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Shedding new light on LED efficiency droop

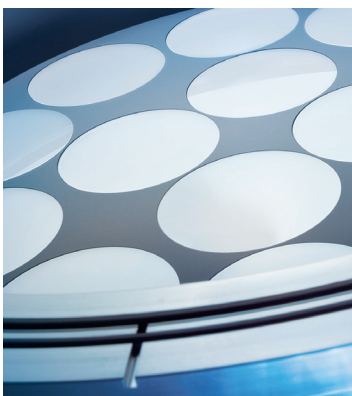
China solid-state lighting to drive Q2 MOCVD rebound



Skyworks buys SiGe & AnalogicTech • Sulfurcell now Solteature
Cree's 231lm/W white LED • Flexible CIGS boosted to 18.7%

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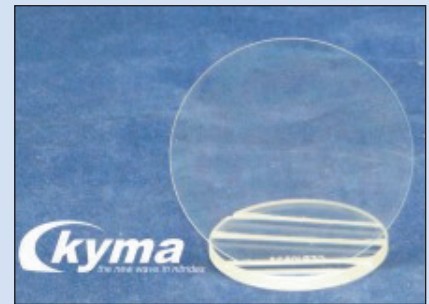
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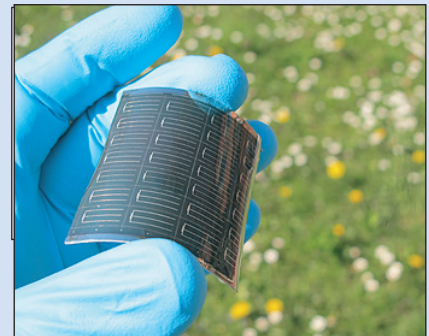
Vol. 6 • Issue 4 • May/June 2011



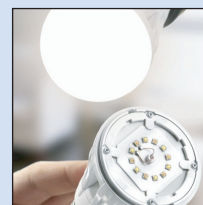
p15 TriQuint's new site for its design center in San Jose, CA.



p52 Kyma's new 2"-diameter AlGaIn template, with 5µm epi-ready buffer.



p91 Empa raises its efficiency record for flexible thin film CIGS solar cells from 17.6% to 18.7%.



Cover: Osram Opto Semiconductors' Brilliant-Mix concept for warm-white light achieves 30% greater luminous efficacy (110lm/W) with a high CRI of more than 90. The new mixing concept is based on OSLOM SSL LEDs in EQ-White and Amber colors, which cover a broad spectrum of 2700–4000K. **p63**

Emerging regions and applications drive growth

In last issue's editorial (just before going to press), as well as reporting first-quarter 2011 financial results for LED maker Cree we previewed Q1 financial results for other companies — now reported in detail in this issue for GaAs RFIC makers (pages 10–21), optical communications component makers (pages 74–80), and MOCVD reactor makers (pages 36–38).

In the latter case, revenue for MOCVD reactor makers Aixtron and Veeco fell 9% and 15% quarter-on-quarter, respectively. Market analyst firm IMS Research firm concurs that total reactor shipments fell by 18% (page 6). However, this is attributed by Veeco to 'lumpy' order patterns, and indeed both firms reported increased orders, presaging a rebound in revenue for Q2/2011. IMS confirms that it expects "significant growth" in Q2 and Q4, when China alone is expected to account for more installations than the entire global 2009 market, as well as being the only region to show year-on-year growth. China's share of MOCVD system installations has already grown from 64% of the global total in Q4/2010 to 74% in Q1/2011.

Aixtron says that it is seeing "rising early demand from the lighting applications industry," adding that "momentum in the development of lighting applications continues to increase, supported by government and public opinion on energy-saving technologies". The firm, which has invested in a major expansion, reckons that it is in a good position to support "what will inevitably become the third and biggest LED investment cycle for energy-efficient lighting applications in the years ahead". Veeco likewise is seeing order strength continuing in China as the country builds its LED infrastructure for solid-state lighting. Correspondingly, Veeco has just opened its new China Training Center in Shanghai, driven by the country's aim to convert 30% of its lighting market to LEDs by 2015 (see page 37). For the same reason, lithography system maker Ultratech has announced its Asia Technology Center in Hsinchu, Taiwan (to be opened in second-half 2011), targeting the HB-LED market in the region.

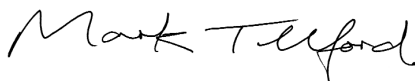
A major factor affecting the adoption of LEDs for general lighting is the cost per lumen, which is dependent on the luminous efficacy of white LEDs. The efficiency of nitride-based LEDs is currently limited by 'droop' as the injection current density increases, the cause of which has been much debated. While the Auger recombination process has been considered to be insufficient to account for the efficiency droop, UCSB has now proposed the 'indirect Auger effect' as a cause, supported by experimental evidence from Germany's Fraunhofer Institute for Applied Solid State Physics (IAF) and Switzerland's Ecole Polytechnique Fédérale de Lausanne (page 112).

Regarding Q1/2011 revenues for GaAs RFIC makers, Skyworks has outperformed its rivals by falling a less-than-seasonal 3% (versus 11% for TriQuint, 23% for RFMD and 28% for Anadigics). Meanwhile, its epiwafer supplier Kopin grew its III-V-related revenue by 16.5%. Skyworks is aided by its strategy of diversification. With a cash balance of \$504m, it is extending this by acquiring AnalogicTech and SiGe Semiconductor (see pages 18–19).

The latter was announced during May's CS MANTECH event, which we will report on in full next issue.

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

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

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- 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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MOCVD reactor shipments down 18% in Q1/2011 but still up 31% year-on-year

2011 forecast cut by only 8 reactors, from 1097 to 1089

Although first-quarter 2011 installations of metal-organic chemical vapor deposition (MOCVD) reactors were down on fourth-quarter 2010 (ending the seven-quarter streak of sequential growth), the outlook for 2011 remains bright for MOCVD and other upstream equipment and materials suppliers, according to IMS Research's 'Quarterly GaN LED Supply and Demand Report'. Global merchant MOCVD reactor shipments fell 18% sequentially to 194 units but this is still up 31% year-on-year, with GaN LEDs the dominant application (with a 97% share).

In Q1/2011, Veeco Instruments Inc of Plainview, NY, USA grew its market share of total MOCVD reactor shipments by one percentage point to 44% while maintaining its 44% of the GaN MOCVD market. Aixtron SE of Herzogenrath, Germany maintained its leadership position in both segments, losing a point of market share in total MOCVD shipments from 53% to 52% while maintaining a 53% share of the GaN MOCVD market. Veeco was number one in China and Europe, while Aixtron led in Korea, Taiwan and the USA.

Regionally, China dominated the GaN MOCVD market as expected, accounting for a 74% share (up from Q4/2010's 64%), while Taiwan maintained a 20% share. Reactors were installed at 23 different companies in China and 9 in

Taiwan. In Q1, the top three MOCVD customers globally — and seven of the top 10 — installed tools in China. In particular, China's San'an Optoelectronics remained the dominant customer for the second consecutive quarter, accounting for more than 20% of tools installed in Q1.

"Looking forward, we are not seeing installations being pushed out in China," says IMS Research's senior VP Ross Young. "We expected to see some delays, but we have only reduced our 2011 forecast by eight reactors from 1097 to 1089 [still up 36% year-on-year]," he notes. In particular, significant growth is expected in Q2 and Q4, when China's installations alone are expected to be larger than the entire worldwide 2009 market.

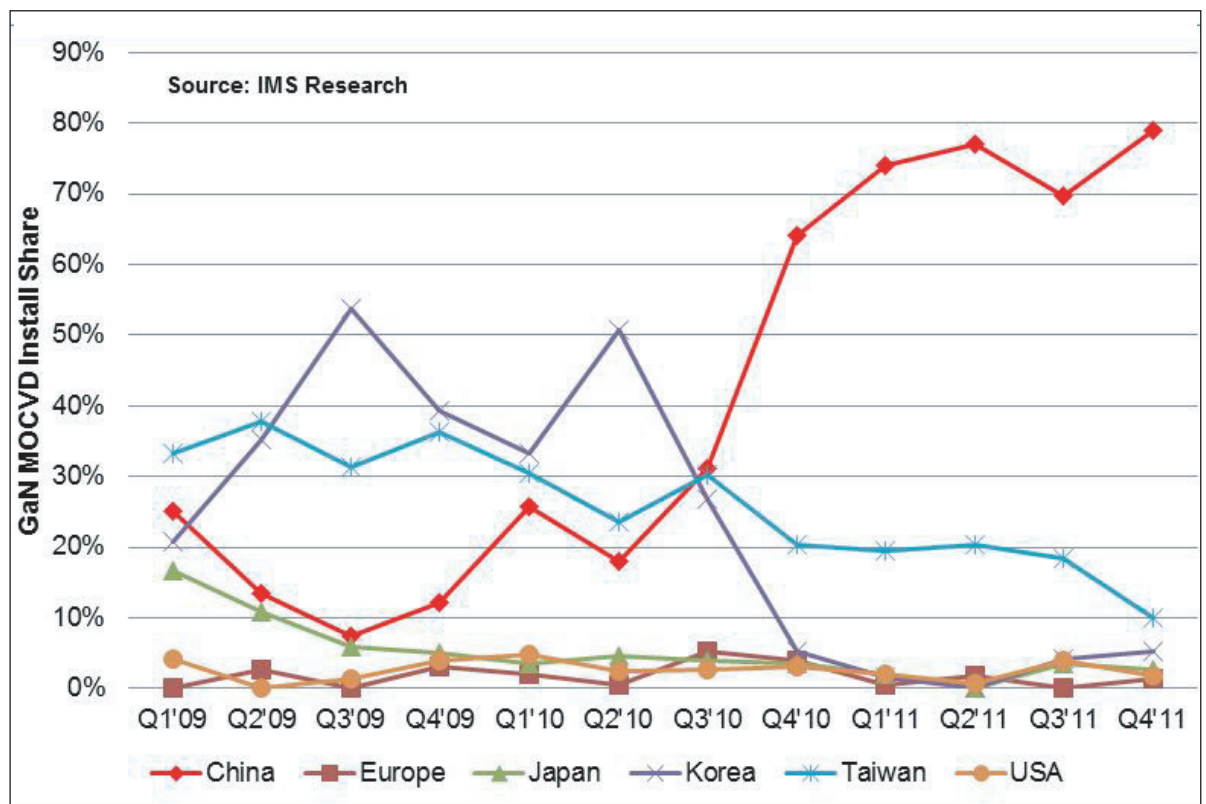
China is the only region expected to show year-on-year growth in

installations, rising 181% to 820 tools (75% of the 2011 MOCVD market, up from 36% in 2010). Taiwan is expected to be the number 2 region, with a 16% share (down from 36%, on a modest decline in installations of 14%). Installations in Korea are expected to be down 85%, to 33 tools.

"A number of companies also provided us with their 2012 plans regardless of whether or not there are MOCVD subsidies," Young continues. "Other incentives and the prospect for rapid growth in LED lighting are proving powerful enough to enable continued investment in LED capacity in China in 2012."

Young presented the latest LED supply & demand information at the SID/IMS Research 'Green Displays' Conference at the SID's Display Week 2011 in Los Angeles in May.

www.ledmarketresearch.com

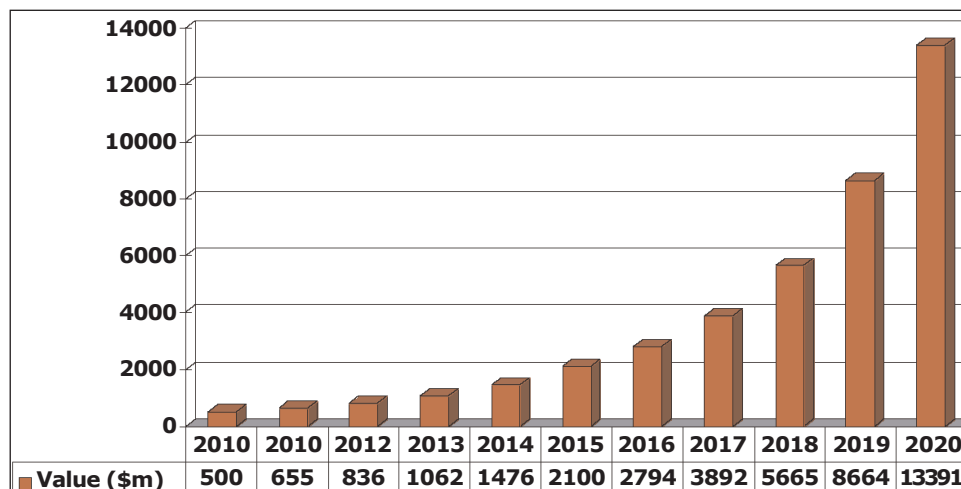


GaN MOCVD installations by quarter (Q1/09–Q4/11).

Packaged LEDs in general lighting worth \$13.4bn in 2020 Growth in UHB-LEDs to outweigh falling ASPs for HB-LEDs

Global consumption of packaged component-level LEDs used in solid-state lighting (SSL) general lighting applications reached \$500m in 2010 and will rise at an average annual growth rate of 33.2% to \$2.1bn in 2015 and then more quickly at 44.9% to nearly \$13.4bn in 2020, forecasts ElectroniCast Consultants in its latest 10-year market study*. The report also forecasts average selling price (ASP) over the 2010–2020 timeframe.

The high-brightness (HB) category also includes ultra-high-brightness (UHB) LEDs (with a luminous efficacy of more than 70 lm/W). UHB-LED prices have a substantial premium over HB-LEDs and, although the quantity of UHB-LEDs produced is currently relatively small, as the use of UHB-LEDs increases the overall effect on the HB-LED category is an increase in annual ASP over 2010–2015.



Market forecast for LEDs used in solid-state (SSL) general lighting (\$m).

Otherwise, the trend is for decreasing ASPs throughout the forecast period, as technology and production yield capabilities improve and competition intensifies, while sales channels improve (driven by the fact that governments worldwide are pushing for energy-efficient general

lighting), says Stephen Montgomery, president-International Business and principal analyst-LED Practice at ElectroniCast.

* Values and prices are at end-user levels, and are in current dollars, including the effect of a forecasted 5% annual inflation rate.

LEDs in signage/professional displays to grow from \$1.52bn in 2010 to \$2.78bn in 2016

Global consumption of packaged LEDs used in signage & professional displays rose 17% from \$1.3bn in 2009 to \$1.52bn in 2010 and will grow to \$2.781bn in 2016, according to a new report by market research firm ElectroniCast Consultants.

"This application category includes LEDs that are used in stationary and vehicle-based signs and displays," says Stephen Montgomery, president- International Business & director of the LED market research group at ElectroniCast. "LEDs are used in building facades, large outdoor video screens, digital billboards, sport/stadium displays, small indoor retail displays, food displays (restaurants/supermarkets), signs on taxis and destination signs on mass-transit vehicles, channel-lettering/light-boxes, and LED/LCD TV screens (used exclusively for professional purposes)," he adds.

The consumption value will increase, with rising quantity growth largely offset by declining average prices (ASPs).

The market share leader in terms of volume (the quantity/number of LEDs) is the standard-type LED, with more than 90% in 2010. However, since there is a huge difference in ASPs between standard LEDs and high-brightness (HB) LEDs, HB-LEDs hold the lead in terms of consumption value, with a market share of nearly 65% in 2010.

The high-brightness category also includes ultra-high-brightness (UHB) light-emitting diodes (with a lumen/Watt rating of over 70lm/W). The ASP for both conventional (standard) and HB-LEDs will decrease annually. However, UHB-LED prices have a substantial premium over the HB-LEDs, and

although there is currently relatively small use of UHB-LEDs in this application, as the use of UHB-LEDs increases, the overall effect shows the HB-LED category with just a slight annual decrease in terms of ASPs (2010–2016).

The America region (South, Central and North America) led in consumption in 2010. However, the Asia Pacific region (APAC) is expanding at a faster pace (by a factor of 3x) in its use of LEDs in this application. According to ElectroniCast, the APAC region will grab the market share lead mid-way through the 2010–2016 forecast period. The Europe, Middle East and African region (EMEA) represented a 24% share of global consumption value in 2010 and is also forecast to grow more rapidly than the Americas.

www.electronicast.com

Smartphones to rise from 27% to 53% of handset sell-through in 2015

Handset sales reach 1.46 billion in 2011

Total handsets sold to end users globally will reach 1.46 billion in 2011 with smartphone sales accounting for 27% of total handset sell-through but, driven by demand for inexpensive Android models, this will almost double to 53% in 2015, according to the quarterly Smartphone Forecast of market research firm Pyramid Research.

"Much of the projected total market growth in 2011 will come from the Africa and Middle East (AME) region, which will see a strong demand for low-end smartphone models, ultra-low-cost handsets and dual-SIM and full touch-screen feature phones," says Stela Bokun, senior analyst & practice leader for Mobile Devices at Pyramid Research.

"The main drivers of the demand in the developed markets will be the launches of a number of flagship high-end devices and new features and technologies," Bokun explains. "However, inexpensive smartphone models, particularly

Much of the projected total market growth in 2011 will come from Africa and the Middle East

those from Huawei and ZTE, also will be in high demand in some of the richest Western European, Asian and North American markets."

Android-based smartphones will continue to shake the smartphone world, but Pyramid's findings predict that, by 2015, Windows Phone will overtake Android and other major competitors and establish itself as the leader in the smartphone OS space.

www.pyramidresearch.com

Smartphone shipments to grow 55% to 472m in 2011 then 982m in 2015

Growth rate more than four times that of overall mobile market this year

Smartphone shipments are forecast to grow 55% year-on-year from 305 million units shipped in 2010 to 472 million in 2011 as a growing number of users turn in their feature phones for more advanced devices, then double to 982 million by the end of 2015, according to the Worldwide Quarterly Mobile Phone Tracker of market research firm International Data Corp (IDC).

Growing at more than four times the rate of the overall mobile phone market this year, the smartphone market is being fuelled by falling average selling prices (ASPs), increased phone functionality, and lower-cost data plans among other factors, which make the devices

more accessible to a wider range of users.

"The smartphone floodgates are open wide," says Kevin Restivo, senior research analyst with IDC's Worldwide Quarterly Mobile Phone Tracker. "Mobile phone users around the world are turning in their 'talk-and-text' devices for smartphones as these devices allow users to perform daily tasks like shopping and banking from anywhere," he adds. "The growth trend is particularly pronounced in emerging markets where adoption is still in its early days. As a result, the growth in regions such as Asia/Pacific and Latin America will be dramatic over the coming years."

www.idc.com

Compound semi firms diversify as handset market presents price erosion

Even while the handset portion of the compound semiconductor market remains the largest revenue producer, leading device suppliers are diversifying their portfolios by developing additional products for infrastructure, broadband and military applications, notes the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint 'Compound Semiconductor Industry Review March 2011: Microelectronics'.

The viewpoint from market research firm Strategy Analytics summarizes March's technology, product, contract, financial and employment developments for microelectronic firms such as RF Micro Devices, Skyworks Solutions, Hittite Microwave, Anadigics, TriQuint Semiconductor, Analog Devices and NXP addressing commercial and military applications using gallium arsenide (GaAs),

gallium nitride (GaN), silicon carbide (SiC), and silicon complementary metal-oxide-semiconductor (CMOS) technologies.

"The handset market continues to drive compound semiconductor volume, but rapid price erosion poses a challenge for suppliers," noted Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. "The March product announcements show activity aimed at CATV, fiber, military and test and measurement markets, as companies try to capture higher-margin opportunities," he adds.

"Some companies are expanding product lines into defense and broadband, which uses new processes to diversify market penetration," comments Asif Anwar, director, Strategy Analytics Strategic Technologies Practice.

www.strategyanalytics.com

EMEA optical network market to grow 7% in 2011 Drop of 11% in 2010 ended with strong rebound at year-end

The optical network hardware market in the Europe, Middle East and Africa (EMEA) region saw a strong rebound in late 2010 due to a year-end spending flurry, but it was not strong enough to turn around the decline for the year (down 11%), according to Infonetics Research's report 'Optical Network Hardware in EMEA: Europe, Middle East and Africa'.

"We forecast an overall gain of about 7% in EMEA in 2011, as a result of a spending recovery in Western Europe; access network deployments in the Middle East, particularly the Arabian peninsula and Israel; and strong growth in metro WDM equipment in Eastern and Central Europe as carriers shift

from microwave to fiber-fed access for wireless backhaul," notes Andrew Schmitt, directing analyst, optical.

In particular, Western Europe led optical hardware equipment spending in EMEA, with a 60% share in 2010. However, among the EMEA regions, the optical hardware market in Central and Eastern Europe is growing the fastest.

For full-year 2010, the EMEA optical network hardware market was led by Alcatel-Lucent (with a market share of about a third), followed closely by Huawei.

In total, the EMEA region represented 30% of worldwide telecom capital expenditures (CapEx) in 2010, and 31% of worldwide

optical equipment spending.

The report tracks SDH and WDM optical hardware for metro and long-haul networks sold by vendors in the EMEA region (including Western Europe, Central and Eastern Europe, the Middle East, and Africa). The service provides vendor market share, market size, and forecasts through 2015 by country and region. Companies tracked in the report include ADVA, Alcatel-Lucent, BTI, Canoga Perkins, Ciena, Cisco, Cyan, ECI, Ekinops, Ericsson, Fujitsu, Hitachi, Huawei, Infinera, MRV, NEC, Nokia Siemens, Nortel, Sorrento, Sycamore, Tejas, Tellabs, Transmode, Turin, Tyco, Xtera, and ZTE.

www.infonetics.com

Point-to-point radio shipments to exceed 2 million in 2015 GaAs RF device revenue to top \$300m

Fueled by rapidly increasing mobile data use by consumers and businesses, wireless point-to-point radios (used to backhaul mobile data) will grow from nearly 1.4 million in 2010 to slightly over 2 million in 2015, according to the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) Data Model 'Wireless Point-to-Point Radio Component Demand'. This growth in demand will account for \$300m of gallium arsenide device revenue in 2015, reckons the firm.

The data model highlights dynamics in the wireless point-to-point radio market, and segments radio shipments by frequency, application and geography. In particular, Strategy Analytics forecasts that the Asia-Pacific region will account for slightly more than half of wireless point-to-point radio shipments over this period. The analysis also indicates strong growth for point-to-point radios above 60GHz, but this segment will account for less than 3% of the total radio volume.

According to the data model, the highest volume of point-to-point radio shipments will occur in the 10–20GHz frequency range, accounting for nearly 46% of shipments over the forecast period.

"The tremendous increase in mobile data consumption is rippling through many market segments," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. "As operators deploy more base-stations to handle the data increase, wireless point-to-point radios are becoming a very attractive option to backhaul the data from the edge to the core of the network," he adds.

"Because of the frequency and performance requirements of wireless point-to-point radios, gallium arsenide will continue to play a key role in this market segment," comments Asif Anwar, director in the Strategy Analytics Strategic Technologies Practice.

www.strategyanalytics.com

Opto industry heads to higher-speed products

To coincide with March's Optical Fiber Communication (OFC) conference, component makers launched and demonstrated a host of new products underscoring the dramatic shift to higher data consumption, according to Strategy Analytics in its viewpoint 'Compound Semiconductor Industry Review March 2011: Optoelectronics, Materials and Equipment'.

"Consumer and business adoption of data-intensive applications is driving changes in the entire electronics industry," says Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. "The optical transport layer is the backbone of this increased demand. The industry is responding with higher-data-rate capacity," he adds.

