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Nitride focus:

- Normally-off transistors

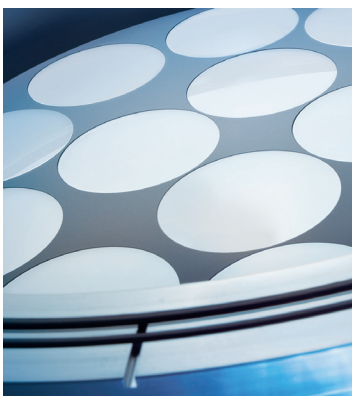
- Efficiency droop analysed



Osram & Lumileds expand in Malaysia • Finisar to buy Ignis
Transphorm emerges • News from OFC: first Terabit PIC

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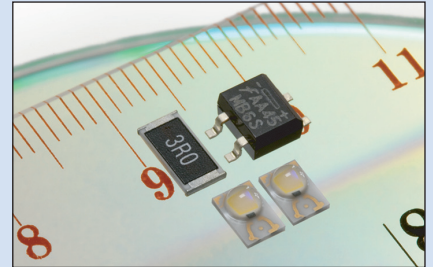
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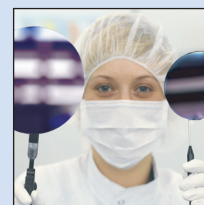
p12 CEO Quinsey and staff ring the opening bell at NASDAQ to mark TriQuint's 25th anniversary and its record earnings in 2010.



p51 Philips Lumileds' new LUXEON H — its first high-voltage LED — together with the electronic components that are required to comprise a system.



p58 Russian President Medvedev visiting Optogan's founders at its St Petersburg plant.



Cover: Germany's Osram Opto Semiconductors is doubling its InGaN LED production capacity by expanding its manufacturing facilities in both

Regensburg and Malaysia from 4" (right) to 6" (left) diameter wafers. The firm is already ranked as the world's third biggest HB-LED maker. **p57**

Nitride developments driving multiple sectors

This issue we focus on technical developments in nitride semiconductors, spanning both microelectronics and optoelectronics applications including light-emitting diodes and solar photovoltaics.

On pages 100–105 we cover reports of research on normally-off nitride field-effect transistors by, respectively: University of California Santa Barbara (the first demonstration of high-frequency operation of N-polar enhancement-mode GaN transistors — MISFETs with an f_T of 120GHz); a team at Hokkaido University's RCIQE and the Japan Science and Technology Agency Core Research of Evolutional Science & Technology (a selective electrochemical oxidation process to form a recessed-oxide-gate AlGaIn/GaN HEMT); and Hong Kong University of Science and Technology (an AlGaIn/GaN HEMT with a Schottky source electrode to yield a tunnel-junction FET with high drive current).

On pages 108–113 we overview developments in nitride photovoltaics, for which — despite the current low solar energy conversion efficiencies — there is scope to absorb a greater proportion of the solar spectrum than conventional solar cell materials (with efficiency of up to 62% theoretically possible for a four-junction nitride device). However, this requires improvements in growth techniques and material quality as well as device structure, as detailed in the article.

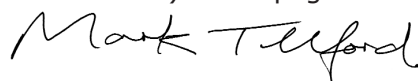
Improvement in nitride material quality is discussed on pages 98–99 regarding the reporting by researchers at Taiwan's Kun Shan University of Technology of their use of a modified one-sidewall-seeded epitaxial lateral overgrowth (OSELOG) method for growing a-plane GaN on r-plane sapphire (reducing threading dislocation densities from about $10^{10}/\text{cm}^2$ to $10^6/\text{cm}^2$). Such a-plane GaN materials can be used to produce green LEDs with small blue-shift at high current density, as well as reduced 'droop' of the external quantum efficiency (EQE) at high current density compared with conventional c-plane GaN LEDs. Poor material quality has limited EQE in a-plane material, but the OSELOG process promises to reduce defect levels and hence boost efficiency.

Nitride LED efficiency droop is also addressed by Taiwanese researchers at Chang Gung University (on page 94) and by a team at Taiwan's National Chiao Tung University and LED maker Epistar Corp (page 96). The latter have cut efficiency droop from 34% to just 4% by developing a graded $\text{Al}_x\text{Ga}_{1-x}\text{N}$ electron-blocking layer (rather than a conventional single-composition EBL) to combat electrons overshooting the active light-emitting region of the device. In contrast, the former researchers argue that hole injection efficiency probably dominates the mechanism of efficiency droop rather than electron leakage, since LEDs with a thinner electron-blocking layer (and hence greater electron leakage but also greater hole injection) showed less droop.

Nitride materials also continue to drive LED manufacturing developments, fueled by demand for LCD TV backlighting and solid-state lighting: both Lumileds and Osram Opto have announced expansions at their Malaysia plants (the latter converting from 4" to 6" wafers) — see pages 50 & 57.

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).

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

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HB-LED market grew 93% in 2010, driven by LCD TV/monitor backlights Solid-state lighting to be market driver in 2014

The global high-brightness (HB) LED market grew 93% from \$5.6bn in 2009 to \$10.8bn in 2010, according to market research firm Strategies Unlimited after analyzing market demand as well as the supply-side activity of more than 40 HB-LED component suppliers. LCD monitor and TV backlights led the growth spurt, followed by mobile display applications.

Ten firms accounted for more than 75% of the HB-LED market. The rank order of the top 10 suppliers in 2010 (by revenue, for packaged LED sales only) is:

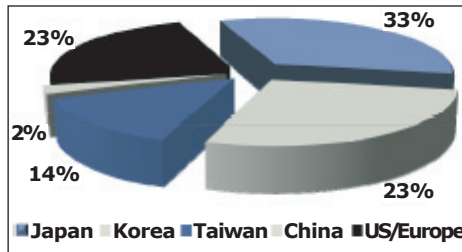
1. Nichia;
2. Samsung LED;
3. Osram Opto Semiconductors;
4. Philips Lumileds Lighting;
5. Seoul Semiconductor;
6. LG Innotek;
7. Cree;
8. Sharp;
9. Toyoda Gosei; and
10. Everlight.

By regional breakdown, of total HB-LED supply in 2010 (by revenue):

- 33% came from Japan;
- 28% from Korea;
- 14% from Taiwan;
- 23% from USA/Europe; and
- 2% from China.

While Chinese HB-LED technologies are currently 3–5 years behind the rest of the world, Strategies Unlimited expects that the investment of \$10.4bn in the SSL industry by 2015 will help to close the gap.

Several paths led to the impressive growth in 2010. Samsung LED, Seoul Semiconductor, and LG Innotek rode the boom in the LCD TV and monitor backlight market. Osram rode the rise of the Chinese HB-LED market, especially in the automobile sector. Lumileds' success in high-power backlight products, cell-phone flash, and architectural lighting contributed to much of its



Regional breakdown of HB-LED supply by revenue.

success. Cree's dedicated focus on lighting ensured its continued strong position in the solid-state lighting (SSL) revolution.

While LCD TV/monitor backlights accounted for most of the jump in HB-LED revenue in 2010, mobile applications were also significant contributors. In particular, the large rise in PC notebook sales and the penetration rate for LED backlights used in notebooks doubled HB-LED revenue over 2009. Strategies Unlimited expects TV and monitor backlights to continue to be a strong engine for growth in the next two years before flattening out in 2013. The overall forecast compound annual growth rate (CAGR) is more than 16% from 2010–2015.

The primary concern for the lighting market in 2010 was LED luminaire design, not performance. HB-LED component revenue for lighting was \$890m in 2010. Solid-state lighting will become the key market driver in 2014 because of the worldwide focus on energy efficiency and the phase-out of incandescent bulbs. The CAGR for HB-LED components for lighting from 2010–2015 is forecast to be 39%.

Strategies Unlimited's HB-LED market analysis was presented by Ella Shum, director of the firm's LED Practice, at the Strategies in Light conference in Santa Clara, CA, USA on 23 February.

www.strategies-u.com

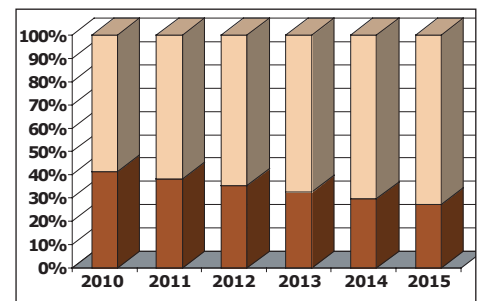
Planar waveguide circuit module market to grow to \$5.9bn in 2015

The value of global planar waveguide circuit (PWC) module consumption in optical communication networks will increase dramatically to \$5.9bn in 2015, with strongly rising quantity growth partially offset by declining average prices, forecasts market research firm ElectroniCast Consultants in a new market analysis.

In particular, the consumption value of integrated multifunction PWC modules held a market share of nearly 60% in 2010 and in 2015 is forecast to rise to more than over 70%.

"The trend is for discrete-circuit (single-function) based PWC modules to be displaced by equivalent performance (multiple-function) planar waveguide modules," says Stephen Montgomery, president of International Business at ElectroniCast. "The combination of the packaging and integrated optics aspects of PWC technology provides for an attractive and powerful technology for modules, which will hold multiple (two or more) functions (integrated multifunction devices); thereby reducing size, weight and cost versus larger, bulkier discrete (single-function) modules," he concludes.

www.electronicast.com



PWC module consumption for integrated (top) vs discrete (bottom) market share (%), based on value.

Penetration of LED backlights into LCD TVs to grow from 21% in 2010 to 53% in 2011

Edge-type to dominate over direct-type

Global shipments of flat-panel LCD TV with LED backlights reached a high of 16.6 million units in fourth-quarter 2010, with strong growth in edge-lit configurations, according to market research firm DisplaySearch's latest 'Quarterly Large-Area TFT LCD Shipment-Advanced LED Report'.

Of total shipments of LCD TV panels, the penetration of those with LED backlights rose from just 2% in 2009, through 9% in Q1/2010, 19% in Q2/2010, 26% in Q3/2010 and 29% in Q4/2010, to 21% for full-year 2010.

Correspondingly, panels with cold-cathode fluorescent lamp (CCFL) backlighting fell from 91% of LCD TVs in Q1/2010 to just 71% in Q4/2010.

Panel makers are targeting further rapid increases in LED-backlight penetration in 2011, from 36% in Q1 to 62% in Q4, for an overall penetration of 53% for full-year 2011. CCFL backlighting will correspondingly fall to just 38% in Q4/2011.

"Despite some buildup of LED-backlit TV panel inventories in the second half of 2010, the industry has recognized that LED backlighting is an irreversible trend, with benefits such as lower power consumption and slimness," notes David Hsieh, VP & research leader for large-area panels at DisplaySearch. "This has encouraged LCD TV panel makers to reduce LED backlighting costs continuously in order to increase shipments," he adds.

The growing awareness of LEDs among consumers has encouraged panel makers to increase LED performance. DisplaySearch expects that LED penetration will therefore pass 50% and become the mainstream for LCD TV backlights.

"This does not mean that CCFL will no longer be in demand, as there are still many end users and emerging markets that are very price sensitive," says Hsieh. "It's important for the industry to maintain support for CCFL panels," he adds.

In Q4/2010, the highest penetration of LED backlights in LCD TV panels was in the 50-60" segment. In particular, penetration was 76% in 50-54" LCD TV panels, 67% in 55-59," and 87% in 60"+. In the 46-47" segment, penetration was 54%. In the 40-42" and 32" segments, penetration was 37% and 17%, respectively, says DisplaySearch.

Nearly all LCD TV panel makers are focusing on edge-type LED backlights in TV panels, with the exception being Sharp, which is producing direct type as well. LG Display led in LED-backlit LCD TV panel shipments in Q4/2010, shipping more than 5 million units for a 31.1% share. Sharp followed closely with 21.5%, then Samsung with 20.8%, and AUO with 14.2%. In terms of LED-backlit LCD TV panel revenues, Sharp and Samsung were tied with 27.3%, LG Display followed with 25.1%, and AUO with 13.9%.

www.displaysearch.com

LCD TV panel shipments by backlight type.

Backlight	Q1'10	Q2'10	Q3'10	Q4'10	Q1'11	Q2'11	Q3'11	Q4'11
CCFL	91%	81%	74%	71%	64%	50%	41%	38%
LED	9%	19%	26%	29%	36%	50%	59%	62%

IN BRIEF

LED market up 67% in 2010 to \$10.2bn

The packaged LED market grew 67% from \$6.1bn in 2009 to \$10.2bn in 2010, according to 'The World Market for LEDs' from IMS Research. The \$4.1bn rise in revenue is by far the largest in the LED industry's history.

The boom in 2010 was due mainly to tremendous growth in LED use in backlighting LCD TVs. "Packaged LED sales for TVs grew from \$0.4bn to \$2.5bn as LED penetration increased dramatically to 27% in 2010... the \$2.1bn increase accounted for half of the growth," says LED research manager Jamie Fox.

"Growth was further driven both by economy recovery (which particularly affected some sectors in 2009, notably automotive and industrial) as well as an increase in sales for backlighting notebook computers and desktop monitors," Fox adds. "Finally, general lighting made its most significant contribution yet in 2010."

The boom of 2010 is unlikely to be repeated as mature markets return to a flatter or steadier growth level, and backlighting markets saturate. IMS forecasts growth of 25% in 2011, and less in 2012. All major backlighting applications (including TVs) are forecast to be at or very close to 100% LED penetration in 2013.

From 2013, general lighting should account for most growth. Excluding general lighting, LED revenue will fall due to price erosion, more efficient (and hence fewer) LEDs, and market saturation. So, the next few years could lead to consolidation among manufacturers.

However, the long-term future remains bright due to the huge potential of general lighting (e.g. hotels, retail, residential and outdoor lighting), believes IMS.

www.ledmarketresearch.com

China indium export policies pushing price over \$1000/kg CIGS could lose out to CdTe & c-Si PVs while alternative sources sought

Indium is heading for prices of more than \$1000/kg, according to industry analyst firm NanoMarkets in a new report 'Chinese Indium Strategies: Threats and Opportunities for Displays, Photovoltaics and Electronics', which examines the impact on the electronics and related materials industries of recent Chinese policies to restrict the export of indium. Even higher prices have been suggested in the Chinese press — as much as \$3000/kg.

China is the world's largest supplier of indium by far, accounting for almost three-quarters of world reserves and about half of production. As such, its policies affect the markets for all indium-related electronic materials.

This activity has recently been formalized in a new Chinese five-year plan, which is designed to stimulate domestic Chinese high-tech industries. NanoMarkets claims that this move by the Chinese government will have significant negative implications for several classes of electronics products (in the areas of displays, lighting, photovoltaics, compound semiconductor chips,

lead-free solders). The report therefore examines China's evolving indium policy in both economic and political terms and explains how it will act as a catalyst for creating new growth opportunities in both the extraction industry and advanced electronic materials industries worldwide, looking especially at the impact on markets for novel transparent conductors and compound semiconductors.

In particular, high indium prices may force the conservative display industry to shift to ITO alternatives, especially those using nanomaterials, believes NanoMarkets.

Japanese indium users — who currently use 70% of China's indium production — may find themselves without sufficient indium within a year. As a result,

A sharp rise in the price of indium will harm the resurgent CIGS PV industry, but in turn this will open the door for CdTe and crystalline silicon PVs

NanoMarkets expects firms in countries that have not been large suppliers of indium (including Australia, Canada, Laos and Peru) to rush into the market.

NanoMarkets also predicts that, for the first time, there will be significant amounts of indium extraction from sources other than zinc mines (e.g. sources such as tin and tungsten mining). The Chinese indium policy seems certain to incentivize new sources outside China to produce indium, either through primary extraction methods or through recycling/reclamation, the firm reckons.

Also, a sharp rise in the price of indium will harm the resurgent copper indium gallium (di)selenide (CIGS) photovoltaic (PV) industry, but in turn this will open the door for cadmium telluride (CdTe) and crystalline silicon (c-Si) PVs, which will become more price competitive, says NanoMarkets. In addition, new classes of absorber materials (zinc or tin) may emerge that are CIGS-like but don't actually use indium.

www.nanomarkets.net

CPV installed capacity to grow at CAGR of 174% to 2015 Concentrated photovoltaics to comprise 4% of solar installations

Concentrated photovoltaic (CPV) installed capacity will grow at a compound annual growth rate (CAGR) of 174% to just over 4% of global solar installations in 2015, forecasts the Strategy Analytics GaAs and Compound Semiconductor Technologies (GaAs) service report 'CPV Technology Market Status Update and Future Prospects', which was presented at the Solartech World 2011 event in Gwangju, Korea (16–17 March).

Solar installations have continued to grow strongly, with new installations reaching 16.3GW globally in 2010, market research firm Strategy Analytics estimates.

Approaches using crystalline silicon continue to be the primary technology, followed by strong momentum behind thin-film technologies including cadmium telluride (CdTe) and copper indium gallium (di)selenide (CIGS).

CPV technology remains behind these.

"While potentially offering 100% improve-

In 2010, some significant projects came into play in the southwestern United States, the Middle-East, Africa and Australia

ment in efficiencies compared to other solar technologies, CPV is only really effective where there is high direct normal solar irradiation," says Asif Anwar of Strategy Analytics. "While this has limited early deployment, the benefits of CPV will translate into rapid growth in these locations," he adds.

"In 2010, some significant projects came into play in the southwestern United States, the Middle-East, Africa and Australia," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service.

www.strategyanalytics.com

GaAs to remain dominant in cellular PAs despite CMOS & LDMOS gaining at low end

Driven by LTE (long-term evolution), multi-mode power amplifiers (PAs), cellphone sales in developing countries and rapidly growing demand for data devices, the cellular RF PA market will grow strongly to \$3.7bn over the next five years, despite competition and pricing pressure, according to the Strategy Analytics RF & Wireless Components market report 'PA Forecast 2011–2015'.

"LTE devices will quickly emerge as the second most significant driver of PA demand after UMTS devices," reckons Christopher Taylor, director, RF & Wireless Components. "Most LTE devices require one 2G/2.5G power amp, one or more 3G power amps, and one LTE power amp. While this may sound like a windfall in the making for PA suppliers, OEMs will demand multi-mode PAs that can handle more

than one air interface to reduce the front-end complexity and bill of materials in LTE mobile devices," he notes. "Multi-mode PAs require improved methods to manage linearity and efficiency, such as envelope tracking, which will bring new players into the PA market as partners or competitors to existing PA vendors," Taylor predicts.

"Changes coming to the power amplifier market represent new opportunities for CMOS PAs to compete with the incumbent GaAs, but also new technical challenges," says Eric Higham, director of the Gallium Arsenide and Compound Semiconductor service at Strategy Analytics. "Overall, GaAs will remain the dominant technology in PAs over the next five years, with continuing gains by CMOS and LDMOS especially in lower-priced mobile devices."

Military spending and GaN adoption driving RF power semi markets

Although spending on RF power semiconductors in wireless infrastructure markets has continued to stagnate, other markets — notably the military — are seeing increased activity, while gallium nitride (GaN) — long seen as a promising new 'material of choice' for RF power semiconductors — is continuing to gain some market traction, according to the new study 'RF Power Semiconductors' from ABI Research (which examines devices that have power outputs of more than 5W and operate at frequencies of up to 3.8GHz, representing the bulk of applications in use today).

"Gallium nitride increased its market share in 2010," notes director Lance Wilson. "It is expected to do the same in 2011," he adds.

"Although its adoption hasn't been as rapid as originally expected, it is nonetheless forecast to be a signifi-

cant force by 2016."

GaN bridges the gap between two existing technologies, exhibiting the high-frequency performance of gallium arsenide combined with the power handling capabilities of silicon LDMOS. It is now a mainstream technology that has achieved measurable market share and in future will capture a substantial part of the market, reckons ABI.

Other than wireless infrastructure, the vertical market showing the strongest uptick in the RF power semiconductor business has been the military, which Wilson describes as being now "a very significant market". While the producers of these devices are located in the major industrialized countries, the military market is now so global that equipment buyers can come from anywhere, ABI comments.

www.abiresearch.com

Base-station PA transistor market to exceed \$1bn in 2014

LDMOS to remain dominant transistor technology over GaN

Power amplifier (PA) transistor revenue from base-stations will grow from nearly \$520m in 2009 to slightly more than \$1bn in 2014, forecasts the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) Data Model 'Cellular Infrastructure Component Demand'. Growth in base-stations and PAs is being fueled by consumer adoption of new data applications, growing wireless subscriptions and next-generation standards, says the market research firm.

The report also forecasts that traditional macro- and micro-cell base-station deployment will peak at slightly over 1 million base-stations per year in 2012 before falling to slightly less than 1 million in 2014. Strategy Analytics sees explosive growth for lower-capacity pico- and femto-cell base-stations, to more than 7.8 million units deployed per year by 2014.

"Mobile operators are responding to consumer demand for data-centric applications by rolling out high-data-rate base-stations," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. "These higher rates require a network architecture that makes use of smaller base-stations, which will fuel strong semiconductor industry growth," he adds.

"We expect to see the market share of gallium nitride (GaN) transistors increase, but LDMOS will remain the dominant power amplifier transistor technology," comments Asif Anwar, director in the Strategy Analytics Strategic Technologies Practice.

www.strategyanalytics.com

Nokia recovering in US smart-phone market as Samsung growth continues

With Microsoft's assistance, Nokia can be expected to recover its recent market share losses in the US smart-phone market, while Samsung will make even stronger market share gains, according to the report 'A Third Ecosystem in the US: Samsung still set for growth, but what role for WP7?' from Strategy Analytics.

The Strategy Analytics Wireless Smartphone Strategies (WSS) service predicts that Nokia's smart-phone market share in the US can rebound to 10% by 2015, with strong marketing support from Microsoft. Samsung's smartphone share is forecast to grow even more impressively, to 21%, over the next 4 years.

While Nokia embarks on its recovery in the US, Samsung's operator relationships, existing overall handset share of 30% and proven experience with Android and Microsoft, all point to substantial smart-phone market share growth for the firm.

"Samsung has established a good track record in the US and is poised for further growth in smart-phone market share," says WSS service director Tom Kang. "Samsung can also choose the best balance between Android and WP7 for its products," he adds.

"Samsung can benefit from the enhanced WP7 ecosystem arising from the Microsoft/Nokia partnership in the US," notes associate director Martin Bradley. "However, if Microsoft's support to Nokia is highly effective in improving Nokia's share, Samsung could consider a more targeted approach for WP7 within its portfolio," he adds. "Microsoft marketing dollars can determine the economics of operating system choices for vendors in the WP7 ecosystem."

Opto sector growth seen at equipment & material suppliers Aixtron and IQE

Despite flattening revenue growth at component makers Oclaro and Cree, Strategy Analytics sees continued growth in the optoelectronics segment of the compound semiconductor industry because of January announcements of new products, equipment orders and capacity expansion.

The market research firm's viewpoint 'Compound Semiconductor Industry Review January 2011: Optoelectronics, Materials and Equipment' captures January's product, technology, contract, employment and financial announcements for major optoelectronic material, device and equipment suppliers including Aixtron, Bridgelux, Cree, KLA-Tencor, Emcore, JDSU, Oclaro, Agilent and IQE (categorized by material and

equipment, laser, LED and compound photovoltaic activity).

"Strong activity at the front-end of the optoelectronic supply chain should sustain continued growth for this segment in 2011," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. "Demand for solar energy is increasing strongly. LED use is quickly expanding into a broadening range of consumer applications," he adds.

"The January product, equipment and capacity announcements show strength in the optoelectronics portion of the compound semiconductor industry," notes Asif Anwar, director in the Strategy Analytics Strategic Technologies Practice.

www.strategyanalytics.com

Micro segment rebounding from slowing growth in Q4/2010

After a strong rebound in the first part of 2010, growth in the microelectronics segment of the compound semiconductor industry flattened in Q4/2010, says Strategy Analytics in its viewpoint 'Compound Semiconductor Industry Review January 2011: Microelectronics'.

The viewpoint summarizes product, technology, contract, financial and employment developments for suppliers including RFMD, Skyworks, Hittite, Anadigics, Freescale, Microsemi and Cree addressing applications using GaAs, GaN, SiC and CMOS technologies.

"The compound semiconductor industry rebounded strongly in 2010, thus slowing growth at some of the major suppliers in the fourth quarter should not be viewed with concern," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. Leading GaAs suppliers continue to find new opportunities

for power amplifiers (PAs) and front-end modules in an increasing portfolio of 4G devices, while Hittite continues to release new products targeted at high-performance, lower-volume markets. There continue to be reports of fundamental R&D for a variety of silicon and compound semiconductor materials.

"The January announcements show significant product development activity that will serve to strengthen growth in 2011," says Higham.

"Rapid consumer adoption of smart-phones and tablets is creating a wave of innovation and product development in the compound semiconductor industry," he adds.

"Results from some of the wafer suppliers were very strong and this also bodes well for growth throughout 2011," notes Asif Anwar, director in the Strategy Analytics Strategic Technologies Practice. "Several foundries are implementing plans to increase capacity."

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TriQuint opens NASDAQ market to commemorate 25th anniversary's record earnings in 2010

RF front-end product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA rang The NASDAQ Stock Market Opening Bell on 25 February at the NASDAQ MarketSite in New York City's Times Square.

"We recently announced record revenue and earnings for 2010, our 25th anniversary," noted president & CEO Ralph Quinsey. "There's much enthusiasm for our new opportunities in high-growth markets such as smartphones, tablet PCs and network infrastructure," he added. "In 2011, we are expanding our fab capacity by up to 40%, investing in R&D and planning to hire up to 500 new employees."

To commemorate its 25th anniversary, Quinsey was accompanied to the opening ceremony by a delegation of staff (winners of a worldwide

In 2011, we are expanding our fab capacity by up to 40%



CEO Quinsey joined by TriQuint staff to ring the opening bell at NASDAQ.

employee contest) representing TriQuint's global workforce and manufacturing operations in Oregon, Texas, Florida and Costa Rica. Quinsey and members of the executive team also hosted TriQuint's annual investor day in New York City on the same day.

www.nasdaq.com

On 8 March, Ralph Quinsey, president & CEO of TriQuint Semiconductor Inc, joined veteran business journalist Joya Dass in the NASDAQ CEO Signature Series (broadcasted from the NASDAQ MarketSite) to discuss the firm's industry, strategy, financials and positioning.

www.triquint.com/multimedia

TriQuint adds packaged BTS linear amplifiers

TriQuint Semiconductor has expanded its 3G/4G base transceiver station (BTS) portfolio with three new high-linearity low-noise amplifiers offering a range of gain options across 50MHz-4GHz.

The TQP3M9006 (offering very low noise), TQP3M9018 (offering flat gain) and TQP3M9019 (offering high peak gain) are cascadable GaAs gain block amplifiers in low-cost leadfree/RoHS-compliant industry-standard 16-pin 3mm x 3mm QFN surface-mount packages. They are suited to receive (Rx) or transmit (Tx) chains in base-station, repeater and other RF systems. All three devices can operate with a single +5V_{DC} supply and are internally matched using an E-pHEMT process, requiring only an external RF choke and blocking/bypass capacitors. The



internal active bias circuit also enables stable operation over bias and temperature variations.

"TriQuint simplifies RF connectivity with a broad portfolio of discrete and integrated devices that

empower the designer with solutions that lower overall costs and speed time-to-market," comments product marketing manager Tuan Nguyen.

www.triquint.com

RF Micro Devices celebrates its 20th anniversary

After being incorporated on 27 February 1991 and holding its initial public offering in June 1997, RF Micro Devices Inc Greensboro, NC, USA is celebrating its 20th anniversary with commemorative events planned at company locations throughout this year.

RFMD was a pioneer in the commercialization of RF components using gallium arsenide, and is currently the leading manufacturer of GaAs technology. In the 1990s the firm was a primary contributor to the rapid growth in the cellular handset market, and in 2000 it was identified by Fortune magazine as the second-fastest growing company in the USA. In 2004, it became the first semiconductor firm to ship 1 billion cellular power amplifiers (PAs), and currently routinely ships more than 3 million RF components per day.

Key products have included RFMD's PowerStar power amplifiers,

its silicon-based cellular switch technology, its PowerSmart power platforms, and its high-power gallium nitride (GaN) technology. Last year, RFMD unveiled a new RF Configurable Power Core at the center of its PowerSmart family of power platforms, and on 14 February this year it unveiled a family of cellular power amplifiers delivering what is claimed to be industry-leading peak efficiency.

RFMD's record of 'industry firsts' includes: first to commercialize GaAs HBT; first 6" GaAs manufacturing capability; first to launch open-loop polar modulation transmit architecture; first to introduce integrated power control for PAs (PowerStar); first to ship RF components with integrated RF shielding; first to commercialize high-performance, low-cost CMOS for switch-based products; first to commercialize RF configurable power core (PowerSmart); first to

exceed 50% peak efficiency in 3G/4G power amplifiers; and first to introduce GaN for CATV amplifier applications.

"We're just beginning to see the many ways in which our products and technologies can positively impact the experience of individuals, companies and markets," believes president & CEO Bob Bruggeworth. "We are very optimistic about our opportunities for revenue growth and strong operating results."

RFMD currently supplies RF components to multiple industries, including cellular handsets, cellular infrastructure, CATV infrastructure, smart energy, WiFi, and aerospace & defense. The firm is also investing in new growth markets, including concentrated photovoltaics (CPV), RF components for automotive and point-to-point radio applications, and GaN-based power and switching components for the defense and power electronics markets.

RFMD expands portfolio of 5GHz WiFi front-end modules for handsets, smart-phones and tablets

RF Micro Devices has expanded its 5GHz WiFi product portfolio to include three new high-band front-end modules (FEMs) with integrated power amplifiers (PAs) delivering high power and linearity and optimized for the rapidly growing smart-phone and tablet markets. Samples and production quantities of the RF5686, RF5506 and RF5516 are available now.

The global WiFi market is growing rapidly and is forecast to represent a greater than \$1bn total addressable market (TAM) by 2014, says RFMD. In particular, the adoption of dual-band WiFi (2.4/5GHz) in handsets is estimated to increase from about 25% of all handsets in 2011 to about 50% in 2012, with increasing emphasis on the 5GHz band 3G/4G smart-phones.

The anticipated growth in tablet devices is also forecast to support 5GHz FEM adoption, as mobile WiFi

chipsets for tablets increasingly adopt dual-band functionality.

To satisfy the growing market demand, RFMD has developed FEMs with high levels of integration, small package sizes, and what is claimed to be best-in-class linearity performance. The firm offers a broad portfolio of highly integrated FEMs that include the PA, the switch, filtering, baluns and an optional low-noise amplifier (LNA) for both single-band (2.4 or 5GHz) and dual-band (2.4/5GHz) operation. Its WiFi product portfolio also includes discrete PAs, switches and switch/LNA products that support integrated chipset solutions.

"RFMD forecasts the WiFi market will expand significantly as dual-band adoption increases and as volume expands across a variety of end markets, including smart-phones, tablets, home automation, WiFi TV, automotive

and personal computing," says Bob Van Buskirk, president of RFMD's Multi-Market Products Group (MPG).

The WiFi market will expand significantly as dual-band adoption increases and as volume expands across a variety of end markets, including smart-phones, tablets, home automation, WiFi TV, automotive and PCs

increasing the reliance on RFMD's core technology and product development capabilities," he adds. www.rfmd.com

"Because carrier requirements continue to demand higher power levels, this is placing an even greater focus on product performance and

IN BRIEF

Linear EDGE/GPRS transmit modules

RFMD says that its new RF9802 and RF9801 build on its RF716x GPRS family, incorporating full EDGE capability while maintaining a common footprint for ease of phone platform design.

Using RFMD's patented Power-Star architecture, the RF9802 includes features such as power flattening (for low power and current variation), V_{BATT} tracking (for improved switching performance at low V_{BATT}), and EDGE Low Power Mode. RF9802 is the full quad-band complement to the dual-band RF9801.

Features include what is claimed to be excellent power margin (34dBm low band P_{OUT}) for ease of design and calibration; scalability from dual- to quad-band and GPRS to EDGE using a series of pin-compatible modules; and best-in-class EDGE linearity performance (high band -67dBc $\pm 400\text{kHz}$ ACPR and $<3\%$ EVM).

Applications include GSM850/EGSM900/DCS1800/PCS1900 products, and 3V quad-band GSM/GPRS/EDGE handsets and mobile data products.

Broadband high-power SP3T switch

RFMD has launched the RF1603A switch, optimized for applications requiring very low insertion loss and high power handling capability with minimal DC power consumption. Linearity suits multimode GSM/EDGE/WCDMA/CDMA/LTE.

Features include 2kV HBM ESD protection on all ports; broadband performance covering all standard cellular frequency bands; and high linearity (IIP2 $>120\text{dBm}$).

Applications include multi-mode GSM, WCDMA, CDMA, LTE band switching; antenna tuning; and receive diversity switching.

www.rfmd.com

Skyworks ramps production of precision analog ICs supporting enterprise access points, cable set-top boxes and wireless video systems

Skyworks Solutions Inc of Woburn, MA, USA is ramping production of various precision analog ICs in support of several customers launching fiber-to-the-curb (FTTC), fiber-to-the-home (FTTH), cable set-top boxes and wireless video systems. Cisco and Motorola, among others, are leveraging Skyworks' power amplifiers, LNAs, gain blocks, attenuators, pin and varactor diodes, as well as switches to enable greater network reliability.

"Consumer demand for anytime, anywhere Internet access is creating exciting new growth avenues for Skyworks as carriers make significant investments in their networks to support wider adoption of new, lucrative services," says David Stasey, VP of analog components.

According to the Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, mobile data traffic is expected to grow at a compound annual growth rate (CAGR) of 92% from 2010 to 2015.

Skyworks offers a broad range of GaAs digital attenuators, PIN diode voltage variable attenuators, and silicon fixed attenuator pads for infrastructure, test & measurement, and other high-performance microwave applications up to 40GHz. High attenuation accuracy allows precise power control. Skyworks' featured attenuators include the AA103-72LF, AA104-73LF and AA116-72LF.

Skyworks' diode product offering includes PIN, Schottky, varactor and limiter diodes for a variety of microwave applications including WLAN, infrastructure, handset, SATCOM (LNB/DBS-CATV), automotive, military, test & measurement, metering, medical, and RFID. The discrete silicon and GaAs semiconductors are available as die, plastic packaged, surface-mount (SMT) and ceramic hermetic pack-

aged devices. Frequency ranges include low frequency, HF, VHF, UHF, L band, S band, C band, X band, KU band, K band, and Ka band. Featured diodes include the SMV1255 and SMS7621 series.

Skyworks' range of PAs and LNAs is designed for cellular applications and diverse markets such as wireless infrastructure, WLAN, automotive, test & measurement, energy management and other high-performance microwave applications. Its LNAs meet the needs of cellular infrastructure, WLAN, WiMAX, ISM, and all applications requiring LNAs from DC to 6GHz, making the devices dual-band capable. The firm's MMIC products are offered in enhancement-mode (E-mode LNA) and depletion-mode (D-mode LNA) pHEMT amplifiers achieving a sub-1dB noise figure (for better Rx sensitivity) and high-linearity performance. Featured devices include the SKY6501X Series, SKY65152-11 and SKY65404-21.

Skyworks' selection of GaAs switches for diverse markets such as WLAN, handset, wireless infrastructure, SATCOM (LNB/DBS-CATV), automotive, test & measurement, energy management, and other microwave applications is available in many different configurations including broadband, high power, high isolation, and low insertion loss, enabling higher transmit power, reflective, and non-reflective. The lead (Pb)-free, RoHS-compliant products are available for applications including antenna transmit/receive (T/R) switches for use in cellular handsets and WLAN systems, synthesizer switches for infrastructure needs, and other high-volume, high-performance needs. Featured switches include the SKY13276-334, SKY13352-337LF and SKY13353-337LF.

www.skyworksin.com

Smart-phone demand drives 34% growth in III-V revenue for HBT epiwafer foundry Kopin in 2010

Further strong growth expected for 2011

Kopin Corp of Taunton, MA, USA has reported revenue of \$120.4m for 2010 (at the low end of guidance of \$120–130m, but up 5% on 2009's \$114.7m). This was driven by \$62.2m for III-V heterojunction bipolar transistor (HBT) epiwafers (up 34% on 2009's \$46.5m), since revenue for CyberDisplay LCDs (used in mobile applications, military thermal weapons sights and wearable computers) fell 15% from 2009's \$68.2m to \$58.2m.

For fourth-quarter 2010, revenue was \$33.1m (roughly level with \$33m a year ago but up 5% on \$31.6m in Q3). This included CyberDisplay revenue of \$18m (level on a year ago but up 20% on Q3's \$15m) and III-V revenue of \$15.1m (level on \$15m a year ago but down 9% on Q3's \$16.6m).

Reflecting an increase in sales of higher-margin products, gross margin has risen from 30.8% a year ago and 32.3% in Q3 to 34.6%. This contributed to full-year gross margin rising slightly from 29.7% for 2009 to 29.9%.

Net income was \$4.7m, down from \$5.3m a year ago but up on \$1.4m in Q3. In 2010 cash generated from operating activities was \$15.1m and capital expenditure was \$17.2m while \$6.7m was used for the repurchase of stock. Cash and marketable securities totaled \$111m at the end of 2010, compared with \$114.5m at the end of 2009.

"The strong demand for smart-phones expected in 2011, as well as the increasing complexity of the front-end components required for

high voice and data speeds necessary to efficiently operate these devices, are significant trends that favor our proprietary III-V technology," says president & CEO Dr John C.C. Fan. "Consequently, we expect 2011 to be another year of solid revenue growth for our III-V products," he adds.

"While we continue to expect the US Army's Thermal Weapons Sight program to contribute materially to our display revenue in 2011, we do have some reservations about the federal budget deficit impact," cautions Fan. "We also expect our commercial display sales to grow."

For full-year 2011, Kopin expects to continue to grow and to generate total revenue of \$130–140m (up 8–16% on 2010).

www.kopin.com

Skyworks supporting HTC's smart-phones and tablets

Skyworks says that it is powering several new Android-based smart-phones from Taiwan-based HTC (one of the fastest-growing companies in the mobile sector) in addition to its latest tablet offering. The next-generation platforms, which include the Flyer tablet, Incredible, Desire S, Wildfire S, ChaCha and Salsa smart-phones, leverage Skyworks' highly integrated power amplifier modules as well as the firm's switch technology.

Skyworks is further expanding its partnership with HTC as it launches devices to meet growing consumer demand for mobile connectivity and social networking applications, says Liam K. Griffin, Skyworks' senior VP of sales & marketing. "Leveraging our analog, RF and mixed-signal design capabilities, we are able to deliver a broad portfolio of solutions to meet our customers' diverse needs while at the same time capturing an increasing level of content," he adds.

Of the Skyworks power amplifier modules (PAMs) selected by HTC, the SKY77701, SKY77703 and SKY77705 are fully matched 10-pad surface-mount modules developed for wideband code division multiple access (WCDMA) applications. The modules pack full 1920–1980MHz (SKY77701), 1710–1785MHz (SKY77703) and 880–915MHz (SKY77705) bandwidth coverage into a single, compact package. Because of high efficiencies attained throughout the entire power range, the PAMs deliver what is claimed to be unsurpassed talk-time advantages. The devices also meet the stringent spectral linearity requirements of high-speed downlink packet access (HSDPA), high-speed uplink packet access (HSUPA), and long-term evolution (LTE) data transmission with high power-added efficiency (PAE). A directional coupler is integrated into the modules, eliminating the need for any external coupler.

Also, the SKY77336 PAM is designed in a compact form-factor for quad-band cellular handsets comprising GSM850/900, DCS1800 and PCS1900, supporting Gaussian minimum shift keying (GMSK) and polar enhanced data for GSM evolution (EDGE) modulation. Class 12 GPRS multi-slot operation is also supported.

Of the switches selected, the SKY13309-370LF is a pHEMT GaAs IC SP3T antenna switch operating in the LF–3GHz frequency range. Switching between the antenna and Tx/Rx ports is via three control voltages. Low loss, high isolation, high linearity, small size and low cost suit wireless WLAN and Bluetooth systems operating at 2.4–2.5GHz.

The SKY13364-389LF is a pHEMT SP10T antenna switch with an integrated CMOS decoder and dual low-pass harmonic filters. It has four WCDMA Tx/Rx ports, four GSM Rx ports and two GSM Tx ports that suit cellular handsets and data-cards.

www.skyworksinc.com

Smartphones and tablets boost Taiwan's WIN and VPEC 46% year-on-year; AWSC to rebound in March

Taiwanese GaAs IC foundry WIN Semiconductors has reported a sequential increase in consolidated sales for February, while rival Advanced Wireless Semiconductor Company (AWSC) posted a drop, according to a report by Digitimes.

WIN's revenue was NT\$619m (US\$21m) in February, up 8.6% on January. Consolidated sales for the first two months of 2011 were up 46.1% year-on-year to NT\$1.16bn.

The firm's February sales bucked seasonal trends thanks to new orders from device maker Skyworks Solutions Inc of Woburn, MA, USA, according to the Chinese-language Economic Daily News (EDN), which added that WIN had snatched a portion of Skyworks' orders from AWSC.

WIN reportedly is also a contract partner for GaAs device maker TriQuint Semiconductor Inc of Hills-

boro, OR, USA. Both Skyworks and TriQuint are among the component suppliers for Apple's iPad 2.

AWSC saw revenue fall 35.5% sequentially from January to February. Sales from January through February totaled NT\$226m, down 12.2% year-on-year.

However, the firm expects revenue to recover in March due to power amplifier (PA) maker Skyworks resuming normal orders. Skyworks reduced orders at the end of 2010 for inventory management purposes. But, with major client Apple reporting strong tablet PC sales and the introduction of the iPad 2, Skyworks has begun raising orders to ASWC. Production time for PAs typically takes eight weeks, so orders from Skyworks should return to normal levels in March and AWSC's revenues for the month should rebound to NT\$150m

(US\$5.07m), reports Digitimes.

AWSC is expected to benefit from the popularity of smartphones and tablet PCs. Combined with rising demand for switches used in Wi-Fi equipment, April revenues are projected to set a new company record. The firm also expects to receive certification from device makers Avago and Sony and should begin limited shipments soon. It expects the new business to contribute to revenue in second-half 2011.

Meanwhile, Taiwanese GaAs epi-wafer foundry Visual Photonics Epitaxy Company (VPEC) has announced revenue of NT\$187m for February, up 0.4% month-on-month and 46% year-on-year. VPEC reportedly has entered the supply chains of both Skyworks and TriQuint.

www.digitimes.com

Anadigics ships CATV hybrid line amplifiers for Shanghai Qianjin Electronics' optical receivers

Anadigics Inc of Warren, NJ, USA is shipping production volumes of its CATV hybrid line amplifiers to Shanghai Qianjin Electronic Equipment Co Ltd for its NOR860T-2 and NOR860T-4 two- and four-way optical receivers, which are optimized for delivering analog and digital video — as well as high-speed data services — over hybrid fiber/coax (HFC) networks.

"Working closely with Anadigics, we have developed our optical receiver products for both established and emerging CATV markets," says Qianjin Electronics' president Wang Guang Hai. "We made the decision to select Anadigics as a key supplier for our optical node products due to its hybrid line amplifier performance and reliability advantages, as well as exceptional customer support."

The hybrid line amplifiers — which use Anadigics' GaAs MESFET process

for a high mean-time-to-failure (MTTF) in an industry-standard SOT115J package — have a high tolerance to ESD and line-voltage surge for enhanced ruggedness in outdoor applications. The ruggedness and reliability help service providers to minimize costly field repairs, says Michael Canonico, Anadigics' VP of worldwide sales. "We look forward to working closely with Shanghai Qianjin Electronics on the design of future CATV infrastructure products."

A report from Strategy Analytics last November forecasts that hybrid amplifier blocks will show steady growth through 2014. The fastest-growing CATV infrastructure segment should be amplifiers for HD-capable networks, with a forecasted CAAGR (compounded average annual growth rate) of nearly 43% from 2009 to 2014.

"With HD-TV, video on demand, and high-data-rate internet, CATV systems are increasingly operating in a fully loaded spectrum," says Joseph Cozzarelli, Anadigics' senior director of Broadband RF Products. The hybrid line amplifiers have low composite triple beat (CTB), composite second order (CSO), cross modulation, and noise figure distortion characteristics for optimal performance in a fully loaded spectrum. The linearity and low noise figures provide minimum signal degradation, Cozzarelli claims. "This level of performance, coupled with the extreme ruggedness of our hybrid line amplifiers, ensures the highest quality video delivery while minimizing costly downtime and service calls from cable plant equipment failures."

www.sq-catv.com
www.anadigics.com

Agilent launches 2011 version of Goldengate RFIC

Agilent Technologies Inc of Santa Clara, CA, USA has announced GoldenGate version 2011, the latest release of its RFIC simulation, verification and analysis software.

Version 2011 targets advanced-node RFIC design with improved performance, fast mismatch analyses for analog/RF applications, and a new easy-to-use graphical user interface. It also extends the software's RFIC analysis to more easily incorporate package and board effects.

"There are various ways to approach performance enhancements," says Paul Colestock, product planning and marketing manager with Agilent's EEs of EDA organization, which supplies electronic design automation software for microwave, RF, high-frequency, high-speed digital, RF system, electronic system level, circuit, 3D electromagnetic, physical design and device-modeling applications. "Agilent's approach is to provide continuous improvement on the circuits that our customers care most about."

GoldenGate version 2011 software delivers the following updates for RF design analysis:

- carrier-analysis improvements that deliver significantly better scalability and performance on multicore CPUs;
- much improved performance of carrier and SSNA noise analyses; fast yield-contributor analyses for RF and analog/mixed-signal designers, including DC, AC and oscillator analysis;
- enhanced fast circuit-envelope analysis that accelerates RF functional path simulations by an order of magnitude or more, with broader support for RFIC-centric source configurations for models including memory effects; and
- an enhanced crystal oscillator convergence option that reduces the frustration of simulating crystal oscillators.

GoldenGate 2011 has a number of improvements for wireless design verification. Fast mismatch analysis dramatically accelerates the block and functional path verification that RFIC designers perform every day, without loss of accuracy, including new support for Cadence corners tool.

The updated adslib for the GoldenGate library now includes delay-

defined transmission lines and Philips-TU Delft standard/user-defined bondwire models. Using this, engineers can simulate more of their designs by including RF package and board effects. Also, by closing the loop between system and circuit designers using the new SystemVue and GoldenGate links and flows, designers can accelerate system-level verification of RFICs.

Version 2011 also improves both the tool's usability and user productivity, e.g. new tree/tabbed graphical user interface for the Cadence Analog Design Environment eases the configuration of RF analyses and environment/options selection.

Agilent's GoldenGate version 2011 is available now, with a starting price of just under \$25,000.

Agilent will demonstrate its newest design and test innovations for RF and microwave research, development and manufacturing at the IEEE Microwave Theory & Techniques Society (MTT-S) International Microwave Symposium (IMS2011) in Baltimore, MD, USA (7-9 June).

www.agilent.com/find/eesof-goldengate2011

EDA software supplier AWR and CapeSym sign reselling deal for electrical-thermal MMIC co-design

High-frequency electronic design automation (EDA) software tool provider AWR Corp of El Segundo, CA, USA has signed an agreement with engineering services company CapeSym Inc (which provides electronic materials processing, process optimization, and thermal management solutions) that names AWR as the global and exclusive reseller of CapeSym's SYMMIC software package for thermal analysis of microwave integrated circuits (MMICs).

Marketed as AWR Connected for CapeSym SYMMIC, the product allows high-power RF designers to perform thermal analysis on MMICs designed within AWR's Microwave

Office software. Demonstrated jointly by the two firms at the IEEE Compound Semiconductor IC Symposium (CSICS) in Monterey, CA last October, AWR Connected for CapeSym SYMMIC is now commercially available.

"High power and heat go hand-in-hand, and our customers performing power amplifier design have repeatedly inquired about coupled thermal solutions," says AWR executive Ted Miracco. "Now, we can offer a technically robust and MMIC-specific circuit simulation and thermal profiling solution," he adds.

"This partnership is ideal because AWR's Microwave Office is the tool-of-choice for leading MMIC design-

ers in commercial, aerospace and defense sectors, and SYMMIC is most impactful when tightly coupled to it," comments CapeSym's founder Shari Motakef. "AWR's outstanding use-model, user interface, and customer support made it a natural choice for us to partner with, not only in terms of functionality but also for the global deployment of our joint solution."

AWR's Microwave Office high-frequency design platform and CapeSym's SYMMIC templates produce what is claimed to be unique electrical-thermal MMIC co-design of high-power RF components.

www.awrcorp.com
www.capesym.com

DOTFIVE presents high-speed SiGe HBTs

3-year EU project demos imaging chip-set for 0.82THz applications

At the International Solid State Circuit Conference (ISSCC 2011) in San Francisco (20–24 February), the European research consortium DOTFIVE detailed its latest high-speed circuits.

Running from February 2008 to end-January 2011, the three-year, €14.75m project DOTFIVE included funding of €9.7m from the European Commission, making it the largest 'More than Moore' nanoelectronics project under the European Union's Seventh Framework Program (FP7) for Research and Technology Development.

DOTFIVE design teams have made use of silicon-germanium (SiGe) process technologies developed in Europe. The technology is targeted at future THz imaging, radar, or communication applications.

The DOTFIVE consortium claims that, over the last 3 years, it has established a leadership position for the European semiconductor industry in silicon-germanium heterojunction bipolar transistors (SiGe HBTs) for millimeter-wave applications, with contributions from semiconductor manufacturers including STMicroelectronics, Infineon Technologies and IHP GmbH. Chips based on SiGe have faster NPN transistors and target integration levels unseen in any other high-frequency silicon bipolar technology.

Germany's University of Wuppertal and IHP discuss circuit results of DOTFIVE's next-generation SiGe BiCMOS technology, an imaging chip-set for applications at 0.82THz. The chip-set (a transmitter and receiver) include all required circuitry (such as frequency multipliers, harmonic mixers, power amplifiers, and on-chip antennas) and run from a 18GHz frequency reference. The circuits operate their transistors sub-harmonically and expand their application beyond their cut-off frequency. Overall, this demonstrates the "highest frequency of operation in SiGe history", it is claimed.

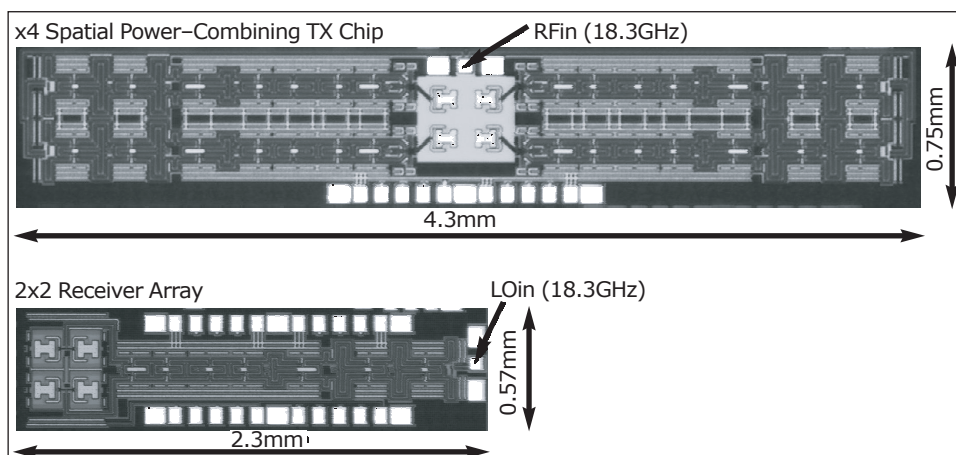


Fig. 1 Micrographs of fully integrated SiGe chip-set for THz imaging applications, presented at ISSCC.

The chips include some of the latest process technologies and focus on novel applications for silicon technologies, says Dr Erik Öjefors, circuit designer at the University of Wuppertal. The DOTFIVE project's transistors are not only designed for high-frequency applications, but also enable lower-power applications and better noise performance at lower frequencies. The technology could also be a key driver for novel applications in a variety of emerging applications in the security, medical and scientific area, it is reckoned.

Prior to ISSCC, the latest DOTFIVE technology achievements were presented by IHP last December at the IEDM 2010 meeting in San Francisco. The technology features HBTs with a maximum oscillation frequency (f_{max}) of 500GHz, and has reached ring-oscillator gate delays as low as

2.0ps, which is a new world record for SiGe according to IHP's Dr Bernd Heinemann.

Last September in Paris, France, the designers and technologists E. Öjefors, F. Pourchon, P. Chevalier and U.R. Pfeiffer of STMicroelectronics and the University of Wuppertal were awarded the 40th EuMC Microwave Prize (a prize given since 1977 for the best contributed paper to the European Microwave Conference) for their work 'A 160GHz Low-Noise Downconverter in a SiGe HBT Technology'.

At the 2010 BiPolar/BiCMOS Circuits and Technology Meeting (BCTM) in Austin, TX, USA (4–6 October), Infineon presented static frequency dividers that showed record operation at 133GHz. Such circuits play a key role in any communication and radar system.

www.dotfive.eu

	2007	2008	2009	2010	2011	2012	2013
ITRS*(GHz) Peak f_{max} in production	280	305	330	350	370	390	410
DOTFIVE Peak f_{max} (GHz) in R&D		330	400	500			500 in production

*RF and Analog Mixed-Signal Bipolar Technology Requirements International Technology Roadmap for Semiconductors 2007 Table RFAMS2a

Manufacturable solutions exist and are being optimized
 Manufacturable solutions are known

Fig. 2 DOTFIVE vs the International Technology Roadmap for Semiconductors.



