

semiconductor TODAY

COMPOUNDS & ADVANCED SILICON

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Nanowires under the microscope Intel's Ge/Si APD outstrips InP

RFIC makers cut Q4 guidance • RFMD lays off 250 staff
First RF graphene FET • Cree boosts white LED to 161lm/W

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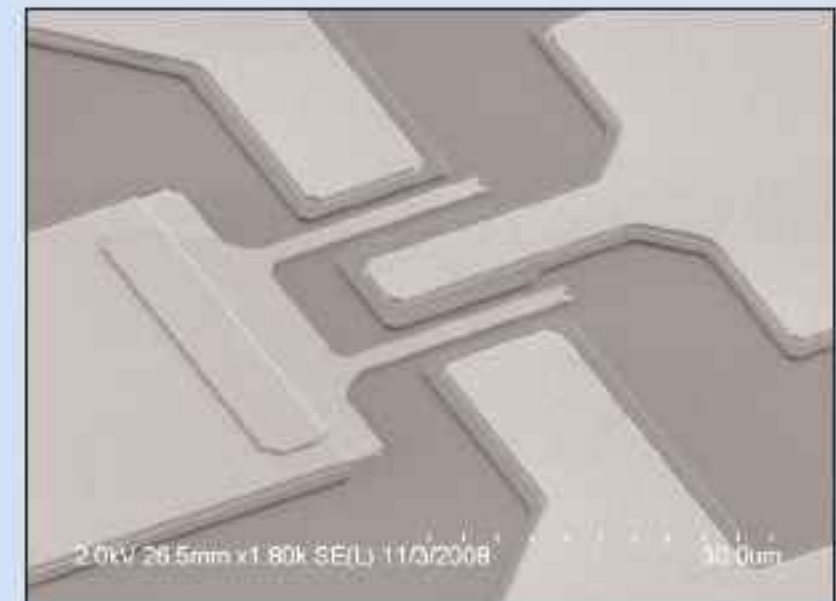
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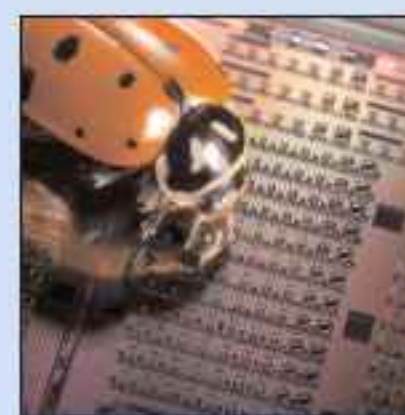
p10 TriQuint's PowerBand RF transistor range offers 50% PAE and 10–50W output across 0.5–3GHz bandwidth.



p14 The first RF graphene FET has been demonstrated by HRL as part of DARPA's CERA program.



p57 Global Solar Energy has begun operation of the 750kW CIGS PV array at its 40MW plant in Tucson, AZ, USA.



Cover: Silicon wafer bearing an array of Intel's monolithic Ge/Si avalanche photodetectors (APDs), of varying designs and diameters (30–50 μ m), with record gain-bandwidth product for any APD (including those based on InP) of 340GHz. Intel targets commercialization in the next 2–3 years. **p43**

2009 GaAs forecast down, but rebound due for 2010

After last issue reporting revenue growth in third-quarter 2008 for GaAs RFIC makers RF Micro Devices, Skyworks and TriQuint, all have since lowered their Q4/2008 forecasts (see pages 6–7). Quarter-to-quarter revenue drops are now expected by Skyworks (down 8–10%), RFMD (down 21–26%) and TriQuint (down a huge 28–33%).

In normal years, a seasonal rise would be expected. This is largely in response to worsening demand from cell-phone handset makers, which are increasingly being affected by the impact on consumers of the global economic crisis. In addition, for smart-phones (which contain more GaAs than other handsets, and have been the bright spot of the industry) Q3 sales were lower than expected, leading to excess inventory at handset makers. Indeed, with overall handset shipments forecast by both top handset maker Nokia and analyst firm Gartner to fall in 2009 (for the first time since 2001's 3% drop), market research firm Strategy Analytics has lowered its expectation for the 2009 GaAs device market from its prior forecast of growth to a contraction of 5% (see page 4).

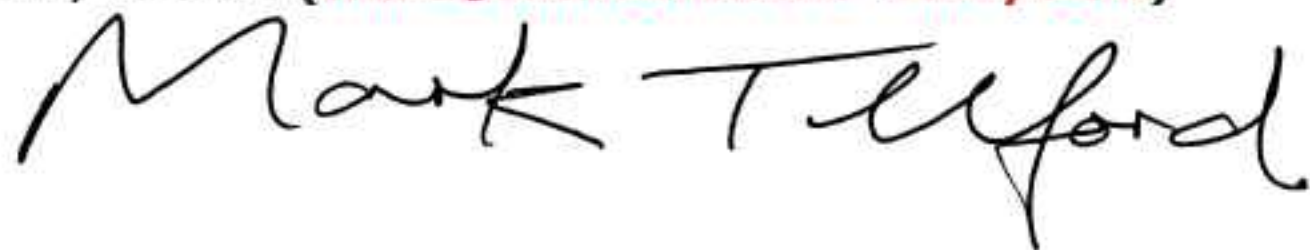
Consequently, after last issue reporting RFIC maker Anadigics announcing cost-cutting measures involving about 100 job losses (15% of its staff), TriQuint has now also said that it is taking significant cost-control measures, including a sharp reduction in temporary staffing, a recruitment freeze, and shutdowns over the holiday period. Meanwhile, RFMD also announced cost-cutting measures including laying off 250 staff (150 through closing its original 4" GaAs fab at its base in Greensboro, NC, USA and 100 at its 6" GaAs fab in Newton Aycliffe, UK, acquired from Filtronic in December 2007).

Nevertheless, despite the unprecedented drop in handset shipments expected in 2009, the economic downturn is still hitting the compound semiconductor sector far less hard than the silicon sector, thanks to the diversified applications of GaAs ICs and consequently lower reliance overall on consumer markets. Also, while handset shipments fall, corresponding GaAs RFIC revenues fare better, not only due to diversification but also since the continuing trend for increasing functionality of multi-mode, multi-band 3G phones is still driving growth in dollar content per phone for GaAs.

Likewise, up the supply chain, while equipment and materials suppliers to the compound semiconductor industry will likely be hit by end-market slowdown, the impact will be less than that from the downturn in silicon. This should benefit those that can divert their focus from the silicon industry to compound semiconductors (e.g. etch & deposition equipment maker Aviza Technology, which says that, for the December quarter, it is not "falling off a cliff" like some other equipment makers — see page 27).

Meanwhile, Strategy Analytics forecasts a return to growth for the GaAs device market in 2010 (albeit at a lower compound annual average growth rate through 2012 of 7% rather than the previously forecasted 9%). So, despite the prospects of the first downturn since 2001, the effects should be far less severe or long-lasting.

Mark Telford, Editor (mark@semiconductor-today.com)



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Editor

Mark Telford
Tel: +44 (0)1869 811 577
Cell: +44 (0)7944 455 602
Fax: +44 (0)1242 291 482
E-mail: mark@semiconductor-today.com

Commercial Director/Assistant Editor

Darren Cummings
Tel: +44 (0)121 288 0779
Cell: +44 (0)7990 623 395
Fax: +44 (0)1242 291 482
E-mail: darren@semiconductor-today.com

Advertisement Manager

Jon Craxford
Tel: +44 (0)207 193 9749
Cell: +44 (0)7989 558 168
Fax: +44 (0)1242 291 482
E-mail: jon@semiconductor-today.com

Original design Paul Johnson
www.higgs-boson.com

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

Regular issues contain:

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

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A hand is shown holding a glowing globe. Inside the globe, a white AIXTRON industrial machine is visible, featuring various panels, screens, and the AIXTRON logo. The background consists of blue and white light rays radiating from the center.

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GaAs device market to shrink 5% in 2009

While maintaining its forecast for the GaAs device market to grow 9% from \$3.5bn in 2007 to \$3.9bn in 2008, market research firm Strategy Analytics has revised July's 'GaAs Industry Forecast Through 2012' for 2009 to a 5% contraction year-on-year due to global recession impacting unit growth across nearly all major end markets.

Growth should return in 2010, but at a reduced compound annual average growth rate (CAAGR) through 2012 of 7%, rather than the previously forecasted 9%.

The corresponding demand for GaAs substrates will decline by 10% in 2009, with growth returning in 2010. The CAAGR for substrate through 2012 should be of 4%, Strategy Analytics reckons.

"Negative growth in handset shipments for the next year, along with slowdowns in other markets, will slow GaAs industry growth over our

earlier projections," notes analyst Asif Anwar. "However, we maintain that the overall metrics for the industry remain strong and we're not going to see the industry collapse as it did in 2001."

In particular, the cellular handset market will continue to drive around 70% of GaAs device demand through 2012, while the Wi-Fi market will

Growth should return in 2010, but at a reduced CAAGR through 2012 of 7% rather than the previously forecast 9%

still grow (at a CAAGR of 20%) to become the second largest market for GaAs in 2012. Demand from the military sector

will not be affected through 2012, but will continue to grow on the back of strong industry backlog. www.strategyanalytics.com

Optical transport to shrink 10% in 2009

The optical transport equipment market grew 7% year-on-year in Q3/2008 (a 20th consecutive quarter of growth), says Dell'Oro Group's 'Optical Transport Quarterly Report'. However, the market is forecast to shrink nearly 10% in 2009.

"This quarter marks the fifth year of growth since the telecom winter of 2001," says Jimmy Yu, director of Optical Transport research. "It is only natural following this strong build cycle that there would be a market contraction, regardless of an economic recession," he adds. "The current global economic strain is forming an additional layer of compression on the optical market in the form of uncertainty that brings cautious spending in both consumers and enterprises." Dell'Oro has hence revised its 2009 forecast to decline from 5% to almost 10%.

The top vendors in Q3/2008 based on market share continued to be Alcatel-Lucent, Huawei, Nortel and Fujitsu, but only Huawei gained market share on a year ago (due to its DWDM long-haul and WDM metro revenues which, combined, grew nearly 90% year-on-year).

www.delloro.com

Shipments of LED-backlit notebook PCs rise 63% in Q3; penetration to rise from 5.4% to 25% in Q2/2009

The market penetration of LED backlights into notebook PC panels rose from 3.4% in second-quarter 2008 to a new high of 5.4% in third-quarter 2008, and is expected to more than double to 12.2% in Q4/2008 as adoption is triggered by low cost and new LED backlight structures, according to analyst firm DisplaySearch.

Correspondingly, due to cost reductions and the launch of new notebook PC models, shipments of notebook PC panels with LED backlights rose to a new high of 2.1 million units, up 63% on Q2's 1.3 million and up 200% year-on-year.

In Q3/2008, 12.1-inch, 13.3-inch and 15.4-inch were the leading sizes of LED backlight notebook panels.

Toshiba Matsushita Display Technology (TMDisplay), which ships mainly 12.1-inch and 13.3-inch panels with LED back-

lights, is the market leader (with a

The penetration of LED backlights into notebook PC panels is expected to rise further to more than 25% in Q2/2009

39% share), followed by AU Optronics (AUO) and LG Display (23% each), and Samsung (12%). It is expected that new 16:9 ratio panels will largely adopt LED backlights in 2009.

Furthermore, with major PC vendors including Hewlett Packard (HP), Dell and Acer having announced plans to launch many new LED-backlit notebook models in first-half 2009, the penetration of LED backlights into notebook PC panels is expected to rise further to more than 25% in Q2/2009, says DisplaySearch.

www.displaysearch.com

High-power RFICs to grow at 6% annually through 2013

ABI Research says that its optimistic forecasts for the penetration of high-powered RF integrated circuits into the mobile wireless base-station market have been borne out by the latest market developments.

The rate of growth in high-power RFIC shipment numbers is expected to level out slightly in 2011, but overall, between 2008 and 2013, revenue should rise a compound annual growth rate (CAGR) of 6%, according to ABI's report 'High-Power RFICs'. This may seem modest, but should be viewed as strong in an overall declining RF power device market for wireless infrastructure, says ABI. By far the largest share of these revenues will go to just three large vendors.

The new breed of high-powered RFICs is intended mainly for use in base-stations for cellular and other wireless infrastructure. "Compared to the discrete devices they can replace, high-power RFICs take up less circuit board space; they are

easier to use; and they cost the same or slightly less," says research director Lance Wilson. Although the conventional wisdom suggested relatively modest and stable growth for these chips, for several years they have been taking an increasingly significant share of this market. ABI expects that the pace of this market adoption will only increase over time.

The 'High-Power RFIC' report forms part of two ABI Research services: its 'RF Power Devices' report is a highly segmented market-based analysis of silicon, gallium nitride, gallium arsenide and silicon carbide high-power RF device technologies; the 'Wireless Semiconductors' research service covers all technology and market issues related to semiconductor supplier roadmap strategies and competitive positioning, component analysis, application-specific components, process technologies and IC architecture, design, and integration issues.

www.abiresearch.com

LED gaining acceptance in automotive market

With global automobile makers looking for more energy efficient interior and exterior lighting, the LED market for automotive applications is expected to rise at a compound average growth rate (CAGR) of 13% from \$690m in 2007 to \$1.2bn in 2011, giving LEDs a market penetration of 8%, according to Digitimes.

The automotive lighting market is divided into interior and exterior segments, and LED applications currently account for up to 60% of the interior lighting market, the market sources noted.

Also, models like the Volkswagen Passat and Honda Accord have started to be equipped with LEDs in their tail-lights, and the LED tail-light market penetration rate may grow from 15% this year to 28% in 2008 with the Asia Pacific region seeing the most significant growth, according to Strategies Unlimited.

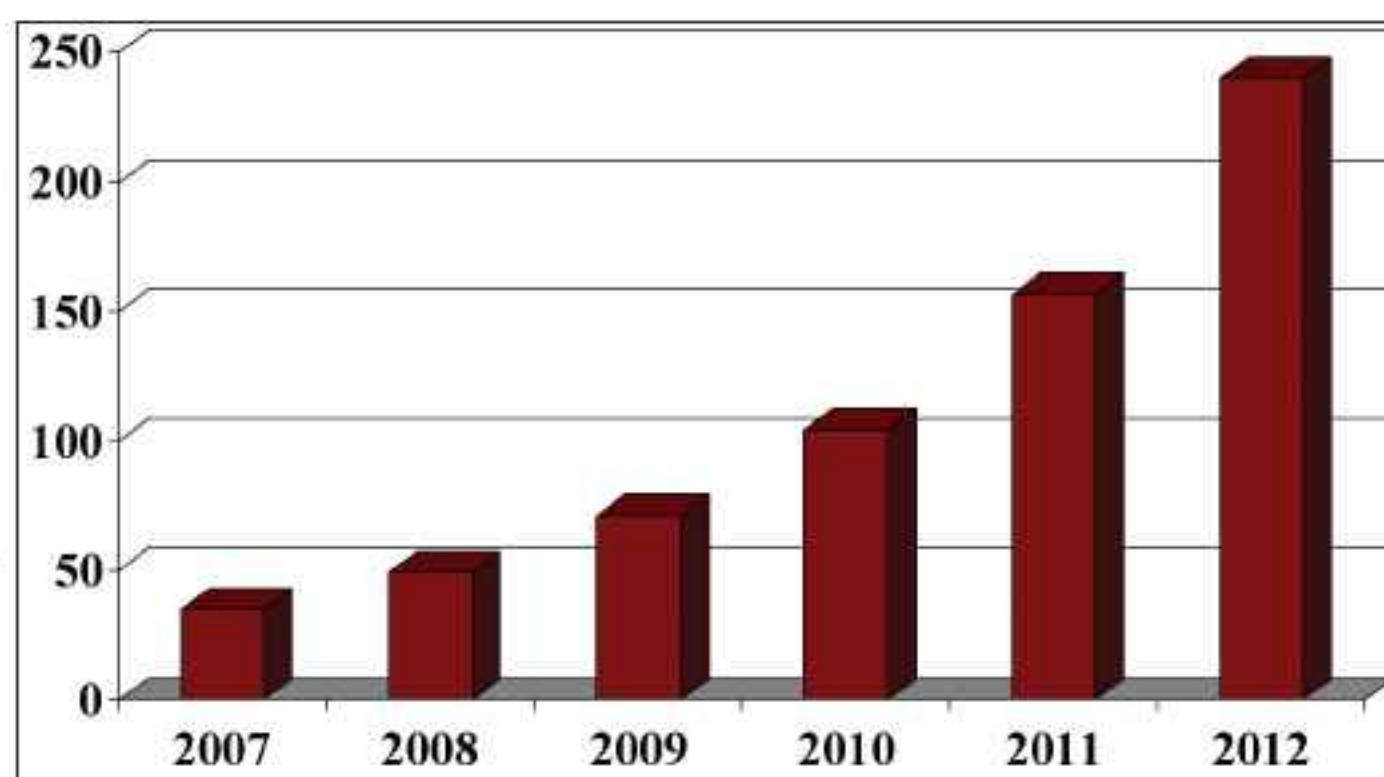
Although LED automotive lighting is only just beginning mass deployment, LEDs have gained acceptance in the automobile market with their advantages in power requirements, longevity and higher per lumen output, as well as the fact as LEDs are mercury-free.

www.digitimes.com

SOA consumption to grow to 240,000 in 2012

Global consumption of semiconductor optical amplifiers (SOAs) will grow several-fold from over 35,000 units in select communication applications in 2007 and almost 50,000 this year to about 240,000 units in 2012, according to the report 'Semiconductor Optical Amplifier Global Market Forecast & Analysis 2007-2012' from ElectroniCast Consultants.

"The primary near-term use of these devices will be as optical switch elements in telecommunica-



SOA consumption forecast (in 1000s).

tion photonic switches, for optical cross-connect and in wavelength

division multiplex links and other digital fiber optic transmission applications," says Stephen Montgomery, president of ElectroniCast Consultants-APAC and the director of the research project. "Laboratory field test and built-in instrumentation also will be a significant SOA user, as well as semiconductor optical amplifier use in optical switch elements in military/aerospace applications," he adds.

www.electroniccastconsultants.com

RFMD lowers revenue guidance and announces cost cutting

To reflect broad-based, reduced demand in its end markets, RF Micro Devices Inc of Greensboro, NC, USA has cut its guidance for its fiscal Q3/2009 (to end-December 2008) to 15–20% below the low-end of the \$253–271m guidance it gave on 28 October (i.e. \$202–215m, down a massive 21–26% on last quarter's \$271.7m and down similarly on \$268.2m a year ago).

Nevertheless, RFMD continues to expect gross margin to improve sequentially and to achieve positive diluted earnings per share (EPS) on a non-GAAP basis. The original guidance forecasted diluted EPS of \$0.00–0.02 (on a GAAP basis) and \$0.05–0.07 (on a non-GAAP basis).

RFMD says that it expects to strengthen its balance sheet and improve its capital structure during the December quarter. Quarterly cash flow from operations should increase significantly on the September quarter, with minimal capital expenditures anticipated. Additionally, RFMD has purchased about \$23m par value (or 10%) of its 2010 convertible debt and continues to have about \$50m available and authorized for common stock repurchases under its existing share repurchase program. The firm says that it may make additional purchases of its convertible debt or common stock from time to time in the open market in accor-

dance with applicable regulations.

"In light of the reduced demand environment, we have taken decisive and immediate actions to maximize cash flow by reducing costs, working capital and capital expenditures," says president & CEO Bob Bruggeworth. "These cost-cutting measures have begun to take effect, and we expect to derive the full benefit of these measures during the March 2009 quarter," he adds. "We are sizing our operating model to match our revenue expectations." RFMD continues to expect \$80–120m in free cash flow (cash flow from operations less capital expenditures) in fiscal 2010.

www.rfmd.com

Staffing to be cut by 250 across Greensboro and UK

At the Barclays Capital investor conference in San Francisco on 9 December, RFMD said it was laying off up to a third of its 300 staff at its 6" GaAs fab in Newton Aycliffe, UK from 19 December.

Compared to prior 24/7 operation, the fab will be run on 8-hour shifts, 5 days a week. Together with previous measures, this should cut operating expenses in the quarter to end-March by 25% on a year ago.

In December 2007, RFMD agreed to acquire the former Filtronic Compound Semiconductor Ltd from UK-based Filtronic plc for £12.5m. The acquisition was targeted at: (i) reducing RFMD's GaAs pHEMT manufacturing costs and providing 30% extra manufacturing capacity to support anticipated near-term growth in handset power amplifiers (PAs) for its Cellular Product Group (deferring \$200m of fab-related capital outlay in Greensboro); and (ii) supplementing the Multi-Market Product Group's product portfolio with Filtronic's microwave and milli-

RFMD's Newton Aycliffe GaAs fab, which is losing a third of its 300 staff



meter-wave component business. After completing the acquisition in March, RFMD announced plans to expand capacity there, creating about 100 new jobs.

RFMD has also announced actions aimed at streamlining operations and cutting GaAs manufacturing costs at its Greensboro campus (to take effect in the March quarter).

RFMD's original, 4" wafer fab (which accounts for less than 10% of the firm's GaAs manufacturing capacity) is being idled and kept in a clean environment (for future restart, if demand requires). All GaAs manufacturing will be transitioned to the site's 6" fab. In addition to 150 job cuts, RFMD expects much lower direct material costs and

higher utilization rates, resulting in lower total manufacturing costs.

Altogether, RFMD estimates that, between December and March 2009, about 250 staff (5% of its global workforce) will be affected.

By reducing its manufacturing cost structure, these actions are expected to positively impact RFMD's cash flow by about \$15m in fiscal 2010 (starting 29 March 2009). "Because existing facilities will be reduced or idled, RFMD will retain the capacity and flexibility necessary to respond to increases in customer demand as the recession wanes and as the company's markets return to growth," concludes the firm's president & CEO Bob Bruggeworth.

Skyworks cuts quarterly revenue guidance from \$240m to \$210–215m

Despite strong order backlog, Skyworks Solutions of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has cut its revenue guidance for fiscal Q1/2009 (to end-December 2008) from \$240m (given on 6 November) to just \$210–215m. Although no less than the \$210.5m a year ago, this is down 8–10% on last quarter's record revenue of \$232.6m.

"We are lowering our guidance to reflect weakness in the handset

and broader analog markets," says chief financial officer Donald W. Palette. "Our 8–10% sequential revenue decline is being driven by recent customer inputs and bookings levels, which point to a broad-based slowdown in several of our end markets," he adds.

"Nevertheless, our diversification, market share gains [e.g. from rival Anadigics] and balance sheet strength are enabling us to maintain strong financial performance during the downturn," Palette claims.

www.skyworksinc.com

TriQuint cuts Q4 revenue guidance from \$160–175m to \$140–145m

RF product manufacturer and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA says that, due to significant order push-outs and a drop in new orders, it has lowered its fourth-quarter 2008 revenue guidance (given on 22 October) from \$160–175m to \$140–145m (still up 9–13% from \$128.5m a year ago, but down a huge 28–33% on last quarter's record \$186.3m).

Assuming the midpoint of this new range, compared with \$475.8m for 2007, full-year 2008 revenue should be about \$566m (up 19%) rather than \$592m (up 24%).

With its market capitalization well below book value, TriQuint is examining the potential impairment of its goodwill, and currently expects to write off the full balance of \$34.2m. The firm says that it is also examining the potential impairment of a cost-based investment in a privately held company and currently expects an impairment charge of about \$2m.

Based on results to date and projections for the remainder of Q4/2008, loss is expected to be 20–22 cents per share. Excluding the unusual items mentioned above, earnings are expected to be 2–4 cents per share and non-GAAP earnings 5–7 cents per share. The firm also expects strong positive cash flow during the quarter.

TriQuint also says that it has taken significant cost-control measures, including a sharp reduction in temporary employees, the closure of most open staffing requisitions, restrictions on discretionary spending, and planned shutdowns over the holiday period. However, it adds that it is continuing to invest in innovative new products, technologies and more efficient processes. "We believe TriQuint remains well positioned financially and strategically heading into 2009, with ample cash reserves, continued market share gains, and a strong technical roadmap," concludes the firm.

www.triquint.com

IN BRIEF

Kopin announces stock repurchase program

Kopin of Taunton, MA, USA, which makes III-V heterojunction bipolar transistor (HBT) epiwafers and CyberDisplay LCDs, says that its board of directors has authorized the repurchase of up to \$15m of the firm's common stock, financed with available cash.

"We believe our stock is currently undervalued," says president & CEO Dr John C.C. Fan. On 5 December, the firm's share price closed at \$1.96 per share. "We see this repurchase program as a prudent use of capital that underscores our commitment to building long-term value for our shareholders," he adds.

With nearly \$92m in cash and equivalents on its balance sheet as of 27 September and no long-term debt, Kopin reckons that it has ample financial resources to fund the program while continuing to execute its growth strategy. "At the same time, we recognize that maintaining a strong cash position is essential in light of the global economic environment, so we want to assure shareholders that our repurchase program will be implemented judiciously," says Fan.

The firm plans to buy shares in the open market or through privately negotiated transactions from time to time, subject to market conditions and other factors and in compliance with applicable legal requirements. The plan does not obligate Kopin to acquire any particular amount of common stock, and can be suspended at any time at the firm's sole discretion. Kopin has about 67.8 million shares of common stock outstanding.

www.kopin.com

Anadigics ships PAs for Sierra's Compass 885 USB modem

Anadigics Inc of Warren, NJ, USA is shipping production volumes of its AWT6155, AWT6221 and AWT6241 power amplifiers (PAs) to Sierra Wireless for use in its smallest HSPA USB modem (the Compass 885), which features a compact USB design and microSD slot that offers high-speed connectivity for both Mac and PC notebook and desktop computers on HSUPA networks. The Compass 885 is compatible with 3G networks worldwide.

"Anadigics is well positioned to capture 3G market share by leveraging our advanced technology to provide customers with higher-performing EDGE and WCDMA PAs," says Ali Khatibzadeh, senior VP & general manager of wireless business.

The AWT6155 is a quad-band polar EDGE PA module in a 5mm² package (half the size of previous-generation PA modules), reducing RF board area in dual-, tri- and quad-band designs. Designed for 3G mobile products, it has two amplifier chains: one to support GSM850/900 bands and one for DCS/PCS bands. Each amplifier chain is optimized for greater efficiency, power, and linearity in a polar loop environment while maintaining high efficiency in GSM/GPRS mode.

The AWT6221 and AWT6241 are both members of Anadigics' WCDMA PA family and incorporate its HELP3 technology to provide low power consumption without the need for an external voltage regulator. The dual-band AWT6221 combines North American cellular and PCS bands in a 3mm x 5mm package, while conserving printed-circuit board area through the integration of two independent PA chains. The AWT6241 is designed for WCDMA/HSPA wireless handsets and data-card applications in the IMT band, and provides low power consumption without the need for an external voltage regulator or DC/DC converter.

www.anadigics.com

2G transmit module to start shipping for emerging market handsets

At its fourth annual Analyst Day in New York, RF Micro Devices said that it had started high-volume shipments of its RF3283CR, a GaAs-based GSM/GPRS transmit module (TxM) optimized for GSM900/DCS1800 (2G) cellular handsets. The RF3283CR is designed to enhance the performance of system-on-chip (SoC) RF solutions, which integrate the cellular transceiver with the baseband.

Since 2G handsets represent the majority of volume in high-growth emerging markets and are increasingly manufactured using SoC RF solutions, the adoption of SoC solutions in 2G handsets increases the total addressable market for RFMD, which claims that the higher levels of functionality and systems-level knowledge in the firm's cellular front ends enhance SoC RF performance.

The RF3283CR contains a cellular power amplifier, a pHEMT antenna switch and harmonic filtering designed to reduce voltage-controlled oscillator (VCO) pulling and

enhance overall system performance. It also features RFMD's TRP-enhanced PowerStar integrated power control technology, which reduces current variation by about 50% into non-ideal (3:1) loads (also known as antenna mismatch), easing handset implementation for OEMs seeking improved total radiated power (TRP) and specific absorption rate (SAR) performance. RFMD claims that the RF3283CR delivers best-in-class harmonic emissions and insertion loss performance (critical front-end parameters when mated with SoC solutions).

The RF3283CR delivers pin-to-pin compatibility with its high-volume predecessor (the RF3283), easing implementation and accelerating time-to-market of 2G handsets for handset development teams. RFMD expects sequential growth in shipments of the RF3283CR in the December and March quarters. It also expects to release multiple new products in support of SoC solutions in fiscal 2010 (from April 2009).

www.rfmd.com

RFMD to support Samsung 3G platform

Two of RFMD's recently introduced WCDMA/HSDPA cellular front ends (RF3267 and RF6266) have been selected by Samsung to support an upcoming high-volume 3G handset platform. The two front ends are highly integrated, ultra-compact (3mm x 3mm x 0.9mm) standard 3G products designed to support the needs of multi-band, multimode 3G handsets and smartphones.

"Our participation on this high-volume platform underscores our design momentum at Samsung and demonstrates our commitment to supporting their success across all major air interface standards," says Eric Creviston, president of RFMD's Cellular Products Group.

Used in combination, the RF3267 (band 1) and RF6266 (band 5 or 8)

provide a compact solution for multi-band, multimode 3G handsets targeting the North American or European Union (EU) markets.

As a result of the Samsung platform design win and based on multiple customer forecasts, RFMD expects volume shipments to start in the December quarter and increase significantly in 2009.

RFMD is accelerating the launch of new standard products to the open market and is targeting front-end market share gains at multiple accounts in the major 2G and 3G standards. It also expects to capture additional dollar content in 3G, as increasingly complex 3G multimode handsets require additional content, including duplexers, filters and front-end power management.

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TriQuint unveils RF transistors with 50% efficiency and 10–50W output across 0.5–3GHz bandwidth

At the MILCOM (military communications) conference and exhibition in the San Diego Convention Center, RF product manufacturer and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA unveiled its new PowerBand family of high-power discrete RF transistors for broadband applications (including radar, signal jammers and wireless communications).

"A traditional high-power RF transistor is designed to operate across a narrow frequency range, such as 2.53–2.65GHz," says PowerBand co-inventor Bill McCalpin, who is general manager of TriQuint's Colorado Design Center (formerly Peak Devices Inc of Boulder, CO, for which McCalpin was CEO until it was acquired by TriQuint in September 2007). "Within that range, it delivers power relatively efficiently. But as bandwidth increases, performance falls," he explains. Existing broadband market solutions therefore trade off performance (efficiency or power) to achieve wide-band service.

In contrast, PowerBand technology (a development of Peak Devices' WiMOS technology) is flexible enough to be applied to most common RF transistor semiconductor processes, including not only silicon RF LDMOS but also gallium arsenide E/D (enhancement/depletion-mode) pHEMT as well as gallium nitride technologies.

The first range of six PowerBand transistors launched at MILCOM consists of: a 30W LDMOS transistor operating at 500MHz–2.0GHz and 28V with a power added efficiency (PAE) of 60%, plus five pHEMT transistors with efficiencies of 50%: 30W and 50W pHEMTs operating at 28V and 500MHz–2.0GHz; a 20W pHEMT operating at 28V and 500MHz–2.5GHz; and 10W and 20W pHEMTs operating at 12V and 500MHz–2.7GHz and 500MHz–3.0GHz, respectively.



TriQuint's PowerBand device.

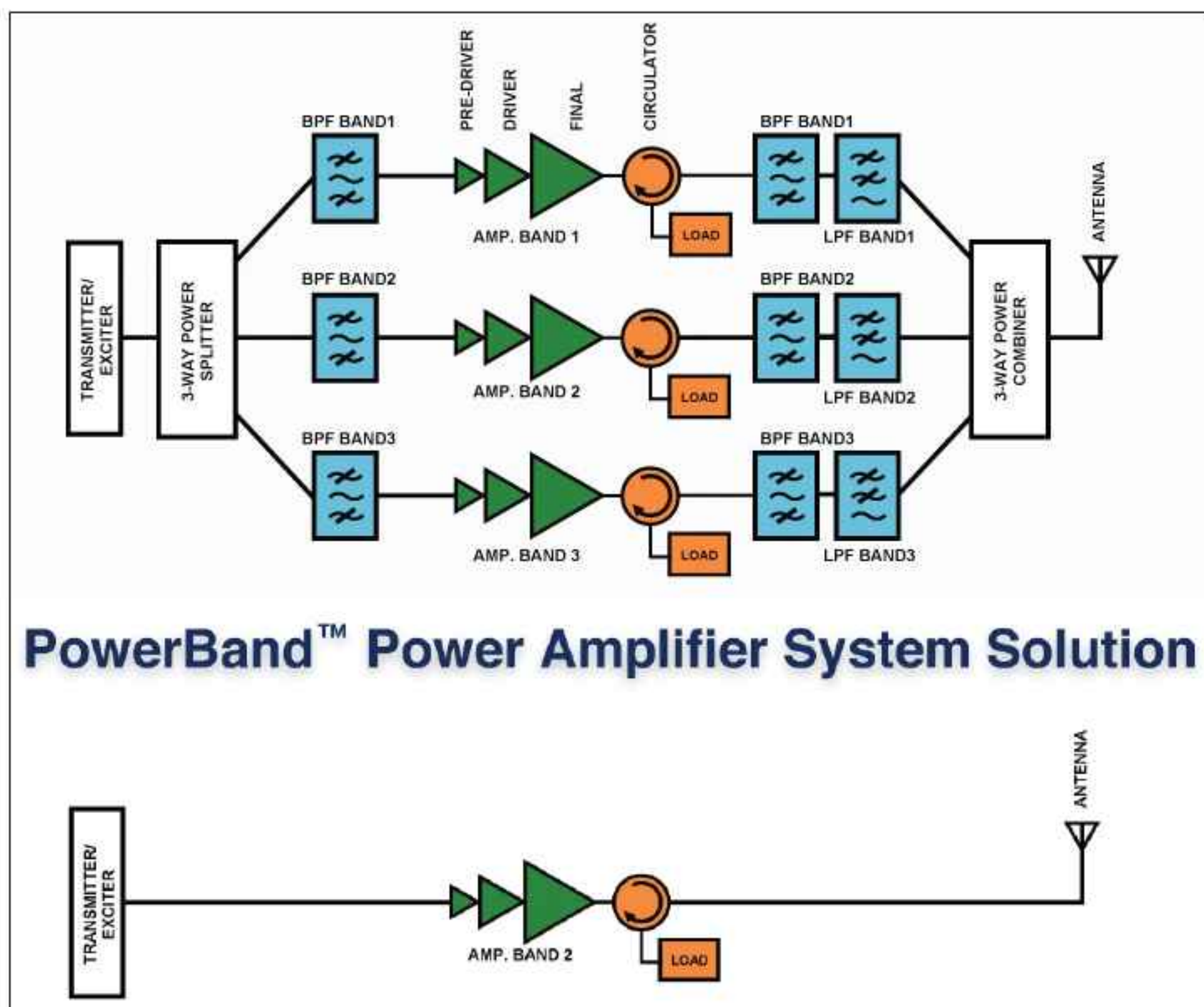
"PowerBand is totally different in its ability to deliver high power (up to 50W) and high-efficiency performance (50% power added efficiency, typical) across a much wider frequency range, from 500MHz to 3GHz [as measured in a broadband fixture]," McCalpin claims.

