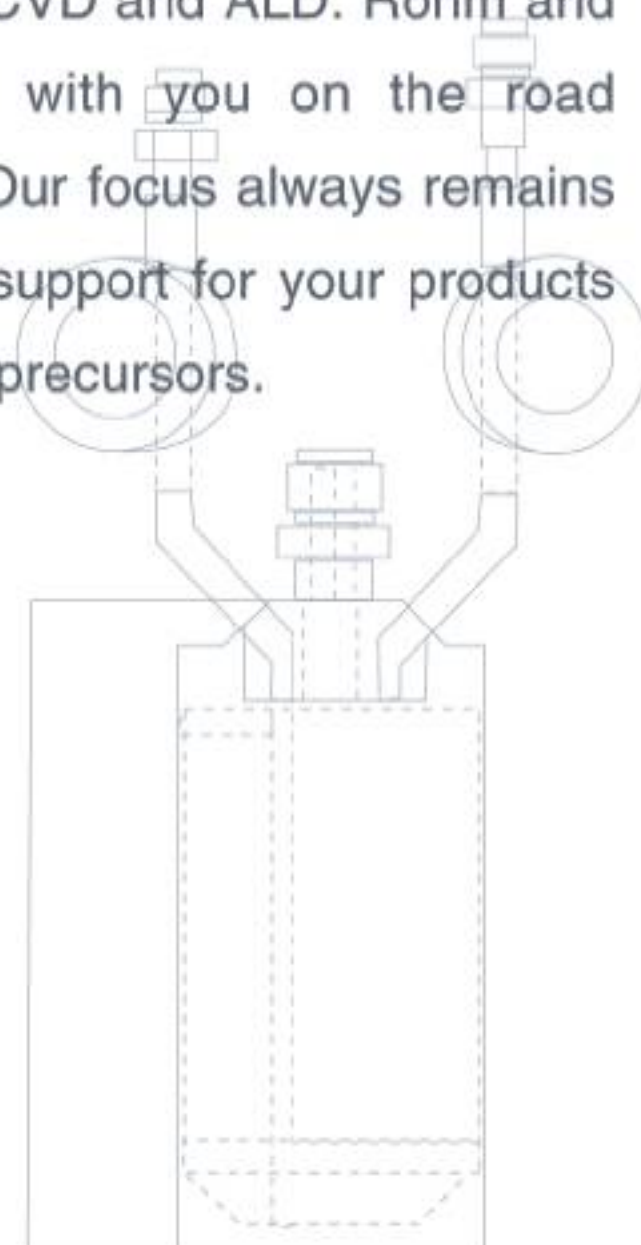
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# TriQuint unveils 'RF vision' to simplify wireless connectivity

Prior to June's IEEE MTT-S IMS 2007 event, RF communications component and module maker TriQuint Semiconductor of Hillsboro, OR, USA unveiled its Network Business Unit's global RF 'Simplifying Connectivity' vision to simplify connectivity in consumer voice, data, music and video for fixed/mobile environments.

"Customers want integrated devices for size- and cost-constrained applications, more packaged product options, especially for higher-frequency applications, and a simpler way to get those products," says networks VP Brian Balut. "Our vision is about anticipating these needs and helping them increase productivity."

"Our customers are developing next-generation products that will enable connectivity convergence," he adds. "People want access when and where they choose, without service quality issues, hence the need for fixed and mobile wireless high-speed connectivity and the products that enable it. And they want it simple. Equipment makers have the same expectation."

The strategy has three elements:

- Simplify RF designs by using GaAs, surface and bulk acoustic wave (SAW/BAW) technologies for chip-level device integration of multiple functions into more cost-effective modules. These handle RF power, switching or filtering functions more efficiently and use less board area (simplifying and speeding device and equipment manufacturing, and reducing time to market). TriQuint's E/D pHEMT process already enables multi-band, die-level integration of amplifiers, switches, filters and low-noise amplifiers to support WLAN a/b/g/n standards, benefiting multiple-input, multiple-output (MIMO) designs that shrink network and CPE wideband wireless connections. "MIMO will mean smaller devices that will be easier to configure and use," Balut says. MIMO also virtually eliminates dropped calls, digital fade and data interruption.

- Package more GaAs devices that were once only available as die-level MMICs (to manufacturers geared to handle non-packaged components). This provides greater access to more product manufacturing options

(which can open up new markets and reduce costs or shorten time-to-market roll-outs, the firm claims).

"One consumer product market where we have already seen what the packaging revolution can do is in two-way satellite ground terminals used for providing high-speed Internet connections," says Balut. "TriQuint has reduced the die surface area for the transmit power amplifier by more than 60% while continuing to improve performance. Products that were once difficult to package or required multiple die in a single package to achieve performance goals are now offered in a selection of packages, making for easier, less-specialized manufacturing. Die shrink has led to cost reductions."

- Improve global access to products. In early May TriQuint simplified its European coverage model by restructuring the distribution and sales channels, giving more convenient, local access to RF professionals augmenting TriQuint's sales team. Also, to enable designers and purchasing agents to more easily browse its RF products, on 5 June TriQuint released its first Product Selection Guide, covering virtually its whole portfolio of amplifier, filter and switch products (streamlining product access while leaving the option of custom solutions).

"TriQuint's vision is to use our technology portfolio to build integrated RF front-end solutions for all fixed and mobile applications," says Balut. "Highly integrated module products and discrete parts will simplify network solutions. Similar to the handset market, TriQuint's network vision simplifies the design, manufacturing and purchasing processes." These trends are also appearing in military product lines, he adds, where defense contractors are expressing preferences for high-performing integrated and packaged devices.

## European sales & distribution restructured

TriQuint has restructured its sales coverage and product distribution in Europe. Redtree Solutions has been made sales representative for much of Europe, the UK, Ireland and the Nordic countries. Existing European distributor Avnet Memec will now also serve France, Italy, the UK and Ireland after previously covering much of Western & Eastern Europe.

Graham Teague, MD/sales director (EMEA) for TriQuint Semiconductor GmbH in Munich, says that Redtree will work with Avnet and TriQuint staff to introduce wireless products and capabilities to new

customers across Europe, while also supporting existing customers.

The logistics expertise of Avnet's distributorship and Redtree's demand creation methods across Europe will offer customers direct, personal service in conjunction with TriQuint offices already serving Europe, says Teague: "Redtree Solutions and Avnet Memec are extensions of our own sales force."

"Many customers who buy through distribution seek an increasing variety of RF technologies to differentiate their end product," says Avnet Memec's president Steve Haynes.



To support its RF vision, at IMS 2007 TriQuint launched new products including RF front-ends for WiMAX radio links, packaged HFETs for base-station and point-to-point radio connections, and packaged amplifiers for satellite ground terminals, along with newly packaged multi-function circuit (MFC) devices for point-to-point radios.

#### **Packaged HFETs for base-station and point-to-point radio**

For base-station, point-to-point radio and general-purpose amplifier applications, TriQuint is sampling the TGF2960-SD (0.5W, nominal) and TGF2961-SD (1.0W, nominal) HFET products, available in industry-standard packages to complement the firm's existing range of die-level discrete products.

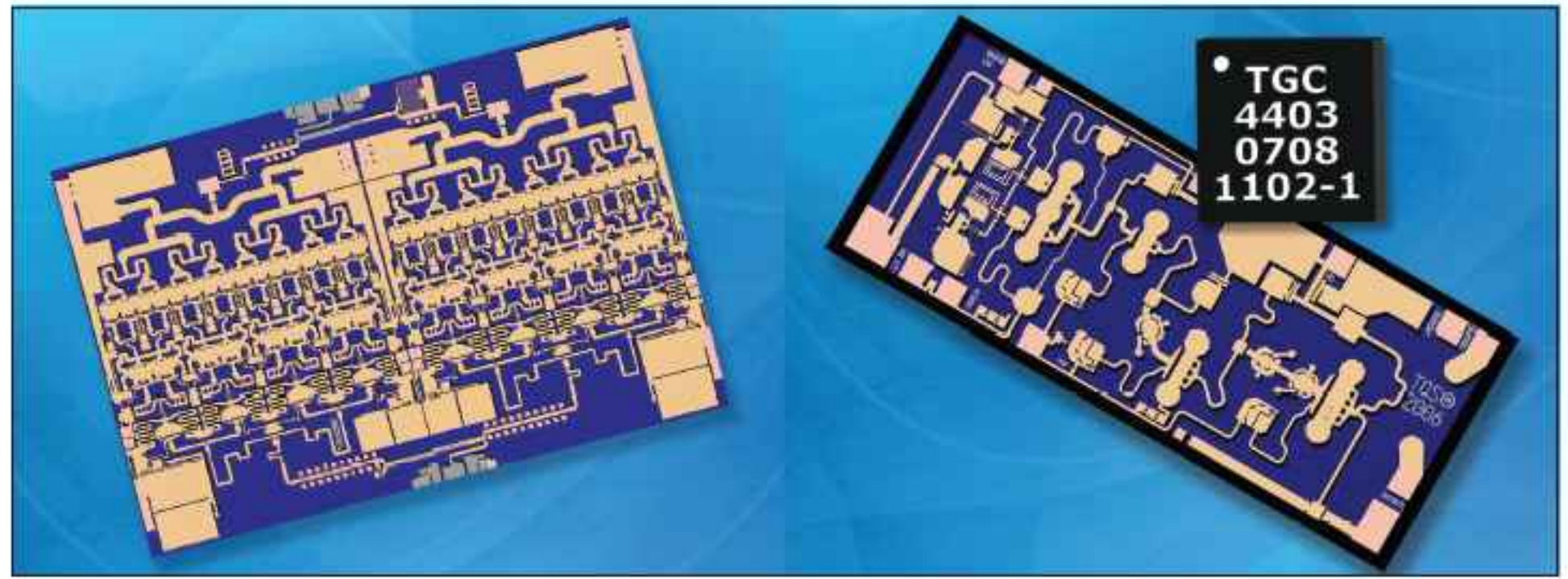
"Equipment and radio designers strive to find cost-effective, high-performance components that may be utilized for multiple functions in their designs," says product marketing director Dan Green. "Customers like to be able to reuse a component in a design or across multiple designs and applications. Packaged HFET power discrete devices fill this role and work to lower bill-of-material component count and overall product cost," he adds. "Packaged HFET power discrete devices are well suited for use throughout the RF and IF signal paths as gain blocks, driver and power stages."

#### **Packaged MFC circuits for digital radio and sat-coms**

As extensions of the die-level TGC4402, TGC4403 and TGC4405 launched at November's Electronica 2006 event in Munich, the TGC4402-SM, TGC4403-SM and TGC4405-SM (in industry-standard 4mm x 4mm x 0.9mm packages) are the first devices in the packaged MFC GaAs IC family.

The newly packaged products address OEM needs for frequency upconversion (amplification) in the transmit (Tx) and local oscillator (LO) chains in point-to-point (PTP) digital radio and sat-com systems.

- The TGC4403-SM frequency doubler operates at 16–30GHz and includes an output buffer amplifier



The TGA4916 die-level HPAs (left) and TGC4403-SM frequency doubler (right).

delivering 20dBm (typical) output RF power and 18dB of gain. High conversion gain allows operation over a –5dBm to +5dBm input power range while consuming only 150mA of quiescent current from a +5V supply.

- The TGC4405-SM single-balanced upconverter features an integrated LO frequency doubler and output post-amplifier, providing typical conversion gain of 13dB across the 17–27GHz RF band.

- The TGC4402-SM upconverting mixer operates at 18–26GHz for designs that require no integrated LO doubler or output amplifier.

The TGC4405-SM and TGC4402-SM have single-ended signal ports and no need for external RF, LO and IF baluns (which are integrated).

#### **Single-chip VSAT HPAs for sat-com ground-terminal RF chipsets**

TriQuint's TGA4916 and TGA4906 die-level high-power amplifiers (HPAs) offer higher performance in a smaller area plus greater cost effectiveness in satellite communications (sat-com) ground-terminal RF chipsets, the firm claims.

The market for earth-station sat-com products is forecast for continued growth through 2011, says Strategy Analytics, with a sizeable shift toward higher-frequency systems: the Ka-band portion of the market should grow from less than 10% of the overall sat-com market in 2006 to nearly 40% by 2011.

The GaAs MMICs were developed as part of TriQuint's program to drive the evolution of VSAT (very small aperture terminal) components for ground-station RF systems.

Since 2001, TriQuint has increased the functionality of VSAT HPAs

within a smaller die surface area. Using 0.15µm GaAs pHEMT technology with three layers of interconnecting metal (3MI) on 50µm substrate material, overall chip size has shrunk by 35%, while the amplifier power density has increased by a factor of six over the product development lifetime, enabling either a reduction in the overall size of finished products (with corresponding cost savings) or placement of more features into the same PC board area.

"Two primary forces are driving the development of new products for VSAT RF front-end applications," says product marketing director Paul Gilgallon. "In the area of die-level products, the push for high integration is a major factor." The single-chip TGA4916 is a 29–31GHz Ka-Band, fully monolithic HPA with 38.5dBm (7W) of saturated output power and 21dB of small-signal gain. TGA4906 is a 'half-chip' 28–31GHz version of the TGA4916 with 36dBm (4W) of saturated output power and 24dB of small-signal gain.

Compared to the prior generation, the latest VSAT HPAs offer greater power added efficiency (PAE at  $P_{sat}$  >18% for the TGA4916 and >20% for the TGA4906, at 30GHz). This translates into less heat accumulation (critical for devices inside ground-terminal radios, typically at the end of a boom affixed to a rooftop dish) and less DC power needed to drive the amplifier.

"The other trend is packaging," says Gilgallon. "The new products will be offered in packaged versions in second-half 2007."

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



# RFMD launches 48V GaN

June's IEEE MTT-S International Microwave Symposium (IMS 2007) in Hawaii saw a plethora of GaN transistor product launches by the main manufacturers as the market develops. As Asif Anwar of Strategy Analytics says, "Gallium nitride transistors and ICs from RFMD and a few other suppliers will capture a significant share of the \$720m+ per year market for power amplifiers for 3G and WiMAX infrastructure, as well as a share in military and defense applications that require semiconductors with high RF output power and high efficiency with high bandwidth."

## RFMD launches family of 48V high-power GaN transistors

RF Micro Devices Inc of Greensboro, NC, USA has launched its RF393X family of five 48V GaN unmatched power transistors, which offer power outputs ranging from 10W to 120W and a wide tunable bandwidth, and which each deliver gain of 14–16dB and a peak drain efficiency of more than 65% at 2.1GHz.

The performance characteristics suit wideband, high-efficiency power amplifier applications, such as broadcast TV, cellular wireless infrastructure, high-power radar, aerospace and avionics.



**RFMD's new RF393X family of 48V GaN unmatched power transistors.**

RFMD reckons that the total addressable market for GaN high-power semiconductors is about \$1bn, of which GaN unmatched power transistors comprise about \$150m. The firm says it is engaged with top-tier customers in multiple markets and expects to start production in second-half 2007.

RFMD aims to leverage its core competences in manufacturing compound semiconductors for cellular power amplifiers as well as its customer relationships in the wireless industry, says president and CEO Bob Bruggeworth, as the firm expands its GaN product portfolio with the aim of opening up new opportunities in multiple high-growth markets.

RFMD is developing three families of high-voltage GaN products:

- GaN unmatched power transistors;
- GaN matched transistors (which include internal matching elements to improve impedance and efficiency, suited to applications like radar and WCDMA and WiMAX infrastructure);
- GaN RFICs (fully matched high-power amplifiers that deliver high efficiency over multiple octaves of bandwidth, suiting applications like military communications, public mobile radio and software-definable radios).

"RFMD is positioned to capture significant market share in the \$1bn high-power semiconductor market," reckons Bruggeworth.

Also at MTT-S, RFMD gave two RF product demonstrations featuring its first-generation GaN high-power transistor technology for commercial and military applications:

- the RF3934 (the 120W product in the RF393X family of 48V GaN unmatched power transistors);
- the RF3825 (a 28V PowerIC delivering 10W power performance from 225MHz to 1800MHz — the widest-bandwidth product in the RF382X family of high-power GaN RFICs (which suits applications such as 3G cellular infrastructure, military communications, software-definable radios and public mobile radio).

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

## Second RF382X GaN PowerIC PA for military supplier

RFMD has started shipping its RF3822 28V GaN 10W PowerIC broadband power amplifier (part of its RF382X product family) to a 'top-tier military supplier' (which, in January, gave RFMD its very first GaN order: for the RF3825 28V GaN 10W PowerIC broadband PA).

The RF3822 is optimized for high efficiency with 16dB gain over a very wide operating bandwidth of 0.1–1GHz in a 50Ω impedance environment, suiting multiple-band and broadband applications such as software-defined radios for military communications. Using advanced heat sink and power dissipation

technologies, the RF3822 has a low-cost, surface-mountable AlN package that is footprint-compatible with standard SOIC-8 packages. The RF382X family's integrated passives offer impedance matching.

These first shipments demonstrate the increasing customer interest in RFMD's GaN technology and associated GaN product portfolio, says Jeff Shealy, VP of the infrastructure product group. "RFMD continues to attract very favorable customer interest from new and existing customers in multiple growth markets, including military communications, wireless infrastructure, public mobile

radio, general purpose amplifiers and high-power radar," he adds.

RFMD's new GaN products are a natural fit with existing multi-market products manufactured using its proprietary GaAs technology, says CEO Bob Bruggeworth.

"RFMD brings tremendous leverage to these markets by utilizing the same manufacturing assets we employ to service the high-volume cellular handset market. RFMD is leveraging our core strengths and leadership position in the cellular market to drive opportunities for revenue and customer diversification in new, high-growth markets."