"We are seeing the majority of new optical networking products and components with data capability of at least 40Gbps, many at 100Gbps, providing faster processing," notes Asif Anwar, a director in the Strategy Analytics Strategic Technologies Practice.

www.strategyanalytics.com

RFMD's quarterly revenue drops 23% to \$213.3m

Nokia falls to 15% of revenue while Samsung ramps up above 10%

For fiscal 2011 (ended 2 April), RF Micro Devices Inc of Greensboro, NC, USA has reported net income of \$124.6m (up on fiscal 2010's \$71m) on revenue of \$1051.8m (up 7.5% on fiscal 2010's \$978.4m). However, fiscal fourth-quarter revenue was \$213.3m, down 18.2% on \$260.8m a year ago and 23.5% on \$278.8m last quarter. In addition to seasonality, the drop is due mainly to a greater-than-expected decline in revenue at largest customer Nokia (falling from half of total revenue at the beginning of fiscal 2011 to less than a third, due to legacy POLARIS transceiver business running down plus Nokia losing market share in the RF front-end market).

Nevertheless, chief financial officer & VP of administration Dean Priddy says that RFMD is executing on a proven growth strategy supported by multiple revenue drivers, including sequential growth in its switch and signal conditioning product line, sequential growth in 3G power amplifiers (PAs), the addition of a second 10% customer in Samsung, and 17% year-on-year growth in the Multi-Market Products Group (MPG).

During the quarter, MPG started production of new gallium nitride (GaN)-based products for high-power military radar (for firms including Elta, Raytheon and Rockwell) and cable TV (for firms including Motorola, Eris and Aurora Networks). Also, RFMD's portfolio of high-performance WiFi front ends is driving exceptional growth (for customers including Samsung, LG, Motorola, Nokia and RIM), as consumer enterprise markets are "exploding", driven by the ongoing convergence of wireless and networking devices.

Meanwhile, RFMD's Cellular Products Group (CPG) has started volume production of new, higher-margin 3G/4G solutions, including the RF724x family of

ultra-high-efficiency PAs and PowerSmart power platforms (shipping just over 1 million chipsets, including starting shipments to Samsung).

"RFMD's strategic restructuring, announced three years ago, is now complete and driving diversified growth opportunities for RFMD," says president

& CEO Bob Bruggeworth.

"Sales in our Multi-Market Products Group grew by more than 30% in fiscal 2011 over fiscal 2010, and in our Cellular Products Group sales to customers outside our largest customer grew by more than 50%," he adds.

Nevertheless, CPG has fallen from 80% to about 75% of company revenue, while MPG has risen from 20% to 25%.

On a non-GAAP basis for fiscal Q4, gross margin has fallen from 39.6% a year ago and 38.7% last quarter to 37.5%. However, gross margin for core revenue was just below 40%. Net income was \$21.7m, less than half the \$43.8m a year ago and \$52.6m last quarter.

Net cash provided by operating activities was \$36.2m. So, after capital expenditure of \$4.8m, RFMD generated \$31.4m in free cash flow during the quarter (making \$188m for full-year fiscal 2011, up from \$177m for fiscal 2010).

"With all major growth drivers intact, we have the confidence to actively put RFMD's superior free cash flow to use," says Priddy. During the quarter, RFMD repur-

chased about 1.7 million shares of common stock and retired \$35.5m principal amount of convertible debt due in 2012. Consequently, during the quarter, total cash and cash equivalents and short-term investments have fallen from \$304.3m to \$291.6m. "In addition to the ongoing optimization of our capital structure, RFMD will continue investing in the R&D and customer-facing resources necessary to outpace the growth rate in our markets," says Priddy.

During the quarter, CPG secured multiple design wins for high-performance, silicon-based switches and switch filter modules across the world's leading smartphone and tablet makers. MPG secured major design wins across multiple growth markets, including wireless infrastructure, smart energy, high-performance WiFi for smartphones and tablets, and point-to-point radio for cellular backhaul.

RFMD expects to further diversify its revenue base, with its largest customer Nokia dropping towards just 15% of revenue in the June quarter. Dictated by Nokia front-end revenue, this should be the lowest-revenue quarter in fiscal 2012: flat to down 5% sequentially, as 8-12% growth in RFMD's core business (driven by new product cycles and technologies, including more than 50% growth for smartphones) is offset by declining sales of legacy products (with POLARIS transceiver products immaterial to financial results).

"The transformation of RFMD has created a highly diversified company with multiple growth drivers," says Priddy. "This sets the stage for accelerating top- and bottom-line growth, driven by continued strength in core revenue and the elimination of the revenue headwinds caused by declining transceiver sales," he adds.

"We expect to achieve our most diverse quarter of customer mix in

Sales in our Multi-Market Products Group grew by more than 30% in fiscal 2011 over fiscal 2010, and in our Cellular Products Group sales to customers outside our largest customer grew by more than 50%

RFMD's history as a public company," notes Bruggeworth. Driven by the continued customer diversification and improved product mix, gross margin should rebound by about 100 basis points. Priddy adds that 40% is within range over the next 2-3 quarters as low-margin transceiver business ends, leaving just the higher-margin core business.

After starting PowerSmart shipments to Samsung in the March quarter, shipments to LG and RIM will ramp in the June quarter (sooner than originally planned), reaching \$25m per quarter in total PowerSmart revenue (and \$75m cumulatively) by the end of fiscal 2012 (with sev-

eral other design-wins expected to ramp beginning in the December quarter, and maybe even September). RF724x 3G PAs will start shipping in volume in the

June quarter to first customer RIM, with multiple smartphone customers ramping in fiscal second-half 2012.

RFMD hence expects to return to sequential growth in the Septem-

Driven by the continued customer diversification and improved product mix, gross margin should rebound by about 100 basis points

ber quarter. "We expect RFMD will take full advantage of global secular growth trends and grow faster than our core markets," says Priddy. RFMD also expects a more diversified customer base and a product mix that is more robust, with a greater representation of new products in MPG and a higher percentage of 3G and 4G products in CPG.

"This will enable broad improvement in our financials, supporting margin expansion, operating leverage, earnings growth, continued strong free cash flow, and superior return on invested capital," Priddy concludes.

RFMD ships 2 millionth MCM for 3G base-station transceivers

RFMD has surpassed 2 million units in cumulative shipments of its multi-chip modules (MCMs) supporting 3G base-station transceiver (BST) applications for the wireless infrastructure end market.

RFMD has been developing and shipping MCMs for the infrastructure industry since 2009. The firm offers a complete portfolio of MCMs to address common frequency bands, 2G/3G standards and all RF functions in the base-station transceiver, including transceiver systems for new 4G LTE networks.

The shipment of over 2 million MCMs in such a short period of time highlights the continued expansion of RFMD's product port-

folio supporting the wireless infrastructure end market, claims Bob Van Buskirk, president of the firm's Multi-Market Products Group (MPG).

RFMD says that its MCM products reduce overall current consumption by using power down and other DC power control functions. The associated reduction in component operating temperatures improves component reliability, which is of critical importance in small remote radio heads (RRHs) located in difficult to access locations, says the firm. The reduced current consumption also benefits manufacturers of multi-standard RRH platforms, allowing customers to meet new 'green' wireless infra-

structure network standards, it adds.

"RFMD is leveraging our extensive library of single-function components and industry-leading scale to deliver our customers MCM solutions promptly and efficiently," says John Pelose, general manager of RFMD's Wireless Products business unit. "Our rapid prototyping capabilities enable our customers to improve their product cycle time and reduce time to market," he claims. "Additionally, our high-volume MCM assembly and test facilities help enable advances in performance at efficient economies of scale."

www.rfmd.com/products

RFMD launches quad-band transmit module family for UMTS/WCDMA/TD-SCDMA

RF Micro Devices Inc of Greensboro, NC, USA says that its new RF3232, RF3233 and RF3234 quad-band transmit modules are suited to use in the final portion of the transmitter section in multi-mode 3G entry-level handsets and connected devices.

The modules are the core of RFMD's RF323x Power Platform and incorporate 50Ω matched input and output ports, eliminating the requirement for external

PA-to-antenna switch module matching components.

Features include what is claimed to be excellent power margin (33.7dBm low-band P_{OUT}) for ease of design and calibration; low-insertion-loss TRx switch ports (0.7dB low-band, 1.1dB high-band) for improved 3G efficiency; robust 8kV ESD protection at antenna port; PowerStar control, including power flattening for low power and

current variation into VSWR, and V_{BATT} tracking for improved switching performance at low V_{BATT} .

Applications of the modules include: being optimized for single- and dual-band 3G entry-level use such as GSM/GPRS and Linear EDGE; pin-compatible products for scalability and platforming; and GSM850/EGSM900/DCS1800/PCS1900 products.

www.rfmd.com

Anadigics' sales fall 28% in Q1 to \$43.5m

RIM to plummet from 38% to 18% of revenue in Q2

For first-quarter 2011, GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported net sales of \$43.5m, level with a year ago period and down 27.8% on last quarter \$60.2m (which had been much better than the expected \$57m).

Of total revenue, the firm's largest North American wireless customer (RIM) contributed \$16.6m (38%). Samsung contributed more than 12%, while ZTE is just below 10% and Huawei is just below 9%.

Revenue consisted of \$36.2m from wireless (down 21% from a higher-than-expected \$46.1m last quarter) and just \$7.3m from broadband (almost halving from the higher-than-expected \$14.1m last quarter). Of broadband revenue, there was a halving for both set-top boxes (from \$4.9m to about \$2.4m). Infrastructure (from \$4.6m to \$2.3m) and WiMAX fell by even more (from \$2.4m to about \$0.9m), while wireless LAN fell less (from \$2.1m to \$1.7m).

"The decrease in net sales at our largest customer is the result of programs reaching end of life and a loss in market share related to the customer's change in chipset vendors [to Qualcomm] that do not utilize our power amplifiers [for which products were not qualified in time for a ramp of their new programs]," says president & CEO Ron Michels. "We remain actively engaged with this large customer and its chipset vendors on next-generation platforms," he adds.

Gross margin has fallen sharply from last quarter's better-than-expected 37.7% to 29.4%. Non-GAAP net loss was \$5m, almost double the \$2.7m a year ago and compared with income of \$4.9m last quarter. During the quarter, cash, cash equivalents and short- and long-term marketable securities fell slightly, from \$106.1m to \$104m.

For second-quarter 2011, Anadigics expects Broadband sales to rise sequentially by about \$2.5m (37%) to \$10m, driven by growth in the cable infrastructure product line. However, despite expecting a rise in revenue from all other key wireless customers (including Samsung, ZTE and LG), shipments to RIM will fall by \$10m (to \$6-7m). So, overall Wireless sales will drop 25-31% to \$25-27m. Total net sales are hence expected to fall by \$6.5-8.5m (15-19%) to \$35-37m.

Gross margin is expected to fall further, to 20-21%, as the rise in higher-margin broadband revenue will be insufficient to cover the decline in wireless. Fab utilization will drop to probably below 50%, reckons

chief operating officer Tom Shields. "Inventory did rise because we anticipated a much higher revenue rate during the second quarter, so we have to pull back," he adds.

While Samsung will be joined by both ZTE and Cisco at more than 10% of revenue each (the latter driven by a rebound in cable infrastructure business), RIM will plummet from Q1's 38% to just 18%.

"While we're working very closely with this customer and its chipset vendor on next-generation reference designs and customer platforms, we will experience further reductions in revenue from this customer through the remainder of this year as several of their products approach end of life," notes Michels. Revenue from RIM is expected to fall to below \$5m in Q3/2011 and perhaps less in Q4. "This significant quarterly revenue change will make the remainder of 2011 challenging as we work very hard to replace the revenue with new business," he adds.

"We continue to place a strong emphasis on gross margin improvements," says Shields. "A re-evaluation is well underway to ensure we address and accelerate the right programs for gross margin optimization," he adds.

"Our first priority is to refocus the company and drive efficiencies across the organization. We are proactively taking steps to align our cost base with revenues over the short-term, while prudently allocating resources to further expand our technology base and product offerings," says Michels. "We've reduced our workforce by just under 10% over the last few days, and we're taking prudent measures to further streamline operating expenses to properly adjust for the lower revenue base," he adds. The cash cost of the workforce reduction will amount to \$1m and should result in annualized savings of \$4m.

In Q2/2011, total cash consumption will be \$9-10m, including cash payments totalling \$3.7m for the management separation and workforce reduction. Together with \$1m allocated for capital expenditures, cash and cash equivalents should fall to \$94-95m.

"We have undertaken other cost-reduction initiatives where appropriate, without jeopardizing our R&D efforts," says Shields. "New product development will be a critical area of focus as we increase the breadth of our product portfolio," says Michels. "We are already heavily engaged with all of our customers and are actively pursuing several new opportunities across both Wireless and Broadband. We have multiple products that are expected to be designed into many wireless platforms, which include Samsung, ZTE, Huawei, which could potentially increase our market share with these customers," he adds. "We have an expanding technology pipeline and strong relationships with our current customers."

www.anadigics.com

The decrease in net sales at our largest customer is the result of programs reaching end of life and a loss in market share

Anadigics launches HELP3DC CDMA/WCDMA/LTE PA series optimized for SMPS devices

RF and mixed-signal semiconductor maker Anadigics Inc of Warren, NJ, USA has launched a new series of power amplifiers (PAs) that leverage the firm's third-generation High-Efficiency-at-Low-Power (HELP) technology.

Provided in a 3mm x 3mm x 1mm package with integrated RF coupler, internal voltage regulation, integrated DC blocks on RF ports, the new HELP3DC AWT663x series PAs are optimized for CDMA, WCDMA/HSPA and LTE devices that include a switched-mode power supply (SMPS), DC/DC converter, or envelope tracking IC to control the PA supply voltage. Anadigics claims that, in this kind of design, HELP3DC PAs provide average current consumption that helps to extend battery life in handsets, smart-phones, tablets, netbooks, and notebooks.

SMPS and DC/DC converters allow handset designers to reduce the PA supply voltage, decreasing average



Anadigics' HELP3DC AWT663x series power amplifiers.

current consumption under selected conditions. HELP3DC PAs have two power mode states for high efficiency across both low and high RF output power levels from a fixed supply using a single mode control input. The PAs also provide low quiescent currents (less than 8mA at 3.4V).

Anadigics says that using a HELP3DC series PA in combination with an external DC/DC converter gives designers additional options to reduce battery current consumption in both high-power and low-power modes. Envelope tracking designs modulate the PA supply voltage to match the demands of the input RF signal.

The AWT663x series consists of the following products:

- AWT6631 for UMTS band 1 (1880–1980MHz) and TD-SCDMA (2010–2025MHz);
- AWT6632 for UMTS band 2, CDMA BC 1, 14 (1850–1915MHz);
- AWT6634 for UMTS bands 3, 4, 9 & 10 (1710–1785MHz);
- AWT6635 for UMTS bands 5 & 6, CDMA BC 0,10 (815–849MHz); and
- AWT6638 for UMTS band 8 (880–915MHz).

Samples of the HELP3DC PAs are available now. Evaluation kits are available upon request.

www.anadigics.com

Anadigics ships production volumes of multi-band AWT6521 power amplifier for Qualcomm's Gobi 3000 module

Anadigics says that it is now shipping production volumes of its AWT6521 multi-mode power amplifier (PA) for Qualcomm's Gobi 3000 module.

With internal voltage regulation and an integrated RF coupler and DC blocks on RF ports (together with two shared RF inputs and five separate 50Ω matched outputs) in a space-saving 5mm x 7mm x 1mm package, the multi-band AWT6521 power amplifier supports WCDMA/HSPA+ and CDMA/EVDO in frequency bands used by operators worldwide, providing users with more choice in carrier networks and the freedom to go without fear of losing connectivity, says Anadigics.

The Gobi 3000 reference design is based on Qualcomm's MDM6200



Anadigics' AWT6521 multi-mode power amplifier.

and MDM6600 chipsets, both of which can provide support for

HSPA+ data rates of up to 14.4Mbps.

"The Gobi 3000 multi-mode platform provides high-data-rate wireless functionality to a broad spectrum of mobile devices," says Anadigics' VP of business development Jerry Miller.

"Qualcomm's selection of our new multi-band power amplifier for the Gobi 3000 platform exemplifies the strength of our successful relationship and the performance advantages of this product," he claims.

"We look forward to working closely with Qualcomm to develop the next-generation mobile solutions that continue to set the standard in wireless connectivity performance," Miller adds.

www.anadigics.com

IN BRIEF

TriQuint's Buhaly named Oregon's 'CFO of the Year'

TriQuint's chief financial officer Steve Buhaly was named 'CFO of the Year' at The Portland Business Journal's annual awards program (an event created to recognize Oregon state's top business leaders). Buhaly received the honor in the public company category.

"Steve Buhaly is a terrific role model for our entire organization. In addition to ensuring high integrity and transparency in TriQuint's public reporting, Steve is a trusted business partner and a valuable voice in strategic planning," comments TriQuint's president & CEO Ralph Quinsey. "He brings common sense and a quick wit to our team."

Buhaly act as a consultant to TriQuint's business units and functional departments. His responsibilities include everything from investor relations, corporate accounting and legal, to information technology, tax and treasury services. "Since joining the firm in September 2007, he has inspired operational improvements and empowered his senior managers," adds the firm.

TriQuint reported record financial results for 2010, growing revenue by 34% to \$878.7m. GAAP net income for the year grew almost 12 fold and non-GAAP earnings nearly tripled. During Buhaly's tenure, the stock price has improved significantly, says the firm. In its earnings release on 9 February, it guided that 2011 revenue should surpass \$1bn. Corporate goals (summarized in the recently filed annual report) include 20% annual growth rate, 20% operating margin, and 20% market share. With no debt and \$198.8m in cash (as of 2 April), TriQuint says that it is poised to continue profitable growth.

TriQuint's quarterly revenue falls 11% to \$224.3m Rebound expected in Q2/2011

For first-quarter 2011, RF front-end product and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported revenue of \$224.3m, down 11% on \$253.4m last quarter but up 24% on \$180.8m a year ago, driven by strong demand for smartphones.

Defense & Aerospace revenue fell 13% sequentially and 24% year-on-year (falling from 13% of total revenue to 8%). Networks revenue grew just 6% year-on-year (falling from 24% of total revenue to 20%). By product type, Radio Access has fallen from 39% of Networks revenue to 30% and Emerging Markets/Other from 20% to 17% while Transport has risen from 41% to 53% (becoming the largest Networks subcategory). During the quarter, the transport portfolio was expanded with three new cable products.

In contrast, Mobile Devices revenue grew 41% year-on-year (rising from 63% of total revenue to 72%). In particular, by air interface standard, 2G (low-end, voice-only phones) has fallen from 8% of Mobile Devices revenue to 2% while 3G/4G has risen from 74% to 77% and Connectivity from 18% to 21% (largely wireless LAN). To support the strong market demand for WiFi connectivity, during the quarter, TriQuint introduced new single- and dual-band WLAN power amplifiers that augment the Texas Instruments WiLink 6.0 and WiLink 7.0 solutions.

On a non-GAAP basis, gross margin was 40%, down only slightly on 40.1% last quarter (due to inefficiencies associated with capacity expansion) and up from 39% a year ago (and almost double the 21% of Q1/2009 two year ago). Compared with Q1/2010, TriQuint has increased GaAs capacity about 25%, bulk acoustic wave (BAW) filter capacity about 95%, and surface acoustic wave (SAW) filter capacity about 30%. In Q1/2011, GaAs fab utilization was 90%.

Including \$5.4m of expenses related to litigation with Avago over BAW filters, operating expenses were \$63.2m (28.2% of revenue), up from \$58m (22.9% of revenue) last quarter.

Although up 47% on \$17.7m (\$0.11 per diluted share) a year ago (despite litigation expenses being \$4.4m higher), net income of \$26.1m (\$0.15 per diluted share) is down 39% on \$42.8m (\$0.25 per diluted share) last quarter. During the quarter, cash, cash equivalents and investments fell by \$24.9m, from \$223.7m to \$198.8m. Capital expenditure of \$51.8m was partially offset by \$10.8m of cash flow from operations and \$12m of cash from stock option exercises.

"Looking ahead, I expect continued solid traction in mobile devices, strength in high-performance optical amplifiers, and good progress in the cable market," says president & CEO Ralph Quinsey.

For second-quarter 2011, TriQuint expects revenue to rebound to \$230–240m. The firm is currently 86% booked to the mid-point of this revenue guidance. With GaAs fab utilization expected to be 85–90%, non-GAAP gross margin should be 40–42%. Non-GAAP operating expenses are expected to grow to \$65–67m (including litigation expense rising to about \$7m). However, non-GAAP net income is expected to rebound to \$0.16–0.18 per share.

"We continue to expect strong revenue growth in second-half 2011, as we have had in past years like 2010," says chief financial officer Steven Buhaly. Last year, about 55% of revenue was in the second half. "It's not unheard of that we have 55–58% of the year's revenue show up in the second half," he adds.

For full-year 2011, TriQuint expects revenue to grow by 20%, and gross margin to be 40–43%.

www.triquint.com

TriQuint celebrates new San Jose design center

On 19 April, TriQuint Semiconductor Inc of Hillsboro, OR, USA, which provides RF front-end product maker and foundry services to mobile device, networks, and defense & aerospace markets, celebrated its expanded San Jose, CA design center with a ribbon cutting ceremony and staff appreciation events.

To accommodate expanding staffing, TriQuint relocated 90 staff from a 35,000ft² office space — formerly WJ Communications (acquired in May 2008) — to a newly renovated 52,000ft² facility just half a mile away in North San Jose, which offers more dedicated lab & conference areas as well as room for staff growth of up to 50% (an additional 40–45 employees).



Ribbon-cutting ceremony at TriQuint's new San Jose design center.

The center supports product development for many markets, including networks infrastructure (base-stations, CATV, WLAN and

WiMAX) and mobile devices by designing and testing amplifiers, LNAs, VCOs, digital step attenuators, mixers and integrated modules.

"Growth in San Jose and each of our major North American manufacturing facilities is evidence of a commitment to simplifying RF connectivity, lowering

overall costs and improving performance for our global customers," commented Brian P. Balut, TriQuint's vice president Networks.

TriQuint Semiconductor recognizes top sales representatives and distributors

TriQuint Semiconductor has announced the winners of its 2010 Sales Award Program.

The awards recognize TriQuint sales representatives' and distributors' overall contribution to its growth, including technical support, increasing design wins, revenue, and high level of responsiveness to customers.

Winners were chosen on the basis of nomination by members of TriQuint's executive sales team and announced at the firm's 2011 Global Sales Conference, an annual training and networking event for representatives and distributors.

The categories, winners and nominees are as follows:

Representative Sales Person of the Year:

Winner:

Jeff Wills, New Era Sales.

Nominees:

Butch Hataway of WES Tech Associates;
Bernd Prediger of Redtree Solutions Ltd;
Gidon Shoham of Omarim



Representative Sales Person of the Year Jeff Wills of New Era Sales (pictured center).

Technologies Ltd.

Representative Company of the Year:

Winner:

Microwave Components Marketing.

Nominees:

Insight Demand Creation;
Omarim Technologies Ltd.

Distributor of the Year:

Winner:

Richardson RFPD Inc (an Arrow Electronics Company).

Nominees:

Marubun Corp;
RFMW Ltd.

IN BRIEF

TriQuint launches PtP solutions

TriQuint Semiconductor has launched two new amplifiers for point-to-point and Ku-band VSAT (12–16GHz) and a third new amplifier for 21–24GHz PtP/K-band applications.

The TGA2524-SM is designed for easy assembly in a 3mm x 3mm QFN package. It also delivers high linearity and 35% lower power dissipation, plus 26.5dBm of saturated output power/23dB small signal gain.

The TGA2533 is a die-level, 2W high-linearity power amplifier designed for multi-chip transceiver modules.

The highly linear TGA4533-SM offers convenience for 21–24GHz applications, low power consumption and 22dB gain.