"PowerBand is disruptive technology, and as such there are sure to be some skeptics," acknowledges president & CEO Ralph Quinsey.

"But the proof is here. We've achieved results that are reproducible and manufacturable," he states.

TriQuint reckons that PowerBand enables savings in space, cost and energy. Because the technology efficiently delivers high power across what is claimed to be unprecedented bandwidth without the traditional sacrifices in efficiency or other key performance parameters, an RF design may require only one transistor line-up instead of several, cutting the bill of materials and size of end-user products by shrinking the space dedicated to RF, says Quinsey.

Many broadband defense and military programs could benefit from new technology, reckons TriQuint. One PowerBand transistor amplifier line-up (containing 2–4 devices, covering an entire band) can replace three or more traditional transistor amplifier line-ups (each containing 2–4 devices). ▶



PowerBand™ Power Amplifier System Solution

RF power amplifier designs using (top) traditional high-power RF transistors and (bottom) a PowerBand transistor.

So, in typical applications, just 2–4 PowerBand devices could replace 6–12 conventional RF transistors.

PowerBand devices have been reviewed by companies that require high-power broadband RF transistors for their designs, including Milpower Inc of El Cajon, CA, USA, a supplier of RF power systems for defense, military and aerospace contractors. "The improved efficiency and bandwidth will pay system dividends in the form of less PCB area dedicated to RF, longer battery life, the opportunity to re-shape end products and reduce size, as well as less need for thermal management," says Milpower's senior development engineer Dean Schulze.

TriQuint says that PowerBand also enables greater efficiency for both mobile devices (extending battery life and reducing system overheating) as well as ground-based RF networks infrastructure (reducing waste heat, which can cut power costs and carbon footprint from heat removal).

There are sure to be some skeptics, acknowledges president & CEO Ralph Quinsey. But the proof is here. We've achieved results that are reproducible and manufacturable

while also cutting the amount of equipment dedicated to thermal management). For both mobile and ground-based RF systems, PowerBand can allow a smaller bill of materials and inventory overhead, as well as simpler and faster assembly, reckons TriQuint. "This innovation can enable new usage models and cost points for a broad range of wireless products," says McCalpin.

Prototype PowerBand devices and evaluation boards (enabling testing of performance across 500MHz–3GHz) are now available; product delivery is scheduled for second-quarter 2009.

www.triquint.com/powerband

New site doubles size of TriQuint's North Carolina Design Center

RF product manufacturer and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA says that its design center in High Point, North Carolina has moved into a new facility to accommodate its growing handset business.

The center opened two years ago with one person and now hosts a team of RF engineers. The team, with a dozen patents and more than 300 years of collective experience in electrical engineering and technical support, develops TriQuint's latest module solutions for mobile phone makers. The new facility is double the size of the first location and will accommodate future growth.

"The new facility has state-of-the-art equipment to complement our

strong RF engineers in developing world-class solutions for our growing customer base," says Darrell Epperson, manager of TriQuint North Carolina.

To augment the North Carolina Design Center's products, technologists at TriQuint's facilities in Oregon, Massachusetts, Florida, and Munich, Germany design the firm's other handset product families, including 3G solutions that have been adopted by most of the major smart-phone manufacturers. TriQuint's mobile handset business uses the firm's broad in-house technology portfolio to design and develop RF front-end solutions including power amplifiers and integrated transmit modules.

www.triquint.com

IN BRIEF

Quinsey named 'CEO of the Year'

TriQuint Semiconductor's CEO Ralph Quinsey has received the Portland Business Journal's 'CEO of the Year' award for technology companies in Oregon. The award was presented at the journal's Annual Most Admired Companies Award Luncheon, attended by more than 800 executives of Oregon's top companies. Quinsey will also be profiled in the 'Most Admired Companies' special publication of the Portland Business Journal.

"Ralph stood out as the technology executive of the year for several reasons, including the company's strong recent financial performance and the positive changes he's made in the company's culture," said editor Rob Smith. "TriQuint also has a strong reputation for customer satisfaction and quality products," he added. TriQuint recently reported third-quarter revenue up 47% sequentially to a record \$186.3m, and major design wins are ramping in 3G mobile phones and wireless-enabled laptops.

www.triquint.com



M/A-COM launches 50W broadband WiMAX/Wi-Fi switch

At November's Electronica 2008 event in Munich, Germany, M/A-COM Technology Solutions Inc of Lowell, MA, USA launched a new high-power (50W) broadband PIN diode switch for WiMAX and Wi-Fi applications.

"With the global demand for high-speed wireless applications growing almost daily, it was imperative that we design and deploy a high-power PIN diode switch that is totally compatible with the latest technologic standards," says Kevin Harrington, HMIC business development for M/A-COM Technology Solutions.

The MASW-000834-13560T PIN diode is a 50W SP2T broadband, high linearity, common anode T/R switch that is suited to high-power WiMAX and Wi-Fi applications. With a 4mm MLP package, it offers wide-band 0.05–6.0GHz performance with good isolation to loss ratio for both Tx and Rx states. The PIN diode provides 50W CW power handling, 65dBm IIP3 at 2010MHz.

www.macom.com

Avago launches first complete GPS RF front-end module with FBAR filters

Avago Technologies of San Jose, CA, USA has launched what it claims is the first complete GPS RF front-end module with FBAR (film bulk acoustic resonator) filters.

The ALM-1712 effectively integrates a GPS low-noise amplifier (LNA) and two FBAR filters, resulting in a complete, compact and high-performance GPS RF front-end module that simplifies the design of a wide range of GPS applications, the firm claims. The module is designed for the 1.575GHz frequency band, targeting handset GPS, recreational and in-vehicle GPS receiver and GPS antenna applications.

Simultaneous GPS, and other location-based GPS services, requires a high level of receiver sensitivity. Avago claims that the ALM-1712 delivers very low noise figures, high linearity and superior out-of-band rejection performance. By integrating a GPS LNA with pre and post high-rejection FBAR filters, the device simplifies and shortens the

RF design process, reduces component count, and provides RF performance levels that are critical in the use of GPS applications, the firm adds.

The ALM-1712 is housed in a miniature 4.5mm x 2.2mm x 1.0mm molded chip-on-board (MCOB) package, reducing PCB space by more than 50% compared to a discreet-only solution. The integration of FBAR filtering enables the module to reach more than 85dBc of cell/PCS-band rejection levels. The ALM-1712 also effectively leverages Avago's 0.5µm GaAs enhancement-mode pHEMT process to deliver a 1.7dB noise figure, 13.5dB gain, and +5dBm IIP3 (input third order intercept point) at typical operating condition of 2.7V and 8mA. At low voltages down to 1.8V, the module can still achieve a very low noise figure and high linearity, suiting use in low-power GPS applications.

www.avagotech.com

Infineon SiGe IC used in Bosch automotive radar system

Infineon Technologies of Neubiberg, Germany says that a chip from its RASIC (Radar System IC) product family is being used by automotive component maker Robert Bosch in its next generation of automotive radar systems, the new LRR3 (third-generation long-range radar). Volume manufacture of the radar chip at Infineon is set to start at the end of 2008, with production startup at Bosch planned for early 2009.

The LRR3 has been developed for adaptive cruise control (ACC) at ranges up to 250m, as well as predictive radar-based safety functions such as predictive brake assist systems, collision warning features and automatic emergency braking.

Infineon is using silicon-germanium (SiGe) technology to fabricate the radar chip, enabling smaller and more cost-effective radar sys-

tems than were possible with components based on more costly gallium arsenide technology, the firm claims.

"The LRR3 radar system was specially developed for high-volume driver assistance systems, and for the first time makes use of silicon-germanium as the semiconductor material," says Dr Dirk Freundt, LRR3 project manager for Bosch. "By employing Infineon's innovative radar chips and avoiding the use of costly special-purpose semiconductors, it has been possible to significantly enhance the functionality of the Bosch sensor, and considerably reduce system costs," he adds. "Bosch is also looking to bring the radar sensor and its functions into the mid-range and compact class, where it could soon be part of a car's standard equipment."

Infineon is Europe's number-one supplier of chips for automotive electronics and, according to a study conducted in May by market research firm Strategy Analytics, has a 9.4% share of a total market worth about \$19.3bn. The radar chips from Infineon's RASIC family were developed and qualified specially for use in cars. Bosch and Infineon have achieved full automotive qualification for the LRR3 radar system.

Strategy Analytics expects that, by 2011, of the three million vehicles with remote warning systems, 2.3 million will use radar systems. By 2014, 7% of new cars could be equipped with a remote warning system, predominantly in Europe and Japan.

www.infineon.com/radar

www.bosch.com

Mitsubishi Electric launches low-noise GaAs HEMT for satellite digital radio and direct broadcast satellite

Tokyo-based Mitsubishi Electric Corp says that it has developed the MGF4921AM, a low-noise GaAs HEMT suitable for low-noise amplifiers in receiver systems for satellite digital radio as well as C-band direct broadcast satellite (DBS).

Satellite digital audio radio service (SDARS), which since 2001 has become commonplace in North America, does not require tuning to adapt to regional broadcasting like analog radio services, attracting the use of SDARS in automobiles for information services such as traffic information and entertainment programs. With similar digital audio broadcasting (DAB) data services also expected to start in other regions of the world, the satellite digital radio market is expected to grow globally in the near future.

At the same time, regarding receive systems for satellite digital radios, a reception converter inside the

antenna receives S-band (2–4GHz) waves from satellites and converts them into a mid-frequency band of 0.8–1.5GHz to send them to the signal processing circuit. There is increasing demand for HEMTs, used in low-noise amplifiers for these converters and, to improve radio sensitivity, there is a need for higher-performance low-noise HEMTs.

Mitsubishi Electric says that it is difficult to balance stability and low-noise characteristics when using 12–20GHz low-noise GaAs HEMTs for low-frequency bands. But, by optimizing the gate width and improving stability for low frequency bands, it has improved the device noise figure to 0.35dB, which is claimed to be an industry-best and 0.1dB lower than the firm's 12GHz model (the MGF4953AM, launched in late May), when measured at 2.4GHz on a stable matching circuit. Using the MGF4921AM in the

first stage of amplifiers (which demands low-noise characteristics) improves the sensitivity in reception converters for satellite digital radios, helping to expand the radio coverage area and to decrease production costs in reception converters, Mitsubishi Electric claims.

The MGF4921AM is housed in an industry-standard 4-lead full-mold package. An unchanged footprint pattern from the previous model should shorten development periods for satellite communication equipment makers, the firm reckons. The sample price is 30 yen. Shipment will begin on 26 January, with production at 500,000 units per month.

Mitsubishi Electric says that, for the second and third stages of amplifiers, it will add to its lineup of low-noise GaAs HEMTs with improvements in output power and distortion characteristics.

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IN BRIEF

Microsemi delivers 4G wireless PA with power-conversion efficiency of 23%

Microsemi Corp of Irvine, CA, USA, which designs and makes analog and mixed-signal ICs and high-reliability semiconductors, has announced production of its LX5537 power amplifier (PA) for IEEE 802.16e WiMAX and WiBro 4G wireless applications using the 2.3–2.9GHz frequency range.

Operating from a single-polarity 3.0–4.2V supply, the LX5537 delivers what is claimed to be best-in-class power-conversion efficiency of 23%, power gain of 31dB or higher, and output power of 25dBm for 3% EVM (3.3V), extending the firm's RF wireless LAN portfolio into next-generation wireless network applications.

"With engagements at the leading 4G OEMs [original equipment manufacturers], our new LX5537 WiMax power amplifier solves the common problems encountered in mobile and customer premises equipment (CPE) WiMAX designs, including challenging performance requirements, solution cost and PCB area," claims Kang Hee Kim, RF product line manager at Microsemi's Analog Mixed Signal Group. The new 802.16e PA joins the firm's line of 802.11a/b/g and 802.11n power amplifiers in its RF portfolio. Microsemi recently surpassed 75 million shipments in 802.11 a/b/g and the latest 802.11n networks.

Offered in a small 3mm x 3mm x 0.9mm 16L QFN package, the LX5537 features a temperature-compensated on-chip output power detector with a wide dynamic range to implement power control with minimum BOM cost and PCB area. The 26dB attenuation function can optionally be used to reach low gain mode.

www.microsemi.com

HRL demos first RF graphene FETs

HRL Laboratories LLC of Malibu, CA, USA says that it has demonstrated the first RF graphene field-effect transistors (FETs), the first milestone in the proposed 51-month, three-phase program 'Carbon Electronics for RF Applications' (CERA) to develop a new generation of carbon-based RF integrated circuits for ultra-high-speed, ultra-low-power applications.

HRL is collaborating with a group of universities, commercial companies and the Naval Research Laboratory (NRL) on the program, which is sponsored by the Defense Advanced Research Projects Agency (DARPA) and under the management of the Space and Naval Warfare Systems Center (SPAWAR). CERA's goal is to exploit the unique qualities of graphene carbon to create components that will enable unprecedented capabilities in high-bandwidth communications, imaging, and radar systems.

The military's ability to develop sophisticated imaging and communications systems is hindered by RF component cost, limited resolution, and high power dissipation, says HRL. A graphene-on-silicon platform could revolutionize military applications because of its high performance, scalability, integration and low cost, the firm adds.

Graphene is a single layer of carbon atoms densely packed in a honeycomb crystalline lattice configuration. The advantages are its high current-carrying capacity, excellent thermal conductivity and low-voltage operational potential.

While graphene FETs have been demonstrated before, most of them used exfoliated graphene films. "HRL, working with the NRL, demonstrated graphene FETs using epitaxial film operating in the RF frequency range," says Jeong-sun Moon, senior research scientist in

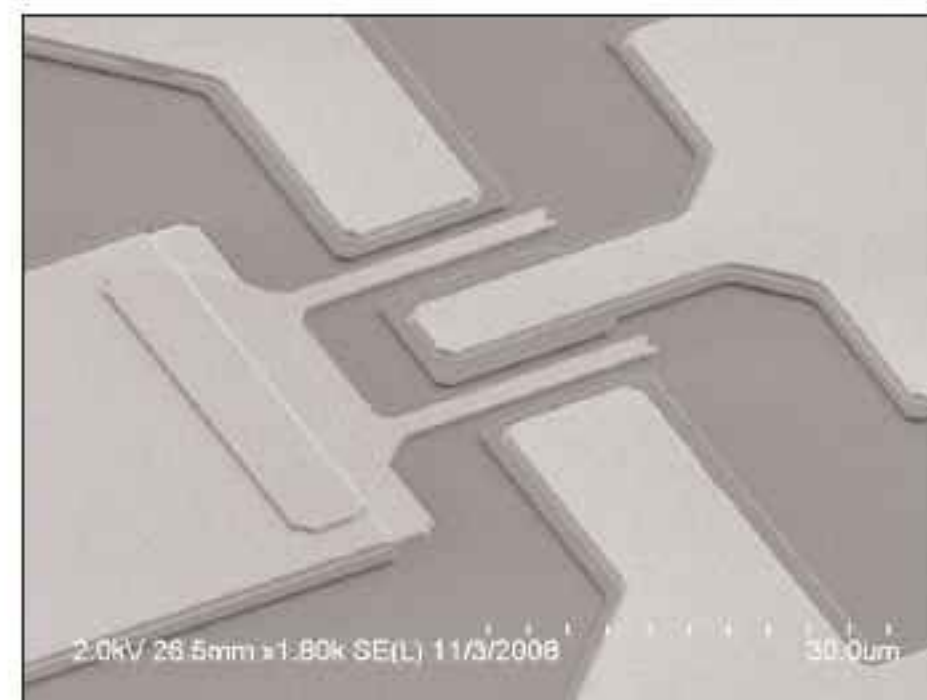


Image of the RF graphene FET, with a gate length of 2µm.

HRL's Microelectronics Laboratory. "This is a key step toward wafer-scale high-speed graphene RF FETs that operate in the RF domain," he adds.

The FETs' on-state current was 1180µA/µm at a drain bias of 1V. RF performance was characterized using an HP8510, yielding an extrinsic current gain cut-off frequency (f_T) of 4GHz with a gate length of 2µm. A record maximum oscillation frequency (f_{max}) of 14GHz was achieved at $V_{ds} = 5V$. The RF speed performance is expected to be improved as the graphene FETs are scaled to sub-100nm gate lengths with reduced parasitic capacitance and resistance.

"The next step will be to continue to optimize material synthesis and device processing to see if we can harness the unique properties of graphene to make a new-generation, state-of-the-art technology for future high-speed, low-cost military RF systems-on-chips," Moon says.

In upcoming phases of the project, the HRL team will fabricate FETs on 100mm-diameter wafers and then scale up the process to 200mm wafers to create a demonstration prototype of the new generation of carbon-based RFICs.

www.hrl.com

www.darpa.mil/MTO/programs/cera

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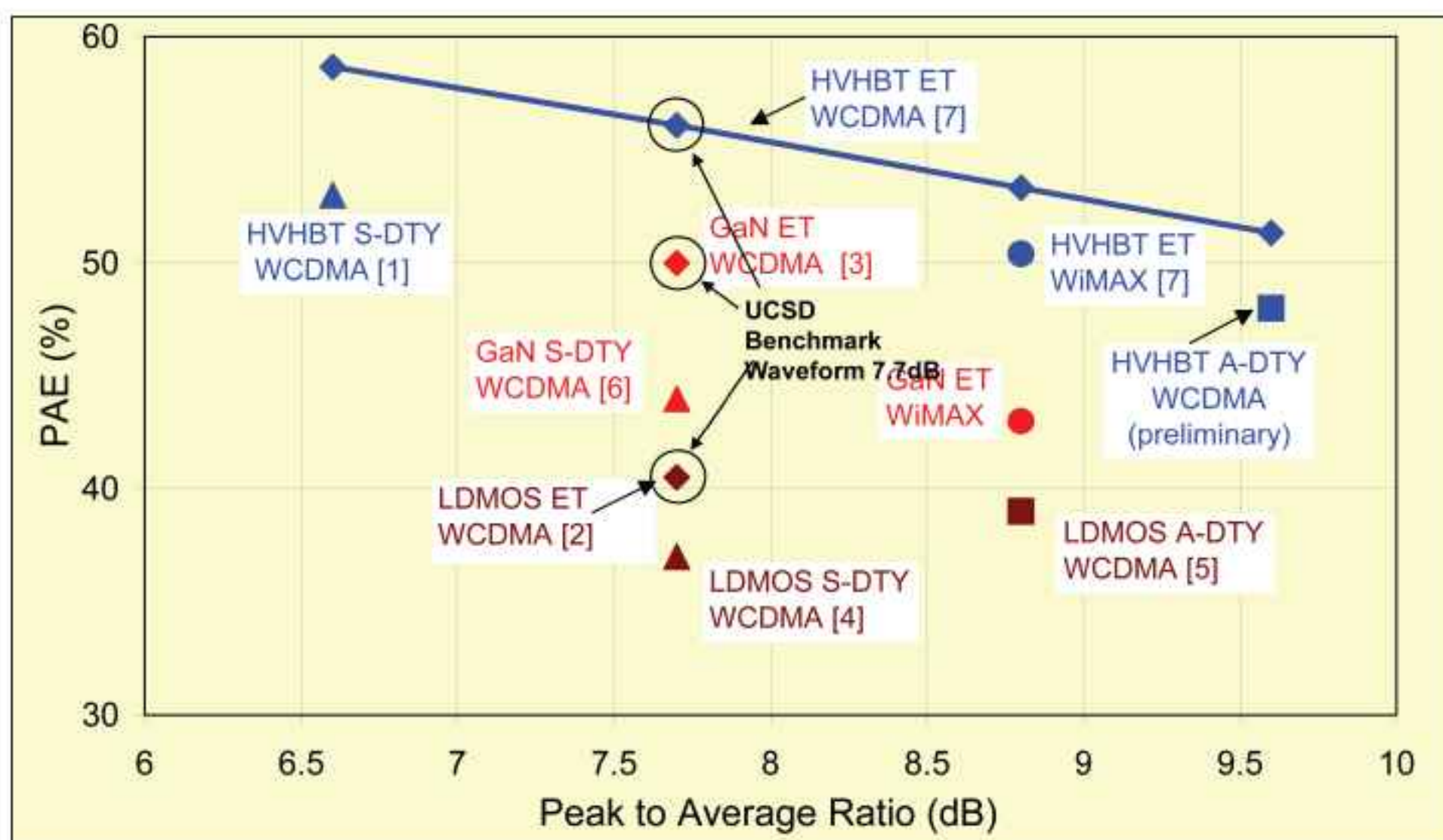
UCSD reports 58% PAE for base-station power amplifiers

Three years after breaking the 50% barrier for power-added efficiency (PAE), at October's 2008 IEEE Compound Semiconductor IC Symposium (CSICS) in Monterey, CA, USA researchers from the University of California, San Diego (UCSD) reported achieving an average PAE of 58% — a record for a single-stage WCDMA base-station power amplifier — with average output power of 42W and a gain of 10.2dB.

Cell-phone reception depends on the strength of signals coming to and from wireless base-stations, the range of which depends on high-power amplifiers that typically have 10% efficiency (i.e. consume ten times more power than they generate). At 58% PAE, 50W of output power would require only 86W of DC power, rather than the 500W required by existing 10%-efficient high-power base-stations. The UCSD study also reports what is claimed to be the best improvement in linearization.

To attain better linearity and the 58% PAE for a WCDMA WiMAX base-station power amplifier, the researchers used high-voltage heterojunction bipolar transistors (HVHBTs) based on gallium arsenide, rather than either the silicon-based technology used in most existing 3G wireless base-stations, or the gallium nitride metal-semiconductor field-effect transistor (MESFET) used to demonstrate the record 50% average PAE in 2005.

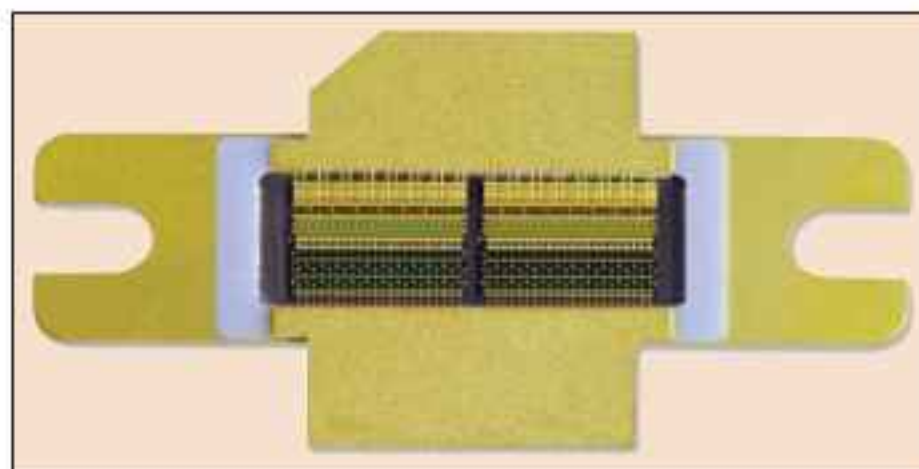
"GaAs HVHBTs are attractive options, since they can provide both high voltage and high efficiency and gain over wide dynamic range signals," says lead author Donald Kimball, principal development engineer at Calit2 (the California Institute for Telecommunications and Information Technology). "Having high efficiency over wide



Efficiency versus peak-to-average ratio for LDMOS, GaN and HVHBT devices.

dynamic range is critical because in 3G systems the demand for power varies widely from instant to instant, given the wide variety of modern cell-phone communications that go well beyond voice calls."

The transistor devices were fabricated using the GaAs HVHBT process of TriQuint Semiconductor Inc of Hillsboro, OR, USA. As with their earlier work, the UCSD engineers combined the heterojunction device with a technique known as envelope tracking, which involves variable power signals instead of the constant feed of DC voltage that is common in high-power amplifiers. The technique adjusts voltage dynamically while reducing the heat generated by the transis-



TriQuint HVHBT module, which exhibits 100W (50dBm) at P1dB: base (bottom lead) collector (top chamfered lead) and emitter (flange).

tor and allowing the amplifier to operate closer to saturation.

"TriQuint provided Calit2 with 15 transistors with a custom on-package match for Envelope Tracking Technology," says Kimball. "They also sent their top engineers to our facility to work with our students on the project." Indeed, the paper presented at CSICS was co-authored by three TriQuint engineers (Craig Steinbeiser, Thomas Landon and Oleh Krutko). Co-authors at UCSD include Jacobs School of Engineering electrical and computer engineering (ECE) professors Peter Asbeck and Larry Larson, as well as ECE graduate students Myoungbo Kwak, Jinho Jeong, Chin Hsia and Paul Draxler (who is also an engineer at Qualcomm Inc). The record was achieved during tests in the High-Power Amplifier Laboratory of Calit2's UCSD Division.

According to UCSD, there are two wireless infrastructure manufacturers — Finland's Nokia and China-based HuaWei — that have already expressed interest in the findings of the research.

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Fujitsu reports record 320W C-band power amplifiers

At the 2008 IEEE Compound Semiconductor IC Symposium (CSICS) in Monterey, CA, USA in October, Tokyo-based Fujitsu Laboratories Ltd reported the development of two RF amplifiers based on GaN HEMTs with record power output in the C-band: one with 320W output and 57% efficiency; one with 250W output and 60% efficiency. These both far outperform the previous record of 220W per package (Figure 2).

Using GaN HEMT technology boosts output power over existing amplifiers using GaAs transistors by more than six-fold (in the case of the 320W amplifier), says Fujitsu, and should enable the extension of transmission range 2.4-fold. In addition, replacing conventional traveling-wave tube amplifiers (vacuum tubes commonly used for high-output-power microwave applications) with this new technology should enable smaller, lighter, more energy-efficient and longer-lasting transmission systems. Transmission at C-band frequencies (4–8GHz) is relatively unaffected by rainfall and fog, and applications include satellite and fixed wireless communications, wireless access, next-generation mobile phone base-stations, air-traffic control radar, and weather radar.

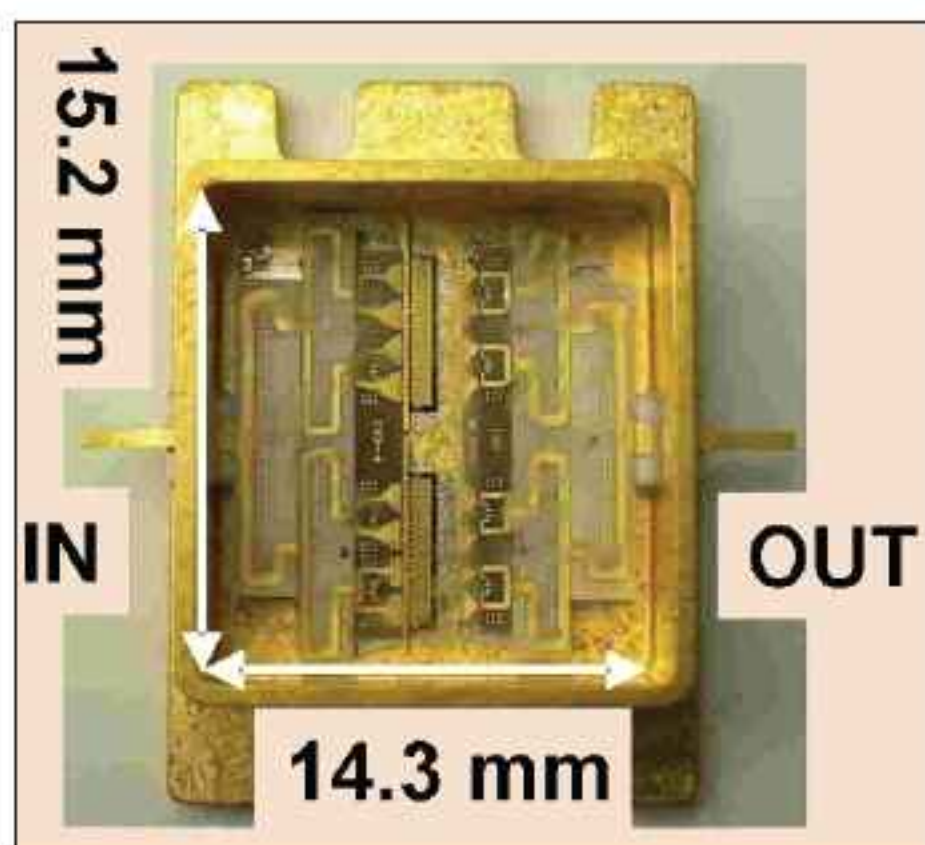


Figure 1. C-band GaN HEMT amplifier.

In particular, high-output-power microwave transmitters are needed to increase the capacity of satellite communication transmissions and extend radar detection range. Since traveling-wave tube amplifiers are based on vacuum tubes, they have shorter life spans than solid-state devices and are larger and heavier as they need high-voltage sources. Solid-state amplifiers based on GaAs transistors can provide only low output from a single element due to their low breakdown voltage, requiring composite output from many transistors to achieve adequate transmission power. The loss due to composite circuitry results in reduced efficiency. By comparison, amplifiers using GaN HEMTs have

higher output power and heat dissipation than GaAs transistors.

Transistor chips for high-output amplifiers are configured with multiple transistors arrayed in parallel. With a single input and output, the signals that move along the chip center and along the edges traverse different lengths of wired lines, inducing a phase difference. So, transistors are operating out of phase with each other, making it difficult to fully maximize the high-output-power characteristics inherent in the transistors.

Fujitsu's new C-band GaN HEMT amplifier consists of two transistor chips that resolve this while giving high output. Use of multi-divided input pathways prevents the occurrence of phase differences to the input signal between the transistors (Figure 3), enabling GaN HEMTs with high output power densities to operate uniformly and to efficiently combine their output power. Since the use of two chips can sometimes create undesirable thermal interference and raise temperatures (reducing transistor output), the chips are spaced from each other (suppressing mutual interference).

Fujitsu says that the technologies should maximize the full high-power potential inherent in GaN HEMTs.