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IN BRIEF

Avago announces changes to board

Avago Technologies Ltd of San Jose, CA, USA and Singapore, which designs and supplies analog interface components for communications, industrial and consumer applications (with a focus on III-V based products), says that James A. Davidson, David M. Kerko and Bock Seng Tan have tendered their resignations from its board of directors due to a re-organization following the secondary public offerings of Avago ordinary shares by sponsor shareholders at the end of February.

Davidson and Kerko were director designees of Silver Lake and KKR, respectively, and Bock Seng Tan was originally the director designee of Seletar Investments Pte Ltd.

Following the sale of shares in February, under the terms of Avago's Second Amended and Restated

Shareholder Agreement, Silver Lake and KKR are each currently entitled to designate only one member to the board. Seletar ceased to be entitled to designate a member following its sale of shares in a secondary offering last December.

Davidson, Kerko and Bock Seng Tan were nominated for re-election to the board at the firm's 2011 Annual General Meeting of shareholders (AGM) on 30 March. However, following their resignations, each withdrew as a candidate for re-election. The board has decided not to fill the vacancies.

www.avagotech.com

Davidson, Kerko and Bock Seng Tan have tendered their resignations following secondary public offerings

TowerJazz expands MPW services to CMOS image sensors, high-speed SiGe and SOI RF CMOS

Specialty foundry TowerJazz (which has two fabrication plants at Tower Semiconductor Ltd in Migdal Haemek, Israel plus one at its US subsidiary Jazz Semiconductor in Newport Beach, CA) says that its Aerospace and Defense business unit has expanded its multi-project wafer (MPW) services to include CMOS image sensors (CIS) as well as high-speed silicon germanium (SiGe) and silicon-on-insulator (SOI) RF CMOS, to be available for on-shore or ITAR (International Traffic in Arms Regulations)-controlled prototype and manufacturing services of advanced semiconductors for the US Department of Defense (DoD) and the broader aerospace and defense community.

TowerJazz's CIS process has already been running in high volume in its Israeli plants, and is now being added to the MPW program in its Newport Beach facility for customers that require on-shore manufacturing. The firm says

that its CIS process enables the customization of pixels per project needs, and its performance (dark current, low noise and dynamic range) enables a rich offering for various digital imaging applications. In addition, TowerJazz says that its patented stitching technology overcomes photolithography tool limitations to seamlessly tile 5.5µm pixel sections into a large pixel array, resulting in ultra-high-resolution color image sensors. The technology enables manufacturing of die sizes up to a single die per 200mm wafer.

TowerJazz has pushed SiGe performance to speeds in excess of 200GHz, and this process is offered on a monthly MPW program for fast and cost-effective prototyping

TowerJazz's presence in the industrial sensor market has grown significantly with new applications such as finger-print detection for homeland security, traffic monitoring cameras and others. CIS process design kits (PDKs) are scheduled for release in first-half 2011, and the MPW is scheduled for availability in Q4.

Also part of TowerJazz's on-shore MPW program is SiGe BiCMOS and 0.18µm RF SOI CMOS. TowerJazz says that it has pushed SiGe performance to speeds in excess of 200GHz, and this process is offered on a monthly MPW program for fast and cost-effective prototyping of high-speed designs in areas such as optical networks, land and air vehicle collision avoidance radar, phased array radar, and other millimeter-wave applications. The RF SOI CMOS MPW program supports 1.8V, 3.3V and 5V CMOS with bulk-like design flow and low-loss substrates for mobile communication and base-station wireless links.

"TowerJazz's aerospace and defense business is experiencing very solid growth in 2011," says Mike Scott, director of sales & marketing, USA Aerospace and Defense Division. "The further expansion of our monthly MPW program will provide an even broader range of advanced technology to our customer base, enabling world-class designs and applications through a cost-effective business model," he adds.

TowerJazz exhibited at the Government Microcircuit Applications & Critical Technology Conference (GOMAC Tech 2011, 22-23 March) as well as at the Hardened Electronics and Radiation Therapy (HEART 2011) conference (30 March), which were both held in Orlando, FL.

www.towerjazz.com

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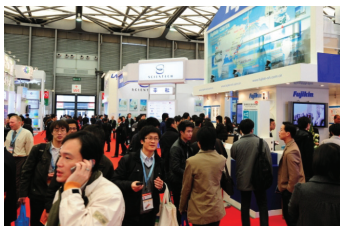


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Cree launches first surface-mount 1200V SiC Schottky

Cree Inc of Durham, NC, USA has made available what it says is the industry's first commercial 1200V surface-mount silicon carbide (SiC) Schottky diode (fully qualified and released for production use).

Packaged in an industry-standard surface-mount TO-252 D-Pak, Cree says that the Schottky diodes deliver the same proven performance as its TO-220 through-hole devices, but with a smaller board footprint and lower profile. This can enable the design of smaller, lower-cost and more efficient solar-power micro-inverters, compared to systems designed with larger and bulkier through-hole parts, the firm claims.

"Customers designing high-efficiency micro-inverters for solar power applications wanted to simplify their designs without compromising system efficiency," explains Cengiz Balkas, Cree's VP & general manager, Power and RF. "They were looking for a surface-mount device that

could deliver the same performance they had come to expect from SiC Schottky diodes — zero reverse-recovery losses, high-frequency operation with a low EMI signature, and reduced operating temperatures," he adds. "Given Cree's experience in developing high-voltage SiC power devices, the move to the surface-mount D-Pak was a natural extension of our Schottky diode product line to serve this critical market."

Design trends in solar-power micro-inverters are requiring the use of surface-mount components with smaller footprints and lower profiles. This enables us to both reduce the size of the inverter circuitry and lower the cost

"Design trends in solar-power micro-inverters are requiring the use of surface-mount components with smaller footprints and lower profiles," says Alessandro Di Nicco, design engineer new platforms at Power-One. "This enables us to both reduce the size of the inverter circuitry and lower the cost, while maintaining reliability and high efficiency, with the eventual goal of physically integrating the micro-inverter into the solar panels themselves," he adds. "Cree's new surface-mount Schottky diodes represent a significant step in that development."

Cree's C2D05120E Schottky diodes are rated for 5A and 1200V, with approximate board-mounted dimensions of 6.6mm wide x 9.9mm long x 2.3mm high. The operating junction and storage temperatures are rated for -55°C to +175°C.

www.cree.com/power

Taiwan's ITRI adopts Synopsys' simulation software to speed SiC power device development

Synopsys Inc of Mountain View, CA, USA, which provides software and IP for semiconductor design, verification and manufacturing, says that the Industrial Technology Research Institute of Taiwan (ITRI) has adopted its TCAD Sentaurus simulation software to support its R&D of silicon carbide (SiC) semiconductor devices.

The firm says that TCAD Sentaurus' modeling enables ITRI to speed the development of SiC power devices (which have superior electrical and thermal properties due to the wide energy bandgap of SiC) via detailed simulations of their electrical and thermal behavior.

Over the past decade, SiC Schottky barrier diodes have become commercially available, resulting in the development of a new generation of SiC devices targeting applications in hybrid and electric vehicles,

smart grid and other innovative power systems. ITRI is researching a wide range of power devices to serve emerging market needs for electric vehicles and solar arrays.

"The market for SiC devices is growing rapidly because of the need for more energy-efficient power switches in major application segments like automotive and energy distribution," says Dr Ming-Jer Kao, EOL deputy general director of ITRI. "The Synopsys TCAD Sentaurus software allows us to simulate the electrical and thermal performance of our devices in a very realistic way," he adds. "This capability is essential for understanding the behavior of our new devices and is used to optimize the device characteristics to meet market requirements."

The TCAD Sentaurus product family comprises 2D and 3D process and

device simulation tools for exploring and optimizing silicon and compound semiconductor technologies. The TCAD Sentaurus tools implement models specific to SiC simulation.

"Power devices are a fast-moving segment of the semiconductor market, with innovation through new device structures and materials addressing increasingly complex and challenging applications," says Howard Ko, senior VP & general manager of the Silicon Engineering Group at Synopsys. "TCAD simulation can help accelerate the commercial deployment of SiC by supporting the design and optimization of new devices," he adds. "ITRI's adoption validates the value Synopsys TCAD simulation brings to SiC power device development."

www.itri.org.tw/eng
www.synopsys.com

SemiSouth ships first normally-off SiC JFET for up to 50kW

SemiSouth Laboratories Inc of Starkville, MS, USA (which designs and manufactures silicon carbide (SiC) technology for high-power, high-efficiency, harsh-environment power management and conversion applications) is now shipping its latest range of vertical trench JFETs (junction field-effect transistors) — including what is claimed to be the world's first normally-off family of devices to handle up to 50kW — in commercial volume quantities.

The firm is rapidly expanding production capacity at its SiC wafer fabrication facility. As an independent, vertically integrated SiC manufacturer with epitaxial and vertical trench process technology, SemiSouth uses a proprietary and patented self-aligned JFET chip design enabling up to ten times smaller die size compared with silicon super-junction MOSFETs or the latest trench IGBTs, it reckons. The firm also holds the record for the lowest 1200V power transistor specific on-resistance (under $2.5\text{m}\Omega/\text{cm}^2$).

The new SJEP120R100, SJEP120R063 and SJEP170R550 normally-off trench SiC power JFETs are compatible with standard gate drive circuitry and feature a positive temperature coefficient for ease of paralleling. The voltage-controlled devices also have a low $R_{\text{ds(on)}}_{\text{max}}$, low gate charge and low intrinsic capacitance. The SJEP120R100 (with an $R_{\text{ds(on)}}$ of $100\text{m}\Omega$) enables extremely fast switching with no 'tail' current up to its maximum operating temperature of 175°C , and the SJEP120R063 (with an $R_{\text{ds(on)}}$ of $63\text{m}\Omega$) can enable switching losses of just $353\mu\text{J}$ at 24A. These JFETs offer a blocking voltage of 1200V and exhibit temperature-independent switching behaviour. The latter device is being designed in by a number of solar inverter companies who are achieving product efficiencies of 98–99%.

SemiSouth also offers a normally-on 1200V SiC JFET (SJEP120R085) for users that can use the normally-on behaviour. It offers the same features as the normally-off SJEP120R100 JFET, plus a higher saturation current (50A), lower on-resistance per unit area ($85\text{m}\Omega$ total), and the same or better switching performance. The device is also being designed in at solar inverter and audio customers for high-efficiency or high-linearity applications.

At 1700V, the new 4A SJEP170R550 SiC JFET delivers a higher blocking voltage (1700V), five times lower on-resistance ($550\text{m}\Omega$), about ten times lower output capacitance ($C_{\text{OSS}} = 20\text{pF}$) and gate charge (Q_{G} of 10nC) than competing 1500V silicon power transistors, it is claimed. The device has a maximum operating temperature of 175°C , and is targeted at auxiliary flyback power supply applications running off the high voltage DC bus in AC drives, UPS (uninterruptible power supplies) and solar inverters.

"Our SiC JFETs enable the most energy-efficient power system designs now possible for a broad range of applications...and they are available in volume production," comments president Jeff Casady. "Power supplies and inverters can now be designed to run up to 50–75% more efficiently and operate at up to four to eight times higher in PWM [pulse width modulation] frequency," he reckons. "The reasonably higher price of the JFET can be off-set by a substantial reduction in the size and cost of magnetics, heat sinks and enables a smaller and lighter overall solution."

Available in plastic TO-247 packages, pricing in 1000-piece quantities is \$12.55 for the SJEP120R100, \$15.50 for the SJEP120R085, \$22.87 for the SJEP120R063, and \$9.06 for the SJEP120R550.

www.semisouth.com

IN BRIEF

Reliability test system for Asia

Accel-RF Corp of San Diego, CA, USA, which produces turn-key RF reliability and performance characterization test systems for compound semiconductors, says that in early January installation was completed of two semiconductor reliability test systems that were delivered in fourth-quarter 2010 to customers in Asia. Shipped to both government research and commercial entities, the systems will be instrumental in the development of compound semiconductor device performance characterization in Asia.

After its entry into the European Union market last year, this represents the start of Accel-RF distributing products to customers in Asia, says president & founder Roland Shaw.

Accel-RF has been selling RF reliability test systems in the USA since 2004. After expanding into Europe in 2009, penetration in Asia is a testament to market acceptance and compelling value, reckons the firm. "Global expansion for complex equipment like ours has to be done carefully and with individual attention," says Shaw, "Even with this major expansion effort, we have maintained a very close relationship with all of our customers."

Service and first-line hardware support for the systems will be performed by Amtechs Corp in Japan and SE Technologies in Taiwan. "As a manufacturer of advanced test instruments, Accel-RF's technical staff will always be partnered with our customers," Shaw says. "Our distributors in Asia for sales, service, and first-line support have a track record of extraordinary support with our market-space and their technical expertise is exceptional," he adds.

www.accelrf.com

Wide-bandgap alliance formed in Taiwan

ITRI, Epistar and Vanguard among 20 members

A total of 20 organizations in Taiwan have formed an alliance to develop electronics devices using compound semiconductors with wide energy bandgaps (i.e. larger than 1 or 2eV), including silicon carbide (SiC) and gallium nitride (GaN), for use in high-power electronics applications such as electric cars and LEDs, says The Taiwan Economic News (CENS).

Wide-bandgap materials are often used in applications involving operation at high temperature and high power (above what can be withstood by narrow-bandgap materials like silicon).

Alliance members are divided into groups for developing substrate materials, epiwafers, devices, modules and inspection technologies. The Taiwan government-backed Industrial Technology Research Institute (ITRI), silicon chipmaker Vanguard International Semiconductor Corp (VISC), and LED chip and epiwafer maker Epistar Corp are among the 20 or so member organizations involved in the alliance.

The alliance's plan is to complete packaging and test verification on 600V devices by the end of this year and, three years later, to start developing application modules for use in electric cars, photovoltaic systems, distributed energy systems, and air-conditioner inverters.

ITRI executives point out that many organizations worldwide have ventured into the development of wide-bandgap technologies in a bid to improve the efficiency of power consumption. The institute forecasts that revenue for SiC semiconductor market will grow at an annual rate of 50% from 2013, to US\$1.83bn in 2019.

http://news.cens.com/cens/html/en/news/news_inner_35576.html

DARPA targets transmitters with improved RF amp power supplies

MPC program seeks efficient high-speed power supply modulator using GaN switch

Military radio communications experts at the US Defense Advanced Research Projects Agency (DARPA) in Arlington, VA, USA are asking industry for ideas on how to develop an RF transmitter integrated as a monolithic integrated circuit or system-in-package module that relies on a monolithic microwave integrated circuit (MMIC) power amplifier integrated with a dynamic-voltage power supply and control circuit.

Scientists in the DARPA Microsystems Technology Office (MTO) have released a broad agency announcement (DARPA-BAA-11-33) for the Microscale Power Conversion (MPC) program to develop a radio transmitter that generates radio signals efficiently through the DC power supply of the transmitter.

Most military RF transmitters currently use large, fixed-voltage power converters to supply conditioned power to the semiconductor power amplifier, DARPA officials explain. This is a barrier to higher levels of microsystem integration.

This is a growing problem because many existing military radio systems, as well as those envisioned in the future, use complex modulation techniques with high peak-to-average ratios in signal amplitude. Although the systems are designed for fixed operation at peak condition, power amplifiers typically operate well below peak output power much of the time.

To improve the efficient use of power and diverse signal waveforms, DARPA scientists are looking for new envelope tracking or other drain bias modulation techniques to enable RF power supplies to operate far more efficiently by changing the DC voltage that it supplies to the power amplifier rapidly.

The Microscale Power Conversion program seeks to develop power electronics technology for efficient, very fast supply modulation with

high power handling capabilities to make practical use of new RF power amplifier designs. The program aims to develop a compact, power-efficient RF transmitter by inventing dynamic power conditioning circuits and closely integrating them with RF MMIC power amplifiers and necessary control circuits.

The electrical supply chain from the AC power source to power amplifier supply typically functions as three lumped stages, DARPA explains: converting AC power to high-voltage DC power; converting high-voltage DC power to an intermediate DC voltage; and, finally, conditioning the resulting power to remove ripple and make subtle adjustments.

In the final stage, the drain bias is either on or off at a set value.

DARPA is focusing the MPC program on the final stage of this process by seeking to develop an efficient high-speed power supply modulator to convert input DC voltage rapidly to any DC supply voltage. For this the key enabling technology will be a fast, low-loss gallium nitride (GaN) power switch.

Scientists at DARPA wants to focus the MPC program first on designing high-speed, low-loss packaged field-effect transistor (FET) power switches, and then on co-designing and prototyping the RF transmitter and supply modulator.

Officials expect to award contracts to several teams in a 2–3 year effort to establish a power switch foundry capability and to demonstrate the feasibility of high-efficiency RF transmitters with microscale power conversion technology.

Firms interesting in submitting proposals to DARPA should send abstracts no later than 11 April, and full proposals no later than 10 June. to John Albrecht (e-mail: DARPA-BAA-11-33@darpa.mil).

www.fbo.gov/spg/ODA/DARPA/CMO/DARPA-BAA-11-33/listing.html

II-VI expanding SiC operations in Mississippi

\$18m investment in 10,000ft² facility to create 100 jobs

The Wide Bandgap (WBG) Materials division of II-VI Inc's compound semiconductor business — which is based in Pine Brook, NJ, USA — says that it is expanding its operations, in two phases, at Mississippi State University's (MSU's) Research Park in Starkville, MS, in order to meet the rapidly growing market demand for single-crystal silicon carbide (SiC) wafers for next-generation electronic devices.

The firm says that the devices should enable dramatic increases in efficiency for a wide range of applications related to energy conversion and switching, including commercial hybrid vehicles, smart-grid power switching, green (windmill and solar) energy generation, and industrial motor drives. The project represents an \$18m investment by the firm and will create up to 100 new jobs locally.

MSU's Research Technology Corporation (RTC) is constructing a new 20,000ft² facility in its Research Park, of which 10,000ft² will be separately utilized by II-VI,

where staff will be engaged in materials manufacturing activities, including fabrication, polishing, cleaning and packaging of SiC wafers prior to shipment to device customers. Construction is expected to start in April, with completion in 12 months.

The State of Mississippi's Mississippi Development Authority (MDA) says that it worked closely with II-VI Inc and local officials to provide assistance for this

first phase of the expansion, via the Momentum Mississippi Incentives program and the Job Protection Grant program. Oktibbeha County also provided assistance to help facilitate this phase of the project.

Staff will be engaged in materials manufacturing activities, including fabrication, polishing, cleaning and packaging of SiC wafers

In addition, for the second phase of the expansion, the City of Starkville and Oktibbeha County are jointly constructing a publicly owned, 20,000ft² facility, in which II-VI staff will be engaged in the firm's expanding crystal growth operations. For this second phase, MDA is providing assistance to the city and county for the construction of the building, while the Tennessee Valley Authority is also providing loan assistance.

"We are grateful to all parties involved who helped bring this plan to fruition and are looking forward to significant future growth and to supporting the local community by bringing high-tech jobs to Starkville," says WBG Materials division general manager Dr Tom Anderson.

Both new buildings will be located in MSU's Research Park. II-VI has been located in Mississippi since 2005 and currently employs six workers in a small, separate pilot facility, also in the Research Park.

www.iivibwg.com

GeneSiC showcases technology at second annual ARPA-E Energy Innovation Summit

GeneSiC Semiconductor Inc of Dulles, VA, USA, which develops silicon carbide (SiC) and silicon-based devices for high-temperature, radiation and power grid applications, was selected for the Technology Showcase at the second annual ARPA-E Energy Innovation Summit (28 February — 2 March) at the Gaylord Convention Center just outside Washington DC.

The event was co-hosted by the US Department of Energy's Advanced Research Projects Agency — Energy (ARPA-E) and the non-profit industry association Clean Technology and Sustainable Industries Organization (CTSI). Hundreds of technologists and

clean tech organizations competed to participate in the Showcase.

As one of ARPA-E's selected organizations, GeneSiC exhibited its silicon carbide to nearly 2000 national leaders gathering to drive long-term US competitiveness in the energy sector, including researchers, investors, entrepreneurs, corporate executives and government officials. More than 200 technologies from ARPA-E awardees, corporations, National Labs and Department of Energy R&D programs were featured at the event.

"This summit brings together organizations that understand the need to collaborate and partner to bring the next generation of energy

technologies to market," says GeneSiC's president Dr Ranbir Singh.

Also present at the summit were research and business development teams from 14 Corporate Acceleration Partners committed to technology commercialization, including Dow, Bosch, Applied Materials and Lockheed Martin.

Other speakers at the summit included US Energy Secretary Steven Chu, ARPA-E director Arun Majumdar, US Navy Secretary Raymond Mabus, former California Governor Arnold Schwarzenegger, and Bank of America chairman Charles Holliday.

www.genesicsemi.com
www.arpa-e.energy.gov
www.ct-si.org

IN BRIEF

Lead-free and RoHS-compliant eGaN FETs from EPC

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA has launched the EPC2001 and EPC2015, two lead-free, RoHS-compliant enhancement-mode gallium nitride on silicon (eGaN) FETs.

The EPC2001 FET is a 100V_{DS} device with a maximum $R_{DS(ON)}$ of 7m Ω with 5V applied to the gate. The EPC2015 is a 40V_{DS} with a maximum $R_{DS(ON)}$ of 4m Ω . Both eGaN FETs provide significant performance advantages over similar state-of-the-art silicon-based power MOSFETs, EPC claims. Both devices have low on-resistance, are smaller than silicon devices with similar resistance, and have many times superior switching performance.

Applications that can benefit from eGaN FET performance increases include DC-DC power supplies, point-of-load converters, class D audio amplifiers, notebook and netbook computers, LED drive circuits and telecom base-stations.

"Protection of the environment is a high priority for EPC and a driving force for offering lead-free, RoHS-compliant eGaN FETs," says co-founder & CEO Alex Lidow. "The EPC2001 and EPC2015 are the first lead-free and RoHS-compliant eGaN FETs to be introduced, and it is our plan to have all eGaN FETs available lead-free and RoHS-compliant within the next 4 months," he adds.

Pricing (in 1000-piece quantities) is \$2.80 for the EPC2001 and \$2.48 for the EPC2015. Both are available through Digi-Key Corp.

For an application note detailing the performance improvements of these next generation devices, see:

www.epc-co.com

Microsemi announces E-mode GaN FETs for rad-hard applications

SiC device maker works with GaN firm EPC

Microsemi Corp of Irvine, CA, USA (which designs and makes high-reliability analog and RF devices, mixed-signal integrated circuits, FPGAs and customizable SoCs, and complete subsystems, based on silicon, gallium arsenide and silicon carbide) has announced the development of enhancement-mode gallium nitride field-effect transistors (E-mode GaN FETs) for satellites and other military power conversion, point-of-load, and high-speed switching applications.

GaN's wide energy bandgap increases performance over existing radiation-hardened silicon MOSFETs, says the firm. The FETs also provide the following features and benefits: extremely low parasitic capacitance, which reduces switching losses by at least 50%, resulting in higher-efficiency circuits; lower on-resistance to minimize conduction losses resulting in circuit efficiency gains; and what is claimed to be excellent radiation performance.

Microsemi is developing a complete line of high-performance FETs for high-reliability space and military applications by working with Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode (eGaN) power FETs based on its proprietary gallium nitride on silicon (GaN-on-Si) technology for power management applications. EPC claims to have been the first firm to introduce enhancement-mode GaN-on-Si transistors as power MOSFET replacements in applications such as servers, netbooks, notebooks, LED lighting, cell phones, base-stations, flat-panel displays, and class-D audio amplifiers, with device performance many times greater than the best silicon power MOSFETs.

The first new devices will be offered by Microsemi in voltages of 40V, 60V, 100V, 150V, and 200V and will have drain-to-source

on-resistance values of 4–100m Ω . The devices are also expected to deliver excellent high-temperature performance with junction temperatures approaching 300°C. A family of standard through-hole and surface-mount packages in addition to flip-chip die will be available.

Preliminary radiation testing of the

Testing of the devices has shown high Single Event Effect and Total Ionizing Dose capability. This allows the devices to operate in high-orbit and deep-space missions without degradation to performance.

devices has shown high Single Event Effect (SEE) and Total Ionizing Dose (TID) capability. This allows the devices to operate in high-orbit and deep-space missions without degradation to performance.

Microsemi will work

closely with the Defense Logistics Agency (DLA) to define the test specifications within standard military drawings (MIL-PRF-19500 slashesheets), assuring the performance capabilities of the products.

A jointly researched paper 'Enhancement Mode Gallium Nitride Characteristics Under Long Term Stress' was presented at the Government Microcircuit Applications and Critical Technology Conference (GOMAC 2011) in Orlando, FL (21–24 March). The study covers the reliability-testing results and demonstrates the stability of the devices at temperature and under radiation exposure.

Prototype customer samples are expected to be available by mid-2011, with production quantities available by November.

www.microsemi.com



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Transphorm emerges from stealth mode prior to launching GaN power modules

Google-backed firm targets high-voltage power conversion

At a private event at Google's headquarters in Silicon Valley in late February, Transphorm Inc of Goleta, CA, near Santa Barbara, CA, USA emerged from stealth mode as it prepares to launch compact power conversion devices and modules based on gallium nitride (GaN) technology, offering increased conversion efficiency.

Last May, the firm completed a \$20.2m Series C financing round led by Google Ventures, joined by existing investors Kleiner Perkins Caufield & Byers, Foundation Capital and Lux Capital (with Google Ventures partner Wesley Chan, Kleiner partner Randy Komisar and Foundation partner Richard Redelfs all becoming board directors). This brought total capital raised from all three rounds to \$38m.

Transphorm was co-founded in 2007 by CEO Umesh Mishra, a professor of electrical & computer engineering at the University of California, Santa Barbara (UCSB), together with his former student Primit Parikh as president. The management team also includes (as vice presidents) Yifeng Wu Ph.D. (Product Development), Jim Hartman (Wafer Fab Manufacturing), Heber Clement (Backend Manufacturing), Carl Blake (Marketing) and Dan Hauck (Worldwide Sales). The firm has 75 employees, including a core staff of researchers from Mishra's lab at UCSB.

Existing silicon-based power converters can be up to 90% efficient, so 10% of energy is lost (e.g. as waste heat). Transphorm says that the hundreds of terawatts of lost energy across the electrical grid is equivalent to 318 coal-fired power plants and costs the US economy \$40bn annually. The firm reckons its power modules can eliminate up to 90% of these losses (boosting efficiency into the upper 90% range), saving energy across the grid. Also, Transphorm claims that its custom-designed power modules are easy to embed in virtually any electrical system, from consumer electronics products to computer servers, HVAC equipment, industrial motor drives, and inverters for solar panels and electric vehicles. It aims to sell modules to power equipment makers.

"Why put up with needless energy waste in every electrical system and device, when we can quickly and cost-effectively design products that are inherently energy efficient?," says Mishra. "Transphorm's next-generation power modules cut waste, increase efficiency, reduce system size and simplify overall product design," he claims.

"It was imperative for our firm to get behind Transphorm because it is the first company with a viable, commercial-scale solution to energy losses associated with high-voltage power conversion," reckons Kleiner Perkins Caufield & Byers

partner Randy Komisar. In contrast, most firms that use GaN are working on low-voltage conversion, comments Mishra.

"Since we deliver a complete solution from the original materials through to the final modules, we are in a position to rapidly innovate and deliver product in quick response to demand," states Parikh. "We look forward to helping our partners open a new era in ultra-efficient and compact power conversion," he adds.

Transphorm is already supplying test converter modules to customers in the areas of computer servers, photovoltaic inverters, and motor drives for building systems.

"We recognize the need to innovate to uncover new opportunities for optimal energy efficiency," says Toshihiro Sawa, managing director, Technology & Development Division of Japan-based motion control firm Yaskawa Electric Corp. "The time is right to develop power conversion technologies that can cut power waste and reduce excess heat, and Transphorm provides a viable solution," he adds.

"It is imperative that power conversion efficiency be increased both to cut unnecessary losses and to save energy, but also to reduce waste heat which has negative impact on volume, weight, cost and reliability," adds Dr Leo Casey, chief technology officer of Satcon Corp.

600V GaN power diode demos 99%-efficient DC-DC boost converter

At the Applied Power Electronics Conference & Exposition (APEC) in Fort Worth, TX (6-10 March), Transphorm announced availability of samples of its first product: power diodes based on its patented EZ-GaN technology.

"For customers looking for a low-risk roadmap to the next generation of power conversion technology,

Transphorm provides a cost-effective, customizable and easy-to-use solution ready for commercial scale," says CEO Umesh Mishra.

To demonstrate its performance, at APEC the firm showcased a Total GaN-based, dc-to-dc Boost Converter running at over 99% efficiency at 400V.

The firm's GaN-based power con-

verters are designed with 600V transistors and low-loss power diodes, making them the industry's fastest and most efficient conversion technology, it is claimed. They come in industry-standard packages and are designed for optimum high-frequency switching, lowest loss and highest efficiency.

www.transphormusa.com



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5N Plus to acquire Belgian specialty metal firm MCP

Acquisition to expand range and global production and distribution

5N Plus Inc of Montreal, Canada has entered into a definitive agreement to acquire Belgium-based MCP Group SA for €105.8m (CDN\$141.8m) in cash, plus a promissory note to the vendors of €61.9m (CDN\$82.9m) and about 11.4 million common shares.

Formed in September 2007 from the merger of specialty metal firms MCP Aramayo Ltd and Sidech SA, the private company MCP is majority-owned by co-CEOs Laurent Raskin and Frank Fache and Belgian industrial group Floridienne SA. It is currently the world's leading producer and distributor of specialty metals and their chemicals (including bismuth, indium, gallium, selenium and tellurium), which are used in a variety of products, mainly related to electronic applications. The firm has about 350 staff in eight production sites and 14 commercial offices across Europe, Asia and the USA.

5N Plus was founded in 2000 after developing electronic materials within Canadian natural resource company Noranda Inc (one of the world's largest mining firms). It focuses on specialty high-purity metals such as tellurium, cadmium, selenium, germanium, indium and antimony and also produces related II-VI semiconducting compounds such as cadmium telluride (CdTe), cadmium sulphide (CdS) and indium antimonide (InSb) as precursors for the growth of crystals for electronic applications, including solar photovoltaic, radiation detector and infrared markets. 5N Plus owns four material subsidiaries: 5N PV GmbH (Eisenhuttenstadt, Germany), Firebird Technologies Inc (Trail, BC, Canada), 5N Plus Corp (DeForest, WI, USA) and Sylarus Technologies LLC (St George, UT, USA). The firm is an integrated producer, with both primary and secondary refining capabilities (enabling it to control the entire manufacturing process), and also

provides recycling services to treat production residues.

"The acquisition of MCP will allow 5N Plus to significantly expand its product offering and to establish a worldwide manufacturing and distribution platform," says 5N Plus' president & CEO Jacques L'Écuyer. "This strategic transaction fits perfectly with

our vision of becoming a global leader in the production of specialty metals for the clean technology market," he adds. In particular, MCP's presence in Asia is expected to create opportunities for 5N Plus to source raw materials, reduce production costs and develop new markets.

5N Plus shares similar values and objectives to MCP, says Raskin. "We strongly believe that the combination of our two companies will yield significant synergies and bring an array of new opportunities."

The acquisition is expected to allow 5N Plus to significantly expand its offering of metals, chemicals and compounds to the clean-tech market. 5N Plus reckons that it will become the leading producer and distributor of bismuth worldwide (a market that is poised for future growth, as non-toxic bismuth is increasingly used in various alloys and compounds). Moreover, MCP's expertise in gallium, indium, selenium and tellurium is expected to further solidify and diversify 5N Plus' position in the solar materials supply chain.

The acquisition is expected to be immediately accretive to 5N Plus' earnings and free cash flow per share, before accounting for any potential synergies. Free cash flow

stemming from the acquisition should further increase 5N Plus' liquidity and flexibility to fund its future growth, the firm reckons.

During 2010, MCP generated revenue of €345m, about 40% related to bismuth products and alloys. Gross margin was about €80m and EBITDA was €35m. Following key investments in 2009–2010, MCP's €92m working capital is at an optimal level to capitalize on market opportunities, reckons 5N Plus. Furthermore, MCP's operations require limited capital investments with tangible fixed assets of about €23m and estimated annual maintenance capital expenditures of €5m.

MCP's current shareholders will become significant shareholders of 5N Plus. Also, its management will remain in place. Fache will join 5N Plus' board of directors on the close of the transaction, and Raskin is expected to also join the board at 5N Plus' next annual meeting.

5N Plus will finance the €105.8m cash cost of the transaction with a combination of cash on hand and new credit facilities of CDN\$140m committed by National Bank Financial Inc (replace 5N Plus' existing CDN\$17.5m revolving credit facility, which is currently undrawn). 5N Plus will also assume MCP's non-recourse debt financings of about €66m, most of which is used for working capital purposes. The €61.9m promissory note will be payable over a three-year period after closing. The 11.4 million shares to be issued will be subject to lock-up provisions lasting up to 18 months.

The transaction is expected to close in mid-April. It has been unanimously approved by the boards of directors of both 5N Plus and MCP and is subject to selected confirmatory due diligence, regulatory approvals and customary closing conditions.

www.mcp-group.com
www.5nplus.com

AXT's Q4/2010 revenue of \$26.9m up 51% year-on-year

Near-term softness in Taiwan LED market to hit Q1

For fourth-quarter 2010, AXT Inc of Fremont, CA, USA, which manufactures gallium arsenide, indium phosphide and germanium substrates and raw materials, has reported revenue of \$26.9m. This is below the expected \$28–29m and flat on \$26.8m in Q3 but up 51% on \$17.8m a year ago.

Total gallium arsenide (GaAs) substrate revenue was \$18.7m, down 2.6% on \$19.2m in Q3 but up 48% on \$12.6m a year ago. Indium phosphide (InP) substrate revenue was \$1.1m, up 1.5% on \$955,000 in Q3 and more than doubling from \$513,000 a year ago. Germanium (Ge) substrate revenue was \$3.4m, up 48% on \$2.3m in Q3 and up 79% on \$1.9m a year ago. Raw materials sales were \$3.5m, down 20% on \$4.4m in Q3 but up 25% on \$2.8m a year ago.

Gross margin has risen from

33.9% a year ago and 39.3% in Q3 to 39.8%. Net income was \$4.9m, down from \$5.6m in Q3 but up from \$2.8m a year ago.

"Revenue for the year increased by more than 72% from 2009 [from \$55.4m to \$95.5m]; our gross margins performance improved by more than 1300 basis points and our net income grew by \$20.5m [from a loss of \$1.9m to a profit of \$18.6m]," says CEO Morris Young. "These results reflect

healthy growth in our markets as well as continued gains, outstanding product quality and tremendous operational execution across our entire organization," he adds.

"While we are experiencing some near-term softness in the Taiwanese LED market and expect seasonality in our first-quarter semi-insulating gallium arsenide revenues, we believe that we will see sequential growth in our business beginning again in the second quarter, driven by positive secular trends in the demand for wireless devices, LEDs and photovoltaics, as well as gains in our positioning within various customers in our market," says Young.

For first-quarter 2011, AXT expects revenue of \$24–25m (down 9% sequentially, but up 28% year-on-year).

www.axt.com

We will see sequential growth in our business beginning again in the second quarter, driven by positive secular trends in the demand for wireless devices, LEDs and photovoltaics

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IN BRIEF

ULED orders Veeco reactors for LED manufacturing ramp

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA says that China-based United LED Shan Dong Corp (ULED), a joint venture formed in March 2010 between Taiwanese silicon wafer foundry United Microelectronics Corp (UMC) and Epistar (Taiwan's biggest LED chip maker), has placed a multi-tool order for Veeco's TurboDisc K465i gallium nitride metal-organic chemical vapor deposition (MOCVD) reactors. The systems will be installed at ULED's facility in Jining City for its high-brightness light-emitting diode (HB-LED) manufacturing ramp.

"The K465i provides the process performance and lowest cost of ownership needed to advance ULED's position as a provider of LED devices for various lighting applications," says Dr Tzu-Chi Wen, vice president, Epi factory of United LED.

"Our systems offer key advantages, including highest capital efficiency and excellent yields, which will help establish ULED as a leader in the growing China market," reckons Bill Miller Ph.D., executive VP, Compound Semiconductor and head of Veeco's MOCVD operations.

With what is reckoned to be superior uniformity and run-to-run repeatability, Veeco says that the production-proven K465i extends capital efficiency (the number of good wafers per day for each capital dollar) for high-volume LED makers. The K465i provides ease-of-tuning for fast process optimization on wafer sizes up to 8 inches, as well as fast tool recovery time after maintenance, the firm adds.

www.unitedled.cn
www.veeco.com

Superabrasives supplier Engis to double size of HQ

New Engis Technology Center adds Wafer Process Lab for compound semiconductors

Engis Corp, which provides superabrasive finishing products and fully configured, custom-developed manufacturing systems for lapping, honing, polishing and grinding, plans an expansion that will nearly double the size of its headquarters in Chicago suburb Wheeling, IL, expanding its manufacturing and warehouse facilities and making space for the new Engis Technology Center.

Engis supplies 'HYPREZ' high-precision micronized diamond, cubic boron nitride (CBN) powders, slurries, compounds, grinding wheels, machine tools and accessories. The privately held firm says that its 'systems approach' combines product and process knowledge to develop complete solutions to improve part quality, lower cost and reduce cycle times. Engis employs about 140 staff in Illinois and 200 worldwide, including five locations in Asia, one in Europe and one in Canada.

The 54,000ft², multi-million-dollar expansion will more than double total space to 121,500ft² and enable the firm to consolidate all engineering, process development labs, manufacturing, warehousing and administrative offices into a single facility. In conjunction, Engis will add new manufacturing, process development and testing and measurement equipment. Construction will start in April and be complete by fall 2011.

"New automated manufacturing equipment will enable us to increase our ability to support global markets, while the Engis Technology Center will enhance our capability to develop turnkey manufacturing solutions," says president Stephen Griffin. "It also demonstrates our commitment to keep and generate future jobs in Wheeling and in the USA," he adds.



Architectural rendering of Engis expansion.

The cornerstone of the expansion will be the new Engis Technology Center, where the firm will work with customers to finish components to nanometer tolerances and achieve mirror surfaces. The center will house five labs:

- The Wafer Process Lab (WPL), which serves the advanced material and compound semiconductor markets.
- The Process Development Lab (PDL), which provides assistance for general industrial lapping and polishing inquiries;
- The Hard Disk Drive (HDD) Lab, which focuses on the data storage industry.
- The Diamond Characterization Lab (DCL), which also includes the Engis Metrology (measurement) Lab.
- The Bore Finishing Lab (BFL), which works with customers on honing and bore finishing applications in the automotive, hydraulic, medical, advanced ceramic, compressor, aerospace and defense industries.

"Consolidating all the labs in one location will enable us to concentrate our engineering resources and enhance our customer service activities," says Griffin.

Engis currently leases space for some of its process labs and other activities at a nearby location. All of these operations will be incorporated into the new expansion.

www.Engis.com

HKUST to use Aixtron CCS reactor for III/V-on-Si research

Aixtron of Herzogenrath, Germany says that in third-quarter 2010 the Hong Kong University of Science and Technology (HKUST) ordered its Close Coupled Showerhead MOCVD platform, a CRIUS CCS reactor in 6x2" (3x3" or 1x6") configuration.

Following delivery in Q1/2011 and commissioning by Aixtron's local support team in a dedicated facility in HKUST's Institute of Advanced Study Lab and Department of Electronic and Computer Engineering, the system will be used to grow As/P/Sb-based materials on silicon substrates for electronics and photonics research applications.

"We have had a close relationship with Aixtron for many years. This has helped foster a great understanding of the company's technology expertise, processes and procedures, making it a very easy decision to select one of their reactors for our new projects," comments chair professor Kei May Lau. "The new reactor will be a vital resource for our further development of III/V growth on silicon wafers research. Its high-temperature (>1000°C) capability will be very important for this exploratory work," she adds.

"Kei May Lau of HKUST has always been at the forefront of III/V compound semiconductor device research and MOCVD technology," says Dr Christian Geng, Aixtron's VP

of Greater China. "Aixtron and its customers will be able to be a small part of this innovative project in the frame of a Demo Laboratory Agreement," he adds. "Lau has been using various Aixtron MOCVD systems, such as single-wafer and multi-wafer reactors for arsenides, phosphides and nitrides. This however will be the first time that Aixtron delivers a Close Coupled Showerhead system," Geng continues. "The strong reputation that this reactor has earned over recent years is once again proving its capability and versatility as a perfect match to the needs of heteroepitaxial research."

Lau joined the university in 2000 and established the Photonics Technology Center for R&D, with a special emphasis on compound semiconductor materials and devices. Lau is an IEEE Fellow and a Croucher Senior Research Fellow. At IEDM 2008, her group reported metamorphic Al_{0.50}In_{0.50}As/Ga_{0.47}In_{0.53}As 1.0µm-gate-length high-electron-mobility transistors (mHEMTs) grown in an Aixtron 200/4 system on silicon substrates with unity current gain cut-off frequency (f_T) and maximum oscillation frequency (f_{max}) of 37GHz and 55GHz, respectively. High-speed InGaAs photodetectors grown on silicon are also being developed.

www.ece.ust.hk/~weekmlau
www.aixtron.com

Finisar buys Aixtron reactor for VCSELs

Aixtron has received a new order for an AIX 2800G4-R MOCVD reactor from Finisar Corp of Sunnyvale, CA, USA.

After delivery in second-quarter 2011, the new system will be used for the production of vertical-cavity surface-emitting laser (VCSEL) devices. The local Aixtron support team will commission the reactor by working with Finisar engineers in their facility at Allen, TX.

"Finisar is seeing great demand for its VCSEL products," comments Curt Barratt, general manager of Finisar Allen. "We have just completed an exhaustive search for the equipment set that will not only fulfill our current product demand, but also manufacture our next-generation products," he adds. "The AIX 2800 G4-R system meets these requirements."

www.finisar.com

IN BRIEF

Samsung selects Veeco MOCVD tool for GaN-on-silicon power electronics research

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA says that Korea's Samsung Advanced Institute of Technology (SAIT) has selected Veeco's TurboDisc K465i gallium nitride (GaN) metal-organic chemical vapor deposition (MOCVD) system for GaN-on-silicon research for power electronics.

"Being selected as a research partner for GaN-on-Si by SAIT is an important strategic R&D win for Veeco," says William J. Miller Ph.D., executive VP of Veeco's Compound Semiconductor business. "We look forward to continuing to work with SAIT to commercialize this technology for high-volume manufacturing of GaN-based power electronic devices," he adds.

"The GaN power electronics market is expected to grow significantly in coming years, with potential applications in energy-efficient power conversion devices," according to Jim Jenson, VP of marketing for Veeco's Compound Semiconductor business.

The K465i incorporates Veeco's Uniform FlowFlange technology for what is said to be superior uniformity and excellent run-to-run repeatability. Low-maintenance TurboDisc technology enables the highest system availability, excellent particle performance and high throughput, it adds. The production-proven K465i also provides ease-of-tuning for fast process optimization on wafer sizes up to 8 inches and fast tool recovery time after maintenance, the firm adds.

www.sait.samsung.com
www.veeco.com

Aixtron's revenue grows more than 2.5-fold in 2010

R&D spending rises 40%, while manufacturing output expanded 50%

Deposition equipment maker Aixtron SE of Aachen-Herzogenrath, Germany says that in 2010 it delivered, for the third year in succession, the best operational performance in its history, with revenue of €783.8m (more than \$1bn) and EBIT (earnings before interest and taxes) margin 35%.

The full-year revenue of €783.8m was higher than the previously guided €750m (and the original guidance of €600m), and over 2.5 times more than 2009's €302.9m (up 159%). By application, 93% of revenue was for LEDs and just 2% for telecoms/datacoms, 1% for silicon, and 4% for displays/other. By geographical region, 91% came from Asia (up from 82% in 2009), 5% from the USA (up from 4%) and just 4% from Europe (down from 14%). Notably, China grew significantly to 25% of total revenue, becoming the second largest region for the first time (after Taiwan).

In particular, fourth-quarter 2010 revenue was €224.7m, up 91% on €117.9m a year ago and up 5.6% on €212.7m in Q3/2010 (and a seventh consecutive quarter of growth).

"What we saw in 2010, was not only a continuation of the market-driven demand for LEDs for TV backlighting, but also an increased effect of government-sponsored demand and some early encouraging investments by customers beginning to position themselves for the emerging LED lighting market," comments president & CEO Paul Hyland.

"The market we serve today has clearly been transformed from one small technical niche market into two significantly larger and sustainable mass markets; namely consumer electronics and utility lighting. In a very short period of time, the industry has found that essential 'critical mass,'" he adds.

Gross margin was 52% in Q4/2010, level with Q3's 52% and up on 47% a year ago. This took

full-year gross margin from 44% in 2009 to 53% for 2010.

The operating result (EBIT) was €86m in Q4/2010, up on €82.6m in Q3 and €33.7m a year ago. Full-year EBIT is up from €62.7m in 2009 to €275.5m in 2010, corresponding to EBIT margin rising from 21% in 2009 to 35% in 2010 (up on original guidance of just 25%).

Net income was €61.6m in Q4/2010, up on €56.8m in Q3 and €24.4m a year ago. Full-year net income has risen from 2009's €44.8m to €192.5m. Free cash flow was €95.9m in 2010 (up from €75.8m in 2009), boosting cash & cash equivalents plus cash deposits from €301.2m to €384.7m.

Equipment order intake rose significantly in 2010, doubling from €370.1m in 2009 to €748.3m for 2010. It grew steadily quarter-by-quarter to €204m in Q4, up slightly on €200.4m in Q3 and up 25% on €163.3m a year ago. Of Q4's orders, latest-generation systems comprised 55% (versus just 35% of Q4 revenue).

Although up 35% on €203.8m a year ago, total equipment order backlog has fallen slightly from €278.7m at the end of Q3/2010 to €274.8m at the end of 2010. However, this has since been revalued (at US\$1.35/€, rather than the US\$1.50/€ set at the beginning of the year) to €302.3m (all shippable in 2011). Management believes that, with this foundation, in 2011 Aixtron can deliver revenue of €800-900m and an EBIT margin of about 35%.

"The foundation of our success in the past has been our commitment to innovative R&D and focused market-led engineering, and these are exactly the same qualities that are required to compete in the bigger and more dynamic markets we will be serving in the future," notes Hyland. "The substantial R&D investments we are making today [€46.1m in 2010, up 40% from €32.9m in 2009 and €3.5m in 1998] are a reflection of our commitment to deliver increasingly customer-focused solutions for that future."

In October, Aixtron completed and moved into the first building phase of its new R&D center in Herzogenrath (accommodating the first 250 staff out of space for 300). Phase 2 (including new application laboratories and a prototype production facility for 150 further staff) is currently being built and should be finished by early 2012. Total investment in the first two phases (totaling 16,000m²) should be €40m.

During 2010, total staffing rose from 687 to 784, while Aixtron ramped up its quarterly manufacturing output by 50%, from about 100 systems to 150 systems.

● The Executive Board and Supervisory Board intends to propose to Aixtron's Annual Shareholders' Meeting in May to pay a dividend of €0.60 per share (four times the dividend figure paid out in 2010). This would result in a dividend payout of €60.7m to shareholders and a pay-out ratio of 31.5% based on the group net income.

www.aixtron.com

Aixtron says that it has a number of stock option programs in place that grant the members of its executive board and its employees the right to purchase Aixtron shares under certain conditions.

Under the terms of the stock option plan 2007, stock options can currently be exercised. New

shares resulting from exercised options are not entitled for dividend for fiscal 2010 and will therefore be traded on the Frankfurt Stock Exchange under the separate ISIN DE000A1H30A0 until and including the day of the annual general meeting (AGM) 2011 on 19 May.

Beiji Haotian upgrades power LED epi capacity with G4 and G5 systems

Tsinghua Uni technology transfer part of high-power HB-LED project

Deposition equipment maker Aixtron SE of Herzogenrath, Germany says that in first-half 2011 it delivered a total of five MOCVD reactors (ordered in second-quarter 2010) — comprising two AIX 2800G4 HT systems in 42x2"-wafer configuration and three AIX G5 HT systems in 56x2"-wafer configuration — to new customer Beiji Haotian Technology Co Ltd of Jiangsu province, China.

The systems will be used for the production of power chip LEDs at a production plant in YiXing city following their commissioning by the local Aixtron support team.

"The close cooperation with Aixtron, who have been working up our capabilities in epitaxy technology, has resulted in a new large-scale investment for our LED epi business," says JiaYe Yang, VP of Beiji Haotian Technology. "This plan also involves further cooperation with Tsinghua University, who will make a technical transfer from an Aixtron Planetary Reactor platform to our new systems," he adds. "Due to the

proven compatibility of these systems and the excellence of the Aixtron process transfer and service, we see this will be a straightforward procedure."

Tsinghua University is involved in a new LED patent technology transfer and long-term cooperation agreement ('Arctic Haotian high-power HB LED Chip Project'), which will take place in the Jiangsu Yixing Economic Development Zone and provide long-term production, R&D and training support.

A major project investment of about 473m yuan (about €51.5m) for 1W high-power chips is planned in the period up to May. Phase II of the LED production project should be completed by the end of 2012 with an additional investment of 500m yuan (about €54.5m). This will include ten new MOCVD units supporting production lines with a total of 567,000 yuan (about €62,000) and a total investment for 1W high-power chips of nearly 1.42bn yuan (about €155m).

www.aixtron.com

LayTec GmbH converts into AG

LayTec of Berlin, Germany (which provides in-situ optical metrology systems for thin-film processes) has announced its conversion from LayTec GmbH (a limited liability company) into LayTec AG (Aktiengesellschaft, joint stock corporation) with entry into the commercial register of Berlin/Charlottenburg.

LayTec will continue being a privately owned company. The conversion does not impose any changes on the shareholder structure, which has been stable for many years, says the firm. The first advisory board was elected at a shareholder meeting last October.

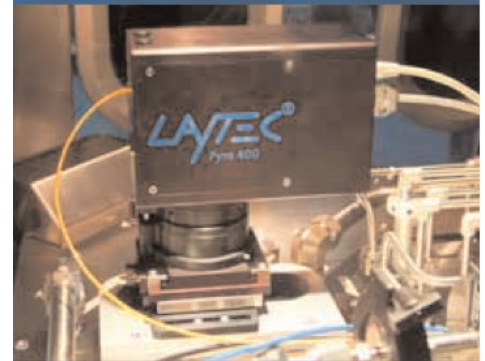
Its chairman, Dr Markus Weyers (in Berlin), is working with Dr Egbert Woelk (in Boston) and Götz Fischbeck (in Frankfurt/Main) to support and advise LayTec's CEO & president Dr Thomas Zettler and his board of managers.

LayTec belongs to the 50 fastest-growing technology companies in Germany (according to the 'Deloitte Fast 50' ranking for the firm's growth in 2005–2009). LayTec reckons that conversion into an 'Aktiengesellschaft' will give it a wider range of options for further growth and for sharing its success with its employees.

www.laytec.de

Real GaN surface temperature

LayTec's groundbreaking new product Pyro 400 finally makes real wafer surface temperature measurements of GaN possible. It offers deep insight into surface temperature changes caused by carrier gas, rotation speed and reactor pressure variations as well as wafer bowing effects. This quantum leap in GaN temperature measurement provides immediate access to emission wavelength variations and thereby provides huge benefit for yield enhancement in future GaN-based LED production.



The Pyro 400 in-situ system can be used in combination with the EpiCurve® TT for simultaneous bowing control.

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info@laytec.de · www.laytec.de

IN BRIEF

Ubilux ramps capacity with first CRIUS II systems

Deposition equipment maker Aixtron SE of Herzogenrath, Germany says that in fourth-quarter 2010 it received an order from existing customer Ubilux of Southern Taiwan Science Park, Tainan County for two CRIUS II MOCVD reactors in 55x2"-wafer configuration, to expand production capacity for GaN-based high-brightness LEDs. The systems will be delivered in first-quarter 2011 and commissioned by the local Aixtron support team.

"Ubilux already has several CRIUS systems for GaN applications as well as a G3 system for GaAsInP application," says Ubilux's president Dr Henry Chen. "We are impressed with these systems' good performance," he adds. "Over the years, we have built up an excellent relationship with the company so we were very interested in acquiring the newest-generation systems for our further expansion plans... This is our first CRIUS II system purchase order," continues Chen. "Once we had finalized our expansion plans, we approached Aixtron's local representatives."

"A notable feature of the Taiwan MOCVD community is the high number of the most advanced technology Aixtron systems that are being used for the mass production of UHB-LEDs," says Aixtron Taiwan's general manager Christian Geng. "Our support and field service is available 24 hours a day, 365 days a year to guarantee customers receive the support they need by phone or on-site," he notes. "Last year the Aixtron Taiwanese support team handled over 1800 installations, upgrades, and customer support requests."

www.ubilux.com.tw
www.aixtron.com

Tekcore installs first of seven Dow VaporStation tools

Dow Electronic Materials of Philadelphia, PA, USA (a business unit of Dow Advanced Materials) says that Taiwan-based LED wafer and chip manufacturer Tekcore Co Ltd has recently installed two VaporStation Central Delivery Systems in its LED manufacturing area.