# Cree samples GaN HEMTs

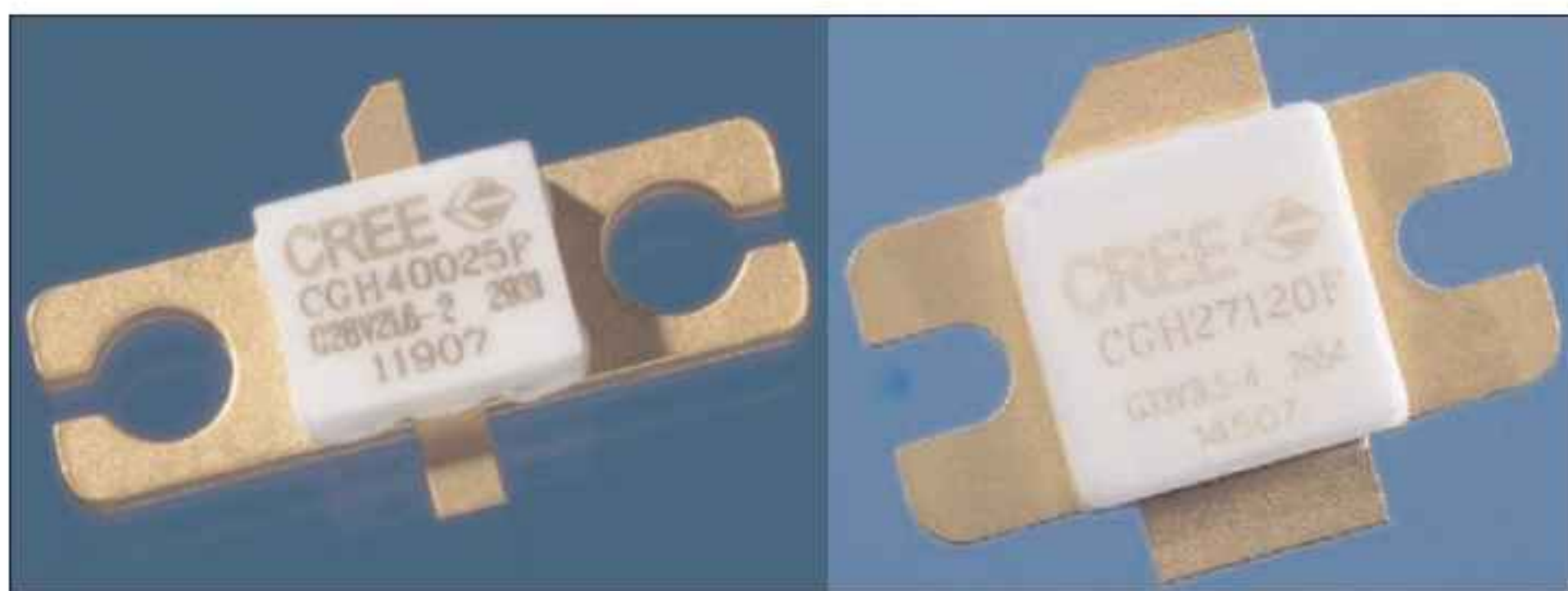
## Cree samples 25W CGH40025 general-purpose GaN HEMT

At the IEEE MTT-S International Microwave Symposium (IMS 2007), Cree Inc of Durham, NC, USA announced sample availability of a new addition to its general-purpose GaN HEMT product line that features the industry's smallest package footprint (0.15" x 0.54" or 0.15" x 0.2") for a 25W transistor, the firm claims.

The CGH40025 covers broadband applications operating at DC to 6GHz frequencies, and typically produces 30W of RF output power at 55% drain efficiency with 14dB of gain when used in a 3.6GHz amplifier.

"The CGH40025F is targeted for numerous applications requiring broad instantaneous bandwidth and high power where amplifier form factor and weight are critical," says Jim Milligan, business area manager for RF products.

Cree also demonstrated a broadband power amplifier based on its CGH40045F 45W RF power GaN HEMT that produces 15dB of gain, 50W of saturated output power and 45% drain efficiency over an instantaneous bandwidth of 500MHz to 2.0GHz, suiting electromagnetic compatibility (EMC) and reconfigurable base-station applications.



Cree's new 25W CGH40025 general-purpose GaN HEMT (left) and the CGH27120 GaN HEMT for WiMAX applications (right) which are both sampling.

## Cree samples new GaN HEMTs for WiMAX applications

Cree has also announced sample availability of three new GaN HEMT devices designed for WiMAX applications.

The CGH27120, CGH27060 and CGH27030 offer linear power output of up to 16W under orthogonal frequency-division multiplexing (OFDM) modulation in small-footprint packages.

"Our GaN HEMT WiMAX devices, used in conjunction with our patented amplifier reference designs, offer a foundation for new levels of system efficiency," claims Milligan. "The combination can enable new system architectures, such as remote radio heads and

distributed base stations, either of which can significantly reduce mobile network capital and operational costs," he adds.

Cree is also demonstrating an amplifier that uses the firm's GaN HEMT transistors to produce more than 30W of average power with greater than 45% drain efficiency at 2.3–2.7GHz.

This represents a 125% increase in efficiency over other commonly available amplifier solutions, the firm claims. Also, the amplifier meets error vector measurement (EVM) and spectral mask requirements for mobile infrastructure requirements, such as WiBro, WiMAX and 3G LTE.

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

## Cree GaN MMIC PDK for Microwave Office design suite

Applied Wave Research Inc (AWR) of El Segundo, CA, USA, which supplies high-frequency electronic design automation (EDA) tools, has launched a process design kit (PDK) that enables monolithic microwave integrated circuit (MMIC) designers to use Cree's high-power GaN MMIC process within its Microwave Office software environment. Designers can now improve productivity by applying AWR's open and integrated design platform to Cree's Wide-Bandgap MMIC foundry services and discrete products, says Cree.

"The release of this kit is an important adjunct to the SiC PDK

[launched at IMS 2006]," says Jim Milligan, business area manager for RF products. "Our customers will now be free to optimally match the unique attributes of both our GaN and SiC foundry processes to their specific application needs," he adds. Wide-bandgap technologies are rapidly being adopted for next-generation commercial and military applications as they enable higher efficiency and greater operating bandwidth than other available device technologies, Cree says.

"The open Microwave Office 2007 design platform integrated with this Cree PDK can be of great ben-

efit to our mutual customers and to the high-frequency design community as a whole," reckons AWR's CEO Dane Collins.

AWR launched the 2007 versions of its Microwave Office design suite and Visual System Simulator (VSS) software the week before IMS 2007, providing new capabilities that help designers deliver next-generation communications products in a shorter design cycle time.

VSS now includes a WiMAX mobile library (compliant with IEEE 802.16e-2005) and a WiMAX fixed library (802.16d-2004).

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

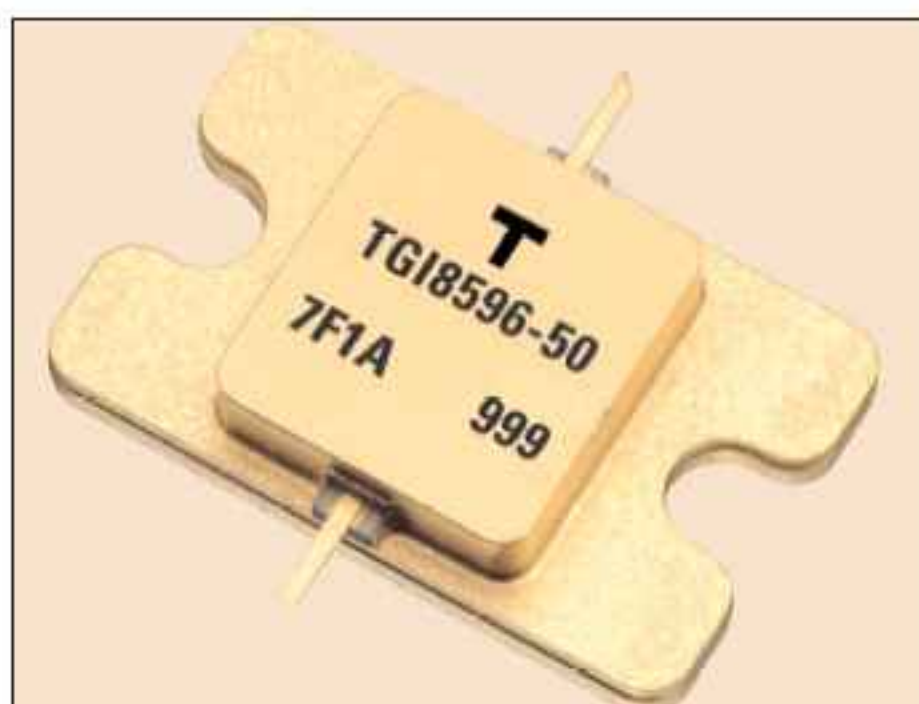


# Toshiba launches its first commercial GaN products

At the IMS 2007 event, Toshiba (Japan's largest semiconductor maker and the world's fourth largest), announced its first commercially available GaN product (with samples available now).

The TGI8596-50 is an internally matched X-band GaN HEMT power amplifier that operates at 8.5–9.6GHz with an output power of 50W. The device features a 3dB compression point of 47.5dBm, linear gain of 9.0dB, and drain current of 4.5A (typical) with a supply voltage of 24V at 25°C. Targeted applications include radar systems and medical applications (such as oncology).

"GaN HEMT amplifiers have the potential to achieve significantly higher gain and output power than



**Toshiba's first GaN product, the TGI8596-50 is an internally matched X-band GaN HEMT power amplifier.**

GaAs FETs at comparable frequency and input power," says Homayoun Ghani, who is business development manager, Microwave, Logic and Small-Signal Devices, in the Discrete

Business Unit of Toshiba America Electronic Components Inc (TAEC). As a follow-on to this initial device, Toshiba is also developing C- and Ku-band GaN HEMTs for satellite communications applications.

Last year, Toshiba announced prototypes of a 6GHz, C-band, GaN power FET with an output power of 174W (at last June's IMS 2006) and a 9.5GHz X-band power FET with an output power of 81.3W (at last November's IEEE Compound Semiconductor IC Symposium 2006). Each device achieved record output power at its respective frequency, showing the potential increase in output that can be achieved with GaN-based devices, says the firm.

[www.toshiba.com/taec](http://www.toshiba.com/taec)

## Nitronex introduces 4W GaN-on-Si pre-driver power transistor for cellular, WiMAX & broadband use

At the IEEE MTT-S International Microwave Symposium (IMS 2007), Nitronex of Durham, NC, USA, a developer and manufacturer of GaN-on-Si RF power transistors for the commercial wireless infrastructure, broadband and military markets, announced that it is sampling the NPTB00004, a high-power (4W) high-efficiency GaN-on-Si pre-driver power transistor that is designed for cellular, WiMAX and broadband applications. Full production qualification is expected in August.

At 900MHz, it has input/output impedances near 50Ω, which reduces the need for external matching circuits. Under WCDMA modulation at 2.1GHz, the power typically delivers 14.5dB of power gain and 25% efficiency at an ACPR of -45dBc, says Nitronex.



**Nitronex's new NPTB00004 4W pre-driver power transistor.**

"The NPTB00004 provides improved power and efficiency for a given linearity compared to existing solutions in the pre-driver market," claims Chris Rauh, VP sales & marketing. Combining Nitronex's SIGANTIC GaN-on-Si process and the qualified low-cost plastic overmold packaging assembly at Amkor Technology Inc, the 1000-piece suggested price is \$9.

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

## First sub-dB, 2W multi-octave MMIC amplifier

At IMS 2007, Kevin Kobayashi, an executive engineering fellow at Sirenza Microdevices of Torrance, CA, USA, presented what is claimed to be the first report of a multi-octave MMIC amplifier with a noise figure (NF) below 1dB and an output power (Pout) above 2W — a 0.2–8GHz high-dynamic-range AlGaIn/GaN-on-SiC HEMT low-noise amplifier/power amplifier (LNA-PA) fabricated by Northrop Grumman Space and Technology.

At a bias of 12V and a current of 200mA, the amplifier achieves an NF of about 0.5dB over a 2–8GHz band. The amplifier also achieves ultra-high linearity with an OIP3 of 43.2–46.5dBm and P1dB of 32.8–33.2dBm (2W) over a 2–6GHz bandwidth. The power-added efficiency at P1dB is 28.6–31%.

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

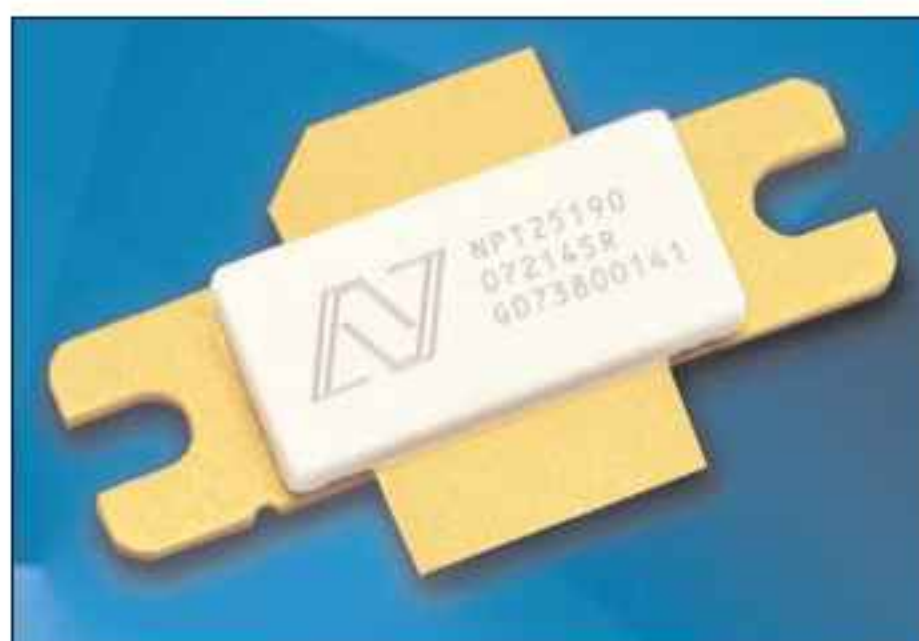


# Nitronex launches its first 48V GaN-on-Si RF power transistors

Nitronex of Durham, NC, USA, which manufactures RF power transistors based on GaN-on-silicon for the commercial wireless infrastructure, broadband and military markets, has launched the first products using its high-voltage 48V GaN-on-Si platform for high-power broadband operation (which was announced in January).

Based on its SIGANTIC process, its NPT25190 and NPT25240 products are designed as high-power output stage devices (190W and 240W, respectively) operating at 2.3–2.7GHz for WiMAX and 3G/3G LTE (long-term evolution) waveforms. Initial samples should be available in Q3/2007 followed by production quantities in Q4/2007.

Nitronex has previously launched 28V GaN-on-Si RF power transistors with output powers of 15W and 100W operating at 2.3–2.7GHz and with



**Nitronex's NPT25190 (190W) 48V RF power transistors for WiMAX and 3G/3G LTE waveforms.**

output powers of 15W and 50W operating at 3.3–3.8GHz.

"We have tried to take into account the requirements being driven by the emerging standards in WiMAX and cellular," said Kevin Linthicum, chief technology officer and VP engineering. "The 802.16e [mobile WiMAX] and LTE systems want to pack more power into ever

smaller footprints while increasing channel bandwidth and peak to average ratio (PAR)," he adds.

Typical performance is rated using a mobile WiMAX waveform defined as a single-carrier orthogonal frequency-division multiplexing (OFDM) signal 64-QAM 3/4, 8-burst, 7MHz channel bandwidth, and 10.3dB PAR @ 0.01% probability on CCDF (complementary cumulative distribution function). Under these test conditions, the NPT25190 delivers 15dB of gain (typical), 22% efficiency, and less than 2.5% error vector magnitude (EVM) — all at a power of >24W at elevated flange temperatures (>95°C), as required by next-generation systems.

Nitronex says that it will also develop devices optimized for 1.8–2.2GHz operation as part of the 48V product line.

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

## Nitronex appoints director of RF product development and supply chain manager to address packaging issues

Nitronex has appointed Doru Roll as director of RF product development.

Prior to Nitronex, Roll led the RF Power Amplifier Development Group at BAE Systems in Wayne, NJ, USA, which develops advanced PAs for military applications. Previously, he managed Agere Systems' Applications Engineering team, supporting its LDMOS RF power device business in Allentown, PA. Roll was also with Ericsson AMT (formerly MPD) in Hauppauge, NY for 10 years, where he developed circuit architectures for enhancing RF PA linearity and efficiency.

"Doru's extensive experience at the device, box and system level greatly enhances our capability to leverage our GaN-on-Si technology platform into products that bring



value to our customers in the WiMAX, broadband and cellular markets," says Chris Rauh, VP of sales and marketing.

Nitronex has also named David M Boulin as its supply chain manager.

Boulin has more than 25 years of industry experience involving high-frequency, high-performance silicon device packaging, fabrication and manufacturing. He joins from Agere Systems, where he was intellectual property licensing



manager then LDMOS Advanced Technology Package project manager. Previously, at Lucent Technologies' Bell Labs in Murray Hill, NJ, he was the SCALPEL advanced lithography International Consortium business manager. As a member of the technical staff at AT&T Bell Labs, Boulin was responsible for developing its 0.25µm technology process.

"Boulin's packaging, project management and international business operations expertise strengthens Nitronex's world-class technology team," says Bruce Cochran, VP of operations. "His contributions will enable us to address key industry packaging issues, such as thermal management and cost reduction while providing unique solutions."



## Samsung joins SiGe's \$20m funding round

SiGe Semiconductor Inc of Ottawa, Canada has raised \$20m in an 'expansion' Series E round of financing. The firm has now raised a total of \$132m in venture capital funding since 1999.

SiGe provides RF front-end solutions including Wi-Fi power amplifiers and front-end modules, GPS receivers and WiMAX transceivers to manufacturers of wireless consumer electronics (e.g. laptop computers, access points, personal navigation devices, personal entertainment devices, and cellular phones). The capital will fund expansion of product lines supporting the Wi-Fi, WiMAX and GPS markets.

Samsung Ventures, the US-based venture capital investment arm of Samsung Venture Investment Corp (SVIC), joins as a strategic investor, together with returning investors 3i Venture Capital, Prism VentureWorks, TD Capital Ventures, VenGrowth Private Equity Partners, RWI Ventures and GrowthWorks.

Also, joining SiGe's board are Samsung Ventures' managing director Bill Byun and 3i Venture Capital partner Jim McLean (replacing previous 3i's representative Sean Brownlee).

"Our objective with this funding is to expand our customer base to drive an increase in our market share across key segments," says president and CEO Sohail Khan. "Expanding our footprint in the market will drive profitable growth and will fuel the development of industry-leading products for emerging wireless applications."

SiGe's sales grew more than 50% in 2006 to \$49.4m (from \$31.8m in 2005). The firm has shipped more than 160m ICs to customers including Arris Interactive, Askey, Broadcom, Centrality, CSR, Gemtek, Mitsumi, Nintendo, Samsung, Tecom, Tyco, and USI.

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

## Axiom appoints APAC sales director and Taiwan distributor

Axiom Microdevices Inc of Irvine, CA, USA, which supplies CMOS silicon power amplifiers for mobile handsets, has appointed Raymond Wang as director of Asia Pacific (APAC) sales, as well as Taiwan-based electronics distributor Watson-Bell Co Ltd.

"The APAC region, especially mainland China, Taiwan, and Korea, is immensely important to the mobile phone industry and requires local sales and design-in support," says CEO Brett Butler. Axiom has had local engineering support covering mainland China and Taiwan, but Wang will increase the momentum behind our growing market footprint in this critical region."

Prior to joining Axiom, Wang was director of China sales for Paradigm

(later sold to REMEC Inc), where he managed sales in excess of \$65m, supporting customers such as Nokia, Huawei, ZTE, Lucent, China Mobile and China Telecom. Wang was also managing director of Great China Paradigm Wireless System Ltd.

Axiom's alignment with Watson-Bell supports its growth plans in the Asia Pacific region by providing an additional sales and technical support channel for its line of CMOS PA products to the Taiwanese cellular handset ODM/OEM community.

Wang, the existing local engineering support and Watson-Bell will augment Axiom's previously announced coverage in Korea, says VP of sales Bill Sweeney.