<http://jp.fujitsu.com/group/labs/en>

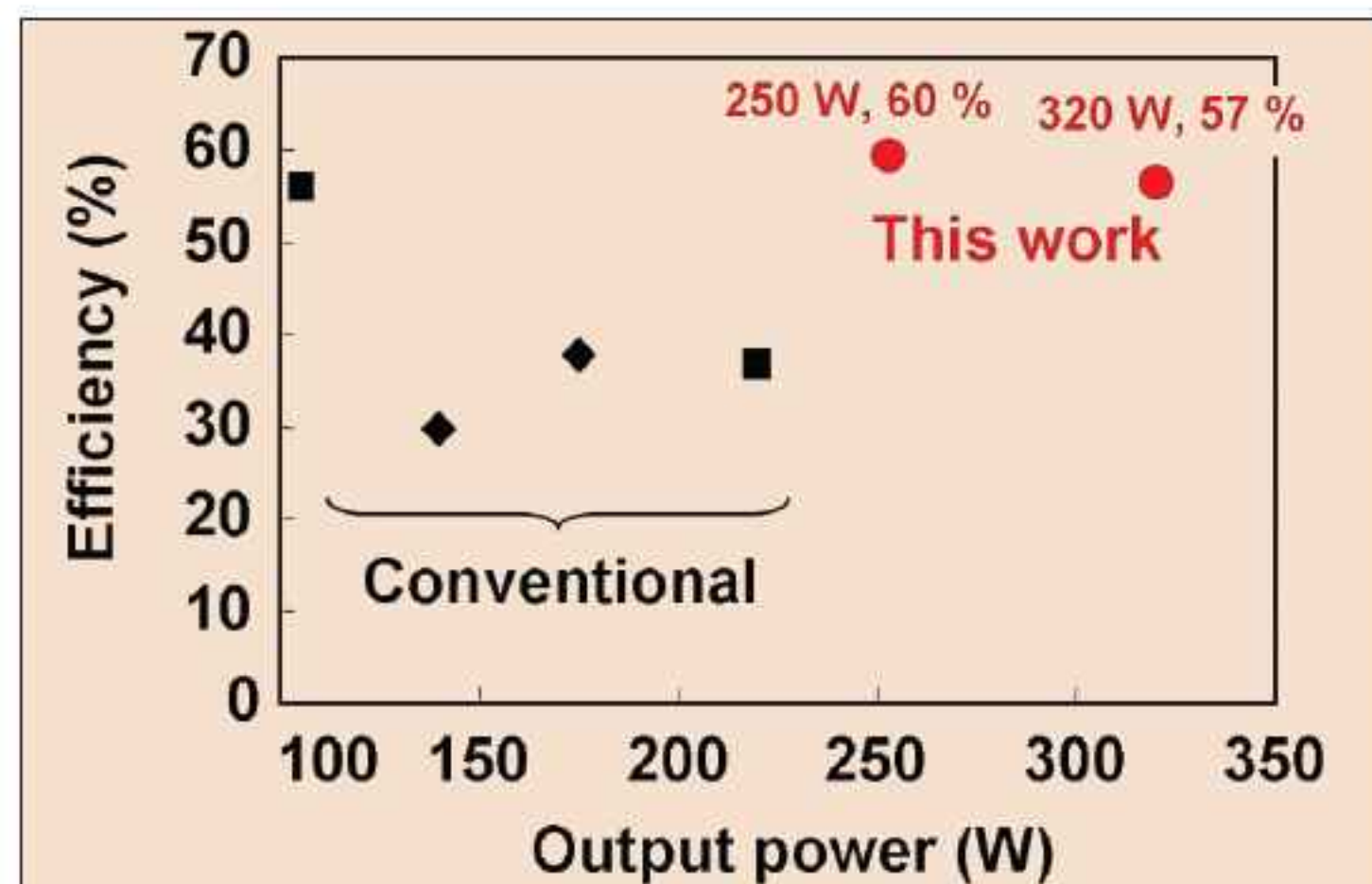


Figure 2. Power vs efficiency for C-band PAs >100W.

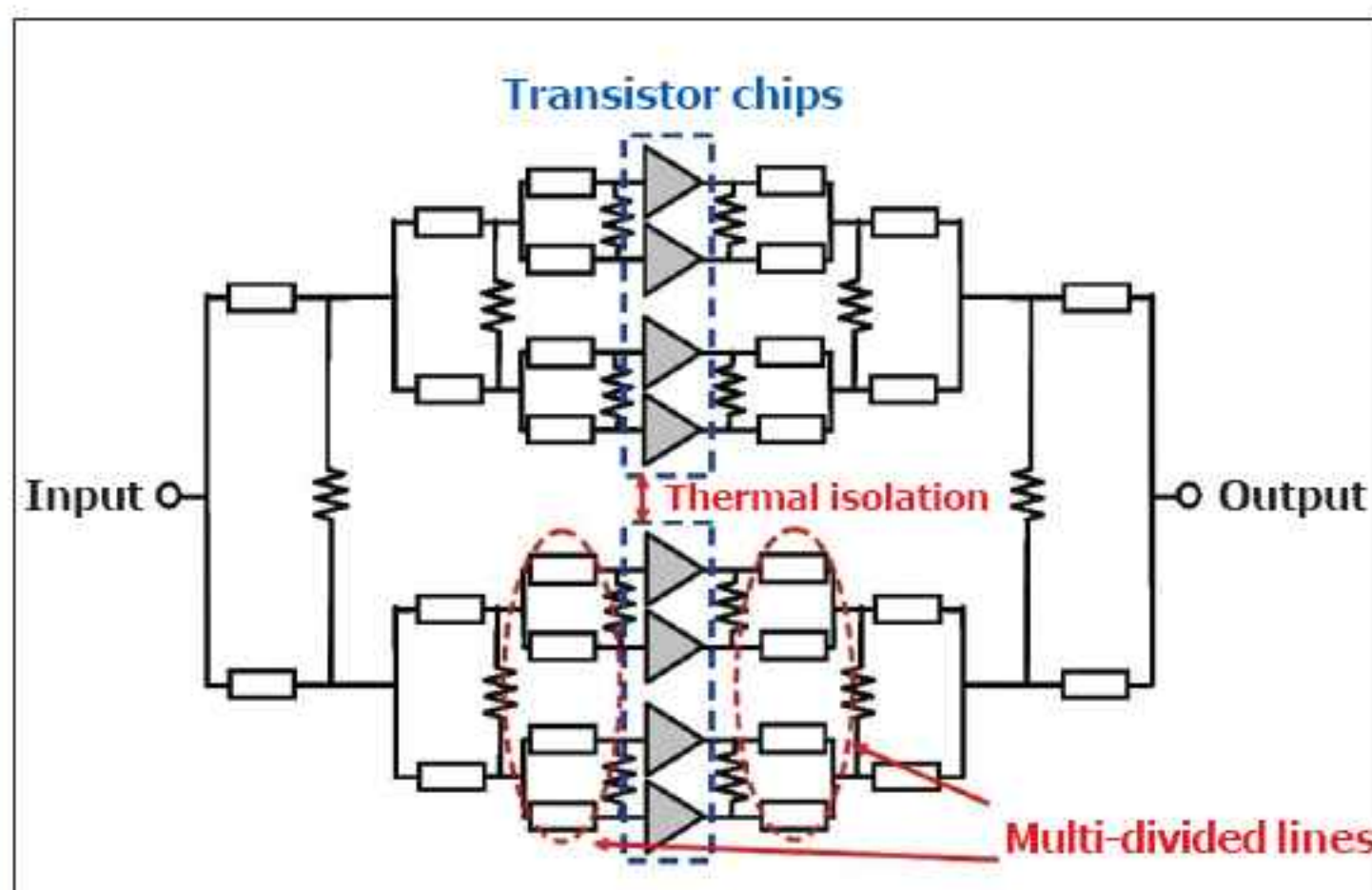


Figure 3: Structure of the amplifier circuit.

Showa Denko acquiring ESICAT's SiC epiwafer business

In response to growing demand for power device applications, Tokyo-based Showa Denko K.K. (SDK) has agreed that, by the end of this year, it will acquire the silicon carbide (SiC) epitaxial wafer business of ESICAT Japan LLP of Tsukuba, Japan.

ESICAT was founded in September 2005 by six individual partners, together with SDK, to use proprietary technology owned by SDK, Japan's National Institute for Advanced Industrial Science and Technology (AIST) and the Central Research Institute of Electric Power Industry (CRIEPI) to develop commercial production of SiC epiwafers for power device applications. AIST supported ESICAT as one of its 'technology transfer ventures', allowing the use of its intellectual property and facilities as well as providing information. ESICAT



ESICAT's 2", 3" and 4" SiC epiwafers.

began selling SiC epiwafers in November 2006, and now supplies 2-, 3- and 4-inch wafers.

SDK and ESICAT have agreed the take-over with a view to expanding the business and encouraging growth in the SiC epiwafer market for power device applications.

Compared with conventional silicon-based devices, SiC-based devices have better performance and are expected to be used increasingly in power conversion devices and inverter modules in

electric power, automotive, railroad, and electrical appliance markets. However, says SDK, the development of SiC devices has been delayed because of the lack of a stable supply of high-quality SiC epiwafers in Japan.

SDK says that it is focusing on R&D of new products that will drive future growth, concentrating managerial resources on six SMU (strategic market unit) projects. The firm adds that developing SiC epiwafers for power devices is a key element of its R&D strategy.

● ESICAT presented its products at an exhibition sponsored by the Japan Society of Applied Physics' professional group for silicon carbide and related wide bandgap semiconductors (8-9 December) in Tokyo.

www.esicat-j.com/eng

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IN BRIEF

Microsemi's SiC RF power devices for VHF and UHF radar win award

Microsemi Corp of Irvine, CA, USA, which manufactures analog/mixed signal ICs and high-reliability semiconductors (using silicon and GaAs), says that its first two RF power transistors using silicon carbide technology for high-power VHF- and UHF-band pulsed radar applications (launched in early October) have been recognized by the editors of Electronic Design magazine as a 'best in 2008' design in their annual product awards issue.

The 0150SC-1250M and 0405SC-1000M are the first parts in a series of SiC RF power transistors that Microsemi is bringing to the market, using a new production capability. Microsemi aims to develop additional high-power SiC devices for applications ranging from HF through to S-band radar.

Microsemi aims to develop additional high-power SiC devices for applications ranging from HF through to S-band radar

Microsemi claims that the new transistors deliver the industry's highest peak power in compact packages — advantages that SiC technology brings to applications in avionics, radar, and electronic warfare.

The two SiC-based products use new Microsemi chip design and processing enhancements to offer high power as well as small transistor and circuit size over the specified frequency range with a 300 microsecond pulse width and 10% duty cycle.

www.microsemi.com

SiCrystal selects Eyelit's MES, quality and asset management software

Single-crystalline silicon carbide (SiC) wafer manufacturer SiCrystal AG of Erlangen, Germany has selected the Enterprise Manufacturing and Quality Suite of Eyelit Inc of Mississauga, Ontario, Canada, a provider of manufacturing software for visibility, control, and coordination of manufacturing operations.

Eyelit's solution replaces an internally developed system, improves product visibility and supports increasing production volumes. Systema GmbH will lead the implementation of Eyelit's solution at SiCrystal, as well as provide local European product support.

"We found the Eyelit solution much more flexible and a better fit for our IT architecture," says SiCrystal's production manager Erwin Schmitt. "We needed better operational information, especially detailed material and equipment information; we also felt we could implement Eyelit faster than other solutions at a much lower cost. In addition, Eyelit's solution is much easier to manage and one that could expand with our growing business. We also liked the flexibility both Eyelit and Systema showed

during the sales process and feel confident they are the right partners for SiCrystal for this mission-critical manufacturing solution," he adds.

"We already have several projects underway with Systema, encompassing MES [manufacturing execution system] implementation, factory automation, and material handling," states Dan Estrada, Eyelit's VP of sales & business

Eyelit's solution replaces an internally developed system

development. "This selection expands Eyelit's successful distribution partner network. We will be adding partners in Asia soon,

as we continue our rapid growth and global expansion," he continues.

"Eyelit offers a proven solution which takes advantage of new technologies, such as open-source Linux. This allows for dramatically lower costs than legacy MES solutions, which require fixed, complex architectures running on older platforms such as VMS and are written in either Cobol or Fortran."

www.eyelit.com

SemiSouth receives SBIR contract to develop high-speed SiC JFETs

SemiSouth Laboratories Inc of Austin, TX, USA, which designs and manufactures silicon carbide (SiC) based discrete electronic power devices and epiwafers, has been awarded a Small Business Innovative Research (SBIR) Phase I contract related to high-efficiency SiC power electronics, based on the US military's increasing need for high-voltage, high-frequency power transistors. The award was the result of work that was led by Drs Dave Sheridan and Mike Mazzola.

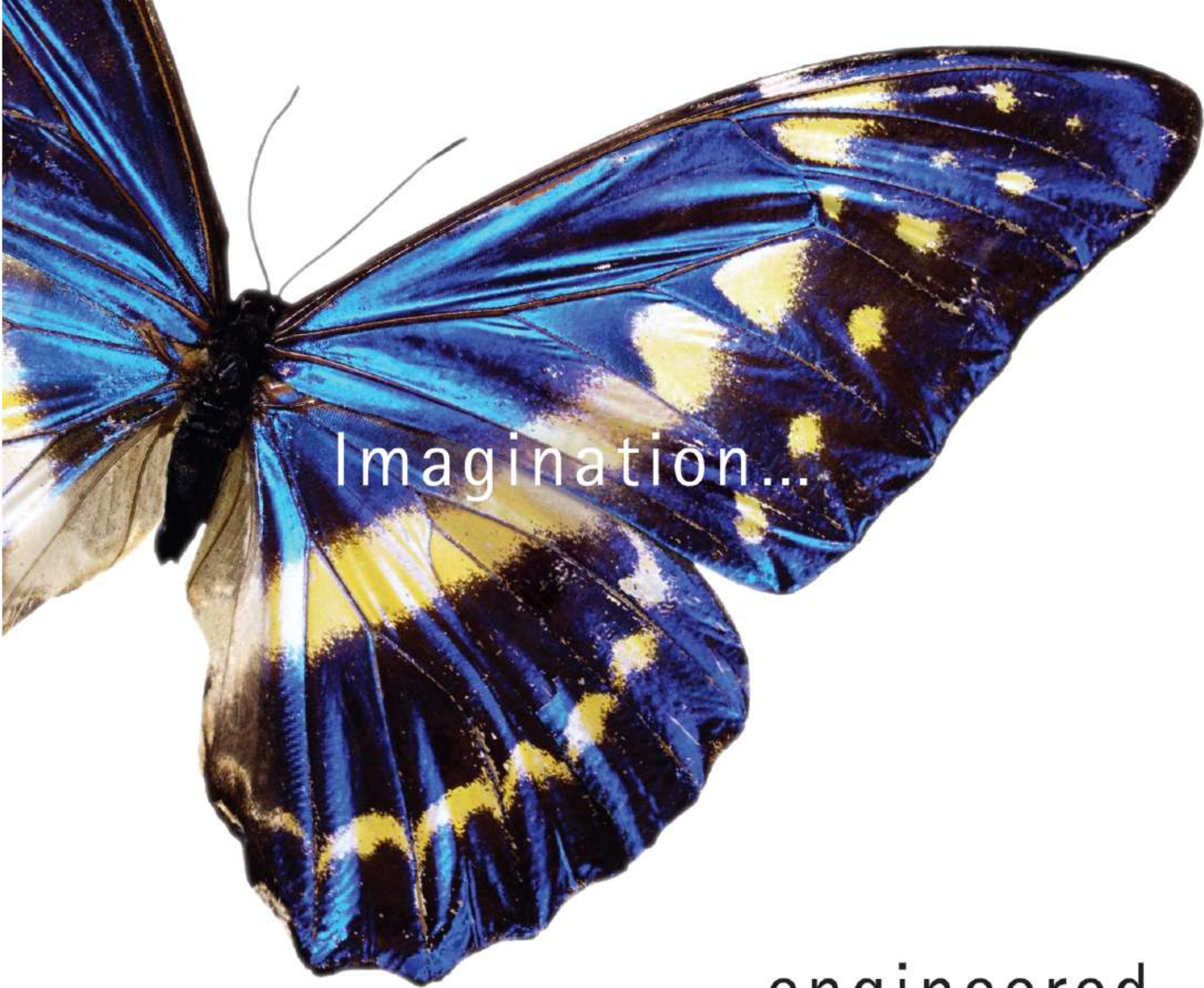
"This award will help fund a new class of high-speed JFETs, with

blocking voltages of 2kV," says Sheridan, who is SemiSouth's director of engineering. "In addition to Navy applications, these devices will be well suited for renewable markets such as solar and wind," he adds.

Since its formation in 2000, SemiSouth has received 17 Phase I or Phase II SBIR/STTR contracts (including this latest) related to SiC device development.

Work on the project is already underway, and results are expected in first-quarter 2009.

www.semisouth.com



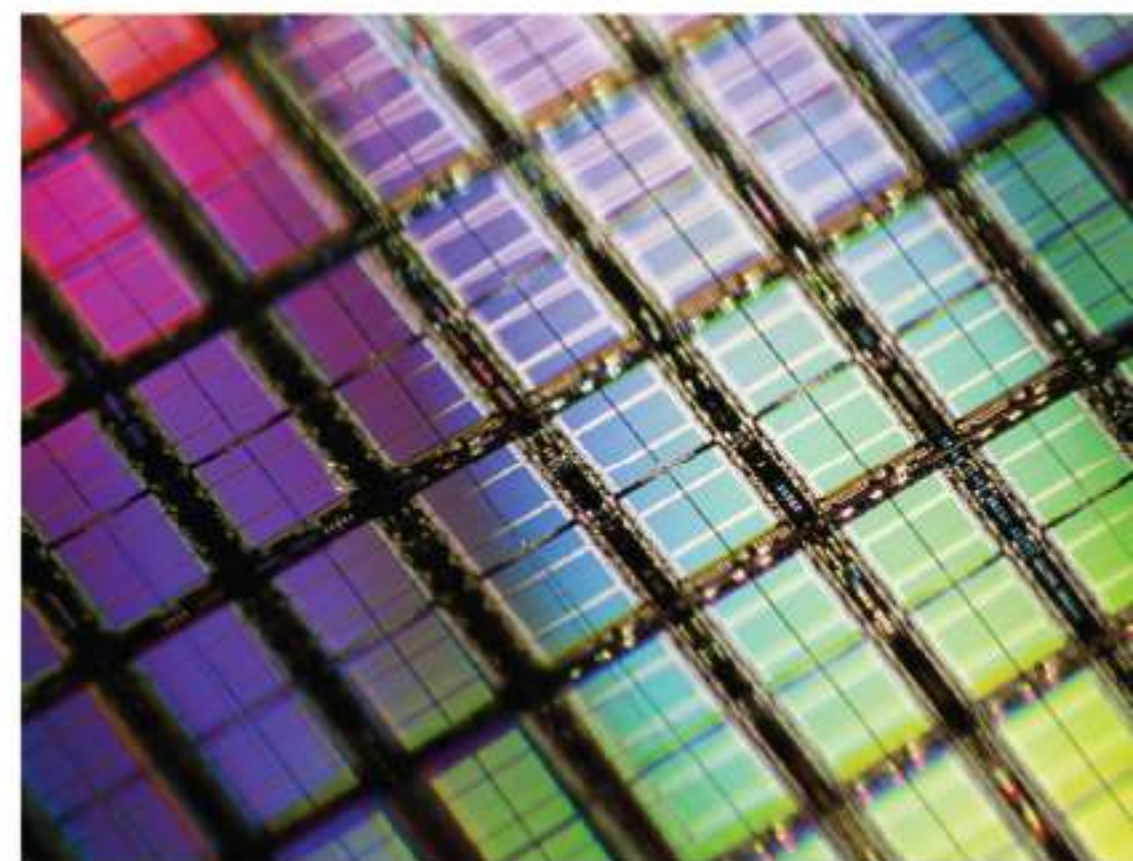
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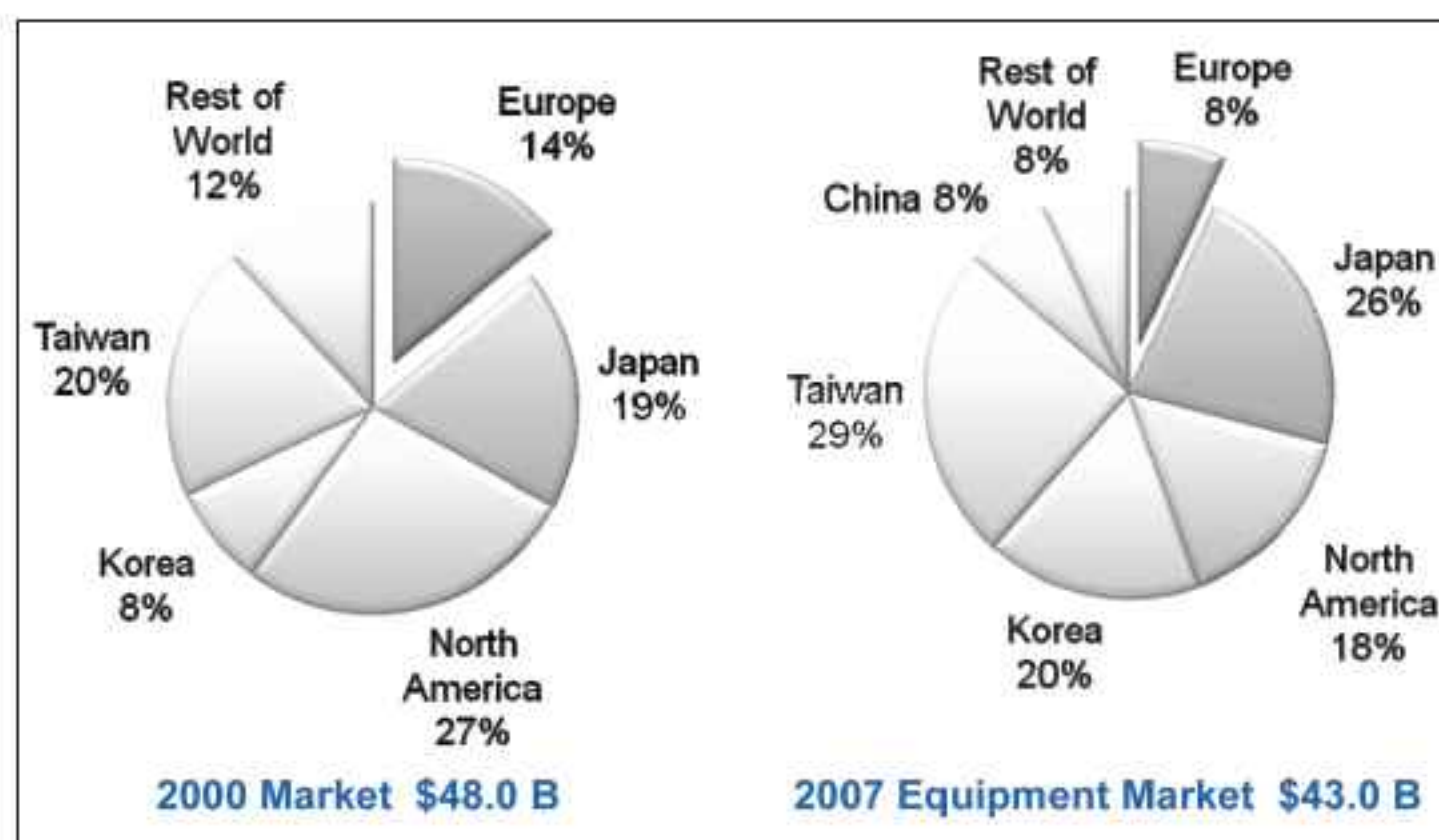
Decline in European semiconductor industry endangering half a million jobs

During the 3rd SEMI Brussels forum, SEMI Europe (the European branch of global industry association Semiconductor Equipment and Materials International) presented EU officials with its SEMI White Paper, which warns that the decline in the European semiconductor industry could put as many as half a million European jobs at risk. It also

makes six recommendations **Decline in European semiconductor equipment market.** calling on EU and national

polycymakers urgently to invest to support the industry, given its primary importance to the health and global competitiveness of the EU economy.

Equipment & materials suppliers contribute €9bn and semiconductor device makers €20bn (€29bn collectively) directly to the EU economy and provide around 215,000 direct jobs (105,000 in equipment & materials; 110,000 device making), which rises to half a million jobs including indirect jobs. The European semiconductor industry value chain provides a significant contribution to the gross domestic product of 11 EU countries, particularly Austria, Belgium, France, Germany, Ireland, Italy, the Netherlands, and the UK. For example, in Germany, 80% of its exports are dependant on ICT, and semiconductors enable 10% of its GDP. However, the importance of this value chain to EU growth and competitiveness goes beyond the industry itself, and is instrumental in providing European firms in key industries (e.g. energy, transportation, telecoms, defence, aerospace, medical equipment and biotechnology) with the products that help them to remain competitive in globalized markets. One estimate puts the semiconductor industry at the origin of 90% of innovations made in these key sectors of the European economy.



However, despite comprising 45 countries with 37% of the world's GDP, Europe's share of the global semiconductor device market fell by almost a quarter, from 21% in 2001 to just 16% in 2007 (the smallest share of any region). European semiconductor manufacturing has also been contracting again by almost 25% in just two years from 2005 to 2007. Also, on 19 November the Semiconductor Industry Association in the USA predicted a slump in global semiconductor sales for 2009 which risks exposing Europe's position further.

The decline of market share, despite the continuous increase in total volumes sold, is also a reflection of the role played by manufacturing, which is differentiating and moving away from Europe due largely to the unfavorable global economic conditions. European semiconductor equipment and materials suppliers are mostly small- and medium-sized indigenous European businesses that rely on a future European semiconductor industry to guarantee their own future and that of the 105,000 European jobs they represent.

"If semiconductor manufacturers leave Europe, indigenous equipment & materials producers will face an uncertain future," said Franz Richter, chairman of the SEMI European Advisory Board. "The current economic crisis and rising

unemployment underscore the urgent need to safeguard jobs in the European semiconductor industry. Supporting a robust and competitive semiconductor industry in Europe is critical to keeping jobs in Europe across all industries and supporting key European economies," he adds.

SEMI says the Brussels forum showed that there are opportunities ahead that Europe can and must grasp

to stay competitive, requiring leadership and coordination in terms of devising sector-specific industrial innovation policy solutions at both EU and EU Member State level.

During the forum, SEMI's European Advisory Board hence made eight visits to the European Parliament and Commission, meeting over 40 officials, including Viviane Reding, the Commissioner for Information Society and Media, to express the need to support a more competitive European semiconductor industry.

In particular, at the forum, on behalf of the European Semiconductor Industry Association (ESIA), Enrico Villa (senior advisor to the CEO and COO of device maker STMicroelectronics NV) highlighted how major European OEMs' semiconductor spending worldwide in 2006 was \$14.7bn for wireless applications (a 34% share of the global total, with as much as \$9.4bn in Europe), \$6.7bn for automotive applications (a 43% share), and \$1.5bn for medical applications (a 52% share), compared to just \$4bn for computers & peripherals (an 8% share). Europe therefore presents a major semiconductor market for applications such as wireless, where compound semiconductor technology can increasingly provide a refuge for device makers hit by the consumer-driven downturn in silicon markets.

www.semi.org/BrusselsForum



www.iqep.com

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SDK forms China JV for making ammonia

Showa Denko K.K. (SDK) says that it is establishing a joint venture (JV) in Quzhou, Zhejiang Province, China to produce high-purity ammonia for the electronics industry at a capacity of 500 tons per year, with start-up in June 2009 and staffing of about 20. The chairman is Toshio Ohi, director & executive officer of SDK's Chemicals Sector.

The JV, Zhejiang Quzhou Juhua Showa Electronic Chemical Materials Co Ltd, will be owned 51% by SDK, 20% owned by Quzhou-based chemical producer Zhejiang Juhua Co Ltd and 29% owned by its affiliate Zhejiang Jinju Chemical Co Ltd (established earlier this year).

Zhejiang Jinju Chemical will supply the new plant with raw material (industrial ammonia), electricity and other utilities. The JV will use SDK's purification technology for the production of high-purity ammonia and sell all products to companies within the Showa Denko Group.

As well as being used as a nitride-film-forming gas in producing semiconductors, liquid crystal displays, and GaN-based LEDs, ammonia is increasingly used in producing solar cells based on polycrystalline silicon.

SDK says that demand for high-purity ammonia in China is increasing rapidly, reflecting the growth of its electronics industry. Depending on future demand, the firm will consider expanding the plant's production capacity to 1000 tons a year by the end of 2010.

SDK has also expanded capacity at its subsidiary Taiwan Showa Chemicals Manufacturing Co Ltd from 1200 to 1500 tons per year.

SDK says that, by fully utilizing the new plant in China as well as its existing production sites in Japan (Kawasaki) and Taiwan (Tainan), it will strengthen its supply of high-purity ammonia to the growing East Asian market. SDK aims to expand semiconductor-processing materials operation as one of its strategic businesses.

www.sdk.co.jp

Aixtron orders Edwards GaN exhaust treatment systems for lab

Deposition equipment maker Aixtron of Aachen, Germany has expanded its installed base of exhaust-gas treatment systems from Edwards of Crawley, West Sussex, UK with the purchase of two GaNcat abatement systems, representing a significant expansion in Aixtron's abatement capacity. Aixtron will use the systems in its R&D laboratory to handle exhaust generated by the metalorganic chemical vapor deposition (MOCVD) process.

"The GaNcat system is an ideal solution for MOCVD exhaust management," claims Dr Paul Rawlings, general manager of Edwards' Exhaust Management Business.

"We are particularly encouraged by Aixtron's adoption of the system and the potential it brings, as Aixtron's tools proliferate in the market."

The GaNcat system's unique dry chemical technology significantly reduces operating costs by eliminating the need for fuel and water in the abatement process, Edwards says. The system treats the ammonia flows present in the exhausts of nitride-based MOCVD processes by

decomposing the gas into its constituent elements, nitrogen and hydrogen, using a heated dry cartridge technology. The cartridge removes pyrophoric metal-organic gases, including trimethyl gallium (TMG), trimethylindium (TMI) and trimethylaluminium (TMA), without adding external traps by incorporating a special pre-cleaning stage that converts these compounds into stable inorganic solids.

Each GaNcat cartridge has a capacity to treat up to 20slm of ammonia, and multiple cartridges can be configured in parallel to accommodate any level of gas flow. A spare cartridge can be included, ready to be brought on-line to replace a cartridge that has reached its full capacity, and an optional monitoring system can check the outlet of each individual cartridge to monitor its performance and indicate when change-over is required. The GaNcat system features Edwards' proven Gas Reactor Column technology, which has an installed-base of nearly 3000 units worldwide.

www.edwardsvacuum.com

TEL & Edwards co-develop PFC abatement system for dielectric etch processes

Vacuum and exhaust management equipment maker Edwards of Crawley, West Sussex, UK and Japanese process equipment maker Tokyo Electron Ltd (TEL) have agreed to jointly develop a perfluorocarbon (PFC) gas abatement system for dielectric film etching equipment. The PA-01E will be available in mid-2009.

"The contribution of PFC gases to global warming has been extensively documented, and we look forward to working with TEL's engineering staff to provide an effective, low cost-of-ownership gas abatement system specifically designed to reduce the dangers of PFC pollution as a result of the

semiconductor etch process," says Edwards' CEO Nigel Hunton.

The PA-01E system will be equipped with a plasma abatement device, collectively developed with Adtec Plasma Technology Co Ltd of Hiroshima, Japan, which offers a high transformation rate and stable operation. It is also designed to have a significantly lower cost-of-ownership due to its reduced requirement for energy, consumables and maintenance.

In addition, the system will be designed to abate carbon monoxide in addition to PFCs, eliminating the need for separate abatement hardware.

www.tel.com

FEI launches automated strain analysis software package for S/TEM systems

FEI Company of Hillsboro, OR, USA, which provides atomic-scale imaging and analysis systems, has launched its new, automated TrueCrystal Strain Analysis package, which can be installed on a Titan or Tecnai scanning/transmission electron microscope (S/TEM) system and allows engineers to achieve highly accurate measurements in a fraction of the time of existing techniques, it is claimed.

"Silicon strain engineering is an important process innovation in advanced semiconductor manufacturing; it allows for improved device performance and efficiency at advanced technology nodes," says Joseph Race, product marketing manager at FEI's Electronics Division. "Currently, only TEM has proven capable of measuring these induced lattice strains at the required spatial resolution," he adds. "TrueCrystal

Strain Analysis is a complete analytical package for the determination of strain along any line in a crystalline sample, at the nanometer level."

Tony Edwards, VP & general manager of FEI's Electronics Division, adds, "FEI's TrueCrystal Strain Analysis package is an example of our corporate commitment to providing customers with comprehensive, application-specific solutions that aim to maximize TEM productivity, reduce data acquisition times and lower overall cost of analysis."

TrueCrystal uses a combination of nano-beam diffraction (NBD) in the TEM, and a powerful off-line data analysis package, to quickly and easily generate the high-quality data required for advanced strained silicon process development.

FEI says the NBD technique is not subject to the limitations observed in more traditional methods, such as

high-resolution TEM (HRTEM) and convergent beam electron diffraction (CBED). The on-line software component works within the microscope user interface, and the straightforward line-scan workflow will be familiar to anyone who has undertaken chemical analysis on a TEM, the firm says. The off-line software component allows for strain analysis of each individual diffraction peak of the acquired diffraction patterns. The resulting data is then used to automatically generate a plot of the strain profile across the acquired line scan. FEI says that, from experiment, through final data reduction, to presentation of results, the TrueCrystal Strain Analysis package, combined with a Titan or Tecnai TEM, allows rapid, accurate strain profile determination in a broad range of samples.

www.fei.com

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OIPT relocation postponed by 2 years to cut CapEx

For its first fiscal 2008/09 half-year (to end-September), the UK's Oxford Instruments plc has reported sales of £92.8m, up 19% on £78.3m a year ago. The firm's major trading currencies (the dollar, Yen and particularly the Euro) contributed 7% of this growth. On a constant-currency basis, growth was 12% (8% from acquisitions).

In addition to a trading loss of £1.9m on revenue of £29.5m (almost flat on a year ago) for the Superconductivity business, the Analytical business (which includes Industrial Analysis, NanoAnalysis and Plasma Technology) contributed revenue of £63.3m (up from £49.6m a year ago) and a trading profit of £5.4m (up from £2.8m, contributing to overall trading profit rising by £1.5m to £3.5m).

In particular, Plasma Technology (which makes etch and deposition equipment) has been supported by new atomic layer deposition (ALD) tools and demand for equipment in the high-brightness LEDs (HB-LEDs) and photovoltaic (PV) markets.