Tekcore is now running the first tool in production to deliver trimethylgallium (TMG) to multiple epitaxial growth reactors. The second delivery system, Dow's new patent-pending, third generation of the VaporStation Central Delivery System, has also been installed at Tekcore and ramp up for production has started. The systems are the first of seven Tekcore has ordered from Dow Electronic Materials.

The VaporStation Central Delivery System is designed to deliver TMG and other metal-organic precursors to multiple chemical vapor deposition (CVD) reactors from a central supply source cabinet using a high-purity carrier gas. Dow says that this delivery technology enables users to run several reactors with no downtime for precursor cylinder

change, providing significant opportunity for increased reactor throughput and lower cost of ownership. Also, as a result of less material handling, the tool provides greater safety in production areas.

"We are very pleased with the successful integration of the VaporStation Central Delivery System into Tekcore's production line," says Joe Reiser, global business director, Metalorganic Technologies, for Dow Electronic Materials. "They quickly began to benefit from the delivery system's throughput, economy and safety advantages." Manufacturers are seeking ways to eliminate costly inefficiencies, such as calibration runs and cylinder change-outs associated with on-board cylinders, he adds.

High-quality materials and precise delivery of metalorganic precursors are essential to fabricating reliable LEDs, says Dow Electronic Materials, which claims to be the leading supplier of precursors (including TMG) to the LED market.

www.dow.com
www.tekcore.com.tw

Praxair Electronics president adds role of president Praxair Asia

Anne Roby, president of Praxair Electronics (a division of Praxair Inc of Danbury, CT, USA that supplies gases for III-V epi growth), has been named president of Praxair Asia, responsible for the growth and profitability of Praxair's industrial gases business in China, India, South Korea, and Thailand. She will retain responsibility for the global electronics business (with operations in Asia, Europe and North America).

"Anne's extensive knowledge of Praxair's business and capabilities, along with her proven leadership abilities, puts her in a strong position to continue to deepen Praxair's presence in the important Asian

economy," says executive VP Ricardo Malfitano.

Roby joined Praxair in 1991 as a development associate in its R&D organization. She became global marketing manager for chemicals and refining in 1996 and a pipeline sales & business manager in the North American Industrial Gases business unit in 1999. She was made area director in 2004.

In 2006, she became VP of the US South Region, responsible for business in a seven-state area. She was made VP, global sales, for Praxair Inc in 2009, and then president of Praxair Electronics in 2010.

www.praxair.com

Johnson Matthey reports rapid growth of hydrogen purifier sales to LED makers in 2010

Johnson Matthey of West Chester, PA, USA, which designs, manufactures and distributes hydrogen purifiers, says that sales increased dramatically for its PureGuard hydrogen purifiers in 2010 as it shipped its purifiers to new and expanding fabs for semiconductor applications including metal-organic chemical vapor deposition (MOCVD) processes for LED production, crystal growth and photovoltaic (PV) deposition processes. In particular, the increase was due largely to the continuing rapid growth of LED production in Taiwan and China.

In China for example, Johnson Matthey has supplied purifiers to two major high-tech manufacturers. One is focusing on the development and large-scale production of ultra-high-brightness red, orange and yellow LED epitaxy and chips, light communication components and other optoelectronic devices, says Stuart Bestrom, sales manager for Johnson Matthey's Gas Purification Technology (GPT) group. The other large Chinese customer — which designs, makes and distributes full-color ultra-high-brightness LEDs, epitaxial wafers, photo-diode detectors and compound solar cells (with an annual throughput of 550,000 epiwafers and 16bn LEDs) — purchased several Model PSH-60 purifiers capable of hydrogen flows of 60Nm³/hr.

Johnson Matthey's PSH Series bulk hydrogen purifiers are capable of providing 99.999999%-pure hydrogen for wafer fabrication. The HP Series purifier product line is the most popular, since this technology provides the purest hydrogen.

Johnson Matthey is seeing similar success in Taiwan, Bestrom notes. Among the major customers that have purchased several Model PSH-60 purifiers is a leading maker of pure-play, high-power InGaN LED wafers and chips (and the only one in Taiwan offering a full spectrum of

products including high-power InGaN blue, green and near-UV LEDs). Another leading Asian manufacturer is using the firm's purifiers to supply ultrapure hydrogen (having recently added 34 new high-throughput MOCVD tools).

China is strengthening its position as a major global manufacturer of LEDs, according to business-to-business media firm Global Sources. In recent months several leading international suppliers have invested in the construction of factories in the Pearl, Yangtze and Minjiang River delta regions, Bohai Rim Economic Region, and even in some parts of Middle Western China.

With global demand for LEDs outpacing yield, manufacturers are looking to expand production capacity to curtail a looming deficit in supply, says Global Sources. The growing popularity of LED-backlit LCD TVs is expected to exacerbate the shortage, as each LCD panel for TVs generally requires 300–500 LEDs with a uniform level of brightness, compared with only about 50 LEDs required for laptops.

"China will become important to the global LED industry this year," says Zheng Haowen, director of the National High-Tech Enterprise Development LED Professional Committee. "The total foreign investment for the sector is pro-

jected to exceed 60bn Yuan (\$8.8bn), a phenomenal increase from about 10bn Yuan (\$1.5bn) in 2009," he adds.

Bestrom says that in 2010, China reportedly added more than 1200 MOCVD systems, reflecting the "extraordinary prosperity" of the country's LED industry. The main motives encouraging such LED growth are the subsidy policies of the Chinese government and the huge prospects for the LED market, he continues.

In Taiwan, total LED production value reached \$5.43bn last year according to the country's Photonics Industry & Technology Development Association (PIDA). PIDA adds that, with the continued expansion of the LED application market, the annual growth rate is predicted to be 40% this year, then 40% in 2012 (reaching \$11.3bn).

Last year, reports PIDA, Taiwan was the number-one-ranked country in the world in terms of the production output of LED wafers and chips, with sales of just under \$2bn. Indium gallium nitride (InGaN) LEDs comprise 52% of the production value; the market for packaged LEDs was slightly less than \$3bn. The LED lighting segment in Taiwan is expected to grow rapidly in the next two years.

According to Bestrom, Johnson Matthey's palladium membrane technology is preferred by PV and semiconductor fabs for use with the compressed hydrogen supply that is common in Asia and particularly China. "Compressed gas source contains higher levels of impurities and varying quality, and our palladium membrane technology offers the best capability to remove all oxygen and carbon impurities to parts-per-billion levels, with no effect from input impurities," he claims. "These impurities must be consistently removed to assure the brightest LEDs."

www.pureguard.net

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IN BRIEF

SPTS promotes managing director of Single Wafer Division to chief operating officer

SPP Process Technology Systems Ltd (SPTS) of Newport, Wales, UK, the plasma etch, deposition and thermal processing equipment subsidiary of Sumitomo Precision Products Co Ltd (SPP), has promoted Kevin Crofton to the newly created role of chief operating officer (COO).

Crofton was serving as executive VP in charge of global customer operations and as managing director of SPTS' Single Wafer Division before his promotion. He will continue to report to president & CEO William Johnson and will provide operational direction to facilitate the firm's continued expansion.



"Kevin has been instrumental in the formation and subsequent rapid growth of SPTS, especially in the expansion of our global sales and service network," says Johnson. "In the past 16 months, he has steered our global field operations to much success, both in gaining new customers and increasing the number of technology applications," he adds. "In his new role, Kevin will continue to lead our field operations and the UK Single Wafer Division to further growth, while in addition, providing operational direction to the Thermal Products Division in San Jose, California."

Crofton has a bachelor's degree in aerospace engineering from Virginia Tech, and a master's degree in international business from American University. He is an 18 year veteran of the semiconductor equipment industry.

www.spp-pts.com

Oxford Instruments Optoelectronics Laboratory opened at ITRI

The official ceremony to celebrate the opening of the Oxford Instruments Optoelectronics Laboratory at the Industrial Technology Research Institute (ITRI) in Hsinchu, Taiwan has taken place, attended by dignitaries from both organizations and key customers of UK-based etch, deposition and growth system maker Oxford Instruments.

ITRI's president Dr Jyuo-Min Shyu and Oxford Instruments' chief executive Jonathan Flint opened the laboratory, and also in attendance were David Campbell, director, British Trade and Cultural Office, Taiwan, and Yung-miao Wang, a senior specialist in the Department of Industrial Technology (DoIT) of the Ministry of Economic Affairs (MOEA).

The opening follows the signing in early February of a research-based collaboration agreement, based on Oxford Instruments providing a high-brightness light-emitting diode (HB-LED)-related process research center staffed by the firm's process engineers at ITRI, benefitting both ITRI and Oxford Instruments' extensive Far Eastern customer base.

Oxford Instruments said at that time that it would be installing several more systems in ITRI's cleanroom, and that its process engineers would have the use of this and selected other equipment at the institute in order to provide process demonstrations and to support customers in the Far East in the performance of their tools. Oxford Instruments also said that this would in effect expand its research capabilities so that it can provide its process offering more effectively to customers in Asia. Oxford Instruments already had a number of systems installed at ITRI including a PlasmaPro System100 multi-chamber cluster tool incorporating plasma-enhanced chemical vapor deposition (PECVD), reactive ion etching (RIE) and atomic layer



ITRI's Jyuo-Min Shyu and Oxford Instruments' Flint at the signing.

deposition (ALD), a PlasmaPro System100 ICP380 plasma etch tool, and a PlasmaPro System80Plus PECVD plasma deposition tool. Three further systems have been installed in the Optoelectronics Laboratory — a PlasmaPro NGP1000 PECVD system, a PlasmaPro NGP1000 Etch system, and a PlasmaPro System133 ICP380 — with additional tools following in the next phase.

"ITRI's mission is three-fold: to expedite the development of new industrial technologies, to aid the process of upgrading industrial technology techniques, and to establish future industrial technology," said Shyu at the opening. "Collaborations such as this one with Oxford Instruments allow us to achieve our goals and stimulate relationships globally with important players in the nanotechnology arena," he adds.

"We are here to celebrate a research-based collaboration that will advance Taiwan's industry through the creation of a center of expertise built around Oxford Instruments' core technologies in plasma-enhanced etch, deposition and fabrication," commented Flint. "This relationship offers the opportunity for research staff from ITRI, process engineers and customer support staff from Oxford Instruments, and our customers to work together for mutual success."

www.itri.org.tw/eng

www.oxford-instruments.com

OIPT sells systems to European LED maker Optogan

Oxford Instruments Plasma Technology (OIPT) says that, as demand for LED lighting increases, the firm is playing an increasingly important role in the manufacture of high-brightness LEDs (HB-LEDs). In particular, LED maker Optogan Group of Landshut, Germany has placed a multi-system order for Oxford Instruments' etch and deposition systems, including PlasmaPro System133 ICP and PlasmaPro 800Plus RIE etch systems plus a PlasmaPro 800Plus deposition system.

The PlasmaPro System133 process tool offers up to 27 x 2" batch etch capability for gallium nitride (GaN)-on-sapphire wafers, while the PlasmaPro 800Plus tools present a flexible solution for plasma etching and deposition processes on large batches of up to 43 x 2" wafers, in a compact footprint, open-loading system.

Founded in Helsinki, Finland in 2004 by Russian entrepreneurs and

scientists from Ioffe Institute in St Petersburg, Optogan is a vertically integrated developer and manufacturer of HB-LEDs for applications including solid-state lighting. As well as having an R&D facility in Helsinki, since founding Optogan GmbH in Germany in 2005 the firm has established epitaxy and chip R&D

plus a pilot line in Dortmund and, last year, its Fab1 chip fabrication plant in Landshut. Also, after founding CJSC Optogan in Russia in 2009, last May it acquired a facility in St Petersburg, where it has established LED component and luminaire production lines. The firm has ordered the

Optogan has successfully operated one of our systems for several years, and has now chosen further Oxford Instruments' production systems

OIPT systems for installation at its high-volume production manufacturing line in Landshut.

"Optogan has successfully operated one of our systems for several years, and has now chosen further Oxford Instruments' production systems for their large-batch, high-yield and high-speed capabilities," says OIPT's sales & customer support director Mark Vosloo. "We offer customers the advanced technology systems and processes, supported by expert engineers for installation and after care the industry demands," he adds.

"We have been working with Oxford Instruments' systems successfully for several years," comments Hans-Peter Ehweiner, managing director of Optogan GmbH. "High throughput, repeatability, and excellent local customer support are the key factors to ensuring our strong growth of LED chip manufacturing in Germany."

www.optogan.com

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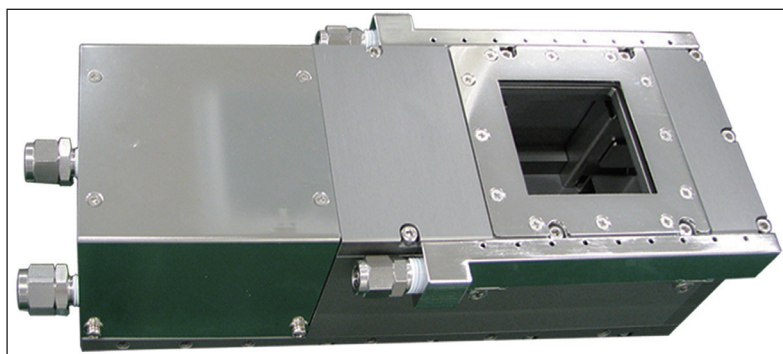
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USHIO America launches VUV ashing system for nano-imprint lithography equipment

USHIO America Inc of Cypress, CA, USA (a subsidiary of USHIO Inc of Tokyo, Japan that provides specialty and general-illumination lighting solutions) plans to start selling the nano-imprint VUV (vacuum ultraviolet) ashing system 'CHIPs' (Compact HiPower System) in the USA in March. Incorporated into nano-imprint lithography (NIL) equipment for fabricating circuit patterns of devices including LEDs, MEMS, functional films and biochips, CHIPs allows non-contact and damage-free cleaning, surface improvement, and ashing of templates and workpieces.

NIL technology transfers a circuit pattern by directly imprinting a template (or mold) with the circuit pattern onto a workpiece (a resist-coated silicon, sapphire, or film substrate). It has the advantage of being a low-cost process (allowing large-area pattern transfer) and being suitable for mass-production. NIL has already been put into practical use for fabricating circuit patterns with line-widths on the micron (μm) scale. Via further R&D, NIL has evolved to establish a finer-pattern process technology on the nanometer (nm) scale.

Ushio says that, due to putting a workpiece into contact with a template, the NIL process currently



USHIO's CHIPs nano-imprint VUV ashing system.

faces the following challenges, which are becoming obstacles for fabricating finer patterns as well as for enhancing productivity:

1. contamination of templates with resist residue;
2. increase in resist fill time and fill failures;
3. deterioration of release property between a template and a workpiece.

Conventional wet- or dry-cleaning equipment needs to be separately installed to clean the templates used for a certain number of process cycles by removing them from the NIL equipment. This causes downtime, reducing productivity. Also, wet-cleaning equipment has some disadvantages: it has insufficient cleaning capability, causes the risk of generating chemical residue, and requires additional

processes (such as drying and waste disposal). Meanwhile dry-cleaning equipment using a plasma has disadvantages in that can cause

damage to the workpiece and requires additional components (such as a vacuum chamber).

To meet these challenges, USHIO has developed the CHIPs nano-imprint VUV ashing system by applying and optimizing its lighting-edge technologies to NIL in order to achieve non-contact and damage-free high cleaning power using VUV light. In addition, CHIPs can be incorporated into the NIL equipment to allow a reduction in NIL equipment downtime as well as automation of the NIL process, thus enhancing productivity and yield and lowering the NIL process' cost of ownership (CoO).

USHIO exhibited and participated in the SPIE Advanced Lithography 2011 conference in San Jose, CA, USA on 27 February to 3 March.

www.ushio.com

Palomar expands on high-volume high-brightness LED assembly services

Microelectronics and optoelectronic packaging system maker Palomar Technologies Inc of Carlsbad, CA, USA (a former subsidiary of Hughes Aircraft) says that, to meet increasing customer demand, additional cleanroom space has recently been added in the laboratory of its Precision Microelectronics Assembly Services contract assembly division, increasing production capacity by 50%.

Assembly Services provides prototyping, test, measurement and production for high-accuracy and complex wire and die-attach applications, with expertise including development and production for applications such as HB-LEDs, RF power modules, military hybrids and laser diode packages.

"Assembly Services enables organizations around the globe to achieve balance between speed

and reliability in precision assembly of high-volume HB-LED packaging without investing in capital equipment," says Assembly Services general manager Donald Beck.

Worldwide account manager Steve Buerki highlighted Palomar's expanded HB-LED assembly services at the Strategies in Light conference in Santa Clara, CA (22-24 February).

www.palomartechnologies.com

Plasma-Therm takes majority stake in Advanced Vacuum Etch and deposition tool maker expands product lines and markets

Plasma process equipment maker Plasma-Therm LLC has secured majority shareholder status of vacuum and thin-film equipment provider Advanced Vacuum AB of Lomma, Sweden. Both operations have partnered to create a strategic alliance with complementary etch and deposition systems that support the needs of R&D through production environments.

Established in 1993, Advanced Vacuum provides services and products for the vacuum and thin-film technology industries. Services include vacuum and electronics control systems, and products include open-load plasma etch and deposition systems. Advanced Vacuum is also an OEM equipment supplier for northern Europe through representation of Edwards Vacuum, Advanced Energy and Entegris.

Plasma-Therm systems support specialty markets including solid-state lighting, thin-film head, MEMS, photomask and compound semiconductor applications. The firm has sales, service and spares locations throughout North America, Europe and Asia-Pacific.

Plasma-Therm says the mutually beneficial partnership will strengthen their respective product offerings and expand an established sales and service network. With additional support and funding through Plasma-Therm, Advanced Vacuum will be able to dedicate additional resources to product development.

"Having a world-class partner who can provide financial support, technology and a solid service infrastructure will allow us to increase our product portfolio and grow our market share," says Advanced Vacuum's CEO Thomas Engstedt.

"The two companies, each a leading supplier for etch and deposition systems, will extend their market reach in the areas of dedicated R&D systems, failure analysis and non-clustered platforms," reckons Plasma-Therm's CEO Abdul Lateef. "Advanced Vacuum brings an outstanding reputation for providing high performance at low cost and will complement Plasma-Therm's value-driven product portfolio of systems intended for production," he comments. "With this transaction we anticipate expansion into applications that will leverage Advanced Vacuum's capabilities for custom vacuum equipment design and fabrication," he adds. "The large combined installed system base will benefit from their expertise in control system upgrades."

www.advanced-vacuum.se

www.plasmatherm.com



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Kyma produces record 300mm AlN-on-Si template Tool to be released for full production; AlN-on-sapphire also planned

Kyma Technologies Inc of Raleigh, NC, USA, which provides crystalline gallium nitride (GaN) and aluminum nitride (AlN) materials and related products and services, has commissioned its new high-volume aluminum nitride template manufacturing tool by producing what is said to be the world's first 300mm (12-inch) diameter AlN-on-silicon template that is suitable for high-quality GaN growth.

While other large-area AlN processes have existed in the market for many years, Kyma claims that its process is the first that is capable of direct insertion into existing LED and power device production processes that grow GaN and related alloys such as indium gallium nitride (InGaN) and aluminum gallium nitride (AlGaIn).

Designed and constructed by chief engineer Dr Bob Metzger, the new AlN template tool incorporates many of the features of, as well as improvements to, Kyma's patented

and proprietary III-N Physical Vapor Deposition of NanoColumns (PVDNC) technology, which the firm has used for more than 10 years. Kyma initially used PVDNC technology for its bulk GaN development efforts, until 2006 when it began supplying AlN templates to the commercial market. Due to the system's flexible design and Kyma's long experience with PVDNC for nitride growth applications, it is also possible to run additional template substrates (such as sapphire, patterned sapphire, and silicon carbide) in the AlN process.

"Market interest in our AlN templates has grown rapidly over the last 18 months, especially in the LED sector, where significant LED improvements have been observed by customers using our PVDNC AlN templates," says chief technology officer & VP business development Dr Ed Preble. "Specific improvements cited include: improved wavelength and brightness binning,

lower defect density in the LED active region, higher device thermal conductivity, and up to 30% higher MOCVD system throughput," he adds.

"This new tool increases our capacity 10-fold for 2", 3" and 4" wafers; enables us to address the growing demand for larger 150mm and 200mm diameters; and also further raises the bar with its 300mm capability," Preble continues. "While we acknowledge that work remains to improve the deposition uniformity for 300mm sizes, we are positively thrilled with the uniformity and repeatability of the 2" through 200mm sizes and look forward to qualification of the new tool with our customers," he adds.

Kyma also plans to demonstrate large-diameter AlN templates on sapphire and to release the new AlN template tool for full production in the coming weeks.

www.kymatech.com

Kyma and Sinmat cooperate on crystal fabrication Nitride materials provider teams with CMP specialist

Kyma Technologies and Sinmat Inc, a provider of chemical mechanical planarization (CMP) technologies for wide-bandgap materials, have agreed to cooperate on advanced crystal fabrication to better serve their customers.

A primary goal is to provide a single entry point to access a variety of services that until now have been provided separately by Kyma and Sinmat. Together, the firms aim to provide one-stop shopping, from boule-grinding, slicing, and orientation-fixing, through to mechanical polishing and CMP. These services are available for a wide variety of materials ranging from silicon carbide, sapphire, gallium nitride, aluminum nitride, and silicon to emerging materials

such as diamond.

"This partnership with Sinmat realizes our final goal towards offering our customers a complete portfolio of crystal fabrication services," says Kyma's technical sales engineer Tamara Stephenson.

"Since we announced the opening of our custom crystal fabrication facility earlier this year, customer interest has been excellent, ranging from simple crystal slicing and shaping to more complex device-wafer backside processing," she adds. "Our partnership with Sinmat will allow us to go all the way to making epi-ready crystalline substrates for a range of materials."

"Sinmat's leading expertise and capabilities in advanced surface

modification chemistry and engineering is a perfect complement to Kyma's leading expertise and capabilities in crystal fabrication processing," reckons Kyma's president & CEO Keith Evans.

"By working together, our customers can leverage the strengths of both companies together with the simplicity of a simple and organized customer-supplier interface," he adds.

"This agreement provides a unique opportunity for crystal growers to transform their boules into epi-ready wafers utilizing state-of-the-art technologies from both companies," believes Sinmat's VP & chief technology officer Rajiv Singh.

www.sinmat.com

EVG adds mask aligner for HB-LEDs, boosting throughput and yield

At the Strategies in Light 2011 event in Santa Clara, CA, USA (22–24 February), EV Group (EVG) of St Florian, Austria, which makes wafer-bonding and lithography equipment for the advanced semiconductor and packaging, MEMS, silicon-on-insulator (SOI) and emerging nanotechnology markets, launched the latest addition to its portfolio of products created to optimize manufacturing of high-brightness light-emitting diodes (HB-LEDs), compound semiconductors and power electronics.

The EVG620HBL fully automated mask alignment system builds on EVG's field-proven mask aligner platform, adding a high-intensity ultraviolet (UV) light source and five cassette stations — significantly more than competitive offerings, it is claimed — to enable continuous fabrication of devices. The EVG620HBL hence delivers throughput of up to 165 six-inch wafers per hour (up to 220 wafers per hour in first print mode) with what is claimed to be the industry's highest alignment accuracy and yield.

According to market research firm Global Information Inc, the consumption of HB-LEDs will continue to grow at rapidly over the next decade, from \$10.09bn in 2010 to \$46.05bn in 2020. Key drivers will include explosive growth in solid-state lighting and general lighting applications, as well as signage, professional displays, and stationary (non-vehicle) signals. To meet this increased demand, HB-LED makers must quickly ramp up to higher production capacity, as well as optimizing their manufacturing processes to ensure the highest yields — all of which elevates their need for automated manufacturing solutions with the lowest cost of ownership, says EVG.

As with its dedicated EVG560HBL automated wafer-bonding system introduced last July, EVG developed



The new EVG620HBL mask aligner, which targets high-brightness LEDs.

the EVG620HBL aligner to address these needs. The firm notes that its bonders and mask aligners are being deployed by four of the top five major HB-LED makers. Building on this, the 620HBL was created in response to demand for a mask alignment system dedicated to meeting these devices' yield and throughput requirements.

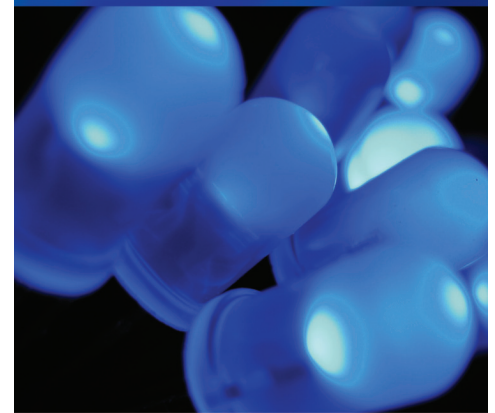
Another feature of the EVG620HBL is the availability of special recipe-controlled microscopes whose illumination spectrum is optimized to ensure the best pattern contrast with various wafer and layer materials, including substrate materials such as sapphire, silicon carbide (SiC), aluminum nitride (AlN), metal and ceramic. The new mask aligner also features high-accuracy handling and alignment of fragile or warped wafers.

"Just last month, one of the leading HB-LED manufacturers ordered an EVG560HBL bonder, and the EVG620HBL is the latest result of our ongoing efforts around enabling HB-LED manufacturers to develop more efficient, cost-effective and higher-yielding devices to meet their customers' demands," says executive technology director Paul Lindner.

www.evgroup.com

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Monocrystal triples revenue in 2010 to \$153m

Shift to larger-size sapphire wafers accelerates

For fourth-quarter 2010, Monocrystal Inc of Stavropol, Russia, which manufactures large-diameter sapphire substrates for LED and RFIC applications (as well as screen printing metallization pastes for silicon-based solar cells), has reported preliminary revenue of a record \$59.3m, up 38% on Q3 and up 241% year-on-year. The sapphire segment contributed a record \$39.3m, up 50% sequentially and up 388% on a year ago. The pastes segment contributed \$20m, up 13% sequentially and 105% on a year ago.

For full-year 2010, revenue was \$153m, more than tripling from 2009's \$50.3m. Revenue from sapphire grew 250% from \$25.4m to \$89m. Revenue from solar pastes grew 161% from \$24.5m in 2009 to \$63.9m. Gross margin grew strongly from 32.3% in 2009 to 58.6%, and net income from \$4.7m to \$54.1m.

Results far surpassed the targets set for 2010, says CEO Oleg Kachalov. "Both our core markets,

LED and solar, have gone through significant expansion in the last year, and we were able to leverage our core competencies in technology and production to drive the new strategy, add capacity and introduce innovative products to capitalize on these market opportunities," he adds.

"Increased ASPs [average selling prices] and a shift in our product mix towards selling more polished and larger-diameter products for LED were accompanied by improvements on cost reduction, running our sapphire production capacities at full steam, and fostering close relationships with our customer base," comments chief financial officer Andrey Komkov.

Although Q1/2011 has brought certain stability in pricing of sapphire products for LEDs, demand remains strong,

Although Q1/2011 has brought certain stability in pricing of sapphire products for LEDs, demand remains strong

notes Monocrystal. New LED technologies that are coming onto the market are expected to speed up developments in the entire LED chain and in the LED lighting in particular. Considering the looming possibility of more rapid and widespread adoption of LED lighting products by commercial and industrial clients, and also that there is still an untapped opportunity and strong players in backlighting, the LED market may begin its next wave of growth sooner than expected, reckons the firm.

"In addition to accelerating developments in the LED lighting space, we observe a rapid shift at the forefront of LED manufacturing towards using larger-size sapphire wafers," says Kachalov. "By providing our competence in sapphire-for-LED technology, we at Monocrystal are very pleased to support our customers in their transition to 6-inch and 8-inch wafers to help them increase productivity and cut costs."

www.monocrystal.com

Kyma CEO named Triangle Top 50 Entrepreneur

Kyma Technologies Inc of Raleigh, NC, USA, which provides crystalline gallium nitride (GaN) and aluminum nitride (AlN) materials and related products and services, says that its president & CEO Dr Keith Evans, has been named by the Triangle Business Leader Magazine as a 2011 Triangle Top 50 Entrepreneur.

Evans joined Kyma in January 2005 as its third CEO after the firm closed on a small C-round investment. Since then, without any additional equity financing, he has led the company through a series of events, including the development of several key strategic partnerships, restructuring of its senior debt, reinvention of the management team, multiple acquisitions, and major diversification of the

product line. Kyma transitioned to profitability in 2007 and has remained profitable ever since.

Evans credits the award to the team at Kyma and the Raleigh-Durham Research Triangle Park's business-supportive community, including the Council for Entrepreneurial Development (CED), the NC Board of Science and Technology and its NC Green Business Fund, the NC Department of Commerce, the US Department of Agriculture (USDA), and both US Representative David Price and US Senator Kay Hagan.

The Triangle's Top 50 Entrepreneurs awards are sponsored by Business Leader Media, which publishes the Triangle Business Leader Magazine. Business Leader Media limited the

award criteria to include only leaders who have made a significant impact on the Triangle business community. The winners are being honored at a ceremony in Raleigh on 3 March, and will be featured in the March issue of Business Leader Magazine.

This is the third regional award that Kyma has received in under a year. Last summer, Kyma was named by private, non-profit organization CED (formerly The Council for Entrepreneurial Development) as a 'North Carolina Company to Watch'. Last September, chief technology officer Dr Edward Preble was named by Business Leader Media as a 'Triangle Mover and Shaker'.

<http://triangle.businessleader.com>
www.kymatech.com

GT Solar wins \$41.6m order for sapphire furnaces from new Asian customer

GT Solar International Inc of Merrimack, NH, USA (a provider of polysilicon production technology as well as sapphire and silicon crystalline growth systems and materials for the solar, LED and other specialty markets) has received an order for sapphire crystallization furnaces worth more than \$41m.

This is GT Solar's fourth order for its sapphire crystallization furnaces in recent months. In January, GT Solar received a \$33.3m order from South Korean polysilicon provider OCI Company Ltd, and in December it received two orders totaling more than \$84m from China's Jiangsu Jixing New Material Co Ltd and Jiujiang Sapphire Tech Co Ltd (affiliates of two long-term photovoltaic customers).

"We continue to see interest in our advanced sapphire furnace from new market entrants who are interested in producing sapphire material for high-brightness (HB) LED applications," says president & CEO



GT Solar's sapphire furnace.

Tom Gutierrez. "Our sapphire crystallization furnace provides a scalable and reliable architecture allowing companies to quickly ramp

to volume production to produce low-cost, large-area sapphire substrates," he adds.

The furnaces ordered by the new manufacturer will initially produce 85kg boules. During its recent fiscal third-quarter 2011 quarterly earnings call, GT Solar announced an enhancement to its sapphire furnace that will increase output capacity

to 100kg per cycle. The firm says that this scalability gives users an upgrade path to higher levels of throughput and productivity, providing a higher return on investment.

www.gtsolar.com

We continue to see interest in our advanced sapphire furnace from new market entrants who are interested in producing sapphire material for HB-LED applications

GT Solar settles IPO securities litigation for \$10.5m

GT Solar has reached an agreement in principle to settle two putative securities class-action lawsuits related to its initial public offering on 24 July 2008.

The terms of the proposed settlement (which includes no admission of liability or wrongdoing by GT Solar or by any other defendant) provide for a full and complete release of all claims that were or could have been brought against all defendants in both the federal and state securities actions. GT Solar will pay \$10.5m into a settlement fund. Of this, the firm will contribute \$1m and its liability insurers will contribute \$9.5m. The firm's contribution represents its contractual indemnification obligation to its underwriters. Both the terms of the proposed settlement and the plan of distribution for the

settlement fund are subject to further documentation and court approval.

"This settlement, once approved by the federal and state courts, will resolve these matters in a way that is in the best interests of GT Solar's shareholders," comments GT Solar's president & CEO Tom Gutierrez. "This settlement will provide GT Solar with certainty on the federal and state securities lawsuits, will eliminate the uncertainties and further expense associated with those litigations, and will eliminate an unnecessary drain on management time," he adds.

The actions to be resolved by the settlement include a consolidated federal securities case pending in the US District Court for the District of New Hampshire, and a state securities case pending in

the Superior Court of Hillsborough County, NH. In addition to GT Solar, both the federal and the state securities lawsuits also name as defendants certain of the company's current and former directors and officers, together with the underwriters of the IPO and certain private equity funds that had invested in the firm prior to the IPO.

A shareholder derivative action pending in New Hampshire state court is not part of the proposed settlement of the securities cases. The derivative action is premised on the same purported misconduct alleged in the federal and state securities cases. The firm and other defendants intend to continue to defend that action vigorously.

www.gtsolar.com

Bridgelux claims first commercial-grade performance for silicon-based LED

8" fab sought for 135lm/W GaN-on-silicon technology

LED chip and lighting array maker Bridgelux Inc of Livermore, CA, USA (which claims to be the only vertically integrated maker of LED solid-state light sources specifically for the lighting industry) says that it has demonstrated gallium nitride-on-silicon based LED technology exhibiting luminous efficacy of 135 lumens per Watt, representing the industry's first commercial-grade performance for a silicon-based LED.

When grown in high volume, most LED epiwafers use sapphire or silicon carbide (SiC) substrates as the starting material. But large-diameter sapphire and SiC is costly, difficult to process, and not widely available. Production costs have hence inhibited the widespread adoption of LED lighting in homes and commercial buildings. However, growing GaN on larger, low-cost silicon wafers that are compatible with high-volume semiconductor manufacturing can deliver a 75% improvement in cost over existing approaches, says Bridgelux.

The 135lm/W performance was achieved at a correlated color temperature (CCT) of 4730K using a single 1.5mm power LED operated at 350mA. The LEDs have very low operating voltages, requiring just 2.9V at 350mA and <3.25V at 1A.

The low forward voltage and excellent thermal resistance suit high-performance, illumination-grade applications, says the firm. Optimization of the epitaxy process on 8-inch silicon wafers will make LED manufacturing compatible with existing automated semiconductor lines.

Bridgelux says that the move to a silicon substrate will be a revolutionary step for the LED industry, and that the firm is well positioned to take advantage of the introduction of the technology. Over the past five years, Dr Steve Lester has fostered a team of materials

scientists and chip design engineers at Bridgelux dedicated to GaN-on-silicon R&D. Concurrently, industry-wide R&D of GaN growth on silicon has increased rapidly. As a result, the latest GaN-on-Si performance levels reported by Bridgelux are comparable to

The latest GaN-on-Si performance levels reported by Bridgelux are comparable to state-of-the-art sapphire-based LEDs available 12-24 months ago

state-of-the-art sapphire-based LEDs available 12-24 months ago. The firm anticipates the delivery of its first commercially available GaN-on-Si products over the next 2-3 years.

Bridgelux, which maintains an asset-light operating model, aims to leverage its R&D and intellectual property position in LED epitaxy to jointly manufacture silicon-based LEDs. It is currently in discussions with a number of established semiconductor firms regarding use of the many fully depreciated 8-inch semiconductor fabrication operations available around the globe.

"Bridgelux's achievement is a significant reflection of the strength of our leadership in silicon materials and epitaxial process technology," reckons CEO Bill Watkins. "The significantly reduced cost structures enabled by silicon-based LED technology will continue to deliver dramatic reductions in the up-front capital investment required for solid-state lighting," he adds. "In as little as 2-3 years, even the most price-sensitive markets, such as commercial and office lighting, residential applications and retrofit lamps, will seamlessly and rapidly convert to solid-state lighting."

www.bridgelux.com

Bridgelux adds board member as chair of audit committee

Bridgelux says that George de Urioste has joined its board of directors, serving as chairman of its audit committee.

de Urioste has more than 30 years of experience in the semiconductor and enterprise software industries. "George's experience as CFO and COO in publicly held companies is well suited to Bridgelux's needs as we embark on our next phase of growth," says

CEO Bill Watkins. "His success in growing and managing world-class operations and teams will be instrumental."

Previously, de Urioste served in 2008 as interim chief financial officer and then interim chief operating officer of Marvell Technology, a \$3bn semiconductor provider of analog and digital signal processing products for data storage, mobile and video communications.

While CFO, its market capitalization grew from \$6bn to \$10bn. de Urioste was also COO and CFO at Chordiant Software Inc and CFO at Remedy Corp when both firms were publicly held. More recently, he was a member of the board of directors and served for three years as the audit committee chairman at Saba Software Inc. de Urioste is also a Certified Public Accountant.



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Lumileds introduces 'Freedom From Binning'

LED maker targets the demise of color bin charts for white LEDs

Philips Lumileds of San Jose, CA, USA has announced a development that it reckons will relieve luminaire manufacturers' and lighting designers' concerns over the consistency and uniformity of white light and simplify the design process for LED solutions.

Lumileds' says that, with its vision for 'Freedom From Binning', its white LUXEON emitters will be so uniform and consistent that there will be no color bin selections. Buyers of the new LEDs, initially released at correlated color temperatures (CCTs) of 2700K and 3000K (with others to follow), will receive LUXEON LEDs that are already tested and binned at real-world operating conditions so that their performance for color, light output, and efficacy are already known. Lumileds will proliferate Freedom From Binning through new product introductions this year and into the future.

"At random, I can lay a thousand of these new LUXEONs in a straight line and the consistency and color quality from LED to LED will be as good or better as what you would see with many of the bulbs in use today," says CEO Michael Holt. "The lighting industry has yearned for quality of light, simplicity of design, and more efficient light sources in mass quantities and reasonable costs that enable solutions that improve on what's possible with conventional lamps," he adds. "By combining our unique TFFC and Lumiramic phosphor technologies with new manufacturing capabilities that allow us to 'hot' test and color bin, Philips Lumileds' Freedom From Binning is charting a new course for the LED manufacturing industry to follow and moving us ever closer to the lighting industry."

Lumileds reckons that the lighting community will want to look at LED performance information in a new

way as a result of these advances. Although typical datasheets present data for LEDs at 25°C, it's well known that the actual operating temperature is closer to 85°C (sometimes higher) and that the performance numbers reported are essentially overstated. LUXEON products that offer Freedom From Binning are tested at 85°C, so the actual color point and performance numbers are known. "We sacrifice the marketing value of higher lumen and efficacy numbers for accuracy and confidence," comments Holt. "We can calculate performance at lower temperatures, but that would defeat the point and potentially mislead," he adds. Most datasheets from LED makers include the information required to understand performance at elevated temperatures and the industry is able to make real-world comparisons between products.

Lumileds' new LUXEON S LED delivers 1300 'hot' lumens

At the Strategies in Light conference in Santa Clara, CA, USA (22–24 February) and the EuroShop conference in Dusseldorf, Germany (28 February–2 March), Lumileds launched LUXEON S, which it says should change expectations of what's possible with its latest generation of LUXEON LEDs. Designed with retail spot and down-lighting in mind, LUXEON S aims to enable simple, effective, and efficient lighting, as a replacement for existing halogen and CDM (ceramic discharge metal halide) lighting.

"The design of this product, from the Thin Film Flip Chip and Lumiramic phosphor to the tight alignment between the nine LED die in the package, contributes to the color performance, industry-leading flux density, and punch unique to LUXEON S," claims Frank Harder, VP marketing LUXEON Product Lines. "Also, by hot testing at 85°C and

achieving 'Freedom From Binning', we continue to move closer to the lighting industry in language and expectations for LUXEON performance," he adds.

The LUXEON S surpasses the color quality and beam uniformity of any other comparable LED available, it is claimed. As the first 'Freedom From Binning' LED from Lumileds, there are no color bin selections to be made. With a correlated color temperature (CCT) of 3000K and a color rendering index (CRI) of more than 80, all LUXEON S emitters are targeted to the black-body curve and populate an area within a 3-step MacAdam Ellipse. The result is what is claimed to be unmatched uniformity and consistency within the light beam and between emitters.

The 1300 'hot' lumens that LUXEON S delivers come from a very small optical source that enables a

10° beam from a compact reflector less than 50mm in diameter. In a retail spot or down-light the result is tight, sharp beams that deliver high Punch — high center beam intensity with beam uniformity and a crisp single shadow — that highlights and gives depth to objects that are being illuminated.

Consuming 18W for 1300lm and 9W for 790lm, the LUXEON S delivers luminous efficiency of 72–88lm/W versus 65–90lm/W for a 20W CDM and just 15–26lm/W for a 50W halogen lamp and 17lm/W for a 75W halogen lamp.

At EuroShop, LUXEON S was shown in Fortimo solutions from Philips and others with solutions targeted at the retail and hospital-lighting segments.

LUXEON S is available for prototyping and development from Future Lighting Solutions.

www.FutureLightingSolutions.com

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Lumileds to expand Malaysia facilities

In mid-February, Glenn Brownlie, general manager of Philips Lumileds Lighting Malaysia (part of power LED maker Philips Lumileds of San Jose, CA, USA) signed a lease agreement with Datuk Rosli Jaafar, general manager of Penang Development Corp (PDC), for a 12-acre plot next to the Penang International Airport in Bayan Lepas, Malaysia, in order to expand Lumileds' existing LED manufacturing facilities in Bayan Lepas (where the firm has 1800 staff). Construction was due to begin in March, and take 12–15 months.

Lumileds first came to Penang in 2000 as Lumileds Lighting Sdn Bhd before becoming Philips Lumileds Sdn Bhd in 2006 when Lumileds was bought by Philips. Its competencies there have since grown from standard assembly production to manufacturing and developing phosphor for converting blue LEDs into white LEDs, as well as R&D activities, focusing on the firm's



Penang's chief minister Lim Guan Eng signing a plaque to commemorate his first visit to Lumileds' factory. From L-R: VP of Asia operations Jascha Ortmanms; site financial controller Akos Nagy; and Philips Lumileds Lighting Malaysia general manager Glen Brownlie.

range of mobile-phone camera flash products (i.e. the LUXEON Flash).

Brownlie said that the new site will accommodate: a facility dedicated to phosphor and new-product R&D, as well as a design centre; a new facility for Philips Lumileds' Global Customer Quality Team and Finance

Team; and a cleanroom manufacturing facility for the production of high-brightness power LEDs, LED modules and assemblies. With completion of the first phase of construction, Lumileds will double its existing manufacturing floor space.

Lumileds says that, in order to reduce energy consumption and carbon footprint (in line with the State's 'Cleaner, Greener Penang' campaign), the new facilities will be the first in Malaysia to be designed with 100% LED lighting, both interior and exterior, it is claimed.

"Philips Lumileds has pledged to invest significantly in the development of skilled engineering talents in Penang and Malaysia and will also grow its workforce considerably over time," said Penang's chief minister Lim Guan Eng.

Last August, Eng paid his first visit to Lumileds' existing Bayan Lepas facility, where he signed a plaque to commemorate the occasion.

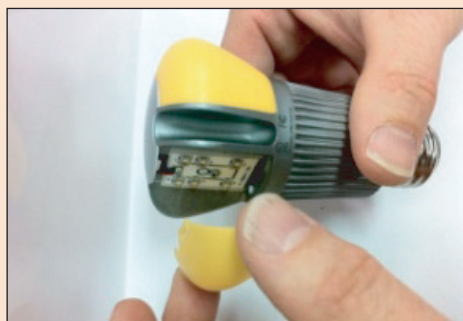
www.philipslumileds.com

Lumileds' LUXEON LEDs first to light ENERGY STAR qualified 60W-equivalent retrofit bulb

Philips Lumileds says that its LUXEON power LEDs are lighting the world's first ENERGY STAR qualified LED replacement for a 60W incandescent bulb.

In production and available to consumers and professionals alike, the Philips AmbientLED bulb (also sold professionally under the Philips EnduraLED brand) using 18 LUXEON Rebel LEDs has met or exceeded the quality and energy efficiency requirements for a 60W LED equivalent set forth by ENERGY STAR.

"LUXEON LEDs deliver the light, reliability, and efficacy required by retrofit bulb manufacturers to meet increasingly stringent standards worldwide," says Steve Barlow, Lumileds' executive VP of sales & marketing. "We are well beyond demo and prototype bulbs not only



AmbientLED 60W equivalent lamp.

for 60W equivalents but also for MR16s, PAR lamps, GU10, and other form factors that are widely used," he adds. "Our sights are now set clearly on enabling replacements for 75W equivalent bulbs."

At operating conditions, which can reach 100°C or higher inside the LED, the LUXEON in an ENERGY STAR qualified solution must provide enough light to deliver at least

800lm, a color rendering index (CRI) of 80, and they must be reliable enough to support a minimum three-year warranty. In the case of the newly qualified AmbientLED, a six-year warranty is offered for the LUXEON-based solution.

Lumileds says that, because there are so many different types and styles of bulbs, it is continuously broadening its portfolio of LUXEON LEDs with different CRI, CCT (color correlated temperature), and light output characteristics in order to meet the needs that vary by bulb type and by geographic region.

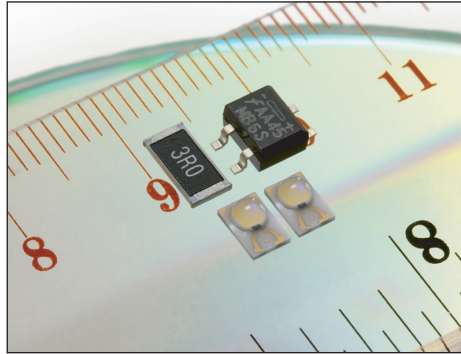
LUXEON LEDs for retrofit solutions are available from Future Lighting Solutions. Design resources, engineering resources and prototyping assistance are available from both Philips Lumileds and Future Lighting Solutions.

Lumileds launches its first high-voltage LED

Philips Lumileds of San Jose, CA, USA has expanded its LUXEON LED portfolio for the illumination market with its first high-voltage emitter. The new LUXEON H emitter joins the recently released LUXEON S (the first product with 'Freedom From Binning'), and the LUXEON Rebel and LUXEON Rebel ES (the most widely used power LEDs).

LUXEON H emitters are driven directly with rectified AC voltage rather than constant DC current. This high-voltage architecture maximizes space for additional thermal management, permitting an increase in the thermal limit for even the smallest bulbs, says Lumileds. The 50V LUXEON H flexibly supports both 110V and 240V solutions.

Designed to meet the demands of space-constrained retrofit bulbs, LUXEON H emitters deliver what is claimed to be industry leading thermal performance and reliability as well as high-quality, warm-white light. Two correlated color temperatures (CCTs) are available, 2700K and 3000K, with typical color ren-



LUXEON H LEDs and the electronic components required for a system.

dering indexes (CRI) of 83. Typical flux is 84 lumens and 90 lumens, respectively, for the two CCTs. The LUXEON H emitters are identical in footprint to the existing compact LUXEON Rebel and LUXEON Rebel ES LEDs, simplifying implementation.

"Our thin-film flip-chip technology allows us to continue to develop innovative solutions, like the multi-junction die in LUXEON H, for the illumination market," says Frank Harder, VP of product marketing for LUXEON. "The base of some bulbs is so small that it's impossible to fit

both an electronic driver and a heatsink in the space. LUXEON H only requires a bridge rectifier and a resistor, both of which are very small, and the remaining space can be used for thermal management," he adds. "And, because we don't use direct red die like most other HV solutions, LUXEON H offers consistent, stable color from the instant the LED is powered and maintains its color through its life-time."

Initial uses of LUXEON H are expected in the retrofit bulb market, where form factors for the bulbs are already defined and space is at a premium—especially so for the smallest bulb types ranging from the candelabra to the intermediate Edison, E10-E17 types. Lumileds expects new solutions using LUXEON H to come to market during second-quarter 2011.

Philips Lumileds' new LUXEON H LED is in volume production and is available with standard lead times via its distribution partner Future Lighting Solutions.

www.philipslumileds.com

LUXEON LEDs light up China's Guangzhou TV Tower

Philips Lumileds says that the Canton Tower (also known as the Guangzhou TV tower) is one of the recent projects in Guangzhou, China that has used its LUXEON LEDs — in this case more than 330,000 emitters — to bring a unique and distinctive landmark to life.

Also acclaimed as 'Slender Waist', the 610m-high Canton Tower is the world's highest stand-alone TV tower. It relies on its LED lighting solution from Philips to integrate regular lighting with festival lighting to meet the overall night-view plan of the Guangzhou government and enhance the urban image of Guangzhou as an international metropolis. The colorful, dynamic and vivid visual effect of the tower is made possible by more than 6000 LED lumi-



Guangzhou TV Tower lit.

naires from Philips using just 500kW of power.

Recently, more than 700,000 LUXEON LEDs were used to illuminate the banks of the Pearl River in Guangzhou. Lumileds has also supplied its LUXEON white LEDs for projects including the street lighting on Liao Ning Avenue in the Si Chuan Province, the Guangzhou Opera Hall, and the Liu Wu Tunnel Lighting in Anhui Province, China.

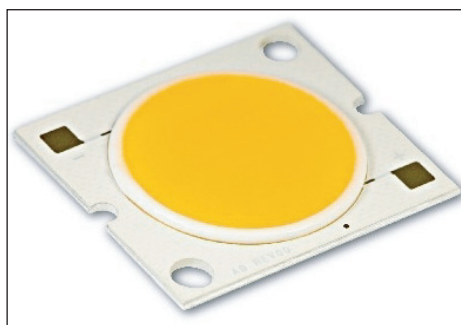
Lumileds says that its LUXEON LED portfolio offers application performance that makes it easier for luminaire designers, architects and specifiers to create and select new solutions with confidence and certainty that the LEDs will deliver the desired light output, efficacy and color quality. LUXEON LEDs are already widely used in shops, on roadways, in hotels and restaurants, offices and homes.

Seoul Semiconductor launches Acriche A7 and A8 AC LEDs for lighting applications

After in January releasing two new DC-powered white high-brightness LEDs (the Z-Power LED Z6 and Z7 series) according to its 2011 plan that aims to release new products every month in 2011, in February South Korean LED maker Seoul Semiconductor (SSC) launched its new Acriche A7 AC-powered LED for lighting applications.

Acriche, which can operate under both AC and DC power supplies, is one of the flagship products of Seoul Semiconductor. It can be operated on common household AC voltages such as 110V/220V without a converter. SSC says that the new A7 version is smaller in size but significantly improved in terms of reliability and its ability to withstand electro-static discharge (ESD).

The A7 is a 3.2W LED (a popular choice for general illumination applications) that provides 305lm and is offered in an ultra-small (8mm x 8mm x 3.7mm) ceramic-circuit package. SSC claims that it is very low in 'cost per lumen' compared with other lighting-class LED products, suiting commercial



Seoul Semiconductor's new Acriche A8 LED.

lighting products such as downlights, MR16, PAR30 and PAR38 replacement lamps.

Also, the A7 can last more than 40,000 hours and improves the lifespan of the end product because a converter is unnecessary. Traditionally, DC LED lamps have lasted about 10,000 hours because of the short lifespan of some of the components in the converter. However, since the Acriche does not require a converter, lamp makers can achieve cost savings while improving system efficiency and lifetime, says the firm.

Subsequently, in March, Seoul Semiconductor also launched the

Acriche A8 AC- and DC-powered LED for downlight application.

The A8 can replace a 60W incandescent bulb using just a single package. The firm says that this is competitive in terms of cost since, as well as avoiding the use of an AC-DC converter, it removes the SMD processing of dozens of DC LED packages on an expensive metal substrate (for thermal emissivity purposes).

The A8 is designed specifically for downlighting, which is the most demanding of LED lighting applications, says the firm. In particular, it is offered in an ultra-thin package (25mm x 22mm x 2mm), COB style with a brightness of 700lm (sufficient to replace a 60W light bulb with just one A8 package).

Customized for incandescent bulb/downlight and indoor lighting, the A8 can last as long as the life of the LED chip since it does not require a converter.

Seoul Semiconductor has started mass production of the A8, and samples are available upon request.

www.acriche.com/en

Seoul Semiconductor earns EPA recognition for LM-80 testing

South Korean LED maker Seoul Semiconductor (SSC) has been added to the US Environmental Protection Agency (EPA) list of recognized laboratories for conducting LM-80 testing of LEDs. LM-80 testing is a key requirement to ensure lumen maintenance standards are met by LEDs intended to be used in luminaires targeted for ENERGY STAR certification.

The firm is now officially recognized to provide the solid-state lighting market with its LM-80 test reports, the LED reliability evaluation standard of the EPA's ENERGY STAR Program. So far, few firms worldwide have obtained the certification, says Seoul Semiconductor. The firm joins the list as a

first-party testing lab authorized to test its own LEDs and modules.

Illuminating Engineering Society (IES) LM-80 is a standard testing method for measuring the lumen maintenance (light depreciation over time) of LED light sources over a 6000 hour time frame. Seoul Semiconductor says that LM-80 testing is a meaningful way to provide comparable measurements of lumen maintenance and eliminate confusion occurring from LED makers using different test methods.

The firm says that to be recognized by the EPA for LM-80 testing and testing its LED technology and products on its own required a significant investment in test equip-

ment, procedures and personnel to perform the tests, demonstrating its commitment to providing reliable LED emitters and modules while meeting local standards and requirements around the globe.