[www.axiom-micro.com](http://www.axiom-micro.com)

## UQM wins \$750,000 USAF contract to develop SiC electric motor controller

UQM Technologies Inc of Frederick, CO, USA has been awarded a further \$750,000 Phase II Small Business Innovation Research (SBIR) contract (over two years) from the U.S. Air Force to advance the development of a silicon carbide electric motor controller for the USAF Advanced Power Technology Office of the 542<sup>nd</sup> Combat Sustainment Wing at Robins Air Force Base (in cooperation with the U.S. Army National Automotive Center and Mississippi State University). The focus will be to improve the power density and packaging of previous generations of SiC power modules developed in other Air Force programs.

Coincident with the project, UQM will convert a conventional pick-up truck to all-electric operation using a motor controller containing the higher-power SiC modules being developed. The results from this testbed will then be compared to those of other all-electric pick-up truck testbeds operating with earlier generations of the SiC modules.

"This project creates another opportunity to showcase our 160 horsepower propulsion system and advance the commercial prospects of SiC power modules by reducing their size and improving power density," says UQM's director of engineering Jon Lutz. "Improvements in power density and packaging are important attributes in reducing the production cost of the modules and their potential to achieve commercial success," he adds.

As a manufacturer of power-dense, high-efficiency electric motors, generators and controllers for automotive, aerospace, medical, military and industrial markets, UQM focuses on developing products for the alternative energy technologies sector. This includes propulsion systems for electric, hybrid electric, plug-in hybrid electric and fuel cell electric vehicles, under-the-hood power accessories and other vehicle auxiliaries and distributed power generation applications.

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





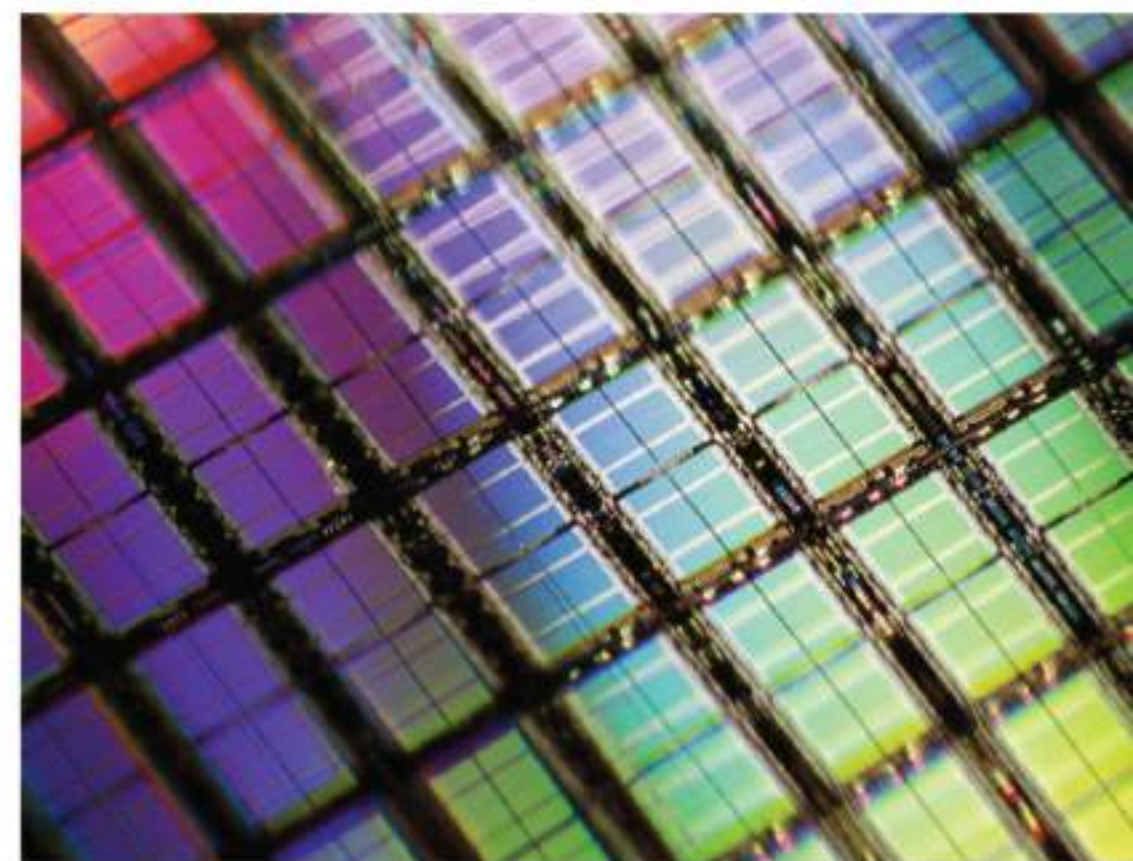
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## IN BRIEF

### EpiLEDs expands for GaN HB-LEDs

In Q1/2007, Taiwanese LED maker EpiLEDs Technologies Inc ordered two Thomas Swan Close Coupled Showerhead (CCS) CRIUS MOCVD reactors (in 30x2" wafer configuration) from Aixtron for installation at its facility in the Tainan Science-Based Industrial Park. They will be used for the volume production of GaN-based high-brightness LED chips, alongside two existing Aixtron AIX 2600G3 HT reactors, which were already operating at full capacity.

"It is our strategic plan to secure a strong share of the solid-state lighting market," said president Steve Ku. "With these new Thomas Swan MOCVD tools we will have the means to achieve this promptly and efficiently."

EpiLEDs was formed in August 2006 as a joint-venture between DRAM silicon chip maker ProMOS Technologies and chip processing equipment maker Hermes-Epitek, both of Taiwan, to make InGaN/GaN-based LEDs on sapphire substrates. EpiLEDs started pilot production in Q1/2007, and has already launched blue and green HB-LED chips and epiwafers.

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

### Tegal ships etch tool to HB-LED maker

Plasma etch and deposition system maker Tegal Corp of San Jose, CA, USA has shipped an additional 901ACS production tool to a 'leading opto/LED manufacturer' (joining the firm's existing installed base of 900 Series etch systems) to support capacity expansion for lighting and optical sensor device production.

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

## BOC Edwards launches six-port Helios for high-hydrogen-flow gas abatement

BOC Edwards has extended its range of Helios exhaust gas abatement systems (used mainly for MOCVD growth of III-V materials) to high-hydrogen-flow processes (such as Si and SiGe epitaxy and LPCVD tungsten as well as compound semiconductor MOCVD).

In addition to an inlet for gas box purges and other ancillary operations, the Helios 6 has six process gas inlets and can reduce hydrogen concentrations below the lower explosive limit (LEL) in flows as high as 200slm, which lowers the overall cost of ownership, says regional business manager Peter Holland. "High fuel efficiency and no requirement for compressed air contribute additional cost savings when compared to alternative technologies, while our unique combustor is designed to reduce the hydrogen content to safe levels even at the highest flow rates," he adds.



The six inlets of BOC Edwards' new Helios 6 gas abatement system.

In the future, the six-inlet head design will also be available on BOC Edwards' family of Atlas gas abatement systems, which was launched in March at SEMICON China 2007

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

## Edwards independent again after nearly 40 years as part of BOC

In early June, New York-based private equity firm CCMP Capital completed its €685m acquisition (announced in March) of vacuum, abatement and chemical management equipment maker BOC Edwards of Crawley, UK from Germany-based The Linde Group (the world's biggest producer of industrial gases, which acquired parent company BOC Group plc last September for €12.4bn).

The acquisition marks Edwards' return to independent status nearly 40 years after being acquired by BOC.

"In the last 40 years our business has grown out of all recognition," says BOC Edwards' chief executive Nigel Hunton. "We feel that our return to independent status, with a strong partner in CCMP, makes us well placed for

success as we transition to our next phase of development"

CCMP Capital Advisors' Stephen Welton said: "As an independent company, BOC Edwards is ideally positioned to drive further growth in core existing markets such as semiconductors, with an exciting range of new products coming through whilst actively developing in new emerging markets such as solar, where we will focus considerable additional resources."

BOC Edwards has over 4000 staff. According to VLSI Research Inc's ranking of the top 10 merchant suppliers of critical subsystems to the semiconductor, flat panel display, and data storage industries in 2006 (released in May), BOC Edwards retained second place, with revenues of \$601m.



# AXT expanding into LEC GaP

Substrate and raw material supplier AXT Inc of Fremont, CA, USA has appointed Chia-Li Wei senior director of technology, responsible for all aspects of technology development. Based at AXT's manufacturing facility in Beijing, China, Wei reports to chief operating officer Minsheng Lin.

With over 30 years experience in compound semiconductor manufacturing, Wei brings expertise in MOCVD epitaxial processing and liquid-encapsulated Czochralski (LEC) growth of gallium phosphide and gallium arsenide.

Wei spent more than 25 years in epitaxial process engineering positions with the Hewlett-Packard Optoelectronics Division (OED), which was acquired by Lumileds and later became Philips Lumileds. Previously, he spent three years in process engineering development in LEC growth of both indium phos-



**Chia-Li Wei, AXT's new senior director of technology.**

phide and low-defect gallium arsenide with the central research lab of Varian Associates.

"Having known him for more than 30 years, I look forward to leveraging his considerable expertise in

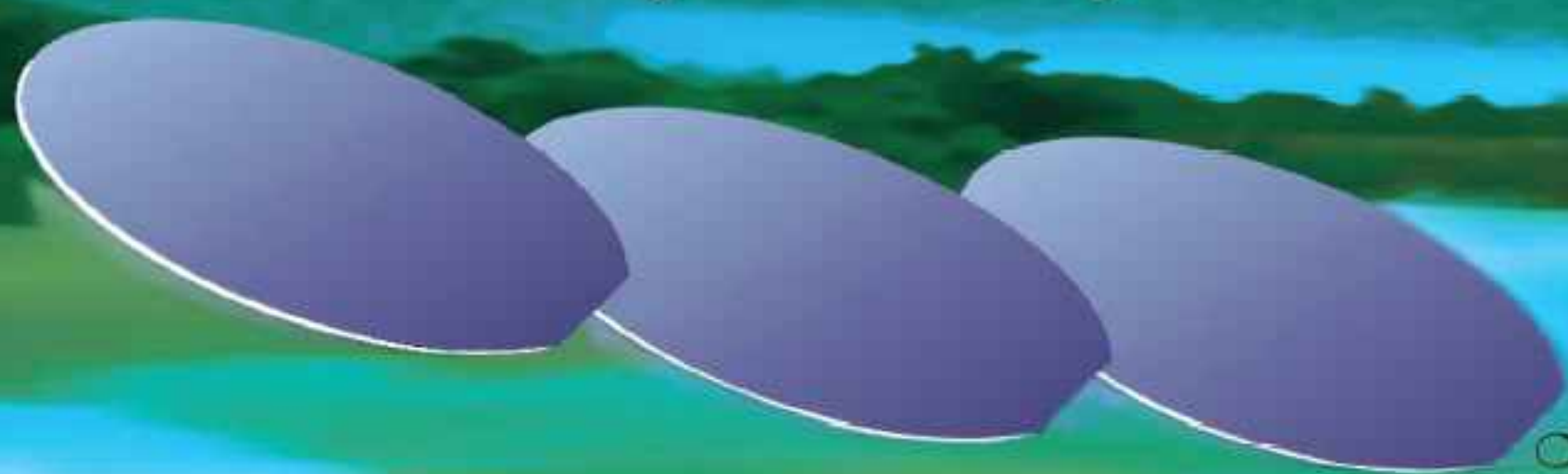
MOCVD epitaxial processing to further strengthen our position in the compound and other specialty semiconductor market," says CEO Phil Yin. "Further, his vast experience in liquid-encapsulated Czochralski (LEC) crystal growth technology will allow us to broaden our product portfolio and increase our total market opportunity by offering an alternative to substrates grown using vertical gradient freeze technology (VGF) for certain applications that are not currently addressed at AXT," he adds. "It will also allow us to explore new compound semiconductor substrate products such as gallium phosphide, which are best produced using LEC technology. I believe that Chia-Li will be a tremendous asset to our team and I look forward to his many contributions in the coming years."

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

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- We buy used wafers and sell recycled wafers



## IN BRIEF

### Riber receives order from European research institute

MBE equipment maker Riber of Bezons, France has received an order for a Siva21 research machine from a new customer, an unnamed institute in Europe.

Including the three orders of research systems received at the start of May, Riber's order backlog is now 10 research machines: two Compact12; five Compact21; one Siva21; and two Epineat.

Developed for research on SiGe, oxides and magnetic compounds, Riber says that the newly introduced Siva21 integrates the best features of its Compact21 MBE research system and its EVA32 system (with which Riber enjoyed success in the 1990s for silicon and metal research).

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

### ClassOne expands

After opening its former 10,000ft<sup>2</sup> facility in April 2005 (which was expected to suffice for five years) ClassOne Equipment Inc has expanded into a new 40,000ft<sup>2</sup> sales, marketing, and technical support facility in Decatur, GA, USA to supply fully reconditioned processing equipment such as mask aligners, etchers, polishers, dicing saws, and microscopes.

The facility has 10,000ft<sup>2</sup> of lab space, for refurbishing, showcasing and demonstrating equipment, and customer preview and test of equipment prior to purchasing.

"This new facility will provide us with the additional capacity we require to support our growing staff, provide us with the ever increasing amount of space we need to showcase and store our burgeoning inventory, and provide us with the additional room we need for upcoming product lines," said president Byron Exarcos.

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

## Nextreme adds high-power packaging expert for business development

Nextreme of Research Triangle Park, NC, USA, which makes thin-film thermoelectric components for thermal management and power generation, has appointed Dr Paul A. Magill as VP of marketing and business development.

Magill has over 20 years of experience in the electronics and optoelectronics industry, with expertise in sensors and laser diode applications as well as electronics and MEMS packaging and manufacturing.

"Magill is an experienced entrepreneur who has a track record in founding and building technology companies," says CEO Jesko von Windheim. "He understands both the technical and business aspects of managing breakthrough technologies... Furthermore, his background in semiconductor packaging, photonics and thermal management are a perfect fit for the company."



Magill was a founder and chief technology officer of Unitive Electronics Inc, a packaging service that he spun out of the Microelectronics

Center of North Carolina (MCNC) and was bought by Amkor in 2004. He also had a major role in starting up Optical Process Automation (acquired by JDSU in 2000). At JDSU, Magill managed groups in advanced packaging, standardization and automation of photonic products. More recently, he co-founded Avo Photonics, an optoelectronic design and contract manufacturing firm in Philadelphia, PA, where he was CTO and VP for business development.

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

## JPSA achieves lift off for LEDs

At July's SEMICON West show in San Francisco, J P Sercel Associates of Manchester, NH, USA is showing its new IX-4000 series UV laser workstation, available in both diode-pumped solid-state (DPSS) laser and excimer laser versions for wafer dicing and/or LED lift-off.

The IX-4000 ChromAblate excimer laser version can micromachine features to 2µm or be configured for large-area exposure of up to 5mm x 5mm for LED lift-off, via drilling, and thin-film patterning. Automation features include dual-cassette loading ports, production-grade load/unload robotics, wafer

pre-aligners and a vision system for unattended production.

The IX-4500 ChromADice DPSS laser version integrates high-speed wafer die singulation with a wafer loading system (dual SMIF or FOUP load ports). Operating costs are less than \$2 per wafer, and process yields are >99% with ultra-narrow kerf widths, JPSA claims. Available with wavelengths of 1064–266nm, the IX-4500 can process a variety of materials, from Si to sapphire. When equipped with the Toxic Wafer Debris nozzle, materials such as GaAs and InP can be handled.

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

## QA manager appointed for ISO qualification

JPSA has appointed Joseph Brun as quality assurance manager. He will focus on bringing the firm into compliance with ISO 9001:2000.

In over 30 years of experience, Brun has held inspection, quality

engineering and management positions with both start-ups and established companies, including, most recently, Dynamics Research Corp and Kokusai Semiconductor Equipment Corp.



## Disco's blade-saw and Synova's water jet-guided laser technologies combine to form hybrid dicing tool

Synova of Lausanne, Switzerland and Disco Hi-Tec Europe GmbH of Munich, Germany (a subsidiary of Japan's Disco Corp) are partnering to develop a hybrid dicing tool that combines Synova's patented Laser MicroJet technology with Disco's latest-generation blade-saw dicing systems.

The introduction of new materials with more complex layers in increasingly feature-dense chips thin enough to fit into ever-smaller packages has made wafers brittle and damage-prone during traditional dicing. The partnership therefore aims to provide a dicing solution for both current and next-generation ICs that cost effectively meets yield and throughput requirements.

Limited to joint-development work with Disco's blade saw, the agreement enables both firms to pursue collaborative R&D efforts to hasten

the integration of Synova's core technology into Disco's systems.

Synova's Laser MicroJet has a water jet that guides the cutting laser beam onto the wafer. The water jet also cools the material surface for optimal protection against thermal damage, as well as providing a protective layer against deposition or contamination, boosting device yields, it is claimed.

The resulting solution will enable chip manufacturers to meet dual need for higher throughput and minimal damage on wafers of any thickness, the firms claim. The first tools are scheduled for introduction in late 2007. Both firms will contribute to manufacturing the hybrid tool, and will share marketing and sales efforts.

"Driven by market demand, we've been afforded the opportunity to partner with the leader in this space

to develop a new breed of dicing systems that incorporate the utmost capabilities of both companies' industry-proven technologies," says Synova's CEO Bernold Richerzhagen. Disco's market expertise and worldwide support and distribution infrastructure complement Synova's laser technologies, processes and applications, he adds.

"Synova's water jet-guided approach offers a number of valuable benefits for a variety of processes," says Disco Hi-Tec Europe's executive VP Karl Heinz Priewasser.

The partnership enables the firms to leverage each other's business and technology strengths, while leaving each to freely continue to market and directly sell its independent dicing systems and pursue individual technology development.