On 9 April (near the start of the half-year period), the firm acquired Technologies and Devices International Inc (TDI) of Silver Spring, MD, USA — which makes template substrates using hydride vapor phase epitaxy (HVPE) — for £1.2m, plus deferred consideration of £0.5m paid on 1 October. Further contingent consideration of up to £2.8m is payable based on post-acquisition

revenue growth (the best estimate is currently £0.7m). TDI has since contributed revenue of £0.4m and a loss before tax of £0.7m.

Oxford Instruments has also seen continued organic growth across its core products, although at a slower rate than last year. This reflects weakening in the growth of customer demand, particularly in the USA. However, the firm reckons that it has grown market share in key areas, helped by technical innovations and improvements in customer service. Aided by exchange rates, gross margin rose from 40.2% to 41.2%.

"We are now half way through our five-year plan and we are pleased to report continued growth in sales, margin and market share in the first half of this year," says chairman Nigel Keen.

On 22 September the firm disposed of Oxford Instruments Plasma Technology's loss-making MBE product line (valued at £1.2m) to French MBE firm Riber SA for £0.3m, resulting in a loss of £0.9m. Despite this, Oxford Instruments' overall adjusted profit before tax rose by £0.8m to £2.6m.

"The results of our investments to date provide a sound platform for growth," says Keen. "Disposal of the MBE business in September has allowed us to focus on the new opportunities in HB-LEDs and PVs... We are investing in our TDI business to develop an [HVPE] industrial tool for the production of HB-LEDs."

Total orders for Oxford Instruments in the half-year to end September were £97.5m (exceeding revenues by £4.7m). "However, should there be a prolonged market downturn, organic growth will be more difficult to achieve," Keen adds.

"Our product portfolio is strong, and we have good geographical spread, which should help to insulate us if there is a softening in demand in the second half of the year," says Keen. "The benefits of our recent acquisitions and new product introductions together with the weakness of sterling are likely to have a positive effect during the remainder of this financial year." These factors underpin the firm's continued confidence in delivering a full-year performance in line with expectations.

In addition, "New opportunities for margin improvement are presenting themselves in the current business climate, as we have greater leverage with our suppliers as well as opportunities to reduce other costs," says Keen.

● Due to worsening conditions in the UK commercial property market, Oxford Instruments has renegotiated its option to sell Plasma Technology's site, while preserving its beneficial commercial conditions. By postponing Plasma Technology's relocation (scheduled for 2009) by two years, the firm aims to cut capital expenditure in the current financial year.

www.oxford-instruments.com

Order from Asian HB-LED maker for first three of up to 15 systems

Oxford Instruments Plasma Technology (OIPT) says that it has recently won an order for three Plasmalab System133 ICP380 plasma etch tools, for shipment in December to a leading manufacturer of high-brightness LEDs (HB-LEDs), based in Asia. The order is the first of a potential total of up to 15 systems that may be required by the customer over the next 12 months.

This follows OIPT receiving orders for more than 20 systems in October, the fourth best ever month for orders, consolidating a 12 month period that has already seen OIPT's first and second best order months.

"The combination of a highly motivated, experienced and skilled sales team, selling excellent systems and process capabilities, means that OIPT has been able to remain extremely competitive and increase

its order levels, even during such challenging times," says sales director Mark Vosloo. "OIPT is able to use its capabilities to enter newer markets such as photovoltaics and LED lighting, where our leading-edge technologies are in increasing demand and our wide range of products, such as plasma etch and deposition, atomic layer deposition and ion beam etch and deposition, contribute to our success."

Aviza increases gross margin after restructuring

For its fiscal 2008 (ended 26 September), etch and deposition equipment maker Aviza Technology Inc of Scotts Valley, CA, USA has reported sales of \$133m, down a massive 42% on \$231m in fiscal 2007.

"During the year we saw continued oversupply of DRAMs, which severely affected capital spending by customers worldwide," says chairman, president & CEO Jerry Cutini. "The unfolding global financial crisis has exacerbated these problems, resulting in falling ASPs [average selling prices] among most device types and clearly showing in consumer demand for end products," he adds. "The current global economic downturn ranks as one of the most challenging that our industry has ever faced... We are now in a period of demand-driven recession, the length of which no one is able to forecast."

Compared to a profit of \$383,000 in fiscal 2007, net loss was \$47.4m, while cash and cash equivalents fell during fiscal 2008 from \$23.1m to \$14.9m.

Consequently, to decrease its overall dependence on the falling DRAM market, Aviza has been downsizing its programs, products and spending related to trench capacitor technology for DRAMs, involving ceasing development of large batch thermal systems.

Meanwhile, in April, Aviza announced a restructuring of its product strategy, served markets and internal operations to refocus on growth market segments with its single-wafer products, including its core strengths in atomic layer deposition (ALD) technology for the sub-45nm nodes, and PVD and etch technologies for the 3D-IC, MEMS and III-Vs markets.

Most of Aviza's business has now shifted to these markets. "We believe we have made substantial inroads into those end markets, all of which have positioned us to improve the balance of our business opportunities," says Cutini.

For example, in September Aviza received multiple orders for its Delta i2L plasma-enhanced CVD (PECVD) and Omega i2L etch systems from what it described as "one of the world's leading optoelectronics manufacturers" for the production of GaAs- and InGaN-based LEDs for solid-state lighting, mobile communications and automotive applications. In addition, in October Aviza shipped multiple Sigma fxP PVD systems to a 'top-three GaAs device maker' (a

foundry in Taiwan), after in July receiving its largest ever GaAs system order, worth \$15-20m, from Taiwan's WIN Semiconductors Corp (the world's largest pure-play GaAs foundry) for a suite of single-wafer processing systems consisting of Sigma fxP PVD, Delta fxP CVD, Omega fxP and i2L etch systems.

For fiscal fourth-quarter 2008, net sales were \$35.5m (at the low end of August's \$35-40m guidance range). Although this is down 29% on \$50.2m a year ago, it is up slightly (by 6%) on fiscal Q3's \$33.5m.

Also, operating expenses have been cut from \$16.3m last quarter (\$7.3m R&D and \$9m selling, general & administrative) to \$15.8m (\$6.6m and \$7.4m, respectively), despite a one-time restructuring charge of \$1.8m (due mainly to an impairment of a previously licensed technology as well as severance pay, with headcount now below 500). Operating loss has been cut from \$5.3m to \$2.9m.

Although still up on \$2.6m a year ago, net loss has been cut from last

The global economic downturn ranks as one of the most challenging our industry has ever faced

For the December quarter, we're not falling off a cliff like you've seen some of the other equipment companies

quarter's \$5.6m to \$3.1m in fiscal Q4. Excluding stock-based compensation, amortization expense, depreciation expense, net interest expense, restructuring and other one-time charges, income taxes and net other (income) expense, adjusted net income was \$941,000 (better than August's guidance of between adjusted net loss of \$3m and adjusted net income of \$100,000). Though still down on adjusted net income of \$65,000 a year ago, this is an improvement from an adjusted net loss of \$3.6m in fiscal Q3.

In particular, gross margin improved from last quarter's 32.9% to 36.5%, the highest since the firm became publicly listed. "It is a reflection of our ongoing efforts to sustain our financial performance in the face of an extremely challenging macroeconomic environment, which is expected to continue well into 2009," says Cutini.

Nevertheless, predicated on Aviza's continued focus on a shift in product mix, for fiscal first-quarter 2009 (to 26 December 2008) Aviza expects net sales to fall to \$25-32m, with between adjusted net income of \$50,000 and adjusted net loss of \$4m.

However, given the current economic environment, Aviza considers this to be a good performance. "For the December quarter, we're not falling off a cliff like you've seen some of the other equipment companies," says executive VP & chief financial officer Patrick O'Connor. The overall semiconductor equipment market should fall 20-25% in 2009 but, after talking to customers, he believes that Aviza's targeted sectors are going to perform better than that. "We remain committed to focusing on our served market with single-wafer products," adds Cutini. "In the short term, we're going to have bumps in the road like everybody else, but over the long-term we're going to see pretty decent growth in those markets that we serve."

www.aviza.com

IN BRIEF

SUSS MicroTec appoints CEO

The supervisory board of wafer process and test equipment supplier Suss MicroTec AG of Garching, Germany has appointed Frank Averdung to its management board as CEO, effective from June 2009 at the latest. His activities will focus on sales, marketing and group strategy.

Averdung is currently managing director of Carl Zeiss SMS GmbH (SMS – Semiconductor Metrology Systems) of Jena, Germany, which specializes in the inspection and repair of photo-masks. He has also been managing director and/or general manager with equipment makers such as NaWoTec GmbH, ETEC Systems and Applied Materials.

"Averdung brings to the table not only industry and market expertise, but also an understanding of technology and, above all, a high level of assertiveness," says Dr Franz Richter, chairman of Suss MicroTec's supervisory board. "These characteristics are of great value to SUSS MicroTec in light of the long-standing expansionary policy and our goal of improved profitability," he adds. "Averdung has had an extremely strong impact on the strategic orientation of the respective companies and divisions during the various positions of his professional career."

"My experience can help advance us into attractive niches of the semiconductor market and utilize the existing market potential more quickly and comprehensively," reckons Averdung.

www.suss.com



Frank Averdung.

EVG's fiscal 2008 revenue growth exceeds 15%

EV Group (EVG) of St. Florian, Austria, which manufactures wafer bonding and lithography equipment for the MEMS, nanotechnology and semiconductor markets, says that its revenue for fiscal 2008 (ended September 30) has increased by more than 15%. The firm attributes most of the growth to the burgeoning demand in both the 3D interconnect/through-silicon via (TSV) and nanoimprint lithography (NIL) markets. Furthermore, despite the current global economic slowdown, EVG adds that it remains cautiously optimistic about its outlook for 2009, given the expected growth opportunities as these novel technologies gain market acceptance/penetration.

"Our leading-edge solutions provide a true value add to our customers and are the cornerstone in strengthening our technology leadership position and market share. To this end, our strategy has always been to leverage our existing core capabilities and extend this knowledge and expertise into other synergistic markets that can truly benefit from us," says founder & president Erich Thallner. "This has

allowed EVG to grow consistently over the years since our inception in 1980-ultimately enabling us to weather some of the effects associated with various cyclical industries like the semiconductor market, even at the most tumultuous of times, like we are seeing today."

EVG says it will continue to invest in 3D/TSVs and NIL in order to help its customers overcome the yield and performance challenges as they scale down to 32 and 22nm geometries. The firm recently shipped its 100th NIL system, and claims that it has more NIL systems in the field than any other firm (around 30% of the market share).

"Looking ahead, even though the macroeconomic environment is expected to be more challenging in 2009, specifically in market segments that are automotive and consumer-product driven, we expect that new technologies, such as backside illuminated image sensors or even higher functional density cell phones, will drive continued growth for EVG's 3D IC lithography and wafer bonding equipment, among others," concludes Thallner.

LayTec sells 100th EpiCurveTT sensor; recruits Japan & Korea sales engineer

LayTec GmbH of Berlin, Germany has delivered its 100th EpiCurve wafer curvature sensor. Originally developed in 2005 as an R&D tool, it is now its bestselling product, especially for LED manufacturing. As many as 75% of the sensors have been delivered to industry, mainly in Europe, Taiwan and Japan.

Also, LayTec has recruited Dr Yuto Tomita as a new member of its sales team, in charge of sales in Japan and Korea.

Tomita gained a master degree in chemical engineering at Japan's



Yamagata University in the group of professor Junji Kido, before studying at the Technical University of Dresden then gaining a PhD degree at IPMS Fraunhofer Institute in Dresden, Germany. His work there concerned alternative transparent electrodes for the replacement of indium tin oxide (ITO) in organic LEDs, particularly Al-doped ZnO and highly conductive polymers.

www.laytec.de

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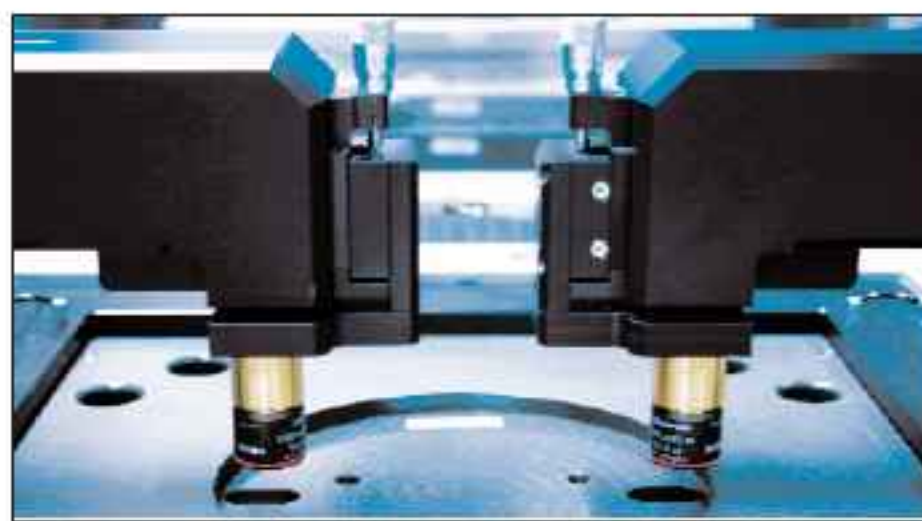
www.EVGroup.com

EVG launches new suite of aligners and measurement systems for 3D IC and other advanced semiconductor, MEMS and nanotech device manufacturing

EV Group (EVG) of St. Florian, Austria, which manufactures wafer bonding and lithography equipment for the MEMS, nanotechnology and semiconductor markets, has launched the NT series — a new, yet already field-proven suite of mask aligners, wafer-to-wafer (W2W) bond aligners and measurement systems — to address increased demand for higher-precision alignment accuracy.

The shift to smaller geometries, along with more feature-dense packages, adds a host of challenges surrounding precision alignment capabilities, which can greatly impact device failure intolerance and, ultimately, yield and cost, says the firm. The EVG-NT series offers dramatically increased alignment accuracy of 1–0.1 μ m for the manufacture of advanced MEMS, compound semiconductor, silicon-based power, 3D IC and nanotechnology devices — unlike anything else on the market, the firm claims. The first units of the NT system have already been installed at customer sites worldwide and passed the acceptance tests.

“Structural integrity and, ultimately, device performance is impacted by alignment inaccuracies throughout the production process, increasing the total cost of manufacturing,” says executive technology director Paul Lindner. “There are a host of variables to consider in the manufacturing process that can affect alignment accuracy — including temperature and substrate materials — and the movement to smaller, more feature-dense packages greatly exacerbates the problem. In fulfilling our commitment to enabling our customers, we have introduced the EVG-NT series to solve these issues,” he adds. Customers have already qualified the first systems in the field, and data have confirmed quoted specifications.



SmartViewNT W2W bonder aligner.

The EVG-NT series features next-generation alignment and measurement systems with significantly increased alignment precision, including the following mask aligners, a W2W bond aligner, and an alignment measurement system:

- The EVG620NT and EVG6200NT mask aligners — which handle substrate sizes of less than 5mm up to 150mm and 3 inches up to 200mm, respectively — offer new features including a granite base, active vibration isolation and linear motors to meet higher precision and throughput requirements. Built upon EVG’s most flexible and versatile aligner platforms, the new systems enable manufacturers to easily scale between R&D and volume manufacturing in a simple one-to-one process transfer from manual mode to full automation. The ease of ramp-up to volume manufacturing, coupled with improvements in alignment accuracy (down to 0.1 μ m), deliver significant cost-of-ownership (CoO) benefits.

- Multiple wafer stacking and bonding processes require an alignment accuracy of less than 1 μ m. To meet this challenge, the SmartViewNT W2W bonder aligner uses a high-precision alignment stage that comprises top- and bottom-side microscopes to ensure the highest degree of accuracy. The versatile bond aligner can also handle all types of alignments, including W2W, backside and infrared transparent. Initial results for W2W alignments demonstrated face-to-face alignment

accuracy of better than 0.3 μ m, eliminating the need for post-processing steps such as generating backside alignment keys and double-sided polishing (enabling lower cost of ownership). In a side-by-side comparison of the SmartViewNT to its predecessor, alignment accuracies increased by more than 60%, 300% and 40% for SmartView, backside and transparent alignments, respectively, EVG says — enabling the system to effectively address stringent precision requirements.

- The EVG40NT is designed to perform highly accurate non-destructive alignment accuracy measurement of single- and double-sided structured wafers, as well as bond interfaces. EVG says that the new system overcomes the limitation of conventional double-view microscope and infrared systems, which rely on a cumbersome, time-consuming procedure to calibrate the optical axis. The EVG40NT is a highly flexible tool that can

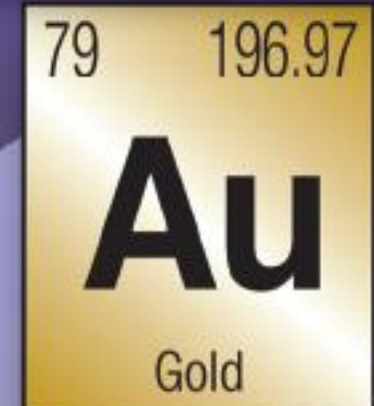
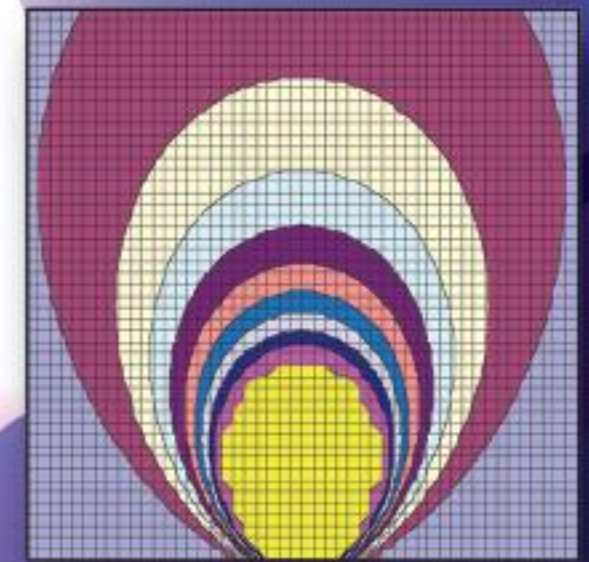
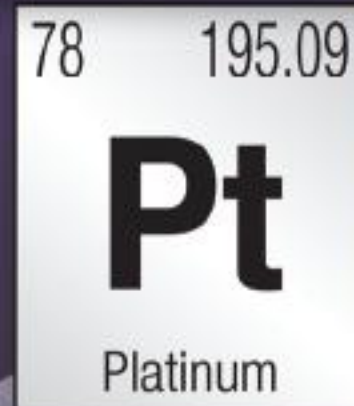
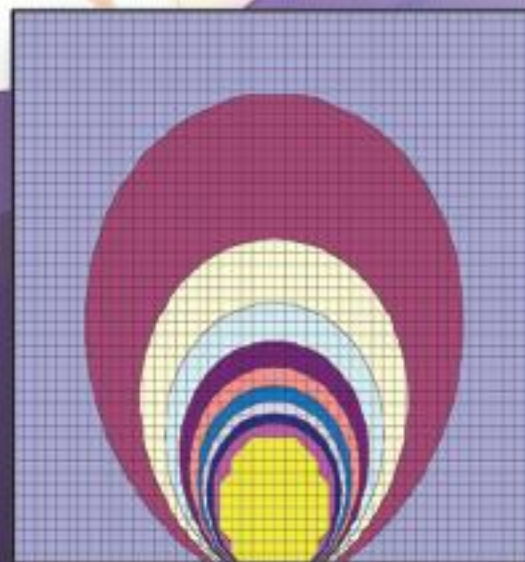
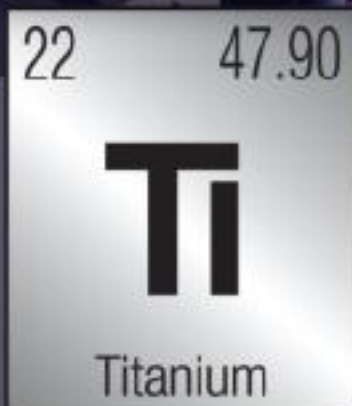
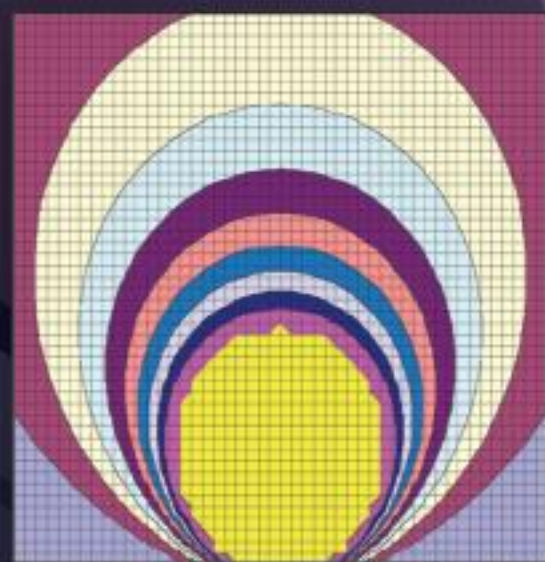


quickly provide an unlimited number of measurement points across the wafer surface, the firm adds. Compared to the previous generation, the NT series’ improves throughput up to five fold, offering 200–300 measurements per hour. Additionally, while process dependent, results have shown a 60% increase in accuracy, producing a measurement accuracy of better than 0.2 μ m. The results are highly repeatable and reproducible, with a statistic probability of >99%, the firm claims.

EVG says that each system in its NT family has already been installed and qualified by leading-edge manufacturers globally.

www.EVGroup.com

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IN BRIEF

sp3 appoints director of sales

sp3 Diamond Technologies Inc of Santa Clara, CA, USA, a supplier of CVD diamond film products, equipment and services to markets including electronics, lasers, LEDs, semiconductors and MEMS, has recruited industry veteran William Peifer as its director of sales. He is tasked with increasing sales of CVD diamond products for thermal management applications (such as DiaTherm and wafer-scale diamond) as well as supporting existing sales efforts for non-thermal related applications (including DiaTips, DiaPak, DiaBide and DiaDress). Peifer will also be responsible for accelerating the expansion of sp3's sales organization, mainly through the addition of representative organizations across the USA.

Peifer has broad experience in moving various novel technologies to adoption in real-world applications, says president & COO Dwain Aidala. "He brings significant experience with thermal management applications at the device and systems levels, and a broad network of government and commercial customer contacts that he will be able to utilize to leverage sp3's products into new applications in key markets, such as military, industrial and aerospace," he adds.

Most recently, Peifer was with Yamaichi Electronics Inc USA, responsible for increasing sales of Yflex LCP (liquid crystal polymer) material into the photovoltaic industry, and worked on heat dissipation solutions. Previously, he handled business development for DVK Integrated Services Inc, with a particular focus on heat dissipation materials. Peifer has also worked for Covenant Electronics Inc and Seiko Epson Corp affiliate SMOS Systems Inc.

www.sp3diamondtech.com

Rubicon amends Peregrine agreement to provide relief

Rubicon Technology Inc of Franklin Park, IL, USA, which makes sapphire substrates and products for the LED, RFIC, semiconductor and optical industries, has amended its sapphire supply agreement with its key silicon-on-sapphire (SoS) RFIC customer, Peregrine Semiconductor Corp of San Diego, CA, USA.

Peregrine's obligation to purchase material from Rubicon in 2008 and first-half 2009 has been replaced by a multi-year agreement under which Peregrine has committed to source at least 50% of its sapphire purchases from Rubicon through 2011.

"This amendment to our agreement provides some relief to our customer as they work through their inventory and re-affirms our long-term position as a key supplier to this global market," says Rubicon's CEO Raja Parvez. Following nearly \$7m of order push-outs from 2008 into first-half 2009 (including \$4.3m of SoS substrates for Peregrine), at the end of October Rubicon

reported third-quarter 2008 revenue up just 2% to \$11.8m (down on original guidance of \$12.5m) and lowered Q4/2008 guidance from \$8-8.5m to just \$4-6m.

Rubicon also says that it has participated in Peregrine's recent financing round, purchasing \$2m in the firm's preferred stock. "Our

This amendment provides some relief to our customer as they work through their inventory

strong financial position provides us the flexibility to reinforce our relationship with Peregrine through this investment, validating the strength of our

valued business partnership as industry-leading innovators, and demonstrating our commitment and belief in the long-term growth opportunities in the global SoS RFIC market," adds Parvez.

www.rubicon-es2.com

Crystal IS wins \$800,000 DoD grant to develop AlN substrates for effective deep UV LEDs

Crystal IS Inc of Green Island, NY, USA, a manufacturer of UV-LEDs based on aluminum nitride (AlN) substrate technology, is to receive an \$800,000 appropriation from the US Department of Defense to advance development of large AlN crystals for effective deep-ultraviolet sources.

As part of the program, Crystal IS will partner with the Army Research Laboratory in Adelphi, MD and the Electro-Optics Center (EOC) at Penn State University. The program will leverage the recent development of large single-crystal AlN substrates into robust semiconductor sources of deep-ultraviolet light as well as other high-power, high-

temperature applications for the military, says the firm.

"Our unique technology allows us to manufacture UV-LEDs with unsurpassed performance at truly commercially viable costs," claims Crystal IS's CEO Steven Berger. "This grant serves as yet another validation of using AlN-based UV-LEDs to enable cleaner water and air for consumer, industrial and government customers."

The primary applications of UV-LEDs are as long-lasting, energy-efficient water and air disinfection devices. Crystal IS Inc is developing its deep UV-LEDs at 265nm, the peak germicidal wavelength.

www.crystal-is.com

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Solar Power Generation USA will look at how the different levels of government are contributing to solar policy as well as understanding the potential of CSP, CPV in the U.S. and globally. It is a must attend for anyone charged with solar technology development, manufacturing, finance, utilities, policy makers and regulators.

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- **John Rei** *Chief Operating Officer*, Sopogy
- **Nancy Hartsoch** *Vice President*, SolFocus
- **Thomas Fair** *Executive*, NV Energy
- **Rich Halvey** *Program Director - Energy*, Western Governor's Association
- **Marco DeMiroz** *Partner*, Trinity Ventures
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- **Mike Nedd** *Assistant Director - Minerals and Realty Management*, Bureau of Land Management
- **Jim Baak** *Director of Utility Scale Solar Policy*, The Vote Solar Initiative
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IN BRIEF

Aixtron delivers MOCVD reactor to Showa Denko

In Q3/2008, Aixtron delivered an AIX 2800G4 HT Planetary Reactor MOCVD system (its flagship product for large-scale GaN-based LED manufacturing) to Japan-based ultra-high-brightness LED maker Showa Denko K.K. Ordered in Q1/2008, the system is in 11x4"-wafer configuration.

"Our existing AIX 2800G4HT Planetary Reactor system has been serving us very well and now we are ready to further scale up production, as announced last year," says Showa Denko.

www.aixtron.com

Indium Corp promotes Giasone to metals manager

Indium Corp of Clinton, NY, USA has promoted Emily Giasone to metals manager for its Metals, Chemicals and Energy (MCE) business unit, responsible for purchasing and trading indium, gallium, germanium and bismuth raw materials, selling select MCE products in the China market, and gathering and synthesizing market data from refineries and traders to guide metal purchases and pricing.

Giasone is based in Turin, Italy and reports to Claire Mikolajczak, director of Metals and Chemicals. She joined Indium Corp in 2006 as an account specialist, contributing to the firm's growing metals business, especially indium and germanium.

Indium Corp supplies materials to the electronics assembly, semiconductor fabrication and packaging, solar photovoltaic, and thermal management markets, and has facilities in China, Singapore, South Korea, the UK, and the USA.

www.indium.com

Russian GaN-based LED lighting JV established after OptoGaN acquisition

ONEXIM Group Ltd, the Ural Optical and Mechanical Plant (UOMP) and the Russian Corporation of Nanotechnologies (RUSNANO) have formed a 50:33:17 joint venture to manufacture GaN-based LED chips, lamps and lighting systems (investing about \$34m, \$22m and \$11.5m, respectively).

The unique chip production technology was created by Vladislav Bougrov and Maxim Odnoblyudov, who were PhD students of Nobel Prize winner Zhores Alferov at the Ioffe Physico-Technical Institute in St Petersburg in the 1990s before working at Finland's Helsinki University of Technology then, in late 2004, founding OptoGaN in Helsinki to develop GaN-based LEDs. OptoGaN used the R&D lab of Micronova's Centre for Micro and Nanotechnology in Espoo — run jointly by the VTT Technical Research Centre of Finland and Helsinki University of Technology (TKK) — and cooperated with the latter's Laboratory of Micro and Nanosciences, whose professor Harri Lipsanen developed a growth technique that can reduce the amount of crystal defects that suppress brightness in GaN-based LEDs and lasers. What is claimed to be a record low amount of defects allows devices to work without losing effectiveness at high-density currents, enabling a high brightness-to-price ratio for LED chips. OptoGaN subsequently developed high-brightness LED wafers, chips and manufacturing processes (as well as pilot line and production facilities in Dortmund, Germany).

Most recently, OptoGaN was acquired by ONEXIM, a private investment fund founded by Mikhail



Documents establishing the JV were signed by Anatoly Chubais, director general of the Russian Corporation of Nanotechnologies (RUSNANO), Mikhail Prokhorov, president of ONEXIM Group Ltd and Sergey Maksin, director general of the Ural Optical and Mechanical Plant (UOMP).

Prokhorov in May 2007. RUSNANO was founded in July 2007 and allocated 130bn rubles (\$4.6bn) by the Government of the Russian Federation to implement its policy, develop infrastructure, and establish projects in the sphere of nanotechnology, e.g. by acting as an early-stage co-investor in projects with significant economic or social potential to reduce risks for private investor partners.

The establishment of the new joint venture allows what is described as one of the most promising developments by Russian scientists to return to Russia. Fabrication of the epitaxial heterostructures will be based in St Petersburg's special economic zone. LED chip, lamp and lighting product assembly will take place in Yekaterinburg, based on UOMP's lighting products division.

The global LED market is expected to rise at a compound average annual growth rate (CAAGR) of 23% from \$4.2bn in 2007 to \$12bn in 2012. In particular, the market for LED lighting products is growing at 37% per year. LED lamps already have a 3.5% share of the Russian lighting systems market, it is reckoned. The new JV aims to generate annual revenue of 6000m rubles (\$200m) by 2013.

www.optogan.com

www.onexim.ru

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PhotonStar and University of Cambridge win UK funding for £1m LED lighting R&D program

LED lighting designer PhotonStar LED Ltd of Chilworth Science Park, Southampton and the University of Cambridge have won funding from the UK government's Technology Strategy Board for a 24-month collaborative R&D program 'LED Lighting for the 21st Century' (LL21C).

The project aims to produce high-power gallium nitride (GaN) LEDs capable of 95% light extraction using an electrical isolation layer that is designed to dramatically simplify packaging, boost performance and reduce costs for general lighting applications. The total project size is about £1m.

"Advanced light and laser sources are an area where the UK has an excellent reputation for world-class research activity, a healthy industrial base and the capability to exploit the results globally," comments Iain Gray, chief executive of the Technology Strategy Board. "Innovative R&D, such as the LED lighting for the 21st Century project, will enable the UK to develop world-leading technologies that have global market potential," he adds.

"It's a great win for us and endorses all the work we have been doing in this area," says PhotonStar's chief technical officer Dr Majd Zoorob, who co-founded the firm in 2007 with CEO Dr James McKenzie.

At this year's Architectural, Commercial and Retail Lighting show (ARC '08), PhotonStar launched its first product, the CeilingStar5-IC (the first of its Performance Eco-lighting products), a downlighter for fully insulated ceilings. CeilingStar5 produces 450 lumens at thermal equilibrium from 8W of circuit power in either warm-white or neutral-white colors and provides equivalent illumination to a 60W incandescent downlighter or a 35W MR16 downlighter. In February PhotonStar acquired an optical and electrical characterization laboratory able to handle LED technology (from the LED die, through LED modules to the luminaire).

"The funding, combined with being able to work with such a prestigious team at Cambridge University, will enable us to push the boundaries in this all-important area of lighting...

will be able to advance the energy and environmental benefits of LEDs even further," Zoorob adds.

"LEDs have great potential to dramatically reduce carbon dioxide emissions [by 10-15% from power stations] and reduce waste associated with disposal of conventional and low-energy light bulbs," comments professor Colin Humphreys, director of The Cambridge Centre for Gallium Nitride in the University of Cambridge's Department of Materials Science and Metallurgy (founded in 2000). A key focus of the center's research is GaN LED lighting. If LED lighting was used in homes and offices, the energy saved could enable the UK to close eight power stations (or avoid building eight new ones), it is reckoned.

The Technology Strategy Board is investing over £7m in 12 lighting technology R&D projects, while the UK's Engineering and Physical Sciences Research Council is contributing nearly £1m to five of the projects.

www.photonstarlighting.com
www.msm.cam.ac.uk/GaN

Sharp and Nichia agree LED & laser cross-licensing

Japanese electronics firm Sharp Corp of Osaka City and LED maker Nichia Corp of Anan City, Tokushima Prefecture have entered into a patent cross-licensing agreement covering LEDs and laser diodes.

The agreement grants each other the right to use inventions related to LEDs and laser diodes covered by patents owned by the respective companies in Japan and in major countries.