"TriQuint continues to grow its portfolio with a wide range of solutions offering convenience and performance for simplified RF connectivity," says marketing manager James Nelson.

www.triquint.com

Enhanced TriQuint PDKs support Agilent's ADS 2011 EDA software for next-gen wireless design flow

TriQuint Semiconductor has announced enhanced TriQuint process design kits (PDKs) with support for the Advanced Design System (ADS) 2011 electronic design automation (EDA) software of Agilent Technologies Inc of Santa Clara, CA, USA, as well as the development of an ADS RF Module PDK for TriQuint's RFIC/MMIC and RF Module integrated design flow.

The upgraded ADS Foundry PDKs enable both TriQuint's foundry customers and in-house design engineers to take advantage of new capabilities in ADS 2011. Specifically, they provide a fully integrated front-to-back product design flow with customized DRC and LVS solutions, offering a unified EDA software suite for schematic capture, simula-

tion, layout, and layout verification.

"We have upgraded our PDKs utilizing the new ADS 2011 capabilities in order to provide continued superior design support for our mutual customers and to our in-house product designers," said Glen Riley, VP of TriQuint's Commercial Foundry business unit.

TriQuint has also expanded ADS deployment for an integrated RF Module design flow. Further collaboration between the firms led to the validation and deployment of an ADS RF Module PDK within TriQuint that integrates multi-technology IC and RF Module layout features, providing a complete electrical and physical RF Module design flow. The integrated module design flow removes design translation errors,

shortens product development cycle times and enables design optimization for module product manufacturing yield, reducing overall engineering and development expenses.

"Our best engineers have been working together, and the improved productivity and ability to optimize today's complex MMIC/RFIC module design flow is exactly what we had hoped to achieve when we started the development of ADS 2011," says Mark Pierpoint, VP of Agilent EESof EDA (which supplies EDA software for microwave, RF, high-frequency, high-speed digital, RF system, electronic system-level, circuit, 3D electromagnetic, physical design and device-modeling applications).

www.agilent.com/find/eesof-ads

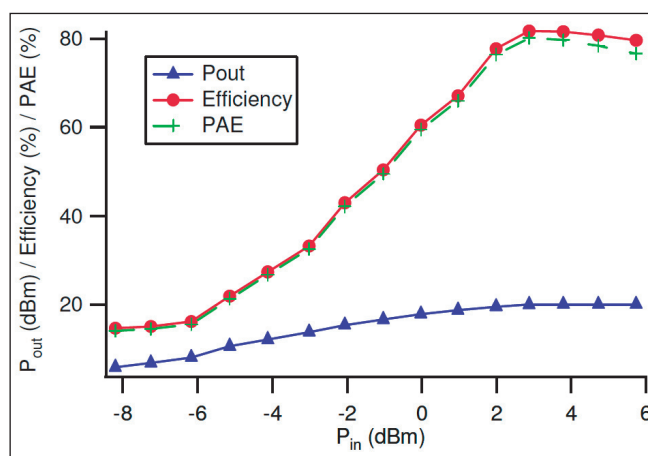
Mesuro demonstrates first-pass design success for multi-harmonically matched MMIC power amplifier

Mesuro Ltd of Cardiff, UK, which is commercializing RF test & measurement technologies from Cardiff University's Centre for High Frequency Engineering, says that it has again proved how its waveform engineering approach to power amplifier (PA) design yields major reductions in design costs and improves product time to market, through 'right-first-time' design.

Using TriQuint Semiconductor's commercially available TQPED 0.5 μ m GaAs pHEMT foundry process with data from characterization performed on Mesuro's active harmonic load-pull solution, the completed design produced a first-pass MMIC power amplifier with an efficiency performance of >80%.

The use of the original device measurement data meant that the designer was able to produce the design without the need for a non-linear I-Q device model.

For this reason it is often necessary for the designer to rely on



Measured PA power sweep at the designed frequency of 900MHz.

experimental investigations. This build and test approach is often frustrating, since it can be very time consuming and does not usually allow the flexibility or the quantity of investigations to be undertaken, says Mesuro.

The firm says that the multi-harmonically matched MMIC PA design process allowed the

designer to understand accurately how component sensitivities would affect the proposed performance of the amplifier at the investigation phase prior to any expensive fabrication being undertaken. This means that the designer could better understand the trade-offs that could be made in the impedance matches to increase the probability of a

first-time success after fabrication.

Mesuro says that the ability to get close to the optimum performance first time provides designers with the opportunity to hugely reduce design costs by reducing the number of design iterations required, allowing them to get a product to market quicker, it is claimed.

www.mesuro.com

Skyworks' revenue beats guidance, up 37% year-on-year June-quarter revenue to rise 6% to record \$345m

For its fiscal second-quarter 2011, Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has reported revenue of \$325.4m (exceeding guidance of \$310–320m). This is up 37% on \$238.1m a year ago and down only 3% on last quarter's record of \$335.1m (compared with normal March-quarter seasonality of down 10–15%). The top customers were Foxconn, Nokia and Samsung.

"Sequential revenue performance demonstrates how a diversification strategy and growth in new market segments are contributing to stronger financial results," comments president & CEO David Aldrich.

On a non-GAAP basis, gross margin has increased from 42.3% a year ago to 43.9% (slightly above the forecast 43.8%, but down on 44.7% last quarter). Net income was \$78.7m, up on \$44.2m a year ago but down on \$84.7m last quarter.

Cash flow from operations was \$92m. During the quarter, the firm ended the quarter nearly debt-free, with cash balance rising from \$450m to \$504m. This followed capital expenditure of \$32m (reflecting process investments to complement existing assembly & test capacity). "We have completed

the majority of our capacity investments in Mexicali, and we anticipate that CapEx will begin to moderate back towards maintenance level over the next couple of quarters," says VP & chief financial officer Donald Palette.

During the quarter, Skyworks secured analog design wins with STMicroelectronics for its next-generation IP TV chip set reference design; ramped production of precision analog ICs supporting enterprise access points, cable set-top boxes and wireless video systems for Motorola and Cisco among others; supported General Dynamics with high-power switching solutions for military land mobile radios; captured multiple infrastructure sockets with Ericsson, Huawei and ZTE for WCDMA base-station transceivers; launched a family of antenna switch modules for smart-phones, tablets and datacards supporting 3G handsets and HSPA+/LTE-enabled devices; and powered HTC's next-generation Android-based smart phones and newest tablet offering with front-end solutions. Skyworks was also the first semiconductor firm to receive the 2010 Best Quality award from Samsung for excellence in overall product quality and supply-chain efficiency.

"Skyworks is capitalizing on consumers' skyrocketing demand to be

connected anytime and anywhere via smart phones, tablets and home automation systems in addition to energy management solutions and supporting network infrastructure," says Aldrich. "The growth in analog semiconductor content associated with this increasing demand plays directly to Skyworks' technology leadership and scale," he adds.

"Based on our broad customer base, diversification into new markets and increasing share gains, we are again planning to grow faster than our addressable market in the third fiscal quarter of 2011," says Palette. Skyworks expects revenue to rise 6% to a record of about \$345m, with gross margin bouncing back up to 44.5–45%. "Third-quarter guidance puts us squarely on a path to approach a \$1.5bn revenue run rate with \$2 in annualized EPS by the end of this fiscal year," he adds.

"We fully expect momentum achieved in the first half will translate into further market share gains during the remainder of the fiscal year throughout fiscal 2012 and beyond," says Aldrich. "Our strategy of diversifying across base-band partners, among OEM customers and new vertical markets while continuously improving operational execution is clearly working."

www.skyworksin.com

Skyworks joins Electronics Industry Citizenship Coalition

Skyworks has released its 2010 Sustainability Report, a voluntary non-financial public document that addresses its commitment to sustainable business practices. It highlights annual improvements and provides an overview of initiatives in multiple areas, from environmental efforts and labor practices, to its health & safety programs, ethics policies and stewardship activities.

In 2010, Skyworks improved energy efficiency by 28%, water

efficiency by 19% and hazardous waste efficiency by 13% on 2009. Almost all of Skyworks' products sold were RoHS-compliant and over 70% exceeded regulatory requirements for voluntary halogen-free industry standards.

Skyworks recently joined the Electronics Industry Citizenship Coalition (EICC), an alliance of electronics firms working to improve environmental and working conditions in the information & communication

technologies supply chain. Skyworks has long aligned its sustainability efforts to EICC's Code of Conduct, which establishes guidelines for performance and compliance across a broad range of areas. Skyworks says membership of the coalition allows it to participate in the further development and implementation of standardized programs and tools to aid the industry in its efforts towards sustainability.

www.eicc.info

Skyworks to buy power management firm Advanced Analogic Technologies

Expanded analog portfolio to speed entry into adjacent vertical markets

Skyworks Solutions Inc of Woburn, MA, USA, which manufactures high-reliability analog and mixed-signal semiconductors, has signed a definitive agreement to purchase Advanced Analogic Technologies Inc (AnalogicTech) of Santa Clara, CA.

AnalogicTech is an analog semiconductor firm focused on enabling energy-efficient devices for the application-specific power management needs of feature-rich consumer electronic devices (such as mobile handsets, digital cameras, tablets, notebooks, TV and LCD displays) as well as devices in a broad range of computing, industrial, medical and communications applications. The firm also licenses device, process, package, and application-related technologies. Assets include design centers in Santa Clara and Shanghai as well as Asia-based operations and logistics.

The latest deal comes just nine days after Skyworks agreed to purchase SiGe Semiconductor Inc of Andover, MA (a fabless supplier of highly integrated silicon-based RF front-end solutions enabling wireless connectivity).

Skyworks says that the AnalogicTech acquisition expands its portfolio with highly complementary analog semiconductor products including battery chargers, DC/DC converters, voltage regulators and LED drivers. According to the market research firm Gartner, the

analog power management market is expected to grow from \$9.9bn in 2010 to \$12.1bn in 2014.

"Skyworks' acquisition of Advanced Analogic Technologies will enable us to further capitalize on our strong smart-phone, tablet, set-top box and infrastructure positions with an expanded and differentiated product portfolio while accelerating our entry into new vertical markets," says president & CEO David J. Aldrich. "At a higher level, analog power management semiconductors represent a strategic growth market for Skyworks as our customers increasingly demand both ubiquitous wireless connectivity and power optimization across seemingly every kind of electronic platform. With Advanced Analogic Technologies, Skyworks will be well positioned to address these massive twin market opportunities leveraging our broad customer relationships, innovative product portfolios and increasing operational scale," he adds.

"Together, we can better address our customers' demand for highly integrated power management solutions across a broader range of markets and applications," says AnalogicTech's president, CEO & chief technical officer Richard K. Williams.

Skyworks is to buy AnalogicTech for a nominal price of \$6.13 per share (a 52% premium on its 30-day

trailing average), consisting of \$3.68 per share in cash and .08725 of a share of Skyworks' common stock for each outstanding share of AnalogicTech common stock.

The amount of stock is based on the average closing price of Skyworks' common stock over the 30-trading days prior to 26 May. At that average price, the stock component of the price has a nominal value of \$2.45. This value will be tested again at closing, based on the average closing price of Skyworks' common stock during the five trading days prior to the closing. If the average pre-closing value is lower than \$2.45 then the amount of cash per share will be increased by the difference, and if the average pre-closing value is higher than \$2.45 then the amount of cash per share will be reduced by the difference, to maintain a calculated nominal value of \$6.13 per AnalogicTech share in either case.

The transaction is subject to approval by AnalogicTech's shareholders, and is also subject to other customary closing conditions (including the receipt of applicable regulatory approvals). Excluding any non-recurring acquisition-related charges and amortization of acquired intangibles, Skyworks expects the acquisition to be immediately accretive to non-GAAP earnings post-closing.

www.analogictech.com

M/A-COM promotes distribution director to VP sales

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) has promoted Jack Kennedy to VP of sales (reporting to chief operating officer Robert Donahue), responsible for its global sales organization.

Most recently, since November 2010, Kennedy served as director of global distribution, delivering significant enhancements to its efficiency and performance. His previous roles include: strategic account lead; global account director; sales manager; and field sales engineer.

"Jack's understanding of our busi-

ness, our products, the industry, and our customer base is comprehensive," comments Bob Donahue. "That, combined with his inherent leadership skills and successful track record, will greatly benefit M/A-COM Tech and its ability to meet the needs of its customers."

www.macomtech.com

Skyworks buys SiGe Semiconductor for \$210m

Short-range, Si-based products complement wide-area front-ends

After signing a definitive agreement of 17 May, Skyworks Solutions Inc of Woburn, MA, USA, which manufactures high-reliability analog and mixed-signal semiconductors, has acquired SiGe Semiconductor Inc of Andover, MA, a fabless supplier of highly integrated RF front-end solutions enabling wireless connectivity.

SiGe Semiconductor says that its predominant use of standard silicon-based processes and its fabless manufacturing model enables it to achieve high levels of functional integration, leverage the economies of scale of high-volume manufacturing technology, maintain low costs, and accelerate time-to-market. It has shipped more than 750 million front-end solutions since the firm's inception, primarily consisting of Wi-Fi front-end modules and power amplifiers.

Skyworks offers diverse standard and custom linear products supporting automotive, broadband, cellular infrastructure, energy management, industrial, medical, military and mobile handset applications. Its portfolio includes amplifiers, attenuators, detectors, diodes, directional couplers, front-end modules, hybrids, infrastructure RF subsystems, mixers/demodulators, phase shifters, PLLs/synthesizers/VCOs, power dividers/combiners, receivers, switches and technical ceramics.

Skyworks says that the acquisition complements its wide-area front-end solutions by adding SiGe's short-range, silicon-based products, enabling it to offer a comprehensive wireless networking product portfolio supporting all key operating frequencies with architectural flexibility to address a variety of high-growth applications. Specifically, Skyworks expands its addressable content opportunity within several strategic product areas including smart-phones, tablets, gaming consoles, notebook PCs and home automation systems.

"This acquisition is highly complementary in terms of our addressed markets, sales channels, process technologies, design methodologies and baseband partnerships," says president & CEO David J. Aldrich. "At the same time, the SiGe business presents significant operational and cost synergies, yielding immediate earnings accretion and long-term shareholder value creation," he adds.

Skyworks expands its addressable content opportunity within several strategic product areas including smart-phones, tablets, gaming consoles, notebook PCs and home automation systems

"Skyworks clearly represents the best strategic and cultural fit for SiGe Semiconductor," comments SiGe's president & CEO Sohail Khan. "Both companies have a long history of front-end innovation and a shared vision of the future of band-intensive wireless networking," he adds. "Together, we can develop and deliver products of unprecedented integration and improve our customers' performance in the increasingly connected wireless world."

Skyworks paid \$210m in cash, plus an additional \$65m if certain performance targets are met over the next 12 months. Excluding any non-recurring acquisition-related charges and amortization of acquired intangibles, Skyworks expects the acquisition to be immediately accretive to non-GAAP earnings.

Skyworks says that SiGe's diverse product portfolio provides the performance, range and reliability required by 802.11b/g/a/n, Bluetooth, WiMAX, GPS and ZigBee systems. SiGe's use of silicon-based semiconductor technologies simplifies the integration of RF signal processing for many leading consumer, commercial and industrial electronics firms. Key SiGe customers include Cisco, Dell, Huawei, Hewlett-Packard, NetGear, Itron, Microsoft, Nintendo, Samsung and Sony.

www.sige.com

M/A-COM Tech hires corporate controller

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components, and subassemblies for RF, microwave and millimeter-wave applications) says that Michael Dys has joined it as corporate controller, reporting to chief financial officer Conrad Gagnon.

Dys will be responsible for all global accounting functions, budgeting and forecasting, as well as financial planning and analysis. He

will also provide financial perspective to other business leaders toward optimizing M/A-COM Tech's operational efficiency.

"Michael's extensive experience with substantial global players in our market space, his diverse business background, and his hands-on approach make him the ideal professional for this role," believes Gagnon. "His successful career to date in the microwave industry has

demonstrated hands-on leadership, effective financial control and attention to the bottom line," he adds.

Dys was most recently controller at Aeroflex/Micro-Metrics, and was previously VP & corporate controller at Skyworks Solutions Inc of Woburn, MA, USA (which manufactures high-reliability analog and mixed-signal semiconductors).

www.macomtech.com

Skyworks unveils broadband quadrature modulators for cellular infrastructure

Skyworks Solutions Inc of Woburn, MA, USA has launched three wide-band quadrature modulators for cellular infrastructure and high-performance radio link applications. The modulators are the latest additions to the firm's wireless infrastructure portfolio and are designed to support leading 3G and 4G base-station providers.

The fixed-gain quadrature modulators deliver what is claimed to be excellent phase accuracy and amplitude balance, enabling high performance for multi-carrier communication systems. They also have greater than 500MHz 3dB modulation bandwidth, a low noise floor and a wide operating frequency range, supporting multi-band designs and network requirements.

According to a recent In-Stat Mobile Internet Group research report, infrastructure expenditures by mobile operators will need to scale up by more than 40% in the coming years to meet fast-approaching network demand. As a result, mobile operators will not only need to install new base-stations, routers and backhaul network equipment, but will need to upgrade and expand existing infrastructure to avoid network traffic jams and preserve their highly profitable data service revenue, all of which will require increased analog and mixed-signal content.

"With the addition of these new modulators, Skyworks continues to capitalize on the network infrastructure side of the mobile Internet phenomenon," says Liam K. Griffin,

Skyworks' executive VP & general manager of high-performance analog. "Skyworks is pleased to offer our customers a multitude of high-performance, cost-effective solutions as they build out their networks to support the staggering increase in mobile data traffic," he adds.

Skyworks claims that the SKY73077 (for 1500–2700MHz), SKY73078 (for 500–1500MHz) and SKY73092 (for 400–6000MHz) quadrature modulators have high linearity, excellent I/Q phase accuracy and amplitude balance, suiting use in high-performance communication systems. The modulators accept two differential baseband inputs and a single-ended local oscillator, and generate a single-ended RF output.

www.skyworksinc.com

Quantum Devices Award for Notre Dame's Seabaugh

Professor Alan Seabaugh, director of the Midwest Institute for Nanoelectronics Discovery (MIND) and associate director of the Center for Nano Science and Technology (NDnano) at the University of Notre Dame's Department of Electrical Engineering, received the 2011 Quantum Devices Award at May's International Symposium on Compound Semiconductors (ICSC) in Berlin, Germany.

Established in 2000 to recognize "pioneering contributions to the field of compound semiconductor devices and quantum nanostructure devices", the award cites Seabaugh's "seminal contributions and leadership in semiconductor devices and circuits based on quantum mechanical tunneling such as tunnel-FETs and resonant tunneling transistors".

<http://mind.nd.edu>

Hittite maintains growth in Q1/2011 Income down slightly due to Arctic Silicon acquisition expenses

For first-quarter 2011, Hittite Microwave Corp of Chelmsford, MA, USA (which designs and supplies analog and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems as well as instrumentation) has reported revenue of \$67.2m, up 24.1% on \$54.2m a year ago and 2.5% on \$65.6m last quarter (and towards the high end of mid-February's guidance of \$65.5–67.5m).

Of total revenue, 44.6% came from the USA (\$30m, level on last quarter) and 55.4% came from outside the USA (\$37.2m, up from \$35.6m. This compares with Q4/2010's split of 45.7%:54.3%.

Gross margin of 73% is down from 74.5% last quarter and 73.4% a year ago. Operating expenses have risen further, from \$14.7m a year ago and \$16.7m last quarter to \$17.9m (due largely

to an increase in R&D expenses from just \$7m a year ago and \$8.3m last quarter to \$9.4m).

Net income was \$20.2m, up on \$16.1m a year ago but down slightly on \$20.9m last quarter, after including transaction costs and expected operating expenses attributable to mixed-signal IC technology developer Arctic Silicon Devices of Trondheim, Norway (acquired in mid-January for about \$12m in cash and equity). However, this was slightly above mid-February's income guidance of \$19.2–20.1m.

Consequently, during the quarter, total cash and cash equivalents rose by \$16.3m, from \$295.5m to \$311.8m.

For second-quarter 2011, Hittite expects revenue to rise further to \$67.5–69.5m, with net income of \$19.8–20.6m.

www.hittite.com

Kopin's Q1 revenue up 37% year-on-year to record \$35m

Smartphone demand drives III-V revenue up 16.5% on last quarter

For first-quarter 2011, Kopin Corp of Taunton, MA, USA has reported revenue of a record \$34.9m, up 5.4% on \$33.1m last quarter and 37% on \$25.4m a year ago.

Revenue from Displays (used in mobile applications, military thermal weapons sights and wearable computers) was \$17.3m, down 4% from \$18m last quarter but up 59% on \$10.9m a year ago, due mainly to higher military display sales. Revenue from III-V heterojunction bipolar transistor (HBT) epiwafers was \$17.6m, up on 16.5% on \$15.1m last quarter and 21% on \$14.5m a year ago, reflecting stronger orders from integrated circuit partners.

Although down on 34.6% last quarter, gross margin of 33.3% (as a proportion of product revenue) is up from just 26.5% a year ago, reflecting increased in sales of military displays and leveraging the III-V fixed costs over greater volume.

Net income was \$2.1m. This is less than half last quarter's \$4.7m, but that was boosted by \$2m (the receipt of \$1.4m in insurance proceeds and \$0.6m from the sale of patents that the firm was no longer using). Compared with a year ago, net income has more than doubled from \$1m (a profit only due to \$373,000 from insurance proceeds and \$686,000 from the sale of stock of IC maker Micrel Inc of San Jose).

We continue to expect III-V to grow at an annualized rate of 20–25% over the next several years, driven primarily by global smartphone demand, says president & CEO Dr John C.C. Fan

"Our earnings reflect our commitment to maintaining prudent expense management, while at the same time investing strategically in R&D and capacity expansion to execute our growth strategy," says president & CEO Dr John C.C. Fan. R&D expenses have risen from \$4.3m (16.9% of revenue) a year ago and \$5.8m last quarter (17.5% of revenue) to \$6.4m (18.3% of revenue), due to the firm's investments in the Golden-i display product, III-V products for smartphones, and the acquisition of Forth Dimension Displays Ltd (FDD). Although down on \$111m at the start of first-quarter 2011, Kopin still has cash and marketable securities of \$99m. The firm also has no debt.

"We continue to expect III-V to grow at an annualized rate of 20–25% over the next several years, driven primarily by global smartphone demand," Fan says. "In our display business, as is the historic pattern, revenue from military applications fluctuates quarter to quarter but we expect strong military revenues in 2011 as we continue to supply the US Army's Thermal Weapons Sight program," he adds.

"Looking ahead, we are focused on our two main goals: extending the leadership position of our III-V products to take advantage of the expected growth in smartphones and tablets; and advancing the development schedule for Golden-i toward a planned launch in 2012," Fan concludes.

Based on the current business environment and conversations with its customers, Kopin is affirming its guidance for full-year 2011 revenue of \$130–140m (up 8–16% on 2010).

www.kopin.com

IN BRIEF

Kopin receives CLARUS Award from MDB Capital

Kopin has received the CLARUS Award, presented by MDB Capital Group at the second annual Bright Lights Conference in New York City.

Kopin was selected by PatentVest (MDB's proprietary IP business intelligence platform) as one of the 40 most innovative public companies from more than 1500 small-cap companies with granted US patents. Firms were selected on the basis of their rate of innovative change as well as the uniqueness, quality and industry impact of their patents.

"Intellectual property is an integral part of the success of our products using innovative nanotechnologies, and we are pleased to have our strong IP portfolio recognized with this award," says Kopin's president & CEO Dr John C.C. Fan. "We continue to advance our IP strategy, pursuing patents on new innovations and discoveries related to our III-V transistors, Golden-i wearable headset computer, and display technologies," he adds.

"Kopin was the top company in its industry with the highest Tech Score and number of patent grants, and we are honored to recognize their achievements in driving IP as an asset class and the impact they are making on innovation in America," comments MDB Capital Group's CEO Christopher A. Marlett.