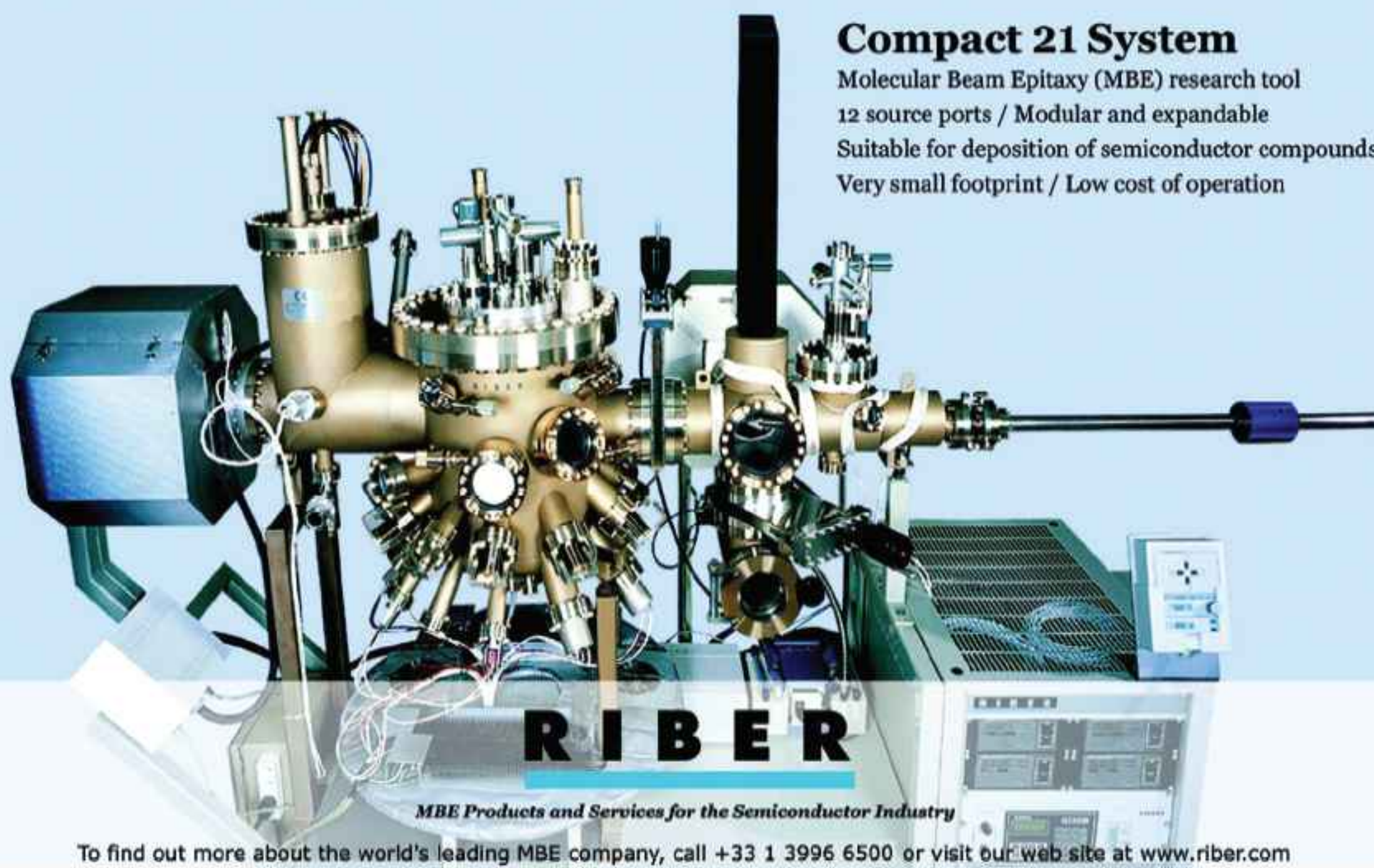
[www.disco.co.jp](http://www.disco.co.jp)

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

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# UK government grants £3m to develop GaN LEDs on 6" silicon for low-cost solid-state lighting

The technology program of the UK government's Department of Trade and Industry (DTI) has awarded a UK-based consortium a three-year contract worth just under £3m (\$5.94m) to demonstrate high-quality GaN-based LEDs on 6" silicon substrates. The ultimate goal of the project is to enable large-scale production of low-cost LED lamps for solid-state white lighting.

Currently, a major barrier to using LEDs is the relatively high cost and low yield. So, the project aims to reduce costs and improve consistency by applying mature large-scale semiconductor processing methods (proven in volume production) to grow GaN-based light-emitting structures on large-diameter silicon substrates.

The project partners therefore combine expertise in commodity

III-V semiconductor manufacturing with capabilities for GaN growth, fundamental science, and expertise in packaging and LED marketing:

- Filtronic, which makes GaAs-based RFICs for the wireless telecoms and defence industries at its 6" fab in Newton Aycliffe, County Durham (formerly a Fujitsu silicon DRAM fab and now the largest compound semiconductor plant in Europe);

- QinetiQ, a defence and security technology company formed in 2001 from the UK government's Defence Evaluation & Research Agency (DERA), and whose Optronics Centre in Malvern, Worcestershire grows GaN-based structures for microwave transmitters;

- MOCVD reactor maker Thomas Swan Scientific Equipment Ltd, based in Cambridge (and a

subsidiary of Aixtron AG of Aachen, Germany);

- Cambridge University, whose professor Colin Humphreys leads a research team there developing GaN-based devices;

- Forge Europa, which designs and develops solid-state LED displays, assemblies and light sources, and is the exclusive UK and Ireland distributor of Cree's XLamp series of power LED devices.

The partners add that the project should provide not only a dramatic step forward on the solid-state lighting roadmap but also a route for the UK to enter what it describes as a major market in future.

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

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

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

[www.msm.cam.ac.uk](http://www.msm.cam.ac.uk)

[www.forge-europa.co.uk](http://www.forge-europa.co.uk)

## BluGlass produces first blue light from GaN on 6" glass

BluGlass Ltd of Sydney, Australia (spun off from Macquarie University, New South Wales in mid-2005) has succeeded in producing what it claims is the world's first blue light emission from the uniform deposition of gallium nitride on a 6"-diameter coated glass wafer.

The emission of continuous blue light (which, after conversion by a phosphor coating, yields white light from high-brightness LEDs for the \$100bn general lighting market) has not previously been achieved from 6" GaN-on-glass. Last November BluGlass demonstrated scale-up of deposition from 2" to 4" diameter, and this March it demonstrated short-lived blue-light emission from a GaN LED structure fabricated on a commercial glass

substrate co-developed with French materials group Saint Gobain (which last October signed an 18 month joint development agreement). Also in March, as well as highly uniform nitride deposition on 4" glass wafers, BluGlass also demonstrated good uniformity over a 6" wafer area. The firm aims to move to 8" and eventually even larger wafers

The latest increase in scale offers the LED market the possibility of additional cost efficiencies, claims CEO David Jordan. Compared to current 2" industry-standard sapphire or silicon carbide substrates for commercial blue LED production, a 6" wafer has nine times the area and can therefore produce nine times the number of LEDs.

In April, BluGlass released an independent study which suggested that using its remote plasma CVD (RPCVD) process for low-temperature deposition of GaN onto 2" glass substrates (rather than conventional MOCVD on sapphire) can cut the cost of manufacturing GaN-based LEDs by 48% at the epiwafer level, which would translate into a 10% cost saving after the LED was manufactured into a simple lighting device. Then, in early May, BluGlass signed its first design and manufacture agreement with Ireland-based EMF Semiconductor Systems Ltd to provide componentry that will form the backbone of its first commercial-scale prototype GaN-based LED manufacturing system.

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



## Fox's LEDs to be distributed by AP in UK and Ireland

AP Technologies Ltd, a distributor of optoelectronic components, sub-systems and supporting electronics of Bath, UK, has been appointed as a distributor in the UK and the Republic of Ireland for all the LED product lines of The Fox Group Inc (grown on 2"-diameter sapphire substrates using Fox's proprietary HVPE hydride vapor phase epitaxy process at its LED manufacturing subsidiary in Montréal, Canada). AP will provide a highly qualified local sales channel providing technical and commercial support, says Fox.

This follows April's appointment of Orsay-based Opton Laser International as the exclusive distributor of Fox's AlGaIn-based UV and blue LEDs in France (see April issue, p25).

Founded in 1999, Fox launched its FoxBlue LEDs (emitting at a wavelength of 460nm) in October 2004 and its FoxUV LEDs emitting at 360–365nm in August 2005 and at 350–355nm in July 2006.



Fox Group's UV LED chip.

"The 350–365nm range is 'the new frontier' for LED technology and The Fox Group is well-placed to stimulate this market with an exciting technology roadmap for wavelength reduction and efficiency improvement," says AP's director Martin Sharratt. "UK and Irish companies have proven to be keen adopters of LED technology and I am confident that this pattern will be repeated in the UV region."

Fox's line of FoxUV LEDs is undergoing continuous improvement, with radiant power output per dollar doubling in the past 12 months and a product development roadmap that is set to be the industry leader at the 350–365nm range, the firm claims. The developments are enabling applications in medical, biophotonics, sterilization, biotech sensor, instrumentation, machine vision, telecoms, industrial curing, fault detection, anti-counterfeiting, forensics, military, and homeland security applications.

"We are confident that AP Technologies will be highly effective in finding and serving the numerous innovative early adopters of UV LEDs in the UK and Ireland, where there exist strong traditions of pioneering in optics and optoelectronics," says Fox Group's president and CEO Barney O'Meara.

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

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

## Production solutions for HB LEDs

Systems and processes with industry-leading batch capability

Oxford Instruments' process tools offer industry-leading production solutions for HB LEDs; high throughput and high yield with excellent in-wafer, wafer-to-wafer and run-to-run uniformity.

### Substrate preparation

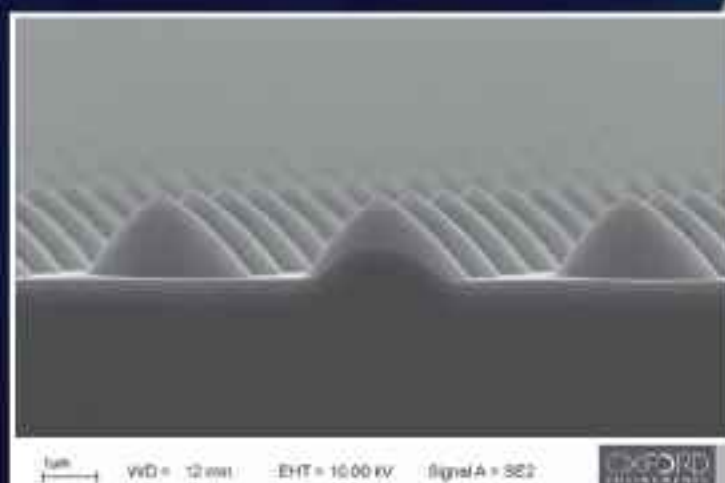
Sapphire, SiC, GaN etching  
20 x 2" up to 4 x 4"

### GaN, AlGaIn, AlGaInP and related materials etching

20 x 2" up to 4 x 4" (GaN, AlGaIn)  
10 x 2" up to 3 X 4" (AlGaInP)

### Hard mask and passivation

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## Anglia distributing Cree & Avago LEDs in UK and Ireland

At early June's EuroLED show in Birmingham, UK, Wisbech-based Anglia announced a distribution agreement to sell and support Cree's XLamp power LEDs in the UK and Ireland.

"We are seeing increasing demand for LED products across all aspects of our business," says Anglia's CEO Steve Rawlins.

"Anglia's strong market presence, outstanding growth in recent years and demonstrated technical ability makes it a solid sales channel for Cree," says Cree's senior VP of sales Bob Pollock.

"Anglia's commitment to delivering LED solutions and to educating the marketplace about the revolution in lighting is exciting."

As well as sharing a booth with Cree, Anglia also shared a booth with Avago Technologies to promote their distributor relationship announced in March for Avago's optoelectronic components in UK and Ireland. Anglia is franchised to distribute the complete product portfolio, but the main emphasis will be on LEDs, especially for the lighting market. This was Avago's first new distributor appointment in the UK for 15 years.

"Anglia's access to a unique customer base perfectly complements our existing network today," said Steffi Kircher, Avago's sales director for distribution in Europe, the Middle East and Africa. "With a strong technical group that is highly focused on demand creation, Anglia will successfully extend Avago's product reach into this region."

Rawlins added: "We've already identified numerous opportunities amongst our customers for their products... Avago has recognized the changing shape of the UK electronics market and the value of working with local distributors."

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

## Cree customer LED Lighting Fixtures receives its first patent

LED Lighting Fixtures Inc (LLF) of Morrisville, NC, USA has been issued with its first patent (US Patent no. 7,213,940 'Lighting Device and Lighting Method'). This covers LLF's core technology for what it claims is a unique approach for creating white light that allows it to use any chip source or package available, says founder, managing director and co-inventor Tony van de Ven.

White light is typically produced from LEDs by either coating true blue LEDs with a YAG phosphor or combining red, green and blue LEDs. LLF's approach delivers high efficacy and excellent color quality, the firm claims.

"LLF's technology will deliver the first high-volume, energy-efficient lighting products to the market and our fixtures should outperform all conventional sources, including

compact fluorescent bulbs," van de Ven claims.

LLF demonstrated its LR6 products and its new LR4 four-inch downlight product at May's 2007 Lightfair International trade show in New York City. LLF is also displaying two new commercial prototype lights: a high-output recessed downlight that delivers over 1500lm; and a recessed 2 foot by 2 foot architectural luminaire that produces over 3500lm. Both designs are targeted to replace existing fluorescent troffer fixtures that serve as a standard for commercial lighting.

LLF currently uses XLamp XRE white LEDs made by Cree Inc of Durham, NC, USA for its products. LLF has over 50 additional patents pending in the USA and subsequent patent filings worldwide.

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

## XLamp used in Beta LED's fixtures

Cree Inc of Durham, NC, USA, says that its XLamp XR-E LEDs provide the light source in a new line of high-performance outdoor lighting fixtures called THE EDGE from the Beta LED division of Beta Lighting of Sturtevant, WI, USA (founded in 1992 as the architectural, rep-marketed division of Ruud Lighting Inc).

Designed for street, parking lot, parking garage, walkway and building-mounted applications and exhibited at Lightfair in May, THE EDGE range includes models for a variety of applications (including an area luminaire, canopy luminaire, parking structure luminaire, bollard and wall pack) and sets new performance standards for outdoor LED lighting fixtures, claims Beta LED's founder and president Al Ruud. "We were looking for high brightness, efficiency, reliability, color stability and high-volume production," he says. "We chose Cree XLamp LEDs for this innovative new



THE EDGE line of LED luminaires.

line because of their commitment to producing the highest-performing LEDs in the industry." XLamp LEDs have a luminous efficacy of 70lm/W and a color temperature of 6500K, making them a viable alternative to high-intensity discharge (HID) sources, says Beta Lighting.

"Robustness and reliability are also important issues for us," Ruud adds. "We have tested THE EDGE fixtures in extremely hot, cold and humid environments with zero failures."

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

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



# OptoGaN raises €5m for GaN-based LED technology

At the end of May, OptoGaN Oy of Helsinki, Finland raised €5m (\$6.7m) in its latest round of funding led by Denmark-based Via Venture Partners (founded in early 2006), joined by existing investors VNT Management Oy (via its Power Fund I) and government-owned Finnish Industry Investment Ltd. Via Venture Partners' principal Peter Thorlund Haahr joins OptoGaN's board.

OptoGaN says the funding will be used mainly to develop its GaN-based LED chips for low-cost general lighting and to introduce them to the market.

OptoGaN was founded in Helsinki in late 2004 by Russian physicists Dr Maxim Odnoblyudov and Vladislav Bougrov from Ioffe Institute in St Petersburg. The firm uses

the R&D laboratory of Micronova's Centre for Micro and Nanotechnology on the Otaniemi Technology Campus in Espoo — run jointly by the VTT Technical Research Centre of Finland and Helsinki University of Technology (TKK) — and cooperates with the latter's Laboratory of Micro and Nanosciences, whose professor Harri Lipsanen has developed a multi-step growth technique that can reduce the amount of crystal defects that suppress brightness in GaN-based LEDs and lasers.

OptoGaN subsequently developed its high-brightness LED wafers, chips and manufacturing process using Micronova's facilities.

OptoGaN also has a pilot line and production facilities in Dortmund, Germany. "The semiconductor

production expertise originates from Germany," says Antti Kumm, investment director at Finnish Industry Investment Ltd.

"With a strong financial partner like VIA and the expertise it provides, we are convinced that we will meet our aggressive targets over the coming years and become the leading independent LED chip manufacturer," says CEO Bernd Meyer.

● When University of California Santa Barbara's professor Shuji Nakamura received his Millennium Technology Prize at Micronova last September, a collaboration was agreed between the UCSB and TKK's GaN researchers, led by Lipsanen (involving OptoGaN).

[www.micronova.fi](http://www.micronova.fi)

## Lumination launches violet-chip-based warm-white LED

GE Consumer & Industrial's LED business Lumination LLC (formerly Gelcore) has launched the Vio high-power white LED, which combines a 405nm violet-emitting chip (which operates at a higher-efficiency wavelength than blue LEDs, it is claimed) with a proprietary blend of phosphors on its hemispherical lens (for converting the violet light to white light). Luminous efficiency is up to 45lm/W in warm white colors.

The Vio LED is offered in options of 1W or 4W power output (with typical flux of up to 162lm), and in color temperatures of 3500K and 4100K (with 3000K to be available in late 2007/early 2008). The simplified, tight, application-driven color bin limits (with part-to-part color variation of just  $\pm 200\text{K}$  for full distribution and  $\pm 100\text{K}$  for sub-bins) are centered on general illumination ANSI color points. Furthermore, over a 50,000 hour rated life (operating at 500mA and at a max-



**Lumination's new Vio white LED.**

imum operating board temperature of 85°C), in addition to 70% lumen maintenance, Lumination reckons that the VIO's violet-emitting chip technology produces a color shift of less than 100K. "Our violet-chip technology offers the best available control of color shift in white LEDs," claims VP of marketing Kraig Kasler.

The minimal color shift overcomes many inherent color-control issues of standard blue or red-green-blue

LED devices, the firm claims. As well as flexible options for color temperature and color rendering index (CRI = 70 at 45lm/W or 85 at 38lm/W), the Vio also provides high efficiency at warmer color temperatures.

Therefore, as well as area, display, accent, landscape and architectural lighting, applications include standard fixtures for general illumination.

"Often, LEDs used in fixtures produce glare or bright spots. The use of multiple point sources in fixtures (e.g. several LEDs grouped together) has the potential to produce multiple shadows," continues Kasler. "Vio LEDs eliminate such distractions. High-power, 4W Vio LEDs distribute diffused light more evenly over a 180 degree beam angle," he adds. "Based on its performance, our Vio LED is a real alternative light source that will maintain a consistent appearance over a period of years," he claims.

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



# Taiwan forms LED alliance for standards and quality

Taiwan's Ministry of Economic Affairs (MOEA) and the Department of Industrial Technology have set up an alliance for R&D on LED lighting standards and quality, involving seven Taiwanese LED lighting-related member companies — Alliance Optotek, China Electric Manufacturing, Epistar, I-Chiun Precision Industry, Lite-On Technology, Lustrous Technology and Wei Min Industrial — reports the Digitimes web-site.

In order to improve the competitiveness of Taiwan's LED lighting industry, the alliance's aim is to integrate technologies within the LED and lighting industries and develop the first complete LED lighting measurement standard in Taiwan.

The alliance plans to develop LED T-bar indoor lamps with 100lm/W light efficiency and 20,000-hour expected lifetime, LED headlights, and LED street lamps, along with quality verification technologies, the MOEA adds.

Previously, in late April (according to the Taiwan Economic News), at a conference of domestic industrial leaders and experts called to discuss development strategies for the domestic LED lighting industry, participants had urged the MOEA to see that national standards for LED lamps were established "as soon as possible", so that local manufacturers could make the patent arrangements

that they need to challenge for leadership in the international market.

At the conference, economics minister Steve R.L. Chen affirmed the government's confidence in the development of the LED industry as Taiwan's third 'trillion NT dollar industry' (after semiconductors and TFT-LCD thin-film-transistor liquid crystal displays).

He also announced that the MOEA is spending NT\$2bn (US\$60.6m) for R&D over the next four years to help develop Taiwan's LED industry, aiming to boost its production value to NT\$540bn (US\$16.36bn) in 2016.