LEDs feature long service life and low power consumption, and are increasingly expected to be the strongest candidate for the next generation of lighting devices. LEDs have been adopted mainly for use in backlights for mobile phones and

PDA's, but in the future they are expected to gain acceptance not only for general illumination applications but also for use in large numbers in the backlights of LCD TVs and for automotive lighting.

Laser diodes have long been the key device used in recording and playback of optical disks such as CDs and DVDs but, with HDTV images becoming increasingly familiar, demand is growing rapidly for blue-violet laser diodes for use in recording and playback of terrestrial digital broadcasts, and for Blu-ray Disc recorders and players.

Sharp started the development of LEDs in 1968 and began mass production in 1970. Also, in 1982, it was first to begin mass production

of infrared laser diodes for CDs, and this February started mass production of 250mW, pulsed-output, high-power blue-violet laser diodes.

Now, by working towards the development of a vertically integrated business model based on these two devices, including LED lighting and Blu-ray Disc recorders, Sharp is aiming to create products that feature both devices at their core.

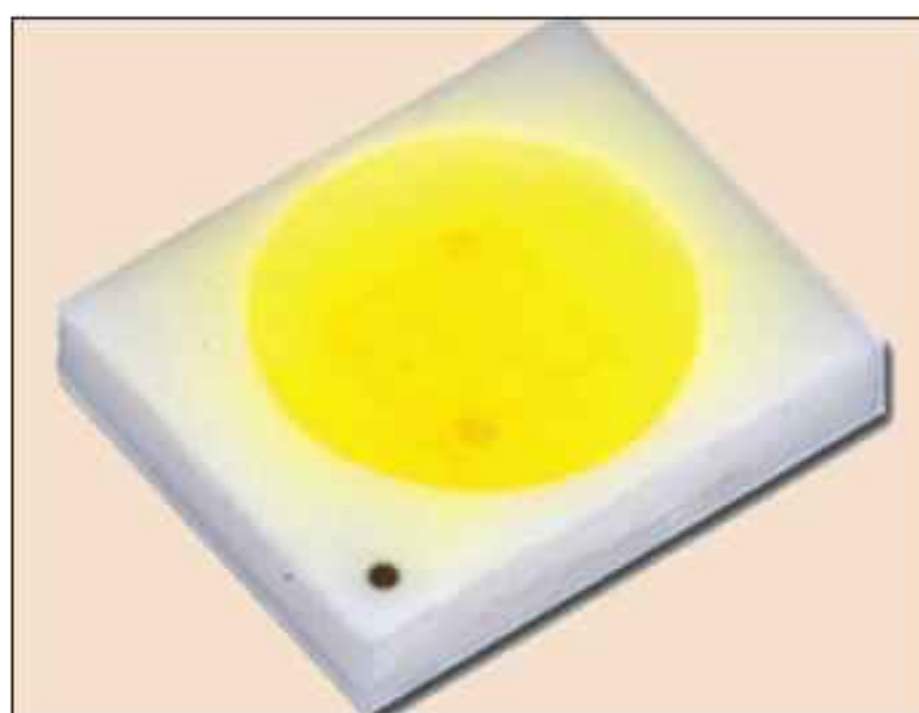
By entering into the cross-licensing agreement, Sharp and Nichia aim to create higher-performance LEDs and laser diodes, enabling the two firms to respond to rapidly expanding market demand.

www.nichia.com
<http://sharp-world.com>

Seoul Semiconductor launches 1.2mm-thick, 120lm white LEDs

Korean LED maker Seoul Semiconductor Co Ltd has introduced a 1.4W ultra-slim Z-power LED series. The Z1 is available in both warm-white (NZ10150) and pure-white (WZ10150) colors.

"Maximum lumens of NZ10150 and WZ10150 are 95 and 120 respectively, the average lumens being 80 and 105 each," said a company representative. "Because the body of Z1 is made of ceramic with high thermal conductivity and equipped with spacious radiation plate, customers can manage heat easily. Because these features enable Z1 to emit bright light much longer in high temperature (in other words, it maintains its reliability longer), it can be quite useful in designing indoor and outdoor lightings, and home appliances."



Seoul Semi's new Z1 white LED.

With a thickness of 1.2mm, the Z1 series LEDs can be used in various fields of lighting, such as sign display, replacement plate lighting (in refrigerators, for example), cabinet lighting installed in narrow spaces, security lighting and decorative recessed lighting, adds the firm.

www.seoulsemicon.com

SemiLEDs selected as Technology Pioneer by World Economic Forum

SemiLEDs Corp of Boise, ID, USA, which manufactures high-brightness LEDs at its plant in Hsinchu Science Park, Taiwan, is one of 34 firms selected by The World Economic Forum for recognition as a 2009 Technology Pioneer for "accomplishments as innovators of the highest caliber, and whose technologies will have a deep impact on business and society".

To be selected as a Technology Pioneer, a company must be involved in the development of life-changing technology innovation and have the potential for long-term impact on business and society. It must also demonstrate visionary leadership, show all the signs of being a long-standing market leader, and its technology must be proven. SemiLEDs has been named in the Energy/Environment sector for high-efficiency and low-cost LED technology for solid-state lighting.

Founded in December 2004, SemiLEDs was the first company to



6" wafer on flexible copper alloy.

mass produce high-power LEDs on a flexible copper alloy base. The firm claims that its 'metal vertical photon' (Mvp) LEDs have better electrical and thermal conductivity, making them brighter, more efficient (>100 lumens/Watt) and less prone to overheating. It also claims that its technology proves that an energy saving of more than 50% for commercial, public and residential lighting is achievable at a cost similar to conventional light sources.

SemiLEDs says that it is also using its metal alloy technology to produce ultraviolet (UVA) HB-LEDs for applications in sterilization (e.g. in rural areas).

www.semileds.com

IN BRIEF

Seoul enters cross-license agreement with TridonicAtco

Seoul Semiconductor Co Ltd (SSC) has entered into a cross-license agreement with TridonicAtco Optoelectronics GmbH of Dornbirn, Austria and its patent partners regarding making white LEDs using silicate system phosphors.

Since phosphors are indispensable for making white LEDs, incorporating silicate phosphors (which is significantly different to using conventional phosphors) is covered by a wide range of patents.

SSC says that, under the cross license agreement, it is in a very strong position to make and sell its own white LEDs using silicate phosphors as well as expand and accelerate relevant R&D activities.

www.tridonicatco.com

Avago launches 3W white LEDs for solid-state lighting

Avago Technologies of San Jose, CA, USA has added 3W high-power cool-white (ASMT-Mx20) and warm-white (ASMT-Mx22) low-profile LEDs to its Moonstone product range.

Capable of being driven at high currents with typical light output of 145 lumens (at 700mA), the new LEDs suit streetlight, architectural, portable, retail and lighting applications. The low-profile design also suits applications where height is constrained.

The ASMT-Mx20/22 Moonstone LEDs offer a 120° viewing angle, good color and light output uniformity, and low thermal resistance to maintain long-term device reliability. Both products are compatible with standard surface-mount technology (SMT) reflow soldering processes.

www.avagotech.com

NIST devises LED test method comparable to lighting tests

At the 2008 CIE Expert Symposium on Advances in Photometry and Colorimetry in Turin, Italy, researchers at the US National Institute of Standards and Technology (NIST) presented a new, economical method to allow LED and lighting manufacturers to obtain accurate, reproducible, and comparable measurements of LED brightness and color. Up to now, the lack of common measurement methods among LED and lighting manufacturers has delayed the commercialization of solid-state lighting products.

The quality of light that high-power LEDs produce depends on their operating temperature. To speed production, LED makers typically use high-speed optical pulses to measure the color and brightness of their products. However, because pulsed measurements do not give the LED chip time to warm to its normal operating temperature, the measured light output quality is not the same as would be realized in actual lighting products.

The lighting industry uses a steady-state DC measurement approach (similar to that used for traditional incandescent and fluorescent lamps) involving turning the



NIST's Yuqin Zong.

light on, letting it warm up, and measuring the characteristics of the light produced. Though time-consuming, DC measurement provides a more realistic test of how the lighting product will perform. The problem was that researchers did not understand how the DC results correlated with the pulse measurement results that LED makers use.

NIST's Yuqin Zong and Yoshi Ohno have created a standard high-power LED measurement method that satisfies the needs of both LED and lighting makers. The method uses the fact that the optical and electrical characteristics of an LED are inter-related and a function of the LED's junction temperature (the temperature of the chip inside the LED, which is normally very difficult to measure).

The new method entails mounting

the LED on a temperature-controlled heat sink set to the desired LED junction temperature between 10°C and 100°C. After applying a pulse of electricity through the LED and measuring the voltage flowing across the junction, the researchers turn on the DC power to the LED and adjust the temperature of the heat sink to ensure the voltage remains constant. The method allows measurement of the LED's light output at a junction temperature similar to that found in a commercial lighting fixture (important to lighting manufacturers) but at high speed (important to LED manufacturers). The measurement results can be reproducible regardless of pulse or DC operation, or type of heat sink, say the researchers.

The new method also allows the measurement of heat flow in and out of the LED, enabling LED and lighting manufacturers to improve the LED's design and the thermal management system of the associated lighting product. Effective thermal management is important in lighting products, because LEDs perform more efficiently and last much longer at lower temperatures.

www.nist.gov

Osram forms LED lighting joint venture with Traxon

Lighting manufacturer Osram of Munich, Germany is strengthening its portfolio in professional LED lighting by setting up a joint venture (as majority shareholder) with Hong Kong-based Traxon Technologies Ltd, which employs about 135 staff, operates globally, and reported sales of about €17m in fiscal 2008.

The joint venture will bring together the combined expertise of Osram and both Traxon Technologies companies Traxon (which focuses on LED systems and solutions, and has contacts in project business worldwide with architects and lighting designers) and e:cueLighting Controls (which provides light man-

agement and control software) to offer integrated LED projects, systems and solutions for fast-growing markets such as architectural, hospitality and shop lighting.

Operating under the new name Traxon Technologies — An Osram Company, the JV will continue to operate from the head office in Hong Kong while Traxon's R&D activities will remain in Paderborn, Germany and Hong Kong. "We will continue to build on our partnerships around the world," says Traxon's CEO Nicolai Wiest. The global market volume for professional LED systems and solutions is about €700m and, with forecast annual growth of

around 20–30%, is a major growth driver in the lighting industry.

"This new joint venture will make Osram one of the leading providers of LED lighting solutions," reckons Osram CEO Martin Goetzler. "The benefits of this partnership are very clear: we intend to create an integrated offering across the entire LED spectrum which will be marketed through the joint worldwide partner and sales network... The joint venture will also act as a powerful driving force for the continuing innovative development of Osram's components business," he adds.

www.osram-os.com

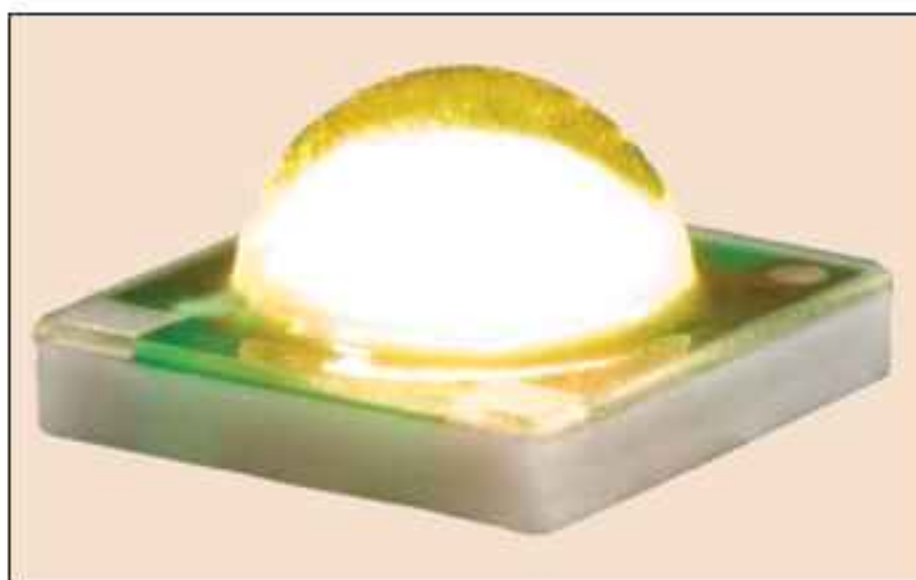
www.traxontechnologies.com

Cree claims record 161lm/W from white-light power LED

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA says that it has reported what it claims are industry-best R&D 'hero' results for luminous efficiency of 161 lumens per watt for a white high-power LED with a die size of 1mm x 1mm.

Cree's tests confirmed that the LED produced 173 lumens of light output and achieved 161 lumens per watt efficacy at a color temperature of 4689K. The tests were conducted under standard LED test conditions (meaning an instantaneous rather than steady-state measurement) at a drive current of 350mA, at room temperature.

Earlier this year, in July LED maker Osram Opto Semiconductors GmbH of Regensburg, Germany claimed a record 136lm/W luminous efficiency and 155lm output from a 1mm x



White LED made by Cree.

1mm white LED (with a color temperature of 5000K) driven at 350mA, and Philips Lumileds Inc of San Jose, CA, USA reported 140.1lm/W and 138lm. Previously, in September 2007, Cree reported record efficacy of 129lm/W and output of 135.7lm for a cool-white LED (with a color temperature of 5813K) driven at 350mA. Japan's Nichia has reported white LEDs with higher efficiency, but only at a

drive current of 20mA.

"Cree is inventing, commercializing and delivering LED lighting innovations that aim to obsolete the energy-inefficient light bulb," says John Edmond, Cree co-founder and director of advanced optoelectronics. "Our advances in brightness and efficacy come from a focus on end-to-end innovation that can enable LED lighting to address growing numbers of lighting applications while saving energy, saving money and helping to protect the environment," he adds.

While the latest level of performance is not yet available in production LEDs, Cree says that it continues to ship millions of lighting-class XLamp LEDs with light output of more than 100 lumens.

www.cree.com

Cree announces volume availability of LR24 recessed LED luminaire

Cree has announced the volume availability of the LR24, a 24-inch square, recessed LED luminaire which, the firm claims, delivers high-quality, energy-efficient light for suspended-ceiling applications traditionally addressed by linear fluorescents (lay-ins or troffers).

The LR24 is the newest addition to Cree's family of recessed LED fixtures and, claims the firm, delivers the uniform, high light levels required for offices, schools, hospitals and retail environments while consuming less electricity than most linear fluorescents.

The LR24 has a superior color-rendering index (CRI) of 92 compared with 70-80 for fluorescents. It is also dimmable to 5% with standard protocols — providing additional design flexibility and further energy-saving potential.

"With the addition of the LR24, we can light an entire office using Cree LED fixtures," says Neal Hunter, Cree's president of LED lighting. "You can have it all — superior energy efficiency, natural-



Cree's 24-inch square LR24 recessed LED luminaire installed in a ceiling.

looking light, no toxic mercury and an ultra-low maintenance system, designed for 50,000 hours," he adds.

Cree has already installed more than 1000 early-production LR24s in various national-account projects. "We have installed LR24s on one floor at the US Federal Reserve in Washington DC as part of our ongoing energy-efficiency program," says US Federal Reserve plant manager Chris Jennings. "We look forward to evaluating additional Cree LED lighting prod-

ucts in other applications within the Federal Reserve."

Cree says that the use of LED lighting can be a great advantage in gaining LEED (Leadership in Energy and Environmental Design) certification. "The use of LED lighting for general illumination can dramatically lower a building's energy-density, allowing an architect to re-introduce accent or decorative lighting — something that is sometimes sacrificed in buildings pursuing LEED certification today," says Tom Liebel, AIA, LEED AP, associate principal at Marks, Thomas Architects. The LR24 delivers high light levels at only 0.5-0.75W/ft², says Cree.

The LR24 has already been recognized for its superior efficacy in the 2008 Lighting for Tomorrow solid-state lighting competition, organized by the American Lighting Association, the US Department of Energy (represented by Pacific Northwest National Laboratory) and the Consortium of Energy Efficiency.

www.CreeLighting.com

Philips illuminates world's first 'LED nation'

A three-acre island off the USA's Connecticut coast is set to become an 'off-grid' model of efficiency — in part by adopting LED lighting.

North Dumpling Island is owned by inventor Dean Kamen, who has established it as an independent nation — complete with its own constitution, flag and national anthem. When the US Coast Guard cut electrical connectivity to the island's lighthouse in favor of solar power, Kamen decided to use renewable energy sources exclusively, together with the latest technical innovations in lighting, water purification and appliances (many of which are his own inventions). As a result, the island will achieve net zero energy (i.e. its energy use will be negated by its energy generation).

The fully converted and self-sustaining island will be unveiled in the Spring during a two-day fundraising event for FIRST, an organization founded by Kamen to inspire young people's interest and participation in science and technology.

"With increasing strain on our world's energy resources, our goal is to make North Dumpling a small but prominent example of what can be achieved on a larger scale with

today's emerging energy-saving technologies," says Kamen. "The role of lighting alone as a chief energy drain has been well proven, and Philips' LED lighting systems merge the best of technical innovation with societal benefit."

The official lighting provider to the island is Philips Color Kinetics of Burlington, MA, USA (the leading center of innovation and product development for Philips' global LED lighting systems business). Installation is now underway and includes:

- replacing incandescent sources with LED alternatives inside Kamen's properties, cutting their lighting-related energy by 70%;
- adding controllable, multi-color LED lighting for special effects on the island while still cutting overall energy by nearly 50%;
- improving the 'usefulness' of illumination via the directional nature of LED sources which, unlike the island's former floodlighting system, project light exactly where it's needed for greater efficiency;
- allowing the basement space to be illuminated, where the prior incandescent sources generated too much heat to be safely installed.

"There's a common misperception that adopting energy-efficient light-

ing means sacrificing the quality and experience of light that we're accustomed to. That's simply not the case with LED systems which, when engineered properly, can mimic nearly any 'shade' of white light — from warm incandescent to cool fluorescent," says Philips Color Kinetics' chief technology officer Fritz Morgan. "Moreover, the inherently digital and directional nature of LED sources allows us to control and customize light as never before."

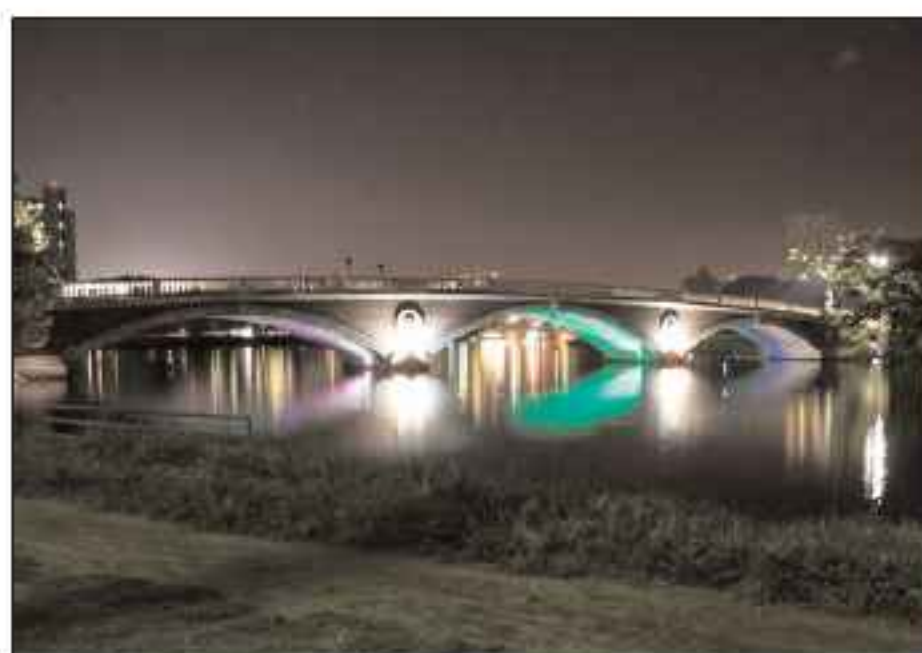
Philips participates in many government and industry initiatives related to energy conservation. As a founding member of the Next Generation Lighting Industry Alliance, it has helped to develop a technology roadmap for the US Department of Energy as well as Energy Star criteria for LED lighting. The firm also played an instrumental role in the formation and leadership of the Lighting Efficiency Coalition, and recently received a Champion of Energy Efficiency Award from the American Council for an Energy Efficient Economy — largely for leading the charge to phase out inefficient incandescent lamps in the US market.

www.colorkinetics.com
www.philips.com

Luminus' PhlatLight LEDs illuminate footbridge

PhlatLight LEDs made by Luminus Devices Inc of Billerica, MA, USA are being used to permanently color the Weeks Memorial Footbridge that links Cambridge and Allston, MA.

The PhlatLight LED color-changing wash lights were specially designed for the Weeks Bridge by Luminus Devices and lighting artist John Powell of Light Time in Space Inc. To illuminate the bridge, four water-proof fixtures were developed. Each contains only two PhlatLight LEDs of each color, red, green and blue. By combining the three colors, the LEDs can be mixed into virtually any color to slowly and subtly illuminate the bridge.



Luminus' PhlatLight LEDs on the Weeks Memorial Footbridge.

"In densely populated metropolitan areas, such as Cambridge, traditional lighting sources make it extremely difficult to see the atmosphere above the haze," said Powell.

"The addition of lights to the underbelly of the Weeks Footbridge is the continuation of an architectural lighting effort first undertaken in December 2001 with John Powell. In 2004, working closely with Powell, the Charles River Conservancy started permanent illuminations to several Charles River bridges and a new bridge was added every year," said Renata von Tscherner, president of the Charles River Conservancy. "We look forward to working with them [Luminus] in the future on additional illumination projects along the Charles River," Tscherner adds.

www.luminus.com

Ford introduces new Mustang incorporating Osram Joule standardized automotive LED system

Press day at the 2008 Los Angeles Auto Show on 19 November saw the unveiling of the 2010 Ford Mustang, which incorporates Osram LED lighting systems from front to back.

Osram's Joule standardized automotive LED system powers not only the brake and tail-lighting, but also a unique sequential rear turn signal. The vertical tail-lamp design uses three LED bulbs that fire sequentially, from the center out (a feature not seen on the Mustang since the '60s).

Unlike traditional incandescent signal lights, the Joule system uses LEDs that consume 10 times less energy, generate less waste and offer flexibility in design, as well as saving the user up to 4 gallons of gasoline per year, reckons the firm.

Osram LEDs also light the Mustang interior's center stack, window switches, door lock lights and headlamp switches. The ambient interior



Ford Mustang's rear light cluster.

lighting system uses Osram's TopLED family of LEDs to light cup holders, door panels, foot wells and consoles. A programmable system allows interior lighting to be customized, with a choice of seven colors: red, green, blue, orange, purple, white and ice blue. Previously, Osram's TopLED was the driver behind the industry-first color-configurable instrument cluster in the 2005 Ford Mustang.

"LEDs continue to define the future of automobile lighting when it comes to environmental sustainability, practical functionality and design flexibility," says David Hulick, global product marketing manager at Osram for its Automotive LED Systems strategic business segment. "The reduction in energy consumption, coupled with its long-lasting durability, means less waste is generated in the form of replacement parts and packaging," he adds. "The design flexibility offered by LEDs makes them even more desirable for defining the signature look of one of America's most celebrated vehicles."

Osram also worked with Valeo Sylvania to supply the complete exterior package, including fog lamps, LED CHMSL, front and rear side marker lamps and the D3S XENON headlamps.

www.sylvania.com

Lansing expands trial of Luxeon-based street lighting

LED maker Philips Lumileds of San Jose, CA, USA says that Lansing Board of Water and Light (LBWL), a municipally owned utility in Lansing, MI, has expanded its trial of street lamps based on its Luxeon LEDs with the addition of six new fixtures illuminated by neutral-white Luxeon Rebels. The city now has 23 Luxeon-based street lights, and LBWL officials are considering a much larger pilot to determine whether the 34,000 high-pressure sodium and metal halide street lamps in the greater Lansing area will eventually be replaced with LED models.

Lansing's first 17 Luxeon-based street lamps were installed in 2007 to explore the possibility of illuminating area roadways and sidewalks with LEDs in order to reduce energy and bulb replacement costs. The LED light engines used in the fixtures were designed by Midwest Circuits of Ferndale, MI, a manufac-



Conventional (left) and LED (right) streetlamp in Lansing.

turer of LED assemblies for outdoor lighting applications.

Lumileds says that public reaction to the initial LED street lights has been positive. In a recent survey, 85% of respondents said that the new fixtures have a pleasant glow, sufficient brightness and a safe light pattern. The vast majority also said that they supported the installation of solid-state street lamps in other neighborhoods.

"The 'green' movement is making it important for us to implement environmentally friendly solutions

wherever possible, and that includes street lighting," says LBWL street lighting designer Roger Adsit. "Everything is going well with the Luxeon-based fixtures in this pilot so far, and we are continuing to pursue the possibility of transitioning to LED street lamps over the long term."

Lansing is among a growing number of municipalities worldwide that is evaluating the use of solid-state illumination for street lights to take advantage of the cost, performance and technical benefits of LEDs (which include an energy saving of up to 50%, long life, mercury-free construction, and better color rendering that can help improve safety and security by reproducing truer color and sharper detail — particularly compared to the yellow light cast by sodium lamps). * A white paper 'LEDs: Coming Soon to a Street Light Near You' can be downloaded from

www.lumileds.com/pdfs/WP14.pdf

IN BRIEF

Repretech to distribute Firecomms' POF transceivers and VCSELs in Northern and Eastern Europe

Firecomms Ltd of Cork, Ireland, which manufactures high-speed plastic optical fiber (POF) transceivers and visible-wavelength vertical-cavity surface-emitting lasers (VCSELs), has significantly expanded its Northern and Eastern European sales channel through a strategic partnership with Repretech Nordic Oy of Espoo, Finland.

Repretech will leverage its 20 years experience as a manufacturer's representative of electronic devices to represent Firecomms in the key markets of Denmark, Finland, Norway, Sweden, Belarus, Estonia, Latvia, Lithuania, Russia, and Ukraine.

"This agreement allows us to expand our presence in these most important markets by strengthening our existing customer relationships and leveraging Repretech's considerable expertise," says Hugh Hennessy, Firecomms' VP of worldwide sales and marketing. "With a highly synergized product line and offices throughout the region, Repretech is well positioned to expand Firecomms' growing customer base," he adds.

The markets for high-speed plastic optical fiber transceivers and surface-emitting lasers are growing rapidly and expanding to various market segments, says Repretech's general manager Paul Budiansky. Firecomms is a leading developer of the components, which are a natural fit to Repretech's product portfolio, he adds.

www.firecomms.com

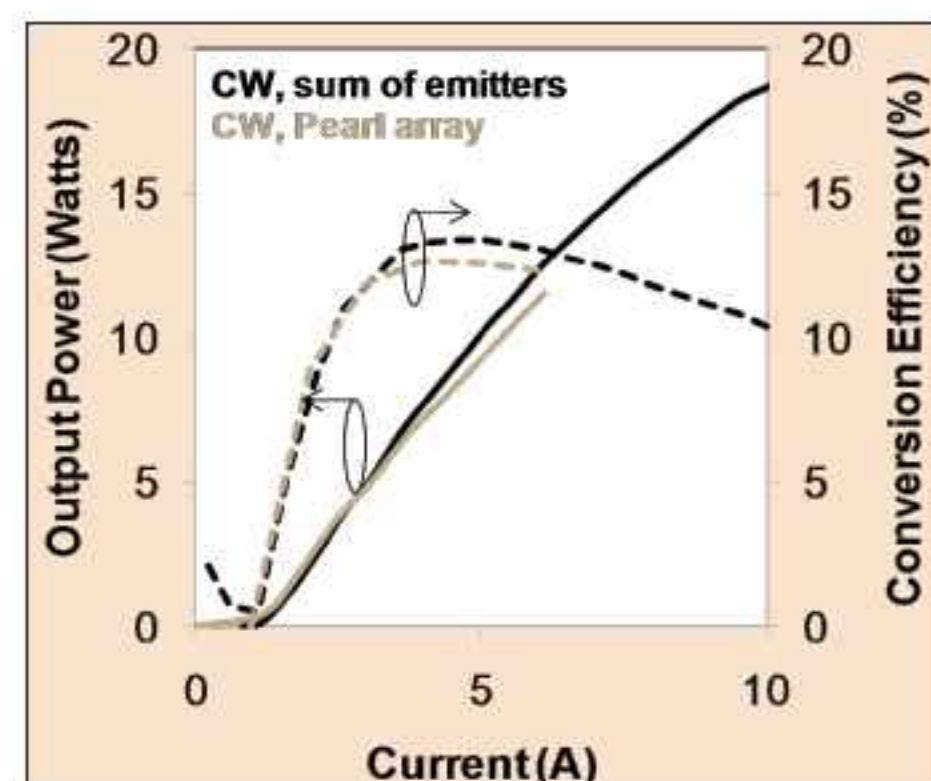
nLight launches new-generation 1400–2000nm InP-based lasers for medical applications

High-power diode laser manufacturer nLight Corp of Vancouver, WA, USA has introduced a new generation of 1400–2000nm laser diodes based on indium phosphide that provide higher power and better efficiency. The firm says that the wavelengths open up a wide range of surgical and aesthetic medical applications through either direct use or to pump holmium or erbium lasers.

At 1.9 μ m, the Pearl fiber-coupled module provides up to 20W output power from a single 400 μ m 0.22NA fiber with >10% wall-plug efficiency. Single emitter chips produce up to 1.5W rated power on expansion-matched substrates.

At 1.4 and 1.5 μ m, the module provides up to 40W from a single 400 μ m 0.22NA fiber and >30% wall-plug efficiency. Single-emitter chips produce up to 3.5W rated power on expansion-matched substrates.

"For more than five years nLight has supported advanced research to develop applications using InP



Output & efficiency at 1900nm.

semiconductor laser diodes," says Joe DeBartolo, VP sales & marketing. "With our experience and over 13,000 actual hours on lifetest under accelerated current and temperature conditions, we are excited to help bring new solutions to medical applications."

nLIGHT featured its enhanced InP product lines at the MEDICA 2008 event in Düsseldorf, Germany (19–21 November).

www.nlightphotonics.com

Alfalight launches 6W uncooled 940nm pump laser for CaTV and FTTx amplifiers

Alfalight Inc of Madison, WI, USA, which manufactures high-power diode lasers for industrial, defense and telecoms markets, has made available the AM6-940B-20-608, a 6W, 940nm uncooled multimode laser diode for cladding-pumped telecom fiber amplifiers (e.g. erbium-ytterbium fiber amplifiers for CaTV and FTTx networks).

The AM6-940B-20-608 includes an on-board thermistor for temperature tracking, supporting complete system diagnostic and performance monitoring. It is available in a compact, hermetic 6-pin package and is offered with a 105 μ m, 0.22 NA fiber.

The device is fully qualified and meets all GR-468 standards.

At pricing comparable to previous 4W devices, the new higher-output diode improves dollar-per-watt performance by about 50%.

"Alfalight has been delivering fully qualified pump diodes for telecom applications since 2003," says Ron Bechtold, VP of sales & marketing. "With this latest 940nm device we continue to advance dollar-per-watt performance for high-reliability laser diode pump solutions for telecoms applications." Pricing is \$450 each in quantities of 10 plus.

www.alfalight.com

Ge/Si yields record 340GHz gain-bandwidth product for APD

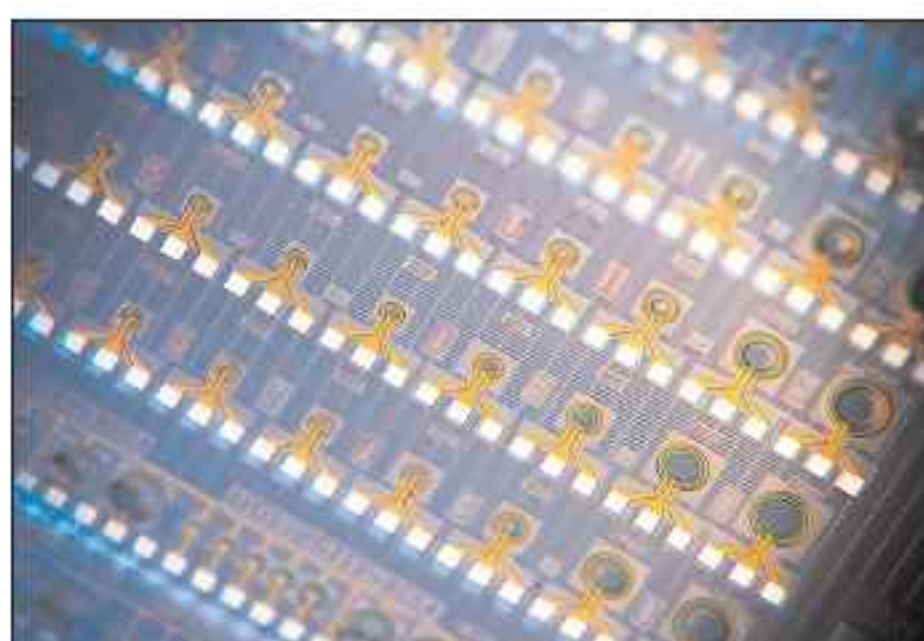
Intel has claimed record performance compared to commercially available avalanche photodetectors (APDs) based on InP by demonstrating a monolithic germanium/silicon APD with a 340GHz gain-bandwidth product (Nature Photonics; doi:10.1038/nphoton.2008.247).