The Bright Lights Conference is said to be the only conference with an exclusive focus on publicly traded companies possessing disruptive and market-changing IP, providing institutional investors with a venue to discover the largely unrecognized value of embedded IP.

www.mdb.com

TowerJazz launches fastest foundry SiGe technology

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) has announced the availability of SBC18H3, which it claims is the industry's highest-speed foundry silicon-germanium (SiGe) technology.

The technology addresses next-generation needs for high-speed interfaces in communication protocols such as Thunderbolt, optical fiber, and high-data-rate wireless by improving performance while reducing noise and power consumption of key building blocks. SBC18H3 also targets applications such as automotive collision avoidance systems, millimeter-wave radar and gigahertz (GHz) imaging.

SBC18H3 is TowerJazz's third-generation 0.18 μ m SiGe technology and offers transistors with 240GHz f_T and 260GHz f_{max} in what is described as a cost-effective and analog-friendly 0.18 μ m node. The

technology is built on the same mature integration platform used for the prior two TowerJazz SiGe processes now in high-volume production (SBC18H2 at 200GHz and SBC18HX at 155GHz). Intellectual property of high-speed components such as transimpedance amplifiers (TIAs), laser drivers, SerDes, CDRs from H2 and HX can be readily ported to the new H3 process since they are all in the same 0.18 μ m node, allowing them to benefit from improved performance as well as reduced power consumption and noise.

Power consumption is dramatically reduced with H3 where, for example, a 77GHz amplifier can be made to consume three times less DC power than was possible with older technology. At the same time, noise is improved to levels that far exceed those of prior SiGe technology and are superior to numbers typically reported for more expensive III-V material systems, it is claimed (minimum noise figure at 20GHz is measured at <1dB and at 40GHz at

only 2dB). This can be important in many communication systems but particularly in wireless applications, improving sensitivity of GPS systems, for example, says the firm.

SBC18H3 process design kits (PDKs) include mm-wave components important for high-speed designs such as a transmission-line toolbox, p-i-n diodes for RF switching, and support for small-size MIM capacitors. TowerJazz offers a monthly multi-project wafer (MPW) service for quick and cost-effective prototyping of designs, and leading customers have already built initial SBC18H3 prototype designs through this.

"The process extends the high-end of our overall portfolio of SiGe technology that currently spans from the 0.35 μ m to the 0.13 μ m node and is available in two of our 8-inch factories for flexibility of supply and capacity," says Dr Marco Racanelli, senior VP & general manager, RF and High Performance Analog Business Group.

www.towerjazz.com

TowerJazz launches wireless antenna switch SOI process

TowerJazz has made available its wireless antenna switch SOI (silicon-on-insulator) process technology, which is applicable to multiple wireless standards.

The firm claims that SOI-based solutions cost substantially less than legacy solutions based on GaAs pHEMT or silicon-on-sapphire (SOS) technologies. It adds that its SOI technology is unique relative to other SOI processes in maintaining full compatibility with its bulk CMOS process, enabling integration of control functions, low-noise amplifiers (LNAs) and power amplifiers on a single chip. High-end smartphones can benefit most from integration, while lower-end phones can benefit simply from the lower cost of SOI, making the technology relevant for most of the 1.4 billion handset units sold each year, the firm reckons.

In addition to the process, design IP is available to kick-start the design effort. An example is a switch IP block optimized to achieve channel isolation of better than -40dBm, insertion loss of 0.47dB in low-band and 0.58dB in high-band, low harmonics of better than 75dBc at cellular power levels, and intermodulation distortion measured as low as -117dBm.

The SOI process combines a 6- or 4-metal-layer CMOS process with high-resistivity SOI substrates. It is a 0.18 μ m technology with dual-gate 1.8V and 3.3V or 5V MOSFETs and a 5V RFLDMOS with an f_T (threshold frequency) of 19GHz and a breakdown of 20V. The 3.3V and 5V FETs facilitate integration of HVC-MOS blocks, while the 1.8V FETs allow integration of logic functions. The LDMOS device provides reliable, high-performance RF power.

The passive components include silicided and unsilicided poly resistors, 2fF/ μ m² and stacked 4fF/ μ m² metal-insulator-metal capacitors, scalable inductors, and discrete size baluns and transformers.

TowerJazz says that, while using an SOI starting material, the technology offers 'bulk-like' behavior of the active MOSFETs, free of floating-body effects for ease of IP integration. Isolation between device wells and of field areas below sensitive passive components and metal routing is provided by an oxide-filled trench to the buried oxide.

"Unlike other SOI technologies, our process allows the seamless integration of existing bulk IP such as power control, low-noise amplifiers and even power amplifiers," claims Dr Marco Racanelli, senior VP & general manager, RF and High Performance Analog Business Group.



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IBM's 8HP silicon germanium process meets Tektronix 30+GHz oscilloscope design goals

Test instrumentation maker Tektronix Inc of Beaverton, OR, USA has announced that validation of application-specific integrated circuits (ASICs) designed in IBM's 8HP silicon germanium (SiGe) BiCMOS Specialty Foundry technology are exceeding target specifications for a planned new performance oscilloscope capable of greater than 30GHz bandwidth across multiple channels while minimizing noise found in older chip sets.

The new oscilloscope platform aims to meet electronic designers' needs for more accurate characterization of high-speed serial data beyond 10Gb/s, and will enhance optical modulation analysis of 100 Gigabit Ethernet (100GbE) where complex signaling requires accurate bit capture.

"This represents our first commercial integration of 8HP technology and clearly shows the latest generation of SiGe is delivering significant performance differentiation to the industry's most demanding oscilloscope applications," says

Roy Siegel, general manager, Oscilloscopes, Tektronix. "This year, we will be delivering a new series of performance oscilloscopes with the lowest noise and class-leading signal acquisition performance across multiple channels," he claims.

"IBM's SiGe technology has long delivered the performance and reliability our customers demand and, as our lab demonstration indicates, this will continue well into the future."

IBM's 8HP technology is a 130nm SiGe bipolar complementary metal oxide semiconductor (BiCMOS) process that offers 2x performance

This represents our first commercial integration of 8HP technology and clearly shows the latest generation of SiGe is delivering significant performance differentiation to the industry's most demanding oscilloscope

over the previous generation. SiGe technology leverages highly reliable and mature fabrication processes associated with the silicon industry, but with performance levels comparable to that of materials such as InP and GaAs, it is claimed. Unlike those alternatives, SiGe BiCMOS provides access to high-speed bipolar transistors on the same die as standard CMOS, enabling a class of circuitry that marries extreme performance with large-scale integration. Tektronix says it is this union that has allowed it to reliably deliver feature-rich, high-speed data acquisition systems for over a decade.

"As Tektronix's lab demonstration makes very apparent, IBM's 8HP SiGe technology continues to deliver a winning combination of speed, accuracy and integration required for high-end instrumentation," comments Regina Darmoni, director, Specialty Foundry, IBM.

Initial Tektronix product deployments using 8HP SiGe technology are expected later this year.

www.tektronix.com

Sapphire-on-silicon RFIC supplier Peregrine strikes global distribution agreement with Digi-Key

Internet-based electronic components distributor Digi-Key Corp of Thief River Falls, MN, USA and fabless RFIC supplier Peregrine Semiconductor of San Diego, CA have finalized a global distribution agreement involving Peregrine's UltraCMOS silicon-on-sapphire (SOS) RFIC products.

Peregrine's RF switches, digital step attenuators, PLL frequency synthesizers, mixers and prescalers are now available for purchase on Digi-Key's global websites and will be featured in future online catalogs.

Peregrine leverages its proprietary UltraCMOS technology to enable the design, manufacture, and integration of multiple RF,

mixed-signal and digital functions on a single chip. Products target a broad range of applications in the aerospace & defense, broadband, industrial, mobile wireless device, test & measurement equipment, and wireless infrastructure markets.

"Our goal is to provide the best products from antenna in to data out, and we believe Peregrine's advanced

Our goal is to provide the best products from antenna in to data out... Peregrine's advanced technology will help us achieve that goal

technology will help us achieve that goal," says Mark Zack, Digi-Key's VP of semiconductor product.

"OEM engineering teams designing tomorrow's wireless products are increasingly faced with complex RF integration challenges, and they need simple solutions, fast," says Dale Robinette, Peregrine's director of worldwide sales. "Peregrine continues to drive its growth by accessing new customers in all parts the world; adding Digi-Key to our channel partner strategy broadens our reach to this audience, expands our sales support capability, and ultimately puts our product closer to the customer."

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Strained Layer & Quantum Well
Multi-junction CPV Cells

Cree adds lower-amperage 1200V Z-FET for 3–10kW solar, power supply and motor drive applications

New silicon carbide MOSFET delivers energy efficiency to expanding list of power applications

Providing power electronics design engineers with a way to increase the efficiency of high-volume power inverters for alternative energy and other power electronic applications, Cree Inc of Durham, NC, USA has extended the product range of its Z-FET family with a lower-amperage 1200V SiC MOSFET. The device complements the firm's existing 1200V SiC MOSFET and features a smaller current rating that enables it to be included in a wider range of applications at a lower price point or used in parallel to optimize system cost and performance.

The new device is designed to replace the silicon insulated-gate bipolar transistors (IGBTs) that are currently used in power inverter designs between 3kW and 10kW. Applications include high-voltage power supplies and auxiliary power electronics circuits, especially those designed for conversion of three-phase input power, solar power inverters, industrial motor drives, high-power DC data-center power architectures, and PFC (power factor correction) circuits.

"The addition of this new switching device to our Z-FET SiC power MOSFET family gives our customers a greater range of flexibility in matching the price/performance requirements to their applications," says Dr John Palmour, Cree co-founder & chief technology officer, Cree Power & RF. "The smaller die size provides a lower price point, yet still delivers all the benefits of silicon carbide switching performance at 1200V. It's further evidence that we're committed to establishing a comprehensive range of SiC MOSFET products that we believe will eventually replace silicon devices in many high-volume

power electronics applications, especially those with 1200V and higher breakdown voltage requirements," he adds.

"By using the new Z-FET SiC MOSFETs in conjunction with Cree's silicon carbide Schottky diodes to implement 'all-SiC' versions of critical high-power switching circuits and power systems, power electronics design engineers can achieve levels of energy efficiency, size and weight reduction that are not possible with any commercially available silicon power devices of comparable ratings," Palmour continues.

Cree's new SiC MOSFET is rated for 12A at its operating temperature of 100°C and delivers blocking voltages up to 1200V with a typical on-state resistance ($R_{DS(ON)}$) of just 160mΩ at 25°C.

Unlike comparably rated silicon switching devices, Cree's new SiC MOSFET exhibits an $R_{DS(ON)}$ value that remains below 200mΩ across its entire operating temperature range. This reduces switching losses in many applications by up to 50%, increasing

Addition of this new switching device to our Z-FET SiC power MOSFET family gives our customers a greater range of flexibility in matching the price/performance requirements to their applications... The smaller die size provides a lower price point, yet still delivers all the benefits of SiC switching performance at 1200V

overall system efficiencies up to 2% while operating at 2–3 times the switching frequencies when compared to the best silicon IGBTs. As a result of this improved efficiency, SiC devices have lower operating temperatures and fewer thermal management requirements, which combine with their ultra-low leakage current (<1μA) to reduce system size and weight and increase reliability, says Cree.

"The new 1200V Z-FET is the latest in what we anticipate to be a comprehensive range of SiC MOSFETs with both higher and lower amperage/voltage ratings," explains Dr Cengiz Balkas, Cree VP & general manager, Power & RF. "By providing our customers a wider selection of devices and ratings, we are expanding the range of power electronics applications that can benefit from the unique efficiencies of SiC technology," he adds. "Compared with commercially available silicon devices, SiC power devices enable higher energy efficiency, faster switching speeds and improved device reliability that simplify system design while enabling unprecedented performance and, ultimately, at a cost advantage," Balkas continues.

"In addition to the discrete packaged devices, we anticipate increased customer demand for MOSFET die for use in the development of power modules and micro-circuit assemblies."

Designated the CMF10120D, the new SiC MOSFET is housed in an industry-standard TO-247 package. CMF10120D power devices are fully qualified and released for production.

www.cree.com/power

CISSOID releases THEMIS-ATLAS power driver evaluation kit; chipset for SiC switches selected by FUPET consortium

Fabless high-temperature semiconductor firm CISSOID of Mont-Saint-Guibert, Belgium has released an Evaluation Kit for THEMIS and ATLAS, a power transistor driver chipset specifically designed for motor drives and power converters for applications such as aerospace, renewable energies and electric & hybrid vehicles. The Japanese R&D consortium for Future Power Electronics Technology (FUPET), which involves 22 firms (including Nissan Motor, Fuji Electric and Sanken Electric) and three academic sectors in these areas, has selected THEMIS-ATLAS for its developments around silicon carbide (SiC) and power conversion.

CHT-THEMIS and CHT-ATLAS integrated circuits are designed to drive SiC MOSFETs and JFETs as well as silicon IGBTs and MOSFETs and gallium nitride (GaN) power switches. CISSOID's new chipset can be used either in applications operating in a hot environment or in systems that will see an increase in the junction temperature due to the power density in the power

stage. THEMIS and ATLAS can also be used in lower-temperature applications to achieve a dramatic increase in the lifetime (more than an order of magnitude gain compared to traditional solutions, it is reckoned).

CISSOID says that, with the new chipset, aeronautic applications such as EMA- and EHA-type actuators for X-by-wire, as well as solar inverters, can now reach more than 25 years of lifetime expectancy at 125°C.

CHT-THEMIS and CHT-ATLAS are available in ceramic package forms, guaranteed for operation from -55°C up to +225°C. The Evaluation Board implements one CHT-THEMIS IC and one CHT-ATLAS IC, respectively the controller and the push-pull driver stages of the power transistors. Current output is controllable through two distinct channels capable of sourcing/sinking up to 4A total to the gate of the power transistor. Depending on the type of power transistor that the user implements, this typically translates into a total current capa-

bility of up to 150A in the power stage. A complete set of built-in protection features, such as under-voltage lockout, de-saturation detection, soft-shutdown and active Miller clamping are included.

The Evaluation Board is built from a 200°C polyimide PCB, and is populated with CHT-THEMIS and CHT-ATLAS ICs in ceramic packages guaranteed for -55°C up to +225°C. It hence supports short excursions to 200-225°C for testing. The Evaluation Kit includes the Evaluation Board, the complete electrical schematic, the Gerber files, the bill of materials and an Application Note.

The Evaluation Kit THEMIS-ATLAS (EVK-TIT9036) is priced at €2850. The ICs CHT-THEMIS and CHT-ATLAS are available for sampling and evaluation. Pricing starts at €532.53/chipset up to 200 units in CSOIC ceramic package. The chipset is also available in plastic SOIC package (as CMT-THEMIS and CMT-ATLAS) for maximum temperature of 175°C.

www.cisoid.com

Cree signs silicon carbide materials license agreement with Japan's Nippon Steel

Cree Inc of Durham, NC, USA, which makes silicon carbide substrates as well as power devices, has entered into a global SiC materials license agreement with Nippon Steel Corp.

Nippon Steel and affiliates including Nippon Steel Materials Co Ltd have been given the right to make and sell SiC materials for electronic device applications. Over the agreement's lifetime, Cree will receive certain financial considerations from Nippon Steel. It was also granted rights to Nippon Steel's relevant SiC-related patents. No technology transfer between the parties was included.

SiC is used in the production of a broad range of lighting, power and communication components, including LEDs, power switching devices and RF power transistors for wireless communications. SiC devices are currently used for solar inverters, high-voltage power supplies and power conditioning in industrial power applications.

"Cree is a pioneer in SiC materials technologies, resulting in energy-efficient power switching devices and high-brightness LEDs," claims chief operating officer Steve Kelley. "We are pleased that Nippon Steel

joins us in supporting the electronics device industry with licensed SiC materials," he adds.

"Nippon Steel has been conducting intensive R&D on SiC materials over 20 years," says Dr Misao Hashimoto, Nippon Steel fellow & director of the Advanced Technology Research Laboratory. "The good working relationship between Cree and Nippon Steel enabled us to achieve our commitment for growing the global SiC market."

www.nsc.co.jp/en/company/business/material.html
www.cree.com

IN BRIEF

Nitronex ships 500,000th device

Nitronex Corp of Durham, NC, USA, which was founded in 1999 and designs and makes gallium nitride on silicon (GaN-on-Si) RF power transistors for the defense, communications, cable TV, and industrial & scientific markets, has shipped more than 500,000 production devices since launching its first production-qualified products in 2006. Volume production began in 2009, and shipments predominantly consisted of 10 different products to five customers, with a roughly even split between domestic and international sales.

"Shipping more than 500,000 devices is a testament to the early successes we've had in military communications, jammers, and cable TV infrastructure," says president & CEO Charlie Shalvoy. "We provide our customers with complete RF solutions including final, driver, and pre-driver discrete and MMIC amplifiers, product models, reliability data, and applications support," he adds. "We have also established a robust supply chain with US manufacturing partners based on our proprietary GaN-on-silicon technology... this is more scalable than competing technologies that are based on exotic substrates," he believes. "We look forward to continued growth by expanding into emerging GaN markets such as radar and eventually commercial wireless infrastructure."

Nitronex claims its patented SIGANTIC GaN-on-Si process is the only production-qualified GaN process using an industry-standard silicon substrate. The firm says this results in a robust supply chain which, combined with innovative new products, has positioned it to benefit from the significant growth expected in GaN markets in upcoming years.

www.nitronex.com

Imec processes first power devices on 200mm CMOS-compatible GaN-on-silicon

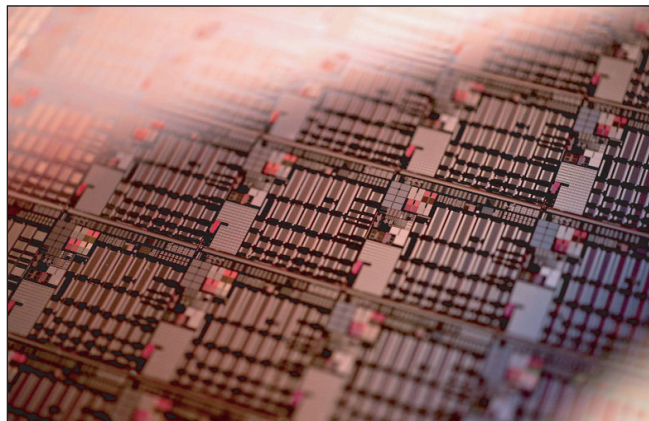
Applied Materials' MOCVD system and gold-free metallization yield GaN MISHEMT

Nanoelectronics R&D center Imec of Leuven, Belgium and its partners in its GaN industrial affiliation program (IIAP) have produced device-quality wafers with gallium nitride/aluminium gallium nitride (GaN/AlGaN) layers on 200mm silicon wafers.

With these wafers, functional GaN metal-insulator-semiconductor high-electron-mobility transistor (MISHEMTs) were processed using standard CMOS tools. The processes that were used are compatible with the strict contamination rules in a standard CMOS processing line (e.g. no use of gold), says Imec, which adds that these first GaN devices on 200mm wafers are a key milestone on the path to cost-effective production of power devices in high-productivity 200mm fabs.

Imec recently produced 200mm GaN-on-Si wafers with crack-free surfaces and a bow of less than 50µm. The wafers were made using an advanced MOCVD system from the semiconductor industry's largest equipment maker Applied Materials Inc of Santa Clara, CA, USA. The ability to use 200mm wafers is a key milestone, says Imec, because it brings processing within reach of regular high-productivity 200mm fabs, allowing an important cost reduction compared with processing smaller wafers on dedicated processing lines.

A second prerequisite for cost-effective processing (next to the wafer size) is that power devices can be fabricated with processes that are compatible with standard CMOS processes and tools, says Imec.



Power devices on 200mm CMOS-compatible GaN-on-Si wafer.

The research institute proved this by processing its GaN-on-Si wafers using standard CMOS tools, yielding functional GaN MISHEMTs. All equipment was verified for its capability to handle the wafers, and required only minimal adjustments in software and hardware.

Conventionally, gold is used for ohmic contacts and gate structures in

Imec based the ohmic contact formation on a gold-free metallization system, and modified the Schottky gate to a gate-dielectric-based gold-free MIS structure

power devices, but it makes GaN processing incompatible with conventional CMOS processing. To overcome this, Imec based the ohmic contact formation on a gold-free metallization system, and modified the Schottky gate to a gate-dielectric-based gold-free metal-insulator-semiconductor structure. The introduction of this MISHEMT structure had the added advantage of reducing the high leakage current of conventional HEMTs, adds Imec.

www.imec.be

Mitsubishi's GaN HEMT power amplifier for C-band satellites hits record power-added efficiency of 67% Record raised from 60% using harmonic tuning circuit

Tokyo-based Mitsubishi Electric Corp has developed a gallium nitride high-electron-mobility transistor (GaN HEMT) power amplifier (PA) for C-band satellites with what is claimed to be record power-added efficiency (PAE) of 67% (up by more than seven percentage points compared with conventional amplifiers). The amplifier is expected to lead to smaller and lighter transmitter devices to help microwave communication satellites save power. Mitsubishi Electric presented the breakthrough at the 2011 IEEE Microwave Theory & Techniques Society (MTT-S) International Microwave Symposium (IMS 2011) in Baltimore, MD, USA (5–10 June).

Mitsubishi Electric says that, as more satellites complete their operational lifespan, demand is increasing for new microwave communication satellites with smaller, lighter and more efficient satellite

transponders. Conventional transponder devices use traveling wave tube amplifiers (TWTAs) because solid-state power amplifiers with GaAs HEMTs, which lack sufficient output power and efficiency, require an additional amplifier to

attain high output power. More efficient GaN HEMT amplifiers with high output power, high-field electron velocity and high breakdown fields are expected to replace TWTAs in communication satellites.

As more satellites complete their operational lifespan, demand is increasing for new microwave communication satellites with smaller, lighter and more efficient satellite transponders

The new amplifier's PAE of 67% is enabled by what Mitsubishi Electric claims is the world's first harmonic tuning circuit — consisting of a MIM (metal-insulator-metal) capacitor and a spiral inductor — placed in front of each GaN HEMT cell on the substrate. The PAE was improved through the second-harmonic impedance of the GaN HEMT using a highly accurate input control.

The internally impedance-matched GaN HEMT amplifier has a high output power of 107W (50.3dBm) but a small package size of 17.4mm x 24.0mm x 4.3mm and a light weight of 7.1g.

Going forward, Mitsubishi Electric intends to further enhance the efficiency and power performance of its GaN HEMT amplifiers for satellites and wireless communication systems.

www.MitsubishiElectric.com/semiconductors

EPC launches 2nd-gen 200V eGaN power transistor

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA has introduced the EPC2010 as the newest member of its second-generation enhancement-mode gallium nitride on silicon (eGaN) field-effect transistor (FET) family (launched in March with the EPC2001 and EPC2015 eGaN FETs).

The firm's new EPC2010 FET is a device with a drain-source voltage (V_{DS}) of 200V and a maximum on-resistance ($R_{DS(ON)}$) of 25 milli-Ohms with 5V applied to the gate. The firm says that the latest EPC2010 provides significant performance advantages over the first-generation EPC1010 eGaN FET. It has an increased pulsed current rating of 60A (up from 40A), improved $R_{DS(ON)}$ at very low gate voltages, and lower capacitance.

Compared with a state-of-the-art silicon power MOSFET with similar

on-resistance, the EPC2010 is smaller and has many times superior switching performance, says EPC. Applications that benefit from eGaN FET performance include high-speed DC-DC power supplies, point-of-load converters, class D audio amplifiers, hard-switched and high-frequency circuits.

"EPC was the first company to make gallium nitride power FETs commercially available," claims co-founder & CEO Alex Lidow. "With our second-generation of products, we are now raising the bar for the performance of gallium nitride FETs," he adds. "In addition, our new generation of eGaN products are the first gallium nitride FETs to be offered as lead-free and RoHS [Restriction of Hazardous Substances]-compliant."