In particular, the MOEA's Bureau of Energy is providing: NT\$1.05bn (US\$31.81m) to help manufacturers develop high-efficiency, high-end LED lighting sources; NT\$45m (US\$1.36m) to develop quality-control and inspection equipment and devices; NT\$210m (US\$6.36m) to develop standard modules for general illumination; NT\$60m (US\$1.81m) to establish indigenous LED standards and inspection platforms; and NT\$80m (US\$2.42m) to promote up-, mid-, and downstream integration in the industry.

**The Bureau of Energy is replacing all of Taiwan's conventional traffic lights with LEDs within the next three years**

Also, the Bureau of Energy (which has pinpointed LEDs as a critical industry for environmental protection and energy conservation) is replacing all of Taiwan's conventional traffic lights with LEDs within the next three years (with about 430,000 yet to be replaced). It is also encouraging the replacement of conventional emergency-exit lights with LEDs, and choosing representative buildings for the installation of LED lighting. The bureau also aims to install LEDs in all of Taiwan's 1.35 million street lamps. Demonstration LED street lamps are due to be ready for use in 2008.

The Bureau of Standards, Metrology and Inspection recently completed the formulation of national standards for LED traffic signs, and has added national standards for LED lighting sources in emergency lights, according to the bureau's director general, C.S. Chen. The completion of revised regulations for the use of LEDs in street lamps is expected to be announced by the end of 2007.

Both the Bureau of Energy and the Department of Industrial Technology have promised support for domestic manufacturers developing LED lighting via special development projects, for which the usual ceiling of NT\$30m (US\$0.91m) on subsidies per R&D project does not apply.

[www.digitimes.com/displays/a20070611VL202.html](http://www.digitimes.com/displays/a20070611VL202.html)

## Existing Taiwanese LED-focused alliances

In March, to strengthen Taiwan's LED industry, the government-sponsored Industrial Technology Research Institute (ITRI) formed the Taiwan Optoelectronic Semiconductor Industry Association (TOSIA) along with 14 Taiwan LED chip makers and packagers, including Arima Optoelectronics, Bright

LED Electronics, Epistar, Everlight Electronics, Formosa Epitaxy, Kingbright, Ledtech Electronics, Ligitek Electronics, Lingsen Precision Industries, Lite-On Technology, Opto Tech, Para Light Electronics, Tyntek and Unity Opto Technology.

Also, in February, an alliance to develop products for the LED auto-

motive lamp after-market (AM) was formed, led by Taiwan's Automotive Research & Testing Center (ARTC) and including the firms AMA Precision, Depo, Epistar and Everlight. ARTC says that the aim is to develop three new LED-based headlights for the automotive market over the next 18 months.

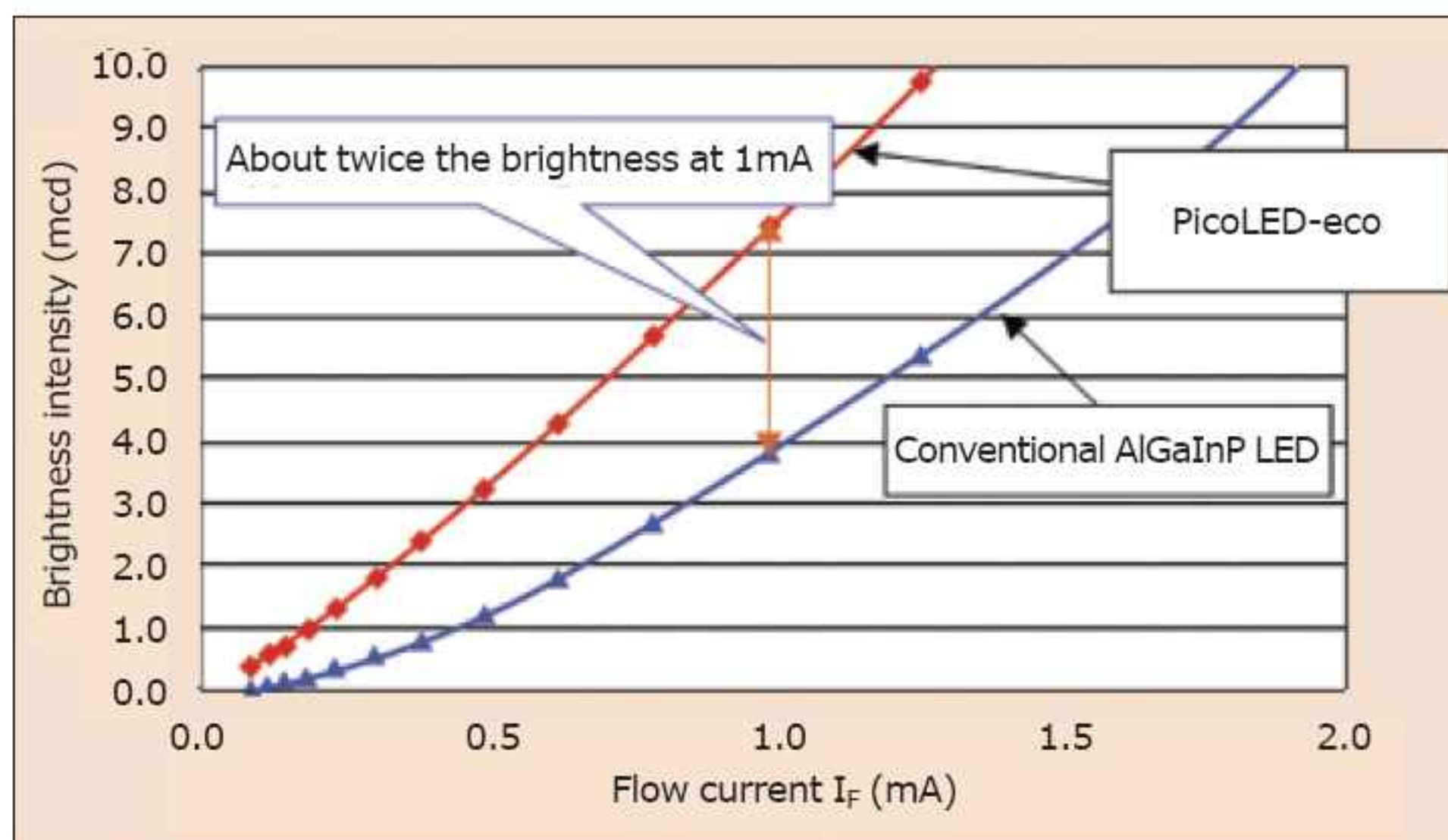


# Rohm's PicoLED-eco halves energy consumption

Rohm Co Ltd of Kyoto, Japan has launched the PicoLED-eco (SML-P11 series) AlGaInP-based red, orange, yellow and green LEDs.

The new series supplements the SML-P12 ultra-compact PicoLED range (sampled in January — see February issue, page 20 — and in mass production since April), which Rohm claims has the smallest, thinnest LED package in the industry: 1.0mm by 0.6mm (1006 size) by just 0.2mm high — 53% and 74% smaller in area and volume, respectively, than the current standard product's 1.6mm x 0.8mm (1608 size).

Rohm claims that, in the low-current regime of 1mA, the PicoLED-eco yields about twice the brightness compared to conventional products. Conversely, at the same brightness, the energy consumption is roughly halved. Also, the high-reliability AlGaInP



Intensity versus current for Rohm's SML-P11 series PicoLED-eco LED.

structure prevents brightness degradation, even after long-term continuous use.

This suits use in compact portable devices such as thinner mobile phone keypads as well as small, thin, low-energy products such as

high-density 1.5mm-pitch full-color dot-matrix units and compact, seven-segment displays with 0.5mm high characters (an industry first, broadening the possible applications of numerical displays).

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

## Avago launches 0.5W HB-LED in PLCC-4 SMT package, targeting interior/exterior lighting and backlighting

Avago Technologies of San Jose, CA, USA has launched what it claims is the industry's first 0.5W high-brightness LED in a compact, industry-standard PLCC-4 surface-mount (SMT) package.

The 0.5W power LEDs feature what is claimed to be the industry's smallest package size (3.2mm by 2.8mm by 1.9mm), have a wide 120° viewing angle, and are optimized for long operating life under severe environmental conditions. Also, the LEDs were designed to dissipate heat more efficiently to provide better thermal management and consistent light output. Moreover, the high-brightness output per LED and small package footprint provide greater



Avago's 0.5W high-brightness-LEDs in PLCC-4 SMT packages.

flexibility in the size, shape and appearance of lighting assemblies.

The white (ASMT-QWB2), amber (ASMT-QAB2), red-orange (ASMT-

QHB2), and red (ASMT-QRB2) LEDs can be used in automotive interior and exterior applications for backlighting dashboards, dome and map lighting, puddle lamps, rear reverse lamp indicator lighting and license plate illumination. They can also be used for decorative lighting in general lighting applications, channel lettering in electronic sign and signals (ESS) applications, and backlighting instrument panels and displays in industrial equipment, office automation and home appliance applications.

Typical luminous flux is 9.8–17lm at 150mA drive currents. Optical efficiency is 30lm/W.

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



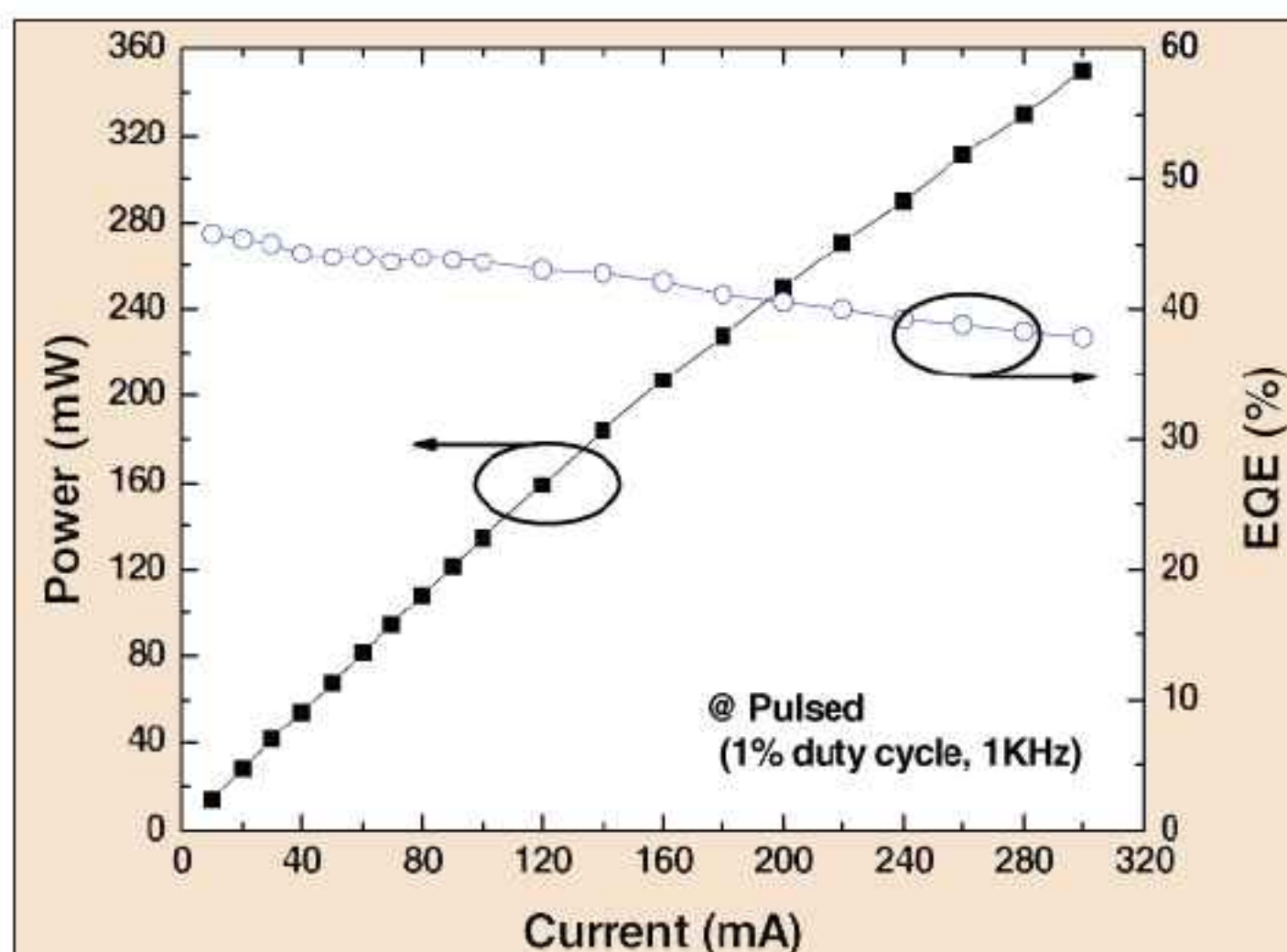
# UCSB boosts output for high-efficiency non-polar GaN LEDs

The research group at the University of California, Santa Barbara (UCSB) led by Shuji Nakamura and Steve DenBaars has fabricated improved MOCVD-grown non-polar m-plane GaN LEDs with a thick, six-period InGaN multi-quantum-well (MQW) active region that have record output power and external quantum efficiency at the peak blue-violet emission wavelength of 402nm (Kwang-Choong Kim et al, *physica status solidi - Rapid Research Letters*, Vol 1, issue 3 (May), p125).

Non-polar GaN should yield higher-efficiency LEDs than conventional polar c-plane GaN material. But previously the conversion efficiency and output power of non-polar GaN LEDs have been lower due to the high density of extended defects (e.g. threading dislocations and basal stacking faults) in non-polar GaN grown heteroepitaxially on foreign substrates such as r-plane sapphire or m-plane SiC.

However, in mid-December, the group reported record external quantum efficiency (EQE) of 41% and output power of 25mW for a non-polar GaN LED with a standard chip size (300µm x 300µm) and pulsed operating current (20mA). The latest figures are 28mW and 45.4%. But more significantly, with increasing drive current the output power increases almost linearly up to 210mW at 160mA and, at a drive current of 200mA, is as much as 250mW (showing hardly any signs of saturation, in contrast to conventional polar c-plane GaN LEDs). EQE is still a high 41% at 200mA.

The latest improvements are due partly to using low-extended-defect free-standing m-plane GaN substrates sliced from c-plane bulk GaN crystals, which are now commercially available, made by the Optoelectronics Laboratory of Japan's Mitsubishi Chemical Corp using HVPE.



Output power and external quantum efficiency vs current.

As well as using a conventional 300µm x 300µm chip design with an unoptimized ITO p-type contact, a U-shaped Ti/Al/Au n-type contact and standard processing techniques, the chips were diced and packaged using standard die and wire bonding and then molded with epoxy. So EQE at high power could be boosted by using optimized ITO p-contacts and more advanced fabrication.

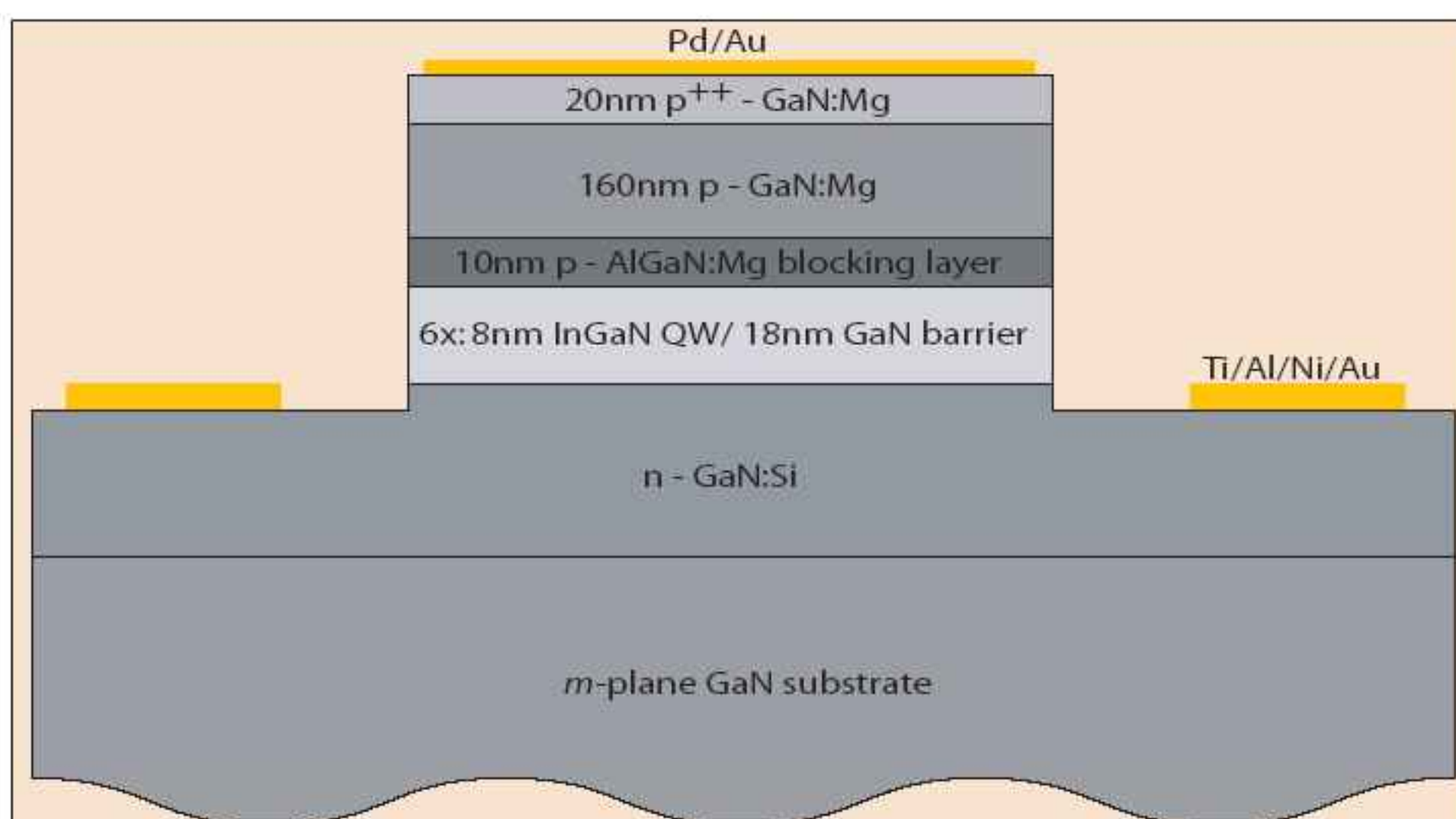
However, in a commentary article in the same issue, Ulrich Schwarz of Universität Regensburg and Michael Kneissl of TU Berlin in

Germany say that a major challenge is the development of large-area substrates and inexpensive non-polar GaN structures. Also, an extension of the 402nm emission wavelength to the blue and green spectral region needs to be considered. In addition, the lifetime of the LEDs must be established.

Due to the high cost of non-polar GaN substrates, Schwarz and Kneissl expect initial applications of non-polar GaN to be not blue and white LEDs but laser diodes (e.g. for micro-projector displays in mobile phones or high-resolution home theatre projectors.)

● The research is funded by UCSB's Solid State Lighting and Display Center (SSLDC) and the program Exploratory Research for Advanced Technology (ERATO) of the Japan Science & Technology Agency.