"Achieving LM-80 certification is an important step in showing Seoul Semiconductor's commitment to the US lighting market and in meeting the exacting standards set to protect consumers," says Brian Wilcox, VP of sales for North America. "We are dedicated to complying with the industry standards and government regulations that will help speed LED adoption in the general illumination market space".

www.acriche.com/en

Taiwan's Tekcore and Korea's Seoul Semiconductor to form sales & distribution joint venture

The board of directors of Taiwan-based LED chipmaker Tekcore has approved plans to form a new sales and distribution venture with South Korean LED maker Seoul Semiconductor and its subsidiary Seoul Optodevice, according to a report by Digitimes. The joint venture will initially be capitalized at NT\$60m (US\$2.03m), with the South Korean firms and Tekcore contributing 51% and 49%, respectively.

The cooperation should allow Tekcore to develop overseas business markets and receive patent licensing for white LEDs, the firm says. Seoul Semiconductor had previously also formed a strategic partnership with Taiwan-based LED chipmaker Huga Optotech.

Seoul Semiconductor and Tekcore have done businesses together for the past 10 years and, due to the strong growth in LED TV backlight applications, Seoul Semiconductor became Tekcore's largest client in 2010, accounting for just under 20% of revenue, according to Tekcore.

In addition to the South Korea market, the new venture aims to bring LED lighting products to the USA, Europe and Japan, according to Digitimes. Seoul Semiconductor and Tekcore are scheduled to sign a partnership agreement and begin the company registration process in the second quarter.

The partnership should also help Tekcore to secure long-term orders, increasing Seoul Semiconductor revenue contribution to 30%, it is said. As a precedent, when Huga, Seoul Semiconductor and Seoul Optodevice established a joint venture in 2009, Huga saw the proportion of its total revenue coming from the South Korean companies jump from just over 10% to 20-30%.

With the market penetration of LED TVs expected to rise to 40-50% in 2011, Seoul Semiconductor (which supplies LEDs to Samsung Electronics) has looked to strengthen its relations with Taiwan-based LED chip makers. In particular, as Samsung LED ramps up in-house production and enters the LED lighting sector, Seoul Semiconductor will be more aggressive in improving its product development capability and management of upstream suppliers and downstream clients, says the report.

Tekcore posted NT\$2.438bn in revenues for 2010, up 94% on 2009. Although profit in fourth-quarter 2010 was affected by a drop in capacity utilization, full-year net income reached a record NT\$350m (US\$11.82m).

www.digitimes.com

The partnership should also help Tekcore to secure long-term orders, increasing Seoul Semiconductor revenue contribution to 30%



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Cree hires senior VP of sales & business development

Cree has recruited Bruce Renouard as senior VP – sales & business development, responsible for LED chips, LED components, materials and power & RF components.

Cree says that the newly created position is part of its ongoing investment in sales and marketing to further enable the LED lighting and power markets.

“As we continue to lead the LED lighting revolution and drive adoption into new applications, we are also focused on enabling our customers,” says chairman & CEO Chuck Swoboda. “Bruce’s demonstrated sales leadership and experience in selling integrated solutions around key components will be a great addition to the Cree management team.”

Renouard joins Cree after 9 years at Power Integration Corp, where he was VP of worldwide sales.

Cree cuts revenue forecast by 15% LED chip and component demand and pricing lower than expected

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has cut its revenue forecast for fiscal third-quarter 2011 (ending 27 March) by about 15%, from \$245–265m to \$215–220m.

This follows a decline in revenue from \$268.4m in fiscal Q1 and \$257m in fiscal Q2, and would be down about 7% on \$234.1m for fiscal Q3/2010.

The revised revenue forecast is attributed mainly to lower sales of LED chips and LED components. The firm says that demand for LED components is improving post-Chinese New Year, but revenue is lower than originally targeted. It has taken longer to work through customer inventories than previously anticipated and pricing was lower than forecast. The LED chip business is also weaker than targeted due to more aggressive pricing and weaker demand.

Cree has also cut its forecast for gross margin from 46% to about 43%. This is attributed mainly to increased pricing pressure in the LED chip product line. Operating expenses are expected to be slightly lower than previously targeted \$73m (or \$62m on a non-GAAP basis).

“The LED components business appears to be turning the corner,” comments CEO & chairman Chuck Swoboda. “Despite the challenges we faced in Q3, distributor sell-through has improved and we target solid growth next quarter,” he adds. “Based on our preliminary outlook for Q4, we are currently targeting revenue to increase 10–12% in fiscal Q4 [i.e. to \$237–246m], led by growth in LED components.” This forecast is even even after factoring in a “very aggressive pricing environment”.

www.cree.com

XLamp MT-G LED launched for 35–50W halogen MR16 retrofit

Cree has made available samples of a new lighting-class LED designed for high-output, small-form-factor directional lighting applications.

The XLamp MT-G LEDs are optimized for 35–50W halogen MR16 retrofit bulbs and other accent, track, display and down-lighting used in retail stores, residential settings, museums, art galleries, hospitality and landscapes. They are the first commercial LEDs to deliver sufficient light output for these applications, claims Cree.

The multi-die XLamp MT-G LED features Cree EasyWhite technology to deliver consistent color in a small (9mm x 9mm) highly efficient package. The LED is designed for the high-lumen, small-footprint requirements of 35 and 50 Watt halogen retrofit lamps. Cree says that it engaged

driver, thermal and optic providers to create an MR16 lamp reference design to further enable its LED customers to quickly address this market.

Cree claims that the MT-G is the first LED in the industry binned and tested at 85°C, which can simplify luminaire design calculations and speed time-to-market. At 85°C, the MT-G LED delivers up to 560 lumens at 1.1A or

LED-based MR16 lamps have been a tremendous challenge for the lighting design community in terms of both light output and color consistency due to their small size and limited capacity for thermal management

up to 1525 lumens at 4A in warm white (3000K).

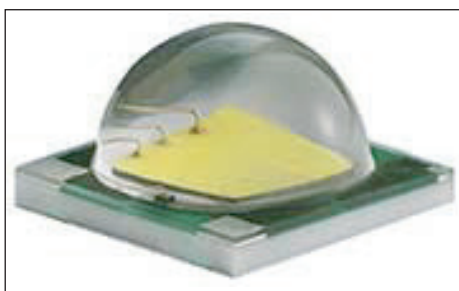
“There are no energy-efficient alternatives for many high-lumen, small-form-factor, directional lighting applications,” says Paul Thieken, director of marketing, LED components. “Until now, LED-based MR16 lamps have been a tremendous challenge for the lighting design community in terms of both light output and color consistency due to their small size and limited capacity for thermal management,” he adds. “Cree developed this LED from the ground-up with applications like these in mind, and its introduction signals the arrival of the LED lighting revolution in these high-profile markets.”

Production volumes are available with standard lead times. The reference design is available for free at <http://mtg.cree.com>

Cree extends XM-L LED range from cool white, claiming record-efficacy warm- & neutral-white lighting-class LEDs

Cree has announced the commercial availability of XLamp XM-L LEDs in neutral- and warm-white correlated color temperatures (2600–5000K CCT), extending the XM-L family to a wide range of mainstream indoor and outdoor lighting applications. Cree previously launched cool-white (6500K) XM-L LEDs last November.

Light output and luminous efficacy, respectively, are up to 113 lumens and 117 lumens per watt for warm-white (3000K) XM-L LEDs and up to 134lm and 138lm/W for neutral-white (4000K) XM-L LEDs at a drive current of 350mA, and up to 220lm and 108lm/W for warm-white (3000K) XM-L LEDs and up to 260lm and 128lm/W for neutral-white (4000K) XM-L LEDs, at a drive cur-



Cree's XLamp XM-L LED.

rent of 700mA. Driven at 3.0A, XM-L neutral-white LEDs produce 850lm at 84lm/W.

Unlike competing LED solutions that use large-footprint packages and diffuse optical sources to deliver hundreds of lumens, XM-L LEDs provide breakthrough performance in a compact footprint

and small optical source size, claims Cree. This high lumen density can simplify designs and reduce costs for lighting manufacturers building products for directional-lighting applications, such as high-bay, parking, roadway, track, spot and LED replacement lamps, says the firm. XM-L LEDs enable manufacturers to easily control the light output and place light exactly where it is required, minimizing wasted light and light trespass, it adds.

"Cree is the only LED manufacturer currently delivering production volumes of warm- and neutral-white LEDs at these performance levels," claims Paul Thieken, Cree's director of marketing, LED Components.

Cree launches XLamp ML-B lighting-class LED for distributed illumination

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has announced commercial availability of the XLamp ML-B LED. Designed for quarter-watt operation, it brings lighting-class performance to distributed lighting applications where the light source is visible, such as panel lights and LED-based fluorescent tube replacements.

Lighting manufacturers have tried to achieve a uniform lighting appearance by placing many low-power LEDs in close proximity under a diffuser. This use of typical low-power LEDs will not enable manufacturers to meet rigorous ENERGY STAR requirements or customer's expectations, says Cree. In contrast, ML-B LEDs are designed to last 50,000 hours and to provide the lighting-class levels of efficacy, thermal resistance and reliability that can enable ENERGY STAR-qualified fixtures.

"ML-B LED delivers lighting-class performance with the smooth, uniform appearance that lighting



Cree's new XLamp ML-B LED for distributed illumination.

manufacturers want for distributed lighting applications," says Paul Thieken, director of marketing, LED components. "The ML-B LED provides the right balance of lumen output, footprint, efficacy and value for direct-view lighting," he adds.

The ML-B LED delivers luminous flux up to 30lm at 80mA in cool white (5000K) and up to 24lm in warm white (3000K). It shares the same footprint and package with the XLamp ML-E LED and, like the ML-E, provides uniform color over angle and a 120° viewing angle.

www.cree.com

Zumtobel downlight agreement extended

Cree has announced a two-year extension of the strategic agreement that it signed with lighting provider Zumtobel Lighting GmbH of Dornbirn, Austria in 2008 as the firms continue to work together to bring LED lighting to Europe.

"Cree and Zumtobel see the LED lighting revolution taking hold in Europe," says Ty Mitchell, VP & general manager, Cree LED Lighting. "Zumtobel is a market-leading lighting company and is providing their customers with high-quality LED lighting based on Cree TrueWhite Technology," he adds.

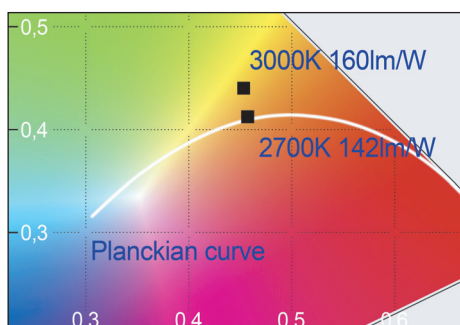
"In the past years, Cree has become one of our preferred suppliers in the LED lighting business," says Zumtobel Group's CEO Harald Sommerer. "As we combine the best available technology with our outstanding lighting expertise and our strong IP position, we enhance our leading position to bring LED lighting innovation into our markets."

www.zumtobel.com

Osram hits record 142lm/W efficiency for 2755K warm-white LED at 350mA/mm²

Osram Opto Semiconductors GmbH of Regensburg, Germany has set a new laboratory record of 142lm/W for the luminous efficiency of a warm-white LED light source. With a correlated color temperature (CCT) of 2755K the LED achieves a good color rendering index (CRI) of 81. Measurements were taken under standard conditions: room temperature and pulsed mode at an operating current density of 350mA/mm².

Bright warm-white light with high efficiency is particularly important for lighting applications in the residential sector. Osram Opto says that the lab setup for a warm-white LED shows the enormous potential of energy-saving semiconductor light sources: the peak value of 142lm/W measured under standard conditions is achieved at a color perception that very closely matches that



The lab setup for a warm-white LED achieves a peak value of 142lm/W directly on the Planckian curve at 2700K; an optimized setup at 3000K could achieve 160lm/W.

of a classic incandescent lamp (color coordinates cx 0.46/cy 0.41 on the Planckian curve).

"If we explore this technical approach further and allow deviations from the Planckian curve, we should even now be able to achieve higher efficiency values of up to 160lm/W

for a correlated color temperature of 3000K (cx 0.45/cy 0.44)," says Dr Norwin von Malm, pre-development manager at Osram Opto. "If we apply this approach to a 2mm² chip, we can improve efficiency by a further 10–15% for the same operating current," he adds. "We would then expect 180lm/W for a pure warm-white LED and good color rendering."

The increase in efficiency was made possible by combining new procedures in thin-film and UX:3 chip technologies and in conversion. Osram Opto says that its development engineers have benefited from combined know-how in all aspects of the production process, including epitaxial growth, thin-film chip architectures, conversion processes and package technologies.

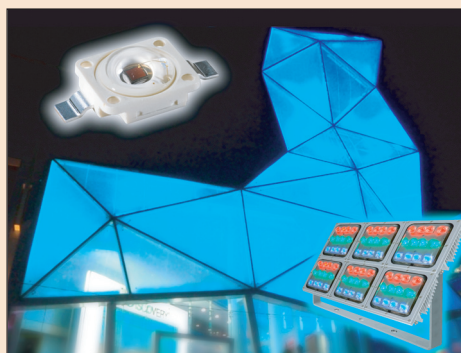
www.osram-os.com

Osram LEDs rejuvenate Bangkok's Siam Discovery Center

Osram Opto Semiconductor says that its Golden DRAGON Plus LEDs are at the core of fixtures using Signex LED architectural lighting, illuminating the multi-dimensional bubble-like structures at the front of the rejuvenated Siam Discovery Center (one of Bangkok's first shopping malls).

Opened in 1997, the Siam Discovery Center has become a landmark in Bangkok. Its 'One Floor – One Concept' configuration has gained acclaim among tourists and local shoppers.

"When we were asked to create a lively illumination design for the Siam Discovery Center, we immediately picked the Golden DRAGON Plus RGB LEDs for their versatility in color rendering," says Pongsorn Ouvuthipong, LED product director, Lighting and Equipment Public Company, which designed and installed the Signex lighting fixtures with a computer-



The Siam Discovery Center in Bangkok, Thailand.

controlled DMX512. "These RGB LEDs enable a wide range of colours, offering designers excellent flexibility in creativity," he adds. "Their consistency of color bin also helps deliver accurate lighting effects."

There are 24,000 LEDs deployed in the 650 sets of floodlights behind the transparent plastic bubbles. The color-changing effect is designed by VISION DESIGN

STUDIO (Thailand), which programs the computer system and creates color patterns each evening. There will also be special lighting designs for different events.

Osram Opto says that the new LED architectural lighting adds a sense of modernity to the center and makes the shopping mall more prominent among the surrounding buildings.

"Given the hot climate of the city, the robust thermal management of these LEDs — with thermal resistance of up to 11K/W — ensures the stability of the illumination effects," says Kai-Chong Cheng, marketing director of Osram Opto Semiconductors Asia Ltd. "The long lifetime of over 50,000 hours (depending on operating conditions) of these LEDs also reduces maintenance work, causing minimal disruption to this busy shopping mall," he adds.

Osram Opto expands LED chip making in Malaysia and Germany to 6" wafers

Conversion from 4-inch wafers to double capacity

LED maker Osram Opto Semiconductors GmbH of Regensburg, Germany says that it is to increase its production output significantly by converting its two indium gallium nitride (InGaN)-based LED chip manufacturing facilities to 6-inch (150mm) wafers while expanding both plants.

A new production building is currently under construction at the firm's site in Penang, Malaysia, while in Regensburg the available space is being reallocated. The two facilities will each be converting to the new manufacturing technology, introducing 6" wafers to replace the current 4" wafers. These measures are expected to almost double the firm's chip production capacity for white LEDs by the end of 2012.

The Penang chip plant, which opened nearly two years ago, has been earmarked for further expansion



New production areas being created at Osram Opto's site in Penang.

and conversion to 6" wafers. Its total manufacturing area will be increased to about 25,000m² in 2012, creating about 400 extra jobs. At the Regensburg plant, the available area will be reallocated and InGaN LED chip production will be converted step by step from 4" to 6" wafers from as early as this summer.

The capacity expansion will primarily affect InGaN chips employing

thin-film and UX:3 technology, which are required in the production of white LEDs. These will be manufactured on 6" wafers from the outset and not on wafers of 4" diameter.

Osram Opto reckons that the expansion will put it on track to cash in on the growth potential of international LED markets, as well as securing its international market position. The company was ranked by market research firm Strategies Unlimited as the third biggest HB-LED maker by revenue in 2010.

"By expanding our capacities for high-performance InGaN chips, we are consistently consolidating our market position," says CEO Aldo Kamper. "The LED market harbors great growth potential in many different fields of application, and we intend to continue harnessing this."

www.osram-os.com

Osram Opto's Multi CHIPLEDs used in FormoLight's displays

Taiwanese display maker FormoLight Technologies has developed a high-performance LED video display for indoor and outdoor applications that uses Multi CHIPLEDs from Osram Opto Semiconductors to produce high-quality images with brilliant colors and sharp contrasts.

The Multi CHIPLEDs comprise what is claimed to be the smallest RGB LED on the market. Their compact size permits a special image format. In this display for interior use, the LEDs are not used as backlighting (hidden from observers as in LCD appliances), but are clearly visible on the surface. However, they remain undetected by observers, because the Multi CHIPLEDs are very small (1.6mm x 1.6mm and 0.9mm thick) and are barely visible through the black LED housing.

"Information has to be presented clearly in every respect. This concerns not only the concept of visualization, but also the technical reproduction," explains Sven Weber of Osram Opto. "Excellent image quality is needed, which is easier to realise thanks to the advantages of LEDs, such as their directional characteristics and light quality," he adds. "The black LED housing reflects almost no ambient light, thus ensuring a perfectly flawless image." The FormoLight display thus has rich colors, sharp contours and depth of field, showing high-quality images rich in contrast, says Osram Opto.

The firm says that its Multi CHIPLEDs produce a homogenous image from every perspective. Such homogeneity is based on two principles: LEDs can be packed

very closely because of their compact size (the distance between pixels can be as little as 2mm); and the special casting material ensures a perfect color mix. The LED contains three chips (red, green, blue) in Thinfilm or ThinGaN technology, each of which can be controlled separately. The color impression remains constant across the entire viewing angle and also appears brilliant viewed from the side, claims Osram Opto. Due to the LEDs' sharp contrasts and high output, this high image quality is maintained even in very light rooms.

Use of the technology is also worthwhile from an economic perspective, claims the firm: LEDs are characterized by low power consumption and long durability.

www.formolight.com

Russian President visits Optogan's St Petersburg plant

Optogan has hosted a visit by Russia's President Dmitry Medvedev to its LED lamp production plant in St Petersburg, Russia, which was opened last November by Sergey Ivanov, deputy Prime Minister of the Russian Federation.

Optogan's chip technology was created by Vladislav Bougrov and Maxim Odnoblyudov, who were PhD students of Nobel prize winner and Russian Academy of Science member 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 (together with Alexey Kovsh) founding Optogan Oy in Espoo, Helsinki to develop GaN-based LEDs.

In addition to Optogan having an R&D facility in Helsinki, since founding Optogan GmbH in Germany in 2005 it has established epitaxy and chip R&D plus a pilot line in Dortmund and, last year, its Fab1 chip fabrication plant in Landshut. After founding CJSC Optogan in Russia in 2009, last May it acquired the industrial facility and infrastructure of Elcoteq in St Petersburg, where it has estab-



President Medvedev with Optogan's founders Maxim Odnoblyudov, Vladislav Bougrov and Alexey Kovsh.

lished LED component and luminaire production lines.

The new Fab2 St Petersburg plant makes LED components, lamps and light fixtures, making Optogan a vertically integrated manufacturer of GaN-based HB-LED chips, components, lamps and luminaires. The plant aims to fulfil the rapidly growing domestic demand.

"Our LED production in St Petersburg started in 2010 and is the largest [LED component and module manufacturing plant] in East Europe and CIS," says Optogan Group's

CEO Odnoblyudov. With an overall investment of 3.35bn rubles (€80m), the plant covers 15,000m² of floor space (including 5000m² of clean-room). The first production line has an annual production capacity of 360 million LEDs (30 million per month), and further capacity extensions are scheduled for the end of 2011.

Total company staffing is more than 250, but is expected to rise to as many as 800.

"A continual improvement of the technology and the placement of a complete production process in Russia will lead to a noticeable price reduction which, in turn, will lead to even stronger sales within the domestic market," reckons Odnoblyudov. To achieve this goal, Optogan plans to enter into collaborations with both national and international lighting manufacturers.

www.optogan.com

Luminus powers Aiptek pico projector

At the 2011 International Consumer Electronics Show (CES) in Las Vegas (6-9 January), Luminus Devices Inc of Billerica, MA, USA, which develops and manufactures big-chip PhlatLight (photonic lattice) LEDs for illumination applications, announced that it is powering Aiptek Inc's new PocketCinema V50 Projector (one of the world's smallest projectors, enabling instant projection anywhere for business presentations, photo sharing with family and friends, and gaming).

The PocketCinema V50 Projector achieves sharp, rich image quality by combining DLP (Digital Light Projection) optical technology with Luminus' SBT-16 LED pico-projection chipset, which is

designed specifically for hand-held projectors that use micro-displays of 0.2-0.45" with individual red, green and blue LEDs.

The V50's 848 x 480 (WVGA) resolution enables image projection up to 85 inches from iPods, digital cameras, camcorders, mobile phones, PCs or notebooks and gaming consoles. The built-in reader is compatible with an extensive list of business and multimedia file formats, including 720p high-definition video, allowing immediate projection of presentations or movies without having to convert files. The V50 also offers a battery life of up to 2 hours.

"The improved image resolution and built-in functionality to make

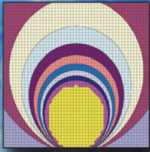
the projector compatible with wireless devices improves the viewing experience because they are easy-to-use by consumers and affordable," reckons Julie Lin, Aiptek's senior manager, marketing & sales.

"The V50 is one the world's most versatile pocket projection systems, making it ideal for business presentations and on-the-go gaming and picture and video sharing," says Stephane Bellosguardo, Luminus' director of product marketing, display business group. "Luminus' SBT-16 LEDs are ideally suited for palm-size projectors such as Aiptek's V50, providing a high brightness level as well as high efficiency to maximize battery life," he claims.

www.luminus.com

FerroTec

Temescal is now a
division of Ferrotec



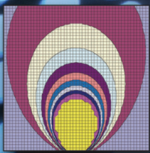
22 47.90

Ti
Titanium



78 195.09

Pt
Platinum



79 196.97

Au
Gold

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IN BRIEF

DILAS' range gains 1210nm and 1320nm diode laser bars

DILAS Industrial Laser Systems of Mainz, Germany (a division of high-power diode laser maker DILAS Diodenlaser GmbH) has broadened the spectrum of its diode laser bars by adding the new wavelengths 1210nm and 1320nm. DILAS now covers the wavelength range between 1 μ m and 2 μ m with the specific wavelengths 1064nm, 1210nm, 1320nm, 1470nm, 1550nm and 1940nm. The new 1210nm and 1320nm diode laser bars boast wall-plug efficiencies of >40%.

Based on conduction-cooled diode laser arrays, DILAS' fiber-coupled diode laser modules generate output powers of 12W, 25W, 40W, 100W, using a standard single-core 600 μ m fiber with a numerical aperture of <0.22 and SMA-905 fiber connector. Such fiber-coupled diode laser modules suit integration into applications targeted at the medical market, says the firm.

Easily integrated into OEM equipment, the sealed, conduction-cooled, fiber-coupled modules feature

options such as a power meter, visible pointer, serial fiber interlocks, and user-exchangeable protection window, providing flexibility for integration into larger systems.

The high-power diode laser bars can be integrated into all DILAS packages, ranging from single-bar configurations up to large-scale stack modules (including hundreds of bars per module).

www.dilas.com

**Alfalight announces strategic investment & technology development agreement with In-Q-Tel Partnership to advance development of man-portable military laser systems**

Alfalight Inc of Madison, WI, USA, which manufactures high-power laser diodes and handheld infrared and visible laser systems, has announced a strategic investment and technology development agreement with In-Q-Tel (IQT).

Launched in 1999 as a private organization, IQT is an independent strategic not-for-profit investment firm that works to identify, adapt, and deliver technology solutions to support the missions of the US intelligence community.

The partnership aims to advance Alfalight's development of high-performance, man-portable military laser systems. It builds upon the firm's established core semiconductor laser technology, which includes high efficiency, high brightness, and wavelength stabilization, combined with advanced electro-optics and integrated control methodologies, to deliver mission-critical solutions to IQT's customers.

Alfalight's existing products include components, laser subsystems, and handheld infrared and visible laser systems, many quali-

fied to demanding military, aerospace, or telecoms standards. The firm's fully vertically integrated factory has capabilities spanning laser device design, compound semiconductor processing, device packaging, and electro-optical assembly, to deliver rugged, turnkey electro-optical components and systems.

"Alfalight's proven high-performance diode laser technology, integrated with novel electro-optics, provides a uniquely valuable capability for our government partners," says William Strecker, IQT's chief technology officer and executive VP of Architecture & Engineering. "Our strategic investment in Alfalight will accelerate the development and availability of its products and technologies to both public and private sectors," he adds.

"Our partnership with In-Q-Tel enables the expansion of Alfalight's technologies into important governmental applications," says Alfalight's president & CEO Mohan Warrior.

www.alfalight.com

www.iqt.org

U-L-M launches VCSEL and PIN products for 16G Fiber Channel and FDR Infiniband

Philips Technologie U-L-M Photonics GmbH of Ulm, Germany has launched a family of 14Gbps vertical-cavity surface-emitting lasers and PIN photodiodes supporting various array configurations for the upcoming generation of datacom solutions. Qualification lots are available in July.

The data rate exceeds the 10Gbps speed limit that has existed for nearly 10 years. The firm now aims to meet the roadmaps of optical data communication standards, in particular addressing FDR Infiniband and 16Gbps Fiber Channel.

U-L-M Photonics says that its 14Gbps solution, like its previous products, features low power consumption. An increase in bandwidth is achieved at low operating current densities (comparable to the firm's 10Gbps platform), addressing both the tight power budget and the stringent reliability requirements.

The 14Gbps product launch affirms U-L-M's strategy to support the roadmaps of its customers as a dedicated component supplier, says general manager Dr Martin Grabherr.

www.ulm-photonics.de

France's CEA-Leti joins III-V Lab

Alcatel-Lucent/Thales joint venture's III-Vs technology to combine with silicon technology from Leti

In a move targeted at strengthening its industrial research capabilities, the private laboratory III-V Lab has been joined by the micro- and nanotechnology R&D center CEA-Leti of Grenoble, France.

III-V Lab is a joint venture between Paris-based communications technologies provider Alcatel-Lucent (which also includes the communications research center Bell Labs) and French defense & aerospace contractor Thales SA. The JV is located south of Paris in what will become the heart of the Paris Sud Saclay project, a major science and technology park that will combine research organizations, universities, Grandes Ecoles and corporate facilities. CEA-Leti is the Laboratory for Electronics & Information Technology within the French government's research and technology organization CEA.

Aiming to open up new research opportunities, the new public-private partnership will combine III-V compound semiconductor and silicon technologies, and include more than 130 researchers, technicians, and doctoral candidates.

The new partnership leverages the respective expertise of the three players in silicon, microelectronics and heterogeneous integration, bringing specific benefits in:

- the integration of the speed, power and optical capabilities of III-V components on silicon CMOS integrated circuits;
- the development of smarter, smaller components with innovative features by heterogeneously integrating active III-V components (optical, microwave, high-power components) with silicon circuits and microsystems; and
- the production of III-V components on silicon substrates and in silicon microelectronic manufacturing lines to reduce costs.

Since being established in 2004, III-V Lab has already enabled the rapid development of a common platform for dual-use optoelectronic and micro-electronic technology for markets including telecoms, space, defense and security.

CEA-Leti will significantly broaden the scope of the lab's target applications by combining its IP and expertise in silicon, microelectronics and microsystems and in heterogeneous integration.

Focusing on practical applications for the combined potential of semiconductors and silicon, III-V Lab will focus on four main areas of research:

- integrated photonic circuits that combine the active and passive functions of III-Vs and silicon for high-speed telecoms and data transfer;
- high-power and microwave gallium nitride (GaN)-based microelectronics to increase the power density, robustness, energy efficiency and compactness of telecoms, avionics, satellite, defense, energy and transport systems;
- a new generation of cost-effective, compact, ultra-sensitive, highly selective gas sensors for use in security, industrial process control, and environmental monitoring;
- thermal and near-infrared imagery for security and defense applications (the lab aims to develop new types of detectors with increased resolution while

reducing overall cost and speeding their adoption in the industrial-quality control, transportation and environmental markets).

"Their excellence in silicon will bring some exciting collaboration opportunities for the III-V Lab," says Gee Rittenhouse (head of research at Alcatel-Lucent Bell Labs) about CEA-Leti. "III-V semiconductors have already made a strong impact in optical telecommunications, providing several innovative breakthroughs, and the integration in a silicon microelectronic platform is on our roadmap to further improve performance, cost and energy consumption," he adds.

"As the third partner in the III-V lab, Leti adds deep expertise and essential silicon capabilities to our existing strengths in III-V semiconductors, opening broader opportunities for innovation," says Marko Erman, Thales' senior VP Research & Technology. "Thales will be provided

Leti adds deep expertise and essential silicon capabilities to our existing strengths in III-V semiconductors, opening broader opportunities for innovation

stronger competitive advantages through the III-V Lab, thanks to the early availability for system developments of new components with breakthrough performances," he adds.

"Each of us brings very specific and complementary expertise to our pursuit of common goals," comments Leti's CEO Laurent Malier. "Moreover, each partner can capitalize on the developments and transfer new technologies to our customers," he adds.

www.3-5lab.fr

www.leti.fr

GigOptix reports fifth quarter of double-digit growth

GigOptix Inc of Palo Alto, CA, USA, which designs modulator and laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials as well as polymer electro-optic modulators, has reported record revenue of \$26.9m for 2010, up 81.3% on 2009's \$14.8m (which was reduced by a \$1.3m government contract billing rate adjustment).

In particular, fourth-quarter revenue was \$8.1m, up 158% on \$3.1m a year ago and up 12.1% on Q3's \$7.2m (exceeding the expected 7-10%, and the fifth consecutive quarter of double-digit growth).

On a non-GAAP basis, gross margin has risen further, from just 12% a year ago and 55% in Q3 to 56%. This boosted annual gross margin from 51% in 2009 to 55% in 2010.

Non-GAAP net loss for 2010 was just \$0.5m, cut from 2009's \$6.8m. In particular, Q4/2010 yielded a profit of \$0.6m, compared with \$0.3m in Q3 and a net loss of \$5.2m a year ago.

The firm also achieved its third consecutive quarter of positive adjusted earnings before interest, taxes, depreciation and amortization (EBITDA), up from +\$0.9m in Q3 to +\$1.2m, compared with a loss of -\$5.7m a year ago. This took annual adjusted EBITDA to +\$1.9m for 2010, compared with a loss of -\$6.3m in 2009, driven by both revenue growth and gross margin improvement.

"Over the past year we have consistently increased revenue each quarter, improved gross margin, achieved positive adjusted EBITDA and significantly strengthened our balance sheet to improve our overall financial position," summarizes chairman & CEO Dr Avi Katz. Cash and investments of \$4.5m at the end of Q4 are up on \$3.6m a year ago.

"We continued to gain market share, benefitting from the most comprehensive portfolio of electronic devices for fiber-optic high-speed communications available in the market today," claims Katz.

"We achieved several key product milestones during the year, while we continued to strengthen our leadership position as the industry's only pure-play semiconductor provider of optical products focused on enabling 40G and 100G networking systems," claims Katz.

"In line with our stated strategy of providing Bundled Solutions to customers to reduce their R&D costs and simplify their supply chain, we became the first company to offer a complete and cohesive solution set for their 40G and 100G DWDM electro-optical requirements consisting of driver, modulator and TIA," he adds.

Also during 2010, GigOptix transferred production of the industry's first Thin Film Polymer on Silicon (TFPS) optical modulator to contract manufacturing partner Samina-SCI in China and delivered the samples to tier-1 customers (in preparation for volume production ramping in 2011). "These modulators address the need by network operators for faster, smaller and lower-power solutions to handle their bandwidth demands," says Katz. "Moreover, we partnered with Innovative Micro Technology Inc (IMT) as our optical chip fabrication partner to support our future high-volume production requirements," he adds.

During 2010, GigOptix launched a portfolio of ultra-low-power multi-rate SMART receive optical sub-assemblies (ROSAs) and transmit optical sub-assemblies (TOSAs) targeting short-reach datacom applications, demonstrated at the European Conference and Exhibition on Optical Communications (ECOC 2010) in late September. The firm also achieved full production of 10G, 40G and 100G TIAs, and expanded its 100G DWDM portfolio to include single-channel, dual-channel and quad-channel 8Vpp Mach-Zehnder Modulator (MZM) drivers as well as single- and dual-channel 32Gb/s balanced linear TIAs.

"Having greatly expanded our portfolio throughout 2010, we now offer the broadest portfolio of industry-proven 100G solutions," Katz claims. "We also have an extensive roadmap for 100G solutions that are currently in development that will enable smaller and lower-power products... We are well positioned in the 40G and 100G markets to drive future revenue growth as we continue to secure new design wins and increase the adoption of our solutions by additional tier-1 customers," he adds.

Strategic mergers and acquisitions have been a key component of GigOptix's growth plan. "Our recent announcement to merge with Endwave Corp, an acknowledged leader in high-frequency RF solutions and semiconductor products for high-speed wireless mobile backhaul communications, is representative of these key principles," says Katz. "Both companies share a number of clear and unique synergies including complementary technologies, similar product architectures, as well as common customers and markets that are demanding increasingly more bandwidth," he adds. "Combining Endwave's extensive point-to-point microwave radio system knowledge and monolithic microwave IC (MMIC) product portfolio with GigOptix's portfolio of optical modulators and broadband amplifiers positions us to not only expand these market opportunities, but also enables us to increase our penetration of the existing customer bases and market segments. We will be able to offer solutions to both the high-speed optical and microwave RF front ends," Katz continues. "With these expanded capabilities, the combined company will be able to leverage Endwave's manufacturing and GigOptix's high-speed fiber-optic front-end technology to provide cutting-edge solutions for next-generation 100G and 400G drivers and electro-optic sub-

► systems." GigOptix expects the transaction to close in second-quarter 2011.

"Looking forward, we expect to strengthen our portfolio, enabling us to capitalize on more market opportunities as a result of the merger with Endwave," reckons Katz. "We will maintain focus on our successful strategy of being the leading industry provider of high-speed fiber-optic and mobile wireless communications solutions across all applications, all speeds, and all distances, from short reach to ultra long haul," he adds.

"We continue to invest our best efforts to be listed on a national securities exchange, and since the announcement of the transaction with Endwave, we have been in close contact with the management of the major exchanges," discloses Katz. "Our June 2010 conditional approval for NYSE Amex listing expired on 31 December. However, we are actively working on renewal of such position, and we hope to receive it subject to completion of the transaction, so we may be able to commence trading concurrent with the closing of the acquisition, which is expected to occur during the second quarter of 2011."

For first-quarter 2011, GigOptix expects product revenue to grow sequentially by 5%. "In terms of our government contract revenue, we have been recently notified that a number of government earmarks have been suspended, which is expected to impact approximately \$4m of our federal funding as part of the Department of Defense Appropriations Bill that we expected to realize throughout 2011," notes acting chief financial officer Jeff Parsons. "Our outlook for revenue from government contracts is difficult to forecast at this time, and we will not be providing guidance on this segment," he adds. "We continue to aggressively lobby the US Congress to reinstate the earmarks in order to gain continued federal support of our On-Chip Integrated Photonic Polymer Transceiver program."

www.GigOptix.com

GigOptix announces 40G & 100G TIA and MZ modulator design wins

GigOptix has received "significant orders" for both its GX3220 40G transimpedance amplifier (TIA) and GX62455 100G Mach-Zehnder (MZ) optical modulator driver devices from a number of new tier 1 customers.

The initial purchase orders should be delivered in first-half 2011, with the potential to generate significant additional revenue in second-half 2011 and into 2012.

"We are very happy to see our strategy of focusing on the high-growth 40G and 100G markets bearing fruit," says Pdraig O'Mathuna, VP of marketing. "As the only pure-play semiconductor vendor concentrating on the high-speed optical space, we have established a very strong product portfolio in both the 40Gb/s RZ-DQPSK and the 100Gb/s DP-QPSK markets and we have won new customers and grown market share over the last couple of quarters," he claims.

"We are unique in the industry by offering the only Bundled Solution comprised of a TIA, Thin Film Polymer on Silicon (TFPS) MZ modulator with a matched driver," he continues. "Our Bundled Solution provides customers with a mechanism to reduce engineering expenditures and accelerate time-to-market on new products, as well as an opportunity to leverage GigOptix's industry-leading low power solutions

with greater cost efficiencies."

The GX3220 is a low-power differential-input linear TIA designed for 40Gb/s RZ-DQPSK receiver applications with tunable frequency range enabling up to 32Gb/s, a high linearity and low harmonic distortion, and support for a variety of photodiodes. The GX62455 is a high-voltage-output 100Gb/s quad MZ modulator driver in a compact form-factor GPPO module that includes integrated low- and high-frequency chokes and requires no external components. Its connectors are designed to be form-factor compatible with industry-leading 100Gb/s multiplexer and modulators for simpler system integration.

"The 40Gb/s and 100Gb/s DWDM markets are among the fastest-growing segments in optical communications," notes Daryl Inniss, VP & practice leader at market research firm Ovum. "Operators are now upgrading their networks from 10Gb/s to 40Gb/s and 100Gb/s as they seek to address the increasing bandwidth demands from consumers," he adds. In its most recent report on optical components, Ovum forecasted that the 40Gb/s DWDM market would more than double and that the 100Gb/s DWDM market would grow with a compound annual growth rate (CAGR) of 250% over 2011-2015.

Demo of first production 40G DPSK TFPS MZ modulator and bundled solution driver

At OFC 2001, GigOptix demonstrated its 40G DPSK MZM and 100G driver DWDM Bundled Solutions:

- the LX8401 40G DPSK TFPS MZM optical modulator with low drive voltage in a small form factor, designed for long-haul and ultra-long-haul optical transponders;
- the GX62455, a low-power integrated quad channel 32Gb/s driver designed for 100G DP-QPSK long-haul optical transmitters.

GigOptix provides DWDM Bundled Solutions consisting of a TIA, TFPS MZ modulator and matched driver, reducing engineering expenditure, speeding time-to-market for new products and enables users to leverage its low-power solutions with enhanced cost efficiencies. Bundles will address 40G DPSK, 40G RZ-DQPSK as well as 40G and 100G DP-QPSK applications.

www.GigOptix.com

Luxtera launches CMOS-photonics-based optical engine

Luxtera of Carlsbad, CA, USA has announced its new optical engine chip-set supporting next-generation high-performance computing (HPC) and data-center optical connectivity. The optical engine launches Luxtera's chip-set product line as it transitions from the active optical cable (AOC) business to the semiconductor component business model.

The engine supports four fully integrated 14Gbps opto-electronic transceiver channels on a single CMOS chip. Targeted at next-generation InfiniBand, Ethernet, SAS and Fiber Channel applications, it marks the next step in Luxtera's delivery of a fully integrated, low-cost transceiver chip-set family spanning 10Gbps to 1Tbps.

Driven by next-generation CPUs and chipsets supporting PCI-Express 3.0, increasing server network performance requires faster interconnects to balance computing and storage resources and maximize system performance, says Luxtera. To meet this need, InfiniBand is migrating to 4x14Gbps FDR while storage applications are migrating to 4x12Gbps SAS and 16Gbps Fiber Channel data rates, exceeding practical limits of passive copper interconnect longer than a few

meters. In turn, this drives the need for next-generation, high-performance optical connectivity. Luxtera says that, by leveraging the benefits of its silicon CMOS photonics technology, its new optical engine meets this demand with low-cost and high-performance single-chip optical transceivers. Its LUX2020A optical engine will be incorporated into the AOC product family bought in January by Molex as part of Luxtera's transition to a fabless semiconductor chip-sets supplier business model.

"The introduction of Luxtera's optical engine marks the next step in advancement for QSFP AOCs," says Tom Marrapode, director of marketing, fiber optic products group, Molex. "We recently formed a strategic partnership with Luxtera that outlined a product roadmap to support faster data rates and new form factors," he adds. "Molex has been on the forefront of QSFP product family development from electrical connectors to copper and fiber cabling. Luxtera's new optical engine and its integration into Molex's optical transceivers extends our product family to next-generation data rates."

Luxtera's optical engine chip-set consist of a CMOS opto-electronic transceiver chip and a companion

photonic power source. The devices are based on silicon CMOS photonics technology that uses mainstream CMOS fabrication processes to deliver on-chip waveguide level modulation and photo-detection, along with associated electronics, resulting in a fully integrated single-chip optical transceiver. The technology uses a low-cost, highly reliable companion continuous wave (CW) laser, acting as a continuous supply of photons to the chip. This allows the sharing of a single light source across multiple transmitters and eliminates the need for faster, more expensive and higher-power-consuming directly modulated lasers. Luxtera says that, by using a silicon CMOS photonics technology platform, it is able to reuse its baseline technologies to deliver next-generation higher-speed products resulting in what is claimed to be best price-performance and superior reliability versus traditional VCSEL-based optics.

"The technology will be delivered to end users in multiple form factors via our collaboration with Molex and other packaging partners," says VP of marketing Marek Tlalka.

Luxtera will sample its new optical engine in second-quarter 2011.

www.luxtera.com

QSFP+ AOC assemblies for 40Gb/s over 4km reach

Fiber-optic interconnect firm Molex Inc of Lisle, IL, USA has launched its quad small-form-factor pluggable (QSFP+) active optical cable (AOC) assemblies, providing "the longest link distance and lowest power consumption on the market".

The assemblies — demonstrated at OFC 2011 — achieve 40Gbps data rates over reaches of up to 4km using only 0.78W per cable end. By improving overall data-center power consumption, extra ports can be deployed, boosting connectivity options and cost savings.

"They address our customers' high-density requirements while combining high data integrity with

low power consumption," says Tom Marrapode, director of marketing for Molex's fiber-optic products group. "The optical link budget of Molex's QSFP+ AOC supports multiple optical connectors within the optical cable, providing a unique opportunity to support a structured cable system in the user's facility," he adds. "This unique feature adds significant flexibility to the use and installation of QSFP+ AOC in lengths greater than 100m."

Adding to the high-performance capabilities is the use of CMOS photonics technology, which integrates most of the transceiver functionality onto a single chip, providing a low-

cost cable that delivers a reliable, long-reach solution, says Molex.

With four bi-directional optical data links per end (each operating at 1.0–10.3125Gbps), the QSFP+ AOC assemblies are compatible with multiple protocols including InfiniBand single (SDR), dual (DDR) and quad (QDR) data rates, Ethernet systems (10 and 40Gbps); Fiber Channel (8 and 10Gbps) and SAS (6Gbps). Molex also plans to release next-generation InfiniBand FDR data-rate AOC products based on low-power-consumption silicon photonics 56Gbps optical engine technology in third-quarter 2011.

www.molex.com

Bell Labs demos first fully integrated optical OFDM generator based on InP photonics integrated circuits

Alcatel-Lucent of Paris, France says that, at the Optical Fiber Communication Conference & Exposition/National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles, its research arm Bell Labs is demonstrating a range of next-generation technology advances addressing some of the most pressing challenges facing the optical industry: satisfying exponential growth in demand for network capacity and higher data rates while contending with increasingly severe technical limitations and cost constraints.

The solutions presented feature a range of techniques that enable the transmission of data at much higher bit rates and over longer distances than what is currently possible. This is accomplished by: applying higher-order signal modulation to achieve greater spectral efficiencies; heightening the sensitivity of optical receivers to a point approaching their fundamental limit; and exploiting new multimode transmission to increase the capacity of optical networks by orders of magnitude.

- Doubling spectral efficiencies — Spectral efficiency gains have been doubled to achieve a per line transmission rate of 256Gb/s over a distance of 400km, which is more than twice the rate achievable today with the 100Gb/s systems that are just coming on the market. The solution makes use of a high-powered electronic circuit that converts analog signals to digital and employs a 64-QAM (quadrature amplitude modulation) scheme.

- Achieving record modulation/receiver sensitivity — The technique halves the number of photons needed to transmit information and achieves a record degree of sensitivity by applying an advanced 16-ary-pulse-position-modulation scheme.

- Opening a new era of research in optical transmission — Alcatel-Lucent claims that this is the first demonstration of transmission over a new multimode fiber type that has the potential to increase the capacity of a single fiber strand by an order of magnitude. The demonstration takes advantage of advanced fiber design, digital signal processing, and sophisticated mode or core coupling.

Bell Labs also demonstrated what is claimed to be the first fully integrated optical orthogonal frequency division multiplexing (OFDM) generator based on photonic integrated circuits using indium phosphide (InP). It reckons that this is a key advance in making OFDM systems that are cost and power efficient enough for practical use.

Finally, Bell Labs presented specifications for new transport network protocols that will enable enterprises to more easily access large-scale data processing capabilities (high-performance computing) while facilitating outsourcing of their computing infrastructure (cloud computing). The firm demonstrated how network service providers will be able to maintain contracted levels of service for business applications delivered from the cloud using the new protocol specifications in conjunction with high-speed wavelength-switched optical network connections that can be configured on the fly.

Alcatel-Lucent reckons that these innovations represent significant advances in the evolution of optical transmission over the mid to longer term by being able to accommodate demand for increasingly higher transmission speeds required to meet rapidly increasing demand for bandwidth.

www.alcatel-lucent.com

IN BRIEF

Advanced Photonix completes shelf offering with a \$2.4m underwriting

Advanced Photonix Inc of Ann Arbor, MI, USA (which designs and makes silicon, InP- and GaAs-based photodetectors, subsystems, and terahertz instrumentation for telecom, homeland security, military, medical and industrial markets) has entered into an underwriting agreement with B. Riley & Co LLC providing for the sale of 1,200,000 shares of its Class A Common Stock at a purchase price of \$1.97 a share (minus an underwriting discount of \$0.1182 per share).

This follows an underwriting agreement on 6 January for the offering and sale of 2,702,703 shares at a purchase price of \$1.48 per share (\$1.391 per share, net of an underwriting discount of \$0.089 per share), plus an over-allotment option (exercised on 10 January) for the purchase of an 405,405 shares, raising net proceeds of about \$4.264m.

Sale of the shares is pursuant to a registration statement on Form S-3 (File No. 333-171390), filed with the US Securities and Exchange Commission (SEC) on 23 December and declared effective on 5 January.

"This final draw down of our existing shelf registration will be used for our general corporate purposes including (i) working capital needed to support the rapid growth of our HSOR [high-speed optical receiver] products in foreign markets, (ii) accelerated development and marketing of Terahertz applications, and (iii) capital expenditures needed to further automate our manufacturing processes, and increase our productivity," says CEO Richard Kurtz.

www.advancedphotonix.com

Infinera presents first Terabit photonic integrated circuit Coherent detection of 10x100Gb/s channels using QPSK format

At the Optical Fiber Communication conference (OFC) in Los Angeles (6–10 March), Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), presented the results of what it claims is the world's first 1 Terabit/second (Tb/s) PIC, representing another step in the evolution of PIC technology to higher levels of integration and higher data rates.

The talk '10 Channel, 100Gbit/s per Channel, Dual Polarization, Coherent QPSK, Monolithic InP Receiver Photonic Integrated Circuit' by Dr Radhakrishnan Nagarajan (Infinera research fellow and member of the PIC development team) described the structure and performance of a 1Tb/s PIC receiver. Integrating more than 150 optical devices on a single monolithic InP chip, the PIC uses the QPSK modulation format and coherent detection to receive and decode ten channels of 100Gb/s each.

In 2004, Infinera began shipping optical systems based on 100Gb/s PICs. In less than two years, Infinera systems seized first place in the North American long-haul optical networking market, according to data from independent analysts the Dell'Oro Group. Less than a week

ago, in partnership with pan-European service provider Interoute, Infinera announced the results of the latest field trial of its next generation of commercial PICs, which deliver 500Gb/s of capacity on a single pair of chips. Optical systems based on the 500Gb/s PICs are planned for commercial availability next year. The 1Tb/s PIC represents another leap forward in the evolution of photonic integration, says Infinera.

"With PICs, Infinera has applied the manufacturing techniques of the silicon industry to optics, and we expect we will be able to ride a long-term curve of more integration, greater functionality, higher data rates, and improved reliability, at the component level, system level, and network level," says Nagarajan.

With Internet traffic growing at exponential rates (driven by video, cloud computing and mobility), PIC technology will be required to support the growth of network capacity to accommodate this traffic, while reducing the per-bit cost, space, and power consumption, to enable service providers to carry the traffic while maintaining profitable business models, says Infinera. Photonic integration enables greater network reliability because connections between optical components are printed directly onto a chip.

From the point of view of network

architecture, Terabit PICs could enable the use of 'superchannels', or groups of data channels bonded together, to enable more efficient use of network resources and the optical spectrum. At the consumer level, a 1Tb/s PIC could enable the download of one high-definition movie file in a fifth of a second, or support the transmission of 2 million simultaneous videoconferences — all from a single pair of chips, the firm adds.

Also at OFC, in 'Polarization Multiplexed (D)QPSK InP Receiver Photonic Integrated Circuits', Nagarajan presented the use of advanced modulation schemes in PICs.

In addition, Infinera engineers addressed issues in the design and development of next-generation high-capacity systems:

- co-founder & chief strategy officer Dr David Welch spoke at the workshop 'Photonic Integration: More Technologies than Applications?'

- Han Sun and Kuang-Tsan Wu gave presentations on 'A Novel Dispersion and PMD Tolerant Clock Phase Detector for Coherent Transmission Systems'.

- co-founder & chief technology officer Drew Perkins participated in an Optical Internetworking Forum (OIF) panel on '400G vs 1 Terabit: Market Needs and Technical Challenges'.

www.infinera.com

Kish made IEEE Fellow; Welch receives John Tyndall award

At OFC, Dr Fred Kish, senior VP of the Optical Integrated Circuit Group, was made an IEEE Fellow for his contributions in the development and commercialization of monolithic large-scale InP PICs and high-efficiency LEDs.

Also, co-founder & chief strategy officer Dr David Welch received the 2011 John Tyndall Award from The Optical Society (OSA) and IEEE Photonics Society for "seminal contributions to photonic integrated



Kish (left) and Welch (right).

circuits and semiconductor lasers deployed in fiber optic communication systems around the world". The Tyndall Award is one of the

highest honors for individuals in the optical networking industry.

"These awards are recognition of the achievements of the entire Infinera team in developing our groundbreaking large-scale PICs, and we are focused on continuing to innovate and develop new products, technologies and architectures that can help our customers make the network of the future even more powerful, reliable, and economical," comments Welch.

First European PIC-based 100G transmission on subsea network

Communications network service provider Interoute Communications Ltd of London, UK and Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), have completed a demonstration of Infinera's new 500Gb/s PICs delivering 100Gb/s channels on the Interoute pan-European network (the first demonstration of Infinera's PIC-based 100Gb/s channels transmitted on a European network).

Interoute, whose pan-European network was the first in Europe to deploy Infinera's 100Gb/s PICs more than three years ago, is planning to use the firm's next-generation systems (based on 100Gb/s channels enabled by 500Gb/s PICs) to support Europe's demand for high-capacity bandwidth. Interoute's Next Generation Network is claimed to be the most advanced in Europe, and the firm is working closely with Infinera as the supplier brings to market a high-capacity solution based on coherent transmission of 100Gb/s channels.

Infinera's new 500Gb/s PICs each integrate five 100G channels. With the firm's FlexCoherent technology, the network operator can select the optimal modulation format to use for each route on the network, Infinera says. In the demonstration, the 100Gb/s channels were transmitted using PM-QPSK modulation and coherent detection to optimize for optical reach. Infinera's 500G PIC receivers use integrated local oscillators to enable coherent detection of the signals. The pair of 500G PICs integrates more than 600 optical devices, a tenfold increase from today's 100Gb/s PICs which are widely deployed in long-haul and metro networks worldwide.

In the demonstration, the 100Gb/s channels originated in Amsterdam and traveled under the North Sea to London, where they were looped

back and returned to Amsterdam (a total distance of 940km). The signals were received error-free, despite a lengthy unrepeated subsea link of 210km between the Dutch and English coasts. Each 100Gb/s channel is capable of carrying more than 200,000 simultaneous video conferences between London and Amsterdam (based on a standard-definition point-to-point video conference call at 512kb/s) or more than 1.5 million telephone conversations (based on a standard telephone call at 64kb/s).

The coherent 100Gb/s channels were transmitted on fiber simultaneously carrying 200Gb/s of live traffic over 10Gb/s channels, demonstrating that the Infinera Line System (ILS) can carry both types of optical signals without interference. Interoute plans to introduce PIC-based 100Gb/s channels next year.

"Interoute's network is used by all the major incumbents as well as thousands of international enterprises who rely on its resilient high-capacity and low-latency connectivity," comments Interoute's CEO Gareth Williams. "In the service provider market, Interoute is attracting an increasing number of operators looking to outsource part or all of their European networks; innovative technologies like Infinera's 500Gb/s PICs ensure that the network infrastructure is as advanced as Interoute's expertise needed to support these critical projects," he adds.

"Our next-generation solution will once again leverage the disruptive economics of PICs, offering a system with pervasive switched DWDM capacity throughout the network, superior network economics, and the ability for the end-customer to get any service deployed anywhere in the network with unbeatable speed of service delivery," claims Infinera's president & CEO Tom Fallon.

www.interoute.com

Terabit transmitter

At OFC/NFOEC, Infinera principal engineer Peter Evans presented a post-deadline paper on the demonstration of a Terabit PIC transmitter integrating ten wavelengths, each operating at 112Gb/s (totaling 1.12Tb/s).