The advance builds on previous Intel silicon photonics developments in recent years, such as high-speed silicon modulators and a hybrid InP-Si laser (integrating InP onto a silicon-based structure).

In the absorption region of a standard PIN photodetector, a photon creates an electron-hole pair, which is separated by an applied voltage, generating a current.

But in an APD, an electric field across a multiplication region accelerates the photo-electron until it has enough energy to cause impact ionization of a crystal lattice atom. This creates another electron-hole pair, whose electron repeats the process, creating a cascade (avalanche) in which the number of electrons doubles at each impact. Each incoming photon can hence yield hundreds of electrons before they are collected by the electronics (amplifying the signal current). An APD is therefore better at detecting weak, low-intensity optical signals.

Compared to standard silicon photodetectors, APDs are typically made of III-Vs materials, which are better at absorbing the near-infrared light used for fiber-optics communications (since silicon has an indirect energy bandgap). However, they are more difficult to manufacture in quantity, making them expensive. A typical commercial InP-based module can cost more than \$100, limiting the use of fiber-optics mainly to high-volume long-haul telecoms (over tens of kilometers) or connecting servers in massive supercomputers.



Wafer with array of APDs of varying diameters (30–50µm) and designs.

Also, in a typical III-V-based APD, the avalanche process adds noise to the data, which must be cleaned up by extra electronics. In contrast, silicon's material properties inherently allow high gain with less excess 'avalanche' noise than InP-based APDs, as well as a 3–5dB improvement in theoretical sensitivity.

An alternative is hence to combine a silicon multiplication region with a light-absorption layer of germanium (which can more efficiently detect light in the near-infrared). However, due to their different crystal lattice spacings, the stress in Ge films deposited on Si causes defects near the interface. Intel claims that its Ge deposition method helps to overcome this.

Intel's monolithically grown Ge/Si APD has a sensitivity of -28dBm at 10Gb/s (equivalent to commercially available III-V APDs) and a record gain-bandwidth product of 340GHz for any APD operating at 1300nm, compared to about 120GHz for a traditional InP-based APD, Intel says (i.e. it can produce a bigger electrical response, for a given speed, than traditional detectors).

Professors Joe Campbell of the University of Virginia and John Bowers of the University of California, Santa Barbara (UCSB), who held the previous record for an APD, provided consultation and assisted with testing and characterization.

The extra gain could be used to: extend transmission distance (since it can detect weak signals that have lost intensity down the optical fiber); allow the use of cheaper, low-power lasers (particularly for fiber-to-the-home); or provide more moderate gain at higher speeds (helping to cut cost by an order of magnitude for 40Gb/s).

Dr Mario Paniccia, Intel fellow & director of its Photonics Technology Lab, says that this paves the way for developing low-cost CMOS-based APDs for optical links operating at data rates of 40Gb/s or higher and proves, for the first time, that a silicon photonics device can exceed the performance of a device made with traditional, more expensive materials such as InP.

In addition to optical computer and communications links (including extended-reach fibre-to-the-home), the Si-based APDs could also be used to make highly sensitive infrared imaging systems and camera sensors, as well as more sensitive biochips (e.g. using low-cost arrays of the devices).

Numonyx BV, a spin off created in early 2008 from the flash memory businesses of Intel and STMicroelectronics NV that manufactures NOR, NAND, RAM and phase-change non-volatile memory technologies, provided process expertise and manufacturing (on a CMOS production line alongside commercial high-volume memory chip production). "We are committed to enhancing this relationship, to enable further breakthroughs in the silicon photonics area," says Yonathan Wand, Numonyx's manufacturing VP & Fab1 plant manager.

Paniccia says that Intel needs to improve the sensitivity and reduce dark current, but expects commercial silicon APDs in the next 2–3 years.

www.intel.com

Gemfire restarts operations after 2-week hiatus

In late November, Gemfire Corp, which makes integrated optical components and sub-systems based on photonic lightwave circuits (PLCs) for telecom and defense-related applications, restarted all three of its facilities: in Fremont, CA, USA; in Livingston, Scotland (formerly silica-on-silicon firm Kymata, bought by Alcatel Optronics, then Avanex, then Gemfire); and in Jessup, MD, USA (formerly Covega until February, a provider of InP and lithium niobate components and modules to the telecom, industrial, medical, defense and test & measurement industries, before becoming Gemfire's active component division).

After the recent stock market crash, a new investor decided against providing funding, and a couple of large

customers pushed out orders, leading Gemfire to running short of cash. On 5 November, Gemfire hence put the two US plants on ice for two weeks and closed the Livingston high-volume manufacturing plant without notice, putting 250 people out of a job. However, according to president & CEO Richard Tompane, the shutdown was due to UK labour law only allowing the Livingston operation to be temporarily suspended by shutting down the plant then recalling the workers later.

Gemfire's last round of funding was in September 2007 via a private placement of \$37m led by Loudwater Partners (including Centaurus Capital, Uberior Equity Ltd and Palo Alto Investors) to provide the expansion capital required to meet growing

demand for its products. Gemfire's total funding was raised to \$122.7m.

Tompane stresses that Gemfire doubled its revenue last year and (with a full order book) planned to double again this year. Also, the firm is a single source for many of its customers, and holds a large market share for the types of components it supplies. Gemfire has hence been able to restart operations by focusing on current customers and being able to persuade them to either accelerate payment terms or increase their orders.

However, in the current market conditions, with uncertainties in both additional financing and growth, Gemfire shifted out some new programs, adds Tompane.

www.gemfire.com

Tunable laser and transmitter assembly agreements

Members of the Optical Internet-working Forum (OIF) have fine-tuned the organization's Integrable Tunable Laser Assembly Multi-Source Agreement (ITLA-MSA) version 01.2 to include continued refinements, added features, and improved performance. In addition, the ITLA platform has been leveraged into the next-generation tunable laser agreement, the Integrable Tunable Transmitter Assembly (ITTA).

The OIF says that, since the first tunable laser agreement (released in 2002), its tunable laser projects have continued to receive a high level of interest from the industry and from member companies. "The OIF has played a pivotal role in the standardization of tunable lasers in the telecom industry with the ITLA and ITTA multi-source agreements," says the OIF's Software Working Group chair, Raj Batra of component maker Emcore of Albuquerque, NM, USA. "These agreements have helped fuel the rapid adoption and integration of tunable lasers into telecom equipment, allowing vendors to displace fixed-wavelength lasers in DWDM applications," he adds.

The OIF's PLL (Physical Link Layer) Working Group receives continuous feedback from the industry, evolving the ITLA-MSA for changing needs. The new version realizes performance and cost improvements by optimizing the command set which enables the use of smaller, lower-power microprocessors and leads the way to future size reduction of the ITLA. New features have also been added to support applications requiring non-traffic interrupting off-grid tuning as well as those requiring sub-tones for channel identification.

Additionally, a project within the OIF Software Working Group has been created to work on interface testing to help ensure consistent software interface implementations across multiple ITLA vendors.

The ITTA is a tunable laser integrated with a modulator encompassed by a board containing the laser and modulator control electronics. It uses an enhanced version of the ITLA's command interface, extended to include software control of the integrated modulator. The ITTA comes in two form-factors: one that is similar in size to the ITLA, and a reduced-

size version compatible for use within a 300-pin SFF transponder.

The ITTA is designed for use in both 300-pin transponders as well as discrete line-card applications. The ITTA agreement details a communication protocol, electrical interface, power supply, optical specifications, and a mechanical interface for use in telecoms equipment operating in the C- or L-band.

The ITLA and ITTA MSAs are the latest in a series of four tunable laser projects completed by the OIF. The first resulted in the Tunable Laser Implementation Agreement (OIF-TL-01.1) and involved a large number of contributors from a wide variety of consumers and suppliers of tunable lasers. It addressed the communication protocol, electrical interface and mechanical form factor interoperability for tunable continuous wavelength (CW) lasers.

The second project, an MSA for the Tunable Laser Implementation Agreement (IA), generated a more comprehensive specification of the optical, electrical, mechanical, and communication protocols.

www.oiforum.com

GigOptix completes merger with Lumera

Lumera Corp of Bothell, WA and privately owned GigOptix LLC of Palo Alto, CA have completed their merger (announced in late March), becoming GigOptix Inc, based in Palo Alto and maintaining operations in Bothell and Zurich, Switzerland. Its common stock is trading on the Over-The-Counter (OTC) Bulletin Board under the symbol GGOX. The merger follows approval by Lumera's stockholders at their annual meeting on 4 December and previously by GigOptix securityholders on 26 March.

GigOptix LLC securityholders have now received 0.1375 shares of GigOptix Inc common stock for each GigOptix LLC membership unit, and Lumera stockholders have received 0.125 shares of GigOptix Inc common stock for each Lumera share. Lumera stockholders holding stock certificates will soon receive share exchange instructions.

Lumera's closing bid on 9 December was \$1.72, as adjusted to reflect a 1-for-8 reverse stock split.

GigOptix (formerly iTerra Communications until July 2007) is a fab-less provider of high-speed physical

media dependent (PMD) ICs (including modulator drivers, laser drivers and trans-impedance amplifiers) that are integrated into 300-pin transponders, X2, XenPak, XPak, XFP, SFP+, ultra-long-haul, TOSA, ROSA and test & measurement applications for telecom, datacom, Infiniband and consumer optical systems (covering serial and parallel laser technologies from 1G-100Gb/s). Lumera, founded in 2000, designs electro-optic components based on proprietary polymer compounds for the telecoms and computing industries.

GigOptix's Dr Avi Katz continues as CEO & chairman, while Peter Biere will serve as chief financial officer, Andrea Betti-Berutto as chief technology officer, Julie Tipton as VP of marketing, Dr Raluca Dinu as VP of advanced engineering, Vivek Rajgarhia as VP of global sales, and Marc Correa as VP of global operations. Dr Joerg Wieland will serve as VP & general manager of Zurich-based subsidiary GigOptix-Helix AG.

Former Lumera board members C. James Judson and Dr Joseph Vallner

(Lumera's interim CEO) will be on the board of GigOptix, as will Kimberly D.C. Trapp (formerly a board member of both GigOptix LLC and Lumera). Other board members include Stephen C. Johnson (a former GigOptix LLC board member), Neil J. Miotto and Douglas L. Swenson.

"Lumera's advanced polymer modulators combined with GigOptix's high-speed drivers and receivers will provide highly differentiated products addressing the key challenges that face the industry today," says Katz. "With the help of an international commercial network built by GigOptix, the combined company can become a dominant force in the optical communication component business," he believes.

"We closed a chapter on Lumera as a separate company and began a new one as part of a larger entity, GigOptix Inc," adds Vallner. "We are pleased that the shareholders of Lumera have recognized the benefits of combining the two companies to create greater shareholder value in the coming years."

www.gigoptix.com

3S ramps production of terrestrial 980nm pump modules

Telecom laser chip and module maker 3S Photonics of Nozay (Essonne near Paris), France says that, to support growing demand, it has increased production capacity for its terrestrial Mini-DIL 980nm uncooled pump laser modules (the new 1999 PLU Series, which is designed for single-channel fiber amplifiers deployed in high-speed optical telecom networks, and has already been qualified by many customers worldwide).

Uncooled operation (without any thermoelectric cooler) drastically reduces both overall power consumption and power dissipation, says the firm. The pump laser module uses a very compact Mini-DIL package (with a footprint of 7mm x 13mm, and a maximum height of 5.1mm), enabling a small form-factor. It can

also operate over what is claimed to be the widest temperature range currently available on the market (with T_{case} from $-5^{\circ}C$ to $+75^{\circ}C$).

3S says that Mini-DIL pump lasers allow a significant reduction in size and power consumption when designing highly reliable erbium-doped fiber amplifiers (EDFAs) for metropolitan applications, and can be used in conjunction with high-power cooled pump laser modules.

The 1999 PLU provides what is claimed to be a best-in-class operating power of up to 250mW at $+75^{\circ}C$. 3S says that the performance over such a wide temperature range comes from the use of its proprietary chip, introduced more than a year ago and already in mass production. The firm also claims that the module's design

provides good power stability coupled to a very wide dynamic range.

VP of marketing & product management Yannick Bailly says that the 1999 PLU Series leverages 3S' expertise in designing submarine uncooled pump modules, providing the terrestrial market with a cost-effective product with what is described as an unparalleled level of performance and reliability.

The 980nm uncooled Mini-DIL pump module features a very low FIT (failures-in-time) rate, ensuring a high level of reliability (fully qualified in accordance to Telcordia GR-468-CORE specifications). The wavelength is locked using an external fiber Bragg grating (FBG) located in a polarization-maintaining fiber (PMF) pigtail.

www.3sphotronics.com

JDSU takes Bookham, Syntune and Cyoptics to ITC

On 7 November, optical communications component maker JDSU of Milpitas, CA, USA filed a 39-page complaint with the US International Trade Commission (ITC) alleging infringement of two US patents:

- 6,687,278 ('Method of Generating an Optical Signal with a Tunable Laser Source with Integrated Optical Amplifier'); and
- 6,658,035 ('Tunable Laser Source with Integrated Optical Amplifier').

The patents concern the output of a widely tunable laser diode coupled into an optical amplifier monolithically integrated in the same InP-based epitaxial structure via a shared waveguide, part of which is curved to reduce reflections from the output facet, yielding a tunable optical signal. The patents were filed in July 2000 and issued between December 2003 and February 2004 to tunable laser manufacturer Agility Communications Inc of Goleta, CA, which was acquired by JDSU in 2005.

The main defendants are rival tunable laser chip makers Bookham Inc of San Jose, CA, USA and Syntune AB of Kista, Sweden, as well as CyOptics Inc of Breinigsville,

PA, USA, which JDSU says integrates chips from Syntune into products at its facility in Mexico.

JDSU's complaint also names network equipment making customers Tellabs Inc of Naperville, IL, USA, Ciena Corp of Linthicum, MD, USA and Nortel Networks Ltd of Toronto, Canada, plus metro equipment maker ADVA Optical Networking of Munich, Germany, regarding their alleged use and importation of the accused Bookham tunable chips.

The complaint seeks a ban on imports into the USA of the infringing tunable laser chips as well as modules, line cards and systems that use them.

Prior to the ITC complaint, JDSU had previously filed separate litigation in federal court regarding the 6,658,035 and 6,687,278 patents as well as a third patent (US patent number 6,687,278).

Consequently, to counter approaches it said JDSU had made to its customers concerning the

JDSU seeks a ban on imports of infringing tunable laser chips

legal status of its products, in March Bookham filed a complaint against JDSU and Agility in the US District Court for the Northern District of California, San Jose Division seeking declaratory judgments that its tunable laser products do not infringe any valid, enforceable claim of the patents and that all claims of the patents are invalid and unenforceable, as well as claiming relief for statutory unfair competition and intentional interference with economic advantage.

On 21 July, JDSU countersued Bookham for patent infringement, focused on Bookham's tunable laser product line, seeking compensatory damages, treble damages and attorney fees, plus an order enjoining Bookham from future infringement.

Separately, in July, JDSU sued Syntune in California over the patents. In October, Syntune asked the US Patent and Trademark Office to re-examine JDSU's patents.

No trial dates have yet been set for any of the above court cases or the ITC complaint.

www.freepatentsonline.com/6687278.html

www.freepatentsonline.com/6658035.html

JDSU promotes Test & Measurement president to CEO

JDSU of Milpitas, CA, USA, which makes optical components for communications, commercial and consumer markets as well as test & measurement equipment, has promoted Thomas Waechter (president of its largest business segment, Communications Test & Measurement) to president & CEO, from January. Waechter will also be appointed to JDSU's board.

Prior to joining JDSU in 2007, Waechter held a variety of executive positions including CEO for three public companies. As president & CEO of Stratex, he grew revenue substantially and improved profitability and was instrumental in driving its merger with Harris, an independent supplier of wireless transmission systems.

Waechter's experience also includes 14 years with multinational Schlumberger. Over the last eight years he has gained experience in the telecoms industry as CEO and chief operating officer of a number of public firms.

"After a thorough search process we believe we have selected the candidate that best matches the requirements for leading the company during these challenging economic times," says chairman Marty Kaplan. "Since joining JDSU last year, Tom has already made significant contributions to the company's success through operational excellence as well as strategic acquisitions," he adds.

"My priorities are clear: focus the collective talent and commitment

of JDSU to support our worldwide customer base," says Waechter.

"I look forward to continue working with him through my board participation," says outgoing president & CEO Kevin Kennedy, who said at the end of October that he is stepping down, following JDSU's third consecutive quarterly loss in Q3/2008 (on revenue at the low end of its guidance range).

A search for a replacement president of the Communications Test & Measurement business segment (including both internal and external candidates) is underway. David Holly, senior VP in Communications Test and Measurement, will have interim responsibility for day-to-day operations.

www.jdsu.com

CyOptics launches 10Gb/s CWDM TOSAs in support of 40GbE standard

CyOptics Inc of Lehigh Valley, PA, USA, which designs and fabricates InP-based optical chips and components, is expanding its 10Gb/s TOSA (transmit optical sub-assembly) portfolio by making available samples of coarse wavelength division multiplexing (CWDM) TOSAs for the emerging 40GBASE-LR4 standard. Full production will ramp up in second-quarter 2009.

The new 10Gb/s TOSAs (TX1270, TX1290, TX1310, TX1330) operate on the ITU-T CWDM grid of 1271, 1291, 1311 and 1331nm, and meet the emerging 40 Gigabit Ethernet (GbE) requirements for 40GBASE-LR4 standardized by the IEEE 802.3ba Task Force in support of 10km transmission over single-mode fiber.

The TOSAs are based on CyOptics' standard field-proven buried hetero-structure distributed feedback (DFB) laser chip design, with over 2.5 million units shipped since 2005 and more than 24 billion field service hours. The TOSAs incorporate an integrated InGaAsP monitor

photodiode and are packaged in a TO-header with receptacle, compatible with the 10Gb/s XMD multi-source agreement (MSA), for uncooled use over an operating temperature range of -5°C to $+75^{\circ}\text{C}$ and transmission rates of up to 10.7Gb/s.

"The emerging 4x10GbE standard for the 10km interface is the fastest solution to market and uses cost-effective off-the-shelf optical and IC components," says Kou-Wei Wang, VP & general manager of CyOptics' InP OEM business. "Our new TOSAs leverage CyOptics' technology from the rapidly growing FTTx market to enable next-generation 40G Ethernet solutions."

The introduction of these new products enhances CyOptics' 10Gb/s product portfolio of DFB, Fabry-Perot (FP) and electro-absorption modulated laser (EML)-based TOSAs as well as PIN and avalanche photodiode (APD)-based ROSAs (receive optical sub-assemblies).

www.cyoptics.com

Santur ships its 200,000th widely tunable laser

Santur Corp of Fremont, CA, USA, a vertically integrated manufacturer of tunable lasers for metro and long-haul wavelength division multiplexing (WDM) telecoms systems, has shipped its 200,000th tunable laser.

Santur, which is focused on providing devices based on indium phosphide, took about 7 years to ship its first 100,000 devices but only one further year to ship the second 100,000. The ramp attests to the pivotal role played by Santur's unique design and manufacturing capabilities to support the ubiquitous adoption of tunable lasers in metro and long-haul networks worldwide, the firm claims.

Santur's devices have now accumulated over a billion hours of reliable operation in the field.

"At Santur, we are proud of our continued partnership with our customers," says CEO Paul Meissner. "This milestone attests to their trust in our ability to respond to their rapid increase in demand with a highly scalable product," he adds.

Santur claims that it has extended its market share through the design of its distributed feedback (DFB) laser array platform, which enables a high level of integration of various functions (including modulators and amplifiers) in a single indium phosphide device.

www.santurcorp.com

IN BRIEF

3S Photonics awarded ISO 9001:2000 certification

Telecom laser chip and module maker 3S Photonics of Nozay (Essonne near Paris), France has been awarded ISO 9001:2000 certification by audit firm AFNOR, covering all 3S Photonics sites (including its Thai regional office based in Bangkok).

The certification embraces design, development, manufacturing, sales, after-sales and upstream activities such as advanced R&D, and hence will support 3S Photonics' diversification and innovation strategy planned for the next three years, the firm says.

The certification replaces the previous ISO 9001 accreditation awarded in December 2006 to Avanex France SA. 3S was formed when chairman & CEO Alexandre Krivine and entrepreneur Didier Sauvage acquired what was Avanex France SA in April 2007 from Avanex Corp (which in 2003 had acquired what was then called Alcatel Optronics).

3S Photonics says that the new certification validates the efficiency of quality management and quality insurance systems established by the new management team, and is the result of a quality system built around strategic guidelines.

"Some of our components are part of the bedrocks of submarine optical links that ensure Internet connection between continents," says Dominique Laffitte, VP of Quality & Reliability. "Our customers demand that we not only maintain a high level of quality but that we go from strength to strength to improve it," he adds.

www.3Sphotonics.com

Finisar's storage growth offsets Optium's CATV downturn

For fiscal Q2/2009 (ended 2 November) Finisar of Sunnyvale, CA, USA has reported revenue of \$159.5m. This is up 23.9% on last quarter's record \$128.7m and up 58.4% on \$100.7m a year ago. However, excluding \$36.5m from two months of revenue from optical subsystem maker Optium Corp of Horsham, PA, USA following its takeover on 29 August, revenue of \$123m was down 4% on last quarter.

Revenue from network test equipment was \$11.8m, up 20.4% on \$9.8m a year ago but down 9.1% on the record \$12.9m last quarter due mainly to the spin-off of the NetWisdom product line into new firm Virtual Instruments (in which Finisar has a minority stake).

Revenue from optics was \$147.7m, up 62.5% on \$90.9m a year ago and 27.6% on \$115.8m last quarter (although, excluding Optium's \$36.5m, revenue of \$111.2m was down 4%). In particular, revenue for 10–40Gb/s applications was \$54m (up 67.6% on \$32.2m last quarter and almost triple \$18.2m a year ago, due mainly to Optium). Of total optics revenue, by application:

- short-range LAN/SAN (unaffected by Optium) was \$63.3m, up 4% on \$60.8m last quarter due to greater revenue from 8 Gigabit Fiber Channel (compensating for 10 Gigabit Ethernet and 2–4 Gigabit LAN/SAN revenues dropping slightly).

- metro telecoms was \$81m (up 48% on \$54.9m last quarter due to the merger). Of this, \$25.4m was for <10Gb/s applications and \$45.1m for 10–40Gb/s (with 40Gb/s continuing to grow sequentially). Reconfigurable optical add-drop multiplexer (ROADM) products for metro/telecoms contributed \$8.8m (about the same as recorded by Optium last quarter).

- analog & cable TV products were down more than expected from the \$8.1m reported by Optium last quarter to just \$3.4m (due to the credit crunch and cable TV operators being highly leveraged). This accounts for Optium's full-quarter revenue of \$41.5m (\$36.5m post-

merger plus \$5m the prior month) being down on last quarter's \$47m.

Non-GAAP gross margin was 35.6%, down on 40% last quarter due mainly to Optium (whose margins were lower than Finisar's prior to the merger): the blended gross margin for the combined firm last quarter would have been just 36.2%.

Excluding charges (including \$178.8m for goodwill impairment in conjunction with a deterioration in the macroeconomic environment and a material reduction in the firm's market value as of the end of the second quarter), non-GAAP net income was \$10.3m, but down slightly on \$10.9m last quarter due mainly to the inclusion of the Optium results. Nevertheless, earnings before interest, taxes, depreciation, and amortization (EBITDA) was a healthy \$20m, up slightly from \$19.4m last quarter.

During the quarter, Finisar's cash balance fell from \$124.6m to \$51.9m. This was due to the payment of \$92m in debt reduction for the firm's 5.25% convertible notes (which matured on 15 October), partially offset by adding \$31.8m in cash due to the Optium merger.

"We have largely completed the integration of both companies as of the end of last quarter and are already racing to realize additional synergies," says CEO Eitan Gertel. These should amount to \$10–15m annually, including \$5–10m related to manufacturing, mainly transferring products to lower-cost facilities. Capital expenditure hence rose from \$5.6m last quarter to \$9.9m, due to the ongoing expansion of the Shanghai facility and the build-up in production capabilities in Malaysia and Shanghai (in anticipation of transferring certain products there). But, correspondingly, operating expenditure of \$44m is down on both last quarter and a year ago.

"Current economic conditions are challenging," says president & executive chairman Jerry Rawls. Some storage customers forecast stable revenues or small increases (a

reflection of continued growth in information to be stored), but some networking and telecom customers expect sequential revenue declines of 10–14%. "Based on a variety of data points, it appears that revenues in our upcoming quarter will be down on a sequential basis."

For fiscal Q3, Finisar expects revenue to fall 5–10% to \$143–151m: \$10–11m for network tools (down from \$11.8m) and \$133–140m for optics (down from \$147.7m, including Optium again down about \$5m on its pre-merger quarterly run-rate of \$47m). On a non-GAAP basis, gross margin should fall to 34% and net income to just \$4m.

The firm is hence cutting operating expenditure by \$3m per quarter, including 120 job layoffs (12% of US staff). Whereas the impact of a full quarter of the merger would otherwise raise OpEx by \$2m in Q3, OpEx should fall by \$1m. EBITDA should still be a healthy \$12m (despite more than \$8m in depreciation expense). Lower CapEx of \$7–8m will help the cash balance to stay above \$50m, despite an upcoming payment of \$8.4m in non-recurring items related to merger obligations.

For fiscal Q4 (to end April), Finisar expects its pipeline of new products nearing qualification in customers' labs (particularly 10–40Gb/s products and LAN/SAN business) to enter production and drive a return to sequential growth. This could raise revenue back to fiscal Q2's levels, non-GAAP gross margin back to 35% and EBITDA back to \$20m, while CapEx is expected to continue to fall. Also, over the next few quarters inventory levels should fall by perhaps \$10m, so the cash balance should start to rise again.

"Just as we grew at a compound rate of 20% per year for several years following the crash of the tech bubble [of 2001], we believe we will emerge from this downturn in a much stronger position as we continue to expand our product portfolio, our addressable markets, and our market share," believes Rawls.

VCSEL arrays enable 40Gb/s parallel active optical cable

As part of the SCinet Network Infrastructure at November's SC08 supercomputing event in Austin, TX, Finisar demonstrated a new 40Gb/s optical link for data centers and high-performance computer clusters.

Quadwire is a parallel active optical cable that provides a 40Gb/s aggregate link via four 10Gb/s full-duplex channels. Based on the industry-standard QSFP form factor, the new cable uses fiber-optic technology to transmit parallel high-speed data over ribbon multi-mode fiber.

As InfiniBand supercomputing clusters move from double data rates (DDR) to quad data rates (QDR), existing copper cables present physical challenges to the system architecture, says Finisar. In addition to being heavy and bulky, these cables are limited to short distances as data integrity deteriorates over longer links. By contrast, Quadwire features a parallel 4x10Gb/s optical bi-directional link, meeting the needs for increased data rates in longer



Finisar's 40Gb/s optical link for data centers and computer clusters.

lengths (up to 100m) while offering a lighter-weight solution and much smaller bend radius. In addition, Quadwire uses Finisar's vertical-cavity surface-emitting laser (VCSEL)

Active optical cables are emerging as interconnect solutions to overcome limitations of copper

array technology. The cable's small diameter supports large port count architectures, ultimately enabling simpler installations and fiber management, says the firm.

"The physical challenge of connecting InfiniBand clusters with bulky copper cables has been difficult to manage even at DDR data rates of 20Gb/s," says Jag Bolaria, senior analyst at The Linley Group. "As the first QDR (40Gb/s) InfiniBand switches and host channel adapters (HCAs) begin to roll out, active optical cables such as Quadwire are emerging as the interconnect solutions to overcome limitations of copper," he adds.

"Active optical cables are quickly becoming the next-generation interconnects of choice for high-speed data-center connectivity," says Jan Meise, Finisar's director of strategic marketing. "The introduction of Quadwire, our second optical cable product, marks Finisar's entry into parallel connectivity, supporting leading-edge cluster technology with a superior alternative to copper cables."

Finisar is currently supplying samples of the Quadwire active optical cable to customers.

www.finisar.com/cables

Finisar receives Huawei Golden Core Partner Award

Finisar has received the Golden Core Partner award in a ceremony at the corporate headquarters of telecoms network provider Huawei in Shenzhen, China, attended by executive chairman Jerry Rawls and senior VP of sales & marketing Todd Swanson.

This is the third supplier award from Huawei. Finisar was honored for its innovative technology, high-quality, and on-time delivery of optical components for high-speed communications.

Of the more than 1000 suppliers that Huawei works with each year, Finisar was one of only 18 firms to receive the Golden Core Partner Award, which is bestowed on companies that consistently deliver high performance and quality products meeting Huawei's highly specialized needs.

Finisar supplies Huawei with a wide range of optical components (including passive devices, transceivers, and transponders) that are included in its telecoms networking equipment.

"We are very pleased to be honored by one of the world's largest and fastest-growing telecommunications equipment manufacturers," says Swanson. "To consistently achieve the highest levels of performance, quality, and short delivery times while exceeding Huawei's stringent requirements is a testament to Finisar's innovative products and high-volume manufacturing."

www.huawei.com

● Finisar has renewed and extended the maturity of its lines of credit of \$70m with Silicon Valley Bank. Of the total of \$92m, it has also paid the remaining \$22m principal balance of its 5.25% convertible notes at maturity on 15 October.

The line of credit under a non-recourse receivables purchase agreement has risen from \$10m to \$16m, while that under a letter of credit reimbursement agreement has been cut from \$10m to \$9m. Termination dates are extended to 24 October 2009. As of the end of the last fiscal quarter (2 August), Finisar had used \$5m and \$9m under the two agreements, respectively.

Also, a secured line of credit that was to mature on 13 March 2009 has been reduced from \$50m to \$45m and its termination date has been extended to 15 July 2010.

Emcore revenues shrink 20%, driven by PV order push-outs

For fiscal 2008 (to end September), Emcore of Albuquerque, NM, USA has reported revenue of \$239.3m (up 41% on fiscal 2007's \$169.6m), with international revenue more than doubling to \$94.4m (rising from 27% to 39% of total revenue).

In particular, for its fiscal fourth quarter, revenue was \$60.6m (up 29% on \$47m a year ago but down 20% on last quarter's \$75.5m).

The Fiber Optics sector contributed \$46.1m (76% of total revenue), up 48% on \$31.2m a year ago (66% of revenue). This was due mainly to acquiring, in early 2008, the Telecom and Enterprise & Storage as well as the Connects Cable assets of Intel Corp's Optical Platform Division (which added \$16.3m, or 35% of Fiber Optics revenue, in fiscal Q4). However, Fiber Optics was still down 14% on last quarter's \$53.6m after

a \$5m short-fall as demand "dropped off a cliff" after 15 September, leading to multiple orders cancellations.

Demand "dropped off a cliff" after 15 September, leading to multiple orders cancellations

The Photovoltaics sector contributed \$14.5m (24% of total revenue), down 34% on last quarter's \$21.9m and 8% on \$15.8m a year ago (34% of revenue). A \$5.3m drop in US government revenue (due to the termination of engineering and manufacturing contracts) offset growth in space and terrestrial concentrating photovoltaic (CPV)-related product sales. In addition, the adoption of CPV technology was adversely affected by it not being clear whether the investment tax credit in the USA was to be extended beyond the end of 2008. The uptake of CPV components was hence slowed significantly and delivery schedules pushed out.

Despite better utilization of the China manufacturing plant and the use of contract manufacturers, Fiber Optics gross margin has fallen from last quarter's record 27% to just 8.9%, due mainly to significant inventory write-downs. Photovoltaics gross margin has fallen from 17.3% a year ago and -3% last quarter to -31.6% due to \$6.9m of inventory write-downs and product warranty accruals from CPV-related business, following significant project losses on several initial CPV system installation projects (mainly from higher-than-expected material, freight and installation costs). Overall gross margin is down from 18% last quarter to -0.8%.

Net loss has grown from \$7.7m last quarter to \$19.4m (after being cut from \$17.5m the prior quarter). As of the end of September, cash, cash equivalents, available-for-sale securities and restricted cash totaled \$24.7m, working capital totaled \$70.5m, and the firm had no outstanding long-term debt.

Emcore also said that it was in negotiations with an investor to sell a minority equity stake in its Photovoltaics business as an initial step towards a potential spin off. "We've received additional indications of interest from a number of other parties as well," adds chief financial officer John M. Markovich.

To conserve cash in response to recent global economic uncertainty, Emcore has undertaken several cost-cutting initiatives, including a recent workforce reduction of about 100 staff and contractors, a significant reduction in fiscal 2008 staff bonuses, the elimination of fiscal 2009 merit rises, a significant

Emcore has undertaken a workforce reduction of about 100 staff and contractors

reduction in capital expenditure, and greater emphasis on improving working capital management. "We're also very selective in the focus on our efforts in product development," says president & CEO Hong Q. Hou.

"During the year, we launched our new CPV terrestrial systems business and achieved significant market penetration in both CPV components and systems in the first full year of operation," says Hou. In late November, Emcore announced its first deployment of a CPV solar power system in China with the XinAo Group, one of China's largest energy firms. Emcore and XinAo continue to discuss possible construction of a joint-owned plant in China to manufacture CPV systems designed and certified by Emcore for XinAo's coal gasification project and the Chinese market.