In 1000-piece quantities, the EPC2010 is priced at \$5.06 and

is available through distributor Digi-Key Corp.

EPC has also made available the EPC9003 development board (priced at \$95 each) to demonstrate the performance of the EPC2010 and to expedite design-in efforts, making it easier for users to start designing with the 200V eGaN FET in applications such as solar microinverters, class D audio amplifiers, Power over Ethernet (PoE), and synchronous rectification.

An application note detailing the performance improvements of the EPC2010 eGaN can be found at http://epc-co.com/epc/documents/product-training/Characteristics_of_Second_Generation_eGaN_FETs.pdf http://epc-co.com/epc/documents/datasheets/EPC2010_datasheet_final.pdf <http://digikey.com/Suppliers/us/Efficient-Power-Conversion.page>

IN BRIEF

Transphorm orders Aixtron 6" GaN-on-Si MOCVD reactor

Aixtron has received an order for a AIX 2800G4 HT MOCVD reactor in 6x6"-wafer configuration from Transphorm .

The system will be used to ramp up production of GaN devices for highly efficient and compact power conversion solutions by transferring its GaN-on-silicon material growth technology to large-scale production. The tool has been installed and commissioned at Transphorm in Goleta by Aixtron's local support team.

"We look forward to continuing our excellent working partnership as we develop materials for new applications and expand our capacity," says president Primit Parikh. "The system we have selected meets all our needs... An impressive feature is the scaled multiwafer platform that will give us forward process compatibility as well as enable a straightforward capacity upgrade when we need to further expand. With it, we will be able to use multiwafer large-area 6" GaN-on-silicon technology in our proprietary GaN devices," he adds.

"We chose Aixtron as our partner due to its advanced equipment having the capabilities and performance essential for a complex project such as ours," Parikh says. "They also provided highly experienced, committed support engineers to work closely with our US team, ensuring a smooth installation and commissioning."

Transphorm aims to provide cost-competitive and easy-to-embed III-nitride-based power conversion modules that reduce energy loss by up to 90%. These can help to simplify the design and manufacturing of motor drives, power supplies and inverters for solar panels and electric vehicles.

www.aixtron.com

Transphorm unveils GaN transistor

At the PCIM Europe conference in Nuremberg, Germany (17-19 May), Transphorm Inc of Goleta, CA, near Santa Barbara, CA, USA is unveiling its EZ-GaN transistor, the latest in its line of products designed to eliminate the power waste that occurs during power conversion in everyday electrical systems and devices.

Transphorm claims to be the first firm to provide a viable solution to the power conversion problem. Its gallium nitride (GaN) products are designed to replace legacy silicon-based power conversion technology, which can no longer provide efficiency gains without compromising system performance, the firm says, adding that it is redefining electric power conversion to help customers optimize their use of existing electrical generation.

Transphorm says that its 600V transistor can replace silicon-based super junction transistors and IGBT devices in switch-mode power conversion circuits, such as bridge converters and inverters, in order to reduce switching losses by up to 95%. The release of the transistor follows the EZ-GaN diode launched in March.

That launch was just 2 weeks after the firm emerged from stealth mode on 23 February. Backed by \$38m in funding from Google Ventures, Kleiner Perkins Caufield & Byers, Foundation Capital and Lux Capital, 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 firm has 75 employees, including a core staff of researchers from Mishra's lab at UCSB.

"This is the first 600V GaN HEMT device to survive accelerated life testing per JEDEC industry standards, which Transphorm has demonstrated in engineering tests," says CEO Umesh Mishra. "Our transistor has proved that it is possible

to switch extremely fast without increasing electromagnetic interference (EMI), a feat never before achieved and most believed to be infeasible," he claims.

Transphorm has developed and supplied efficient, compact GaN solutions for electrical energy conversion. The transistor is the latest product that offering opportunities to reduce the size of systems while improving and maintaining efficiency, which is no longer possible with silicon-based conversion devices, the firm claims. For example, a unique aspect of the transistor is its improved packaging, which reduces ringing that results in equal or lower EMI.

"Our competitors are using silicon devices, which have up to 25 times as much switching losses compared to our transistor," says president Primit Parikh. "Customers are already using the transistor in products such as power supplies, PV inverters and motor control systems."

By using a proprietary EZ-GaN transistor and diode, Transphorm says that it can reduce power system size and increase energy density while reducing overall system cost. The EZ-GaN transistor is the latest product aimed to achieve new levels of product performance in semiconductor devices operating at 600V or above. Transphorm designs and supplies application-specific modules for a variety of customers, and plans to launch new products on a quarterly basis.

Transphorm acknowledges the US Office of Naval Research for the initial and sustained funding of all aspects of its GaN technology, including materials, RF transistors and power transistors. It also acknowledges funding from DARPA and the support of ARPA-E in the development of high-frequency, compact and efficient GaN-based inverters that it reckons will revolutionize motor drives in the future while also helping to provide near-term solutions.

www.transphormusa.com

National Instruments to buy RF design tool supplier AWR Microwave Office & Visual System Simulator to boost NI's RF design & test capabilities

National Instruments Corp (NI) of Austin, TX, USA (which provides automated test equipment and virtual instrumentation software) has signed a definitive merger agreement to acquire AWR Corp of El Segundo, CA, USA, a supplier of electronic design automation (EDA) software for designing RF and high-frequency components and systems for the semiconductor, aerospace & defense, communications, and test equipment industries. Upon closing of the transaction, AWR will continue to operate as a subsidiary of NI under the leadership of the existing management team.

The fast design cycles and increasing complexity of RF and wireless systems demand better integration between design and test, says National Instruments. RF system designers need to validate their simulations with actual measurements, while RF test engineers need to increase test re-use and decrease test time through more design integration. By increasing the effectiveness of integration between AWR design tools and NI software and hardware, NI and AWR reckon that, together, they can improve customer productivity through increased connectivity between design, validation and production test functions.

"AWR has an exceptional team with strong RF talent and technologies that expand the NI platform into RF design, which is complementary to our capability to make measurements across the RF design flow," says NI's president, CEO & co-founder Dr James Truchard. "This combination will accelerate the deployment of RF and wireless technologies and offers a significant benefit to the customers of both companies," he believes.

National Instruments and AWR reckon that they both deliver unique strengths that, together, will enable customers to more productively design and test their RF systems. The acquisition should strengthen both firms' core software brands, NI LabVIEW, AWR Microwave Office and Visual System Simulator, as well as the NI RF testing hardware platform. The full suite of AWR design tools, in combination with a complete RF testing platform from National Instruments, will provide a platform to decrease the time to market of RF designs, the firms say. NI will also augment its current academic and university RF and communications initiatives to include AWR software tools, so educators and students can benefit from the improved teaching and learning experience for the rapid design and prototyping of RF systems.

"There is clear synergy between the customers and product offerings of both companies," says AWR's CEO Dane Collins. "National Instruments has a leading platform in prototyping and testing of RF systems which is complementary to AWR's RF circuit and system software design tools, to the benefit of mutual customers," he adds. "Together, we are better able to support and service our growing global installed base."

The aggregate purchase price to be paid at closing is about \$58m (including \$7m in cash on the AWR balance sheet). In addition, an earn-out provision is payable over three years.

The transaction is expected to close within 30–45 days and is subject to customary closing conditions (including Hart-Scott-Rodino regulatory clearance).

www.awrcorp.com

www.ni.com

IN BRIEF

Accel-RF launches flexible fixture for RF measurement

Accel-RF Corp of San Diego, CA, USA, which produces turn-key RF reliability testing systems for compound semiconductor devices, has announced the availability of a Stand-Alone Reconfigurable Generic RF Fixture for characterization and measurement of RF devices.

"With one of Accel-RF's SMART Fixtures, testing of over 15 commercially available package types can be accomplished in the same fixture," says president & founder Roland Shaw. "This provides our customers with ultimate flexibility for characterizing RF devices with a consistent interface and RF/microwave platform," he adds. The Accel-RF SMART Fixture includes heater, heater-controller, bias-pulsing and RF-pulsing control, and cool-zones for input and output RF/bias boards.

The custom adapter-plate design can accommodate multi-pin or two-pin device package types typically used for discrete transistor or MMIC device testing.

"The fixture provides all DC bias and RF transmission integrity for these various requirements with a common interface," says Shaw. "As part of our commitment to the reliability community and the RF test industry in general, we are continuing to add more package types each quarter," he adds. "A consistent, clean fixture design, with excellent RF performance for the myriad of package types being used for the wireless industry, is not only more efficient, but saves considerable human and financial resources."

Accel-RF SMART 'Flexible' Fixtures are already shipping to customers, and are available in single quantities with quantity price breaks.

www.accelrf.com

AXT's Q1 revenue falls 8.6% to \$24.6m

Raw material purchasing boosts gross margin from 39.8% to 43.4%

For first-quarter 2011, AXT Inc of Fremont, CA, USA, which makes gallium arsenide, indium phosphide and germanium substrate and raw materials, has reported revenue of \$24.6m, down 8.6% on \$26.9m last quarter but up 31.8% on \$18.6m a year ago. "Our first quarter revenue results reflected the seasonality that we had guided for," notes CEO Morris Young.

Total GaAs substrate revenue was \$15.9m, up 19% on \$13.4m a year ago but down 15% on \$18.7m last quarter.

However, InP substrate revenue was \$1.3m, up on \$1.1m last quarter and \$875,000 a year ago.

Ge substrate revenue was \$3m, down on \$3.4m last quarter but almost double \$1.6m a year ago.

Raw materials have risen from \$2.7m a year ago and \$3.5m last quarter to \$4.4m.

"Optimal revenue mix and our successful raw material purchasing strategy allowed us to achieve our highest gross margin performance in many years," says Young.

Gross margin has grown from 36.1% a year ago and 39.8% last quarter to 43.4%.

Compared with \$3.9m a year ago, operating expenses have been cut back from \$5.1m last quarter to \$4.2m.

We see solid demand for our semi-insulating and semiconducting GaAs substrates from our traditional markets, and we are making good progress on our plans to further penetrate strategically important markets

Income from operations has risen further, from \$2.9m a year ago and \$5.6m last quarter to \$6.5m. Net income of \$4.2m is down from \$4.9m last quarter but up from \$2.6m a year ago.

"As we move into Q2, we are very pleased to see solid demand for our semi-insulating and semiconducting gallium arsenide substrates from our traditional markets, and we are making good progress on our plans to further penetrate strategically important markets for our products," says Young.

For second-quarter 2011, AXT expects revenue to rise to \$26.5–27.5m.

"Our unique business model continues to provide us with exciting growth opportunities, positioning us well for continued expansion in 2011," reckons Young.

www.axt.com

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Dow wins Epistar's first Supplier Award

Epistar Corp (Taiwan's biggest high-brightness LED epiwafer and chip maker) has awarded its first ever Supplier Award to the Metal-organic Technologies business of Dow Electronic Materials of Philadelphia, PA, USA (a business unit of Dow Advanced Materials). Dow was recognized for "ensuring the supply of precursor materials, improving product quality, providing excellent material and process support for manufacturing, offering superior customer communications and achieving high customer satisfaction".

"Dow has demonstrated itself to be an exceptionally trustworthy partner over the past year that deserves more than an excellent supplier award," commented Epistar's chairman Dr BJ Lee upon presenting the award on 30 March at its facility in Hsinchu, Taiwan. "Dow is a key, long-term supplier that we rely on for critical materials and technical service, both now and in the future," he added.



From left to right: Dow Electronic Materials' Greater China sales & operations director Leo Tsay and global business director Joe Reiser together with Epistar's chairman Dr BJ Lee and president Dr MJ Jou.

Attending the award ceremony on behalf of Epistar were Dr Lee, president Dr MJ Jou, logistics director Jack Lin, and procurement deputy manager Cathy Lin, as well as Derek Ma, vice director of LED epiwafer and chip maker Huga Optotech Inc (in which Epistar is the largest shareholder). Accepting the award

for Dow's Metal-organic Technologies business were global business director Joe Reiser, Greater China sales & operations director Leo Tsay, and Taiwan sales manager Johnny Chien.

"It is a tremendous validation of our efforts to receive this recognition from Epistar, which acknowledges the quality of products, technical expertise

and personnel we bring to every customer," said Reiser. "We look forward to building on our cooperation with Epistar and continuing to enhance our product and service offerings to increase our support in the future."

www.epistar.com.tw/index.php
www.dow.com

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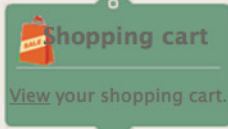
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Customers who need 25 wafers once a year and customers who require 1000 wafers/week receive the same high quality service.

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IN BRIEF

GPI orders multiple MaxBright systems

Genesis Photonics Inc (GPI) of Southern Taiwan Science-Based Industrial Park (TNSIP) has placed a multi-unit order for the Veeco TurboDisc MaxBright multi-reactor GaN MOCVD system (launched in February).

Founded in 2002, GPI focuses on providing GaN-based LED epiwafers and chips. It will use the systems to boost capacity for the production of high-brightness LEDs (driven by applications such as backlighting, lighting, displays and automotive).

"We have been very pleased with the production-proven performance of Veeco's K465i MOCVD systems already installed," says GPI's chairman & CEO David Chung. "They helped us to achieve LED brightness higher than the industry average. By now adding Veeco's new MaxBright systems, we will further lower our LED manufacturing costs, maximize our fab space, and accelerate our productivity," he adds.

"Our customers are resonating with the message that the MaxBright system can deliver more good LEDs for less money than other tools on the market," says William J. Miller, executive VP, Veeco LED & Solar. "We are particularly pleased that GPI is choosing MaxBright, which further solidifies our relationship with this important customer as they grow their position in the LED industry," he adds.

MaxBright is reckoned to be the most productive, lowest-cost-of-ownership MOCVD system available for manufacturing HB-LEDs. Available in a 2- or 4-reactor cluster architecture, it delivers a productivity gain of up to 500% and a 2.5x increase in footprint efficiency over the K465i system.

www.g-photonics.com

www.veeco.com/maxbright

Riber expects revenue to grow 35% in 2011, then double by 2015

At its combined general meeting, Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, set out its objectives for this year and presented its development plan for 2011–2015.

Due to its portfolio of orders, Riber forecasts strong growth in its business during 2011. At the end of April, order backlog was €19.7m (more than doubling from €9.2m a year ago), including certain sales to be delivered after 2011.

In view of the current order book and the firm's financial performance in first-quarter 2011 (in which revenue almost doubled year-on-year, from €2.9m to €5.7m), revenue is expected to grow to €27–29m for full-year 2011 (up 35% on 2010's €20.7m), enabling Riber to achieve further improvement in profitability.

In Riber's MBE Systems business, growth will be driven by the expansion of the firm's commercial offerings, enabled by the development of dedicated systems for research institutes and for the semiconductor industry, which is seeing an average annual growth rate of 8%.

The firm reckons that its Services and Accessories business will continue to capitalize on its installed base of 800 systems, combined with growth in epitaxy equipment sales and the development of activities in emerging countries. Sales are expected to grow 40% by 2015.

Diversification into the organic LED (OLED) and copper indium gallium diselenide (CIGS) thin-film

Diversification into the organic LED (OLED) and copper indium gallium diselenide (CIGS) thin-film solar cell markets, which look set for strong growth, is also expected to support sales, as well as consolidate Riber's position as a high-value-added equipment maker.

Looking ahead to 2015, Riber is targeting €40m in revenues (nearly double 2010's €20.7m).

www.riber.com

Riber receives order for clustered MBE research reactors

Riber has received an order for two Epineat MBE reactors, connected to a central automated cluster, for research applications.

The firm claims that the systems from the Epineat range represent the most efficient solution for developing or producing compound semiconductor materials on 4-inch substrates. The cluster — a recent technological innovation by Riber — makes it possible to automatically move the substrates between various pieces of equipment while remaining in an ultra-vacuum environment at all times,

allowing significant benefits in productivity and performance.

Riber says that the new order, to be delivered in 2012, confirms the relevance of its business model and strategy, which is focused on:

- capitalizing on the installed base and growing sales of epitaxy equipment, spare parts and accessories, as well as the corresponding services;
- launching a range of high-value-added equipment and services for high-growth application fields (thin-layer solar cells, organic LED lighting and displays etc).

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Veeco's revenue drops 15% in Q1 due to 'lumpy' order patterns

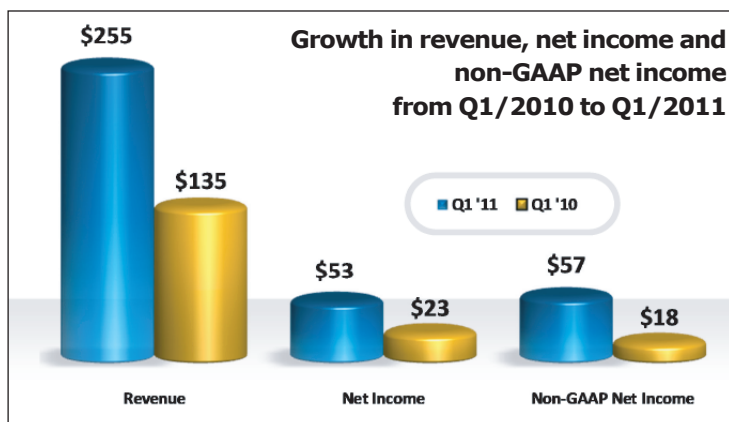
China solid-state lighting driving Q2 rebound

For first-quarter 2011, epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has reported revenue of \$254.7m, up 89% on \$134.8m a year ago but down 15% on Q4/2010's record \$300m for continuing operations (excluding the Metrology business, sold to Bruker Corp of Billerica, MA, USA on 7 October).

Of this, 16% came from Data Storage revenue of \$40m, up 72% on \$23.2m a year ago but down 4% from last quarter's \$41.9m (the best since Q4/2008). The other 84% of total revenue came from LED & Solar revenue of \$214.7m, up 93% on \$111.5m a year ago but down 17% on \$258.1m last quarter. In particular, MOCVD revenue was \$204m, down 15% on last quarter's record \$240m.

Gross margin has risen from 42.1% a year ago but fallen slightly from 50.9% last quarter to 50.8% (below the expected 51–52%). Non-GAAP net income was \$56.6m, up on \$17.6m a year ago but down on \$67.9m last quarter. Operating cash flow was an extremely strong \$75m, resulting in cash and short-term investments rising during the quarter from \$715.4m to \$779m.

Order bookings totaled \$230.9m (down 3% on \$238m a year ago and 22% on last quarter's \$294.9m). Of this, 14% was for Data Storage (\$32.6, up 24% on \$26.4m a year ago but down 22% on \$42m last quarter). The other 86% of orders came from LED & Solar (\$198.3m, down 6% on \$211.7m a year ago and 22% on \$252.9m last quarter, due mainly to the timing of customer deposits for MOCVD systems). In particular, MOCVD system orders were \$186m (down 16% on \$221m last quarter). During the quarter, backlog fell from \$555m to \$530m.



"We continued to experience strong demand for MOCVD systems [with orders from 15 customers] and, while China remained the majority of our bookings [with orders from Lattice Power, Shanghai Epilight, Nantong Tongfang, Smartlighting, Shandong Huaguang, and United LED], we also received orders from key customers in Taiwan, Korea and the US," says CEO John R. Peeler.

In February, Veeco launched its newest-generation MOCVD system, the TurboDisc MaxBright Multi-Reactor cluster, yielding strong quoting and purchase order activity with key LED customers in all regions. During the first quarter, the firm shipped three MaxBright 4-chamber systems. "Orders [for MaxBright] have been received from three of the top-tier Taiwanese LED makers, as well as from key customers in Korea and China," says Peeler. "Customers are clearly recognizing that we are helping to enable the industry's transition to LED lighting with a unique value position and the most productive MOCVD systems on the market."

In second-quarter 2011, Veeco is planning to ship 4–8 MaxBright systems. The firm expects total revenue to rise to \$255–285m, gross margin to rebound to about 50%, and non-GAAP net income to \$51.8–62.3m.

"We currently forecast Q2/2011 orders at 25% or more above the Q1 level, and we have visibility for continued order strength through Q3," adds Peeler. "We are experiencing extremely strong levels of quoting activity,

very positive customer reaction to MaxBright, and a large number of multi-system deals currently on the table," he continues. "We expect MOCVD order patterns to remain lumpy from quarter to quarter, depending upon the timing of customer deposits." Veeco sees order strength continuing in China as the country builds its LED infrastructure for solid-state lighting, and quoting activity in Korea and Taiwan is also picking up, with improved utilization rates being reported at key customers.

We currently forecast Q2/2011 orders at 25% or more above the Q1 level

"Veeco's \$530m in backlog, combined with our forecasted Q2 revenue increase

and very positive order outlook give us even greater confidence in our full-year 2011 guidance of over \$1bn in revenues and non-GAAP earnings per share of greater than \$5," says Peeler. "We are well positioned from a technology, product, and operational standpoint to grow our LED & Solar and Data Storage businesses in 2011 and beyond," he concludes. In addition, copper indium gallium diselenide (CIGS) Solar business should begin to deliver as Veeco ships tools to key customers.

www.veeco.com

Veeco opens Shanghai customer support & training center China Training Center to speed LED production ramp

As part of its significant expansion in Asia announced last Fall, epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has officially opened its China Training Center (CTC) in Shanghai in order to better support the rapid growth of the LED industry and the needs of customers. The grand opening was attended by guests including local government officials and several of Veeco's key Chinese LED customers.

"China is making an enormous investment to become a world-leading manufacturer of LEDs, both for its own domestic consumption and to export. In fact, China has stated targets to convert 30% of the domestic lighting market to LEDs by 2015," commented CEO John R. Peeler at the ribbon-cutting ceremony. China represented nearly 30% of Veeco's 2010 revenue (\$267m, up from \$30m in 2009), and Chinese firms will potentially represent more than half of its \$1bn-plus revenue forecasted for 2011. "We shipped MOCVD tools to 20 customers last year, including existing LED manufacturers, joint venture companies as well as some new start-up enterprises," he adds.



From left to right: Justin Wang (general manager, Veeco Greater China region); David D. Glass (executive VP & CFO); John R. Peeler (CEO); William J. Miller (executive VP, LED & Solar); Peter Collingwood (senior VP, Sales & Services).

"Many of our customers are building or significantly expanding factories, often in new 'LED/green energy' parks," says Peter Collingwood, senior VP, sales & service. "Our training center in Shanghai was therefore developed specifically to help our Chinese customers 'go faster' to ramp production of LEDs."

About 1700m² in size and housing about 40 Veeco employees, the CTC site is equipped with three classrooms as well as Veeco's TurboDisc K465i MOCVD system. Training will include TurboDisc MOCVD system introduction, epitaxial process

characterization, and more advanced hands-on training classes in hardware maintenance and troubleshooting.

"This training center is the first of its kind to be established for the LED industry in China," says Justin Wang, general manager, Veeco Greater China region.

"Our goal is to train hundreds of engineers to use our MOCVD tools in the next 12 months," he adds.

"Veeco will invest over \$30m in 2011 to dramatically expand its Asia footprint to help customers continue to accelerate the pace of adoption of LEDs for consumer electronics and solid-state lighting, including additional new R&D/demo and process support sites in Hsinchu, Taiwan (opening in August) and Seoul, Korea (opening early 2012)," says Peeler.

www.veeco.com

Elec-Tech places order for multiple MaxBright MOCVD reactors

Elec-Tech International has placed a multi-unit order for Veeco TurboDisc MaxBright GaN MOCVD systems (launched in February) for the production of high-brightness light-emitting diodes (HB-LEDs) at its facility in Wuhu, China.

Elec-Tech International is a Shenzhen-listed electronics firm that has signed a joint venture cooperative agreement with South Korean firm EpiValley to jointly develop the Chinese LED market.