The paper describes the use of narrow-linewidth lasers and dual states of polarization to achieve 112Gb/s per channel. Error-free transmission was achieved for all ten channels.

Terabit PICs will enable a move from 100Gb/s channels to Terabit channels. Implementation of Terabit FlexChannels (designed to leverage the fiber spectrum to achieve greater spectral density) should enable scaling to 25Tb/s. Large-scale photonic integration enables Infinera's FlexChannels, which are designed to implement Terabit channels more cost-effectively than conventional discrete-based optical networks because integrating large numbers of lasers and other optical components into PICs reduces the cost-per-bit of reaching high levels of fiber and system capacity. In an analyst briefing session, co-founder & chief strategy officer Dr David Welch cited an analyst estimate that Infinera has a four-year lead on the rest of the industry in its capabilities for the development and volume production of large-scale active monolithic PICs. "As we collapse layers in the network, PICs are the technology that enables us to deliver a digital optical network with unconstrained bandwidth throughout the network, pervasive, integrated switching, and the capability to deliver additional packet features cost-effectively," Welch said.

Infinera's 500Gb/s PIC should be commercially available in its systems next year. It plans to deliver systems based on PICs with 1Tb/s capacity or greater in future systems.

www.infinera.com

NeoPhotonics grows for eighth consecutive year to record \$184.1m revenue

Q4 margin hit by price reductions and products discontinuations

For fourth-quarter 2010, NeoPhotonics Corp of San Jose, CA, USA has reported record revenue of \$51.3m, up 9% on \$47.2m in Q3/2010 and up 19% on \$43.1m a year ago as demand for products to support network upgrades globally more than offset typical seasonality. This boosted full-year revenue to a record \$184.1m, up 19% on 2009's \$155.1m (the firm's 8th consecutive year of growth).

NeoPhotonics is a vertically integrated designer and manufacturer of photonic integrated circuit (PIC)-based components, modules and subsystems for bandwidth-intensive, high-speed communications networks. Products include III-V-based active semiconductor, silica-based passive PLC (photonic lightwave circuit) and silicon-based MEMS (micro-electro-mechanical system) multi-dimensional switching functions in a single product, with integration enabled by nanomaterials and nanoscale design and fabrication technologies. The firm has ISO 9001:2000 certified engineering and manufacturing facilities in both Silicon Valley and Shenzhen, China.

"Our strong financial performance demonstrates the positive demand we are seeing for our PIC-based technologies and products with the world's largest network equipment manufacturers," says chairman, president & CEO Tim Jenks.

"The rapid growth of content, including HD and 3D video, music, social networking, video conferencing and other multimedia, delivered over the wireless and wireline networks is driving a rapidly increasing demand for bandwidth," Jenks comments. "The demand for bandwidth is further intensified by the proliferation of network-attached devices, including tablet computers, that are enabling consumers to access bandwidth-intensive content anytime and anywhere over fixed

and wireless networks, including 3G and LTE networks," he concludes.

NeoPhotonics says that in 2010 it made significant progress qualifying new PIC-based product designs, ending the year with 97 cumulative, multi-year product family design-wins to its tier-one customer group (an increase of 17 product family design-wins since the end of 2009). The tier-one customer group includes each of the world's largest network equipment manufacturers, which collectively comprise about 90% of the global market for network equipment.

Of NeoPhotonics' 'speed and agility' PIC-based and other products (supporting transmission speeds of 10Gbps and above) as well as xOADMs and drop modules, in 2010 the firm launched both 40 and 100Gbps versions of an integrated coherent receiver using its proprietary hybrid PIC technology. It also launched a PIC-based 40Gbps optical demodulator for high-speed direct detection systems. Commercial shipments of both started in Q4/2010.

Of NeoPhotonics' 'access' PIC-based and other products providing high-bandwidth connections over fixed and wireless networks — including fiber-to-the-home or

fiber-to-the-premise (FTTx) networks — in 2010 the firm launched a pluggable version of its optical line terminal transceiver for the central office (which allows carriers to add bandwidth capacity by 'hot plugging' the product into a system line-card that may not have been fully populated at installation). It also launched a compact pluggable transceiver that integrates two fast Ethernet or gigabit Ethernet transceivers into the same form factor (allowing network equipment manufacturers to double the port density on line-card solutions). Commercial shipments of both started in Q4/2010.

On a non-GAAP basis, gross margin rose from 28.8% in 2009 to 31.7% for 2010. However, gross margin for Q4/2010 is down from 36% a year ago and 30.9% in Q3 to 28.3%, due mainly to negotiations completed with certain customers resulting in a decrease in product prices for those customers, excess and obsolete inventory expenses associated with certain products that were discontinued in the quarter, and an increase in the payroll tax rate in China. Quarter-to-quarter variability in gross margins is expected to continue, comments the firm.

Net income rose from just \$0.3m in 2009 to \$8.6m for 2010. However, although up from \$1.2m in Q3, net income of \$1.7m in Q4 almost halved from \$3.3m a year ago.

After the end of the quarter, this February NeoPhotonics completed an initial public offering of common stock, raising gross proceeds of \$94.9m (before underwriting commissions and offering expenses).

For Q1/2011, NeoPhotonics expects revenue of \$44–47m, and non-GAAP gross margin of 28–30% and net income of break-even to –\$0.8m.

www.neophotonics.com

The firm launched both 40 and 100Gbps versions of an integrated coherent receiver using its proprietary hybrid PIC technology. It also launched a PIC-based 40Gbps optical demodulator for high-speed direct detection systems. Commercial shipments of both started in Q4/2010

NeoPhotonics launches coherent receiver with integrated polarizing beam splitter

At the Optical Fiber Communication Conference and Exhibition/National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles (8–10 March), NeoPhotonics Corp of San Jose, CA, USA, which designs and manufactures photonic integrated circuit (PIC)-based modules and subsystems for bandwidth-intensive, high-speed communications networks, launched a PIC-based integrated coherent receiver (ICR) for 40 and 100Gbps dense wavelength division multiplexing (DWDM) transmission systems that incorporates an integrated polarizing beam splitter (PBS). The firm previously launched its initial ICR (without integrated PBS) at OFC/NFOEC 2010 in San Diego last March.

The new ICR is designed to eliminate the need for system designers to place a PBS externally, decreasing circuit board footprint requirements. The product supports the OIF Implementation Agreement for

Integrated Dual Polarization Intra-dyne Coherent Receivers. The ICR is designed to provide advanced demodulation to analyze the state-of-polarization and optical phase of a phase-modulated signal relative to an externally supplied optical reference signal, enabling recovery of the phase-polarization constellation of 100Gbps dual-polarization quadrature phase-shift keyed (DP-DQPSK) format signals.

"Key benefits of the NeoPhotonics ICR with an integrated PBS include that it allows customers to eliminate an external beam splitter from line-cards and simplifies fiber routing," says chairman & CEO Tim Jenks. "By using our photonic integration technology, we are able to integrate the PBS without changing the ICR form factor, streamlining the design-in process for our customers."

NeoPhotonics also offers PIC-based 90° hybrid coherent mixers and DQPSK demodulators.

* At OFC/NFOEC, NeoPhotonics' chairman & CEO Tim Jenks, together with a panel of industry peers, discussed the topic 'Where is the Optical Components Market Going?' at the 2011 OSA Executive Forum. Panelists evaluated technology developments, evolving customer needs, capital requirements and other elements that will impact business models in the reinvigorated optical components sector.

In addition, at OFC/NFOEC, David Piehler, Access Technology director at NeoPhotonics, gave two presentations, including an invited talk, on topics related to optical access networks:

- 'Next-Generation Components for Optical Access Networks';
- 'Implementing High [>2048] Split Ratios in any PON'.

NeoPhotonics also showcased a complete line of PIC-based and other products for access, metro, long-haul and other applications.

www.oiforum.com

NeoPhotonics' photonic integrated circuit products surpass 3 billion operating hours without field failure

NeoPhotonics says that its PIC products have accumulated more than 3 billion hours of operation without a reported field failure.

The firm has ISO 9001:2000 certified engineering and manufacturing facilities in both Silicon Valley and Shenzhen, China.

Since 2003, the firm has shipped more than 240,000 PIC modules for deployment in telecoms networks worldwide, including thermally stabilized arrayed waveguide gratings (AWGs), athermal AWGs, coherent mixers for 40 and 100Gbps coherent systems, and splitters for FTTH PON networks. Together, these products have operated in the field for more than 3 billion hours. Without reported field failures, the upper limit on the FIT rate of NeoPhotonics' PIC

products is 0.3. A FIT rate of 1 represents one failure in 1 billion hours of operation.

"Reliability has been one of the most important characteristics of our products, and our design for reliability starts with the beginning of product development," says CEO & chairman Tim Jenks. "With the accelerating deployment of 100Gbps data transmission, a single 40-channel AWG deployed several years ago may soon be carrying a few trillion bits of information every second. At those data transmission volumes, a single point of failure in a network could disrupt tens of millions of individual phone calls and other data flows, and our customers look to NeoPhotonics to provide the reliability necessary to minimize

the risks of these types of field failures," he adds.

"NeoPhotonics designs its products for reliability by subjecting design elements to highly accelerated stress testing (HAST), carrying out Telcordia qualification testing its products, and conducting ongoing reliability testing (ORT) on production samples during the product's life cycle," says Dr Wupen Yuen, VP of R&D. "Because our PIC products integrate many functions into a single optical chip, thereby eliminating many interconnection and packaging elements, we believe we are able to achieve much higher product reliability than is possible with comparable products made of non-PIC discrete components."

www.neophotonics.com

Oclaro launches third-gen 40G PM-QPSK transponder; samples receiver & modulator for coherent modulation

At the Optical Fiber Communication Conference and Exhibition/National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles (8–10 March), optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA launched the MI 5000XM, its third-generation 40G PM-QPSK transponder, which features an integrated modulator, receiver and what is claimed to be the industry's first single-chip application-specific integrated circuit (ASIC) solution for enabling coherent detection.

The firm also announced the sampling of a new coherent receiver and 40G PM-QPSK modulator that enable users to build their own coherent-based transponders or line-cards for delivering higher performance and longer reach in fiber-optic networks.

There are three dominant 40G modulation formats generally used in networks currently: DPSK (differential phase-shift keying), DQPSK (differential quadrature phase-shift keying), and PM-QPSK (polarization-multiplexed quadrature phase-shift keying). Oclaro says that PM-QPSK, coupled with coherent detection and digital signal processing, provides a cost-effective way for optical signals to reach longer distances with compensation for large amounts of optical impairments such as chromatic dispersion and polarization mode dispersion. The solution also provides a stepping stone to future 100G networks that will be based entirely on coherent detection.

Oclaro claims to be the leader in volume shipments of 40G DPSK line-side 300-pin transponders and is now the first firm to deliver a coherent transponder solution incorporating the MUX, A/D and DSP functions in a single ASIC chip (developed in partnership with mixed-signal IC design firm ClariPhy Communications Inc of Irvine, CA, in which Oclaro invested last May).

Oclaro reckons that, along with its existing portfolio of components and modules, it has now established a leadership position in 40G high-bit-rate products and is well positioned to become the leading supplier for 100G deployments. In future, the firm will continue to deliver products for all 40G modulation formats, and will provide the flexibility of purchasing complete transponder solutions or individual components.

"The explosive growth of the Internet is driving an insatiable 'need for speed' in the core network — and this is where Oclaro is focused," says chief technology officer Andy Carter. "This third generation of 40G coherent solutions will allow service providers to deploy highly scalable and flexible future-proof architectures, and this is just the next step towards delivering the 100G speeds that will be required in the future," he adds.

By extending its family of 'plug-and-play' transponder solutions, Oclaro says that it is offering rapid time to market with an optimized coherent solution. The MI 5000XM delivers what is claimed to be best-in-class OSNR (optical signal-to-noise ratio) performance, lowest power consumption and highest chromatic

and polarization-mode dispersion tolerance in the industry. The transponder is designed to work in both dispersion-managed and unmanaged solutions and can support distances up to 3000km without dispersion compensation. The MI 5000XM (part of Oclaro's plug-and-play 40G portfolio) can be used directly on blades already designed for an Oclaro transponder module, and uses an industry-standard i2c command-set and provides fully autonomous set-up and control.

In addition, for companies wishing to build their own coherent transponders, Oclaro is now sampling a 40G coherent receiver and the new lithium niobate PM40 modulator, which is based on Oclaro's PM100 modulator (launched last September to support 100Gb/s optical network applications) but is designed on a less complex chip technology to deliver much lower product costs.

The PM40 modulator and the 40G integrated receiver are currently sampling to customers, and general availability is planned for this summer. The MI 5000XM transponder will be sampling in April, with general availability planned for second-half 2011.

www.oclaro.com

Oclaro executives present at OFC/NFOEC

At OFC/NFOEC 2011, Oclaro executives presented on three panels, including the following:

- OSA Executive Forum Panel 4 — 'Where is the Optical Components Market Going?': Speaker — Alain Couder, president and CEO;
- OFC MarketWatch Panel III — '100G Ecosystem: Enabling Technology and Economics': Speaker: — Terry Unter, president & general manager, Optical Networks Solutions;
- OFC Workshop on 'Optical Start-

ups — 10 Years After the Bubble': Speaker — Yves LeMaitre, executive VP of Strategy and Corporate Development.

Also at OFC/NFOEC, Dr Norman Swenson, chief technology officer of mixed-signal digital signal processing IC design firm ClariPhy Communications Inc of Irvine, CA, USA (in which Oclaro has a stake), chairing a panel discussing recent progress from 10Gbps to 100Gbps, and future challenges addressing rates above 100Gbps.

Analog Devices unveils first 11Gbps and 6Gbps integrated optical receivers

At March's Optical Fiber Communications Conference & Exposition (OFC 2011), Analog Devices Inc (ADI) of Norwood, MA, USA, which provides semiconductors for signal processing applications, has introduced what it claims is the first commercially available 11Gbps and 6Gbps integrated optical receivers.

Manufactured on ADI's proprietary XFCB high-speed complementary bipolar process on bonded silicon-on-insulator (SOI), the 6Gbps ADN3000-06-50 and 11Gbps ADN3000-11-35 integrated optical receivers (which have detector sizes of 50µm and 35µm, respectively) integrate a germanium photodiode with a transimpedance amplifier to reduce system component count to one device and cut power consumption by at least half compared with current solutions, it

is claimed. They consume only 65mW while running on a single 3.3V power supply offering typical sensitivity of -19dBm OMA (optical modulation amplitude) at 6Gbps and -17dBm OMA at 11Gbps.

The monolithic approach eliminates photodiode-to-TIA (transimpedance amplifier) wire bonds, allowing for a fully characterized solution that reduces design complexity and improves design reliability in fiber-optic networks (since a fully characterized interface between the photodiode and the TIA guarantees stability without worrying

The monolithic approach eliminates photodiode-to-TIA wire bonds, allowing for a fully characterized solution

about bond wires). No separate tests are required for the TIA and photodiode, while a single, fully tested die solution also reduces cost.

The new optical receivers are fully compatible with normal incidence, standard telecom and datacom ROSAs (receive optical subassemblies) used currently. No additional components are needed inside the ROSA. The devices are also wavelength agnostic, working across all key optical wavelengths including 850nm, 1310nm and 1550nm. ADI says that the technology is extensible to multi-channel devices and will allow high-performance optical communications links to migrate to higher-volume applications, such as active optical cable (AOC) and high-performance computing.

www.analog.com/ADN3000

POF-PLUS reports Gigabit transmission

At the Optical Fiber Communication conference (OFC 2011) in March, POF-PLUS presented results of its research into and development of commercially viable technologies for transmission at Gigabit speeds over plastic optical fiber (POF).

Launched in January 2008 and sponsored by the European Union, the three-year POF-PLUS project is supported by some of Europe's largest telecom operators. Members of the POF-PLUS research consortium include: Eindhoven University of Technology, Firecomms, France Telecom, Fraunhofer Institute for Integrated Circuits, project manager Institute Superiore Mario Bella (ISMB), POF Application Center (POFAC), Lucent S.p.A., Politecnico Di Torino, Rossetta IP and Telecom Italia

The POF-PLUS project develops new photonic components and transmission technologies for large core POF systems, aiming at the unprecedented implementation of

tens of Gbps transmission over this medium. The project targets next-generation home networks and optical interconnects in short-reach broadband connectivity applications, including storage area networks (SAN), enterprise communications, and consumer displays for uncompressed video (e.g. HDMI).

At OFC, POF-PLUS consortium members Firecomms, Lucent and Rosetta IP gave live demonstrations of Gigabit Ethernet transmission using media converters. Member organizations Fraunhofer Institute for Integrated Circuits and POF Application Center (POFAC) showcased novel developments of the new Gigabit transmission technology on the Plastic Optical Fiber Trade Organization (POFTO) booth 2615. The development of parallel optical transceivers for transmission of multi-gigabit transmission speeds was also featured on the POFTO booth.

Also, in the POF Symposium, a full overview of the results of the Gigabit transmission project was given in a presentation by professor Roberto Gaudino of the Politecnico di Torino. The presentation was concluded by Hugh Hennessy, VP of sales & marketing of Firecomms Ltd of Cork, Ireland (a manufacturer of transceivers for POF), with a discussion of the roadmap to commercial deployment of Gigabit technology.

"For several years major operators across Europe have deployed POF in home networks because of the simplicity and ultra-thin nature of POF," says Firecomms' chief technology officer John Lambkin. "With these presentations, POF-PLUS is demonstrating how POF home networks, with guaranteed reliability and the lowest maintenance costs, are future-proofed for the next 20 years or more."

www.ict-pof-plus.eu

www.ofcnoec.org

Opnext gives live demonstrations at OFC/NFOEC

At the Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles (8–10 March), optical module and component maker Opnext Inc of Fremont, CA, USA displayed multiple demonstrations on the exhibit floor, including:

- the first live technical feasibility demonstration of a CFP MSA (multi-source agreement) 100GBASE-ER4 client-side module running at 40km over single-mode fiber at OTU4 data rate (111.8Gbps);
- a next-generation 300-pin 40Gbps DPSK line-side module in a 3.5" x 4.5" small form factor, suited to high-port-density applications (Opnext claims to be is one of the leaders in shipments of DPSK line-cards and line-side MSA modules);
- the firm's newest 40Gbps technology in a QSFP+ (quad small-form-factor pluggable plus)

module — the QSFP+ 40GBASE-LR4 uses 4x10G CWDM integrated optics to transmit 40GbE traffic over 10km of single-mode fiber; and

- a tunable TOSA (of compact size for XFP module applications) showing wavelength tuning of an internally designed new tunable laser to deliver stable wavelength control.

Opnext also participated in the Ethernet Alliance Interoperability demo, showcasing a live demonstration of some of the latest products developed for use in next-generation data centers.

In addition, Opnext display samples included its 100Gbps DWDM single-wavelength PM-QPSK coherent module.

"Opnext continues to invest in the 40Gbps and 100Gbps products and technologies that will enable our customers to provide cost-effective networking solutions to their

customers," says chairman & CEO Harry Bosco. "Close partnerships with our customers are essential as we address the expanding bandwidth requirements and the technical challenges these requirements present in optical networking," he adds.

Also, Opnext representatives participated in the OFC/NFOEC conference program, including:

- MarketWatch, 'Panel III: 100G Ecosystem: Enabling Technology and Economics', Ross Saunders (Opnext Subsystems);
- Ethernet Alliance Panel, 'Panel 1: The Future of Higher Speed Ethernet', Jon Anderson (Technical Marketing);
- Poster Presentation, 'Demonstration of World-First 103Gbits Transmission over 40km Single Mode Fiber by 1310nm LAN-WDM Optical Transceiver for 100GbE'.

www.ofcnfoec.org

Opnext demonstrates 40GBASE-LR4 QSFP+ transceiver module for 40 Gigabit Ethernet over 10km single-mode fiber

At OFC/NFOEC 2011, Opnext demonstrated its quad small-form-factor pluggable plus (QSFP+) transceiver module (which will enter production in second-half 2011).

Existing QSFP+ modules primarily support multimode applications (with a 100m limitation), making the single-mode QSFP+ the next logical addition. Opnext's 40GBASE-LR4 QSFP+ module uses single-mode optics to transmit 40GbE traffic over a distance of 10km.

The 40GbE QSFP+ module extends Opnext's existing 40G family of products, which includes the 40GBASE-LR4 module in the larger CFP form factor (which is seeing initial deployments in customer systems now and has just been announced as production released). 40GBASE-LR4 technology offers OEMs a lower-cost,

longer-reach alternative to traditional 40G Sonet/SDH client interfaces and makes 40G deployments more economically viable in high-speed switches and edge routers, says Opnext.

The QSFP+ 40GBASE-LR4 transceiver module is the newest technology for OEM next-generation systems where industry leaders are

As QSFP+ emerges as the standard for 40GbE, adapting the technology to longer-reach single-mode applications enables our customers to increase their network speed, realize higher port density and lower overall power consumption

eager to extend reach, increase speed and lower their customers' overall power consumption in support of large data-center and enterprise applications, says Opnext. Moving to 40GbE QSFP+ also significantly improves port density.

"As QSFP+ emerges as the standard for 40GbE, adapting the technology to longer-reach single-mode applications enables our customers to increase their network speed, realize higher port density and lower overall power consumption," says Rich Zoccolillo, president of Opnext's pluggables business unit.

"With the QSFP+ 40GBASE-LR4 transceiver module, Opnext is building on its existing leadership in high-speed, single-mode transceivers and optical integration," he adds.

www.opnext.com

Opnext demos tunable TOSA delivering wavelength stability

At OFC/NFOEC, Opnext demonstrated its integrated tunable TOSA (transmission optical sub-assembly), highlighting automatic wavelength tuning designed to deliver stable wavelength control.

The tunable TOSA has been designed in-house specifically to help to reduce wavelength inventories and address wavelength needs and time-to-market requirements, says Tadayuki Kanno, president of Opnext's module business unit.

Developed in collaboration with Hitachi's Central Research Laboratory (CRL), the tunable TOSA is a hybrid design that combines the tunable laser and indium phosphide Mach-Zehnder (InP-MZ) chips to offer optical shutter functionality. It delivers system performance to address mode-hopping for optimized wavelength stability in a

variety of DWDM applications, says Opnext. In addition, the design can flexibly support negative chirp or zero-chirp dense wavelength division multiplexing (DWDM) applications to replace DWDM-XFP or 300-pin tunable transponders.

"Network equipment manufacturers are rapidly deploying tunable XFPs over 300-pin transponders because they are smaller and more cost effective," says market research firm Ovum's VP & practice leader Daryl Inniss. "We project tunable XFPs to grow at a compounded annual growth rate of over 50% from 2010 through 2013; they represent one of the fastest-growing market segments in the optical component space," he adds.

Working samples of the tunable XFP will be available in June, with mass production planned for late fall.

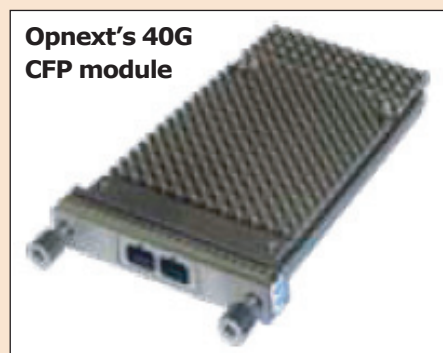
Opnext announces production release of 40GBASE-LR4 CFP transceiver

Opnext has announced the production release of its TRC5B20 40GBASE-LR4 CFP transceiver, a pluggable module capable of transmitting and receiving 40 Gigabit Ethernet (40GbE) and OTU-3 traffic over reaches of up to 10km on single-mode fiber.

Opnext says that the transceiver's multi-rate and multi-protocol capability enables greater flexibility in system design for connecting high-speed switches and routers, as well as large data centers where the 100m reach of multimode fiber is insufficient.

With the release of the IEEE-802.3ba standard published last June, interest in new 40GbE and 100GbE transceivers has increased dramatically, says Opnext, and system vendors are already working on releasing next-generation products supporting this standard.

The firm says that, using its



expertise in developing low-power distributed feedback (DFB) lasers, the 40GBASE-LR4 transceiver design has uncooled CWDM (coarse wavelength-division multiplexed) DFB lasers that deliver superior performance while consuming less power. 40GBASE-LR4 technology offers OEMs a lower-cost, longer-reach alternative to traditional 40G Sonet/SDH client interfaces and makes 40G deployments even more economically viable in high-speed switches and edge routers, adds the firm.

IN BRIEF

Opnext launches next-gen 40G DPSK line-side module

At the Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles (8-10 March), Opnext launched its next-generation 40G differential phase-shift keying (DPSK) multi-source agreement (MSA) module.

The OTM-440S is a 300-pin module in a 3.5" x 4.5" small-form-factor mechanical package and is designed for metro, regional and long/ultra-long-haul optical transmission applications. Complementing the existing OTM-440 module (currently in volume production), it will be available starting in second-quarter 2011.

The OTM-440S is compatible with 50GHz reconfigurable optical add-drop multiplexer (ROADM) technologies and, combined with tunable dispersion compensators (TDCs), can be readily deployed in dense wavelength division multiplexing (DWDM) networks engineered for 10G non-return-to-zero (NRZ) modulation formats. With its smaller form factor and lower power consumption, the OTM-440S suits applications requiring high port density.

"We have invested in the next-generation DPSK module with a focus on reducing the form factor and power consumption," says Mike Chan, president of Opnext's subsystems business unit and executive VP, business development & marketing.

According to optical communications market research firm LightCounting, 40Gbps DPSK modules played a significant role in growing the DWDM market segment by more than 40% in 2010.

www.opnext.com

Finisar offers to acquire Ignis

Tunable laser targeted for 10Gbps tunable 300-pin and XFP products

Fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has entered into a transaction agreement to make a recommended voluntary public cash offer to acquire all of the outstanding shares of Ignis ASA of Oslo, Norway not currently owned by Finisar for NOK8 per share, or an aggregate purchase price of up to about NOK425m (\$76m).

Finisar has also just acquired a total of 18.3 million Ignis shares from certain existing Ignis shareholders, for NOK8 per share (a total of NOK147m, or \$26m). This brings Finisar's total ownership to about 25.7 million shares (32.6% of the outstanding Ignis shares on a fully diluted basis).

Listed on the Oslo Stock Exchange, Ignis provides optical components and network solutions for fiber-optic communications. It operates globally through four subsidiaries: Syntune in Sweden, Ignis Photonyx in Denmark, SmartOptics in Norway, and Fi-ra Photonics (71.8% owned) in Korea. The firm's product and services portfolio comprises passive optical components including optical chips, splitters and multiplexers, active optical components such as tunable lasers and modulators, and WDM-based solutions enabling the building of high-capacity optical networks.

"Ignis has developed many innovative new technologies and currently offers multiple industry-leading products that are focused on attractive growth markets," says Finisar's CEO Eitan Gertel. "This acquisition represents an extension of our vertical integration strategy," he adds. "Ignis has developed, amongst other of its product technologies, a tunable laser that is integrated with a modulator and a semiconductor optical amplifier (SOA) and that Finisar believes has the highest performance currently

available in the market." The tunable laser will be used in Finisar's 10Gbps tunable 300-pin and tunable XFP product lines. Finisar estimates that the combined worldwide market for these products will be about \$250m in 2011 and will grow to \$400m in 2015.

"This acquisition will also enable us to offer our customers a number of new 40/100Gbps products based on advanced optical device integration technologies from Ignis' various business units," Gertel says. "We look forward to working with the Ignis employees to grow our combined business," he adds.

"Our unique technologies and innovative solutions are the base of the product platform we offer to a wide range of markets and customers around the world," says Ignis' CEO Thomas Ramm. "We have developed a strong collaborative relationship with Finisar and its employees over the years and believe that our two companies share a common culture focused on innovation... Finisar represents a strong strategic fit for Ignis."

The offer price represents a premium of 58.4% over the closing share price of Ignis on 21 March (the last trading day prior to Finisar's public announcement of its intention to make the offer) and a premium of 61.5% over the adjusted volume weighted average market price for the three month period preceding the announcement.

Certain Ignis shareholders, including all members of its management and board owning shares, have committed to accept the offer subject to certain conditions. The shares that have been committed on these terms represent about 19.7% of the outstanding shares of Ignis on a fully diluted basis and, together with the shares currently owned by Finisar, would total about 52.3% of the outstanding shares. NOK80m (\$14m) of the consideration to be paid to certain of these shareholders will be subject to an escrow arrangement related to Ignis' acquisition of SmartOptics Holdings AS last December and will be released to the former SmartOptics shareholders only upon the achievement of certain financial and other milestones related to the ongoing operations of the SmartOptics business.

Finisar has been informed by Ignis that another party has recently made an offer to acquire Ignis and that, after considering both offers, Ignis' board of directors has adopted a resolution to recommend Finisar's offer to its shareholders. An offer document setting forth the terms of Finisar's offer will be distributed to all Ignis shareholders following review and approval by the Oslo Stock Exchange (expected in late March or early April). The Ignis board will issue a formal statement regarding Finisar's offer as soon as the offer document is available.

Completion of the offer will be subject to the satisfaction or waiver by Finisar of customary conditions, including acceptance of the offer by the holders of at least 67% of the outstanding Ignis shares on a fully diluted basis. The transaction is not expected to require approval by competition or antitrust authorities in any jurisdiction. The offer will not be subject to any financing conditions and will be funded from

Ignis has developed, amongst other of its product technologies, a tunable laser that is integrated with a modulator and an SOA and that Finisar believes has the highest performance currently available

► Finisar's existing cash resources. The offer and resulting purchases are expected to close early in Finisar's fiscal first-quarter 2012 (ending 31 July 2011).

Ignis' revenue of NOK68m for the quarter to end-December 2010

(NOK88m on a pro forma basis, including the operations of SmartOptics). Finisar expects the acquisition to be dilutive to its non-GAAP earnings per share by about \$0.02 per share in its fiscal first-quarter but, subject to the achievement of anticipated synergies, to be accretive within a year following the closing.

The transaction agreement provides that the board of directors of Ignis may withdraw its recommendation only if it receives a competing offer that it considers to be more favorable to Ignis' shareholders than Finisar's offer. Under certain circumstances, including the withdrawal of the board's recommendation and the subsequent lapse of Finisar's offer, Ignis would be required to pay a break-up fee of \$1.5m to Finisar.

In connection with the transaction agreement, Finisar has agreed to provide Ignis with a bridge financing facility under which it may borrow up to \$3m after 15 April for working capital purposes. Loans under the facility will bear interest at the rate of 5% per annum, will be secured by certain assets of Ignis, and will be payable on 31 December 2011.

www.ignis.com
www.finisar.com

Finisar has been informed by Ignis that another party has recently made an offer to acquire Ignis and that, after considering both offers, Ignis' board of directors has adopted a resolution to recommend Finisar's offer to its shareholders

Finisar grows 57.6% year-on-year to record quarterly revenue of \$263m Margins hit by shortage of wafers for VCSELS

For its fiscal third-quarter 2011 (to end January), fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has reported another revenue record for continuing operations of \$263m, exceeding the guidance of \$247–262m (and up 9.2% on \$240.9m last quarter and 57.6% on \$167m a year ago).

Growth was driven primarily by demand for 40Gbps transponders, wavelength selective switches (WSS) and reconfigurable optical add-drop multiplexer (ROADM) line-cards. Of the \$22.1m increase in revenue from last quarter, sales rose just \$0.3m (7.4%) for products for analog and cable TV applications and \$2.6m (2.8%) for less than 10Gbps products, but as much as \$10.4m (9.7%) for 10Gbps or faster products and \$8.8m (22.7%) for WSS/ROADM line-card products.

"We achieved new company records for quarterly revenues, non-GAAP operating income and non-GAAP net income during the quarter," says CEO Eitan Gertel.

On a non-GAAP basis, gross margin rose from 32.2% a year ago to 34.7%, reflecting a favorable shift in product mix and a reduction in manufacturing unit costs due to higher shipment volumes. However, this is down on 35.5% last quarter as a result of unexpected under-utilization in the vertical-cavity surface-emitting laser (VCSEL) fabrication facility in Allen, TX due to a shortage of wafer availability.

Non-GAAP operating expenses have risen from \$39.7m a year ago and \$44.6m last quarter to \$46.4m, but fallen as a percent of revenue from 23.8% a year ago and 18.5% last quarter to 17.7%, due mainly to revenue growing faster than expenses. Operating income has hence risen from \$14.2m (8.5% of revenue) a year ago and \$40.9m (17% of revenue) last quarter to \$44.7m (17% of

revenue). Net income has risen from \$11.5m a year ago and \$38.3m last quarter to \$42.5m.

On 27 December, Finisar raised net proceeds of \$117.9m from a common stock offering. Also during the quarter, Finisar repaid \$17.3m of bank debt associated with its Asian subsidiaries. So despite this, plus capital expenditure of \$19m (up from \$13.4m last quarter), cash and cash equivalents rose from \$184.9m to \$310.2m.

However, Finisar says that, during fiscal fourth-quarter 2011 (to end April), it will be impacted by the full three months of the annual price negotiations with telecom customers that typically take effect on

We achieved new company records for quarterly revenues, non-GAAP operating income and non-GAAP net income... Net income has risen from \$11.5m a year ago and \$38.3m last quarter to \$42.5m

1 January, the 10-day-long shutdown at certain customers for Chinese New Year in February, the adjustment of inventory levels at some telecom customers (particularly for

products that had previously been on allocation and long lead times, including WSS and ROADM line-cards), and a slowdown in business in China overall. The firm hence expects a drop in revenue to \$235–250m, and in non-GAAP operating margin to 13–15%.

"We continue to execute on our new product development programs, including tunable XFP, to generate a significant pipeline of products, which we expect will enable us to win new opportunities with customers and expand our market share," says Gertel.

Finisar demonstrates 80km 10G SFP+ transceiver and industry's first 4x25G DFB-based CFP modules as it launches industrial-temperature SFP+ transceivers

At March's Optical Fiber Communication conference (OFC), component and subsystem maker Finisar Corp of Sunnyvale, CA, USA gave several transceiver demonstrations.

The industry's first demonstration of a 4x25G DFB-based CFP optical transceiver showed two 100G Ethernet (100GE) CFP modules transmitting IP packets error-free at 103.1Gb/s over 20km of single-mode fiber, greatly exceeding the 10km maximum distance standardized by IEEE's 100GBASE-LR4 for this application. Finisar also demonstrated an 80km 10G SFP+ transceiver for telecom client and metro applications. It also launched a family of industrial temperature (-40°C to 85°C) SFP+ transceivers, targeting wireless applications.

● 4x25G DFB-based 100GE CFP modules for 100Gb/s Ethernet

The 100GE CFP prototype modules are based on four DFB lasers running at 25.8Gb/s each, and are fully compliant with the CFP multi-source agreement (MSA) and 100GBASE-LR4 (4x25Gb/s) optical interface of the IEEE 802.3ba standard. By using integrated transmitter optics based on directly modulated 4x25G DFB lasers, Finisar's second-generation CFP modules offer a significant decrease in both power dissipation (12W) and cost compared with firm's first-generation 100GE LR4 CFP module (which is already in full production and shipping in volume).

"We are on track with the development of our next generation of 4x25G CFP transceiver modules," says Christian Urricariet, director of product marketing for high-speed optics. "This technology represents a fundamental breakthrough, enabling a new generation of standards-based 100GE modules," he believes. "Compared to other competing solutions, these modules will be more power efficient, more cost effective, and will enable a new generation of higher-density systems based on 100GE."

● 80km 10G SFP+ transceiver for telecom client and metro

Finisar also demonstrated its new multi-rate transceiver (designed for 80km 10G telecom client and metro applications, including SONET LR-2, OTN P1L1-2D2 and 10G Ethernet ZR), showing 10.7Gb/s error-free transmission over 80km of single-mode fiber, as well as transmitter jitter generation within the SONET requirements at 10.7Gb/s. The transceiver uses an internal CDR (clock & data recovery) to improve the signal integrity, enabling users to design SFP+ line-cards with a higher number of ports and longer traces between serializer/deserializer (SerDes) chips and transceiver ports.

The 80km 10G SFP+ has the same performance as its equivalent XFP transceiver, but with 1.5W lower power consumption and a smaller footprint. The new transceiver extends Finisar's 10G SONET/SDH/OTN SFP+ product family, enabling telecoms systems firms to deploy high-density next-generation 10Gb/s platforms.

● Industrial-temperature 10G SFP+ transceivers

Finisar launched a new family of industrial-temperature (I-Temp) 10G SFP+ transceivers for applications such as access backhaul, wireless (LTE) and other outside-plant equipment. The I-Temp transceiver family includes a 300m SFP+ SR (short reach), a 10km SFP+ LR (long reach), and a 40km SFP+ ER (extended reach) module. The 10km SFP+ LR transceiver is in production now, while the 300m SFP+ SR and 40km SFP+ ER transceivers will both sample in second-half 2011.

"Our engineering investments in these next-generation technologies demonstrate Finisar's commitment to the transceiver market," says VP of marketing Rafik Ward, who says the firm offers a complete portfolio of products across different data-rates, applications and form factors.

● Finisar demos first 1x9 WSS with Flexgrid technology

At OFC, Finisar gave what it claims is the first public demonstration of a 1x9 WSS (wavelength selective switch) with Flexgrid technology, part of the firm's reconfigurable optical add-drop multiplexers (ROADM) portfolio. The new 1x9 WSS with Flexgrid technology (which is shipping now) has been designed to enable telecoms carriers to migrate to higher data rates, including 400Gb/s and beyond, without replacing deployed WSS modules.

Finisar says that its Flexgrid technology is unique in its ability to allow carriers to dynamically change channel spacing to precisely match the required signal bandwidth with minimal wasted optical spectrum. Specifically, existing ROADM deployments concentrate on fixed 50GHz channel spacing, which can support data rates up to 100Gb/s. By leveraging adjustable channel spacing from 50 to 200GHz in spacing increments of 12.5GHz, Flexgrid enables carriers to efficiently carry all future transmission formats up to 1Tb/s on existing ROADM infrastructure, at whatever bandwidth these signals may require.

A key aspect of the demonstration is the flexibility and performance of Liquid Crystal on Silicon (LCoS) technology, which serves as the architectural foundation for Finisar's WSS platform. The LCoS architecture enables Flexgrid technology to be implemented through firmware and calibration changes alone. Furthermore, existing ITU standard 50GHz and 100GHz grids are fully supported, with no performance penalty. "Flexgrid is the critical technology that will allow tier-one carriers to efficiently deploy next-generation networks," believes CEO Eitan Gertel.

www.finisar.com



38th International Symposium on Compound Semiconductors – ISCS 2011

23rd International Conference on Indium Phosphide and Related Materials – IPRM 2011

Following the last year's success in Takamatsu, Japan, in 2011 **Compound Semiconductor Week** brings together 2 conferences **in Berlin, Germany, on May 22 – 26, 2011**

38th International Symposium on Compound Semiconductors (ISCS)

- Crystal growth and deposition techniques
- Oxides and carbon related materials
- Nanotechnologies and nanostructures
- Physics, simulation and characterization
- Light emitters and detectors
- High frequency and high power electronics
- Novel device concepts (spintronics, metamaterials, nanowires)
- Sensors and actuators

23rd International Conference on Indium Phosphide and Related Materials (IPRM)

- Bulk materials and epitaxy
- Nanostructures and novel materials
- Optoelectronics and related processing technologies
- Electron devices and related processing technologies
- Photonic integration technologies

Plenary Speakers:

Andre Geim (Nobel Laureate in Physics 2010) - University of Manchester: „Graphene“

Connie Chang-Hasnain - University of California, Berkeley: „Novel Nanophotonic Devices“

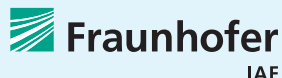
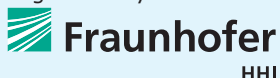
Meint Smit - Technical University Eindhoven: „A new era for InP-based photonics“

Rump session:

Semiconductor Quantum Dots for Electronics and Photonics: Promises and Accomplishments
organized by Dieter Bimberg, Technical University Berlin

Registration for attendees and exhibitors is open at: www.csw2011.org

Organized by:



Avago unveils fiber-optics for data-center, storage, computing and consumer applications

At March's Optical Fiber Communication Conference (OFC 2011), Avago Technologies has announced availability of multiple new solutions in its portfolio of 10–120 Gigabit fiber optics, and in booth 2001 is demonstrating technologies developed with partners and customers.

The set of optical solutions, which covers both embedded parallel modules and industry-standard pluggable modules, enables designers to differentiate their products and solve interconnect bandwidth challenges, says the firm.

New optical solutions and demonstrations at OFC include:

1. sampling availability of Avago's small-footprint MiniPOD embedded parallel optical transmitters and receivers enabling bandwidth of up to 120Gbps;
2. announcement of the first QSFP+ 40G-iSR4 pluggable parallel optic transceiver module for 40 Gigabit Ethernet applications and high-density 10 Gigabit applications, along with a demonstration of the technology using new Top-of-Rack (ToR) data center switches from a leading manufacturer;
3. demonstration of the first multi-Gigabit consumer optical interconnect; and
4. demonstration of 25Gbps vertical-cavity surface-emitting laser (VCSEL) integrated into an SFP+ platform interoperating with the latest Avago 40nm Serial/Deserializer (SerDes) core.

1. Embedded parallel optics yields highest-bandwidth interconnect

Avago's embedded parallel optics allow fiber-optic interfaces to be located close to an ASIC or FPGA and deliver what is claimed to be the world's highest bandwidth. These benefits are leveraged in applications such as next-generation supercomputers powering scientific research breakthroughs, as well as for high-performance routers, switches and other data-center equipment enabling cloud comput-

ing, server virtualization and video-on-demand.

In particular, MicroPOD embedded parallel optics are said to be the smallest 120Gbps optical transmitters and receivers. They offer 12 transmit or receive channels at up to 10.3125Gbps while consuming only 125mW per channel. The modules deliver high performance in both air-cooled and water-cooled environments.

MicroPOD devices have an 8.2mm by 7.8mm footprint with an LGA electrical interface for ultra-dense embedded solutions, while the new MiniPOD arrays have a 22mm by 18.5mm footprint with a 9mm by 9mm MegArray connector for simplified embedded solutions and ease of manufacturing. At OFC, Avago announced sample availability of MiniPOD interconnects, which feature a low-cost, removable fiber cable connection and a pluggable electrical connection that provide flexible cable management at installation, simplifying design and lowering cost for switching and supercomputing applications.

2. Expanding MSA-compatible pluggable optics portfolio

Avago is expanding its portfolio of multi-source agreement (MSA)-compliant pluggable optics with a four-channel, parallel, QSFP+ transceiver for 40 Gigabit Ethernet with the added capability of interoperating with IEEE 10GBASE-SR compliant products. The transceiver integrates four data lanes in each direction, with each lane operating at 10.3125Gbps. This provides an aggregated bandwidth of 40Gbps for short-range, multi-lane data communication and interconnect applications. The device allows optical interoperability with any 10 Gigabit Ethernet transceiver, compliant to the IEEE 802.3ae 10GBASE-SR specifications, of form factors such as SFP+, XFP and X2.

Avago demonstrated connectivity between 10GBASE-SR (SFP+) and

the new QSFP+ 40G-iSR4 module over 100m of OM3 multi-mode fiber. Using new ToR data-center switches, the demonstration connected two high-performance servers with 10GbE SFP+ network interface cards and showed real-time streaming of multiple HD movies simultaneously.

In early March, Avago launched two new mini-SFP+ (mSFP) transceivers that enable increased port density in Ethernet and storage equipment. The AFBR-54D7APZ addresses 8Gbps Fiber Channel for storage applications, and the AFBR-703SNZ targets next-generation 10Gbps Ethernet equipment. Both pluggable modules raise port density by 30% over industry-standard SFP+ transceivers while delivering the same data-transmission performance.

3. Demo of first multi-Gigabit consumer optical interconnect

In a joint collaboration with VIA Labs and DisplayLink, Avago demonstrated the first multi-Gigabit consumer optical interconnect, showing HD video streaming through a USB 3.0 active optical cable. This surpasses the limitations of existing copper interconnects in the computing and consumer electronic space, allowing longer distances at higher-speed data rates while maintaining low cost and low power.

4. Demo of technology for 25G serial interconnects and beyond

Avago demonstrated its high-temperature 25Gbps 850nm VCSEL integrated into its high-volume SFP+ production platform operating over 100m of OM3 multi-mode fiber. The SFP+ interoperated with Avago's latest 40nm SerDes core. Its ASICs integrate the SerDes cores, boosting the bandwidth of datacoms for servers, routers and networking, computing and storage applications. Avago also recently demonstrated its first 28nm SerDes core with industry-first 30Gbps performance.

www.avagotech.com

Avago mini-SFP+ transceivers boost port density for storage and Ethernet equipment

Avago Technologies has announced two new fiber-optic transceivers that enable increased port density in Ethernet and storage equipment. The new mini-SFP+ (mSFP) AFBR-54D7APZ transceiver addresses 8Gbps Fiber Channel for storage applications and the AFBR-703SNZ transceiver targets next-generation 10Gbps Ethernet equipment designs. Both pluggable modules increase port density by 30% over industry-standard SFP+ transceivers, while delivering the same data-transmission performance.

The mSFP transceivers incorporate Avago's 850nm vertical-cavity surface-emitting laser (VCSEL) and PIN detector technology, ensuring that the AFBR-54D7APZ module is compliant with 8.5/4.25/2.125GBd Fiber Channel specifications and that the AFBR-703SNZ module complies with IEEE 802.3ae 10GBASE-SR standards.

The devices use the SFP+ electrical



connector and I2C interface, and are compliant with the small form pluggable (SFP) multi-source agreement (MSA) electrical specifications for duplex transceivers. The mSFP modules are designed for low power consumption, with typical dissipation of 0.6W. Avago says that the modules feature enhanced EMI performance for high-port-density applications. They also offer full real-time digital diagnostic monitoring, as well as operation over wide temperature and supply voltage ranges (-10°C to $+80^{\circ}\text{C}$ and $3.3\text{V} \pm 10\%$, respectively).

Using OM3 fiber, the AFBR-54D7APZ achieves data rates of 8.5Gbps for

up to 150m and the AFBR-703SNZ achieves data rates of 10Gbps for up to 300m.

"Avago is committed to innovating and partnering with customers to expand our leadership position in 8 and 10Gbps SFP+ transceivers," says Victor Krutul, director of marketing for Avago's Fiber Optics Products Division. "These new mSFP modules enable our customers to develop more efficient storage and Ethernet equipment with higher port density," he adds. Avago recently exhibited a high-density DCX Backbone modular switch from Brocade that leverages the mSFP technology for 64 ports in a switching blade that could only house 48 SFP+ ports.

Avago says that it has teamed with multiple cage and cable suppliers to provide complete 8Gbps Fiber Channel and 10Gbps Ethernet mSFP solutions.

www.avago.com

Xilinx FPGAs interoperable with SFP+ and QSFP+ modules

Interoperability testing has been completed between the Virtex-6 HXT field-programmable gate arrays (FPGAs) of chip provider Xilinx Inc and the SFP+ and QSFP+ optical transceiver modules of Avago. The testing proves the design and interoperability of 10 and 40 Gigabit Ethernet ports using optical interfaces from Avago with what is said to market-leading transceiver jitter performance for the Virtex-6 HXT FPGAs.

"The Xilinx Virtex-6 HXT FPGA with integrated GTH transceivers was designed to meet the demanding jitter requirements for the 10Gbps optical interfaces," says Nick Possley, Xilinx's director of Wired Communications. "Superior jitter performance enables us to support Avago's 10 Gigabit Ethernet SFP+ optical module connectivity without the need for external re-timers," he adds.

"Xilinx designed the GTH transceivers in Virtex-6 HXT devices to be optimized for demanding optical interfaces, and the proof of that effort is evident in our ability to support 10 Gigabit SFP+ Ethernet optical ports up to 300m for 10GBase-SR using modules from Avago," Possley continues.

"System engineers can now design with confidence when developing systems using high-bandwidth optical interconnects and Xilinx FPGAs," comments Victor Krutul, director of marketing for Avago's Fiber Optics Product Division.

Link verification has been completed with 10 Gigabit Ethernet SFP+ modules using both short- and long-range fiber, as well as with 40 Gigabit Ethernet QSFP+ modules using short-range fiber. Avago claims to be the only firm shipping 40 Gigabit QSFP trans-

ceivers. Also, a complete test suite to verify compatibility with the IEEE 802.3ae 10GBASE-SR, 10GBASE-LR, and the SFP+ SFF-8431 MSA specifications has been completed using SFP+ modules, with operation verified over full specified link distances of 300m for OM3 multi-mode fiber and 10km for single-mode fiber.

Xilinx Virtex-6 HXT devices interface to industry-standard SFP+ and QSFP+ optical modules at line rates up to 11.18Gbps addressing next-generation application needs. Also, due to the jitter performance (sub-500fs rms random jitter at 11.18Gbps) and signal integrity, the need for external conditioning circuitry is eliminated. The jitter performance provides system designers with the margin needed to build robust high-speed interfaces.

www.xilinx.com

Mitsubishi develops first monolithically integrated 43G RZ-DQPSK transmitter

At March's Optical Fiber Communication Conference (OFC 2011) in Los Angeles, Tokyo-based Mitsubishi Electric Corp will present what it claims to be the first fully monolithically integrated laser diode for use in transmission devices that transmits large data volumes between metropolitan areas at 43Gbps using return-to-zero differential quadrature phase-shift keying (RZ-DQPSK).

With transmission volume over optical communication networks increasing rapidly, densely spaced wavelength division multiplexed channels, higher-bit-rate transmission and multi-level formats such as DQPSK are in demand for long-distance transmission, says Mitsubishi Electric. Previously, it was common for transmission device makers to use several different chips (such as LiNbO₃ Mach-Zehnder modulators and tunable lasers). However,

devices measure several centimeters or more in length and require relatively large driving power.

Mitsubishi Electric now claims to have achieved the first monolithic integration of three functional chips — a tunable laser array (whose wavelength can be controlled between 1572nm and 1612nm), an RZ Mach-Zehnder modulator (which modulates the output power intensity) and a DQPSK Mach-Zehnder modulator (which modulates the signal phase) — into a single chip. Mitsubishi Electric has hence developed what it claims is the first 40G RZ-DQPSK transmitter monolithically integrated with a tunable distributed feedback (DFB) laser array and Mach-Zehnder modulators.

The fully monolithic integration and InP-based modulator effectively minimize device size and

power consumption. The chip's dimensions are 9.6mm x 0.75mm (less than one hundredth of the size of conventional chips). The module's volume, including the chip, can hence be minimized to less than one third of the size of conventional modules, says the firm.

The new laser diode achieves tuning control over 95 channels on the 50GHz grid of the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) covering a 40nm wavelength range over the L-band from 1572nm to 1612nm.

Mitsubishi Electric says that in future it plans to enhance the performance of high-power, low-consumption and clear optical waveforms, and to also develop a light source for C-band wavelengths (from 1530nm to 1570nm).

www.MitsubishiElectric.com

Civcom launches first multi-rate tunable optical transceiver for SAN

At the Optical Fiber Communication Conference and Exhibition/National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles (8–10 March), optoelectronic module maker Civcom of Petach Tikva, Israel is launching what it claims is the industry's first multi-rate transceiver for dense wavelength division multiplexing (DWDM) telecom and data optical networks.

The new MLR transmitter/receiver supports 1–10Gbps rates, allowing usage of the same line-card as network capacity grows, reducing a client's total cost of ownership (TCO). The transceiver is a small-size long-reach widely tunable module, suited to storage-area network (SAN) applications. Channel capacity upgrades on SAN systems traditionally required the replacement of the line-card array on both transmitter and receiver ends. The

new module allows the flexibility of using the same card as system capacity is upgraded, saving additional lifecycle investments.

"Our customers support the world's highest-capacity, leading network and telecom carriers," says Yair Itzhar, VP worldwide sales & marketing. "With the new module Civcom uses its expertise in highly tunable DWDM components to offer the flexibility required for operators supporting the rapidly growing SAN market," he adds.

Civcom says that system vendors and line-card manufacturers can now offer an unprecedented broad range of applications, bit rates and channel flexibility:

- 10 Gigabit Ethernet at 10.3125Gbps;
- Legacy 1 Gigabit Ethernet at 1.25Gbps;
- 10 Gigabit Fiber Channel (GFC) at

- 10.51875Gbps;
- 8 GFC (8.5Gbps), 4 GFC (4.25Gbps), 2 GFC (2.125Gbps), 1 GFC (1.0625Gbps); and
- QDR, DDR, and SDR Infiniband.

As is the case with all Civcom's FREE LIGHT transponder modules, the MLR interface is compatible with the 300-pin MSA and I²C interface and uses a widely tunable laser to cover the entire C-band.

It uses a negative- or zero-chirp Mach-Zehnder indium phosphide (InP) modulator to enable high performance under OSNR (optical signal-to-noise ratio) load across the entire C-band and over long distances. A configurable CDR (clock & data recovery) is used to tune the transceiver between data rates of 1.06, 1.25, 2.12, 4.25, 8.5, 10.3 and 10.5Gbps through standard I²C commands.

www.civcom.com

JDSU adds 40/100G modulators and receivers

At the Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles (8–10 March), optoelectronic chip and module maker JDSU of Milpitas, CA, USA has launched new 40G and 100G optical components which it says provide a cost-effective solution for the high-speed data transmission requirements of network equipment manufacturers (NEMs).