"As with most new technologies, we incurred significant start-up costs associated with establishing new product lines and building the required infrastructure," says Hou. "However, we have now established a leading position in this emerging market and have positioned Emcore for future growth in this segment."

Regarding the Fiber Optics sector, the Intel acquisitions significantly enhanced Emcore's product portfolio and expanded its customer base, providing increased leverage and scale. The comprehensive and diversified product portfolio in broadband, telecom, enterprise, specialty and high-performance computing markets — vertically integrated with an offshore low-cost manufacturing infrastructure — should put the fiber-optics business on a path to recovery, Hou reckons.

As of 30 September, Emcore's order backlog totaled \$56.3m (\$35.2m for Photovoltaics and \$21.1m for Fiber Optics). In partic- ➤

ular, in early August Emcore said that it had entered into two new long-term supply agreements for solar cells and receivers with a total value of over \$40m. The larger one is a four-year supply agreement for solar cells for incorporation into CPV solar power systems in the USA (focused on the California market). The firm has also substantially reached an agreement with two other major customers with their CPV system product qualified for the European market (to be announced in the near future), says Hou.

In addition, amid the current financial crisis, the investment tax credit in the USA was extended for eight years. "The USA is clearly becoming the center stage of the solar power opportunity. Thus we have adjusted our business development strategy to focus on the opportunities in the USA, especially in the south-western states," says Hou. "Working with our strategic partners, we have responded jointly to a number of RFPs by public utility companies in the south-western states," he adds. "The role of our partners in this

project is to organize equity and project financing and serve as owner/operators of the project." With three CPV receiver lines in Albuquerque and a fourth line in Langfang City, China now operational too, this capacity should be able to serve market demand over the next 12 months, so capital spending will slow significantly. However, Emcore is in active discussions with several potential international partners to license the CPV system manufacturing process in each of the firm's local markets to accelerate business growth.

Also, early September saw a long-term, multi-year purchase agreement with a major satellite integrator, and Emcore is currently negotiating a new pur-

The USA is clearly becoming the center stage of the solar power opportunity... we have adjusted our business development strategy to focus on the USA

chase agreement with an existing major customer for their future demand. "Our visibility for our space business is relatively good through mid-2009," adds Hou.

"Although we remain quite cautious about the current economic downturn, we believe that the company is now well positioned in its markets and our company remains very focused on continuing to lower our cost structure, managing our working capital and achieving profitability," Hou says.

For the December quarter (fiscal Q1/2009), Emcore expects revenue to be relatively flat sequentially, both overall and in the fiber-optics business (as demand seems to have stabilized). In addition, the bottom line should improve significantly.

Based on new design wins and newly qualified products and opportunities in the pipeline, the March quarter (fiscal Q2/2009) should see a noticeable business recovery. For full-year fiscal 2009, revenue is expected to increase by 10% compared to fiscal 2008.

www.emcore.com

Kopin receives \$600,000 NASA contract to develop nanostructured InGaP solar cell materials

Kopin Corp of Taunton, MA, USA, which makes III-V heterojunction bipolar transistor (HBT) epiwafers and CyberDisplay LCDs, has been awarded a \$600,000 NASA contract to produce nanostructured solar cells consisting of indium gallium phosphide (InGaP) materials. The goal of the two-year Phase II Small Business Innovation Research (SBIR) program is to develop a solar cell design that is more efficient and less expensive than conventional multi-junction technology.

"The material structures used in conventional solar cell designs significantly limit their power conversion efficiency and performance, requiring a trade-off between current and voltage," says Dr Roger E. Welsch, Kopin's director of New Product Development. "We are

employing a proprietary, patent-pending structure incorporating InGaP barriers, the same material used in our HBT wafers for billions of cell phones," he adds. In the Phase I program, Kopin produced several InGaP-based test structures that demonstrated a significant increase in the open-circuit voltage without any degradation in current. In this follow-up Phase II program, the firm aims to further enhance performance while maintaining its long-term objective to produce high-efficiency photovoltaic cells with low cost and good stability.

"This SBIR program is part of Kopin's strategy to leverage our unique expertise in nanostructured III-V materials to create high-efficiency solar cells at low cost for the emerging terrestrial renewable

energy market," says president & CEO Dr John C.C. Fan. "For unconcentrated sunlight, we believe our innovative approach in this SBIR program has the potential to achieve conversion efficiencies exceeding 40% with a single p-n junction device, approximately 20% higher than the current efficiencies of today's best multi-junction solar cells."

This is the second NASA contract awarded to Kopin this year for the development of nanostructured solar cell technology. In May, it received a two-year, \$600,000 award for the development of indium nitride (InN)-based cells, focused on producing high efficiency and resistance to extreme conditions such as those found near the sun.

www.kopin.com

Concentrix inaugurates 25MW CPV module production line

At an official inaugural ceremony, Concentrix Solar GmbH of Freiburg, Germany opened its new concentrator photovoltaic (CPV) module production line, which has been in operation since September.

Concentrix was founded in February 2005 as a spin-off of Freiburg-based Fraunhofer Institute for Solar Energy Systems ISE and up to September had been operating a 1MW pilot plant. To enable Concentrix to establish permanent facilities in Freiburg, the City of Freiburg supported the firm in its search for a location and a suitable building. Concentrix says that it chose Freiburg for its production facility site because it can draw on a network of local partners. The firm has an especially close working relationship with Fraunhofer ISE for carrying out further developments of its FLATCON technology, which uses a Fresnel lens to concentrate sunlight 500 times onto a small GaAs-based solar cell.

Up to now, this has enabled a record module efficiency of 23% (proven in May under normal operating conditions for a 5.6kW CPV system in Seville, Spain feeding energy into the utility grid). Concentrix has also supplied 500kW of CPV systems for the 1.7MW first



Concentrix's 25MW CPV module plant.

phase of a 3MW pilot-plant project of Spain's Institute of Concentration Photovoltaics Systems (ISFOC) in Puertollano, Castilla-La Mancha.

However, since October, Concentrix has been producing a new generation of modules that are more cost efficient and have higher efficiencies than their predecessors. External measurements performed at Fraunhofer ISE have confirmed a new average module efficiency of 27.2%, twice that of typical silicon modules (13–14%).

"With the start of production on an industrial scale [with an annual capacity of 25MW], we have made the decisive step from a start-up company to a successful industrial concern," says chief operating officer Karl Friedrich Haarbürger, who has been responsible for setting up the new production line.

For module production, Concentrix uses affordable machines from the electronics, circuit board and insulating glass industries. "Constructing a fully automated production line with industrial throughput for concentrator modules is a milestone for us and also for the field of concentrator photovoltaics," adds CEO Hansjörg Lerchenmüller.

"However, this is just the beginning and serves only as an entry into industrial production," he adds. "Our goal is to grow with increasing speed in order to reach grid parity as soon as possible with our technology. With this first step, we are on the right path." With a floor area of 4000m² available for production and services, the building and infrastructure are designed so that the production capacity can be quickly expanded up to 100MW.

Concentrix currently has 60 staff, but expects this to grow to 100 next year. In the course of further expanding shift operation, the firm plans to employ additional qualified personnel from the fields of electronics and electrical engineering. Concentrix is also recruiting technicians in power plant engineering as well as technicians and engineers in the field of development.

www.concentrix-solar.de

Concentrix connects 100kW Abengoa installation to Spanish grid

After completing a 100kW installation (consisting of 19 x 5.75kW FLATCON trackers) at the 2MW power plant of investment partner Abengoa Solar at the Solúcar Complex in Sanlúcar la Mayor near Seville, the end of September saw connection to the public utility grid under Spain's feed-in tariff law.

The 'Casaquemada' power station consists of both silicon flat modules and concentrator PV modules mounted on tracking systems (one

of the first power plants of its kind to combine the two).

"Casaquemada is an important step for us to show that FLATCON is a competitive technology and an alternative to conventional photovoltaics technology," says Concentrix's CEO Hansjörg Lerchenmüller. "The technology has proven itself in a commercial power plant, clearly demonstrating that a mature state has been reached".

By 2013, a total power of 300MW

is to be installed at Casaquemada, enough to supply 153,000 houses in the Seville region. "Concentrix Solar achieves an impressive efficiency with its technology," says Abengoa's PV director Fernando Celaya. "The excellent results of the test trackers on our test fields have reinforced our decision to use the technology from Concentrix Solar in the 2MW project in Casaquemada," he adds.

www.abengoasolar.com

SolFocus and Samaras to develop first commercial CPV project in Greece: 16MW plant to 2500 residents

Concentrator photovoltaic (CPV) system maker SolFocus Inc of Mountain View, CA, USA has agreed with Concept, a division of Greek renewable energy development firm Samaras Group of Thessaloniki, to jointly develop the first commercial installation of CPV technology in Greece. As part of the deployment, SolFocus will expand its European operations (which are headquartered in Madrid, Spain) to open a subsidiary in Greece.

Spanning multiple sites, the deployment will have the capacity to produce 1.6MW of power using the SolFocus 1100S system. Launched a month ago, the 1100S uses III-V-based solar cells to achieve panel efficiencies of 25%, which the firm claims is the highest energy yield for PV systems currently on the market. Installation will begin in spring 2009, with the first delivery of power expected in the summer.

"We view this groundbreaking project as the beginning of a promising collaboration with SolFocus," says Samaras Group's president Dimitrios Samaras. "We will introduce the unrivaled efficiency of CPV solar technology to Greece and other regions in southern Europe," he adds.

In the first year of production, the system should have the capability



Close-up of SolFocus' CPV system.

to meet energy demands for a small town with about 2500 residents, while preventing the release of 2800 tons of carbon dioxide, SolFocus reckons.

"The group's selection of the new SolFocus system validates the real-world performance, efficiency and scalability of our technology," says SolFocus'

president Mark Crowley.

"Our partnership will enable SolFocus to expand into the lucrative Greek market, which

is boosted by favorable incentives and strong demand for electricity," he adds.

As part of the deployment, SolFocus will open a subsidiary in Greece

The CPV system's scalable design employs rows of reflective, glass-based optics to concentrate sunlight 500 times onto III-V-based solar cells that have high efficiency (approaching 40%, more than twice that of traditional silicon solar cells). Like the smaller SF-1000S, the SF-1100S uses about a thousandth of the active solar cell material compared to traditional PV panels. In a solar-rich country like Greece, such efficiency can accelerate the trajectory for solar energy to reach cost parity with fossil fuels, SolFocus claims.

SolFocus integrates its CPV panels with a tracking system that continuously aligns the solar array with direct sunlight throughout the day as the sun moves across the sky. The firm says that the 1100S system's tracking capability results in the matching of energy generation to peak demand periods.

The Samaras project follows the announcement in early November of a \$103m (€80m) project with EMPE Solar that will deploy the same solar technology in a 10MW installation in several sites across southern Spain by the end of 2010 (expected to be Europe's largest deployment of CPV technology) — see November issue, page 49.

www.solfocus.com

www.e-concept.gr

CPV maker CompSolar focusing on flexible substrates

Compound Solar Technology Corp (CompSolar), the first Taiwan-based producer of glass-based concentration photovoltaic (CPV) solar cells made from gallium arsenide, says that it has been developing flexible GaAs CPVs based on various kinds of flexible substrates, which will form the basis for the firm's operations in 2009, according to president Jeffery Lin.

CompSolar holds more than 40 technology patents, including

patents for III-V multi-junction solar cell production, thermal sinks through modular packaging, and solar tracking. In 2007 the firm developed multi-junction solar cells with energy conversion rates exceeding 30%.

The solar tracker of a GaAs CPV system can capture sunlight for eight hours a day on average, which is much longer than the average of 2–3 hours for fixed crystalline silicon solar cell systems.

A GaAs CPV system can therefore generate more power than a crystalline silicon solar cell system of the same size, says Lin.

CompSolar says that it is capable of designing solar cells based on various flexible substrates and manufacturing GaAs CPV cells using its self-designed chemical vapor deposition (CVD) and physical vapor deposition (PVD) processes, as well as delivering modules.

www.compsolar.com

Sunovia and EPIR improve growth of CdTe-on-Si for CPVs

Sunovia Energy Technologies Inc of Sarasota, FL and EPIR Technologies Inc of Bolingbrook, IL, USA (in which Sunovia has a stake) have made what they say are substantial improvements in their process for growing high-quality single-crystal cadmium telluride (CdTe) on silicon.

The achievement is the foundation for creating ultra-high-efficiency multi-junction solar cells with substantially lower costs than current multi-junction photovoltaic (PV) approaches, the firms claim. The process improvements involved increasing single-crystal growth rates by over 500%, allowing lower processing times per wafer and more PV cells per deposition chamber per day, increasing throughput and lowering costs.

The breakthrough should accelerate the demonstration of an initial 20MW manufacturing system for ultra-high-efficiency, low-cost solar cells. The firms believe that the system can be duplicated for much less than the typical cost for existing advanced solar cell manufacturing systems.

Further, deposition uniformity has been improved, with crystal quality distributions being reduced closer to the 55 arcsecond x-ray rocking curve width previously reported. Improving uniformity should make larger wafers and larger deposition chambers possible, helping to increase throughput and lower costs.

Sunovia and EPIR's CdTe-on-Si technology is currently being funded and developed to produce high-sensitivity, long-wavelength infrared (IR) imaging technology with what is claimed to be much larger formats and substantially lower cost than existing technology. Breakthroughs made in developing IR technology are directly transferable to producing high-efficiency, low-cost multi-junction PV cells.

The firms claim that their approach of growing high-quality II-VI semiconductor materials on low-cost large silicon wafers via EPIR's high-throughput deposition (HTD) technology for concentrator photovoltaic (CPV) systems offers several advantages over current technologies. These include the following:

- The II-VI material system offers many different opportunities for creating multi-junction cells that can effectively span the solar spectrum.
 - Use of active silicon growth substrates leverages micro-electronics industry technology to obtain large and low-cost, high-quality wafers.
 - II-VI multi-junction solar cells in CPV systems use less than a thousandth of the cadmium and tellurium of their polycrystalline thin-film counterparts, avoiding concerns of environmental toxicity and raw material supply.
 - The HTD process does not use the highly toxic and flammable materials used in III-V semiconductor deposition processes, and hence does not require extensive and expensive safety systems, allowing faster capacity commissioning and regulatory approval.
 - HTD requires less than 20ft² per MW of production capability at an investment far less than the \$1.5M/MW of current high-efficiency thin-film deposition systems.
- www.sunoviaenergy.com
www.epir.com

First Solar completes 2MW Southern California plant

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe), says that it has completed Southern California Edison's (SCE) solar photovoltaic power plant installed on the rooftop of a commercial building in Fontana, CA. First Solar was selected in mid-July to engineer the rooftop system, manufacture the solar modules, and supply the balance-of-system equipment for the project.

The 2MW plant will generate enough electricity to supply about 1300 average Southern California households. This is the first project in SCE's plan to install 250MW of solar generating capacity on large commercial rooftops throughout Southern California over the next five years. SCE is the largest elec-

tric utility in California, serving a population of more than 13 million via 4.8 million customer accounts in a 50,000-square-mile service area within Central, Coastal and Southern California.

Also, after a formal bid process, SCE has selected First Solar to install its 250MW rooftop initiative's second project, a 1MW project on a commercial building in Chino, CA.

"SCE is leading the energy sector with its innovative strategy to use commercial rooftops in highly populated areas for new solar generation installations, selecting sites where customer peak demand is

highest," says John Carrington, First Solar's executive VP of global marketing & business development. "SCE's 250MW solar rooftop initiative brings essential energy sources to the grid quickly, supports California's economy with new green jobs, and protects our environment by developing more clean solar energy for Californians," he adds.

"We are driving solar technology forward and identifying creative new ways to integrate solar power into the electricity grid," says Edison International's chairman & CEO Ted Craver. "A program of this scale could transform solar generation, helping bring costs down and providing us with another important way to meet the environmental challenges of the future."

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Johanna Solar starts CIGSSe PV module production

Johanna Solar Technology GmbH of Brandenburg an der Havel, Germany says that its manufacturing line has started production of its thin-film photovoltaic module, which is based on p-type copper, indium, gallium, sulfur and selenium (CIGSSe) absorbing layers on Mo-covered glass substrates.

Johanna Solar was founded in 2005 by IFE Solar Systeme GmbH of Oldenburg, Germany. In August 2005, it licensed the CIGSSe technology from Photovoltaic Technology Intellectual Property Ltd (PTIP), a spin-off of South Africa's University of Johannesburg, where it had been developed over a period of 13 years by professor Vivian Alberts and his team.

"All necessary steps for the commercialization of our high-quality and high-yield thin-film solar modules have been introduced," says Dr Volker Probst who was appointed chief technology officer in late June.



Johanna Solar's CIGSSe thin-film PV module manufacturing plant.

The production site is ready for serial production just one year after the process equipment was installed. This first phase of the plant has a nominal capacity of 30MW and has created more than 200 jobs.

"The roadmap for the further technological development of our production is clear," add managing directors Peter Forch and Gerhard Bookjans. The goal is a continuous increase in efficiency and a reduction in production costs.

Johanna Solar's products will be distributed from early summer 2009

onwards via Oldenburg-based firm aleo solar AG, which was formed in 2001 to manufacture solar modules using silicon-based photovoltaic cells and in 2006 acquired a 19% stake in Johanna Solar. In June 2007, Johanna Solar granted aleo solar the right to distribute up to 80% of its solar modules for at least five years. aleo's chairman Jakobus Smit expects great demand for Johanna's products in the fast-developing market for PV rooftop installations in Germany, Italy, and France.

www.johanna-solar.com

Amelio forms Jordan JV for Gigawatt-scale project

The Al-Husseini Group, a diversified real-estate, industrial and trading organization based in Amman, Jordan, and Amelio Solar of Ewing, NJ, USA, a developer of thin-film photovoltaic module technologies and related manufacturing and power generation solutions, have formed a joint venture to bring large-scale PV energy production capacity to the Hashemite Kingdom of Jordan in cooperation with the government and the national utility. Unlike most neighboring countries in the region, Jordan has no significant oil reserves.

The JV has launched a multi-year project to construct a 1 Gigawatt PV power generation plant in Jordan. The JV will first deploy and operate an integrated factory that will serve as a dedicated, low-cost supply of thin-film amorphous silicon, CIGS (copper indium gallium diselenide) and related hybrid PV modules using a manufacturing

platform created and installed by Amelio Solar. Over a three-year installation period, the factory should reach an annual module manufacturing capacity of 200MW, beginning with a 22MW manufacturing line to be completed in 2009. The modules will be used mainly in the construction of the PV power generation plant, designed by Amelio Solar, which should reach a total power generation capacity of 1GW by 2017. The factory also will supply PV modules for export to other Amelio Solar PV power generation projects around the world and for sale on the open market.

"We are pleased to be introducing to our country this strategic technology and production platform, and we are grateful for the leadership and support of his Majesty King Abdullah and the cooperation of the Ministry of Energy in this important effort," says Al-Husseini Group's CEO Omar Al-Husseini.

"Our joint venture is bringing this capability to Jordan on a scale that will provide a truly cost-competitive, renewable source of electricity for today and the future, as well as a foundation for industrial growth in the new energy economy."

The project represents the largest implementation to date of Amelio Solar's manufacturing-integrated platform for low-cost construction of PV power generation capacity, says the firm's chairman & founder Dr Zoltan Kiss. "The market has come a long way in the 25 years since our team built one of the world's first thin-film photovoltaic module factory and power plant," he adds. "Jordan's progressive business environment, technical capabilities and vast solar resources are an ideal combination for a large-scale solar energy program using thin-film photovoltaics."

www.ameliosolar.com

www.alhusseinigroup.com

Largest CIGS PV array goes live

Global Solar Energy Inc of Tucson, AZ, USA, which manufactures copper indium gallium diselenide (CIGS) thin-film photovoltaic (PV) cells for both glass modules and flexible substrates, has begun full operation of what it claims is the largest solar electric array world-wide using CIGS PV technology. The 750kW system at Global Solar's 100,000ft² manufacturing 40MW facility in Tucson is the first commercial-scale deployment of the firm's CIGS thin-film PV technology and will help to power its manufacturing plant.

The system is financed, owned and operated by MMA Renewable Ventures LLC, a subsidiary of Municipal Mortgage & Equity LLC that provides renewable energy to businesses, utilities and government. Tucson-based Solon Corp, a subsidiary of Global Solar's largest customer Solon AG of Berlin, Germany that has just finished ramping up a 60MW large-scale PV module factory, produced and installed the PV modules and designed the array. Covering 310,000ft², the system features a ground-mounted solar array that uses 6600 Solon solar modules incorporating Global Solar's CIGS thin-film solar cells.

"This new solar system solidifies the vitality and longevity of CIGS technology in the thin-film space," says Global Solar's president & CEO



Global Solar's CIGS PV plant in Tucson.

Mike Gering. "We are proud to be instrumental in this industry first," he adds, claiming that Global Solar is the only CIGS provider to have its technology powering a commercial-scale solar array.

Global Solar is purchasing the power generated from MMA Renewable Ventures under the terms of a long-term commercial financing agreement. The thin-film PV system will generate more than 1.1 million kilowatt-hours (kWh) of renewable electricity annually. The ground-mounted system is expected to offset 30,000 tons of carbon dioxide over its expected 25-year lifetime.

"CIGS technology will contribute to driving down solar energy prices, bringing renewable energy to the masses," reckons Solon's CEO Olaf Koester. "Solon Corporation's vision is to help spark the widespread adoption of solar energy in the USA by designing, constructing and maintaining large-scale photovoltaic power plants," he adds.

"We are constantly looking for ways to deliver affordable energy at scale," says MMA Renewable Ventures' CEO Matt Cheney. "Global Solar is a leader in CIGS materials and we value the opportunity to showcase its thin-film technology."

Through its agreement to purchase the renewable energy credits generated by the array, funding of the project was helped by Tucson Electric Power (TEP), a subsidiary of UniSource Energy Corp of Phoenix, AZ that provides power to about 400,000 customers in southern Arizona. UniSource Energy founded Global Solar in 1996 as a subsidiary, before selling it in April 2006 for \$16m to a German venture capital investor (81% owner) and Solon AG (19% owner). The credits will help TEP to pursue goals established under Arizona's Renewable Energy Standard, which calls on electric utilities to work toward securing 15% of their power from renewable resources by 2015.

"This project helps us build toward the clean energy future we envision for Arizona," says Philip Dion, VP of legal & environmental services for TEP and UniSource. "Companies such as Global Solar, MMA and Solon exemplify the best and brightest in renewable energy technology," he adds.

www.globalsolar.com

Global Solar Energy opens CIGS plant in Germany

On 19 November, Global Solar Energy Inc held the official opening ceremony for its CIGS PV solar cell production facility at the Berlin-Adlershof science and technology park in Germany.

Although not expected to reach full capacity until 2009, the 35MW facility completes the firm's major expansion in 2008, and has brought its total manufacturing capacity to 75MW.



(left to right): R Erdmann, J Mühlning, G Schöttler, M Müller, M Gering, T Krupke.

Attending the ceremonies were 150 invitation-only guests and executives from Global Solar's headquarters in Tucson, AZ, USA. Guests were taken on special guided tours to offer a 'behind the scenes' look at the production facilities.

Global Solar says that the facility offers a site with imbedded infrastructure and close proximity to several research institutions.

Probing hydrogen's impact on ZnO

Hydrogen-free substrates provide basis for p-type doping in ZnO devices.

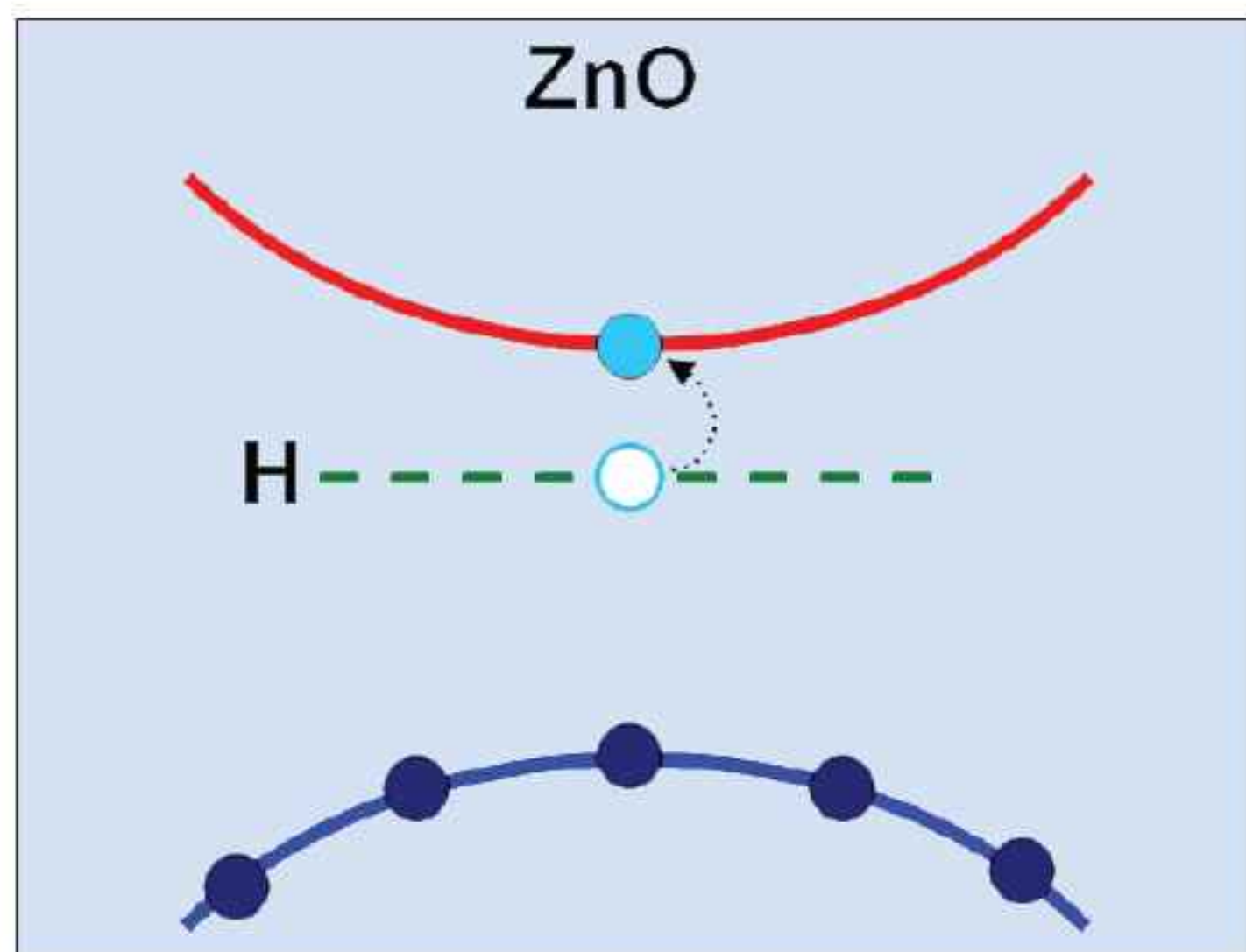
Zinc oxide (ZnO) would be a perfect low-cost solution to light emission but for one thing — it is extremely difficult to find suitable doping processes for creating p-type material (i.e. with holes, rather than electrons, as the majority carrier). Light emission, for example, depends on the ability to bring together electrons (from n-type material) and holes (from p-type material) so that transitions across ZnO's 3.4eV energy bandgap can take place, producing ultraviolet light that can be used with phosphors to produce white light.

ZnO's wide bandgap is comparable with the GaN semiconductor system widely used for short-wavelength/white light and blue laser emission devices. Some UV laser diodes have been produced in ZnO, along with novel electronics devices, some of which are based on the material's piezoelectric properties. ZnO is also being developed as a transparent conductive oxide to replace expensive alternatives such as indium tin oxide (ITO). While zinc is the 23rd most abundant element on earth, gallium only occurs in trace amounts of the order of tens of parts per million (~50ppm in bauxite and zinc ores) and is extracted as a byproduct of aluminum and zinc production.

The main problem is that, when it is not intentionally doped, ZnO tends to be strongly n-type, creating a large compensation that needs to be overcome before p-type materials can be reached. Finding out the nature of the n-type unintentional doping could lead to more effective methods of creating p-ZnO, opening up new opportunities for lower-cost ZnO-based electronics and light emission.

It is believed that hydrogen contributes to the n-type character of ZnO crystals. Hydrogen is almost impossible to avoid in semiconductor processing without special measures being taken. Its incorporation in bulk ZnO increases the material's conductivity — indeed, such an effect has been used to construct hydrogen detectors.

Now, a German research team at Ruhr-University Bochum and University Erlangen-Nuremberg have performed high-resolution electron energy loss spectroscopy (HREELS) measurements on hydrogen-treated ZnO substrates to disentangle the nature of the doping effect



Hydrogen atoms have been shown to always result in n-doped ZnO.

of hydrogen in zinc oxide [Qiu et al, *Phys. Rev. Lett.*, **101**, 236401, 2008].

Compared with previous research, the researchers found a lower ionization energy (~25meV) for hydrogen as a donor of electrons to the conduction band. This compares with the energy value of about 26meV that is equivalent to the temperature of 300K, suggesting a high ionization rate at room temperature.

HREELS involves scattering electrons from materials and determining the properties of the energy loss from inelastic scattering. Since the mean free path of the incident electrons corresponds to a few monolayers of material, the technique reveals the surface properties.

The ZnO(000-1) substrate was prepared with oxygen as the termination by using suitable sputtering and annealing processes. The O-ZnO surface reacts with water vapor, forming a stable HO-terminated surface. The HO surface adds a new peak to the energy loss spectrum at 449meV, associated with a stretching vibration of the HO formation.

The quasi-elastic peak around zero energy loss is related to an interaction between the incident electrons and plasmon states in the material under study. The plasmon energy is in turn related to the carrier density. For the HO-terminated wafer the full-width at half

maximum (FWHM) of the quasi-elastic peak of 6meV corresponds to a reasonably low carrier density of $9 \times 10^{13}/\text{cm}^3$.

After exposure to atomic hydrogen (from H_2 dissociated by a tungsten filament), the peak broadens to 24meV at 300K, corresponding to a carrier density of $1 \times 10^{17}/\text{cm}^3$. The hydrogen atoms are believed to enter interstitial positions between the zinc and oxygen lattice sites. One reason for hydroxylating the surface is to avoid an H-induced surface state that was posited by another group as being the explanation for the quasi-elastic peak broadening.

When the substrate is annealed after exposure to hydrogen the broadening decreases steadily with annealing temperature, indicating a reduction in the carrier density. These results from annealing are interpreted as showing desorption of the hydrogen from the substrate.

The temperature dependence of the quasi-elastic peak below room temperature (300K) was used to determine the ionization energy of the H atoms for producing electrons in the conduction band. This was found to be $25 \pm 5 \text{meV}$. This compares with $35 \pm 5 \text{meV}$, as determined by a group using electron paramagnetic resonance (EPR) spectroscopy. These values differ

significantly with the traditional understanding dating back to 1957 that the ionization energy is about 51meV.

With a higher binding energy, the ionization rates at room temperature would be significantly lower. It is speculated by the German researchers that previous high values for the ionization energy might be due to contributions from defects, such as oxygen vacancies.

The researchers plan to use the technique with other forms of ZnO doping, particularly with metals. Some first tests have been made using copper, for example. There are also plans to use hydrogen-free substrates to produce p-type behavior with suitable dopants.

Professor Christof Wöll of Ruhr-University Bochum comments: "For the fundamental studies we are doing right now on 'perfect' model systems, nitrogen is best for p-doping because we can insert it in a very controlled fashion. Later we will test other elements, because for technical applications nitrogen is (probably) not well suited."

<http://link.aps.org/doi/10.1103/PhysRevLett.101.236401>

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

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Nanowire transistors, lasers and hetero-engineering

Semiconductor nanowires constitute a growing field of research, particularly as the size of commercial devices decrease. **Dr Mike Cooke** looks at some recent research looking to achieve ultra-small transistors, photovoltaic devices, lasers and bandgap engineering.

The focus in the mainstream semiconductor has been on the nano-scale for some time. As this research and development progresses, the challenges are certainly immense, but also new opportunities come in view. In addition to research aimed at characterizing CMOS structures and interconnection wires with nano-scale dimensions, there are hopes of using semiconductor nanowires for transistor channels, single-electron memory, nanoelectrodes, photonics (light/laser production, sensing), and energy conversion (battery and photovoltaic). Scientific activities include fundamental electron transport studies, and chemical and biological sensing and manipulation. Here we focus on recent attempts to produce transistors, photovoltaic devices, lasers and heterostructures in various materials.

Transistors

CEA-LETI has integrated on one silicon-on-insulator wafer different advanced transistor structures to test the capabilities of stacked nanowire transistors (3DNWFET, Figure 1). Adding an optional independent gate structure creates a device called a Φ FET (Figure 2).

These structures involve sub-15nm diameter nanowires being stacked in 3D configurations using a 'FinFET-like CMOS technology'. When the SiGe is etched away from alternating superlattice layers of Si and SiGe, multiple silicon nanowire channels remain. Gates are then wrapped around each individual nanowire. A high-k dielectric/metal gate electrode stack is used.