"Our goal is to become one of the top three LED companies by output and sales revenue in China

within two years, and we have an aggressive plan to achieve this goal," says Elec-Tech's chairman Tony Wang. "By adding Veeco's new multi-chamber MaxBright, we expect to be able to compete in a very high-production environment and drive down the cost of LEDs," he adds. "We are excited by what we have seen with MaxBright in terms of its cost-of-ownership model, ease-of-use, and the great footprint advantage it will offer us in our fab."

"When we selected Veeco last year as our primary equipment supplier, it was not just because of

the success of the K465i, but also because of the roadmap they shared with us on the new multi-reactor MaxBright system," Wang continues. "Also, Veeco's service and support has been excellent, so we have a lot of confidence giving them these additional orders for our capacity ramp," he adds.

"Elec-Tech is moving fast to ramp capacity and gain share in the LED market," comments William J. Miller, executive VP, Veeco LED & Solar. "We are pleased to be able to support this ramp with our latest-generation MaxBright product."

www.electech.com.cn/en/

Aixtron's revenue drops 9% in Q1

...but orders rise, driven by new-generation systems

For first-quarter 2011, deposition equipment maker Aixtron SE of Aachen-Herzogenrath, Germany has reported revenue of €205.4m, down 9% on €224.7m last quarter but up 33% on €154.5 a year ago, driven by a continuing high demand for LED deposition equipment. In particular, of total revenue, 54% was for new-generation systems.

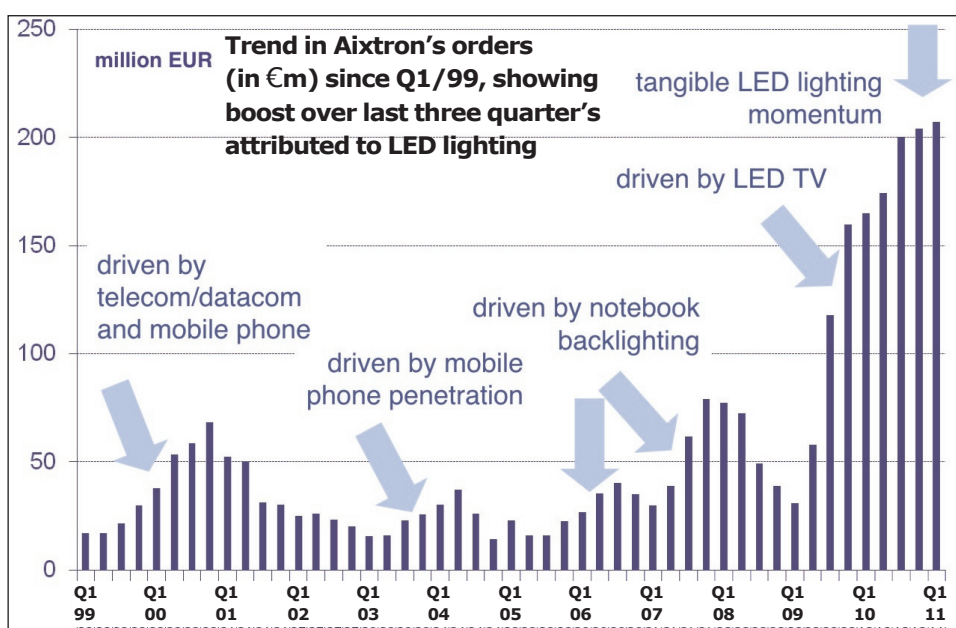
Of total revenue, 89% came from Asia and 6% from the USA and 5% from Europe. By application, 89% of revenue was for LEDs and just 4% for telecoms/datacoms and 7% for displays/other.

"Whilst the first quarter of 2011 has been a testing time for many in the global community, we are very pleased to still be able to report a continuation of the high level of demand for our systems," says president & CEO Paul Hyland.

Although down on 52% last quarter, gross margin of 51% is up on 50% a year ago. Coupled with lower operating expenses, operating profit (earnings before interest and taxes) rose from €46.4m a year ago to €74.9m (although this is down on €86m last quarter). EBIT margin has risen from 30% to 36% (though down on last quarter's 38%).

Though down on €61.6m last quarter (27% of revenue), net profit of €52.3m (25% of revenue) is up from €31.8m (21% of revenue) a year ago. Free cash flow was €11.7m. During the quarter, cash & cash equivalents plus cash deposits rose from €384.7m to €394.8m.

Equipment order intake was €210.3m, up 3% on €204m last quarter and up 25% on €168.5 a year ago. Aixtron says that the ongoing demand reflects the continuation of strong demand from LED backlighting manufacturers and, significantly, rising early demand from the lighting applications industry. With 65% of these orders being for Aixtron's latest-generation G5 and CRIUS II equipment, the customer adoption rate (from 8%



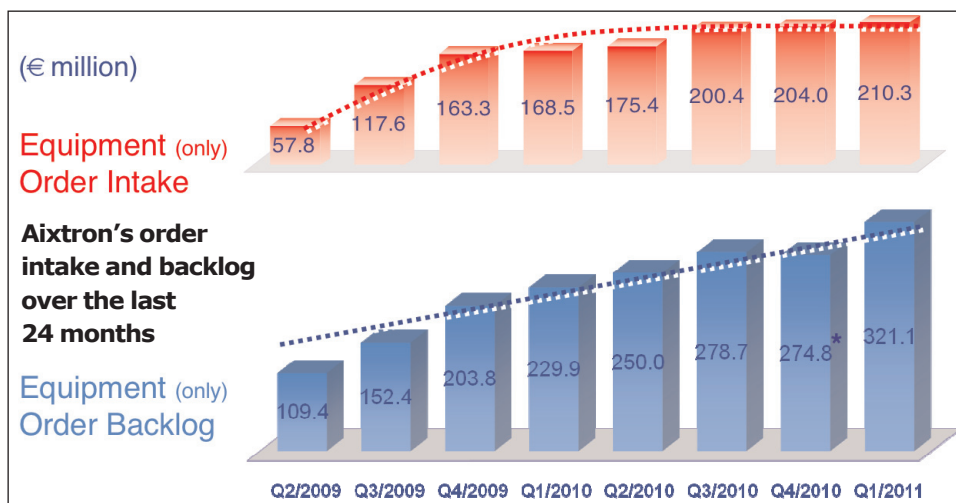
in Q2 through 29% in Q3 to 55% in Q4/2010) is faster than for previous-generation system introductions.

With 54% of revenues and 65% of the orders received in Q1 being for new-generation 'Integrated Concept' (IC2) systems, the rapid rate of customer adoption is an encouraging indicator that the transition period between G4/CRIUS and G5/CRIUS II is coming to an end, says Aixtron, and bodes well for future business development.

Moreover, momentum in the development of lighting applications continues to increase, supported by government and public opinion on energy-saving technologies, the firm comments, adding that recent

events in Japan have only intensified that focus. Aixtron reckons that it is in a good position to deliver against a proven roadmap to supply cost-effective production solutions "required to support what will inevitably become the third and biggest LED investment cycle for energy-efficient lighting applications in the years ahead," believes Hyland.

By the end of Q1, Aixtron's order backlog was €321.1m, up 17% on €274.8m at the end of last quarter (since re-valued to €302.3m, at \$1.35/€) and up 40% on €229.9m at the end of Q1/2010. Management has confirmed its guidance for 2011 of revenue of €800-900m and operating margin of 35%.



Changelight receives Aixtron's 2000th MOCVD system

Aixtron has announced installation of its 2000th MOCVD system at LED and solar cell maker Changelight of Xiamen, Fujian Province, China.

The system is part of a multi-tool order for 60x2"-wafer AIX 2800G4-R systems for advanced optoelectronic devices and will be installed and commissioned by the local Aixtron service team.

Changelight was Aixtron's first customer to use the AIX 2800G4 reactor in China, and its AlGaInP LED epiwafers and chips are among the best at the domestic Chinese level in terms of scale, output and sales, says Aixtron's VP sales Dr Bastian Marheineke. In 2010, multiple Aixtron G3 and G4 systems were installed at the Xiamen facility, together with others at Changelight's site in Yangzhou.

The vast majority of systems sold by Aixtron in 2010 (almost 95%) are used for making LEDs. In first-quarter 2011, about 90% of revenue came from sales into Asia, with almost 90% of systems being for LED manufacturing. "China will undoubtedly be our biggest market in 2011," says Marheineke.

"Development from our initial private enterprise to the present listed



DianMing Deng and Marheineke.

company is inseparable from the great support we have enjoyed from the Aixtron team since our foundation in February 2006," comments Changelight's president DianMing Deng. "We have had an intensive relationship and cooperation over the past five years. Today, our manufacturing facilities are based exclusively on Aixtron MOCVD equipment, which has been pivotal in our becoming the biggest supplier of high-quality AlGaInP red orange yellow (ROY) HB-LED chips in China," he adds.

"The new systems form part of our future expansion plans in Yangzhou, which was opened in April 2010," continues DianMing Deng. "Looking to the future, I see our strategic cooperation partnership with Aixtron will become deeper and broader."

www.changelight.com.cn

Aixtron's shareholders approve resolutions

At its 14th annual general meeting, Aixtron's shareholders voted in favor of resolutions presented by its executive and supervisory boards.

Following the legal conversion of the firm from an AG structure into a European Company (SE) at the end of 2010, shareholders elected a new supervisory board. In the first ordinary general meeting of the SE, professor Petra Denk was elected as a new member. Denk holds a Doctor of Physics and teaches Business Administration and Energy Management at the University of Landshut. Joachim Simmroß, who has been involved

with Aixtron for over 21 years and was a founding member of the supervisory board, did not put himself forward for re-election.

The following resolutions were also approved:

- a dividend payment of 60 Euro-Cents per share for fiscal 2010;
- approval of the activities of executive board and supervisory board members during fiscal 2010;
- remuneration of the first supervisory board of Aixtron SE;
- election of auditors and Group auditors for fiscal 2011; and
- creation of new authorized capital 2011.

IN BRIEF

Samsung LED to boost HB-LED production with Aixtron G5 reactors

Deposition equipment maker Aixtron SE of Herzogenrath, Germany says it has received a large multiple order for the LED production platform AIX G5 HT MOCVD Planetary Reactor from Korea's Samsung LED.

Samsung LED has been using AIX 2800G4 HT gallium nitride metal-organic chemical vapor deposition (MOCVD) systems for several years. Following commissioning of the first two G5 systems in 2010 and at the beginning of this year, the firm has now sought to expand its capabilities through Aixtron's latest generation of AIX G5 HT MOCVD Planetary Reactors.

The new systems will be installed this year at Samsung's latest production facility and used for volume production of high-brightness (HB) blue and white GaN-based LEDs for television back-light units (BLU) and LED lamps for solid-state lighting applications.

"Having become the leading local supplier for GaN-based HB-LEDs in Korea, Samsung LED has continually expanded capacity," says Aixtron's VP sales Dr Bastian Marheineke. "Once again this will be achieved by adding more reactors of choice from Aixtron," he adds.

Formed in April 2009, Samsung LED is one of the fastest-growing LED manufacturers in the world, says Aixtron, and is currently the global leader in the LED BLU module industry. The ultra-slim BLU module minimizes the thickness of all displays such as TVs, notebook PCs, monitors, and DIDs.

www.samsungLED.com
www.aixtron.com

Aalberts buying high-purity gas & chemical system maker Lamers

Industrial Services subsidiary expands in LED and solar markets

Aalberts Industries N.V. has agreed to acquire Lamers High Tech Systems B.V. of Nijmegen, The Netherlands from gas supplier Air Liquide group of Paris, France, subject to anti-trust clearance.

Since 1984 Lamers has been active in the development, engineering, manufacturing, assembling, testing and qualification of systems for the control and distribution of high-purity gases and chemicals. The systems are used in both photolithography systems supplied to the semiconductor industry and metal-organic chemical vapour deposition equipment (MOCVD) supplied to the LED industry. They are also used in the solar photovoltaic manufacturing process. The LED and solar markets are fast-growing renewable energy markets, where Industrial Services strives to increase its market share. Besides this Lamers is active in the installation of high purity distribution networks for gases and fluids, as well as hook-up activities.

Since 1999, Lamers has been a member of Air Liquide group. Now, with about 300 employees at its two manufacturing facilities in Nijmegen and Kerkrade, The Netherlands, Lamers generates annual revenue of about €90m. Together with the existing employees, the management team will continue to manage Lamers at both locations.

Aalberts says that Lamers' systems are engineered in close cooperation with customers from design to start up. Using its experience in high-purity tube systems, valves, fittings, sensors and flow measuring instruments, the firm delivers fully or semi-automated systems, either in-house or on the customer site. The systems are used to inject a specific mixture of gas with the

exact specified temperature, pressure, humidity and purity to the different manufacturing process steps in the photolithography and MOCVD equipment. Lamers uses manufacturing processes such as (semi-) automatic welding processing of tube systems, computer-aided tube bending, and the latest testing and qualification technology, such as particle and moisture measurement, as well as helium leak testing under vacuum (all a cleanroom environment).

Aalberts says that the acquisition is in line with its strategy of enhancing the position of its Industrial Services subsidiary. It reckons on benefitting from the following:

- Lamers should reinforce Aalberts' position as a technology partner in the semiconductor market with tailor-made systems for high-purity gases and chemicals. Aalberts has been active in this market for many years by supplying subassemblies, vibration control systems and surface treatment of components.

- Aalberts now has the opportunity to expand its position in the fast-growing LED and photovoltaic markets, selling other products, systems and processes through its sales channels.

- By using Lamers' technology other markets can be explored,

such as micro-electro-mechanical systems (MEMS), chemical and pharmaceutical delivery systems (markets in which Industrial Services is not yet active).

- Lamers' technology and experience of systems for the control and distribution of high-purity gases and fluids can also be used for other markets in which Industrial Services is already active, such as the medical and precision engineering industry.

- The technology and portfolio of high-purity tube systems, valves, fittings, sensors and flow measuring instruments used in Lamers' systems can be developed further by using Aalberts' product development know-how and sales channels.

- By using Industrial Services' international network, Lamers should have the opportunity to serve its customers globally (which more often need a local tailor-made service).

- Within Aalberts' Flow Control subsidiary, the Lamers systems can be sold together with the clean gas activities in laboratories, universities and research centres (markets where Aalberts has a worldwide presence).

- Lamers can use the manufacturing machining capacity within Industrial Services to develop and deliver its systems more rapidly and efficiently.

Aalberts says that the acquisition will be financed from credit facilities and realised after fulfilment of all formalities and approvals, which is expected before the end of June. The company reckons that Lamers High Tech Systems' financial results should immediately contribute to its profit per share.

www.aalberts.nl

www.lamers-hightech.com

www.airliquide.com

Lamers should reinforce Aalberts' position as a technology partner in the semiconductor market...

Aalberts now has the opportunity to expand its position in the fast-growing LED and photovoltaic markets

LayTec launches PearL in-line PL metrology system for CIGS and CdTe

LayTec AG of Berlin, Germany (which provides optical in-situ and in-line metrology systems for thin-film processes, focusing on compound semiconductor and photovoltaic applications) launched its PearL in-line metrology system at the Intersolar Europe 2011 event in Munich (6–10 June).

As part of LayTec's product line for solar applications, PearL is an optical in-line monitoring system measuring photoluminescence (PL) spectra of thin-film modules in production lines. The system is designed for measurements on copper indium gallium diselenide (CIGS) thin-film photovoltaic production lines. PL spectra allow fast detection of the effective gallium content of the absorber layer during the production process. A product option for cadmium telluride (CdTe) absorbers is also available.

PearL uses LayTec's laser stimulated spectral photoluminescence (sPL) technology for PV absorber layer characterization and process control. Differently to integral imaging solutions (iPL), PearL delivers fast quantitative material parameters based on the spectroscopic response. In a production environment the continuous recording of

the PL spectra is a highly valuable measurement for quality control, says LayTec.

LayTec says that PearL is a result of intensive R&D work by its engineers teamed with experienced semiconductor scientists. The firm adds that the resultant robust metrology solution can control the optical bandgap of PV absorber layers

PL spectra allow fast detection of the effective gallium content of the absorber layer during the production process. A product option for CdTe absorbers is also available

in thin-film CIGS and CdTe solar cells in industrial mass-production lines.

With PearL, LayTec is now making sPL available as an in-line tool.

It can be combined with LayTec's industry-proven SolR system which delivers, for all solar cell layers, tight uniformity control of the film deposition process from the center to the edge of each thin-film module.

www.laytec.de
www.intersolar.de

CVD Equipment raises \$9.6m in stock offering

On 27 May, CVD Equipment Corp of Ronkonkoma, NY, USA (a designer and manufacturer of equipment for developing and manufacturing electronic components, materials and coatings) closed a public offering of 841,695 shares of its common stock (announced on 24 May) at \$10.50 per share (worth \$8.84m).

In addition, sole underwriter ThinkEquity LLC exercised in full its over-allotment option to purchase 126,255 additional shares at \$10.50 each (worth \$1.32m).

In total, 967,950 shares were sold at \$10.50 each. Net proceeds (prior to offering expenses) were about \$9.6m (versus \$8.3m without the over-allotment option). The funds will be used for general corporate purposes, including working capital.

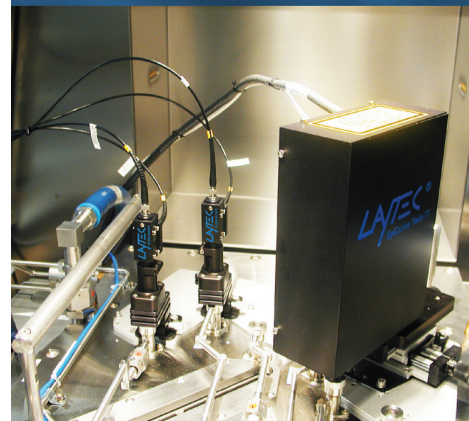
The offering was made pursuant to a shelf registration statement filed with the US Securities and Exchange Commission (SEC) on 14 February, which became effective on 28 February (Registration No. 333-172252).

www.cvdequipment.com

Every move you make

LayTec's uniquely flexible EpiTT in-situ metrology system is adaptable to every MOCVD growth environment and fully upgradeable to Twin TT, Triple TT and EpiCurve®.

Additional multi head and bowing measurement options enable more precise information about homogeneity of the standard growth rate, wafer bow and true temperature parameters. This allows you to create the ideal measurement system for your specific production or R&D application.



The EpiCurve®Twin TT uses two EpiTT heads and a bowing sensor for maximum control of multi-ring reactors.

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OEM Group buys Applied's manual batch tool businesses

Semiconductor capital equipment provider OEM Group Inc (OEMG) of Phoenix, AZ, USA has assumed ownership of the Rhetech Inc of Coopersburg, PA, USA and Semitool Austria GmbH manual batch tool sales and service operations from Applied Materials Inc of Santa Clara, CA and its subsidiary Semitool Inc of Kalispell, MT, USA.

OEMG will control all Rhetech and Semitool Austria sites and offer parts and services as well as system and retrofit orders for transferred products, including Semitool's Cintillio, Scepter, Sirius, Spin-Rinse Dryer, Spray Acid Tool (excluding HF Vapor – MEMS), Spray Solvent Tool and Storm. OEMG will offer the batch spray tools, along with new product additions, under its new Chemical Process Technologies (CPT) group.

OEMG provides 75–200mm new and remanufactured semiconductor capital equipment, upgrades, spares and services to global LED, MEMS, wireless, power, energy-harvesting, WLP (wafer-level packaging), data storage and logic markets.

The latest deal was OEM Group's fourth acquisition in under 3 years,

and its second from Applied Materials. "Based on our track record, OEM Group was ideally positioned to integrate these respected batch-process product lines into our portfolio," says OEMG's president & CEO Wayne Jeveli. "The Cintillio platform, particularly, will offer value and impressive sustainability for chip-makers seeking a low-cost-of-ownership batch-process solution from a flexible, small-footprint tool."

OEM Group serves diverse semiconductor and emerging technologies through its LEGENDS portfolio of products, including MRC Eclipse (PVD), AG Heatpulse (RTP), Varian Legacy Implant, Lam AutoEtch, Tegal 900ACS, 980ACS, 6500 HRe- and 6500 Spectra series thin-film etch products, Sputtered Films Endeavor, and AMS PVD series products.

"We continually seek opportunities to enhance LEGENDS with complementary high-quality products and technologies that will improve our customers' productivity, enable new applications and provide the best and the broadest selection of integrated solutions," says chief technology officer Chris Forgey.

"This acquisition bolsters our already strong European reach with a world-class facility in Salzburg, Austria, and complements OEM Group's existing presence in Japan and Taiwan," says Jeveli. "Our global bandwidth has grown exponentially in less than 36 months to keep pace with demand and to position ourselves for new opportunities," he adds. "Operationally, the addition of the Rhetech facility in Pennsylvania nearly doubles our manufacturing capacity in North America."

All newly received product and service sales orders pertaining to the manual batch product lines purchased from Applied Materials or Semitool will be fulfilled by OEM Group and its subsidiaries. All impacted customers will receive details from OEM Group this week about their pending and future product needs.

"Our new Chemical Process Technologies will be backed by dedicated and uninterrupted engineering support [as with all OEM Group acquisitions]," Jeveli says.

www.oemgroupinc.com

Plasma-Therm wins VLSIresearch awards

Plasma-Therm LLC of St Petersburg, FL, USA has been awarded by equipment users as one of the 10 BEST 2011 Suppliers of Chip Making Equipment and one of THE BEST 2011 Small Suppliers of Wafer Processing Equipment, says market analyst firm VLSIresearch.

VLSIresearch's survey (spanning two and a half months and four languages) received feedback from over 550 organizations for this year's Customer Satisfaction Survey. Participants were asked to rate equipment suppliers in fields including Equipment Performance, Customer Service, and Supplier Performance. Two new categories, Trust in Supplier and Partnering, gave additional insight into key attributes of a supplier's performance in 2011.

It is Plasma-Therm's 12th consecutive year of being voted one of the 10 BEST and THE BEST Small Suppliers of Wafer Processing Equipment in 2011. This year, Plasma-Therm was also voted one of 10 BEST in Focused Suppliers of Chip Making Equipment.

"Customer service and outstanding equipment performance have always been core values for Plasma-Therm," says CEO Abdul Lateef. "These VLSIresearch awards continue to validate that we are successfully implementing our principles into action," he adds.

Founded in 1974, Plasma-Therm designs, makes and supports plasma etch and plasma-enhanced chemical vapor deposition (PECVD) equipment for various high-tech

market segments and industries in markets ranging from university R&D to high-volume production. Served markets include photomask etching, compound semiconductors, wireless communication, MEMS, nanotechnology, data storage, solar cells and LED/photonics processing.

"Plasma-Therm has once again achieved one of the industry's highest standards for customer satisfaction and equipment performance," comments VLSIresearch's president Risto Puhakka. "The Customer Satisfaction Survey has been measuring these industry standards for over 22 years, and Plasma-Therm has proven, year after year, to affirm their commitment to these important goals."

www.plasmatherm.com

Edwards Vacuum opens factory in Korea

Vacuum and exhaust-management equipment maker Edwards Ltd of Crawley, UK has opened its new factory in Cheonan to serve its Korean and other global customers. CEO Matthew Taylor and UK Government Business Secretary Vince Cable officially opened the site in the presence of the Governor of Chungchungnam-do, the Mayor of Cheonan, and British Ambassador Martin Uden.

Edwards has invested about \$100m in the site, which is not only a factory but also a technical center, allowing more local technical applications support for customers as well as the development of product derivatives and the rapid introduction of new products. The facility will be a key hub for the firm's growing range of dry vacuum pumps and systems for the most demanding processes in the semiconductor, solar, LED, LCD and FPD markets. It also has the latest manufacturing equipment to assure product quality, together with lean manufacturing techniques to reduce production times, as well as a range of energy-saving features, says the firm.



Ribbon-cutting ceremony.