"This is the latest step in the continuous expansion of our transmission components portfolio," says Tom Fawcett, JDSU's senior director of transmission products. "These new additions allow us to work collaboratively with our customers as they are developing new solutions to meet the explosive demand for bandwidth," he adds.

The latest offerings from JDSU's transmission components portfolio include:

- 40G QPMZ modulators supporting DP-QPSK coherent detection;
- 40G coherent receivers supporting DP-QPSK coherent detection;
- 40G DDMZ modulators supporting DPSK direct detection;
- 40G DPMZ modulators supporting RZ-DQPSK direct detection;
- 100G QPMZ modulators supporting DP-QPSK coherent detection; and
- 100G coherent receivers supporting DP-QPSK coherent detection.

JDSU says that its ability to leverage in-house fabrication capabilities in indium phosphide, planar light-wave circuits (PLCs) and lithium niobate materials enables high-performance and cost-competitive component solutions across these various data formats and data

rates. This in turn allows service providers to deploy 40G and 100G optical links in a cost-effective manner whenever increased bandwidth is required in the network, the firm adds.

These new additions allow us to work collaboratively with our customers as they are developing new solutions to meet the explosive demand for bandwidth

solutions for 10G, 40G and 100G client and line-side applications.

www.jdsu.com

JDSU's 40G DWDM metro optical network transponder uses Semtech's MUX/DEMUX chipset platform

Semtech Corp of Camarillo, CA, USA, a supplier of analog and mixed-signal semiconductors for high-end consumer, computing, communications and industrial equipment, has integrated its 40Gb/s multiplexer/demultiplexer (MUX/DEMUX) chipset platform into JDSU's 40Gb/s DWDM transponder modules.

Semtech provides 40Gb/s and 100Gb/s MUX/DEMUX chipsets for the emerging short-reach, metropolitan and long-haul optical network markets. JDSU provides integrated 40Gb/s and 100Gb/s optical-to-electrical and electrical-to-optical conversion solutions for these markets.

JDSU's 40Gb/s transponder employs Semtech's SMI4027 MUX and SMI4037 DEMUX chipset to convert data signals from electrical to optical formats and back again. The SMI4027 multiplexer includes an on-chip clock multiplier unit (CMU) that supports data rates from 39.8 to 44.6Gb/s and

combines 16 lanes of 2.5Gb/s incoming data signals into four lanes of 10Gb/s each to enable fast, reliable data transport over optical fiber.

The SMI4037 demultiplexer accepts both single-ended and differential 39.8 to 44.6Gb/s bi-directional NRZ serial data streams and separates (demultiplexes) the data signals into 16 parallel output channels on the out-bound transmission side.

Semtech is a key vendor for JDSU with their MUX/DEMUX solutions at 40G and beyond, states JDSU's John Kavanagh.

40G technology is technically challenging and requires high-level skill sets in analog design, as well as in packaging and testing

"Semtech is a key vendor for JDSU with their MUX/DEMUX solutions at 40G and beyond," states John Kavanagh, VP of supply chain for JDSU's Communication & Commercial Optical Products (CCOP) division. "40G technology is technically challenging and requires high-level skill sets in analog design, as well as in packaging and testing."

"Explosive video, voice and traffic demands, including HDTV, interactive TV, streaming video and 4G, are placing extreme pressures on global carriers to deliver ultra-high bandwidth quickly and in a cost effective, efficient and reliable way," says Sameer Vuyyuru, VP & general manager for Semtech's Transport and Data Communication Group. "JDSU is at the forefront of this wave with a commanding product breadth and depth of technology... We look forward to a long and rewarding relationship," he adds.

www.semtech.com

Emcore demos Infiniband 56Gb/s FDR, 120Gb/s Ethernet CXP AOCs and 14Gb/s OSAs

At OFC/NFOEC 2011, Emcore demonstrated two new interconnect products, including a 56Gb/s FDR (Fourteen Data Rate) and a 120Gb/s CXP active optical cable (AOC) for high-performance computing (HPC), high-end Ethernet router and switch applications. Emcore is also demonstrating 14Gb/s transmit and receive optical sub-assemblies (TOSA/ROSA) for next-generation Fiber Channel storage-area networks.

High-performance computers, telecom routers, storage networks, grid and cloud computing systems require higher-speed interconnects to support the increasing performance requirements. Emcore claims that the FDR and CXP active optical cable products provide the highest aggregated level of data throughput in a compact, lightweight form-factor capable of supporting the bandwidth needs of these next-generation systems.

The 14Gb/s TOSA/ROSA products enable users to support the latest 16x Fiber Channel data rate as market demand transfers from 4–8Gb/s transceivers to 14Gb/s optical transceivers.

“Emcore is the industry leader in active optical cable sales,” states VP of business development Jaime Rejoj. “Leveraging our next-generation VCSEL [vertical-cavity surface-emitting laser] and PIN [photo-detector] we will continue to grow the market,” he reckons.

Emcore’s complete line of data-com products is on display at OFC, including high-bandwidth, parallel optical interconnect products such as the DDR and QDR cables for 4x 20Gb/s and 40Gb/s Infiniband and PCIe applications as well as optically pluggable SNAP12 solutions for up to 75Gb/s telecoms routers, backplane and proprietary high-speed interconnect applications.

Emcore demos tunable XFP product

Emcore Corp of Albuquerque, NM, USA, which makes components and subsystems for the broadband, fiber-optic, and solar power markets, demonstrated its new tunable XFP (TXFP) product at March’s Optical Fiber Communication Conference and Exhibition/National Fiber Optic Engineers Conference (OFC/NFOEC 2011) in Los Angeles.

Emcore’s TXFP technology is based on its patented ClearLight platform (the fourth generation of its external-cavity laser technology, deployed in fiber networks worldwide

since 2004). The firm is currently shipping pilot production quantities of the TXFP, and is ramping domestic and off-shore production.

“Emcore’s TXFP was designed with the goal of enabling our customers to dramatically reduce size, power consumption, and operating expenses, thus replacing legacy 300-pin transponders,” says CEO Dr Hong Q. Hou. “Our TXFP offers industry-leading performance with both negative- and zero-chirp options,” he adds.

www.emcore.com

Emcore adds 1MHz to 40GHz fiber-optic transport to Optiva Platform for satcom and microwave links

Emcore has expanded the Optiva Platform to support analog fiber-optic signal transmission from 1MHz to 40GHz.

Optiva is a modular, plug-in card-based system for transporting a wide range of video, audio and data signals over fiber-optic cable. Emcore recently announced new capabilities for the Optiva Platform, including fiber-optic links for frequency references from 1MHz to 100MHz, IRIG/1PPS, IF, L-band, S-band, C-band, X-band, Ku-band, Ka-band and ultra-wideband (50MHz–40GHz). The addition of satellite RF and analog microwave signals allows integrators to leverage the total capabilities of Optiva, while also realizing cost savings over installing multiple single-purpose products, says the firm.

Emcore is also introducing a new fan-cooled Optiva chassis in a 19” 3U rack-mount enclosure, with what is claimed to be industry-leading plug-in module density, supporting 16 hot-swappable modules and dual redundant power supplies. Optiva products support the industry-standard SNMP Ethernet interface, enabling simple integration into existing

monitoring and control systems.

“The introduction of these new fiber-optic transport modules allows customers to further leverage the versatility and cost-effectiveness

These new fiber-optic transport modules allows customers to further leverage the versatility and cost-effectiveness of the SNMP-managed Optiva Platform

of the SNMP-managed Optiva Platform,” says Dr Ron Logan, VP of Photonic Systems for Emcore. “This, in turn, allows operators, systems integrators and OEMs to deploy a single platform to handle all of their optical transport needs over the industry’s widest frequency range,” he adds.

“Leveraging Emcore’s unique RF photonic wafer fab and vertical integration, Optiva enables a low-cost, high-performance fiber-optic solution for Satcom earth stations.”

Emcore showcased its Optiva Platform products at the SATELLITE 2011 event (15–17 March) in Washington DC.

Emcore aids fastest supercomputer

Emcore of Albuquerque, NM, USA, which makes components and sub-systems for the broadband, fiber-optic, and solar power markets, says that Emcore Connects Cables have been used to connect Tianhe-1A, the world's most powerful supercomputer.

According to the most recent list by independent supercomputing online resource TOP500.org, the Tianhe-1A system took the top spot as the world fastest supercomputer. This accomplishment was made possible by Emcore Connects Cables, which are high-speed interconnect active optical cables (AOCs) used in place of traditional copper cables, enabling system architects to design larger and more powerful supercomputers. Tianhe-1A uses several thousand of these optical cables.

Emcore's quad data rate (QDR) Connects Cables are 40Gb/s cable products with quad small-form-factor pluggable (QSFP) electrical connectors. The firm says the smaller

diameter and lower heat dissipation of the QDR cables enabled Tianhe-1A to more efficiently manage overall power consumption and cooling resources, which are critical factors in high-performance computing system design.

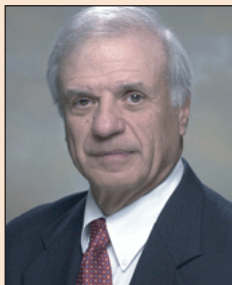
"Emcore pioneered the use of optical cables in high-performance computing (HPC) seven years ago," says Chris Wiggins, director of marketing for Emcore's digital fiber products. "Since then, Emcore has been providing interconnect products enabling several of the world's fastest supercomputers," he adds. "Additionally, Emcore's QDR Connects Cables have experienced strong growth since we introduced the product earlier this year. Our customers cite Emcore's quality, reliability, on-time delivery and competitive pricing as reasons for choosing us over our competitors in the high-performance computing and datacenter interconnect marketplaces."

Defense expert Tegnalia added to board

Emcore's board of directors has elected Dr James A. Tegnalia (who currently lectures at the University of New Mexico and Georgetown University and is a member of the Defense Science Board) to fill a vacancy on its board as a Class C director (for which he will stand for re-election at the 2012 annual meeting of shareholders).

From 2005 to 2009, Tegnalia was director of the Defense Threat Reduction Agency (DTRA) in Fort Belvoir, VA. Previously, he was VP, Department of Defense Programs, Sandia National Laboratories.

Tegnalia has also been assistant undersecretary of defense and acting deputy undersecretary of defense in the Office of the Undersecretary of Defense for Research and Engineering (where he oversaw program manager activity on the JSTARS radar and ATACMS missile) and deputy director and later act-



ing director of DARPA.

Tegnalia has had executive roles in the defense industry, including VP of business development of

the Electronics Group at Martin Marietta Corp, executive VP & deputy director of Sandia National Laboratories, VP business development for the Energy and Environment Sector of Lockheed Martin Corp, and president of Lockheed Martin Advanced Environmental Systems.

"We expect Dr Tegnalia to play a significant role in Emcore's expansion of its product portfolio in the Defense, Aerospace and Homeland Security markets," says Emcore's chairman Reuben F. Richards Jr.

IN BRIEF

Emcore ships over 100,000 active optical cables

Emcore says that it has shipped over 100,000 Emcore Connects Cables, making it the market leader in active optical cables (AOCs).

Emcore Connects Cables are used in interconnect applications including high-performance computing (HPC), storage-area network (SAN) systems, distributed-grid networks, cloud computing systems, and telecoms data-centers. The systems require the use of active optical cables because of their light weight, small size and high bandwidth over long distances, making them the preferred alternative to traditional copper cables.

"As one of the highest-growth optical component segments, the active optical cable market has experienced nearly 30% growth from 2009 to 2010, driven by high-performance computing, commercial cloud networks and network/infrastructure expansion," comments Brad Smith, senior VP of market research firm LightCounting LLC. "The AOC and parallel optical transceiver market will have a 27.5% compounded annual growth rate from 2009 to 2013," he estimates.

Emcore says that it was first to bring optical interconnects to the high-performance computing market and has led the industry in shipments of 20Gb/s and now 40Gb/s AOCs. "We have seen strong year-over-year growth in AOCs, with more than 30,000 quad data rate (QDR) cables shipped in a three-month period, a record quantity," notes Emcore's VP of business development Jaime Reloj. "A new order recently received is for a super-computer that, upon completion, will perform 10 petaflops per second."

www.emcoreconnects.com

RFMD fabricates dual-junction PV cells

Standard 6" wafer equipment used for GaAs/InGaP cells

RF Micro Devices Inc of Greensboro, NC, USA says it has achieved a key performance milestone related to its commercialization of photovoltaic (PV) cells. Specifically, it has fabricated dual-junction PV cells that integrate gallium arsenide and indium gallium phosphide junctions using the firm's standard 6" semiconductor equipment. RFMD says that this clears the way for it to develop triple-junction structures, with the ultimate goal of developing a commercially viable and high-volume-capable compound semiconductor-based process for high-performance PV cells.

"With this achievement, RFMD is demonstrating we possess the critical technologies to produce a low-cost PV product with competitive solar cell conversion efficiency, supported by the quality, reliability, and volumes that characterize the

cellular handset market," says president & CEO Bob Bruggeworth.

In mid-2009, RFMD announced that it had entered into a multi-year Cooperative Research And Development Agreement (CRADA) with the US Department of Energy's National Renewable Energy Laboratory (NREL) to develop a production-capable process technology for high-performance PV cells.

RFMD says that fabrication of the dual-junction PV cells and the associated performance characteristics are consistent with results achieved by NREL in its development of inverted metamorphic multi-junction (IMM) technology. NREL's technology has demonstrated one of the world's highest reported solar cell conversion efficiencies (40.8%), and continued substantial improvements in efficiency are anticipated.

RFMD says that its fabrication of

the dual-junction PV cells was realized using its existing manufacturing capabilities and robust supply chain, which are optimized for high volume, low cost, reliability and performance. The firm says that the conversion efficiency achieved across its 6" wafers was exceptionally uniform, enabling high device yields and tight distributions in concentrated photovoltaic (CPV) product performance.

RFMD says that its development efforts related to a compound semiconductor-based process for PV cells are broadly applicable across technologies, including IMM as well as conventional triple-junction germanium-based CPV devices. RFMD anticipates multiple opportunities related to PV cells, and is engaged with CPV system integrators and solar cell module manufacturers.

www.rfmd.com

Alta raises \$72m to boost economics of high-efficiency PVs

Developments include epi lift-off for GaAs

Development-stage company Alta Devices Inc of Santa Clara, CA, USA says that it has raised a total of \$72m to date in a round of funding that will be used to continue commercializing technology that aims to improve the production economics of high-efficiency solar photovoltaics (PVs). Founded in 2007, the firm is also focused on making breakthroughs in both manufacturing and form factor.

Investors include returning firms August Capital, Kleiner Perkins Caufield and Byers, Crosslink Capital, DAG Ventures, New Enterprise Associates (NEA), Presidio Ventures (a Sumitomo Corporation company), Technology Partners, and Dow Chemical. New investors are Alberta Investment Management Corporation (AIMCo) on behalf of certain of its clients, Good Energies, Energy Technology Ventures

(a joint venture involving GE, ConocoPhillips and NRG Energy), and Constellation Energy.

AIMCo's Jagdeep Singh Bachher has joined Alta's board. Continuing board members include Alta's CEO Christopher Norris, founders Harry Atwater (professor of Applied Physics and Materials Science at Caltech) and Eli Yablonovitch (professor of Electrical Engineering and Computer Sciences at University of California, Berkeley and Lawrence Berkeley National Laboratory), Kleiner Perkins Caufield & Byers partner Bill Joy, August Capital's Andy Rappaport, and Crosslink Capital's Alain Harrus.

"There are a number of advanced materials that could demonstrate higher solar conversion efficiency than silicon," says CEO Christopher Norris. "To date, the challenge of these materials is that they have been expensive to produce and

difficult to implement. Therefore, they are not currently an economic solution for addressing the world's energy needs," he adds. "We are working to solve this problem by leveraging new approaches in several disciplines."

Norris claims that the firm has been making good progress in the lab. "We have a team of technologists working on issues ranging from efficient use of raw materials, better manufacturing processes, and new ways to optimize the conversion efficiency of these materials for energy applications."

One of the technologies on which Alta is seeing good results is epitaxial lift off, according to Kleiner Perkins Caufield & Byers partner Bill Joy. "This is a technique that will enable efficient use of very thin layers of GaAs for solar PV applications."

www.altadevices.com

Tenaska selects Concentrix for 150MW San Diego CPV project

Soitec to build 200MW CPV module manufacturing facility in region

Soitec Group of Bernin, France, which manufactures engineered substrates including silicon-on-insulator (SOI) wafers (as well as III-V epiwafers through its Picogiga International division) says that its Concentrix concentrated photovoltaic (CPV) technology has been selected by Tenaska Solar Ventures (a division of independent energy firm Tenaska of Omaha, Nebraska) to produce 150MW of power for the public utility firm San Diego Gas & Electric (a subsidiary of San Diego-based energy services holding company Sempra Energy). The new Imperial Solar Energy Center (ISEC) West plant will be constructed on a 1057-acre site in Southern California's western Imperial County, and is expected to be completed in 2015.

To support the project, Soitec will build a new factory in the San Diego region to manufacture its proprietary CPV modules. With an annual production capacity of 200MW, the facility will supply modules not only to ISEC West but also to other utility-scale solar power projects throughout the desert southwest of the USA.

San Diego Gas & Electric (SDG&E) signed a 25-year power-purchase agreement with a subsidiary of CSOLAR Development LLC, a renewable energy firm managed by Tenaska Solar Ventures that will develop and operate ISEC West. The ground-mounted CPV plant will have a capacity of 150MW of solar-generated electricity (sufficient to meet the annual needs of about 55,000 California homes).

Soitec notes that its Concentrix CPV technology requires no water for ongoing operations, which is a crucial consideration for the water-constrained Imperial Valley, and that the ISEC West project represents a significant economic invest-

ment in Imperial County, creating hundreds of jobs in the area.

"The start of construction of the Sunrise Powerlink [SDG&E's high-voltage power transmission line, which will bring 1000MW of power from the Imperial Valley to San Diego County] has triggered a wave of proposed new utility-scale solar and wind projects in the Imperial Valley region," says James Avery, SDG&E's senior VP of power supply. "What is unique about this contract is that not only will the Imperial Valley benefit from the jobs created to construct the solar plant, San Diego will benefit from the approximately 450 new jobs that will be created at the new manufacturing facility that will be located here in the region," he adds. "SDG&E's voluntary commitment to obtain 33% of its power from renewable sources by 2020 is creating new jobs in both the Imperial Valley and here in San Diego."

Soitec claims that its Concentrix CPV systems are more efficient and perform better than conventional

solar systems, particularly at locations with extremely hot ambient temperatures and dry weather conditions. Because of the very low temperature coefficient of its multi-junction solar cells, a CPV system's performance is much less affected by temperature than other PV technology. Also, a CPV system's two-axis solar tracker mechanism produces high and constant power production output throughout daylight hours. "The ISEC West solar power plant will demonstrate Concentrix CPV scalability, and commercial viability of this innovative technology for utility-scale deployment," reckons Dave Fiorelli, president of Tenaska's Development Group.

"Our CPV systems are perfectly suited for the very high solar irradiance prevalent in the Imperial Valley," believes Soitec's CEO & chairman André-Jacques Auberton-Hervé. "We are very committed to the US market and look forward to increasing our presence in the San Diego community by contributing to the emerging renewable energy ecosystem in the region," he adds.

The ISEC West project has applied for a US Department of Energy loan guarantee. Upon receipt of the guarantee and closing of its agreement with Tenaska, Soitec will implement capacity investments to construct its San Diego area factory and pursue options for related financing. The factory location is anticipated to be announced this summer, with completion expected within 18 months of construction start. Delivery of CPV systems to the ISEC West solar power plant should begin in early 2013 and finish in 2015. At full capacity, Soitec's San Diego operations will generate up to 450 jobs in the local area.

www.soitec.com
www.tenaska.com

To support the project, Soitec will build a new factory in the San Diego region to manufacture its proprietary CPV modules. With an annual production capacity of 200MW, the facility will supply modules not only to ISEC West but also to other utility-scale solar power projects throughout the desert southwest of the USA

IN BRIEF

Great Place to Work Institute recognizes First Solar Germany

The Great Place to Work Institute (a research and consulting organization active in 40 countries) has recognized the German operations of First Solar as one of the best places to work in Germany.

First Solar finished 14th on the list of employers in the category of firms with 500–2000 staff. It is also the only manufacturer in eastern Germany to be recognized.

The prize was awarded in cooperation with the New Quality of Work Initiative, the Federal Ministry for Labor and Social Affairs, University of Cologne, Handelsblatt newspaper and personalmagazin.

First Solar's German operations include First Solar Manufacturing GmbH in Frankfurt/Oder, a sales & marketing HQ in Mainz, a holding company and a small team in Berlin. First Solar Manufacturing GmbH also made the list of top employers in Germany in 2010.

First Solar employs more than 800 people in Germany (700 in Frankfurt/Oder, and over 100 in Mainz and Berlin) and is expanding German manufacturing to double production and add 500 jobs.

The award resulted from an anonymous survey of staff. Topics such as credibility, respect, fairness, pride and team spirit accounted for 67% of the weighted result. The rest is from a cultural audit analyzing human resources plans and practices.

www.greatplacetowork.com

First Solar grows revenue 24% in 2010 2011 income guidance raised

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement and construction (EPC) services, has reported revenue for 2010 of \$2,564m, up 24% on 2009's \$2,066m.

Fourth-quarter 2010 revenue was \$610m, down 24% on Q3's \$797.9m, but this was due mainly to the timing of system sales and the December implementation of 2011 pricing (partially offset by an increase in volume). It was also down 5% on \$641m a year ago, due to decreased systems revenue and reduced module prices.

Q4 net income was \$156m (\$1.80 per diluted share), down from \$177m (\$2.04 per diluted share) in Q3, driven mainly by the lower revenue and increased expenses (rising from \$110.3m to \$131.1m), partially offset by higher gross margin. However, it was up from \$141.6m (\$1.65 per diluted share) a year ago, driven mainly by higher module production and lower module cost per watt, partially offset by reduced module average selling prices and increased expenses (up from \$121.5m). Full-year 2010 net income has risen from 2009's \$640m (\$7.53 per diluted share) to \$664m (\$7.68 per diluted share).

During 2010, First Solar cut module manufacturing cost 11% year-on-year to \$0.75/Watt by Q4. Module conversion efficiency rose 0.5% year-on-year to 11.6%, and line throughput rose 17% year-on-year to 62.6MW (with operating and announced capacity increasing

to 2.9GW by 2012). Total production in 2010 was 1.4GW, bringing First Solar's cumulative production to more than 3GW.

Also during 2010, First Solar built the largest operational solar PV plants in both the world (80MW, in Sarnia, Canada) and the USA (48MW, Copper Mountain, Nevada), while the pending sale of the Agua Caliente project to NRG will be the largest PV facility in the world (290MW) when completed in 2013. The firm also acquired NextLight and Edison Mission Group to expand its North American captive project pipeline to 2.4GW

"In the fourth quarter the operations team executed well, and we sold 400MW of projects in North America, positioning us to achieve our 2011 growth goals," says CEO Rob Gillette. "We have good demand visibility in 2011 and a broader geographic reach, which gives us confidence in our ability to sell the 2GW that we plan to produce," he adds.

First Solar is reducing the top end of its guidance for net sales in 2011 from the \$3.7–3.9bn forecast in mid-December to \$3.7–3.8bn (up 46% on 2010). However, it is increasing its guidance for operating income from \$875–975m to \$910–980m, and for earnings per fully diluted share from \$8.75–9.50 to \$9.25–9.75 (including \$60–70m of manufacturing start-up expenses and \$15–20m of factory ramp costs). The firm maintains its forecast for total capital spending of \$1.0–1.1bn and operating cash flow of \$1.0–1.1bn.

First Solar recruits chief financial officer

Mark Widmar is joining First Solar on 4 April as chief financial officer, responsible for global financial operations. He succeeds James Zhu (interim CFO since 1 January), who will retain his role as chief accounting officer.

Widmar was previously CFO and president of the Engineered Solutions segment at Graftech International Ltd, a global manufacturer of carbon and graphite materials. Prior to joining Graftech in 2006, he worked at NCR Corp from 2003

as corporate controller and a business unit CFO. Before that he was a division controller for Dell Inc and a business unit CFO for Lucent Technologies. He is also a Certified Public Accountant (CPA).

www.firstsolar.com

First Solar to build 250MW module factory in Mesa

First Solar is to build its new US manufacturing center in Mesa, AZ, about 30 minutes from its corporate headquarters in Tempe (where it has about 200 staff).

The firm will invest about \$300m, adding four manufacturing lines with a total capacity to produce more than 250MW of modules per year and creating about 600 jobs. The plant, in combination with First Solar's recently expanded facility in Perrysburg, OH, will increase the firm's US production capacity to more than 500MW per year.

Construction will begin in second-quarter 2011 and last a year, creating 400–500 construction jobs. Module shipments should begin in third-quarter 2012. The 135-acre site was previously home to a General Motors vehicle testing facility and can accommodate future expansion. It will also include a 3MW rooftop solar installation as well as a ground-mounted PV testing facility.

The factory will use First Solar's continuous manufacturing process, which transforms a sheet of glass

into a complete solar module in less than 2.5 hours, contributing to what is claimed to be the industry-leading energy payback time and low carbon footprint of systems using First Solar's modules.

"Supportive state and federal policies have provided the visibility needed for the US to become our fastest-growing market, and the Mesa factory will enable us to meet that growing demand," says president Bruce Sohn. "Programs such as Department of Energy loan guarantees and the solar investment tax credit are crucial to helping the renewable energy industry quickly reach the scale needed to compete with fossil fuels. Over the long-term, programs like these facilitate the market growth and investment that will support the future expansion of this factory," he comments.

"First Solar's announcement to build a new factory in Mesa and deploy their domestically manufactured modules in solar projects like Agua Caliente in Yuma County will

not only create job opportunities for Arizonans but also represents another important step toward greater energy security," comments Arizona Senator John McCain.

First Solar is building two utility-scale PV projects in Arizona — the 290MW Agua Caliente project in Yuma County for power generation firm NRG Energy Inc of Princeton, NJ and the 17MW Paloma Solar Plant in Gila Bend for Phoenix-based electric utility APS (Arizona Public Service Company) — which are expected to create more than 500 construction jobs. First Solar's North American project pipeline includes more than 2.4GW of projects, which are expected to create about 2000 construction jobs and drive \$6bn of infrastructure investment over three years.

Like all of its PV modules, the entire production output of the Mesa factory will be part of First Solar's pre-funded solar module collection and recycling program (claimed to be the first of its kind).

www.firstsolar.com

First Solar to build 17MW plant for Arizona Public Service Company

For the first time, Phoenix-based Arizona Public Service Company (Arizona's largest electricity utility) and First Solar (Arizona's largest PV manufacturer) are working together. APS has contracted First Solar to design and build the 17MW Paloma Solar Plant in Gila Bend, AZ. APS will own the plant, which is expected to come online in September.

APS is the principal subsidiary of Pinnacle West Capital Corp, and serves over 1.1 million customers in 11 of the state's 15 counties.

Paloma is one of five solar plants under development in APS' AZ Sun program, through which APS will finance and own 100MW of solar photovoltaic power plants in Arizona. Upon completion, the program is expected to have at least six plants, which will be designed and constructed by third-party solar

developers, contractors and equipment providers. With Paloma, the AZ Sun Program now has commitments for 83MW of solar capacity. The entire program is expected to be completed by the end of 2014.

"Through the AZ Sun program, we have been able to move quickly to begin building new solar power plants to complement our other generating resources. We expect these plants to provide clean, reliable energy to our customers for at least the next 30 years," says APS' president & chief operating officer Don Robinson.

With Paloma, APS's total renewable energy portfolio is 875MW, counting projects online and in development. Of that, 288MW is in service now, providing enough electricity to meet the needs of 72,000 Arizona homes.

To be built on the site of a former alfalfa farm, the Paloma plant will use 300,000 PV panels mounted on fixed-tilt steel frames. It is the first time that thin-film panels will be used for an APS solar plant.

Paloma and Cotton Center, APS's other AZ Sun photovoltaic project in Gila Bend, will be under a mile apart.

"Gila Bend is continuing to demonstrate its national leadership in promoting, locating and fast-tracking utility-scale solar," says the town's mayor Ron Henry. "The Paloma plant represents another major solar energy investment APS has made in our community."

Gila Bend is also home to Solana, a concentrating solar plant being built by Abengoa Solar. APS has a contract to purchase all of Solana's generation beginning in 2013.

www.aps.com

XsunX and solar module maker Telecomps to co-develop back-end assembly capabilities

Taiwanese firm is first commercial customer for CIGSolar technology

XsunX Inc of Aliso Viejo, CA, USA, which is developing hybrid thin-film photovoltaic (TFPV) solar cell technologies and manufacturing processes, has entered into an agreement for Taiwan's Telecomps Technology Corp Ltd to use its copper indium gallium diselenide CIGSolar technology. The firms will work together to complete back-end assembly capabilities to produce modules using CIGSolar cells.

The patent-pending system and processing technology CIGSolar focuses on the mass production of individual thin-film CIGS solar cells that match silicon solar cell dimensions and can be offered as a

non-toxic, high-efficiency and lowest-cost alternative to the use of silicon solar cells. XsunX is offering licenses for the use of CIGSolar process technology and plans to generate revenue through licensing fees and manufacturing royalties.

Founded in 1991, Telecomps has expanded its expertise in the electronics component industry, building a network of capabilities in the fast-growing turnkey OEM solar module assembly sector (both silicon and thin-film photovoltaics).

"Telecomps' growing capabilities in the module assembly business will provide us a head start and will help accelerate the adoption of our

CIGSolar technology in the rapidly growing Chinese market," says XsunX's president & chief operating officer Joseph Grimes. "We have targeted the silicon module manufacturing industry as a major customer segment and, with the assistance of Telecomps providing competitive OEM module assembly, we are positioning XsunX customers for success as they compete in the \$18bn silicon solar cell industry," he adds. "In addition to Telecomps, a number of other manufacturers are now seriously exploring the use of our CIGSolar technology as a robust and less expensive alternative to silicon."

XsunX signs multi-megawatt manufacturing system purchase and CIGSolar technology license deal with energy firm Globe Future

XsunX has entered into an agreement with Globe Future Technology Development Co Ltd for the purchase of manufacturing systems and an operating license for XsunX's CIGSolar technology. XsunX will provide Globe Future with an initial baseline production system plus an additional 30MW CIGSolar production system to produce CIGSolar cells.

Globe Future is engaged mainly in industrial investment of operations in the field of management for the energy industry, including new energy-saving technologies and the development of renewable energy projects.

"This agreement further supports our business model and technology plan to introduce to the global market solar technologies that are truly unique and competitive with silicon cell technology," says XsunX's president & chief operating officer Joseph Grimes. "XsunX continues to target the silicon module manufacturing industry as a major customer segment, and we are positioning XsunX customers for

success as they compete in the \$18bn silicon solar cell industry," he adds.

The patent-pending CIGSolar system and processing technology focuses on the mass production of individual thin-film CIGS solar cells that match silicon solar cell dimensions but can be offered as a non-toxic, high-efficiency and lowest-cost alternative.

The firm is offering licenses for the use of the CIGSolar process technology, and plans to generate revenue through licensing fees and manufacturing royalties for the use of

the CIGSolar technology.

Under the agreement with Globe Future, and as a condition to the commitment, the parties will now work to complete a joint specification to ensure that CIGSolar system configuration meets the optimal compatibility and integration for Globe Future's specific needs. Once the parties have finalized specifications for the deliverables, Globe Future will post a letter-of-credit for the payment of the systems.

"We are completing our designs and are preparing to build our first baseline production system for use as our primary marketing tool," Grimes notes. "We can now update these designs to meet Globe Future's specific product needs and re-capitalize our investment rapidly while still meeting our marketing and technology roadmap," he adds. "We hope to secure additional commitments from other pending customers as we move forward."

www.tdglobe.com
www.xsunx.com

We are completing our designs and are preparing to build our first baseline production system for use as our primary marketing tool. We can now update these designs to meet Globe Future's specific product needs

Delaware and Innotek co-developing wide-bandgap CIGS solar cells

Seeking a collaborator to co-develop a high-voltage solar cell, South Korean electronics maker LG Innotek (LGIT) recently awarded a three-year, \$780,000 contract to the University of Delaware's Institute of Energy Conversion (IEC), a Department of Energy (DOE) University Center of Excellence for Photovoltaic Research and Education, to pursue research on wide-bandgap solar cells, which absorb less sunlight but produce a higher voltage than solar cells currently on the market.

LG Innotek is among the world's top-10 electronics manufacturers, producing LEDs used in flat-screen TVs, semiconductors for automobile motors, and camera sensors for mobile phones, including Apple's latest iPhone, among other products. "This research collaboration supports LGIT's technology roadmap and gives us yet another pathway to deliver a technology by outsourcing with one of the top solar research labs," says LG Innotek research scientist JinWoo Lee.

The collaboration evolved after discussions between the firm and IEC representatives during the past year and reciprocal visits by engineering staff from each of the institutions, says William Shafarman, a scientist at IEC who also has an appointment in the University of Delaware's Department of Materials Science and Engineering.

In the project, Shafarman is leading a team of IEC researchers and two graduate students in materials science and engineering. The team will experiment with replacing the elements in thin-film copper indium gallium diselenide (CIGS) solar cells with other elements to achieve a higher voltage, as well as test new solar cell designs. This work will build on results from a recently completed



Bill Shafarman and Peipei Xin, graduate student in materials science, conducting research at IEC. Photo: Kathy F. Atkinson/University of Delaware.

project at IEC supported by the DOE.

Although most CIGS solar cell modules require two pieces of glass (one above and one below), a focus of the program will be to develop a superstrate solar cell structure, which requires only one sheet of glass, on the light-exposed side of the cell, Shafarman said.

"At the end of the project, we'll be combining these ideas to make tandem solar cells, which stack one solar cell on top of the other. The solar cell on top absorbs some of the light, and the cell underneath absorbs the rest. IEC has done pioneering work in this type of solar cell area since the 1980s," Shafarman noted.

"This project will draw on IEC's extensive background in thin-film solar cells and will enable us to revisit research we did over two decades ago," says IEC director Robert Birkmire.

IEC also has projects under way through competitive research grants from the US Defense Advanced Research Projects Agency (DARPA), which is the independent research branch of the US Department of Defense; the DOE; and several companies in the USA and abroad.

www.udel.edu/iec

IN BRIEF

Global Solar adds CTO to focus on BIPV

Global Solar Energy Inc of Tucson, AZ, USA, which makes CIGS thin-film photovoltaic cells, has appointed Dr Urs Schoop as chief technology officer, leveraging his expertise in R&D on CIGS cell production to direct the execution of its technology roadmap.

"Schoop's position as Global Solar's CTO will help launch the company to the next level of product development, and help us continue to be a technology innovator in the emerging BIPV (building-integrated photovoltaics) industry," says president & CEO Dr Jeffrey Britt.

Since being founded in 1996, Global Solar has focused on incorporating its CIGS solar cells (made in two full-scale facilities in Tucson and Berlin, Germany) into applications including light-weight portable solar chargers and traditional glass solar modules, but last August it launched its PowerFLEX BIPV module for rooftops installations. "Schoop's extensive experience in flexible thin-film solar and large-scale manufacturing is critical to advancing our engineering and technical capabilities," he adds.

Previously, Schoop was director of Global Solar's R&D department, helping to improve cell efficiency, extend long-term reliability, and uncover more cost-effective deposition techniques. He also helped develop Global Solar's manufacturing facility in Tucson.

Prior to joining Global Solar, Schoop was a senior scientist with American Superconductor in Boston, MA, where he scaled processes and equipment from the R&D stage up to production for thin-film superconducting wire. He has been active in the thin-film industry and academia for more than 15 years.

www.globalsolar.com

Ascent's 150MW FAB3 project reaches DOE due-diligence review phase

Loan guarantee program may back \$275m of \$375m project

The US Department of Energy (DOE) Loan Guarantee Programs Office (LGPO) has notified Ascent Solar Technologies Inc of Thornton, CO, USA that its loan guarantee application for its proposed 150MW FAB3 project has been selected to advance to the LGPO's due-diligence phase of review. The project has an approximate value of \$375m (\$275m of which would be under the loan guarantee program).

The FAB3 project contemplates the construction of a new manufacturing facility with annual capacity for producing 150MW of Ascent's flexible, monolithically integrated thin-film copper indium gallium diselenide (CIGS) photovoltaic modules. FAB3 will leverage technology advances from the firm's existing manufacturing facilities and will focus on large-volume markets such as building-applied PV (BAPV) and building-integrated PV (BIPV) applications. In March 2009, Ascent expanded from its initial 1.5MW-capacity facility in Littleton, CO by opening its existing 145,000ft², 30MW-capacity FAB 2 headquarters in Thornton.

"FAB3 will bring together our unique approach to manufacturing flexible lightweight modules with the capacity to address the potentially large BIPV and BAPV markets worldwide," says Ascent's president & CEO Dr Farhad Moghadam.

With selection for due diligence, the LGPO is initiating discussions with Ascent regarding detailed due diligence, the negotiation of terms and conditions of a potential loan guarantee, National Environmental Policy Act (NEPA) compliance and all other issues necessary for the LGPO to consider the issuance of a conditional commitment and, potentially, a loan guarantee for the FAB3 project.

Ascent Solar Technologies notes that the LGPO's advancement of its loan guarantee application to the due-diligence review stage is not an assurance that the FAB3 project will be offered a term sheet or

FAB3 will bring together our unique approach to manufacturing flexible lightweight modules with the capacity to address the potentially large BIPV and BAPV markets worldwide

approved for a conditional commitment by LGPO.

The due-diligence process may be terminated by the DOE at any time if it is determined that the project is unlikely to meet LGPO's requirements, which include statutory and regulatory requirements and DOE's policies, procedures and financial requirements.

In order to qualify for appropriated credit subsidy under Section 1705 of Title XVII, FAB3 will be required to commence construction prior to financial closing, which must occur on or before 30 September.

www.ascentsolar.com

Sunload Mobile Solutions to distribute Ascent's EIPV modules in Europe

Ascent Solar Technologies says that Sunload Mobile Solutions GmbH of Berlin, Germany (a manufacturer of solar chargers for small off-grid applications) is to act as an authorized distributor of its lightweight, flexible, thin-film copper indium gallium diselenide (CIGS) modules for electronic-integrated photovoltaic (EIPV) applications in Europe.

Ascent Solar reckons that the agreement will give it access to multiple opportunities within Europe's rapidly expanding off-grid battery charging and portable power markets.

"This relationship establishes a partnership through which we expect to market our lineup of flexible, lightweight CIGS modules for off-grid portable power," says president & CEO Farhad Moghadam. "The innovative European market represents a significant opportunity for Ascent's portfolio of products."



Sunload's Picard solar luggage

www.sunload.com

Solyndra closes \$75m credit facility Rapid manufacturing and sales growth to make firm cash flow positive by end 2011

Solyndra Inc of Fremont, CA, USA, which makes cylindrical copper indium gallium diselenide (CIGS) photovoltaic (PV) systems consisting of panels and mounting hardware for commercial and industrial rooftops, has closed a new \$75m secured credit facility underwritten by existing investors. Proceeds from the financing will be used to support Solyndra's working capital requirements, accelerate the firm's ongoing cost-reduction activities, and execute its expanded channel and segment sales and marketing strategy.

Solyndra's proprietary tubular thin-film solar panels have a 'self-tracking' design — with a 360° photovoltaic surface capable of absorbing direct, diffuse and reflected sunlight (from below) — that capture more sunlight from low-slope rooftops at a lower installed cost than conventional flat-surfaced solar panels, which need costly tilted mounting devices to improve the capture of direct light from the sun, offer poor collection of diffuse light, and fail to collect reflected light. Also, gaps between the tubes and their frame let wind pass through, reducing the need for heavy, roof-penetrating fastenings or anchoring; their lighter weight also allows installation on scantier roofs. Simple horizontal mounting hardware also allows fast and economical installation, claims the firm.

"Solyndra has excellent market-place momentum, with record installations of our product in the fourth quarter and annual revenues exceeding \$140m last year," says president & CEO Brian Harrison. "With strong acceptance of our 200 Series product [launched last October at the Solar Power International 2010 show in Los Angeles], we are seeing growth in the US and markets throughout Europe," he adds. "We have recently reached a

number of significant milestones, including the shipment of nearly 100MW of panels, the completion of more than 1000 installations in 20 countries and the announcement of our PV greenhouse solution."

Construction of the firm's new 300,000ft² manufacturing and customer demonstration facility (employing about 3000 construction workers) has now been completed ahead of schedule. Installation of the remaining production tools will take place in 2011, raising Solyndra's annual production run rate to about 200MW by year's end and 300MW when fully ramped. The new facility will also enable Solyndra to manufacture products with an installed system cost-of-goods sold (COGS) of about \$2 per watt in first-quarter 2013, which is expected to be highly competitive with all other technologies.

"With this round of funding and the continued support of our existing investors we are on track to be cash flow positive at the end of this year," reckons Harrison. "Solyndra's fast and easy-to-install panels are a proven and scalable solar solution, ideal for rooftop applications," he adds. "Today we are demonstrating competitive 'all in' pricing, strong ROI and economics for rooftop owners, and many enthusiastic new and repeat customers."

The new financing also included restructuring of the firm's outstanding indebtedness. Solyndra's existing convertible notes have been exchanged for new notes, and the US Department of Energy (which provided a \$535m loan guarantee in March 2009) agreed to certain loan modifications including an extension of the amortization period. Together with the existing indebtedness, the new credit facility is secured by all assets of the company.

www.solyndra.com

IN BRIEF

Daystar CEO resigns

At the end of February, after a year with the firm, Magnus Ryde resigned from his roles as CEO & director of DayStar Technologies Inc of Milpitas, CA, USA, which is developing copper indium gallium diselenide (CIGS) thin-film photovoltaic products, in order to pursue other opportunities.

"The progress we have made to restructure our balance sheet and in discussions with potential strategic partners have DayStar well positioned for near-term success," says Ryde.

Peter Lacey (chairman since October 2009) has been appointed to the added post of interim CEO. "We appreciate the leadership that Magnus Ryde provided to DayStar during this very challenging time as well as the progress that has been made during Mr Ryde's tenure as CEO to position the company for a successful strategic partnership," says Lacey. "I look forward to taking a more active role in the day-to-day operations of the business and working closely with the rest of the management team," he adds. "I am committed to doing everything necessary to continue to build upon the progress that has been made to position the company for a strategic partnership and to lead DayStar through its next phase of growth."

Previously, from 2003, Lacey was president, CEO & director of Cervus Equipment Corp. He is also the president, CEO and a trustee of Proventure Income Fund, a public real-estate income trust (REIT). Also, from September 2004 he was chairman & director of Eveready Energy Services, a public company listed on the Toronto Stock Exchange that provided industrial and oilfield maintenance and production services.

www.daystartech.com

Sofradir appoints VP of R&D, technology & products

Sofradir of Châtenay-Malabry, near Paris, France, which manufactures cooled infrared detectors based on mercury cadmium telluride (MCT/HgCdTe) for military, space and industrial applications, has appointed David Billon-Lanfrey as vice president of R&D, technology & products. He replaces Philippe Tribolet, who died last November at the age of 51 after a year-long fight against cancer.

As new head of the technology department, Billon-Lanfrey will oversee a team of 100 that includes engineers in metallurgy, semiconductor materials, microelectronics, optoelectronics, micromechanics, cryogenics and other specialty areas in physics and chemistry, all necessary for the development of IR detectors that cover the entire spectrum from visible to VLWIR (very long-wavelength infrared). Sofradir says that his promotion from within the firm ensures the continuation of R&D projects and product developments for customers



Billon-Lanfrey.

and the need to satisfy SWaP (reduce system size, weight and power) requirements for military applications is even more pronounced," notes chairman & CEO Philippe Bensussan. "He is also stepping into the shoes of Philippe Tribolet, a pioneer in infrared technologies," he adds. "His expertise, knowledge and vision of infrared technologies will build upon our tradition of making best-in-class short-wave, mid-wave and long-wave IR detectors and further advance our product portfolio."

Billon-Lanfrey previously headed the R&D optronics characterization

that are currently underway.

"David is taking over the helm of our technological developments at a challenging time, when defense budgets are shrinking

team for five years, responsible for expanding the team, its role and improving its expertise. Before that, for 12 years he was project manager for R&D and product development, where he contributed to developing the SADA II product for the US market. Billon-Lanfrey is a graduate of optronics at Joseph Fourier university in Grenoble (one of France's leading health, science and technology universities).

Billon-Lanfrey will lead the R&D and technological teams at Sofradir as well as the researchers at DEFIR, the firm's joint lab with CEA/LETI. "They have already introduced a huge number of innovations into our processes and products to the benefit of our customers," he comments. "The ability to push the boundaries in performance of our IR detectors has yet to reach its limit due to the versatility of our mercury cadmium telluride technology that can be used to produce IR detectors in every waveband."

www.sofradir.com

Xenics opens US sales & support subsidiary

Xenics nv of Leuven, Belgium, which makes infrared detectors and customized imaging solutions spanning the long-wavelength infrared (LWIR) to the visible (0.4–14 μ m), is broadening its market presence in North America by intensifying sales and application support via its subsidiary Xenics USA Inc in Boston, MA (founded last October, but fully operational only in January). Xenics USA is headed by Luc DeBrouckere as CEO, an industry expert with 35 years of managerial and technical experience in IR imaging.

Xenics says that, after opening a sales and support office (sInfraRed Pte Ltd) in Singapore in 2008, it is now taking the next step in enlarging its footprint on the world market for IR imaging equipment and customized IR imaging solutions. Specifically, Xenics USA is tasked with increasing and facilitating

sales, as well as offering direct local support to industrial and institutional customers throughout the US and Canada.

Besides serving industrial customers, Xenics USA is positioned to better penetrate the strategically important and rapidly growing market for security systems as well as the thriving institutional and OEM markets for governmental projects, where Xenics says it is prepared to meet formidable local competition.

"Our American customers are specifically interested in the range of short-wave and long-wave cameras and advanced IR imaging systems that Xenics is able to offer," says DeBrouckere, citing in particular the firm's IR image capture and processing solutions. "It's important to us to comply with our customers' preference of receiving solid technical and application sup-

port through a US-based entity," he notes.

The product spectrum marketed and supported by Xenics USA will include all products and solutions in the firm's broad-based product portfolio. Technical support staff positions are now filled, and DeBrouckere has begun hiring technical staff in the US for sales and support.

"North America is a very important strategic market for us," says Xenics' founder & CEO Bob Grietens, who is also president of Xenics USA. "Of course, we face tough competition. But Xenics is ready to tackle these challenges and to grow with new products and developments that need strong local support," he adds. "I'm sure our US subsidiary will give a definite boost to our worldwide market share."

www.xenics.com

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InSb

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MOCVD

PIN

GaAs

APD

Polycrystal

Solar Cell

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Exploring droop and wide-well nitride LEDs

Researchers at Taiwan's Chang Gung University conclude that efficiency droop probably dominated by hole injection problems rather than electron overflow.

Researchers in Taiwan have been exploring efficiency droop effects in wide-well light-emitting diodes (LEDs) [Liann-Be Chang et al, Appl. Phys. Express, vol4, p012106, 2010]. Such effects have been widely studied for LEDs that use thin multi-quantum wells (2–4nm), but not so much for wider single-well double heterostructures (DHs).

The results of the researchers' work suggests "that the electron leakage significantly decreases the peak EQE [external quantum efficiency] and shifts the start point of efficiency drop to a higher current density, but is not significantly responsible for the efficiency droop in the wide-well InGaN DH LEDs". The researchers conclude: "Thus, we suggest that the hole injection efficiency probably dominates the mechanism of efficiency droop rather than electron leakage".

The researchers at Chang Gung University produced two structures (Figure 1). The first (LED-1) was a single-well device with a 7.5nm well. The device also incorporated a 20nm electron-blocking layer (EBL) consisting of p-type conducting AlGa_{0.1}N (10% Al). EBLs are used to reduce overflow of electrons from the active region into the p-contact region. Such overflow diverts electrons from recombining directly with holes in the active region, reducing light emission.

The second structure (LED-2) was the same, except that the EBL was thinned to 5nm and an extra 3.5nm InGa_{0.25}N well was inserted between the EBL and p-contact layers. (The researchers found that devices with a

test structure and a 20nm EBL did not have sufficient overflow to give emission from the test well.) The purpose of this well was to detect (through light emission) overflow electrons that evade the EBL. Having a higher indium content (25%) compared with the main well (6% In), one would expect the extra well to emit at longer wavelengths.

The epitaxial structures were produced on sapphire substrates using atmospheric-pressure metal-organic chemical vapor deposition (AP-MOCVD). The epitaxial material was processed into 295µm x 325µm LEDs by standard processes. A 300nm indium tin oxide (ITO) was used to spread the current below the p-electrode. The metal combination used for the electrodes was chromium-platinum-gold.

The electroluminescence (EL) tests were carried out at room temperature with pulsed operation (100µs

5nm p ⁺⁺ -GaN	5nm p ⁺⁺ -GaN
95nm p-GaN	95nm p-GaN
20nm p-Al _{0.1} Ga _{0.9} N	3.5nm In _{0.25} Ga _{0.75} N
2nm GaN barrier	20nm p-Al _{0.1} Ga _{0.9} N
1nm graded In _x Ga _{1-x} N (x = 0.06–0)	2nm GaN barrier
7.5nm In _{0.06} Ga _{0.94} N	1nm graded In _x Ga _{1-x} N (x = 0.06–0)
1nm graded In _x Ga _{1-x} N (x = 0–0.06)	7.5nm In _{0.06} Ga _{0.94} N
2nm Al _{0.05} Ga _{0.95} N barrier	1nm graded In _x Ga _{1-x} N (x = 0–0.06)
3 microns n-GaN	2nm Al _{0.05} Ga _{0.95} N barrier
1.3 microns u-GaN	3 microns n-GaN
25nm GaN buffer	1.3 microns u-GaN
Sapphire	25nm GaN buffer
	Sapphire

Figure 1. Schematic structures of samples LED-1 (reference LED structure) on left, and LED-2 (leakage test LED structure) on right.

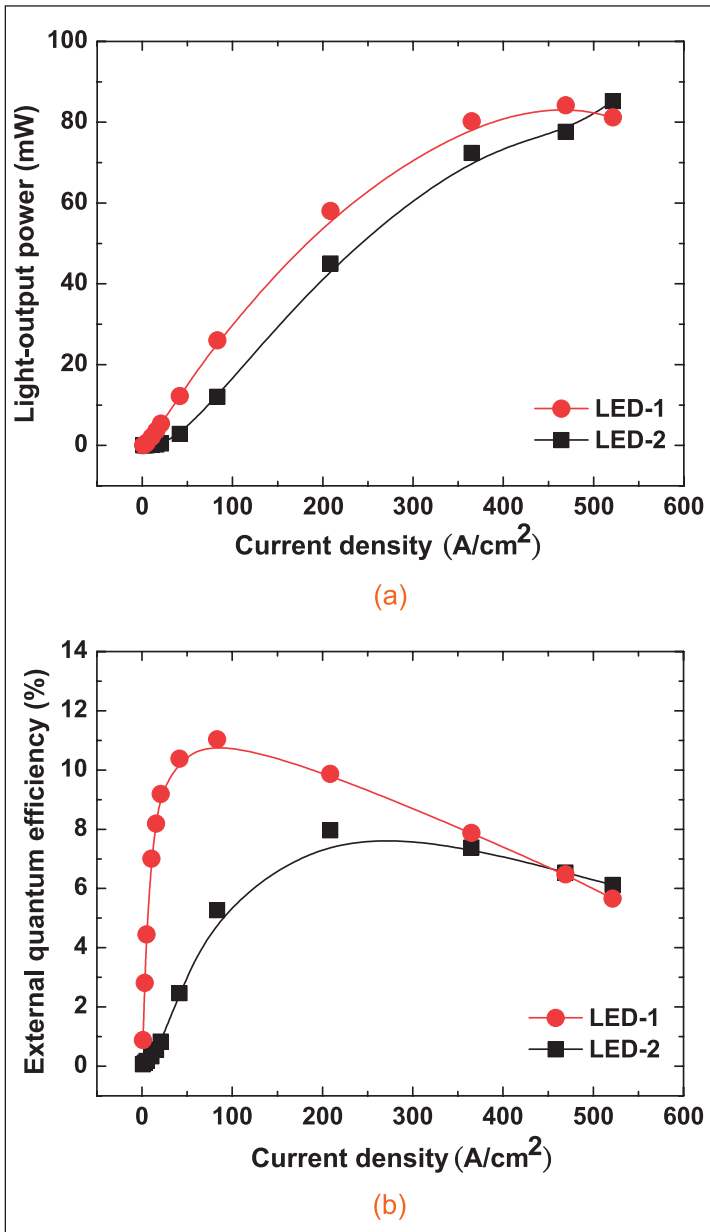


Figure 2. (a) Light-output power of samples LED-1 and LED-2 vs forward current density. (b) EQE of samples LED-1 and LED-2 vs forward current density.

pulse, 1% duty cycle) to avoid self-heating effects. The light output through the ITO film was measured.