[www.engineering.ucsb.edu](http://www.engineering.ucsb.edu)



Schematic cross section of non-polar m-plane GaN LED device structure.



# First short-cavity cw GaN blue laser using etched facets

BinOptics Corp of Ithaca, NY, USA claims to be the first manufacturer to produce a short-cavity, GaN-based, continuous-wave blue laser using etched-facet technology instead of the mechanical cleaving method currently used by the industry.

"Our etched-facet technology allows us to manufacture devices with much shorter cavities than possible with cleaved facets," says CEO Alex Behfar. "We are able to obtain at least three times as many blue lasers from a wafer than can be produced using the conventional cleaved-facet method." Demand for competitively priced blue lasers is growing rapidly, and the firm claims its technology could enable the market for HD-DVDs, game consoles, and optical storage devices using blue lasers to grow with rising consumer demand.

"Although etched-facet technology has clearly demonstrated its value for InP-based communications in meeting the challenging performance and cost targets of telecom and datacom up to 10Gb/s, these

same benefits are only now being realized by BinOptics for GaN-based blue lasers," says Al Schremer, director of GaN R&D. "We have made continuous-wave blue lasers with cavity lengths as short as 100µm and a threshold current as low as 10mA," he adds. "Current cleaved-facet laser cavity lengths are on the order of 500 to 600µm."

Founded in November 2000 and based in the Cornell Business & Technology Park, BinOptics uses lithography and chemically assisted ion-beam etching (CAIBE) in its 10,000ft<sup>2</sup> fab to manufacture monolithically integrated laser chips based on its proprietary etched-facet technology, which significantly reduces the cost of production, testing, and handling compared to conventional laser processing, the firm claims. In addition, because of the technology's flexibility and high yield, it also enables monolithic integration of multiple functions on a single chip. Products include edge-emitting lasers with optional

integrated monitoring detectors as well as the industry's first horizontal-cavity surface-emitting laser (HCSEL). The firm currently manufactures high-reliability InP-based lasers operating at wavelengths of 1310nm, 1490nm and 1550nm and data rates of up to 10Gb/s for datacom and telecom applications such as 10 Gigabit Ethernet, as well as non-telecom applications.

The latest development follows BinOptics last November increasing its funding to \$24.1m through a \$6m series C round, led by new investor STIC International, the Palo Alto, USA-based arm of South Korea's STIC Investments. The firm said at that time that the new funding would support the scale-up of production of its line of InP-based lasers and accelerate product development of etched-facet blue lasers, aiming for roll out in 2007. BinOptics said it was also developing blue lasers for other applications, including displays.

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

## Osram adds white LED to Golden Dragon ARGUS range

At the SID 2007 event in Long Beach, CA, USA in late May, Osram Opto Semiconductors of Regensburg, Germany said that it has added a high-brightness white LED to its Golden Dragon ARGUS family of products, which combines the brightness and uniformity of its proprietary ThinGaN (InGaN) technology with its patented ARGUS lens (designed for high-efficiency backlighting and illumination) and its chip-level conversion (CLC) technology.

Designed as a compact, cost-effective, high-brightness general-purpose LED, each Golden Dragon ARGUS white package contains one HB-LED with a thin phosphor coating over the emission area, applied



**White Golden Dragon ARGUS LED.**

at the wafer level. For applications such as backlighting and specialty illumination, the new LED delivers more usable light with higher brightness and better uniformity (greater than 85% over the entire surface of the backlight) from a

lower profile (<40mm) package, enabling the use of fewer LEDs for reduced part count and cost.

Also, with over 90% of the light available within a 160° cone, the LED is optimized for display and sign backlighting, and its versatility suits general lighting applications, indoor and outdoor architectural lighting, and decorative and entertainment lighting.

The Golden Dragon ARGUS white meets 70% of the NTSC requirements for LCD backlighting applications, and has an operating temperature range of -40°C to +85°C and a lifetime of >50,000 hours depending on conditions.

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



## UK's DTI funds Swansea for laser projection displays

Swansea University in Wales, UK is receiving £322,000 as part of the two-year £1.9m (\$3.7m) 'HELPS' project, funded by the UK government's Department for Trade and Industry (DTI) Technology Program, to develop lasers as replacement light sources in projection display systems.

The project is led by laser manufacturer Bookham Technology, and partners include the Institute of Advanced Telecommunications (IAT) at Swansea University, Manchester-based Digital Projection Ltd, and Southampton's Stratophase Ltd.

"IAT's work focuses on telecommunications, but we are able to leverage our knowledge of optical technologies to provide disruptive laser sources with exceptional projection brightness, efficiency, color gamut and reliability," says professor Nick Doran, IAT's acting head.

The market for high-brightness light sources for the lighting and dis-

play sectors is dominated by inefficient and short-lived xenon or mercury ultrahigh-pressure bulbs, which have a limited lifespan. The brightness of images produced by xenon-based sources degrades significantly after around 1000 hours of use, so the sources need replacing about every six months. Disposal of the light sources on such a regular basis also presents environmental issues.

"Only around 5% of the light produced by xenon sources reaches the screen because it is hard to control the emitted light," says IAT's Dr Nigel Copner, the senior research fellow on the project. "The laser technology we are developing is over 10 times as efficient and provides exceptionally high-quality images, with a much wider range of colors," he claims. "The lasers will last for at least 10,000 hours and possibly for up to 20,000 hours. That's potentially 10 years' usage and, when coupled with the exceptional effi-

ciency, reduces the cost of ownership significantly alongside a greatly reduced environmental impact."

"Ultimately, we aim to produce solutions that will undoubtedly impact on a wide range of display market sectors," says Doran. "If we get this right, we could be looking at a market worth in excess of £1bn (\$2bn) a year just from the cinema projection market. There are very few optical products that can access a market of this scale," Doran adds. "The next few years will see the cinema industry moving away from celluloid to digital projection, with the Hollywood standard being D-Cinema. In doing so, cinemas will also upgrade their projectors, allowing this new technology to be easily adopted."

The technology is expected to also have application in other sectors, such as rear view projection televisions (RPTVs) and office projectors.

[www.swansea.ac.uk/iat](http://www.swansea.ac.uk/iat)

## LBO and Thales developing holographic laser projection

In a collaboration to produce displays for cockpit applications, Light Blue Optics of Cambridge, UK has a joint development agreement to supply French defence firm Thales with engineering samples of its miniature holographic laser projection system.

Founded in 2004, LBO uses laser light sources and holographic techniques to deliver large, full-color, high-quality video images.

A diffraction pattern of the desired two-dimensional image, calculated using LBO's holographic algorithms, is displayed on a phase-modulating liquid crystal on silicon (LCOS) microdisplay. When illuminated by coherent laser light, the display steers the light to where it is needed, making the system highly efficient. No projection lens is needed. Instead, a demagnification lens pair expands the diffracted image from the microdisplay, producing an ultra-wide throw angle greater than 90°. The images are

in focus at all distances from the projector (even on curved or angled surfaces without distortion) eliminating the need for a focus control.

Benefits also include "exceptional levels of brightness and a robust, lightweight optical architecture [without moving parts] that is highly tolerant to a range of microdisplay defects [such as pixel failure]," says LBO's co-founder and director of business development Dr Edward Buckley. As well as low-cost devices for handheld mobile applications, the technology also suits safety critical markets such as automotive, aerospace & defence, Buckley adds.

"This development is a strategic collaboration that will bring LBO's unique command of holographic laser projection together with Thales' unrivalled understanding of human interaction with information display systems," adds CEO Chris Harris. "Coupling our flexibility with Thales' tremendous engineering capacity

opens up a range of near-term opportunities in aerospace & defence."

Thales' VP general manager of Cockpit Interactive Solutions, Bruno Vazzoler, adds, "We have identified a range of early revenue opportunities for LBO's technology."

In late April, LBO also announced a development partnership with Displaytech Inc, which will leverage its experience with fast-switching ferroelectric liquid crystal on silicon (FLCOS) technology to manufacture microdisplays exclusively for LBO.

Founded in 1985, Displaytech has shipped over 16 million devices to consumer electronics companies.

"Our partnership with Displaytech builds on both companies' core competencies — LBO's command of holographic laser projection technology and Displaytech's proven track record of bringing quality, low-cost microdisplays to high volume markets," adds Harris.

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



## Mitsubishi launches record-power 150mW 640nm laser for displays

By optimizing the structure and manufacturing process based on its high-power red 660nm laser diode technology for recordable DVD, Tokyo-based Mitsubishi Electric Corp is sampling the ML520G51, a high-power 640nm (deep-red) broad-area laser diode with record wall-plug efficiency of 23% (up 15% on previous 640nm band laser diodes) as well as low thermal output power.

This enables incorporation into a small hermetically sealed, standard 5.6mm-diameter TO-CAN package, reducing the size of mobile devices.

This allows record optical power output of 150mW cw (between -5°C and +45°C), reducing device

power consumption and lengthening battery lifetime in mobile devices.

As well as applications in the industrial and medical fields, the deep red color at 640nm can express the subtleties of the red spectrum and is suitable for display applications including mobile projectors and laser show devices. In contrast, says Mitsubishi, 620nm light, for example, is not a true red but reddish orange, and the human eye is very sensitive to differences in red light.

The sample price is \$250. Production volume from December will be 10,000 units per month. <http://global.mitsubishielectric.com>

### IN BRIEF

#### Osram signs NA laser distributor

Osram Opto Semiconductors Inc of Santa Clara, CA, USA has established a franchise agreement for Laser Components IG Inc of Hudson, NH, USA (the North American branch of Laser Components) to distribute all of its high-power laser diode products throughout the USA, Canada and Mexico.

Osram aims to broaden the reach of its laser products and allow greater penetration into key target markets, said Osram Opto Semiconductors Inc's president and CEO Tom Shottes.

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

## QPC wins contract and raises an extra \$9.5m in financing

QPC Lasers Inc of Sylmar, CA, USA, which develops and commercializes high-power lasers for the defense, homeland security, industrial, and medical markets, has closed a further round of private financing through the sale of \$10.6m in principal amount of convertible debentures and warrants (the second of two rounds this quarter). Proceeds of \$9.5m will be used for expanded marketing, operations, and general corporate purposes.

"As we continue to execute our growth plan, we believe this financing will provide sufficient cash to support the increased manufacturing and inventory needs that coincide with the ramp in sales orders we have experienced, as well as support the launch of our generation-three lasers due out later this year," says George Lintz, chief financial officer.

"Inclusive of the financing we completed in April, we have raised a total of \$16.9m in the second quarter, and are confident the company now has adequate cash to support our growth and operations for at least the next 12 months," he adds.

● QPC has won a follow-on contract to deliver production prototype lasers to a European customer for high-precision industrial measurement applications. The contract brings the customer's total orders for the product to over \$500,000 in the past 12 months and signals the transition from the development phase to early-stage production.

QPC says that high-precision measurement, motion control, and positioning with lasers are critical to

the defense, homeland security, and industrial markets, where measurement of distance, temperature and pressure is required.

"QPC's proprietary Internal Grating technology offers state-of-the-art performance from a substantially more lightweight, compact and cost-effective laser solution compared with traditional multi-stage gas, solid-state, or fiber lasers," claims Paul Rudy, VP of marketing & sales.

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

### QPC hires VP of manufacturing

QPC has named Ronald Moeller as VP of manufacturing to drive expansion for its new generation of high-brightness laser products.

Moeller brings 20 years of experience in manufacturing, engineering and operations management at venture-stage and emerging semiconductor, laser and photonics firms. He joins from Kotura Inc, a manufacturer of silicon photonics, where he was VP of operations and manufacturing from 2004. Experience includes roles with Ortel (acquired by Lucent/Agere,



then Emcore), Multilink Technology (acquired by Vitesse) and Phasebridge (acquired by Emcore).

"As we accelerate the transition of our technology into commercial production, Ron will be instrumental in leading a scalable ramp up of our manufacturing operations across medical, industrial and defense product lines," says



# Emcore begins to ship products from low-cost China plant

Emcore Corp of Albuquerque, NM, USA, which makes components and subsystems for the broadband, fiber-optic, and solar power markets, has started shipping products from its recently opened low-cost manufacturing facility in the export-processing zone in Langfang City (about 20 miles southeast of Beijing, China).

Emcore China occupies 22,000ft<sup>2</sup>, with a Class-10,000 cleanroom for optoelectronic device packaging. Another 60,000ft<sup>2</sup> is available for future expansion. The firm says it will consolidate and move manufacturing of certain cost-sensitive optoelectronic device products to the plant.

"We will be packaging optical sub-assemblies for broader applications of storage-area and local-area networks, cable TV, and telecom markets," says Dr Charlie Wang (former director of engineering of Emcore Fiber Optics), who has been appointed general manager. "We have already transferred and started the qualification processes for certain products."

"We chose this location because of its convenient access to infrastructures and talent pools of nearby Beijing and Tianjin metro areas," Wang adds. "This facility will experience a very low operating cost in addition to tax and import/export benefits for being located in an export-processing zone."

"The establishment of Emcore China is an important accomplishment as we focus on achieving our goal of profitability," says Emcore's CEO Reuben F. Richards Jr.

"Through our China operations, we will be able to tap into a vast talent pool of low-cost skilled labor and engineering resources. This facility, along with a strategic alignment with our existing contract-manufacturing partners, should enable us to improve our cost structure and gross margins across product lines," he adds. "We expect to develop and provide improved service to our global customers using a local presence in Asia."

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

## JDSU completes Picolight acquisition for pluggable optics

JDSU of Milpitas, CA, USA, which makes components for broadband and optical communications, has completed its acquisition of Picolight Inc of Louisville, CO, USA, a designer and manufacturer of pluggable optical transceivers (announced at the end of February), for about \$115m in stock plus up to an additional \$10m in cash subject to the achievement of certain revenue targets during 2007.

JDSU says that the acquisition strengthens JDSU's position in high-growth pluggable optics for

the enterprise market and adds an established, vertically integrated manufacturing model.

With over 1 million small form-factor pluggable products shipped, Picolight has been a pioneer in developing vertical cavity surface-emitting lasers (VCSELs), used in high-speed and short-to-medium distance optical interconnects. Picolight's 850nm and 1310nm VCSEL-based pluggable optical transceiver products will be added to JDSU's data communications product portfolio, bringing innovative technol-

ogy with the performance, reliability and manufacturability needed to address a wide range of markets.

"Demand for reliable data management and delivery continues to grow, particularly among enterprises," said David Gudmundson, president of JDSU's Optical Communications business segment. "With this acquisition, we are able to serve market demand for 8 and 10 Gigabit data networks, and provide a clear path to 100 Gigabits in the future," he adds.

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

## Berg replaces Veeco-bound Peeler as head of JDSU's Communications Test & Measurement unit

JDSU has appointed Helmut Berg to lead its Communications Test & Measurement business, reporting to JDSU's president and CEO Kevin Kennedy. Berg replaces John Peeler (who has left to become the new CEO at equipment maker Veeco Instruments Inc).

Berg has served JDSU CommTest for 14 years in senior executive roles, most recently as senior VP of its Lab & Production product division.

Since joining JDSU in 1993, he has led the conceptualization and development of the firm's

test & measurement innovations and managed every product line across its Lab & Production, Field Service and Service Assurance Solutions portfolio. Berg has also served on the board of the Alliance for Telecommunications Industry Solutions (ATIS).



# Finisar's telecoms sales counter last-quarter glitch in LAN/SAN

For its fiscal 2007 (to end April), Finisar Corp of Sunnyvale, CA, USA has reported record revenue of \$419.2m (up 15.1% on the prior year's \$364.3m), comprising: network test & monitoring products \$37.8m (down 1.5% from \$38.3m) and optical products \$381.4m (up 17% from \$326.0m), driven by 10–40Gb/s revenue up 123% (from \$18.1m to \$40.3m). Cisco was the only customer comprising more than 10% of revenues (at 21%).

However, fiscal Q4 revenues were down 9.5% on the prior quarter (to \$97.3m), comprising: network test & monitoring products \$8.9m (down 6.6%) and optical products \$88.4m (down 9.8%), though the latter was mitigated by 10–40Gb/s revenue up 28.5% (to \$14.9m).

Specifically, metro Ethernet and local/storage-area network (LAN/SAN) products were hit mainly by the transition of two customers to 'just-in-time inventory' arrangements (with revenue not recognized until stock is drawn from the customer's warehouse, leading revenue in the last six weeks of the quarter to "fall off a cliff", said CEO Jerry Rawls).

Also, certain SAN-related customers are still using up excess inventories stockpiled last year to safeguard

against any risk during Finisar's relocation of VCSEL production in Texas (for LAN/SAN applications) from Richardson to its new fab in Allen. The fab's first MOCVD reactor is now fully qualified internally and externally by all customers for both 8 and 10 Gigabit applications, and by almost all customers for 1 and 2 Gigabit applications, says Rawls. Finisar is now qualifying the second reactor (moved from Richardson in May) and expects to have both reactors qualified and operational by the end of 2007. Only one reactor is needed for current demand, Rawls adds, although the SAN-related excess inventory issues are now concluded.

Despite charges of \$4m related to investigating stock option practices (see below), the better-than-expected gross margin of 39% was down only slightly from Q3's 41%, and still higher than in fiscal first-half 2007. This is due to ongoing cost-reduction efforts and a favorable shift in product mix to more profitable longer-distance telecom and metro Ethernet applications, as well as a vertically integrated business model where higher shipment levels are accompanied by a modest increase in manufacturing costs.

Cash reserves fell from \$135.9m to \$123.7m, due to using \$13.7m to acquire AZNA LLC and Kodeos Communications Inc, with the aim of developing products for long-haul telecoms (a market that Finisar has not addressed previously).

So, despite the year-end problems with customer supply chain and excess inventory issues, Rawls claims progress in the last fiscal year.

"We rolled out a number of new products for 10Gb/s and WDM applications and strongly increased our sales to the telecom equipment industry," he explains. After revenue growth of 123% last fiscal year, Rawls believes that 10–40Gb/s products will generally remain on the same trajectory in fiscal 2008.

For fiscal Q1/2008, Finisar expects revenue to recover to \$105–112m. All optics sectors should rise, with 10–40Gb/s product sales to telecom companies rising to \$17–21m (particularly 10Gb/s XFP SR short-reach modules for DWDM, driven by the adoption of pluggable optics). Also, X2 SR short-reach modules (for 10 Gigabit LANs) are being qualified, says Rawls, with X2 LRM long-reach multimode modules set to follow.

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

## Review of stock option practices finds no wrong-doing

The above non-GAAP financial results are preliminary (until Finisar files its annual report on Form 10-K for fiscal 2007). They do not reflect any adjustments that may be needed due to the review by an audit committee of the board of directors of the firm's historical stock option granting practices between November 1999 and September 2006 (initiated at the end of last November after an initial voluntary review by management).

Finisar has now announced the initial findings of the review. The committee has concluded that, although there was no evidence of wrong-doing, the measurement dates for a number of stock option grants differed from their recorded grant dates, and the firm will need to restate its historical financial statements to record charges for related compensation expense and the tax impact. Finisar is therefore finalizing

revised measurement dates, determining the amount of the non-cash charges for compensation expenses, the resulting tax impact (which may result in additional cash tax liabilities), and the accounting impact on its financial statements for each fiscal period going back to fiscal 2000.