The new facility, which will have a manufacturing capacity in excess of 25,000 units per year, will employ 300 staff initially, growing to 400 by 2012. Edwards expects total staffing in Korea to be up to 700 in 2012.

The new facility brings Edwards' number of manufacturing sites worldwide to seven, including sites in the UK, Czech Republic, and Japan. It also has 15 service centers.

Founded in 1919, Edwards has been present in Asia for more than 40 years (with nearly 60% of revenue now deriving from there) and in Korea for 27 years. The firm

has a long history in Korea and a strong customer base both there and across Asia, says Taylor. "We have invested heavily in the development of our technology support capability in Korea," he adds. "It is not only a factory but also a great centre of technological excellence which enables us to manufacture closer to customers, improves our

response times and customer service as well as providing the leading technology, product quality and sustainable manufacturing which ensures we remain leaders in the global vacuum market," he claims.

"This is a momentous occasion for the company and cements our position as an important business partner for Korea as well as a strong part of the local community," says Edwards Korea's president Sung-Min Lee. "We look forward to recruiting the next generation of engineers."

www.edwardsvacuum.com

SPTS & Griffith University to develop SiC-on-Si technology

Plasma etch, deposition and thermal processing equipment maker SPP Process Technology Systems Ltd (SPTS) of Newport, Wales, UK and Griffith University in Brisbane, Australia have announced a three-year joint development agreement (JDA) targeting the commercialization of silicon carbide on silicon (SiC-on-Si) technology.

As well as being a key substrate for growing GaN films used to make LEDs, the increased radiation hardness, mechanical strength and thermal properties of SiC also make it a suitable replacement for silicon in MEMS devices for harsh environments. SiC is also used to create devices for high-power, high-frequency applications, where its electrical properties are far superior to common silicon.

Technology created by the Queensland Microtechnology Facility (QMF) at the Griffith University's Queensland Micro- & Nanotechnology Centre (QMNC) has demonstrated growth of crystalline SiC directly on low-cost silicon wafers. Funded by Queensland State Government and Australia's National Fabrication Facility, QMF houses a large silicon wafer processing capability and enables R&D of SiC-on-Si for mechanical and semiconductor devices. Via the JDA and its APCVD and thermal products subsidiary SPP Process Technology Systems Inc of San Jose, CA, USA, SPTS will develop the thermal process and equipment expertise needed to commercialize the technology.

QMNC has commercially oriented research into the key technologies of SiC deposition, etch and oxidation.

"The JDA enables transfer of this SiC deposition process technology to device R&D activities, and provides a bridge to volume production through batch processing for up to 300mm-diameter Si wafers," says operations director Alan Iacopi. "SPTS's strength in thermal processing makes them an attractive partner," he adds.

"This JDA is an important step in the commercialization of our SiC research efforts, especially with a partner with the global reach of SPTS," comments project leader Sima Dimitrijevic, deputy director of QMNC.

"This JDA further enhances the portfolio of offerings to our served markets and will help to broaden our customer base," reckons SPTS' president & CEO William Johnson.

www.griffith.edu.au/qmnc

www.spp-pts.com

IN BRIEF

Oxford Instruments wins multiple etch system order from GCS

UK-based etch, deposition and growth system maker Oxford Instruments Plasma Technology (OIPT) has received an order for multiple PlasmaPro System100 ICP 180 etch systems from III-V compound semiconductor foundry service provider Global Communication Semiconductors Inc (GCS) of Torrance, CA, USA. The order will expand GCS' foundry capabilities in dielectric and gallium nitride (GaN) etching and further increase the number of systems installed from Oxford Instruments.

"GCS chose Oxford Instruments because their ICP etchers offer an excellent combination of process capability, consistency, and value," says GCS' VP of operations Franklin Monzon. "As a boutique foundry, GCS has a great diversity of customers who utilize a variety of materials, including GaAs, InP, GaN, and Si, to achieve the desired device performance," he adds. "Most of these customers also require process customization that, in turn, mandates that the process tools be flexible enough for development work but also reliable enough for production."

"The addition of the Oxford Instruments ICP etchers backs up and expands our dry etch process capability so that existing customers, especially in the InP and GaN arenas, get faster, better, service, while at the same time allowing GCS to develop new customers," continues Monzon. "We look forward to expanding our relationship with Oxford Instruments." The new tools will come on-line during the course of GCS' expansion.

www.gcsincorp.com

Further plasma etch, deposition & growth seminars added

Oxford Instruments Plasma Technology (OIPT) is continuing its series of free seminars and workshops (co-hosted with leading research organizations worldwide) with the addition of a further event in Autumn to those already announced for this Summer.

The events are as follows:

● 30 June: 'Knowledge creation partnership—from funding to results', a one-day workshop co-hosted by the UK's University of Southampton, where speakers will talk about atomic layer deposition (ALD), ion beam, plasma sources and other aspects of etch, deposition and growth technologies.

The seminar shares experiences in collaborations between industry and the scientific research community. It also presents technical results of collaborations and how partners can benefit.

Presentations on processing and servicing of Oxford Instruments' equipment will give support to users, and a practical insight into Oxford Instruments and the etch, deposition and growth equipment and process solutions offered.

Program:

1. Initiating and funding successful partnerships:
 - 'Academic/Industrial partnerships — a model for success';
 - 'Understanding public funding sources';
 - 'First results of a successful partnership: Materials and etchers for nanowire biosensors';
 - 'Oxford Instruments/Southampton University collaboration success'.
2. Results of successful partnerships:
 - 'Plasma source & Ion Beam technologies';
 - 'Developing plasma etch processes';
 - 'How to get the most from your tool (CS)';
 - 'ALD and technical achievements/working in a successful partnership';
 - Cleanroom tour & Networking Tea.

Speakers include (from the University of Southampton)

Don Spalinger (director, corporate relationships), Myrddin Jones (lead technologist; Electronics, Photonics & Electrical Systems, Technology Strategy Board) and professor Peter Ashburn (director, Southampton Nanofabrication Center); and (from OIPT) Frazer Anderson (business development director), Mike Cooke (chief technology officer), Bob Gunn (Applications team leader), Nick Curtis (training officer), and Chris Hodson (ALD product manager).

To book, e-mail plasma@oxinst.com

● 14 July — 'New Frontiers in Plasma Nanopatterning', co-hosted by the Molecular Foundry, Lawrence Berkeley National Laboratory (LBNL), CA, USA.

Invited speakers include: professor Steve Shannon (North Carolina State University); professor Friedrich Prinz (Stanford University); Dr Deirdre Olynick (LBNL); Dr Paul Ashby/Dr Dominik Ziegler (Molecular Foundry, LBNL); and Dr Owain Thomas and Dr Leslie Lea (Oxford Instruments).

Topics include talks on:

- 'Energy conservation at the Nanoscale';
- 'Fabrication of high performance cantilevers in aqueous solution';
- 'Radio frequency heating for Nanoscale etching';
- 'Plasma etching/deposition tools and applications'.

Tours of the Molecular Foundry will be available on 13 or 15 July.

Oxford Instruments process experts will be on hand to answer specific Process Application questions.

E-mail nancy.crouch@oxinst.com.

● 18 October — 'Nanoscale plasma processing' at CEA-LETI, Grenoble, France, a one-day event covering plasma processing, including ion beam, MEMS, ALD, and III-V etch.

Presenters include experts from the Oxford instruments Applications team and guest speakers from LETI and other key organizations. A full programme will be available soon.

E-mail: plasma@oxinst.com

www.oxford-instruments.com

OIPT promotes operations director Ayres to new role of general manager

UK-based etch, deposition & growth system maker Oxford Instruments Plasma Technology (OIPT) has promoted Dan Ayres to the newly created role of general manager.

Ayres has over 10 years experience at Oxford Instruments, where he was most recently operations director at Plasma Technology before this latest appointment. Previously, he held roles in the fields of supply chain, product management and project management within the Oxford Instruments Group. Ayres has a degree in engineering, and an MBA from Warwick Business School, which he gained while working for Oxford Instruments.

"To maintain our business' current growth, we need strong focus on the efficiency and effectiveness of all areas," says OIPT's managing director Andy Matthews. "Dan will lead the business, engineering, finance and HR [human resources]



functions towards a clear vision that better delivers the needs of our customers and establishes the competencies and resources that support our future growth," he adds. "Dan's previous experience, together with his work within projects at Oxford Instruments, equips him well to take on this new challenge."

Over the past 12 months, OIPT's site in Bristol, UK has seen a workforce increase of 30%, and an increase of 50% in production facilities. Ayres' appointment will further facilitate this ongoing expansion and enable additional focus on delivering etch, deposition and growth systems, says the firm.

www.oxinst.com

IN BRIEF

New deep silicon etch technology

Oxford Instruments has launched new deep silicon etch technology to provide flexible solutions for micro-electro-mechanical systems.

PlasmaPro Estrelas100 offers process flexibility for the R&D market. Nano and micro structures can be realized as the hardware has been designed to run Bosch and cryo etch technologies in the same chamber. From smooth sidewall processes to high-etch-rate processes, the PlasmaPro Estrelas100 has been developed so MEMS applications can be achieved without the need to change chamber hardware.

Devices emerging in the R&D phase include energy harvesting; speakers; RFID; pico projectors; oscillators; micro fuel cells; and autofocus technologies.

www.oxford-instruments.com

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For more information, please contact Oxford Instruments Plasma Technology:

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www.oxford-instruments.com/plasma



The Business of Science®

Nanotronics launches automated wafer inspection tool

At the 2011 International Conference on Compound Semiconductor Manufacturing Technology (CS Mantech) in Palm Springs, CA (16–19 May), Nanotronics Imaging LLC of Cuyahoga Falls, OH, USA launched nSPEC, a fully automatic inspection system for analyzing transparent and semi-transparent wafers for defects.

Proprietary software and hardware underlying nSPEC enable rapid and detailed analysis of wafer defects. Nanotronics employs 'Point and Shoot' microscopy, as it aims to eliminate a learning curve for users while giving accurate and easy-to-interpret data. The reports of defect classification and mapping

may be custom configured or selected from the provided report templates and library of standard defects. Reports may include density maps, histograms, defect count and applicable statistics, all of which can be configured for the user's specific requirements.

Nanotronics says that the inspection system allows easy set up for repeated quality control testing, but can be set for single image capture or scans. Configuration options include wafer size, type of defects to be identified, and resolution of scan. Various sample chucks are available to meet specific needs. Complete system automation with

cassette-to-cassette loading of 2–8" wafers is available.

Nanotronics Imaging also announced the recruitment of new executive vice president Ivan Elia-shevich (formerly director, sales & business development at epiwafer foundry and substrate maker IQE), who brings a level of expertise in the semiconductor industry that is unique, the firm reckons. "I knew Ivan as a client, who helped me to understand wafer technology," says CEO & founder Matthew Putman. "He is honest, knowledgeable, and a powerful proponent for the customer and supplier," he adds.

www.nanotronicsimaging.com

Nanometrics opens Singapore Advanced Metrology Center

Nanometrics Inc of Milpitas, CA, USA, a supplier of process control metrology systems for manufacturing semiconductors, high-brightness LEDs, data storage devices and solar photovoltaics, has opened its Singapore Advanced Metrology Center, an applications development center for customers using Nanometrics metrology systems.

The center provides dedicated support throughout Asia for customers requiring advanced modeling of complex structures and recipe development. Nanometrics says that its investment in additional applications resources reflects the rapid growth and adoption of optical critical dimension (OCD)

technology in semiconductor manufacturing due to smaller, more complex structures and new materials.

The firm says that the Singapore location provides access to a large pool of technical talent and a significant concentration of its customers. In addition to applications development staff, the facility also includes sales and service support. It also serves as a training center for regional customers and Nanometrics' branch offices.

"This expansion is important to our efforts to improve responsiveness in Asia and to better serve our customers," says Nagesh Avadhany, VP of applications engineering and training programs. "We have a

highly skilled local staff of engineers and scientists who now form the core of our regional applications team. They bring to Nanometrics a vital resource to build our customers' confidence in our ability to enable their most critical structures," he adds.

"Singapore offers a deep talent base, and will serve as a gateway to all of our customers in Asia," says president & CEO Timothy J. Stultz. "This significant commitment to our customers in the region will help us serve them as a more local company, with improved access and communication," he adds. "We look forward to expanding relationships with our customers."

www.nanometrics.com

Dark Field sells inspection tools to CIGS PV firm

Dark Field Technologies Inc of Shelton, CT, USA, which provides laser and camera inspection and metrology systems for the solar thin-film, plastic film, displays, glass, electronics and semiconductor industries, has won an order for multiple systems worth more than \$500,000 from a top-tier manufacturer of thin-film copper indium gallium (di)selenide solar panels.

NxtGen Scribe 100 is an on-line, real-time solar cell scribe metrology tool, which is coupled with NxtGen Wash for on-line haze measurement, washer debris detection, glass defects and length/width/squareness measurement.

NxtGen Scribe 100 uses dark-field optics and high-speed scan cameras to inspect on-line P1, P2 and P3 scribing operations. NxtGen Wash

detects edge chips/cracks and broken corners/flairs, TCO coating defects and washer residue, panel warp/thickness or concentrator profile at $\pm 15\mu\text{m}$. More than 500 million pixels are captured and analyzed in 3 seconds.

Each Dark Field system is custom-designed and produced for individual customers, notes president Tim Potts.

www.darkfield.com

Ultratech plans HB-LED Asia Technology Center in Taiwan ...to aid development of cost-effective, scalable HB-LED processing

Ultratech Inc of San Jose, CA, USA, which supplies photolithography and laser-processing systems used to make semiconductor devices and high-brightness LEDs (HB-LEDs), has announced its Asia Technology Center (ATC) in Hsinchu, Taiwan.

The integrated Class 1000 clean-room provides the capability for leading-edge process development and in-depth demonstrations of Ultratech's Sapphire 100 lithography system, which is designed for customers in the HB-LED market. To further support the firm's Singapore international operations facility (opened last December), the center aims to enable cost-effective, leading-edge process development that can be transferred between sites or across Ultratech's large customer base throughout the Pacific Rim.

Due to open in second-half 2011, Ultratech says that the ATC furthers its ongoing commitment to meet its international customers' needs with advanced technology solutions at the lowest cost-of-ownership.

"With many of our customers located in the Pacific Rim, opening our Asia Technology Center in Taiwan enables us to work with leading companies to develop processes and lithography equipment advances to reduce the cost of manufacturing LEDs," says chairman & CEO Arthur W. Zafiropoulo. "In addition, the facility will be used to provide yield research as well as low-cost patterning solutions," he adds. "Ultratech remains vigilant in its search for ways to provide low-cost solutions to support the significant growth in the HB-LED

markets. We look forward to leveraging our Asia Technology Center to help speed the development of cost-effective lithography processes to support our customers' product and technology roadmaps for new and emerging markets."

Ultratech says that, building on the cost and performance advantages of its 1500 platform, the next-generation Sapphire 100 lithography system provides high operational flexibility due to the benefits of the 1x lens design and market-specific technology options for high-volume, HB-LED manufacturing. The Sapphire 100 was designed specifically to meet the wide range of lithography needs and cost advantages for the HB-LED manufacturing industry, the firm adds.

www.ultratech.com



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IN BRIEF

GT hires VP finance

GT Solar International has appointed John R. Granara as VP finance, chief accounting officer & corporate controller. He succeeds Richard E. Johnson, who resigned to pursue other interests.

Granara has nearly 20 years of international finance experience in leadership and management positions with publicly traded companies. Since January, he was interim chief financial officer at A123. Previously, from 2007 to 2010, he was VP, finance and corporate controller. At A123, he led a worldwide finance organization responsible for accounting, finance, treasury, planning, financial systems, business controls, and external reporting, including staffing and finance activities in China and Korea.

"We are delighted to have an experienced finance executive like John Granara join GT at such an exciting growth phase in the company's development," says chief financial officer Richard Gaynor.

GT Solar launches ASF100 advanced sapphire furnace

GT Solar has launched the ASF100 advanced sapphire furnace growth system. The ASF100 increases yielded output of sapphire material by producing a larger, 100kg sapphire boule in the same chamber as previous versions of the furnace (e.g. the 85kg ASF).

"We have received an enthusiastic response from early adopter customers for our ASF sapphire growth systems as they enter the market to provide high-quality sapphire material for the fast-growing LED industry," says Cheryl Diuguid, VP & general manager of GT Solar's sapphire equipment and materials group. "Our advanced sapphire crystallization systems are built on a highly scalable and reliable architecture that lets customers quickly ramp to volume production with a lower capital investment compared with other competing crystallization technologies," she claims.

With more than 40 years of proven sapphire production and crystalline growth process technol-

ogy, the ASF100 provides a highly automated, low-risk operating environment, capable of producing consistently uniform sapphire boules that yield high-quality material suited to high-brightness (HB) LED applications, the firm claims.

"With competing crystallization technologies, customers entering the sapphire crystallization market are forced to choose between systems that provided quality or systems that offer high throughput," continues Diuguid. "Our ASF100 offers high quality and high volume, so customers get both in one system."

Since the commercial introduction of the ASF system in fall 2010, GT has booked more than \$450m in orders from new entrants and existing sapphire producers. The ASF100 offers a proven path to producing high-quality, large-area sapphire substrates for markets that demand the highest-grade material, the firm adds.

www.gtsolar.com

GT receives largest single order; \$460m of sapphire furnaces for Chinese market entrant

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 its advanced sapphire crystallization furnaces (ASF) totaling \$460.4m from a new market entrant for its new sapphire production facility.

As its largest single order to date, it represents a milestone for GT in the fast-growing LED industry, the firm says. The order will be included in GT's backlog for its current fiscal first-quarter 2012 (which ends on 2 July 2011).

"Our customer is a well established, diversified manufacturing company located in China who is new to the LED industry," says president & CEO Tom Gutierrez.

"The market acceptance of our sapphire growth technology has been remarkable and it speaks to the confidence our customers have shown in our ability to help them build successful businesses

customers have shown in our ability to help them build successful businesses that leverage our crystalline growth expertise and our global equipment installation and support resources," he adds.

According to analyst firm Strategies Unlimited, revenue for high-brightness LED applications will be about \$19bn by 2015, with general lighting applications accounting for about 25% of this. Since high-brightness LEDs are manufactured primarily on sapphire wafers, this growth is driving the expansion of manufacturing capacity to meet the increased demand for high-quality sapphire material, says GT Solar.

GT Solar's full-year income doubles as revenue grows 65%

Sapphire orders boost 2012 revenue guidance from \$850m–1bn to \$1–1.1bn

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 reported revenue for its fiscal fourth quarter (ended 2 April) of \$271.6m, up 3.3% on \$262.9m last quarter and 40% on \$194.7m a year ago. Revenue by business segment was \$79.2m in polysilicon, \$186m in photovoltaic (PV), and \$6.4m in sapphire.

For full-year fiscal 2011, revenue was a record \$899m (up 65% on fiscal 2010's \$544.2m): \$143.6m in polysilicon, \$740.1m in PV, and \$15.3m in sapphire (all of which was sapphire materials revenue).

"We took an important strategic step to diversify the business in fiscal 2011 with the acquisition of Crystal Systems [last July], which has allowed us to enter the high-growth sapphire business," notes says president & CEO Tom Gutierrez. Founded in 1971, Crystal Systems Inc of Salem, MA was a crystalline growth technology firm manufacturing large-area sapphire substrates for the LED, defense, medical and aerospace industries.

Gross margin rose from 40.2% in fiscal 2010 to 42% in fiscal 2011. However, although up on 37.5% a year ago, fiscal Q4's gross margin of 43% is down on 46.4% last quarter.

Net income doubled from fiscal 2010's \$87.3m to a record \$174.8m in fiscal 2011. However, although up from \$33.3m a year ago, fiscal Q4's net income of \$51.9m is down from \$63.6m last quarter.

Cash and cash equivalents at the end of fiscal Q4 were \$362.7m, up from \$320.4m at the end of fiscal Q3 and \$250.7m a year ago. Also, debt was \$120.3m, down from \$125m at the end of fiscal Q3. There was no debt a year ago.

"We concluded the year with a strong balance sheet and cash position, while utilizing \$203.5m of cash to buy back 26.5 million shares from our private equity investor," says Gutierrez.

Net new orders in fiscal Q4 were \$234.2m (\$14.7m in polysilicon, \$125.1m in PV, \$94.4m in sapphire). This took total bookings for full-year 2011 to more than \$1.1bn. As of 2 April, order backlog was \$1.19bn (\$536.7m in polysilicon, \$468.1m in PV and \$184.2m in sapphire). Included in the total backlog was \$445.5m of deferred revenue.

"Our sapphire substrate business continues to be fully booked and our sapphire equipment business has developed rapidly, with over \$484m of orders booked," says Gutierrez. "The healthy pace of business has continued into the new fiscal year, with an additional \$722m of orders booked so far in the first quarter of fiscal year 2012," he adds.

For fiscal 2012, GT Solar has raised its guidance for revenue from \$850m–1bn to \$1–1.1bn. Gross margin should be 42–44%.

"The strength of our balance sheet enables us to significantly increase our investment in a continued flow of new products and additional strategic opportunities," notes Gutierrez. "Combined with our strong backlog and continued bookings momentum, this positions GT very well for the foreseeable future."

● GT Solar is to change its name to GT Advanced Technologies as it establishes a new global brand. The new name reflects the broader range of markets and technologies that the firm now addresses since its acquisition of Crystal Systems in July 2010. The transition to GT Advanced Technologies is expected to be completed in August.

www.gtsolar.com

GT sues ARC Energy

GT Solar International Inc's subsidiaries GT Crystal Systems LLC and GT Solar Hong Kong Ltd have filed a lawsuit in the Hillsborough County Superior Court (Southern District) in New Hampshire against Advanced RenewableEnergy Co LLC (ARC) of Nashua, NH, its CEO Kedar Gupta (co-founder & former CEO of GT Solar) and ARC employee Chandra Khattak alleging misappropriation of trade secrets (relating to GT Crystal's technology for manufacturing sapphire crystals) as a means of entering the sapphire crystallization equipment business. The complaint also alleges civil conspiracy, unfair competition, breach of contract and interference with contractual relations.

"We have an obligation to our shareholders to be diligent about protecting our intellectual property," says GT Solar's general counsel Hoil Kim. "When we believe our intellectual property has been compromised, we will take the necessary action to protect our rights."

ARC's secretary & general counsel Daniel Lyman says it finds the complaint "completely without merit... ARC's sapphire crystallization equipment and processes are entirely our own. We will defend against this action vigorously and we intend to win."

ARC was founded in 2007 to commercialize technologies for LED and other clean energy markets. The firm says it provides highly automated sapphire crystal growth and processing systems to enable rapid scale production and cost reduction of LEDs.

"GT's action will not distract ARC Energy's commitment to providing its customers with the most advanced technologies," ARC says. "Nor will it distract us from our mission to deliver innovative, highly automated, sapphire crystal growth equipment."

www.arc-energy.com

IN BRIEF

GT appoints new board members

GT Solar has appointed Mary Petrovich and Robert E. Switz to its board of directors, serving until the 2011 Annual Meeting of Stockholders on 24 August (when they will stand for election).

"Both individuals are accomplished former CEOs of public companies who have created shareholder value and demonstrated excellent operational and leadership skills," comments chairman Matt Massengill. "They are both experienced directors on the boards of other public companies," he adds. "The GT board will benefit from their insights and experience."

Petrovich was chairman & CEO of AxleTech International LLC from 2001 through the December 2008, then general manager after its acquisition by General Dynamics in December 2008. She is also a director of Woodward Inc and Modine Manufacturing Company.

Switz was a director, president & CEO (from 2003 to 2010) and chairman (from 2008 to 2010) of network infrastructure product and services provider ADC Telecommunications Inc (acquired by Tyco International). He is also a director of Broadcom Corp and Micron Technology Inc.