The process technology consisted of a common flow compatible with standard planar fully depleted (FDSOI) devices that are due to come to prominence in the next decade as device sizes shrink according to the

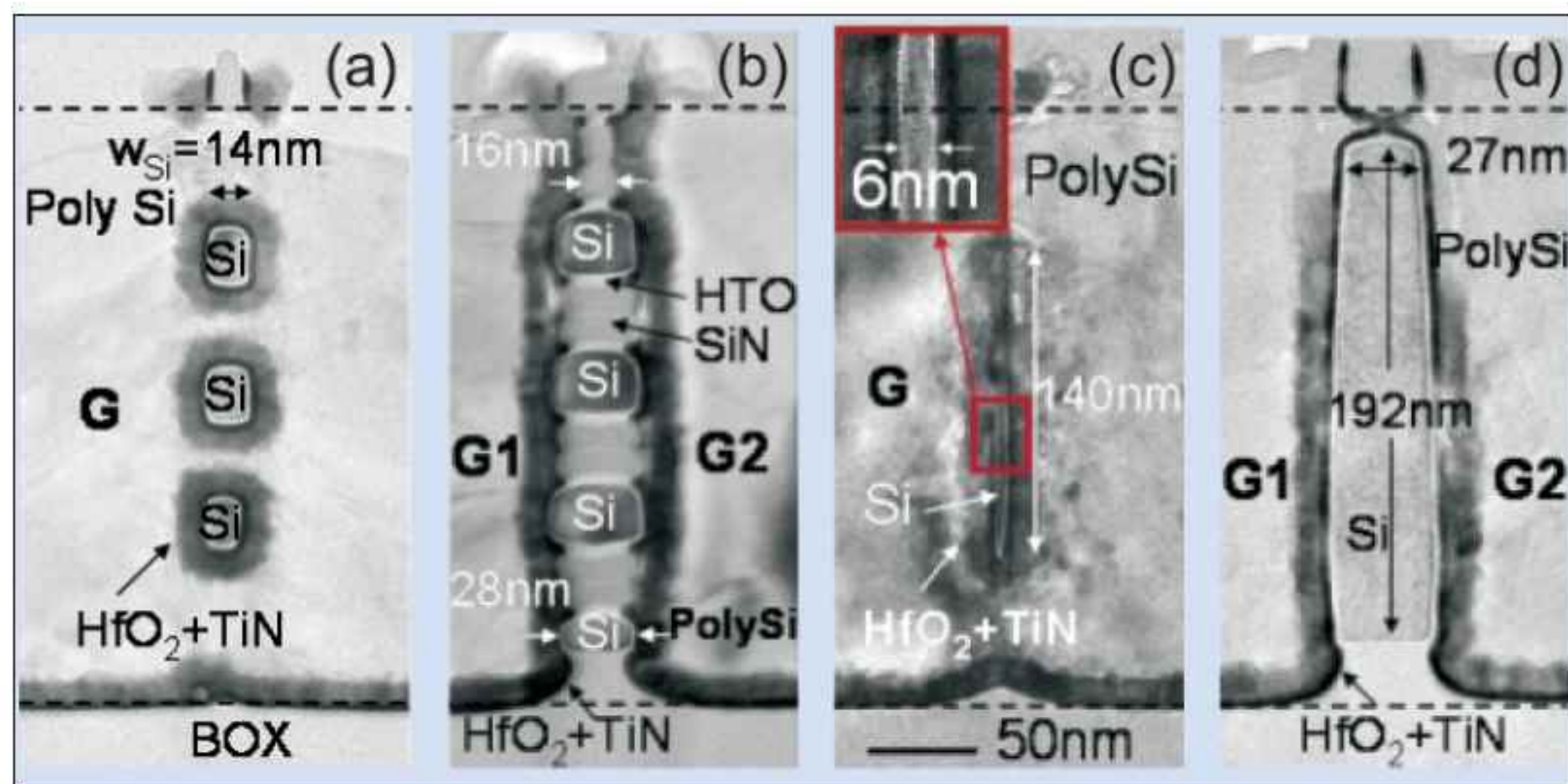


Figure 1. Different nanowire and FinFET structures produced on SOI wafer with HfO₂ TiN poly-Si gate stack: (a) 3D-NWFET; (b) Φ FET; (c) FinFET; (d) IG-FinFET. The distance between the dotted lines is 250nm.

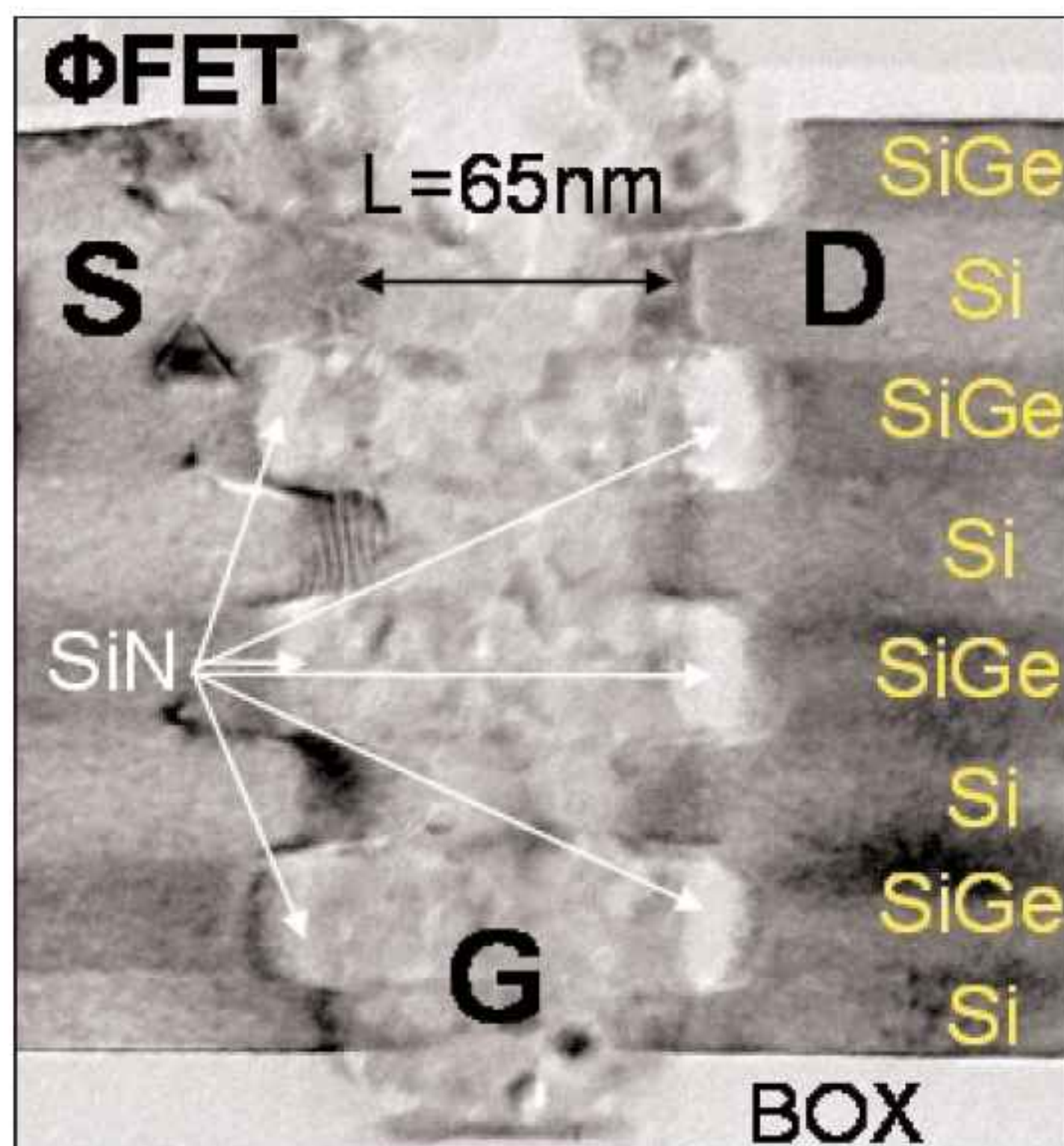


Figure 2. Φ FET in more detail.

International Technology Roadmap for Semiconductors. The devices were processed within CEA-LETI facilities using electron-beam lithography capable of producing 15nm gate-length devices.

FinFETs and independent-gate FinFETs (IG-FinFETs) were co-processed on the same wafer for comparison purposes. The ability to combine different device structures on the same chip also allows optimization of performance, density and power consumption.

Drive currents of 6.5mA/ μm for NMOS and 3.3mA/ μm for PMOS 3DNWFETs are described as 'extremely high'. The 3DNWFET channel width needed for a given drain-induced barrier lowering is relaxed by a factor of 2.5 compared with the FinFET (i.e. the 3DNWFET can be 2.5 times narrower, allowing further technology compression). Other transport properties are also improved.

The Φ FET also showed significant enhancement compared with IG-FinFETs: the off current is two decades smaller, and the sub-threshold slope is also smaller, at 82mV/dec compared with 95mV/dec.

Full results showing the structures and the electrical results were presented at December's IEEE International Electron Devices Meeting (IEDM 2008) [1]. The work was carried out in the frame of the French Carnot Institutes initiative and in collaboration with IMEP Grenoble and STMicroelectronics Crolles, France.

A whole session at IEDM [2] was devoted to other approaches to silicon nanowire transistors along with a number of additional SiNWFET presentations outside this session. Other nanowire research at IEDM included silicon nanowire use in drug delivery systems, biological sensing and battery anodes, and one group described low-power, high-speed InSb nanowire FETs.

Photovoltaics

Silicon nanowires are also the basis of two approaches to photovoltaic devices. University of California Berkeley researchers Erik C. Garnett and Peidong Yang see vertically aligned silicon nanowires as a route to lower-cost photovoltaic devices [3]. This is based on there being less need for ultra-purity in the initial substrate compared with planar silicon photovoltaic devices.

The Berkeley silicon nanowire arrays are produced using a solution phase etch on an n-type substrate. A p-type amorphous silicon shell is then deposited on this core using low-pressure chemical vapor deposition (LPCVD). The shell is then crystallized by using a rapid thermal anneal (RTA) step (1000°C for 10 seconds in forming gas).

Although the efficiency of the resulting cells (Figure 3) was only 0.5%, Garnett and Yang believe that they can develop cells with efficiencies close to that of bulk silicon devices. The nanowires are about 18 μm in length and cover about 50% of the area of the wafer. The core has a diameter of the order of 50–100nm and the shell is

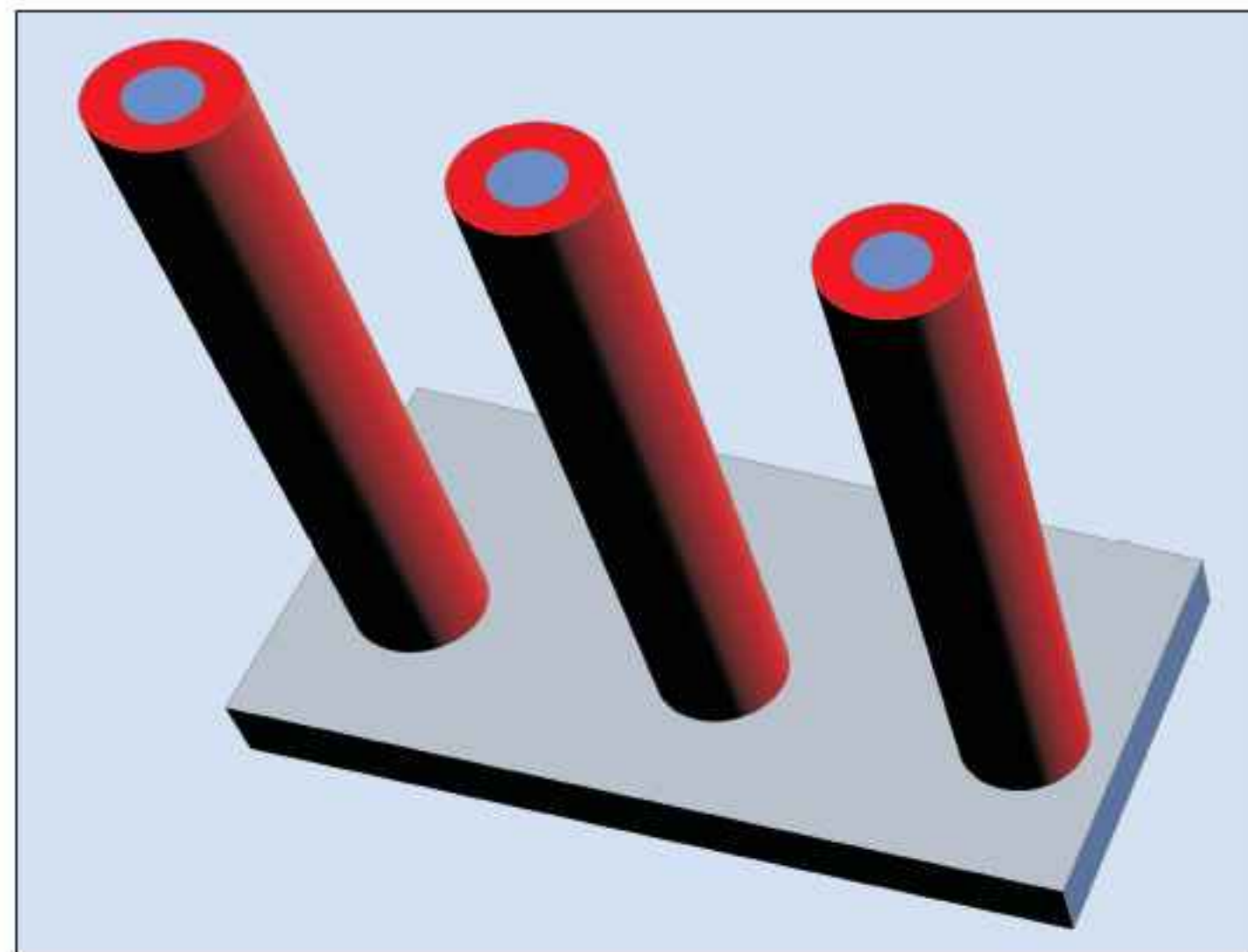


Figure 3. Schematic of Berkeley's vertical nanowire photovoltaic array.

150nm thick to give a total diameter of 350–400nm. The array was tested under AM1.5 conditions (air mass 1.5 solar illumination at zenith angle $\sim 49^\circ$, typical of northern hemisphere conditions for the USA and EU). The open-circuit voltage (V_{OC}) was 0.29V and the short-circuit current (J_{SC}) was 4.28mA. The fill factor (maximum power/ $(V_{OC} \times J_{SC})$) is 0.33. The overall efficiency is 0.46%.

The nanowire's high ratio of surface area to volume exacerbates unwanted recombination at interfaces, reducing V_{OC} and hence the efficiency. One route to higher efficiency is believed to be through improving the surface passivation. Other ideas include reducing the surface roughness of the wires and increasing the p-Si conductivity to reduce series resistance. Concern is also expressed about the quality of the contacts.

Rather than producing the p-n junction in a radial direction, Harvard and Stanford universities [4] have produced axial modulation-doped p-i-n and tandem p-i-n⁺-p⁺-i-n silicon nanowire photovoltaic elements (i.e. the doped elements are ordered along the wire). The diameters of the wires were in the range 200–250nm (Figure 4). AM1.5 testing gave a V_{OC} of 0.29V, J_{SC} of 3.5mA/cm² and 0.5% maximum efficiency for an optimized p-i-n structure. The maximum power output was found to be 4.6pW. This increases to 31pW under illumination of 4.5 suns, which could be arranged under light concentrator conditions.

Performance increases with the length of the undoped intrinsic region (0, 2 and 4 μm lengths were studied). One effect of the increased length of undoped material is to reduce the saturation current of the diode and hence the leakage current when operating as a photovoltaic device.

The tandem arrangement with a 2 μm i-region in each section increased V_{OC} by 57% to about 0.36V over the 0.23V for the comparable 2 μm single device. The



Figure 4. Axial p-i-n Si NWs scheme (A), and SEMs before (B) and after a selective wet etching process (C) that shows p and i regions due to faster etch rate.

power increased 39% from 2.3pW to 3.2pW. Ideally, the tandem arrangement should have given a 100% increase in power. The difference is attributed to parasitic resistances, particularly at the $n^+ - p^+$ tunneling interface between the diodes.

A gold nanoparticle catalyst was used to produce the nanowires using a vapor-liquid-solid (VLS) growth method. The length of the unintentionally doped (i) section was varied to enable tuning of the device properties. The doping was achieved by using different dopant precursors (p from boron, n from phosphorus) at various stages.

The values for V_{OC} in both axial and coaxial/radial geometries are about half that found in polycrystalline planar devices (0.6–0.7V). The similarity of the V_{OC} values suggests that the mechanism for suppression from planar levels may be related. Harvard also produced coaxial p-i-n silicon nanowire photovoltaic devices in 2007 and reported maximum power outputs of 200pW and apparent efficiencies of 3.4% [5]. The wires were produced by similar VLS methods.

Charles M Lieber, principle investigator at Harvard, comments: "Our radial and axial device studies illustrate how structure (axial versus radial p-n junction) and material (single-crystal versus nano-crystal silicon) affect the fundamental parameters of V_{OC} and J_{SC} in nanowire solar cells. The efficiency of the radial device is higher than that of the axial device, because the former has more efficient carrier separation and light absorption processes that lead to larger J_{SC} . Both single p-i-n junction devices have a similar V_{OC} . The axial device is a nano-scale analog of a planar single-crystal silicon solar cell geometry and its photogeneration of carriers is limited to a relatively narrow depletion region of the NW around the intrinsic silicon block.

"We want to emphasize that, although the performance of the axial device is smaller than that of the radial device, it is still comparable to or better than other reported nanowire solar cell results... while the radial has been the best of those reported. Moreover, the axial device represents a unique opportunity to integrate multiple junctions on a single nanowire for higher voltage and power output, as we demonstrated for the first time in the work with tandem axial photovoltaic devices [4]."

Multi-quantum well laser

Harvard University also works on III-V nanowires; with Georgia Institute of Technology, it has been developing a nanowire multi-quantum well laser. These researchers have recently reported a MQW core/shell nanowire heterostructure that enables lasing over a range of wavelengths at room temperature [6]. The team has performed MOCVD to grow uniform, dislocation-free layers of InGaN/GaN on a triangular GaN nanowire core (Figure 5). The InGaN well thickness is 1–3nm, and structures with 3, 13 and 26 wells have been grown. The cores are grown on sapphire substrates using a nickel nanocluster as catalyst. The precursors are trimethyl-gallium (TMGa), trimethyl-indium (TMIn) and ammonia (NH_3) with hydrogen carrier gas. The MQW layers are found to be thicker on two of the faces of the triangular core.

Optical excitation produced lasing in the various structures with wavelengths in the range 365–494nm at room temperature. The threshold depends on the number of wells. Below threshold, the emission has a relatively broad spectral range, but above threshold the emission collapses into a series of narrow peaks, indicative of lasing.

A representative 26-well wire had a threshold of $\sim 900kW/cm^2$ of pump laser power, above which the narrow emission wavelengths around 438nm have full-widths at half maximum of less than 0.8nm (this value is limited by the spectral resolution of the measurement system). The spacing of the emission lines suggests that longitudinal modes of the nanowire cavity are excited. The lasing wavelength is blue-shifted compared to spontaneous emission — a feature of InGaN laser systems, and that has been attributed to band-filling effects and/or photo-induced screening of the internal fields.

The lasing thresholds of the 26-well structures were about 4–10 times lower than those with 13 wells. The thresholds are comparable to optically pumped traditional planar InGaN MQW lasers, but higher than the best values quoted for GaN nanowire lasers. The researchers attribute the higher threshold for InGaN MQW nanowires to their smaller confinement factors. It is hoped to reduce the threshold in future work. A contrast with planar InGaN devices is that the threshold is much less dependent on the emission wavelength. Planar devices show an exponential increase in threshold with wavelength. This is believed to be related to the deterioration in material quality as the indium content grows. For the nanowires, the researchers believe that the problem is less severe, since the layers are single crystal and dislocation free.

The Harvard/Georgia group believes that free-standing injection nanolasers based on the technology are possible. This would involve adding p-type AlGaIn/GaN shells to the structure. The use of such heterostructures opens

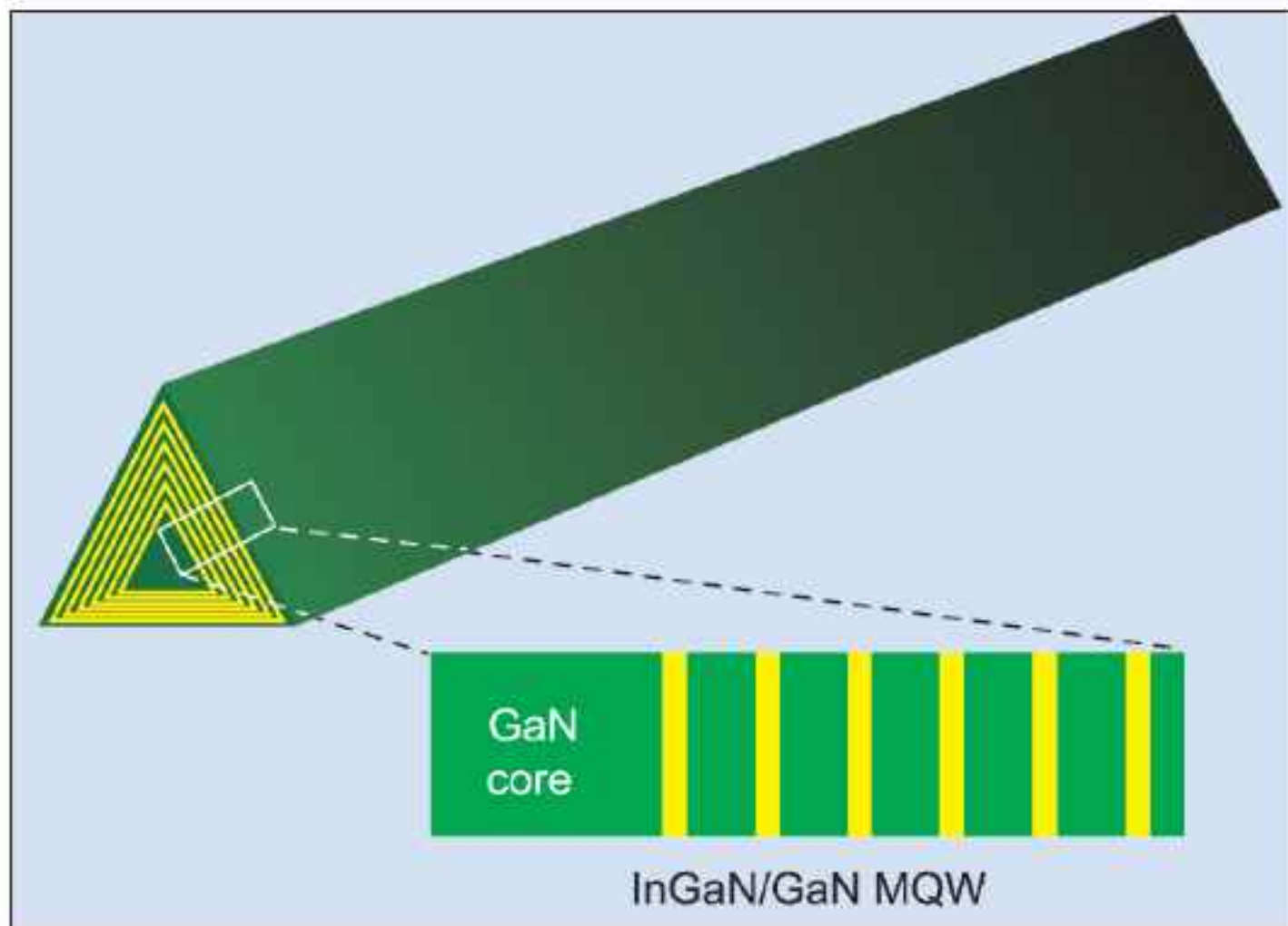


Figure 5. Schematic of GaN nanowire multi-quantum well with triangular cross-section.

up the possibility of engineering the laser wavelength as opposed to the fixed wavelengths of homogeneous compound nanowire lasers previously produced using materials such as GaSb, ZnO, GaN, CdS and ZnS.

Polytype heterostructures

Sweden's Lund University has been studying InAs nanowires. This group has developed a technique to control the crystal structure of such wires [7]. Nanowires made of binary semiconductors, such as InAs, often have a high density of twin defects and stacking faults as they grow. This results in a series of different uncontrollable crystal structures called polytypes. The most common polytypes for InAs nanowires are wurtzite (WZ) and zinc-blende (ZB).

The uncontrollable nature of the change of polytype affects the optical and charge-carrier transport properties of the resulting nanowires. The results can be negative, such as scattering from the fault boundaries increasing resistance to current flow. However, such effects, if they can be controlled, could also lead to new structures and devices based on bandgap engineering. The band offset between the WZ and ZB structures is several tens of meV. In fact, one result of the new WZ-ZB nanowire structures could be a more accurate determination of this offset.

Control over the structure is achieved by varying the size of the gold seed particle and the growth temperature. Smaller-diameter nanowires are largely WZ, moving over to ZB as the diameter increases. Nanowires with diameters of 24nm grown at 460°C had the WZ structure with a stacking fault density of 2 to 3 per micron. Under the same growth conditions, 110nm diameter wires were ZB and had less than 1 fault/micron. Growth at 420°C increases the WZ proportion. This enhances the WZ purity at low to medium diameters and creates a large number of twin-plane faults in the ZB phase at larger diameters.

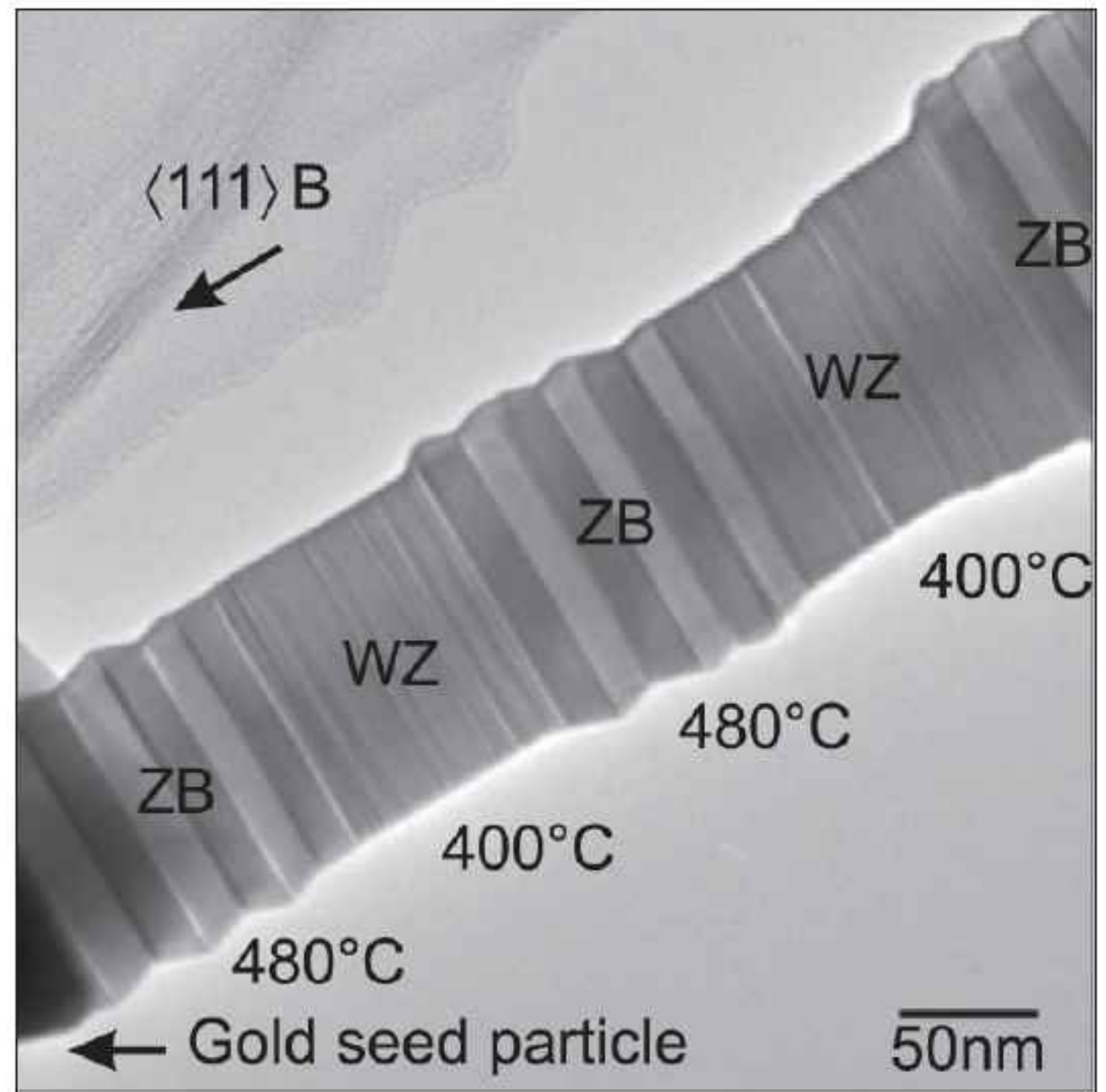


Figure 6. InAs nanowire with different polytypes – wurtzite and zinc blende – down its length.

Superlattices consisting of WZ and ZB segments were grown by alternating the growth temperature between 400°C and 480°C (Figure 6). Three ZB segments were separated by WZ. The WZ parts showed some single stacking faults. The researchers believe that this is the result of non-optimal growth conditions, in particular the switching sequence between the temperatures.

The main energy difference between the WZ and ZB polytypes derives from the ionic interaction between third nearest neighbors. Materials with bonds showing a more ionic nature, such as GaN (ionicity 0.557), tend to crystallize as WZ, while lower-ionicity materials like GaSb (0.108/0.246) generally go for the ZB form. Between these extremes come the standard III-V semiconductors such as GaAs, GaP, InAs and InP. The Lund team believes that its methods are applicable to GaAs and InP nanowire growth.

The wires were grown using commercial metal-organic chemical vapor deposition (MOCVD) techniques at a pressure of 10kPa with hydrogen as the carrier gas. The precursors were trimethyl-indium (TMIn) and arsine (AsH₃). The gold particles were deposited on the InAs substrate using a dedicated aerosol system. ■

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Tokyo, Japan

E-mail: pv@reedexpo.co.jp

www.[pvexpo.jp/2009_eng](http://www.pvexpo.jp/2009_eng)

28 February – 3 March 2009

LED CHINA 2009

Guangzhou, China

E-mail: Led@TrustExhibition.com

www.[LEDChina-gz.com](http://www.LEDChina-gz.com)

4–6 March 2009

PHOTON's 4th Photovoltaic Technology Show 2009 Europe

Munich, Germany

E-mail: ticket@photon-expo.com

www.[photon-expo.com/en/pts_2009_europe/pts_2009.htm](http://www.photon-expo.com/en/pts_2009_europe/pts_2009.htm)

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8-11 March 2009

15th European Molecular Beam Epitaxy Workshop (Euro-MBE 2009)

Zakopane, Poland

E-mail: mbe09@unipress.waw.pl

www.unipress.waw.pl/mbe09

17-19 March 2009

SEMICON/SOLARCON China

Shanghai, China

E-mail: semichina@semi.org

http://semiconchina.semi.org

22-26 March 2009

OFC/NFOEC 2009: Optical Fiber Communication Conference and Exposition and National Fiber Optic Engineers Conference

San Diego Convention Center, CA, USA

E-mail: info@ofcconference.org

www.ofcnfoec.org

7-8 April 2009

Photovoltaics Beyond Conventional Silicon Europe

Dresden, Germany

E-mail: a.foreman@IDTechEx.com

www.IDTechEx.com/peEUROPE

13-15 April 2009

6th China International Solar PV Exhibition

Shanghai International Exhibition Center, China

E-mail: nuogaisi2004@126.com

www.ch-solar.com

20-23 April 2009

Photonics '09: 4th International Specialized Exhibition for Laser, Optical and Optoelectronic Technologies

Moscow, Russia

E-mail: es@expocentr.ru

www.photonics-expo.ru

3-7 May 2009

LightFair International 2009

New York, NY, USA

E-mail: info@lightfair.com

www.lightfair.com

17-22 May 2009

6th International Conference on Silicon Epitaxy and Heterostructures (ICSI-6)

Los Angeles, CA, USA

E-mail: organizers@icsi-6.org

www.icsi-6.org

18-20 May 2009

OPTOmism: Photonics for the Green Revolution

Santa Clara, CA, USA

E-mail: OPTOmismAbstract@oida.org

http://opt09.events.pennnet.com

18-21 May 2009

CS MANTECH (2009 International Conference on Compound Semiconductor Manufacturing Technology)

Tampa, FL, USA

E-mail: csmantech@csmantech.org

www.gaasmantech.org

27-29 May 2009

PHOTON's 5th Photovoltaic Technology Show 2009 Asia

Shenzhen, China

E-mail: ticket@photon-expo.com

www.photon-expo.com/en/pts_2009_asia/pts_2009.htm

1-3 June 2009

SEMICON Russia 2009

Moscow, Russia

E-mail: ovyshkvarkov@semi.org

www.semiconrussia.org

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