Finisar says that it aims to complete its financial assessment and announce the results "at the earliest practicable date".



## Oplink agrees acquisition of remaining shares of OCP

Component, module and subsystem maker Oplink Communications Inc of Fremont, CA, USA has closed its acquisition of the 58.1% stake in Optical Communication Products Inc of Woodland Hills, CA held by Japan's Furukawa Electric Co Ltd. OCP designs, manufactures and sells fiber-optic components (transceivers, transmitters and receivers) for metropolitan, local-area and fiber-to-the-home (FTTH) networks. Oplink is paying Furukawa \$1.50 per share (totaling about \$99m), as agreed when the deal was first announced in late April.

This follows OCP's adoption on 4 May of a 30-day shareholder rights plan as a precautionary measure to "protect the interests of its minority shareholders" (described by Oplink as a 'poison pill' to thwart its deal with Furukawa) and Furukawa's subsequent action at the end of May to increase its number of directors on OCP's board by four (from three out of eight to seven out of twelve, giving it a majority), aiming to amend the rights plan.

However, on 6 June, OCP said that it had reached an agreement in principle for Oplink to acquire the

remaining 41.9% of its common stock for \$1.65 per share. Then, on 20 June, OCP and Oplink signed a definitive merger agreement regarding the outstanding shares.

"After careful consideration of many factors, and following a thorough review with its independent advisors, the special committee and the board have unanimously determined that the merger is in the best interests of OCP and its remaining shareholders," says OCP board member Hobart Birmingham (managing director of The Perreault Birmingham Group LLC, and chairman of the board's special committee of independent directors, formed in late April in response to Oplink's deal with Furukawa).

"This transaction provides significant value for our shareholders, representing a 20% premium over the closing price on the last day of trading prior to the announcement of Oplink's agreement with Furukawa," Birmingham adds.

Completion of the acquisition is expected by September, subject to an affirmative vote by holders of two-thirds of the outstanding OCP shares not currently held by Oplink.

OCP will then become a privately held company, wholly owned by Oplink.

"With this transaction we have combined the strength of OCP's active components with Oplink's passive expertise to create the industry's leading solutions for metro and access applications," claims Oplink's president and CEO Joe Liu. "We will meaningfully broaden our portfolio of offerings and expand our addressable market and customer base. Over time, we plan to achieve revenue growth and cost synergies," he adds.

● Concurrent with the definitive merger agreement, OCP's chairman, Dr Muoi V Tran, has resigned from the board.

Also, the board has been expanded to nine members with the appointments of current Oplink board members Joseph Y Liu, Chieh Chang, Leonard J Leblanc and Jesse W Jack, as well as Dr Robert Shih, an Oplink officer. Oplink and OCP intend that this board composition will remain in effect until the merger is closed.

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

[www.OCP-inc.com](http://www.OCP-inc.com)

## Infinera's \$182m IPO exceeds expectations

Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of InP-based photonic integrated circuits (PICs) and optical networking equipment, closed its initial public offering of 14 million shares of stock at \$13 per share, raising \$182m. (On 21 May, the firm said that it expected to sell the shares for \$10-12 per share, raising \$139m.) After discounts for underwriters, the proceeds are more than \$169m.

Since being founded in December 2000, Infinera has already raised \$315m in private equity funding. The firm started to ship products in November 2004. Losses were \$66.5m in 2004 (on \$0.6m in sales), \$64.8m in 2005 (on \$4.1m

in sales) and \$89.9m in 2006 (when 75% of the \$58.7m in sales came from just two companies: Level 3 Communications and Broadwing, which Level 3 bought in January).

However, most recently, losses have been cut to \$19.8m in Q1/2007 (from Q4/2006's \$25m), while sales rose to \$49.2m (up 12% from Q4/2006's \$44.3m and up almost 17-fold year-on-year from \$2.6m in Q1/2006). During Q2/2007, Infinera won two new customers: San Francisco-based 'business-grade' IP service provider Telekenex and The State of New Mexico's General Services Department, Communications Division. Analysts project that, if the high revenue growth rate continues,

then Infinera should become profitable in about 2009.

In addition to repaying some of its \$334m of debt, Infinera says it will use the IPO's proceeds for general corporate purposes and working capital, to fuel growth, develop new products, or to "expand our existing business through acquisitions of other businesses, products or technologies".

Trading on the Nasdaq Global Market opened at \$16 and closed at \$19.71 at the end of the first day (up 52% on the \$13 IPO price), despite Nasdaq falling 1.8% overall.

● An extra 2.1m shares may go to the IPO's underwriters, raising the offering to as much as \$209.3m.

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



## Advanced Photonix consolidates silicon & III-V opto fabs

Advanced Photonix Inc, a vertically integrated designer and manufacturer of photodetectors, subsystems, and terahertz systems, has completed its new multi-million dollar, 5000ft<sup>2</sup> microfabrication facility for R&D and manufacturing of optoelectronic devices.

The facility consolidates the firm's two microfabrication operations in Camarillo, CA (Class 10,000 rated) and Dodgeville, WI (Class 1,000 rated), which produced silicon photodetectors in PIN, large-area avalanche photodiode (LAAPD) and FILTRODE configurations, into one

centralized facility with a 2000ft<sup>2</sup> class 1000 cleanroom at its subsidiary Picometrix LLC in Ann Arbor, MI, USA (acquired in 2005) which, since 1992, has used MBE to produce standard and customized GaAs, InAlAs and InP high-speed optical receivers in APD and PIN configurations (with bandwidths of 2–60GHz and wavelengths of 700–1650nm for 10–40Gbit/s applications).

Capacity on a three-shift basis is 50,000 four-inch wafers per year.

The consolidation is aided by up to \$1.2m of tax incentives:

- a Single Business Tax credit worth more than \$1.1m over 10 years from the State of Michigan, approved by the Michigan Economic Development Corporation (MEDC);
- a personal property tax abatement of up to \$94,000 over a five-year period from the City of Ann Arbor. The project is expected to create 105 direct and indirect jobs over a 10 year period.

The consolidation should improve efficiency, enhance technology development and reduce costs, says chairman and CEO Rick Kurtz.

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

## Optium banking on 40Gb/s acquisition to boost growth

For its fiscal Q3/2007 (to end-April), Optium Corp of Horsham, PA, USA, which makes optical subsystems supporting core to the edge applications for telecoms and cable TV networks, has reported its eleventh successive quarter of revenue growth: \$34.5m, up just 1% from \$34.1m last quarter but more than doubling (up 110%) from \$16.5m a year ago. This was despite some softness in high-end 300-pin products compared to fiscal first-half 2007.

Net income was \$3.4m, compared to \$3.9m last quarter and a net loss of \$11.0m a year ago (although that included a charge of \$11.2m for acquired in-process R&D related to the acquisition of Engana Pty Ltd, which is now Optium Australia).

"Our profitability continued to be strong in a quarter where we maintained our aggressive ROADM [reconfigurable optical add-drop multiplexer] production ramp to meet customer demand and encountered some product-mix-related gross margin pressure," says chairman and CEO Eitan Gertel. "We also achieved several important strategic and operational milestones in the quarter that will further strengthen our prospects for growth."

Optium added to its product line with the acquisition of Kailight

Photonics Inc of Nes Ziona, Israel (announced at the end of March and completed in May), whose 40Gb/s product line addresses both client-side and line-side applications.

"As we connect our strong base of customers to Kailight's leading technology, we are seeing a very positive response," claims Gertel. "Customers have been particularly interested in our ability to offer module solutions that can be integrated into line-cards cost effectively," he adds. "We expect to make our first 40Gb/s product shipments in our current fiscal fourth quarter."

For its fiscal Q4 (include Kailight operations from 16 May), Optium expects revenues of \$34.5–37.5m (up slightly on fiscal Q3).

"The next several quarters are important investment and expansion periods," says Gertel. "We are working diligently to successfully ramp ROADM production to meet the accelerating opportunities in that market. We are also focused on a successful Kailight transition and ramping our 40Gb/s production platform," Gertel adds. "Our long-term view of Optium's growth potential and continued profitability is stronger than ever," he says.

"We continue to target our revenue mix to the highest-growth areas of the optical market — 10Gb/s, 40Gb/s, ROADM and cable TV and fiber-to-the-home - on a disciplined and highly flexible operating model."

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

### Optium appoints Ciena CFO to board

Optium Corp of Horsham, PA, USA, which designs and manufactures optical subsystems supporting core to the edge applications for telecoms and cable TV network, has appointed Joseph R. Chinnici to its board of directors.

Chinnici has served as chief financial officer of Ciena Corp since 1997 (after joining Ciena in 1994 as controller). Chinnici recently announced plans to retire

from Ciena by the end of 2007.

Chinnici is currently on the boards of directors for Brix Networks and Sourcefire Inc.

As part of the appointment, Optium's board voted to expand its number of directors constituting the full board from seven to eight. Chinnici will stand for election as a Class II Director at Optium's annual meeting of stockholders in 2008.



# Emcore hits record 30.9% efficiency for space solar cells

The PhotoVoltaics Division of Emcore Corp in Albuquerque, NM, USA has achieved record conversion efficiency of 30.9% for a new class of multi-junction solar cells optimized for space applications (compared to 28.5% for its cells currently in production). Emcore has also achieved 37% peak conversion efficiency for its current volume-production terrestrial concentrating solar cell products.

The new Inverted Metamorphic (IMM) solar cell consists of a novel combination of compound semiconductors that enables a superior response to the solar spectrum compared to conventional multi-junction solar cells, Emcore claims. Due to its new design, the IMM cell is about one fifteenth the thickness of the conventional multi-junction solar cell.

"Achievement of 31% conversion efficiency will enable new space power applications in addition to the fact that the IMM cells offer the most sought-after performance characteristics," says Emcore's president and chief operating officer Hong Q Hou.

Developed in conjunction with the Vehicle Systems Directorate of the US Air Force Research Laboratory, the IMM cell will enable a new class of extremely lightweight, high-efficiency, and flexible solar arrays to power the next generation of spacecraft and satellites, as well as forming a platform for future generations of terrestrial concentrator products.

Emcore has achieved 37% peak conversion efficiency (under concentrated illumination conditions) using a production terrestrial concentrator cell that is an evolution of

its proven Concentrator Triple Junction (CTJ) production technology, with which several million CTJ solar cells have been produced and shipped to concentrator photovoltaic (CPV) system manufacturers. Emcore reckons that its investment in technology development should enable the introduction of concentrator solar cell products with conversion efficiency of 40% as part of its planned high-volume product roadmap.

"The successful demonstration of this new class IMM cell represents the most significant improvement in terms of watts/kg and \$/watts in the past decade, which will enable never before envisioned space power applications," reckons PhotoVoltaics Division VP and general manager David Danzilio.

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

## France's Sofradir wins Raytheon contract to supply mercury cadmium telluride detectors to US Army

Sofradir of Veurey-Voroize, Grenoble, France, which manufactures infrared detectors, has won a multi-million dollar contract from The Network Centric Systems business of Raytheon Company in McKinney, TX to supply second-generation mercury cadmium telluride (MCT, or HgCdTe) dewar detector cooler assemblies for a US Army program. The award provides Raytheon and the US Army with another qualified source of critical night vision technology. Sofradir expects the first deliveries to be made later this year.

"Sofradir supplied MCT IR detectors to the US Army several years ago," says CEO Philippe Bensussan. "It is rewarding to be once again providing US soldiers with high-quality technology to detect and identify key battlefield targets day and night."

Sofradir's new penetration of the US market, as an equipment supplier in a major program, comes less than a year after its decision to make the US market a priority and to take steps to reinforce its presence there.

"Our push into the US market, stronger ties with US customers and suppliers as well as our investment in a new facility are all part of our ambitious program to expand," Bensussan adds.

Last November, after commercializing a new third-generation IR detector process, Sofradir received permission to construct a new €9m plant (to be operational by the end of 2007). This will enable it to almost double its production area (to 9000m<sup>2</sup>) and to become the first IR detector maker to use MBE on an industrial scale, the firm

claims (as well as upgrading from 2" to 4" MCT wafers).

Founded in 1986, Sofradir is ranked number 2 for units delivered, having about 20-25% of the world's MCT second-generation detector market. Together with its subsidiary Ulis (specialists in uncooled IR detectors), created in 2002, Sofradir generated revenues of EUR93m (\$121m) in 2006. Sofradir directly exports more than 60% of its products. Customers include Thales, Sagem, Selex, Alcatel Alenia Space and the European Space Agency (ESA).

"We plan to be a leading merchant supplier of infrared detectors in the US and elsewhere in the world; this contract brings us one step closer," Bensussan says.

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





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(NASDAQ: AXTI)



# Honda selling PVs

Honda's solar cell subsidiary Honda Soltec Co Ltd (founded just last December) has begun selling CIGS (copper indium gallium diselenide) thin-film solar cells. Developed and currently made by Honda's production engineering subsidiary Honda Engineering Co Ltd, the cells are available only in Japan in limited areas (mainly in the Kanto region) through distributors that also provide the installation service.

However, this autumn Honda Soltec will start mass production at its new ¥7bn (\$61m) 11,080m<sup>2</sup> plant, which it began constructing at the end of September 2006 within the Kumamoto factory of Honda Motor Co Ltd. A staffing level of 150 and an annual capacity of 27.5MW at full production should lead to the expansion of sales throughout Japan.

The 14.3kg, 1417mm x 791mm x 37mm photovoltaic modules have a maximum output of 125W, based on solar radiation intensity of 1kW/m<sup>2</sup> and a module temperature of 25°C under AM1.5 conditions (where AM = air mass).



The suggested retail price is of the new CIGS solar cells is ¥60,375 (\$496). This compares with an average price for 125W PV modules of about \$610, according to [www.solarbuzz.com/moduleprices.htm](http://www.solarbuzz.com/moduleprices.htm). <http://world.honda.com/HondaSoltec>



## HelioVolt gears up for manufacturing

CIGS solar cell maker HelioVolt Corp of Austin, TX, USA has added two new vice presidents: Larry Peruffo as VP of supply chain and David Bowen as VP of manufacturing operations.

"The speed and efficiency of the manufacturing process is central to producing cost-effective solar energy products," says founder and CEO B.J. Stanbery. "HelioVolt is now ready to build on its core innovation — our proprietary FASST process [based on semiconductor printing] for rapid CIGS thin-film manufacturing," he adds. FASST can apply thin-film PV coatings to a variety of substrates, including conventional construction materials. The operational, manufacturing, and global logistics acumen of Peruffo and Bowen will help pro-

duction scale-up and delivery to worldwide markets, Stanbery says.

In 24 years at Applied Materials (lately as managing director of materials), Peruffo led manufacturing and supply chain process improvements. He will now develop the global supply chain required to implement the FASST manufacturing process across HelioVolt's line of products.

Prior to HelioVolt, Bowen was VP of operations and technology at Essilor Laboratories of America, where he transitioned ophthalmic optics technology from R&D to large-scale production. He will guide strategic operations as HelioVolt expands product development and manufacturing capabilities.

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

## DayStar refocuses on CIGS on glass

DayStar Technologies Inc of Half-moon, NY, USA, which has been developing TerraFoil CIGS photovoltaic cells sputtered on titanium-based foil, reported net losses of \$17.9m in for Q1/2007.

"Our goal in transitioning from a development stage to a commercialization stage company requires a path that accelerates near-term revenue generation," he adds. So, after analysing current market opportunities (including discussions with strategic partners and customers such as Blitzstrom GmbH) and assessing recent technical advances and manufacturing options, the firm has decided (contingent upon new financing) to build its first commercial manufacturing line (a 25MW line in its Santa Clara, CA facility) to produce monolithically integrated CIGS modules on plate glass substrates, which can achieve the cost and performance benchmarks required to meet customers' needs in the shortest timeframe.

DayStar is hence relocating select engineering and administrative functions (and its headquarters) to Santa Clara to assist commercialization, led by Bob Weiss (promoted from VP of Advanced Technologies to chief technical officer).

Flexible CIGS modules still have large future potential market, but there remain technical challenges in product packaging that inhibit early market penetration, says DeLuca.

"The transition to commercialization for our Gen-III facility in California requires a reduction of our New York-based resources," says DeLuca. The firm will continue to work closely with strategic development partners and local stakeholders to fully leverage its capabilities. The equipment and intellectual capability will transition to focus on continued development of future flexible product applications, forming the DayStar Applications Center.

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*Low K/ Copper Dies with Bond Over Active (BOA) Circuitry Design*
3. STATS-ChipPAC, Flynn Carson, Director of Wire Bond Product Engineering  
*Advanced 3D Packaging and Interconnect Schemes*
4. Kulicke & Soffa Industries, Inc., Robert Chylak, Vice President  
*Controlling Pad Structural Damage for an Ultra Fine Pitch Copper Wire Bonding Process*

**Location:** Meeting Room 3014, Level 3 Moscone West Hall, San Francisco, CA



# SiC power devices: if only we had a switch...

**With 4" diameter substrates and zero-micropipe technology now introduced, Dr Philippe Roussel of market research firm Yole Développement considers what else remains in the path of SiC power device market development.**

**W**ith January's introduction of 4" diameter SiC substrates coupled with ZMP (Zero MicroPipe) technology from the acquisition of IntrinSiC Semiconductor Corp of Dulles, VI, USA in July 2006, Cree of Durham, NC, USA is now marketing a product able to match power device makers' main requirements. However, few of them have yet entered the production phase and, apart from Cree itself and Infineon, no other players are commercially active in this segment.

SiC material cost and small wafer diameter are always stated as constraints on the level of interest from the big players in the power device sector. So, now that these two factors are being resolved, the prospect of developing a SiC switch is not so far off.

## **Making money from SiC devices: myth or reality? Market data tells the tale....**

Let's be frank: SiC device manufacturing is not yet the most exciting money-making activity. Neither Cree nor Infineon issue explicit figures, but we estimate that sales of SiC-based power electronic devices generated revenues of about \$15m in 2006 (Cree reported \$17m for both SiC power devices AND wide-bandgap RF devices, while Infineon does not give any details).

The only product that is commercially available is the Schottky barrier diode (SBD), which is now reaching the 1200V and 20A range. This component targets many possible applications (Figure 1), but it is mostly used in high-end PFC (power factor correction) systems where it brings some impressive added value, such as better power conversion efficiency (Cree have demonstrated a 50% improvement in losses), shrinkage of circuit board size, avoidance of RF oscillation, and the elimination of many passive discrete devices.

Theoretically, SiC can be considered as the ideal technology for replacing silicon-based circuits in PFC systems. Moreover, we are talking here about a total accessible market of more than 1.3 billion PFC units in 2006, facing a compound annual growth rate of 12% according to the Darnell Group. The top 3 PFC manufacturers (Delta Electronics, Astec Power/Emerson and Lite-on Technology) generate over \$2.8bn in revenues.

So, why are annual sales of SiC devices only \$15m? The first reason is certainly linked to technology implementation: it is not a chip-to-chip replacement. PFC circuits have to be re-designed to handle and exploit the added value of SiC Schottky diodes.