The researchers found that the effect of the thinner EBL, allowing greater electron leakage into the contact region (but also better hole injection into the wide well), was to reduce the peak efficiency (Figure 2). However, the efficiency droop

Electron leakage significantly decreases the peak EQE [external quantum efficiency] and shifts the start point of efficiency drop to a higher current density, but is not significantly responsible for the efficiency drop in the wide-well InGaN DH LEDs

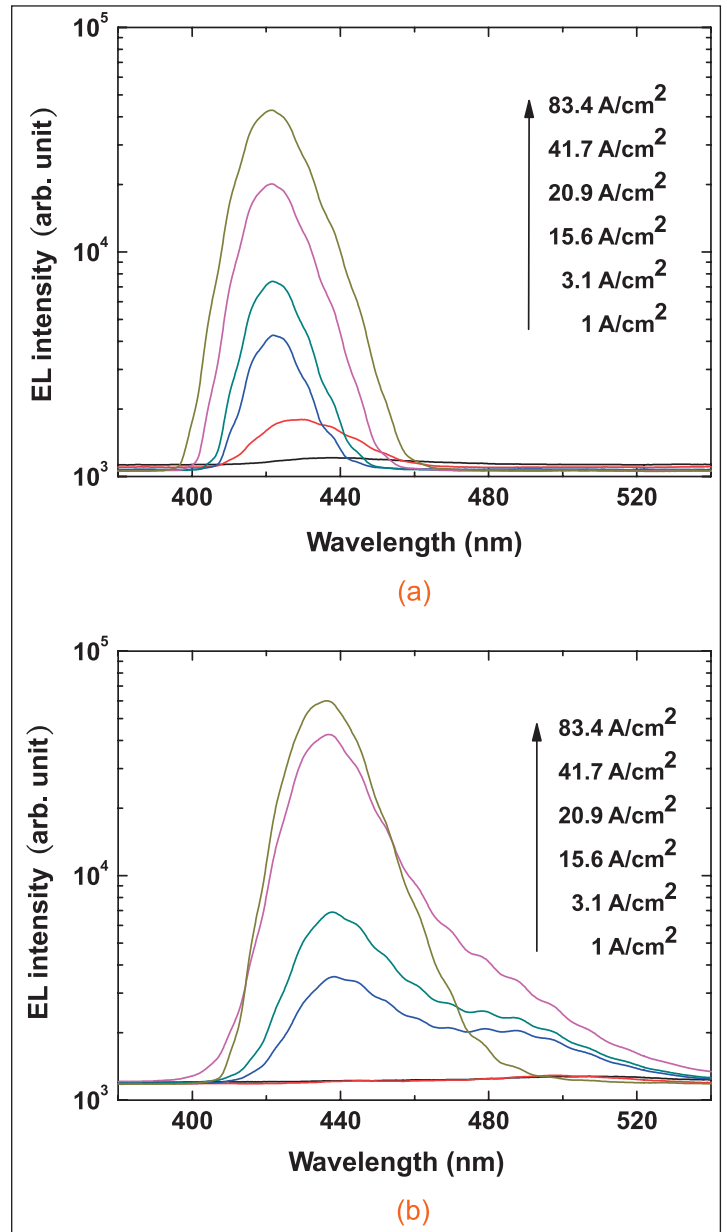


Figure 3. EL spectra with forward current density ranging from 1 to 83.4A/cm² for samples (a) LED-1 and (b) LED-2.

kicked in at a higher injection current (208.6A/cm², compared with 83.4A/cm² for LED-1) and was less steep than for the thicker EBL of the device without test structure.

Another interesting feature is that the light output power of LED-2 exceeds that of LED-1 when the current injection is greater than 500A/cm².

In terms of the output spectrum (Figure 3), the test structure showing electron overflow can be seen as another peak in the wavelength region 480–520nm (blue-green). Initially, the test structure peak dominates (up to 3.1A/cm²), but becomes less significant at higher currents as holes begin to reach the wide-well region. ■

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Author: Mike Cooke

Good grades for reducing nitride LED efficiency droop

Taiwan researchers cut LED efficiency droop from 34% to 4% using graded electron-blocking layer.

Researchers in Taiwan from National Chiao-Tung University and Epistar Co Ltd have developed a graded electron-blocking layer (GEBL) for nitride semiconductor light-emitting diodes that reduces efficiency droop compared with devices with a conventional EBL [C. H. Wang et al, Appl. Phys. Lett., vol97, p261103, 2010].

The efficiency droop for the GEBL LED at an injection current density of 200A/cm² is only 4% from the peak value, compared with 34% for an LED with a conventional single composition EBL. Some of the same researchers recently used grading of multi-quantum well (MQW) structures to alleviate droop effects (www.semiconductor-today.com/news_items/2010/NOV/EPICSTAR_051110.htm).

EBLs are widely used in nitride semiconductor LEDs to confine electrons to the active light-emitting region of the device. Without an EBL, a large proportion of electrons overshoot the active region and recombine with holes in the p-type contact region of the device where they either do not produce light or they emit at a parasitic wavelength.

Table 1. Epitaxial structures grown for LEDs. (The simulations did not include pre-strain superlattice/SL layers.)

p-GaN	contact	200nm
p-Al _x Ga _{1-x} N EBL/GEBL	EBL/GEBL	20nm
6xIn _{0.15} Ga _{0.85} N/GaN	MQW	6x(2.5nm/10nm)
10x(InGa _N /Ga _N)	pre-strain SL	
n-GaN	contact	4μm
LT-GaN	nucleation	
c-plane sapphire		

The EBL generally consists of aluminum gallium nitride (AlGa_N) material. One problem with using such EBLs is that they also hinder the injection of holes into the active layers. Further, nitride semiconductors have large spontaneous and strain-dependent (piezoelectric) polarization electric fields that can reduced the effective barrier height of the EBL for electrons.

Some groups have explored alternative materials to AlGa_N, such as aluminum indium nitride (AlIn_N) or AlGaIn_N, but these materials are difficult to realize and create difficulties in producing high-quality p-GaN layers. ▶

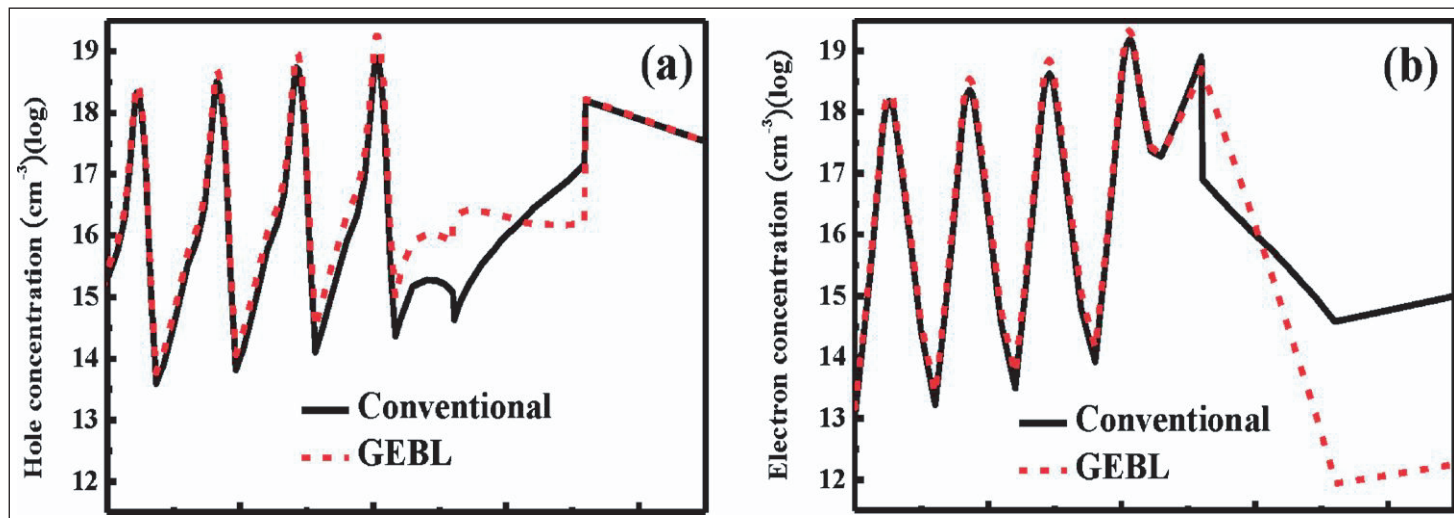


Figure 1. Calculated (a) hole concentration distribution and (b) electron concentration distribution of conventional and GEBL LEDs at a current density of 100A/cm².

► The Taiwan-based researchers instead adopted an AlGaIn EBL structure that had a varying (graded) Al content, developed using simulations (Figure 1). The aim was to reduce the electron concentration in the p-GaN region (right side of plots in Figure 1) and increase hole concentration in the multi-quantum wells (MQWs).

Based on the simulations, epitaxial structures (Table 1) were grown on c-plane sapphire using metal-organic chemical vapor deposition (MOCVD). The graded EBL (GEBL) was achieved by varying the ratio of Al/Ga sources. The EBL/GEBL growth temperature was 870°C. The GEBL was graded from 0% to 25% Al. The conventional EBL contained 15% Al.

Another possible technique for grading AlGaIn is temperature ramping. However, this latter method risks damaging the previous MQW structure and also creates complications due to variable growth rates.

The epitaxial material was used to create LEDs with an indium tin oxide (ITO) transparent conducting spreading layer. Nickel-gold metals were used for contacts. The mesa structures were 300µm x 300µm. Devices with graded and non-graded EBLs were tested.

Both devices had an emission wavelength around 450nm (blue) at 22A/cm² injection current. At the same current, the forward voltage and series resistance were, respectively, 3.28V and 7Ω for the GEBL device and 3.4V and 8Ω for the conventional EBL LED.

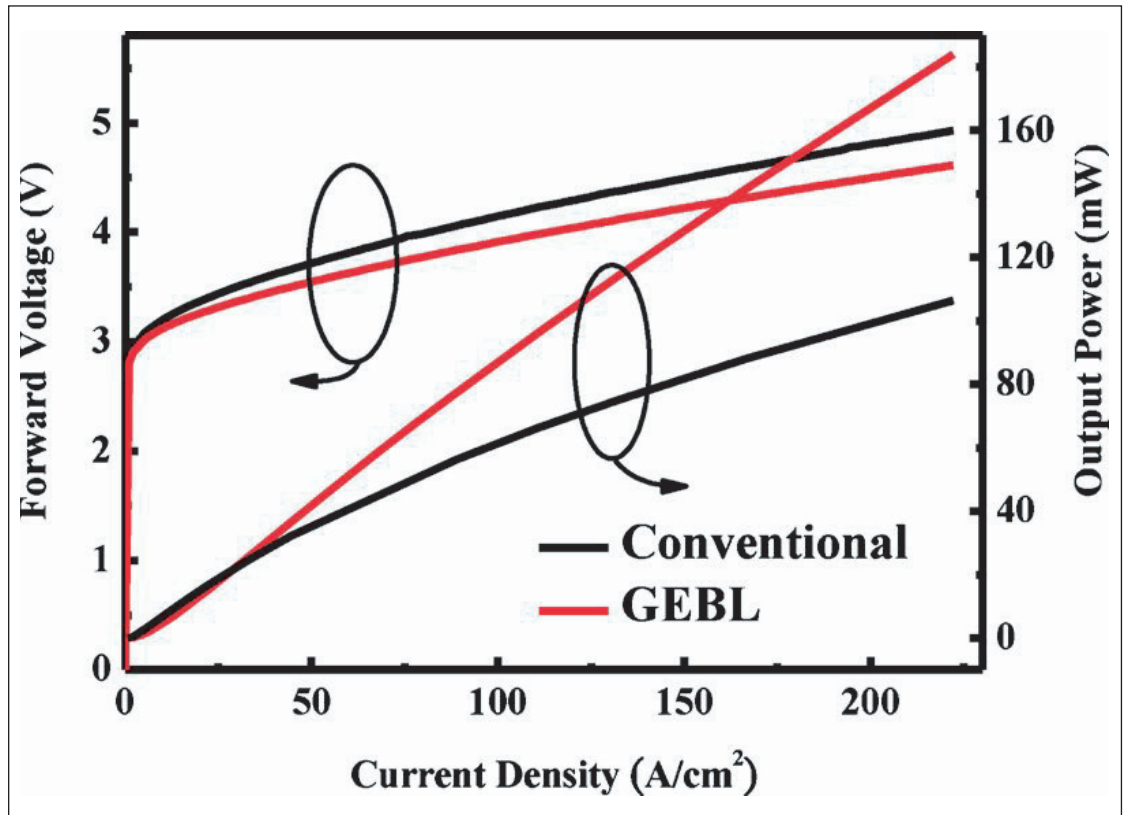


Figure 2. Forward voltage and output power as a function of current density for conventional and GEBL LEDs.

Peak efficiencies occurred at injection current densities of 80A/cm² and 20A/cm² for the GEBL and conventional EBL LEDs. The fall-offs in efficiency (droop) at 200A/cm² were 4% and 34% from their peak values for the GEBL and conventional EBL LEDs, respectively. These improvements are again attributed to better hole injection and electron confinement, 'especially at high current density'

The researchers attribute the improvements for the GEBL LED to better hole injection and higher-efficiency p-type doping of the GEBL.

The light output power (L) for 30A/cm² current injection is slightly less for the GEBL device (see Figure 1). However, at higher currents the GEBL device had L values enhanced by 40% and 69% over the conventional device at 100A/cm² and 200A/cm², respectively.

The researchers explain the lower output at low current for the GEBL LED as being due to a high barrier at the GEBL/p-GaN interface. The holes find it difficult to tunnel through this barrier into the MQW light-emitting region. However, at higher current the tunneling barrier becomes less significant since diffusion becomes the dominant flow mechanism. Improved confinement of the electron carriers also makes a contribution to improved light output at high current.

The peak efficiencies occurred at injection current densities of 80A/cm² and 20A/cm² for the GEBL and conventional EBL LEDs, respectively. Further, the fall-offs in efficiency (droop) at 200A/cm² were 4% and 34% from their peak values for the GEBL and conventional EBL LEDs, respectively (Figure 2). These improvements are again attributed to better hole injection and electron confinement, 'especially at high current density'. ■

<http://link.aip.org/link/APPLAB/v97/i26/p261103/s1>

Author: Mike Cooke

Taking the a-plane to higher crystal quality

Lateral overgrowth used to reduce threading dislocations to $10^6/\text{cm}^2$.

Taiwan's Kun Shan University of Technology has developed a method to improve the crystal quality of a-plane gallium nitride (GaN) grown on r-plane sapphire [Hsiao-Chiu Hsu et al, *Appl. Phys. Express*, vol4, p035501, 2011]. The researchers used a modified one-sidewall-seeded epitaxial lateral overgrowth (OSELOG) method that reduces threading dislocation densities down to $10^6/\text{cm}^2$.

A further attraction is a coalescence thickness of less than 5mm, which is about half that of previous attempts using OSELOG. The researchers believe that the quicker coalescence offers opportunities for higher-throughput processes for crystal quality enhancement (i.e. higher productivity).

Normal c-plane nitride semiconductor LEDs suffer from polarization electrical fields in the active region generated from the ionic nature of the chemical bond between the group III metal (e.g. Ga) and nitrogen atoms. Although some of the polarization field is spontaneous, nitride semiconductors suffer particularly from strain-dependent piezoelectric effects. In light-emitting devices, these fields tend to hold the electrons and holes apart, disrupting their recombination as light. This effect is known as the quantum-confined Stark effect (QCSE).

In the past few years, a number of research groups have been investigating using nitride semiconductors that are oriented in non-polar or semi-polar crystal directions to reduce or eliminate QCSE. Such work has enabled laser diodes with longer-wavelength emission (green) and LEDs with a number of attractive features. Material oriented in these non-standard directions tends to have lower material quality than mature c-plane GaN.

The main non-polar direction material that has been researched

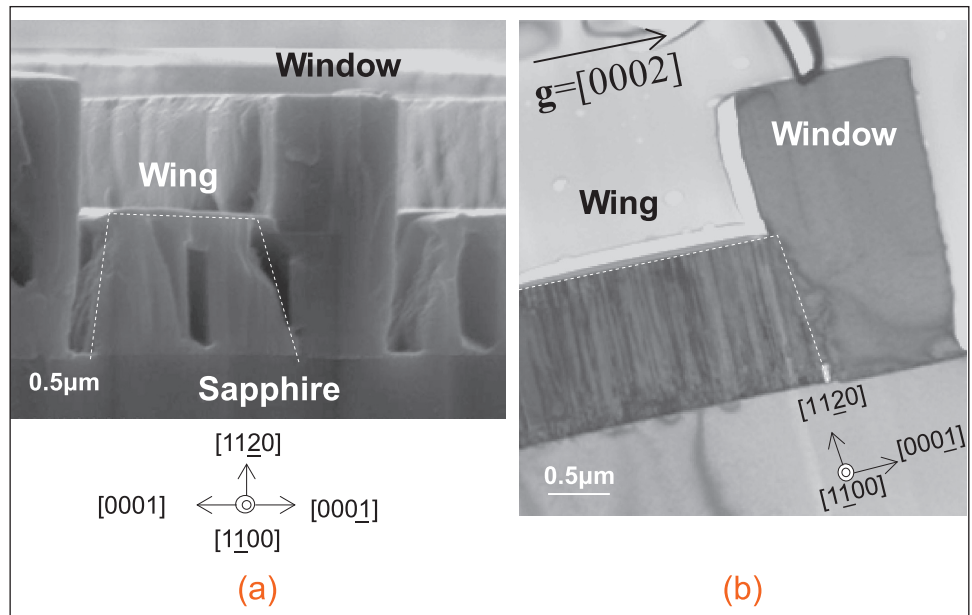


Figure 1. Cross-sectional SEM and TEM images of a-plane GaN after first step of GaN growth with V/III growth rate ratio of 1000. SiO_2 is removed for SEM.

in this way is labeled 'm-plane'. However, there is another non-polar direction, 'a-plane'. This material can be grown on r-plane sapphire substrates using MOCVD. Unfortunately, the resulting crystal contains large numbers of threading dislocations (TDs $\sim 10^{10}/\text{cm}^2$) and basal-plane stacking faults (BSFs, $\sim 10^5/\text{cm}$).

Despite these problems, some groups have reported a-plane devices. In 2008, Rensselaer Polytechnic Institute and Kyma Technologies used a-plane material to create green LEDs with small blue-shift at high current density [Theeradetch Detchprohm et al, *Appl. Phys. Lett.*, vol.92, p241109, 2008, <http://link.aip.org/link/doi/10.1063/1.2945664>]. In that case, the a-plane was cut from free-standing c-plane GaN that had been grown using hydride vapor phase epitaxy (HVPE; this method is also used to produce m-plane and semi-polar GaN pieces, for example, by University of California Santa Barbara and Mitsubishi Chemical).

Cutting non-polar or semi-polar material from free-standing c-plane

GaN material restricts the size of substrates by the thickness of the HVPE growth process. Hence, growing a-plane GaN on r-plane sapphire is attractive if the quality can be increased in a relatively simple, time- and money-efficient manner.

More recently, researchers associated with a variety of Korean organizations (Kongju National University, THELEDS Co Ltd, Korea Electronics Technology Institute, Chungnam National University, Wavesquare Inc) have reported Raman and emission properties of a-plane LEDs grown on r-plane sapphire [Yanqun Dong et al, *J. Appl. Phys.*, vol.109, p043103, 2011, <http://link.aip.org/link/doi/10.1063/1.3549160>]. Although the a-plane device had lower maximum external quantum efficiency (EQE) than a comparison c-plane LED, the a-plane device maintained its EQE to higher currents (reduced 'droop'). Presumably, higher-quality a-plane GaN would exhibit higher EQEs.

The Kun Shan researchers began their a-plane OSELOG with r-plane sapphire prepared with GaN stripes

to act as seeds for the a-plane material. The stripes are formed using a silicon dioxide (SiO_2) mask formed lithographically on a layer of a-plane GaN material. The windows in the SiO_2 layer are then etched down to the sapphire. The 'wing'/seed under the SiO_2 was 2mm wide and the windows were 1.6mm.

Since the seed is a-plane oriented, the c-planes are 'vertical' (rather than 'horizontal' as in c-plane material; the [0001] c-direction is 'horizontal' with a-plane, and 'vertical' with c-plane) and the sidewalls of the stripes can be arranged to be Ga- and N-face.

The re-growth on the seed layer proceeds by supplying precursors (ammonia, trimethyl-Ga) with a high V/III (N/Ga) ratio of 1000 to encourage growth from the N-face (Figure 1). The V/III ratio is then reduced to 220, making the N-face and Ga-face sidewall growth rates nearly equal. This ratio was maintained until the GaN coalesced over the SiO_2 mask (Figure 2).

This process was carried out with various trimethyl-Ga (TMGa) flow rates (15, 30 and 45 standard cubic centimeters, 'sccm') in the second step with V/III ratio 220. An 'as-grown' (i.e. no overgrowth) a-plane GaN sample with a similar layer thickness was used as a reference in the crystal quality characterization.

Measurements on the OSELOG material suggest that the dislocation density over the window regions was 3–4 orders of magnitude (factors of 10) lower than over the SiO_2 'wings'.

Air voids formed near the SiO_2 mask due to the different shapes of the Ga- and N-face growth profiles — for example, the Ga-face growth tended to have an arrow-head shape with [11-2n] facets. However, the exact form depends on the exact growth conditions (temperature, V/III ratio, hydrogen carrier flow rate, etc). The researchers believe these voids do not affect material quality and may even be beneficial in relaxing strain as the temperature is reduced to room temperature after growth.

The coalescence over the SiO_2 mask occurred earlier (after 3.9mm) than with the previous report (10mm) of a-plane OSELOG material from Meijo University in Japan. Adding in the as-grown seed layer, the total thickness of the Kun Shan samples were 5.5mm. The quicker coalescence and hence reduced overall thickness is attributed to 'optimum growth conditions and narrower stripes'.

The Kun Shan researchers comment: 'The result indicated that the modified OSELOG approach is able to reduce the process time and improve the yield when compared with the conventional ELOG technology.'

Apart from electron microscopic inspection, the materials were also characterized using x-ray diffraction (XRD) and low-temperature (11K) cathodo-luminescence (CL; light excited by an electron beam). The XRD scans were carried out along the c-axis and m-axis (Table), and the results suggest improved crystal quality for the 30sccm TM-Ga flow.

The CL spectral measurements over a 20mm x 20mm area were used to assess the various defects using emissions from donor-bound excitons (D^0X , 3.472eV), BSFs (3.417eV) and donor-acceptor pair (DAP, 3.345–2.8eV) recombination.

The Kun Shan researchers interpret their CL results as showing that the TM-Ga flow rate controls the strain in the GaN epilayer. The strain condition affects the tendency to form defects. Low defect levels are needed to create efficient

light-emitting devices.

Again, the lowest level of BSF emission, relative to the D^0X signal, is seen in the middle-range TM-Ga flow of 30sccm (BSF/ D^0X ratio 1.74, compared with 2.15 for 15sccm and 3.54sccm for 45sccm). The DAP emissions provided information about silicon and oxygen donor effects due to decomposition of the SiO_2 mask, along with defect distributions. ■

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Author: Mike Cooke

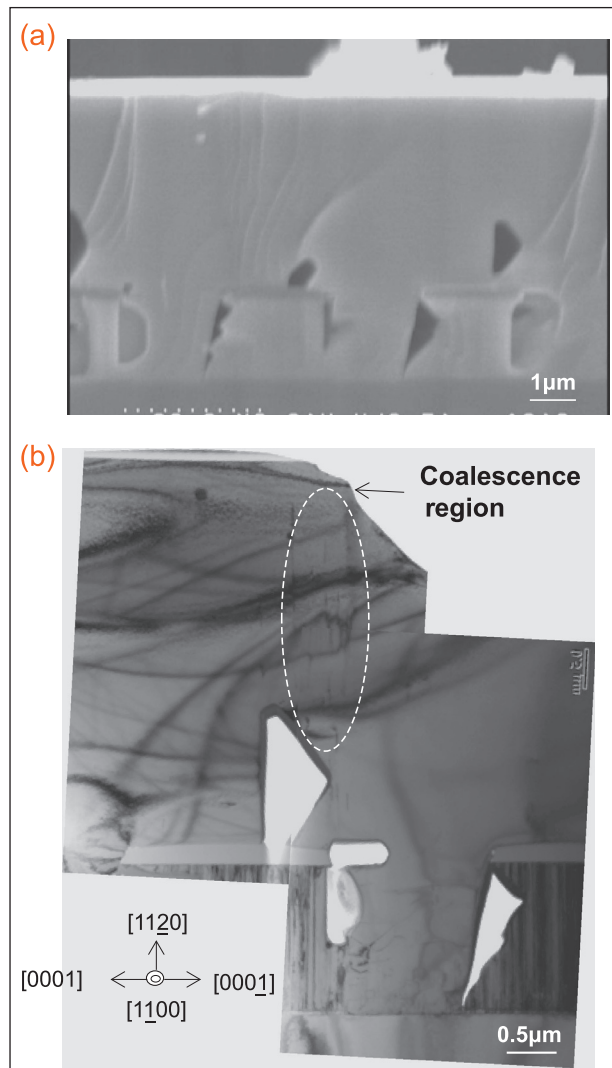


Figure 2. Cross-sectional SEM and TEM images of fully coalescence a-plane GaN after second step with V/III growth rate ratio of 220.

Table. Results for XRD ω -scans along c- and m-axes.

TM-Ga flow (sccm)	As-grown	15	30	45
c-axis	0.398°	0.379°	0.141°	0.387°
m-axis	0.527°	0.301°	0.110°	0.199°

UCSB demos record-frequency normally-off nitride transistor

E-mode N-polar GaN MISFETs with 120GHz current-gain cutoff.

University of California Santa Barbara (UCSB) has reported the first demonstration of high-frequency operation of N-polar enhancement-mode (normally-off) gallium nitride (GaN) transistors [Uttam Singiseti et al, Appl. Phys. Express, vol4, p024103, 2011].

The short-circuit current-gain cutoff (f_T) for the UCSB device was 120GHz. Higher values of f_T have been achieved for Ga-polar depletion-mode (normally-on) devices. For example, groups from HRL Laboratories/NASA's Jet Propulsion Laboratory and MIT reported GaN high-electron-mobility transistors (HEMTs) with f_T values beyond 200GHz at December IEEE International Electron Devices Meeting (IEDM 2010).

However, enhancement-mode devices are more attractive in terms of power efficiency, and a number of approaches are being developed to shift GaN transistor threshold voltages into enhancement. Using N-polar nitride semiconductors, rather than the more usual Ga-polar material, is one such approach and could lead to better carrier confinement in the channel.

Although the 120GHz f_T is promising, there are a number of less attractive features of the present device (Figure 1). First, the power-gain cut-off (f_{max}) for the same conditions was only 11GHz. The researchers attribute this to the high resistance of a thin tungsten (W) gate layer, commenting: "Incorporation of the top T-gate process would reduce the gate resistance, resulting in high f_T and f_{max} simultaneously."

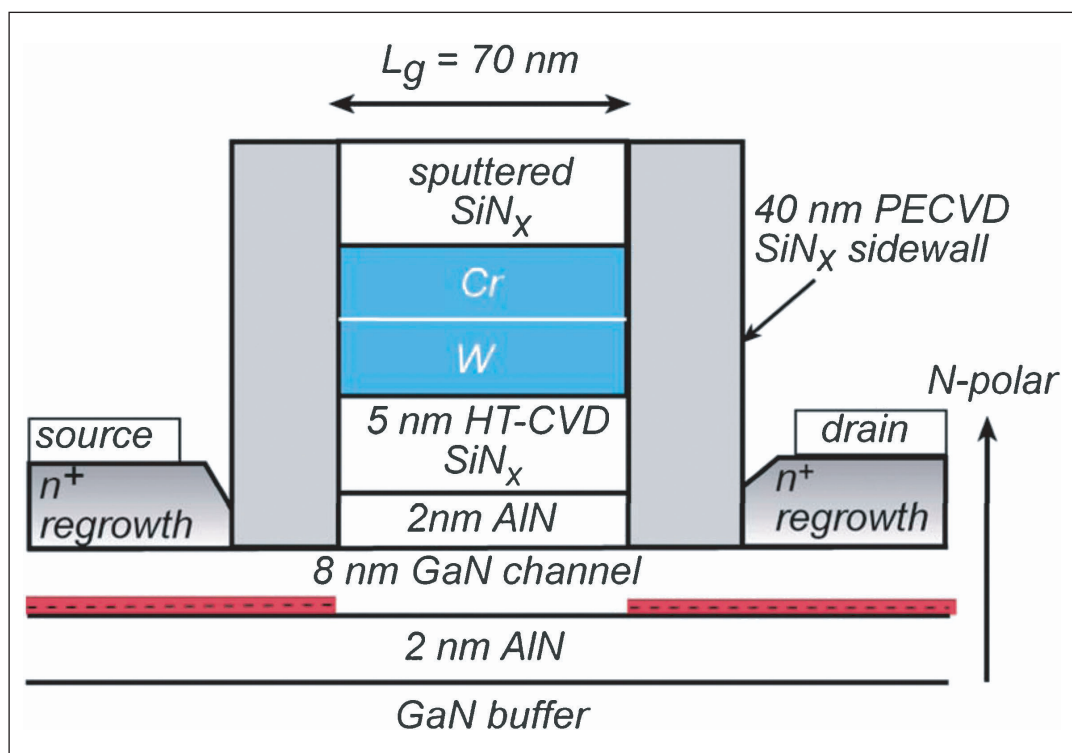


Figure 1. Device cross-section schematic.

Further bad performance characteristics came in the form of poor saturation and high output conductance. These features need to be improved for use in analog circuits. The output conductance problem could be due to positively charged traps at the bottom aluminum nitride/gallium nitride (AlN/GaN) interface beneath the channel. Short-channel effects due to the low ratio (4.6) of gate length to gate-to-2DEG (two-dimensional electron gas) distance are also likely to be involved in the high output conductance. The self-aligned drain formation also leads to a higher drain voltage at the edge of the transistor's active region. The researchers are presently working on these issues.

The on-resistance ($2.6\text{m}\Omega\text{-mm}$) is also higher than previous N-polar devices developed at UCSB. This is ascribed to un-optimized re-growth conditions and sidewall access. The researchers believe that reduced silicon nitride (SiN) surface scattering and thinner

sidewalls could help to improve the on-resistance by reducing sidewall contribution to the source access resistance.

The researchers conclude: "The future devices have to be optimized for low output conductance by further vertical scaling of the channel and the gate dielectric, and also by the optimization of the back barrier design. The growth and structures will also have to be optimized to reduce surface scattering in order to maintain high mobility in the sidewall access regions."

The devices (Figure 1) were grown using plasma-assisted molecular beam epitaxy (PA-MBE) on a carbon-face silicon carbide (SiC) substrate. The device has an AlN back-barrier. The enhancement-mode

behavior is created through an electric field in the channel induced by the polarization of the AlN capping layer.

The source/drain access to the channel was created by etching through the AlN cap. A chromium-tungsten-silicon nitride metal-insulator gate stack was then deposited and patterned using electron-beam lithographic techniques. The gate length was 70nm. The SiN was deposited using high-temperature chemical vapor deposition (HT-CVD). SiN gate sidewalls were formed using plasma-enhanced CVD (PECVD).

The source-drain contact regions consisted of 40nm indium gallium nitride (InGaN) graded to 10nm indium nitride (InN). These regions were highly doped for n-type conduction.

The threshold voltage of the device decreases with increasing drain current due to drain-induced barrier lowering (DIBL). At a drain bias of 3V, the peak drain

current is 0.74A/mm and the peak transconductance is 260mS/mm, respectively. With zero gate voltage, the three-terminal breakdown voltage is 12V.

Small-signal frequency characterization (Figure 2) resulted in the extrapolated current-gain cut-off (f_T) of 120GHz (pad de-embedded value) at a gate voltage of 2.5V and a drain bias of 3.0V. The researchers comment: "To the best of our knowledge this is the highest reported f_T for E-mode GaN devices."

The work had financial support from the US Defense Advanced Research Projects Agency—Nitride Electronic Next Generation Technology (DARPA-NEXT) and the Office of Naval Research—Millimeter-wave Initiative in Nitride Electronics multi-university research initiative (ONR-MINE-MURI) programs. ■

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Author: Mike Cooke

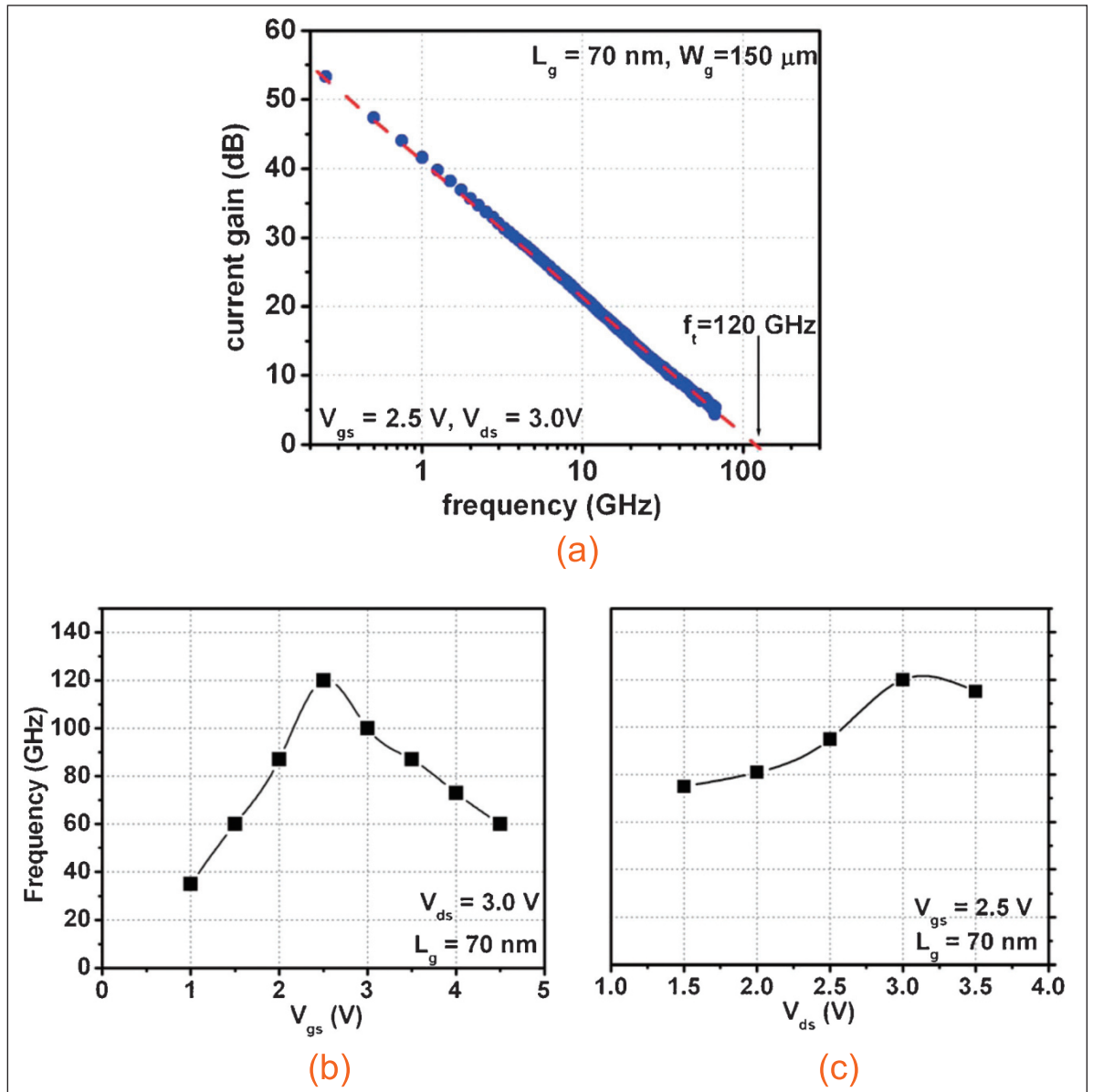


Figure 2. (a) Measured short-circuit current-gain (h_{21}) versus frequency of device. A current-gain cut off frequency (f_T) of 120GHz is extrapolated. (b) f_T versus gate voltage for drain bias 3.0V, and (c) f_T versus drain bias for gate voltage 2.5V.

Normally-off nitride transistor with oxide insulated gate

Electrochemical process used to create native oxide from AlGaN.

Researchers in Japan have developed normally-off nitride semiconductor high-electron-mobility transistors using an electrochemical oxidation process [Naohisa Harada et al, Appl. Phys. Express, vol4, p021002, 2011]. The team consisted of scientists from the Graduate School of Information and Science Technology and Research Center for Integrated Quantum Electronics (RCIQE), Hokkaido University, and the Japan Science and Technology Agency Core Research of Evolutional Science & Technology (CREST) organization.

Nitride semiconductor HEMTs are being developed for high-power and high-frequency handling applications such as power amplification of radio transmission signals, power management and power switching.

Normally-off behavior is desired from the perspectives of low power consumption and for fail-safe reasons in power switching devices.

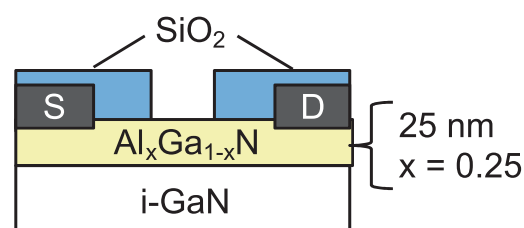
Much work has recently been carried out using various techniques to achieve normally-off behavior in aluminum gallium nitride (AlGaN) HEMTs. As-grown nitride HEMTs tend to have normally-on behavior, where a gate potential is needed to turn off current flow through the channel.

The researchers grew AlGaN/GaN heterostructures on sapphire (Figure 1), using metal-organic chemical vapour deposition (MOCVD). The source and drain contacts consisted of metal multi-layers (titanium-aluminum-titanium-gold), annealed for 1 minute at 800°C in nitrogen.

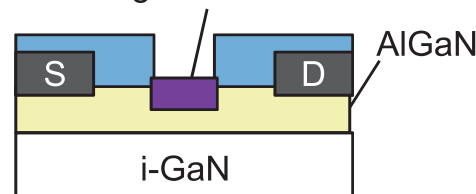
The selective oxidation was carried out using a 100nm silicon dioxide mask. The oxidation window was patterned lithographically and wet etched in a buffered hydrogen fluoride solution. The electrochemical oxidation used an electrolyte consisting of propylene glycol and tartaric acid (3% by weight). A neutral pH of 7.0 was achieved by adding ammonium hydroxide (NH₄OH).

Platinum was used as cathode, and the drain as common electrode. A silver-silver chloride reference electrode was used to control the potential at the AlGaN surface. The oxidation reaction desired was:

1. S/D formation and window opening



2. Selective electrochemical oxidation gate oxide



3. Formation of gate electrode

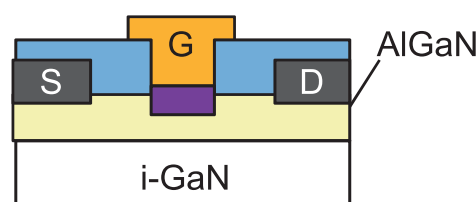
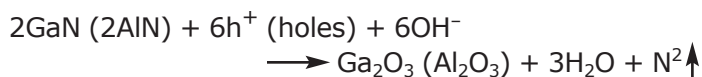


Figure 1. Fabrication process of recessed-oxide-gate AlGaN/GaN HEMT by selective electrochemical oxidation.



The holes were supplied to the reaction through ultraviolet (UV) illumination (25mW/cm², 300–400nm wavelength) of the oxide/AlGaN interface. Initially the oxidation reaction is rather slow because the generated holes are swallowed up by the two-dimensional electron gas (2DEG) at the AlGaN/GaN interface. However, after a few minutes the rate increases due to depletion of the 2DEG, which allows more of the holes

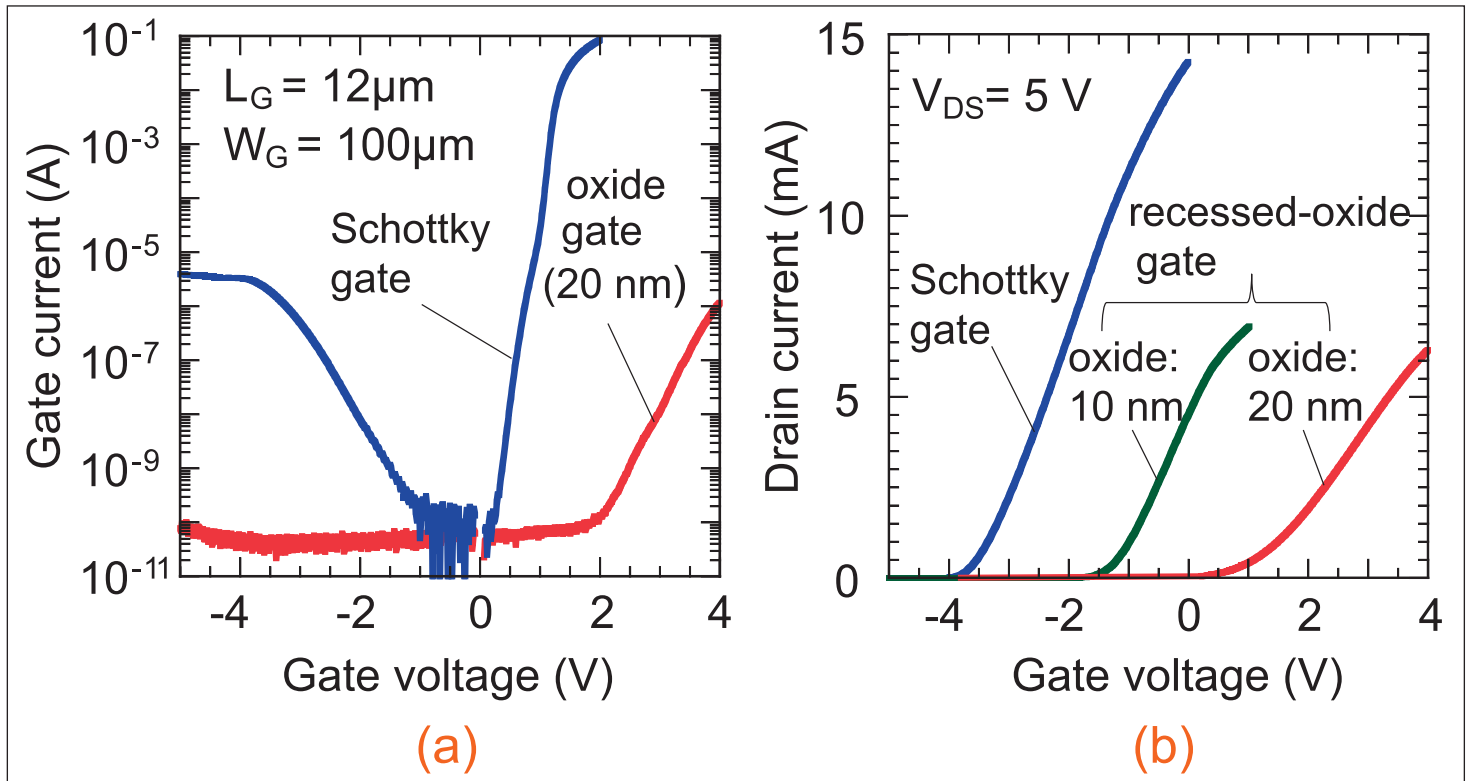


Figure 2. (a) Gate leakage and (b) transfer characteristics of reference Schottky-gate and recessed-oxide-gate HEMTs.

generated by the UV illumination to participate in the oxidation.

The resulting oxide layer is amorphous. A 260 second oxidation resulted in a 7nm oxide layer. The researchers describe the AlGaIn/oxide interface as being 'relatively flat', adding: "The flatness and uniformity of the electrochemical oxide layer is much better than those by dry oxidation at high temperatures". Atomic force microscopy (AFM) measurements gave a root-mean-square roughness for the oxide surface of 1.3nm.

X-ray photoelectron spectra (XPS) studies revealed that the Ga and Al energy levels were close to those seen in Ga_2O_3 and Al_2O_3 . The composition ratio of the two components followed that of the original AlGaIn alloy layer.

The final gate electrode consisted of nickel-gold, deposited after the oxidation process.

The researchers produced recessed oxide-gate and normal Schottky gate HEMTs with a gate length of $12\mu\text{m}$ and a source-drain spacing of $30\mu\text{m}$. The oxide thickness was 20nm, measured using transmission electron microscopy (TEM). The gate control of both

In-situ monitoring of the conductance between the source-drain electrodes during oxidation could lead to more precise control of the HEMT threshold. Further work is needed to characterize the stability and reliability

devices was similar. However, the oxide-gate device had a normally-off behavior.

The oxide-gate device had a relatively high contact resistance for the source-drain electrodes, degrading linearity at low drain bias. The researchers think that the contact resistance problem is probably due to 'a fluctuation of process condition'.

On the plus side, the gate leakage (Figure 2a) is much reduced by the presence of the oxide layer. At a gate potential of 2V, the leakage is nine orders of magnitude less than for the reference device with Schottky gate. The increase in leakage above this potential for the oxide HEMT is blamed on Fowler-Nordheim tunneling through the oxide.

HEMT devices with 10nm oxide were also produced. This device had a similar transfer curve shape to the Schottky device (Figure 2b). The researchers believe that more ohmic source-drain electrodes for the 20nm oxide HEMT would result in a curve with a similar steepness to the 10nm oxide and Schottky HEMTs. The threshold voltage for the 20nm device was +1.2V.

The researchers suggest that in-situ monitoring of the conductance between the source-drain electrodes during oxidation could lead to more precise control of the HEMT threshold. Further work is needed to characterize the stability and reliability of these devices. ■

<http://apex.jsap.jp/link?APEX/4/021002>

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

Normally-off nitride semiconductor tunnel-junction FET with high drive

Schottky source electrode used to achieve 326mA/mm drive current.

Hong Kong University of Science and Technology (HKUST) researchers have produced normally-off nitride semiconductor field-effect transistors with a drive current of 326mA/mm and an on-off ratio of 10^{10} [Li Yuan et al, 'Normally Off AlGaIn/GaN Metal-2DEG Tunnel-Junction Field-Effect Transistors', IEEE Electron Device Letters, published online 6 January 2011].

Attempts to use tunnel junctions to improve silicon metal-oxide-semiconductor FET (MOSFET) performance have usually suffered from low drive currents. Similar problems have been seen in GaN MOSFETs (drive current less than 5mA/mm).

The HKUST researchers have taken advantage of the particular conditions in nitride semiconductor high-electron-mobility transistor (HEMT) epitaxial structures with a two-dimensional electron gas (2DEG) to produce their tunnel-junction field-effect transistor (TJ-FET).

The thin 2DEG forms at gallium nitride/aluminum gallium nitride (GaN/AlGaIn) interfaces due to strong spontaneous and piezoelectric (strain-dependent) polarization electric fields. When a Schottky source metal is used the barrier height (SBH) is of the order of 0.8eV, while the width (SBW) is only a few nanometers. These features create the conditions for efficient quantum tunneling with larger currents.

An added attraction of the HKUST approach is the normally-off, positive threshold behavior. Such devices are sought to reduce power consumption in applications. Conventional nitride semiconductor HEMTs are normally-on, although a number of research groups have demonstrated normally-off behavior using different techniques.

The HKUST researchers developed their device using the epitaxial structure for a standard nitride semiconductor HEMT on Si (111) substrate (Figure 1). The undoped GaN buffer layer was 1.8 μ m thick and the AlGaIn barrier 18nm. The barrier was completed with a 2nm GaN cap layer. A 1nm AlN interface enhancement layer was used between the AlGaIn barrier and the GaN buffer for the purpose of reducing alloy scattering of the 2DEG.

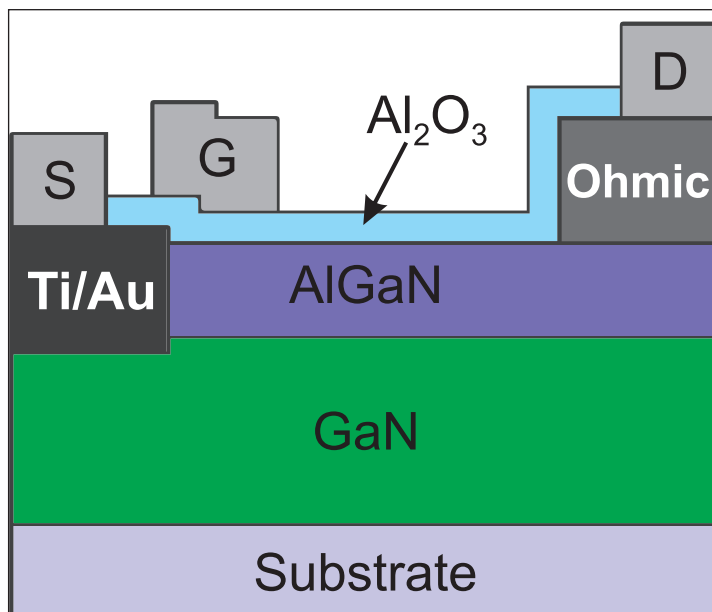


Figure 1. Cross section of AlGaIn/GaN TJ-FET.

The main differences from a normal HEMT is in the metallization — in particular, the use of a Schottky source electrode and a tunnel junction gate. The device fabrication began with reactive ion etching (RIE) mesa isolation with chlorine/helium (Cl_2/He) inductively coupled plasma. The titanium-aluminum-nickel-gold ohmic drain electrode was then deposited using electron-beam (e-beam) evaporation and a rapid thermal anneal (850°C for 35s).

The source electrode was recessed 22–25nm to the level of the 2DEG channel using a further Cl_2/He etch. The Schottky electrode consisted of titanium-gold (30nm–5nm) deposited using e-beam evaporation. The electrode was 'self-aligned' in terms of its definition by photolithography being combined for etch and acetone lift-off steps.

The nickel-gold gate e-beam deposition followed a 10nm aluminum oxide atomic layer deposition (ALD). The researchers created an overlap between the gate and source electrodes of 0.25 μ m so that the tunnel junction could be controlled effectively. Simulations had suggested that a source-gate gap of even 100nm would significantly weaken control of the device. ➤

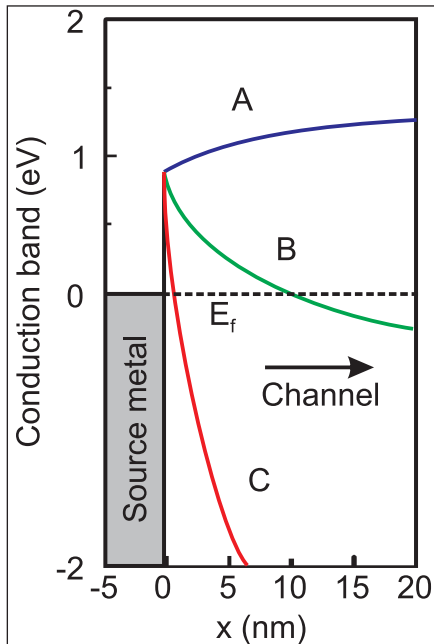


Figure 2. One-dimensional plots of simulated conduction-band energy distribution profile of the TJ-FET with source-drain (V_{DS}) voltage of 10V and source-gate (V_{GS}) voltages of -3V (A), 0V (B), and 3V (C).

The gate controls the Schottky diode formed at the interface between source metal and the GaN/AlGaIn 2DEG channel. At zero bias, the Schottky barrier width (SBW) is about 10nm, according to simulations. The height of the SB is ~ 0.8 eV. As the gate bias is increased, the SBW thins — for example, the SBW is only 1nm with a bias of 3V.

This allows a significant increase in tunneling current. The thinning occurs because the gate bias pulls the GaN conduction band down (Figure 2).

► The researchers also see the reverse current blocking of the Schottky source-channel structure as being beneficial. At large positive drain bias, the Schottky junction is reverse biased. This should suppress leakage through the buffer layer, compared with conventional ohmic source HEMTs.

The devices that were produced had a gate length of $2\mu\text{m}$ and gate-drain spacing of $2\mu\text{m}$. The device demonstrates an on-off current ratio of 10^{10} — four orders of magnitude better than that (10^6) for a traditional (normally-on) HEMT (Figure 3). This is achieved through the much lower leakage current in the TJ-FET arrangement. Even at 50V drain bias, the leakage is of the order of 10^{-8} mA/mm.

The threshold voltage of the TJ-FET is 1.35V. With a source-drain voltage of 10V, the drain current is 326mA/mm at a gate voltage of 3.5V. The transconductance (G_m) is in the range 130–135mS/mm for gate voltages of 2–3.5V. This indicates ‘excellent’ linearity when the device is turned on.

The subthreshold behavior is also sharper. Comparisons between a TJ-FET and a conventional HEMT on the same wafer gave a subthreshold slope (SS) of 89mV/dec for zero drain voltage for the TJ-FET, compared with ~ 120 mV/dec for the HEMT. At 50V drain voltage, the TJ-FET SS was less than 100mV/dec, while the HEMT value was ~ 125 mV/dec.