Secondly, from an economics point-of-view, the PFC market is heavily price-pressurized and the introduction of a new technology is a potential risk that some companies are hesitant to take. Finally, the market price for SiC Schottky diodes is a limiting factor.

A cost breakdown for SiC Schottky diodes is significant in order to illustrate this last point (Figure 2). To summarize, the bill of materials accounts for about 75% of the total device cost (based on production using existing 3" wafers). This is fundamentally different from silicon-based technology, where material is no more than 10%. The advent of 4" SiC material should help to reduce this ratio. Cree has already introduced 4" wafers into its device production, and Infineon may complete the 3" to 4" transition by Q3/2007.

The current market price for SiC Schottky diodes is oscillating somewhere between \$0.30/Amp and \$0.40/Amp, depending on the voltage and lot size. According to both SiC device makers and PFC manufacturers, it

seems that a price level of \$0.20/Amp would give favorable feedback for technology penetration. The first estimates for 4"-based SiC manufacturing cost lead us to think that this threshold should be beaten by 2008, assuming improvements in production yield, reduction in SiC wafer price (\$0.15/mm<sup>2</sup> would be well received) and increases in fab capacity.

**We estimate that sales of SiC-based power electronic devices generated revenue of about \$15m in 2006**

**The bill of materials accounts for about 75% of the total device cost... The advent of 4" SiC material should help to reduce this ratio.**



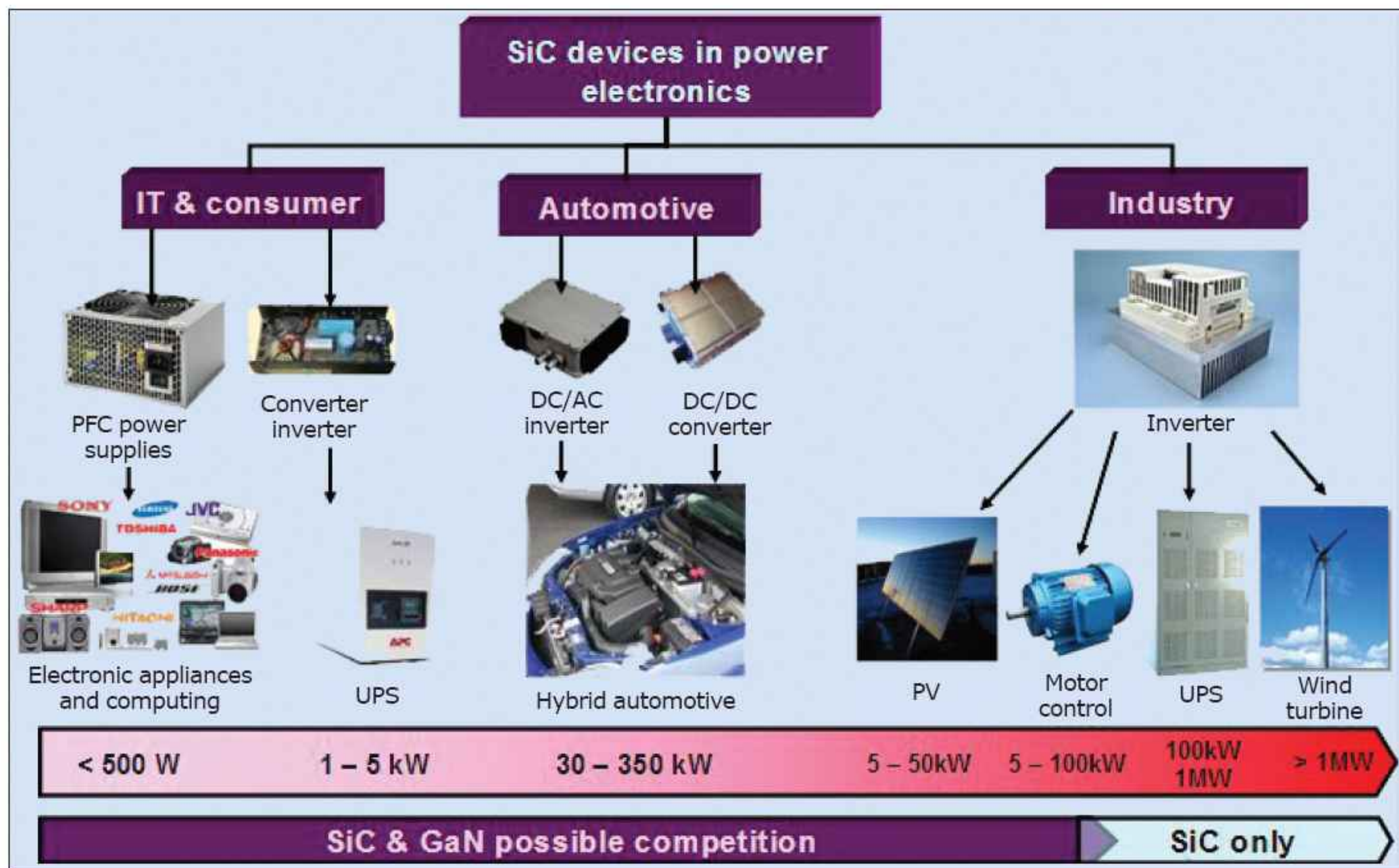


Figure 1. Possible applicative fields for SiC power devices.

### What are the historic 'Godzilla's' doing with silicon carbide?

Another parameter could boost the SiC device market: the expansion of the competitive landscape and the involvement of new players. The silicon rectifier market is led by firms such as Vishay, Shindengen Electric, STMicroelectronics and MicroSemi, who already supply PFC manufacturers in large volumes and benefit from established commercial networks linking to end users.

The strategies of the above device manufacturers regarding SiC are as follows:

- Vishay in 2000 acquired the SiC technology of DaimlerChrysler AG (which the latter had been developing since 1993). Most recently, in November 2006, Vishay bought International Rectifiers' Power Control Systems (PCS) division, in which SiC developments have been achieved.
- Shindengen Electric of Tokyo, Japan is active in SiC technology and has published many papers on the topic.
- STMicroelectronics has been developing SiC Schottky diodes for many years at its R&D center in Tours, France. The firm's Italian manufacturing plant in Catania, Sicily may be used for devices production.
- MicroSemi acquired APT (Advanced Power Technology Inc) in April 2006 and has since established a production capability in Bend, OR, USA.

So, SiC device manufacturing plans are moving rapidly, and further announcements are expected by late 2007.

### The ultimate target: a SiC switch

Diodes and switches coexist quite well together and, even if a hybrid SiC-silicon approach is an option, full SiC electronics is highly desired for many applications.

To highlight this, hybrid electrical vehicles (HEVs) currently use silicon-based insulating-gate bipolar transistors (IGBTs) and diodes in their inverter module to power the (30–50kW) electric motors. This silicon chipset has to be cooled down by a water-based system to maintain a device junction temperature of about 85°C. However, this requires a dedicated water-cooling system, separate to the

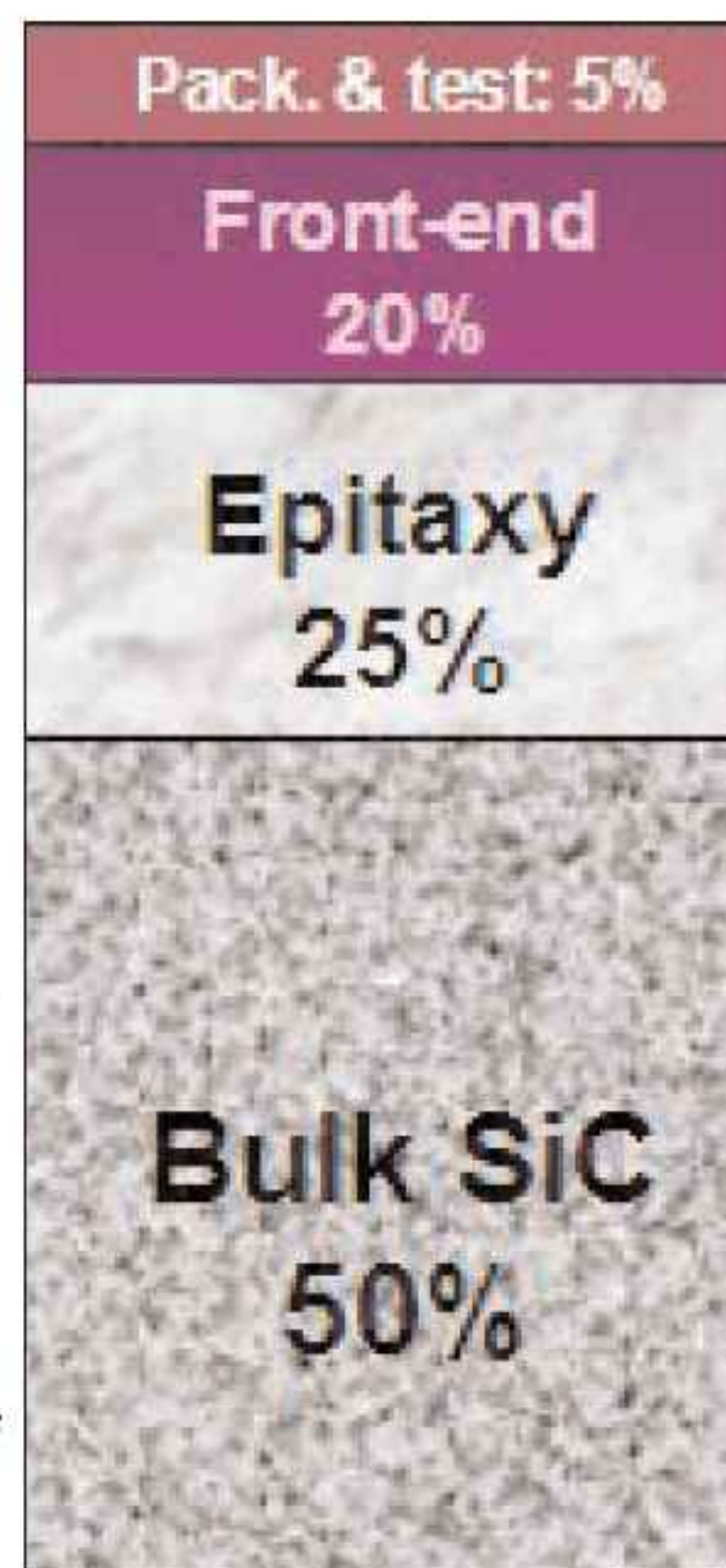


Figure 2. Cost breakdown for SiC Schottky barrier diode.



**Table 1. Involvement of key players in SiC switch development.**

Company	MOSFET	JFET			BJT	IGBT
		Normally-on	Normally-off	Cascode		
Acreo (SW)	x					
Denso (J)	x					
Cree (US)	x	x			x	x
Fuji (J)	x					x
GE (US)	x					
Hitachi (J)	x					x
Matsushita MEI (J)	x					
Mitsubishi (MELCO) (J)	x					x
Nissan Motor	x					
Northrop Grumman (US)	x	x	x	x (full SiC)		
Oki Electric (J)	x					
Philips (NL)	x					
Rohm (J)	x					x
Semisouth (US)		x	x			
Rockwell (US)		x				
SiCED (D)	x	x		x (hybrid Si-SiC)		
Toshiba (J)	x	x				x
Sumitomo SEI (J)		x				
TranSiC (SW)					x	
United Silicon Carbide (US)		x	x		x	

cooling system in charge of the fuel engine, which can handle higher temperatures. One of the objectives of HEV vehicle makers is to simplify this setup by implementing SiC-based electronics that can easily withstand 150°C or more. This would then allow the use of a single water-cooling system rather than two. This way, a money saving of about 15% on the power module could be achieved. However, this approach only applies for a full SiC electronics chipset, and would not be realistic with a hybrid solution.

In terms of the requirements for this particular application, 1200V/100A SiC single chips would fit perfectly.

Up to now, the main R&D effort has been oriented towards SiC MOSFETs (metal-oxide-semiconductor field-effect transistors). Lots of announcements have been made (by Rohm, Cree, Acreo, Toshiba etc). However, in summary, oxide reliability and poor electronic mobility issues remain partially unsolved.

As shown in Table 1, even if the MOSFET remains the most-studied device, alternatives exist, and the JFET (junction gate field-effect transistor) or BJT (bipolar junction transistor) are also within the scope of some prestigious R&D groups.

The common characteristic of the JFET and BJT is that, unlike the MOSFET, it does not use any oxide layer. Recent results from SemiSouth, TranSiC and GeneSiC have been very encouraging: TranSiC is now fine tuning a 1200V, 6A BJT chip with an operation temperature up to 250°C; SemiSouth is focusing on a normally-off version of a SiC JFET; and GeneSiC is concentrating on very high power SiC devices, including MOSFETs and

JFETs. It also has to be noticed that Infineon has announced its intention to produce a SiC JFET in large volume in the very near future. Also, in early 2006, Rohm released results concerning a SiC MOSFET that can withstand a voltage of 900V and has an on-resistance ( $R_{on}$ ) of 3.1mΩ/cm<sup>2</sup>.

## Conclusion

It is now clear that the relative stagnation of the SiC power device market is partly due to the lack of reliable transistor technology. The PFC sector is the only one driving SiC device sales, and prospects for higher market penetration are linked mainly to a drop in device cost. In addition, others applications demand a complete SiC-based switching cell (i.e. a diode and a transistor).

MOSFETs have largely been investigated by major SiC R&D teams. However, it seems more and more certain that JFET or BJT technologies may be first to be released onto the market. So, with big-name manufacturers confessing to facing unresolved problems with MOSFETs, maybe the future is one free from oxides.

*Yole Développement (www.yole.fr) is a market research and strategy consulting company based in Lyon, France. Dr Philippe Roussel (roussel@yole.fr) has headed the Compound Semiconductors division since 1998. Yole produces numerous market reports and is currently publishing its analysis of the SiC, GaN, AlN, power and RF device as well as high-brightness LED markets.*

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This year's 2007 CSIC Symposium consists of a full 3-day technical program, 2 short courses, a primer course, and a technology exhibition. The technical program consists of approximately 60 high-quality state-of-the-art technical papers, 4 panel sessions, 2 Short Courses on 'Compound Semiconductor Devices and Integrated Circuits for Millimeter Wave Imaging' and 'Compound Semiconductor Power Amplifiers' and an Industry Exhibit. The Symposium will also be offering the popular annual introductory level Primer Course on 'Basics of Compound Semiconductor ICs'. This year the Symposium will feature approximately 15 invited papers on a wide range of important topics encompassing device engineering to circuit application using advanced compound and other related semiconductor technologies. In addition, the Symposium will continue the tradition of including important 'late breaking news' papers.

The technology exhibition will be held on Monday and Tuesday. The exhibition will feature informative and interesting displays with corporate representatives on hand. The list of exhibitors can be found in the CSICS advance program which will be published and distributed in late June.

To complement the Symposium, there are several social events which include the Sunday Evening CSICS Opening Reception, the Monday CSICS Exhibition Opening Reception, the CSICS Tuesday evening Theme Party to be held at McMenamins Pub and Breweries Crystal Ballroom, and the CSICS Exhibition Luncheon on Tuesday. The Theme Party will include entertainment and a tasting of locally produced Oregon wine and beer. A breakfast will also be served on Monday, Tuesday, and Wednesday.

The 2007 IEEE CSICS will be held in Portland, Oregon in the Hilton Portland and Executive Tower located in downtown Portland. Proclaimed as North America's 'Best Big City', according to Money magazine, Portland exhibits unmatched natural beauty as well as a wealth of opportunities for leisure, sports, shopping, and outdoor activities. The conference downtown location is within easy access to the vibrant Pearl District with destination restaurants, art galleries, and shopping. While you're in Portland, be sure to enjoy the scenic beauty of the Columbia River Gorge, enjoy the hike to Multnomah Falls and the drive the Historic Columbia River Highway. Other local attractions include Mt Hood, the Willamette River, the rose gardens, the Japanese garden, the Oregon Coast, and the wine country. Portland has an excellent light rail system which can be used as transportation from the Airport to the Hilton and for getting around town.

For registration and further information, please visit the CSICS website at <http://www.csics.org>. Further questions may be addressed to the Symposium Technical Program Chair: William Peatman, Ph: +1-908-668-5000 ext. 5842, E-mail: [wpeatman@anadigics.com](mailto:wpeatman@anadigics.com)

We hope you can attend,  
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[www.icds24.org](http://www.icds24.org)

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E-mail: [aacg@att.net](mailto:aacg@att.net)

[www.crystalgrowth.us/iccg15/index.php](http://www.crystalgrowth.us/iccg15/index.php)

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[www.icfsi2007.com](http://www.icfsi2007.com)

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

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[www.spie.org/app/conferences](http://www.spie.org/app/conferences)

**26-31 August 2007**

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[www.cleo-pr2007.org](http://www.cleo-pr2007.org)

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<http://p12611.typo3server.info/7.0.html>

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**DRIP XII (12th International Conference on Defects-Recognition, Imaging and Physics in Semiconductors)**

Berlin, Germany

**E-mail:** drip12@mbi-berlin.de

**www.drip12.de**

**10–14 September 2007**

**13th International Conference on II-VI Compounds**

Jeju, Korea

**E-mail:** secretary@II-VI2007.or.kr

**http://ii-vi2007.or.kr**

**11–13 September 2007**

**Solid-State Device Research — 37th European Conference (ESSDERC-2007)  
Solid-State Circuits Research — 33rd European Conference (ESSCIRC-2007)**

Munich, Germany

**E-mail:** info@esscirc2007.org

**www.essderc2007.org**

**16–20 September 2007**

**ECOC 2007 (33rd European Conference and Exhibition on Optical Communication)**

Berlin, Germany

**E-mail:** vde-conferences@vde.com

**www.vde.com/Conferences\_en/ECOC+2007**

**16–21 September 2007**

**ICNS-7 (7th International Conference on Nitride Semiconductors)**

Las Vegas, NV, USA

**E-mail:** raabe@tms.org

**www.tms.org/Meetings/specialty/icns**

**17–19 September 2007**

**Applications of High Power Semiconductor Lasers (AHPSL) 2007**

San Diego, CA, USA

**E-mail:** amueller@intertechusa.com

**www.intertechusa.com/conferences**

**23–26 September 2007**

**North American Molecular Beam Epitaxy (NAMBE) 2007**

Albuquerque, NM, USA

**E-mail:** motero@chtm.unm.edu

**http://nambe07.chtm.unm.edu**

**24–27 September 2007**

**Solar Power 2007**

Long Beach Convention Center, CA, USA

**E-mail:** tyager@seia.org

**www.solarpowerconference.com/18/**

**24–28 September 2007**

**NUSOD-07 (7th International Conference on Numerical Simulation of Optoelectronic Devices)**

Newark, DE, USA

**E-mail:** piprek@nusod.org

**www.nusod.org**

**8–12 October 2007**

**European Microwave Week 2007**

Munich, Germany

**E-mail:** vandervorst@eumwa.org

**www.eumwa.org**

**9–11 October 2007**

**SEMICON Europa 2007**

Stuttgart, Germany

**E-mail:** ktorres@semi.org

**www.semi.org**

**14–17 October 2007**

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