The researchers comment: “The TJ-FET shows significantly lower SS than the conventional HEMT due to the

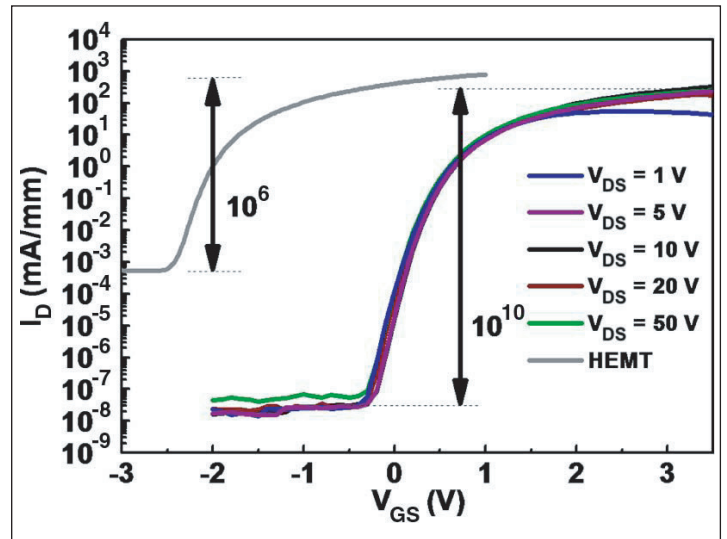


Figure 3. Experimentally measured I_D - V_{GS} transfer characteristics of a TJ-FET at $V_{DS} = 1$ to 50V. Transfer characteristics of conventional (normally-on) HEMT fabricated on same wafer are measured at $V_{DS} = 10$ V and plotted for reference.

sensitive tunnel-current-controlling I_D mechanism by the effective barrier thickness of the source Schottky junction.”

The researchers also determined three-terminal breakdown characteristics at a negative gate voltage of -1V (Figure 4). The researchers compared gate and drain leakage. At less than 70V drain bias, the current leakage was predominantly through the source-buffer reverse-bias Schottky junction. Above this drain bias, the leakage is mainly from the gate through the Al_2O_3 layer. Hard breakdown was reached at 274V, which compares with 117V for the conventional HEMT.

The specific on-resistance of the TJ-FET was $0.69\text{m}\Omega\text{-cm}^2$, including the area of the ohmic drain. ■

<http://dx.doi.org/10.1109/LED.2010.2095823>

Author: Mike Cooke

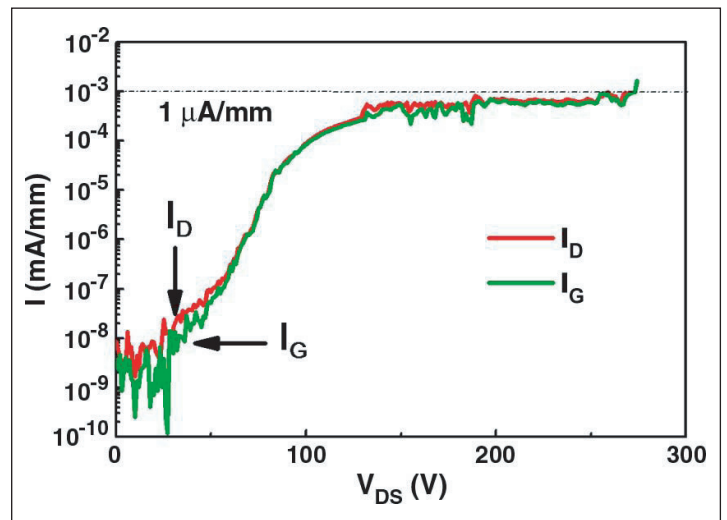


Figure 4. Measured three-terminal OFF-state breakdown characteristics of a TJ-FET at $V_{GS} = -1$ V.

Monolithic InGaAs nanolaser on silicon

University of California at Berkeley is developing a technique that could provide a powerful, new avenue to on-chip nanophotonic devices.

University of California at Berkeley (UCB) has produced III-V indium gallium arsenide (InGaAs) nanolasers monolithically integrated with silicon [Roger Chen et al, *Nature Photonics*, published online 6 February 2011]. Along with many other research groups, the UCB team is seeking to marry light emission and detection technology with mainstream silicon-chip-based electronics.

“Ultimately, this technique may provide a powerful and new avenue for engineering on-chip nanophotonic devices such as lasers, photodetectors, modulators and solar cells,” says the study’s lead author Roger Chen, a UC Berkeley graduate student in electrical engineering and computer sciences.

“Today’s massive silicon electronics infrastructure is extremely difficult to change for both economic and technological reasons, so compatibility with silicon fabrication is critical,” adds principal investigator Connie Chang-Hasnain, UC Berkeley professor of electrical engineering and computer sciences.

At the present stage, the UCB nanolasers are optically pumped using an external titanium-doped sapphire (Ti:sapphire) laser. However, electrically pumped lasers would be needed for the target of combining electronics with light-handling systems such as optical data links. Such links are being sought to overcome the limitations of chip-scale data transport around superfast micro-processors, along with longer distances (board-board, rack-rack, etc).

“In the future, we expect to improve the characteristics of these lasers and ultimately control them electronically for a powerful marriage between photonic and electronic devices,” says Chang-Hasnain.

The researchers believe that their core-shell nanopillar structure could be extended to give layers of n-, intrinsic (i-), and p-type material. Also, quantum wells could be arranged with layers of different alloy compositions.

Until now, III-V integration with silicon electronics has tended to be in the form of wafer bonding processes that generally have low yield of working devices. The alternative of making silicon light up is hindered by the indirect bandgap of silicon, which means that the material is a very inefficient emitter.

Problems in integrating III-Vs with silicon include lattice mismatching and high growth temperature.

The lattice mismatch means that it is difficult to grow high-quality crystalline material. The high growth temperature creates problems for integration with silicon electronic devices, which suffer from degradation at elevated temperatures.

“Working at nanoscale levels has enabled us to grow high-quality III-V materials at low temperatures, such that silicon electronics can retain their functionality,” says Chen.

The UCB approach is to grow small III-V nanopillar structures ‘bottom up’, meaning that no special catalysts or ‘top-down’ structuring (e.g. lithography/etching) are used. Catalyst materials tend to be ‘poisons’ to silicon circuitry. An additional advantage of bottom-up processes is smooth crystal surfaces, avoiding the etch damage of top-down approaches. Rough surfaces would result in scattering losses. The symmetrical hexagonal shape resulting from the basic wurtzite crystal structure of the InGaN also allows true single-mode oscillation.

The nanopillars consisted of an indium gallium arsenide (InGaAs) core and a gallium arsenide (GaAs) shell (Figure 1). After surface preparation, the pillars were grown in an Emcore metal-organic chemical vapor deposition (MOCVD) reactor. Before the growth, in-situ annealing was carried out for three minutes at 600°C. The growth temperature was 400°C, about 200–300°C lower than those typical for III-V materials.

The precursor gases were tertiarybutylarsine (TBA, also present during anneal), triethylgallium (TEGa) and trimethylindium (TMIn). The core growth lasted 60min. This was followed by the shell growth step.

Various indium compositions were used in the core: 12%, 15% and 20%. The shell thickness was also varied, with a 90nm shell used for room-temperature (293K) laser experiments and a thinner 30nm shell used at low temperature (4K). The thicker shell is needed for room-temperature operation to suppress surface recombination.

The nanopillars were vertical on the (111)-oriented silicon wafer substrates used. However, silicon electronics devices are usually grown on (100) silicon, where these nanopillars would grow on exposed (111) facets at an angle (54.7°) to the surface normal. Simulations suggest that such angled nanopillars could still support lasing at up to 70° tilt. ▶

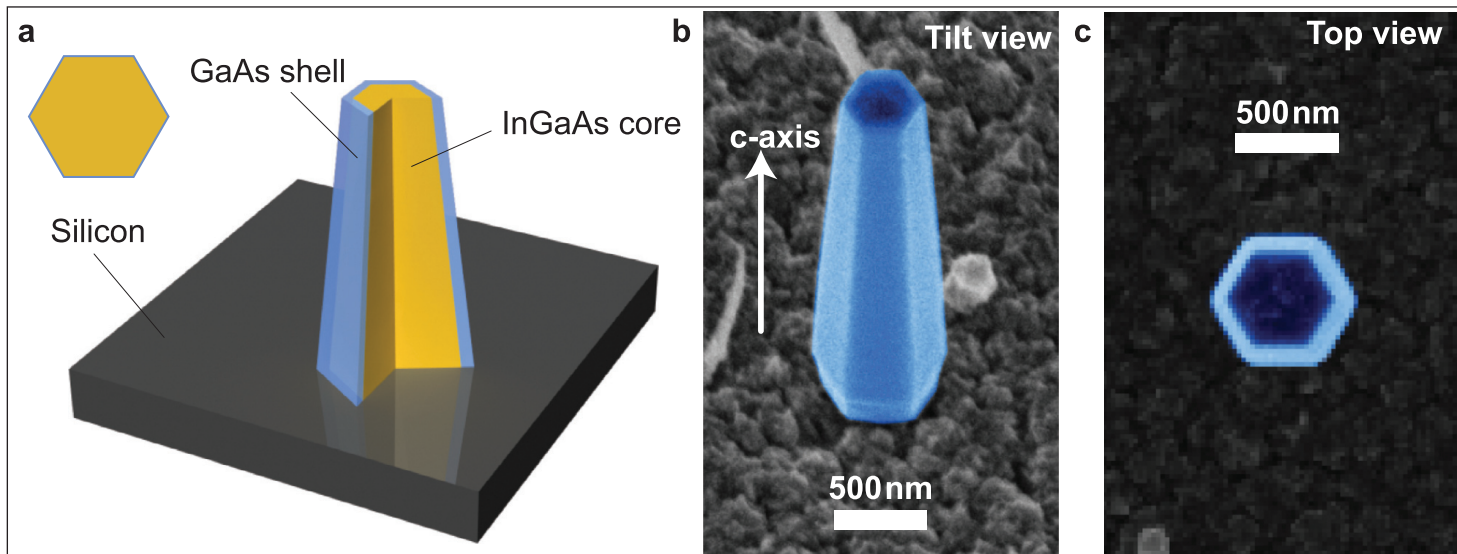


Figure 1. InGaAs/GaAs heterostructure nanopillar lasers monolithically grown on silicon: a, schematic of nanopillar laser monolithically integrated onto silicon (inset: top-view schematic); b, SEM showing well-faceted geometry of nanopillar optical cavity; c, top-view SEM.

► The grown nanopillars cover an area of about $0.34\mu\text{m}^2$ and are tapered with a 5° angle typical between opposite sidewall facets. The structures provide natural optical cavities, 'supporting unique resonances that have not been observed before, to the best of our knowledge,' the researchers report.

The excitation with a mode-locked Ti:sapphire laser exhibits 'clear threshold behavior' at room temperature with a $\sim 950\text{nm}$ (near-infrared) laser oscillation from the 20%-In nanopillars. Shorter wavelengths ($\sim 50\text{nm}$) are achieved with lower-In-content InGaAs pillars. The researchers say that they expect to be able to push the wavelengths of their devices into the silicon transparency region ($>1100\text{nm}$), allowing transmission along silicon waveguides. Another possibility would be to use silica waveguides that are transparent at the demonstrated wavelengths, allowing low-cost silicon photo-detectors to be used.

Low-temperature studies of the structure gave a cavity quality factor of 206 and a spontaneous emission factor of 0.01. The spontaneous emission factor measures the amount of emission coupled into the cavity mode of interest for lasing. The value is considered to be 'reasonable', given the small volume of the nanopillar ($6 \times 10^{-13}\text{cm}^3$).

Laser action is possible because the radiation is coupled into helically propagating cavity modes that reflect from surfaces at a shallow angle. The shallow angle means that the small index contrast between the InGaN nanopillar (3.7) and silicon substrate (3.6) is sufficient to provide the optical feedback that is needed (as indicated by the Q-value of 206)

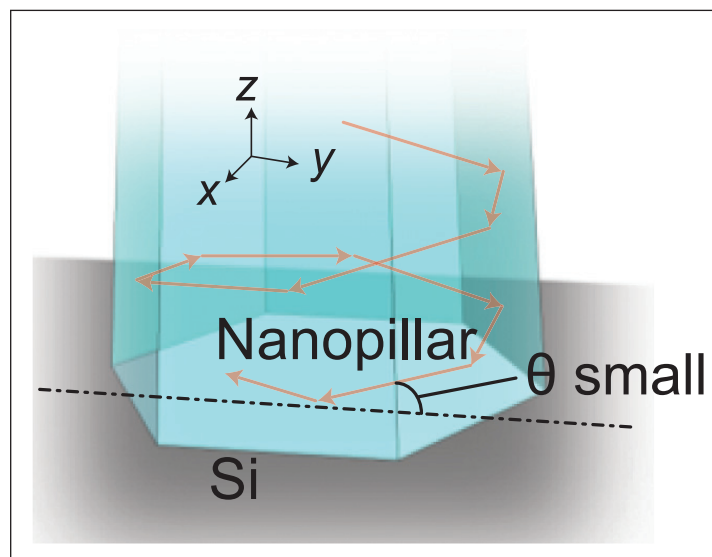


Figure 2. Schematic depicting how a helical ray path enables reflection from a low-index-contrast interface due to glancing angle incidence.

The researchers believe that the laser action is possible because the radiation is coupled into helically propagating cavity modes that reflect from surfaces at a shallow angle (Figure 2). The shallow angle means that the small index contrast between the InGaN nanopillar (3.7) and silicon substrate (3.6) is sufficient to provide the optical feedback that is needed (as indicated by the Q-value of 206). The grazing angle also overcomes absorption effects in silicon that are non-negligible at $\sim 950\text{nm}$.

The US Defense Advanced Research Projects Agency (DARPA) and a Department of Defense National Security Science and Engineering Faculty Fellowship helped to support the research. ■

<http://dx.doi.org/10.1038/nphoton.2010.315>

Author: Mike Cooke

Seeking to unlock wide-range potential of nitride photovoltaics

Up to now, nitride semiconductor solar cells have only responded to the high-energy, short-wavelength end of the solar spectrum. Mike Cooke reports on recent attempts to extend this range.

Nitride semiconductors have remarkable properties in terms of light emission, and it is hoped that in the next few years highly reliable and efficient lighting based on the technology will extend from niche applications into street and general applications, reducing world energy consumption and carbon dioxide emissions. But could nitrides do more and actually provide significant energy from sunlight?

In theory, gallium indium nitride (GaInN) semiconductors should be able to cover the greater part of the range of solar photons (Figure 1). Although adding in aluminum to make AlGaInN could extend this slightly to 200nm (6.2eV) deep-ultraviolet wavelengths, this is not really the direction needed to convert more sunlight at ground level. However, mixed with indium, aluminum (AlGaInN) could provide useful layers in terms of alternative lattice constants.

The potential of the GaInN system allows one to envisage a series of different nitride solar cells designed to extract most efficiently a range of different wavelengths. Even for single cells, one could tune a photovoltaic cell that could achieve better than 50% solar energy conversion by using InGaIn alloy with an indium fraction of 40%. Using triple junctions of nitride material pushes this to almost 60% conversion; a four-junction nitride device has an estimated conversion efficiency of 62%. Of course, all these figures are based on simulations using non-existent ideal materials.

It is envisaged that these devices would be used in concentrator photovoltaic (CPV) systems where optical systems are used to focus the incoming solar radiation on small-area nitride PV chips, lowering costs. Further potential advantages of nitride solar cells are radiation hardness, high thermal conductivity, and high light absorption. These features would enable deployment in harsh environments such as space and deserts.

Unfortunately these remain theoretical hopes because it is very difficult to grow high-quality InGaIn with high

indium contents (>20%). The problem is that the lattice mismatch between InN and GaN is high (~11%). Layers with appreciable indium contents tend to segregate into regions with high and low indium content (phase separation). This is one of the difficulties that have hindered the extension of nitride light-emitting technology to longer wavelengths (e.g. green laser diodes, yellow LEDs).

Despite the difficulties, university groups across the world are developing nitride semiconductors for use in solar cells. Although much of the research in this direction is focused on producing better-quality high-indium-content GaInN or even InN, some groups have produced actual solar cells. These are usually based on established nitride semiconductor technology that has already successfully resulted in light-emitting and laser diodes. Hence the range of wavelengths is restricted to those shorter than green (~530nm), and usually even shorter (violet, ~410nm).

Working up from InN

In Europe, the 'RAINBOW' collaboration [<http://rainbow.ensicaen.fr/>] is seeking to develop high-quality InN and In-rich nitride alloys. The collaboration consists of 13 groups from eight countries. Solar cells are among the targets for these efforts. Recent work coming from one of these institutions includes Universidad Politécnica de Madrid, along with Paul-Drude-Institut für Festkörperelektronik, developing InN/InGaIn multiple quantum wells that emit at the infrared 1.5µm wavelength under 14K photoluminescence [J. Grandal et al, Appl. Phys. Lett., vol98, p061901, 2011].

In the UK, University of Warwick researcher Dr Tim Veal is the principal investigator for the 'Nitride Photovoltaic Materials for Full Spectrum Utilization' project funded by the UK Engineering and Physical Sciences Research Council (EPSRC). The £694,057 (~\$1m) project began in 2008 and is expected to continue to 2013. The project partners will supply samples; the

collaborators are mainly outside the UK: Caen University (France), Cornell University (USA), University of Canterbury (New Zealand), and Sharp Laboratories of Europe Ltd (based in UK). Warwick is also involved in RAINBOW.

The ESPRC project promises that "a comprehensive program of structural, optical and electrical characterization will be undertaken to optimize these alloys for application in nitride-based photovoltaic devices. In parallel with these activities,

experiments will also be undertaken on III-nitride structures to achieve repro-

ducible n- and p-type doping, to develop tunnel junctions, to determine the role of defects in photovoltaic performance, and to optimize metal contacts and transparent conducting oxide (TCO) solar cell windows. Solar cell modeling will be performed using material parameters determined from the experiments to produce optimized designs for high-efficiency nitride solar cells and to investigate new integrated optical/electrical solar cell designs which circumvent traditional current and lattice matching constraints."

Veal comments on progress so far: "Our largest contribution has been to discover the electron accumulation at the surface of InN as opposed to the depletion layer that exists at almost all other semiconductor surfaces. This has implications for contacts (they will be Ohmic rather than Schottky) and in a PV context means that tunnel junctions could be rather difficult to make. We have also studied the change from accumulation to depletion as Ga is added to InGaN alloys.

"Another major consequence of the electron accumulation is that p-type InN (produced by Mg-doping, as with commercial GaN-based devices) does not appear to be p-type from Hall-effect measurements because the surface electron-rich layer dominates these measurements and the 'buried holes' are 'hidden' underneath — when the material is p-type, an inversion layer exists whereby the material is n-type at the surface and p-type beneath.

"We have also investigated p-type doping of InN and both InGaN and InAlN alloys. We have found that p-type doping is possible for all InGaN compositions and all but the most Al-rich InAlN alloys. Obviously, p-type doping is vital for making p-n junctions which are the basis of solar cells."

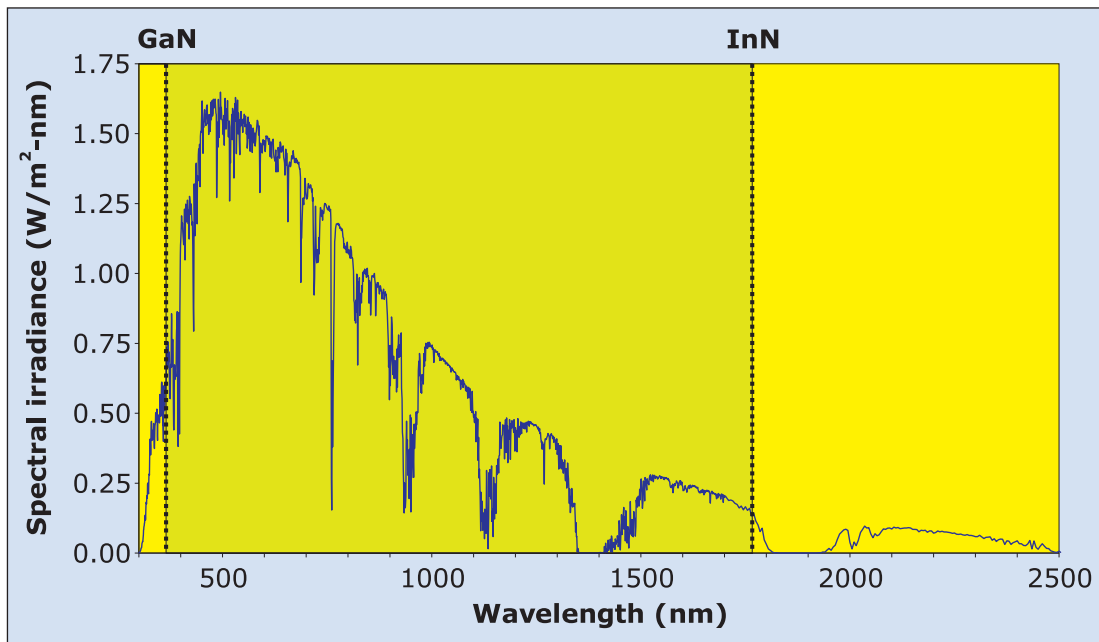


Figure 1. ASTM G173-03 AM1.5G — air mass 1.5 — reference spectrum, representing 'normal' solar light characteristics at the earth's surface at mid latitudes i.e. solar zenith $\sim 48^\circ$, seen as a rough average for conditions in US, Europe and Japan.

Taiwan's National Tsing-Hua University and National Synchrotron Radiation Research Center (NSRRC) have recently been able to avoid electron accumulation in InN by reversing the polarity from (0001)/In-face to (000 $\bar{1}$)/N-face [Appl. Phys. Lett., vol98, p052101, 2011]. A surface treatment is used to remove any In adlayer at the (000 $\bar{1}$) surface.

Tsing-Hua Professor Shangjr (Felix) Gwo, a leader of this research, comments: "For growing high-quality InN samples, nitrogen-plasma-assisted MBE is preferred because of the necessity of low growth temperature (less than 550°C). Additionally, crystal polarity control of III-nitrides by MBE growth can be achieved, in contrast to the conventional MOCVD method.

"For example, for the growth of N-polar InN(000 $\bar{1}$), we can use a crystalline Si₃N₄ buffer layer formed on the Si(111) substrate by nitrogen-plasma nitridation as the growth template. Alternatively, we can also grow both N-polar InN(000 $\bar{1}$) and In-polar InN(0001) on sapphire substrates under suitable MBE growth conditions.

"The implication of our work is that the surface electron accumulation phenomenon is not really 'universal', as claimed by previous studies. Nor is it a real barrier to prevent the realization of p-type doping for high-indium-content InGaN alloys."

Veal's group in Warwick reports that it has also been able to reduce electron accumulation by increasing magnesium (Mg) doping, altering the surface Fermi level in work yet to be published. The researchers think that this is correlated with the amount of surface In-adlayers, since In-In bonding is thought to be a cause of surface donors contributing to electron accumulation. ▶

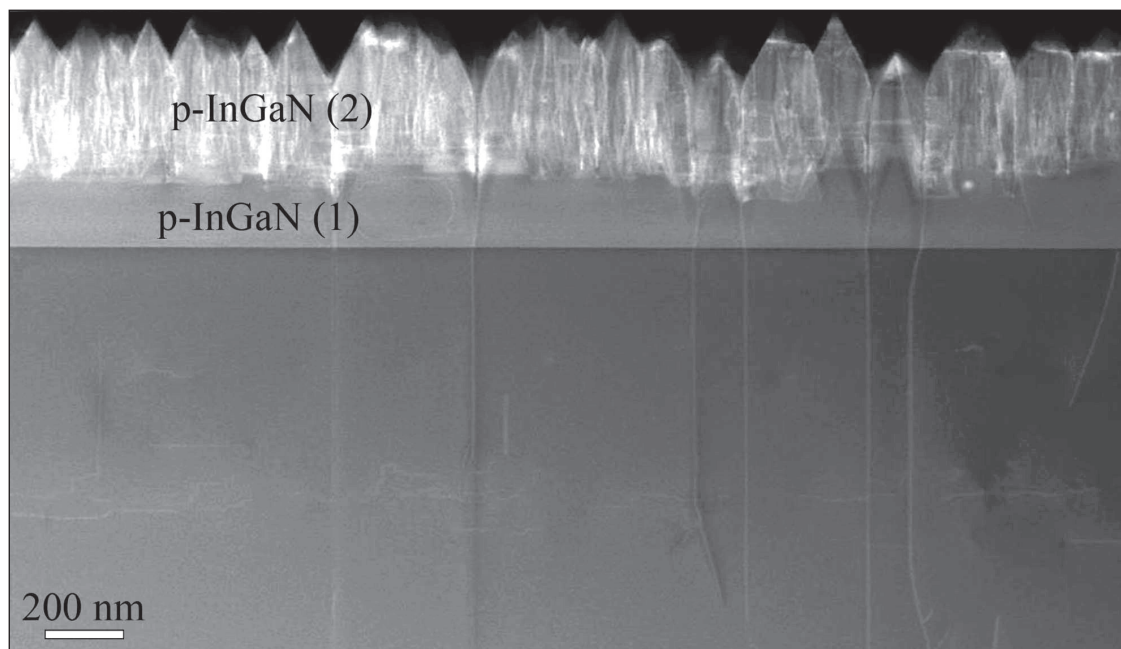


Figure 2. Scanning transmission electron micrograph (STEM) from Japan at National Institute for Materials Science of p-InGaN sample, which shows two obvious regions with different dislocation densities.

► Veal comments: "Our observed reduction of the electron accumulation with increasing Mg doping is rather convenient as it will help in the effort to make tunnel junctions for current collection in the In-rich part of a multijunction solar cell — something that was previously thought to be hampered by electron accumulation."

Further characteristics of Mg doping, in producing p-InGaN alloy, has been the subject of investigations at Japan's National Institute for Materials Science (NIMS) [Liwen Sang et al, *Appl. Phys. Express*, vol3, p111004, 2010]. In normal p-GaN, the Mg acceptor activation energy is quite high, meaning that the density of holes that results is usually lower than that achieved for electrons by silicon-doped n-GaN layers. This imbalance in the ability to produce nitride semiconductor p-n junctions has been a source of difficulty for high-efficiency light-emitting and absorbing devices.

One attraction of Mg-doped InGaN alloy is that the activation energy is smaller than for pure GaN. However, the NIMS researchers found that, although hole density is increased in p-InGaN relative to p-GaN, the material tends to separate into two layers (Figure 2). X-ray diffraction analysis reveals that the first layer is compressively strained to match with the GaN substrate, while the second is relaxed by generating threading dislocations. There was no phase separation observed in an InGaN layer produced under similar conditions but without the Mg doping. The undoped GaN had an In content around 8%. In one of the doped samples, the In content of the strained layers was 6.9%, while the dislocated relaxed layer had an In content of 11.2%.

Solar cell achievements

US company RoseStreet Energy Labs Inc is one company working on producing nitride semiconductor solar cells. The company has close links with the US Lawrence Berkeley National Laboratory (LBNL), with chief technology officer Dr Wladek Walukiewicz working for both organizations.

LBNL, with RoseStreet and Sumika Electronic Materials, has published a potential way to produce multi-band solar cells without multi-junctions [N. López et al, *Phys. Rev. Lett.*, vol106,

p028701, 2011]. Rather than alloying the III-side of the III-V equation, LBNL et al mix nitrogen and arsenic from the group V side, keeping the group III material constant (Ga). The resulting GaAsN material has both a wide and 'intermediate' bandgap that allows for sensitivity to three bands of solar energy (Figure 3). This enabled the researchers to produce 'proof of concept' cells with sensitivity over a wide range of the solar spectrum.

LBNL has been working on the technology of nitride solar cells for some time, producing multi-junction solar cells in 2002. In 2004, researchers at LBNL developed the intermediate-band concept, using zinc manganese telluride (ZnMnTe) doped with oxygen to create the intermediate band. Walukiewicz says of this older process that manufacturing the ZnMnTe alloy is complex and time-consuming, and these solar cells are also expensive to produce in quantity.

The new GaAsN material can be produced using MOCVD. In fact, the nitrogen component is dilute (2.4% nitrogen), so the material is close in structure to the gallium arsenide (GaAs) substrate (heavily doped n-type). The nitrogen atoms substitute for some of the arsenic, producing the intermediate band. The material was designed using LBNL's 'band anticrossing model' that has been developed at the facility for the past ten years. The model suggested that around 2% nitrogen could provide the right sort of material for solar cells.

Kin Man Yu, a collaborator with Walukiewicz since the work in 2002, comments: "We knew where the intermediate band ought to be and what to expect. The challenge was designing the actual device." ►

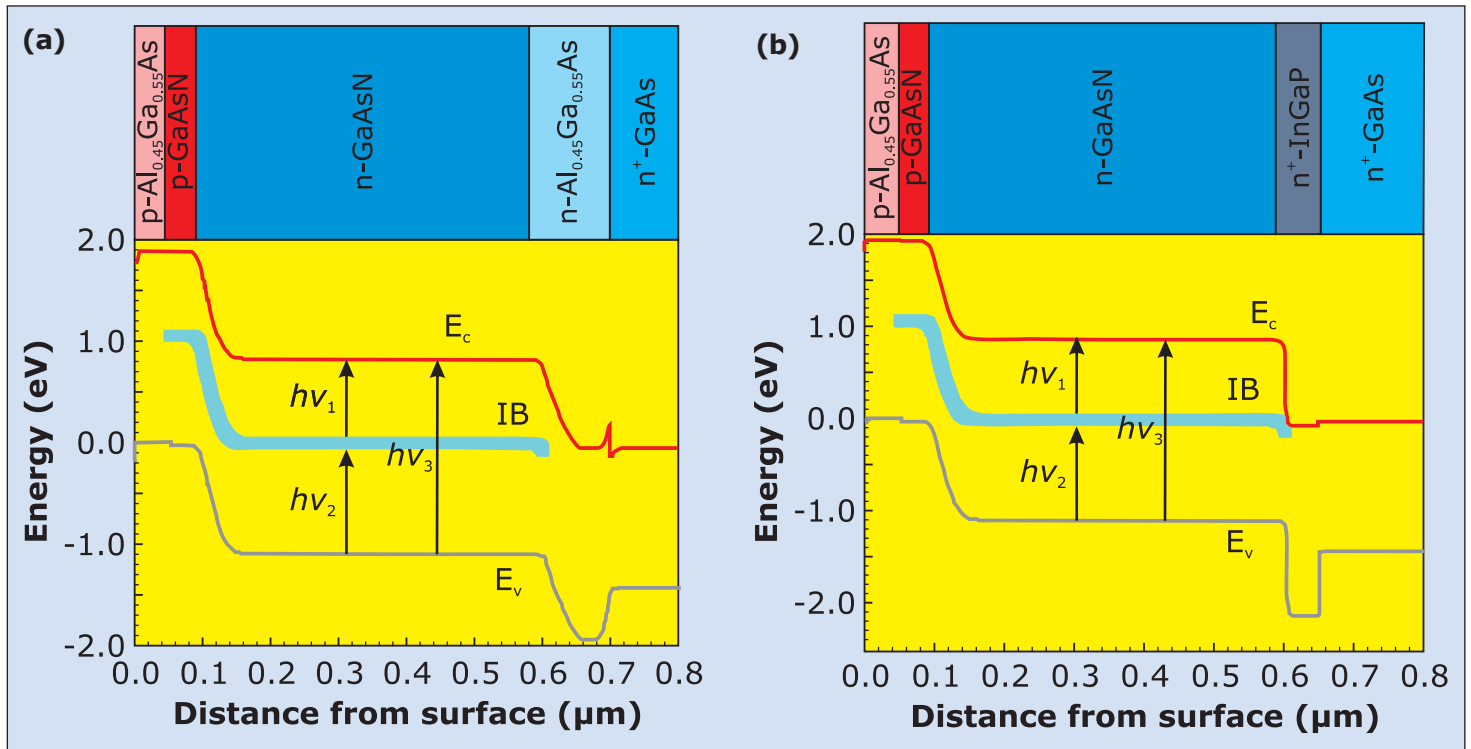


Figure 3. LBNL et al intermediate-band solar cell device structures and band diagrams: (a) shows a device with intermediate band blocked from conducting to the contacts; (b) an unblocked structure.

► Part of the design was aimed at blocking leakage from the intermediate band (Figure 3). The resulting device responded 'strongly' (Figure 4) to all parts of the solar spectrum (1.1–3.2eV). Comparison tests of the device and material included creating devices with unblocked intermediate band, and producing LEDs from the epitaxial structure.

The open-circuit voltage of the blocked intermediate-band structure was 0.92V, while that of the unblocked comparison device was 0.42V. When one compares

these results with the values expected from the full bandgap (2eV) and intermediate gap (1.1eV), there is clearly a large offset in both cases. The offset depends on the material and junction quality, along with the sun concentration factor. The researchers comment on the offset: "The large value of the offset found in both cases is most likely related to a short minority carrier lifetime, as has been previously found in GaInNAs alloys."

University of California Santa Barbara (UCSB) has a

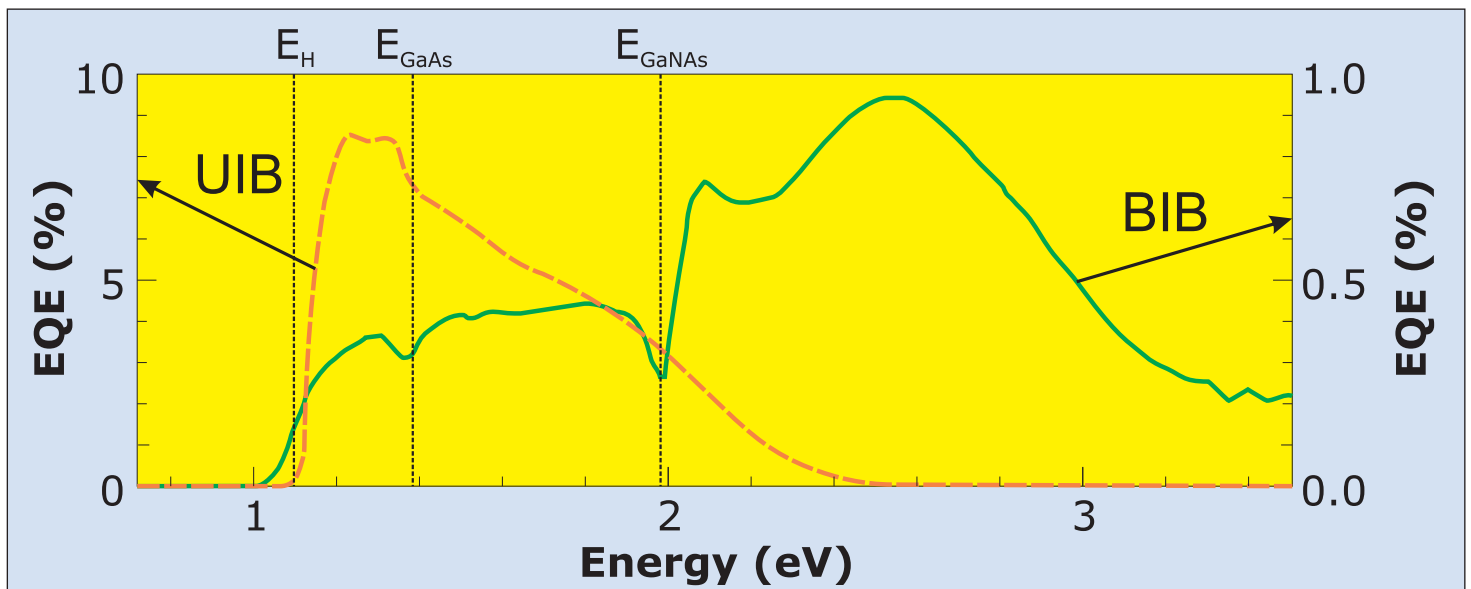


Figure 4. Spectral dependence of external quantum efficiency of LBNL et al intermediate-band solar cell. Solid line represents device with blocked intermediate band (BIB) and dashed line corresponds to cell with unblocked intermediate band (UIB).

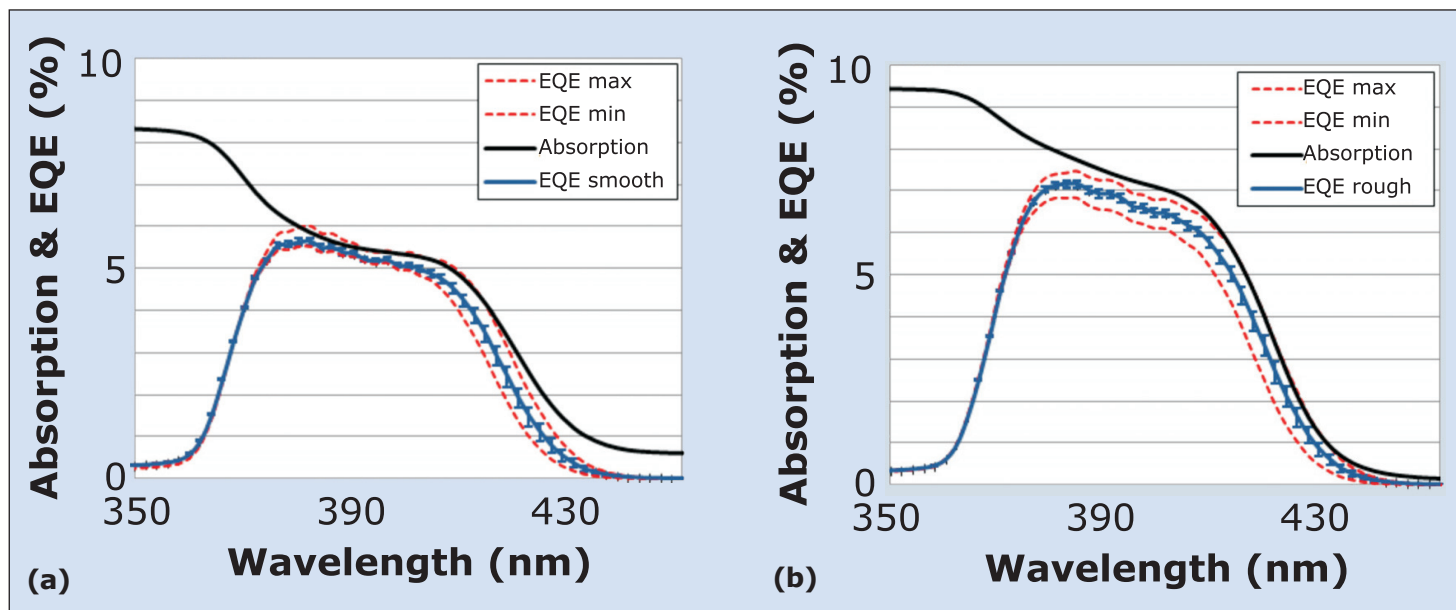


Figure 5. UCSB measured absorption (solid), average (solid with error bars), maximum and minimum (dashed curves) EQE curves for (a) smoother and (b) rough samples. The average EQE and its standard deviation (error bars) were determined from measurements of a total of 12 devices located in the same area of the sample where the absorption was measured.

strong team of nitride semiconductor researchers, including Shuji Nakamura, a pioneer of the field. This year, UCSB has reported nitride semiconductor photovoltaic devices with external quantum efficiencies (EQE) up to 72% [Elison Matioli et al, Appl. Phys. Lett., vol98, p021102, 2011]. One of the researchers, Claude Weisbuch, is also associated with Ecole Polytechnique in France.

Much of the nitride semiconductor work at UCSB concerns light-emitting devices. However, some of the same researchers have previously reported (2008) photovoltaic (PV) devices that achieved up to 63% external quantum efficiency. Although these EQEs are impressive, one has to bear in mind that these devices cover only a small range in a not particularly useful part of the solar spectrum.

In both the latest and 2008 work, UCSB used InGaN active layers with 12% In content. This restricts the effective performance of the devices to the wavelength

range 370–410nm, a tiny sliver of the AM1.5G illumination spectrum (Figure 1). The short-wavelength limit is determined by the bandgap of the p-GaN contact layer and the long-wavelength limit by the active layer bandgap.

In the latest devices, the undoped InGaN active layer was sandwiched between p- and n-GaN layers with high levels of doping ([Si] ~ 6x10¹⁸/cm³, [Mg] ~ 8x10¹⁹/cm³). The high doping was intended to counteract the effects of polarization fields that normally degrade photovoltaic performance in nitride semiconductors. Surface roughening was used to increase the coupling of light into the device. The devices were grown on sapphire using MOCVD.

The EQE follows the absorption curve closely in shape and magnitude (Figure 5) in the InGaN absorption region of (370–410nm). “This means that nearly all absorbed photons in this layer were converted into electrons and holes, and these charges were efficiently separated and transported out of the device,” the researchers comment. Further performance measurements were carried out to determine the standard performance metrics (Table 1).

Meijo and Nagoya universities in Japan have also recently extended previous work on nitride semiconductor solar cells, improving performance through superlattice structures [Yousuke Kuwahara et al, Appl. Phys. Express, vol4, p021001, 2011].

One problem in using GaInN for active layers in solar cells is that misfit dislocations tend to form in thick layers. When a Ga_{0.8}In_{0.2}N layer is put on GaN the critical thickness is of the order 1nm, and the resulting dislocations lead to pits at interfaces that degrade

Table 1. Solar cell performance metrics: open-circuit voltage (V_{oc}), short-circuit current density (J_{sc}), fill-factor (FF = P_{max}/V_{oc}xJ_{sc}), and peak EQE.

Device	V _{oc} V	J _{sc} mA/cm ²	FF %	EQE _{peak} %
UCSB smooth	1.83	0.83	76.6	56
UCSB rough	1.89	1.06	78.6	72
Miejo/Nagoya A	1.83	0.37	50.6	3.5
Miejo/Nagoya B	0.93	3.19	53.3	46.1
Miejo/Nagoya C	1.78	3.08	70.8	59.1

solar cell performance. However, thicker layers are needed to absorb sufficient sunlight.

The Meijo/Nagoya researchers produced devices using a number of thin layers (superlattices) to overcome this problem. The researchers comment: "This is the first time that thick GaInN-based superlattices have been used as an active layer in solar cells to the best of our knowledge."

Previous work by the Meijo/Nagoya group includes using free-standing gallium nitride (GaN) substrates. In that work, the conversion efficiency was 1.41%. This has now been increased to 2.5% for standard AM1.5G illumination. Again, the type of device used covers only a tiny part of the solar spectrum, so the 2.5% conversion efficiency figure is considered high for present nitride-based solar devices. The maximum external quantum efficiency was 59.1% for the best device.

Three devices were produced (Figure 6) with various combinations of superlattice. Sample C was created to combine the good features (Table 1) of the earlier devices, reducing dislocation densities and thus improving the material quality of the subsequently grown material, leading to a device with high EQE and internal quantum efficiency estimated at 88% at 390nm (violet).

Last year, Texas Tech University scientists reported an indium gallium nitride (InGaN) solar cell with characteristics 'significantly higher' than previously reported values for devices with similar In-content in the QWs (~35%) [R. Dahal et al, Appl. Phys. Lett., vol97, p073115, 2010; reported in Semiconductor Today, September 2010, p82].

The Texas researchers used a 12-period multi-quantum well (MQW) structure consisting of InGaN/GaN (3nm/16nm) with the indium content of the well targeted at 35%. The wavelength of the electroluminescence from the structure was around 533nm (green). Standard AM1.5 characteristics were: open-circuit voltage 1.8V, close-circuit current density 2.56mA/cm², maximum power 2.95mW/cm². This gives a fill-factor of 64% (2.95/1.8/2.56).

The conversion power efficiency of 2.95% falls short of the ~8% theoretical maximum for the frequency characteristics of the device. The improvement was attributed to improved InGaN material quality.

One of the reasons for the still too low efficiency was the small thickness of the well regions (12x3nm =

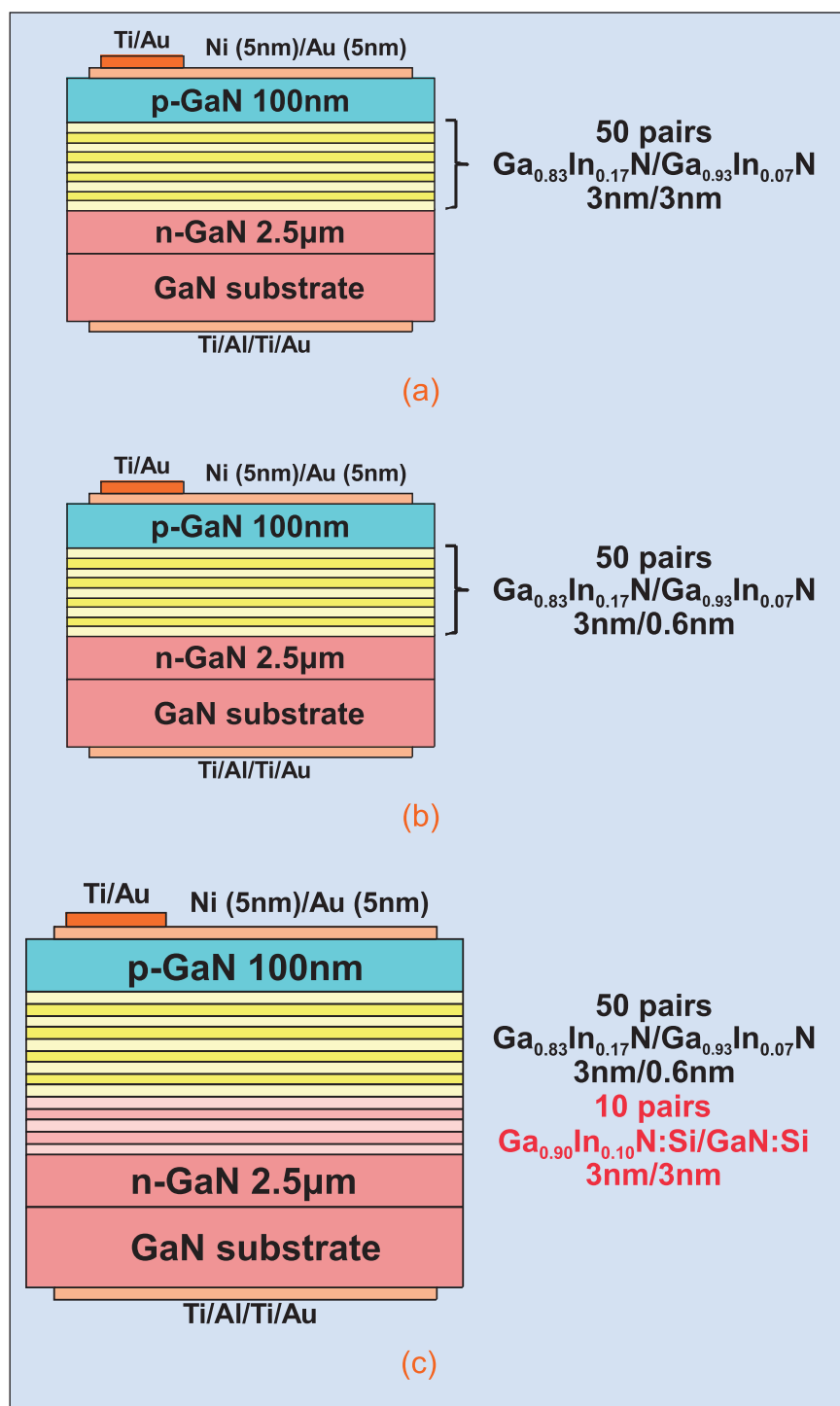


Figure 6. Schematic view of sample structures. (a) Sample A: GaInN-based solar cell with 50 well/barrier layer pairs of Ga_{0.83}In_{0.17}N (3nm)/Ga_{0.93}In_{0.07}N (3nm) as superlattice active layer. (b) Sample B: GaInN-based solar cell with 50 pairs of Ga_{0.83}In_{0.17}N (3nm)/Ga_{0.93}In_{0.07}N (0.6nm). (c) Sample C: Sample B with 10 additional well/barrier pairs of Ga_{0.90}In_{0.10}N:Si (3nm)/GaN:Si (3nm) ([Si] doping concentration in both cases is 3x10¹⁸cm⁻³).

36nm). Complete light absorption would require at least 200nm. Evidence for this came from comparing devices with and without back-reflector. The reflector added 15% to the photocurrent density by effectively doubling the thickness of the well region. ■

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4–6 April 2011

CPV-7 International Conference on Concentrating Photovoltaic Systems

Las Vegas, NV, USA

E-mail: info@cpv-conference.org

www.cpv-conference.org

12–13 April 2011

2011 DOE Solid-State Lighting Manufacturing R&D Workshop

Hyatt Harborside, Boston, MA, USA

E-mail: solidstate@courtesyassoc.com

www1.eere.energy.gov/buildings/ssl/boston2011.html

12–13 April 2011

Short-Distance High-Density Optical Interconnects (SDHD INTERCONNECTS 2011)

Stanford Photonics Research Center,

Stanford University, CA, USA

E-mail: OIDAInfo@osa.org

www.oida.org/events/interconnects11

13–15 April 2011

11th Fiber Optics Expo (FOE 2011)

Tokyo Big Sight, Japan

E-mail: foe@reedexpo.co.jp

www.foe.jp/en

14–15 April 2011

3rd Photovoltaics Thin-Film Week,

including:

– **International Workshop on CIGS Solar Cell Technology**

– **3rd Thin-Film Industry Forum (TIF 2011)**

Berlin, Germany

E-mail: info@solarpraxis.de

www.solarpraxis.de/en/conferences

16 – 21 April 2011

54th Society of Vacuum Coaters Annual Technical Conference (2011 SVC TechCon)

Chicago, IL, USA

E-mail: svcinfo@svc.org

www.svc.org

18–20 April 2011

Semiconductor and Integrated Opto-Electronics Conference (SIOE'11)

Cardiff University, Wales, UK

E-mail: K.A.Shore@bangor.ac.uk

www.astro.cardiff.ac.uk/research/pm/events/?page=sioe

18–21 April 2011

SPIE Optics & Optoelectronics

Prague Congress Centre, Czech Republic

E-mail: customerservice@spie.org

<http://spie.org/x25077.xml>

18–21 April 2011

Photonica – Lasers, Optics & Application 2011:

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6th International Specialized Exhibition for Laser, Optical & Optoelectronic Technologies

ZAO Expocentre, Moscow, Russia

E-mail: ak@expocentr.ru

www.photonics-expo.ru/en

25–29 April 2011

SPIE Defense, Security, and Sensing 2011

Orlando, FL, USA

E-mail: customerservice@spie.org

<http://spie.org/defense-security.xml>

25–29 April 2011

MRS 2011 Spring Meeting

Moscone West and San Francisco Marriott, CA, USA

E-mail: info@mrs.org

www.mrs.org/spring2011

26–28 April 2011

ISSTT 2011: 22nd International Symposium on Space Terahertz Technology

Tucson, AZ, USA

E-mail: info@nrao.edu

www.nrao.edu/meetings

1–6 May 2011

219th Electrochemical Society (ECS) Meeting

Montreal, Canada

E-mail: meetings@electrochem.org

www.electrochem.org/meetings/biannual/fut_mtgs.htm

1–6 May 2011

CLEO: 2011 (Laser Science to Photonic Applications)

Baltimore, MD, USA

E-mail: cleoregistration@osa.org

www.cleoconference.org

3–4 May 2011

International SiC Power Electronics Applications Workshop (ISiCPEAW 2011)

Kista Science Tower, Stockholm, Sweden

E-mail: christian.vieider@acreo.se

www.b2match.eu/insicpeaw2011

9–13 May 2011

E-MRS 2011 Spring Meeting

Congress Center, Nice, France

www.emrs-strasbourg.com

10–12 May 2011

Strategies in Light China 2011

Kowloon, Hong Kong, China

E-mail: lubah@pennwell.com

www.sil-ledchina.com

10–12 May 2011

SEMICON Singapore 2011

Suntec, Singapore

E-mail: cchan@semi.org

www.semiconsingapore.org

15–19 May 2011

LIGHTFAIR International (LFI 2011)

Pennsylvania Convention Center, Philadelphia, PA, USA

www.lightfair.com

16–18 May 2011

International Symposium on Photonics and Optoelectronics (SOPO 2011)

Wuhan, China

E-mail: sopo@scirp.org

www.sopoconf.org/2011

16–19 May 2011

2011 CS MANTECH (International Conference on Compound Semiconductor Manufacturing Technology)

Palm Springs Hyatt Grand Champion hotel, CA, USA

E-mail: csmantech@csmantech.org

www.csmantech.org

16 May 2011

2011 Reliability Of Compound Semiconductors Workshop (ROCS, formerly GaAs REL Workshop)

Palm Springs Hyatt Grand Champion hotel, CA, USA

E-mail: Peter.Ersland@macomtech.com

www.jedec.org/home/gaas/default.htm

22–26 May 2011

Compound Semiconductor Week (CSW 2011): 38th International Symposium on Compound Semiconductors (ISCS 2011) and 23rd International Conference on Indium Phosphide and Related Materials (IPRM 2011)

Berlin, Germany

E-mail: hatice.altintas@vde.com

www.csw2011.org

22–27 May 2011

The Seventh International Conference on Low Dimensional Structures and Devices

Telchac, Mexico

E-mail: fsutara@fis.cinvestav.mx

<http://ldsd.cinvestav.mx>

23–26 May 2011

LASER World of PHOTONICS 2011

Munich, Germany

E-mail: info@laser.de

www.world-of-photonics.net/en

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