The appointments fill vacancies following the resignations last November of Bradforth Forth and R. Chad Van Sweden, both with the GFI Energy Group of Oaktree Capital Management LP (previously a private equity investor in GT).

Also, board member Fusen E. Chen has decided not to stand for re-election following completion of his current three-year term on 24 August. "Fusen provided invaluable insight as we developed the technology strategy and roadmap that are being successfully deployed today," says Massengill.

www.gtsolar.com

GT to supply sapphire cores to Taiwan LED wafer maker Tera Xtal

GT Solar has signed an agreement to supply sapphire cores to Taiwanese LED wafer maker Tera Xtal Technology Corp (TXT).

Tera Xtal is dedicated to manufacturing 2–6" single-crystal sapphire wafers for the LED industry. "We are increasing our volume of epi-ready wafers to meet rising customer demand," says Tera Xtal's president Steven Liu. "We have had a successful, long-standing relationship with Crystal Systems, now GT Solar [since the acquisition last July], and have come to rely on their ability to provide us with LED sapphire material that meets our high standards for quality," he adds.

"Our ability to supply sapphire cores to a leading LED industry player such as Tera Xtal not only demonstrates the quality of the sapphire produced by GT's proprietary Advanced Sapphire Furnaces

but also provides support to our expanding universe of equipment customers as they ramp into production over the coming year," comments GT Solar's president & CEO Tom Gutierrez.

GT says that its new sapphire production facility increases the availability of sapphire material for its LED and specialty market sapphire customers. Initially, material allocation will satisfy both LED and specialty market customers, but long term, as its equipment customers ramp into high-volume production, GT expects that most of its sapphire production will be allocated to meet new specialty market growth in areas such as high-energy lasers, medical devices, and applications requiring large-area substrates for the aerospace and defense industries.

www.teraxtal.com

GT Solar wins \$91m in sapphire furnace orders from Asia

GT Solar International Inc of Merrimack, NH, USA has received three new orders totaling \$91m for its advanced sapphire crystallization furnaces (ASF).

Two orders are from customers in Taiwan: new customer Alpha Crystal Technology, and Tera Xtal Technology Corp (which a week beforehand announced a sapphire material purchase agreement with GT Solar). The third order is from a new customer in China, the Lingyang Group.

"These new orders continue a very robust order rate for our ASF furnaces," says president & CEO Tom Gutierrez. "The interest shown by new market entrants and existing sapphire producers for our ASF systems has surpassed our expectations and is a testament to the confidence customers have for our proven

Interest shown by new market entrants and existing sapphire producers for our ASF systems has surpassed our expectations and is a testament to the confidence customers have for our proven ability to quickly ramp to high-volume, low-cost manufacturing with leading-edge crystal growth technology to meet the market demand for high-quality sapphire material," Gutierrez adds.

ability to quickly ramp to high-volume, low-cost manufacturing with leading-edge crystal growth technology to meet the market demand for high-quality sapphire material," Gutierrez adds.

GT wins \$218.9m sapphire furnace order from China's Haotian Opto Firm to be vertically integrated manufacturer

GT Solar International has received an order for sapphire crystallization furnaces totaling \$218.9m from Guizhou Haotian Optoelectronics Technology Co Ltd (HTOT).

The order continues GT Solar's market momentum for its sapphire crystalline growth technology based on its sapphire furnace. This is GT Solar's fifth order for its sapphire crystallization furnaces in recent months. In late February GT Solar received a \$41m order from a new Asian customer, in January it 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). The latest order is included in GTs backlog for its fiscal Q1/2012 (to 2 July 2011).

"Our entrance into the LED market offers a new strategic growth opportunity for our company and Guiyang City as well as the Guizhou region of China," says Hao Xu, chairman of the board of Guizhou Industrial Investment Group. "Our new sapphire production facility will help to stimulate economic growth in the region and establish HTOT as a leading supplier of material to the LED industry," he reckons.

HTOT aims to be a vertically integrated manufacturer of sapphire products including crystal, cores, wafers and other crystalline products for LEDs, silicon on sapphire (SOS), radio frequency integrated circuits (RFICs), optoelectronics and other optical applications. Once fully operational, HTOT will produce sapphire in volume production of various sizes and orientations of substrates and windows.

"This project requires a technology partner that can deliver reliable, highly productive equipment as well as installation and support



GT Solar's sapphire furnace.

know-how to quickly get our new factory up and running," Xu says. "We selected GT Solar because of its leading technology, proven track record, and years of experience enabling cost-effective, high-volume manufacturing," he adds.

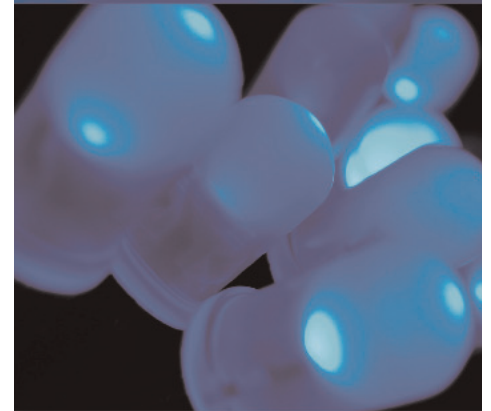
"We look forward to a long and successful partnership over the coming years," says GT Solar's president & CEO Tom Gutierrez. "We continue to see growing interest from companies looking to enter the fast-growing LED industry," he adds. "Our sapphire crystal growth technology provides a proven path to producing high-quality material, and our global installation and support resources enable our customers to quickly ramp to high-volume, low-cost manufacturing."

GT Solar's sapphire furnace technology is the result of more than 40 years of process improvement and development at crystalline growth technology firm Crystal Systems Inc of Salem, MA, USA (acquired last July), a provider of sapphire for the LED and specialty optical and mechanical industries.

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NC Green Business Fund awards Kyma over \$400,000 Manufacturing plant to gain energy-efficient infrastructure

Kyma Technologies Inc of Raleigh, NC, USA, which provides crystalline gallium nitride (GaN) and aluminum nitride (AlN) materials and related products and services, has won a grant from the North Carolina Green Business Fund to develop a more energy-efficient manufacturing facility.

State Commerce Secretary Keith Crisco announced that, state-wide, the NC Green Business Fund (which is managed by the North Carolina Department of Commerce) has awarded 16 organizations grants totaling \$4.6m (funded through the American Recovery and Reinvestment Act). Of this, companies and organizations in

North Carolina's Research Triangle area have been awarded grants worth more than \$2.8m.

Kyma will receive \$427,760 to equip its facilities with several elements of an ultrahigh-energy-efficiency manufacturing infrastructure, including a geothermal heating, ventilation and air conditioning (HVAC) system; better insulation; high-efficiency LED-based solid-state lighting; smart utility-control sensors; and an energy usage monitoring and optimization center.

"While we have always prided ourselves with our relatively low carbon footprint, especially compared to that of many of our

competitors, NC Green's support is going to enable us to improve our plant efficiency by a very significant amount," says VP of operations Dr Heather Splawn.

"This helps us become even greener in the manufacturing of our products," says Kyma's president & CEO Dr Keith Evans. "Our products in turn are used by our customers to make their products greener too."

The market for nitride semiconductor devices is expected to surpass \$65bn over the long term, including more than \$32bn in visible lighting applications and \$33bn in power electronics applications.

www.ncscitech.com/gbf

Kyma launches AlGaN template with 5µm epi-ready buffer 100µm buffer targeted in 6 months; free-standing AlGaN in 2012

Kyma Technologies Inc has added aluminum gallium nitride (AlGaN) templates to its product portfolio.

Kyma developed the product in collaboration with a partner as part of an ongoing advanced mid-UV LED technology research project. However, AlGaN templates also have great potential to impact other applications, including high-power RF communications and high-power switching electronics.

Kyma's initial AlGaN template product offering consists of a 5µm-thick epi-ready $Al_{0.9}Ga_{0.1}N$ buffer layer grown on top of a 2"-diameter sapphire substrate. Additional compositions and thicknesses will be offered in the future.

"Transistors based on AlN/AlGaN heterostructures have already been demonstrated which outperform their GaN counterparts in high-temperature operation that is required for uncooled automotive applications," says chief technology officer Ed Preble. "Our AlGaN templates should support a further boost in transistor performance,



Kyma's new 2"-diameter AlGaN template.

since they support lower-defect-density active regions when compared to typical MOCVD or MBE buffer layers grown on silicon carbide or sapphire substrates," he adds.

"Our engineers have accomplished a lot

We are seeking customer involvement to help us understand how it plays out in their device research

very quickly and have already demonstrated high-Al-content crack-free AlGaN layers over 10µm thick," says president & CEO Dr Keith Evans. "We aren't stopping there. Our goal is to get up to 100µm within the next six months and to demonstrate free-standing AlGaN in 2012."

In future, the firm plans to expand its AlGaN template range to other combinations of Al-content, AlGaN thickness, substrate diameter (e.g. 3" and 4"), and substrate composition (e.g. silicon and SiC).

"It is still an early product, and we are seeking customer involvement to help us understand how it plays out in their device research and how we might further improve it," notes technical sales engineer Tamara Stephenson.

www.kymatech.com

Diamond Materials appoints president & CEO and CTO

Diamond Materials Tech Inc (DMT) of Colorado Springs, CO, USA (a member of the Meyer Burger Technology Group that makes diamond wire cutting technology and consumables under the brand name Diamond Wire Material Technologies for the solar, optical and semiconductor markets) has appointed Tom Devine as president & CEO. He assumed the responsibilities of president in February, and is working closely with CEO John Brenan, who will be transitioning into retirement, so Devine will assume the role of CEO later this year.

Devine has an extensive background in operations, general management and continuous improvement, focusing on helping organizations undergoing rapid growth, post-merger restructurings and Lean Sigma transformations.

Most recently, he was CEO of Boon Edam in North Carolina,

where he was instrumental in building the firm's infrastructure and overseeing the transition to a lean manufacturing culture. Previously, Devine was VP of operations for ABB Semiconductor in Lenzburg, Switzerland from 2000 to 2006. He has also held senior operational and general management roles for technology-based companies including Integrated Device Technology, Paradigm Technology, Headway Technologies and OnQ Technologies. Devine also has a Bachelors of Science in Business Management from Fresno State University.

DMT has also appointed Dr Yancy Riddle as chief technology officer (CTO). Riddle has more than 15 years of experience in engineering, R&D, manufacturing, and business leadership, responsible for alloy design, chemistry development, product design, manufacturing process design and scaling-up,

equipment design, quality control, lean manufacturing, US government contracts, university and National Lab relationships, fundraising, capital improvements, and investor relationships.

DMT says that Riddle has helped to provide new material technologies to the primary metal alloy in a variety of marketplaces including nanotechnology, automotive, aerospace, forestry, military, medical, marine, electrical, industrial tooling, and oil & gas. His background includes roles at Wiremold (LeGrand), Kendall Healthcare (Covidian), Pratt & Whitney, and UCT Coatings as well as numerous academic appointments. Yancy has a BSc in Mechanical Engineering from Northeastern University, an MSc and PhD in Materials Science from Georgia Institute of Technology, and Business Leadership studies from Harvard University.

www.dmt-inc.com

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Samsung focuses on US LED lighting market

Korean electronics firm Samsung has set its sights on the multi-billion dollar lighting market in the USA by making its first LED lamps available in the region.

To channel the firm's expertise in electronics and electro-mechanics into the production of LED lighting, Samsung LED Co Ltd was established globally in April 2009, and it now possesses some of the largest LED production facilities in the world, says the firm. To support expansion into the US market, an American center of operations has also been established in Atlanta, GA, USA.

"The lighting industry has finally caught up with the digital revolution, with microchip technology powering lamps enabling longer lifetimes, more environmentally friendly designs and less energy consumption," says Philip Warner, VP of Samsung LED America.

"The Samsung brand is practically synonymous with consumer electronics. As more and more people recognize the future of home and commercial lighting lies in this amazing digital technology, we are confident Samsung will take a leading position in the market."

The firm's initial line-up ranges from omni-directional incandescent replacements to fluorescent and PAR replacement. Samsung adds that its vertically integrated supply chain allows it to produce all aspects of LED lights, including chips, PKGs, modules, light engines and lamps. The firm also has technology for thermal management, optics, power supplies and lighting controls.

"We will not dilute our offerings with high-efficiency incandescent or even CFLs, as these are yesterday's technologies," says Warner. "Our focus is 100% on LED."

Samsung's LED lights were exhibited at the LightFair International (LFI 2011) show in Philadelphia, PA, USA (17-21 May).

www.samsungLED.com

Seoul Semiconductor's Z4 1W LED provides 100lm/W and CRI >85

In accord with its 2011 business plan to launch a new product for different markets every month, South Korean LED maker Seoul Semiconductor has added to its high-intensity Z-Power LED series by launching the Z4.

The new model is a 1W LED (the most demanding in the existing LED market) and is suited to general lighting such as incandescent lamps and MR16 bulb-type lighting. The firm claims that it provides the best brightness (luminous flux of 100lm), luminous efficiency (100lm/W) and color rendering index (CRI>85) for a 1W LED. The Z4 is available in two colors: warm white and cool white.

Seoul Semiconductor says that the Z4 LED helps to prevent degradation at high temperatures (the most critical aspect for the LED package), with what is claimed to be exceptional reliability and high

protection against heat compared with competing products. The firm claims that the price-competitive Z4 is also highly competitive in 'cost per lumen' (most important for LED lighting). Until now, LED performance was judged by 'lm/W', but now 'cost/lm' is more important for performance after releasing high-intensity products over 100lm, says the firm. In addition, a silicon lens has been adopted for optical safety.

"We have developed the high-efficiency, low-price Z4 series with the goal of increasing our market share in the world's most demanding 1W LED market," says Seoul Semiconductor vice president In-sup Ra. "We will be able to further expand the incandescent lamp and MR16 bulb-type LED lighting market and enhance price competitiveness with this new product," he believes.

www.acriche.com

Production dates for DC-driven Acriche

At the Lightfair International event (LFI 2011) in Philadelphia, PA, USA (17-19 May), Seoul Semiconductor announced the latest extension of its Acriche product family.

Unlike other devices in the family, the new DC-driven Acriche will be optimized for DC operation and still be able to operate on AC power like the traditional Acriche products. Performance will reach 140 lumens and 120 lm/watt when the part is released to mass production in the June time frame. By the end of the year, performance is expected to reach 170lm and 150lm/W.

The new product is classified as a 1 Watt part but will run on only 20mA DC current at 55V in order to improve overall system efficacy at the fixture level. Higher-voltage operation allows the fixture designer to choose more efficient AC-to-DC power supply options to

hold the fixture efficacy higher than could be used for traditional low-voltage LEDs, says the firm. The product can still operate from an AC supply, giving the designer flexibility to use the same product in a variety of applications or situations, especially in space-conscious applications where a converter may not fit.

Seoul Semiconductor says that the new product takes advantage of its patented Acriche intellectual proprietary. The particular technology is just one of more than 300 patents held by Seoul Semiconductor and its subsidiary Seoul Opto Device in the AC LED marketplace. The firm reckons that optimizing for DC operation makes the array desirable for applications where AC power may not be available, such as renewable energy sources like solar power (which produces DC current).

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IN BRIEF

Lumileds and Future Electronics extend distribution agreement

Building on their existing decade-long relationship, LED maker Philips Lumileds of San Jose, CA, USA and Future Electronics (a division of Future Electronics that provides LED lighting components and support services for solid-state lighting products and installations) have extended their exclusive worldwide distribution relationship with a new five-year agreement.

"Our exclusive partnership with Philips Lumileds has provided our customers with access to the world's leading portfolio of LEDs for illumination — LUXEON," comments Jamie Singerman, corporate VP, Future Lighting Solutions. "Our investment in resources, training, design tools, and best-in-class supply chain capabilities has enabled us to become the service leader in the solid-state lighting industry," he claims.

"Future Lighting Solutions has proven over the last decade that with LUXEON LEDs, highly trained LED solution engineers, and the core services of a global solutions provider, they are well positioned to support and enable the growing number of companies that want to enter the solid-state lighting industry," comments Steve Barlow, Philips Lumileds' senior VP of sales & marketing.

www.FutureLightingSolutions.com

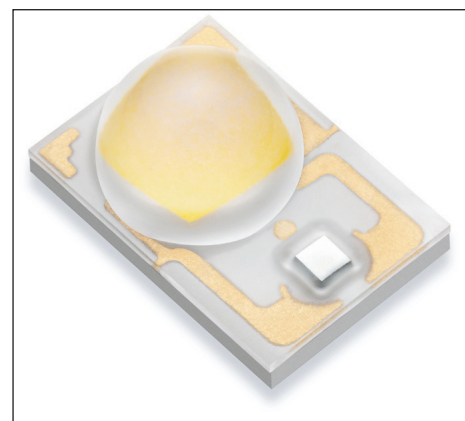
They are well positioned to support and enable the growing number of companies that want to enter the solid-state lighting industry

Lumileds' LUXEON A LED moves into volume production

Philips Lumileds of San Jose, CA, USA says that its LUXEON A LED, launched in April, has moved into volume production and has been submitted for an Innovation Award at the Lightfair International event (LFI 2011) in Philadelphia, PA, USA (17–19 May).

Lumileds says that the LUXEON A is its second hot-tested and specified LUXEON LED launched this year that also delivers on the promise of Freedom From Binning. The firm has committed to delivering illumination-grade LEDs to the industry in a concerted effort to simplify and speed development of new lighting solutions and to deliver the highest quality of light for each application. Advanced manufacturing control allows it to accurately target a specific correlated color temperature so that each LUXEON A LED falls within one 3-step MacAdam ellipse space at actual operating conditions.

"Key to increased adoption of LEDs are ease-of-use and confidence in the quality of light," says Steve Barlow, senior VP of sales & marketing. "Lumileds is simplifying and accelerating the design process with hot testing and Freedom From



Lumileds' LUXEON A LED, launched in April and now in volume production.

Binning. More importantly, with LUXEON A we are proving that consistent quality of light from LED to LED is something that both the luminaire manufacturer and lighting design community can count on," Barlow adds.

LUXEON A was featured at the firm's Lightfair booth in a linear profile intended to demonstrate the consistency and quality of the emitted light. The LED is now in full volume production and is available from Future Lighting Solutions.

www.philipslumileds.com

LUXEON wins Technical Innovation Award

Philips Lumileds' LUXEON A LED (launched in April) received the Technical Innovation Award at the Lightfair International event (LFI 2011) in Philadelphia, PA, USA (17–19 May).

The award is given to the product representing the best leap forward in lighting technology. The firm's third and most recent product to be released this year incorporates two breakthroughs: hot testing and 'Freedom From Binning'.

Lumileds says that LUXEON A provides consistent quality of light from LED to LED. Hot testing and specification at a junction temper-

ature of 85°C ensures the LEDs real-world operating conditions performance and simplifies the design process. Freedom From Binning eliminates color bins (typically a burden on luminaire manufacturers). All LUXEON A emitters fall within a single 3-step MacAdam Ellipse at 2700K and 3000K and deliver what is claimed to be superior quality of light with previously unachievable color consistency from unit to unit.

Lumileds has also previously won the Technical Innovation Award with its LUXEON Rebel and LUXEON Rebel ES LEDs.

First LED replacement for 75W bulb

At the LIGHTFAIR International tradeshow (LFI 2011) in Philadelphia, PA, USA (17–19 May), Netherlands-based electronics firm Philips unveiled its EnduraLED A21 17W light bulb, designed to replace a 75W incandescent bulb while reducing energy consumption by 80% and lasting 25 times longer.

“Consumers do not have to wait for quality alternatives to the incandescent or to sacrifice the soft white light they have become accustomed to because LED can deliver all the benefits without compromising quality,” says Ed Crawford, general manager of Lamps for Philips Lighting North America.

The EnduraLED A21 17W is the latest addition to Philips’ portfolio of LED bulbs that can efficiently replace traditional incandescents. These include 25W and 40W equivalents, as well as the ENERGY STAR-qualified Philips EnduraLED 12.5W bulb (the first commercially available 60W replacement).

The EnduraLED A21 17W, which uses LUXEON LEDs made by LED-making subsidiary Philips Lumileds of San Jose, CA, USA, has also been developed to meet or exceed ENERGY STAR qualifications for an LED-based replacement for the 75W incandescent light bulb. Those specifications call for delivering 1100 lumens with just 17W of electricity, a color temperature of 2700K, a color rendering index (CRI) of 80, and a rated life of 25,000 hours. The new bulb will be submitted to ENERGY STAR in the coming months for qualification testing.

Philips estimates that about 90 million 75W incandescent light bulbs are sold annually in the USA. The firm reckons that switching to this LED replacement has the potential to reduce electricity use by 5220MW, a cost savings of about \$630m annually. According to Philips estimates, switching to the EnduraLED 21 17W could also eliminate 3,255,205 million metric tons of carbon emissions annually (the



Philips EnduraLED A21 17W light bulb,

equivalent of removing nearly 1 million cars from the road).

As with all bulbs in the Philips LED lighting family, the new EnduraLED A21 17W has a rated life of 25 times longer than a standard incandescent bulb. Over its lifespan, it could save a business or household about \$160 per bulb, reckons Philips.

Available in fourth-quarter 2011 in the USA, the suggested retail price for consumers has not yet been finalized but is expected to be \$40–45.

Philips says that, with this latest addition to its portfolio, consumers and businesses have more choices for reducing energy costs over the traditional incandescent bulbs. In addition to offering familiar soft white light, the EnduraLED A21 17W fits into existing fixtures and works with standard dimmers, providing a simple, long-lasting solution for the home. For those within the retail or hospitality sector, the bulb can provide a substantial return on investment through extended bulb life and reduced energy and maintenance costs, Philips claims.

www.philips.com

IN BRIEF

Samsung and quantum dot firm Evident enter LED patent agreement

Evident Technologies Inc of Troy, NY, USA and Samsung Electronics Co Ltd of Seoul, South Korea have entered into a comprehensive patent licensing and purchasing agreement for Evident’s quantum dot LED technology.

The agreement grants Samsung Electronics worldwide access to Evident Technologies’ patent portfolio for all products related to quantum dot LEDs, from manufacture of the quantum dot nanomaterials to final LED production.

“We already enjoy a terrific working relationship and look forward to the future of this technology,” comments Evident Technologies’ CEO Dr Clint Ballinger.

Evident Technologies says that, as nanometer-sized semiconductor crystals, quantum dots have great commercial promise in electronic applications from solar energy conversion to thermoelectrics to LEDs. Evident Technologies claims to be the first firm to commercialize quantum dot LEDs, with products launched in 2007.

Evident Technologies is currently focused on developing next-generation thermoelectric applications using their core quantum dot material technology. “Our goal is to greatly increase the performance of thermoelectric devices through our nano-material advances,” says Ballinger. Thermoelectric devices can be used for solid-state heating and cooling as well as for converting waste heat into electricity directly.

www.samsung.com

www.evidenttech.com

Cree demos record-efficiency 231lm/W white LED

Firm raises its record from 208lm/W achieved in February 2010

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has reported what it claims is an industry-best efficacy record of 231 lumens per watt for a white power LED, significantly beyond Cree's previous industry record.

The efficacy was measured using a single-die component at a correlated color temperature of 4500K. Standard room-temperature 350mA testing was used to achieve the results.

"It wasn't long ago when 200 lumens per watt was considered the theoretical maximum efficiency for a lighting-class LED," says John Edmond, Cree co-founder & director of advanced optoelectronics. "We broke that barrier in 2010 [with a 208lm/W white power LED announced that February], and have now achieved 231 lumens per watt," he adds. "The innovation from our labs is the foundation for our industry-leading XLamp

LED family."

Cree says that the R&D result features advanced aspects of the same technology used in its XLamp white LEDs. The firm believes that higher-performance LEDs can enable new LED-based applications and drive down the solution cost of current LED-based designs.

Cree notes that this level of performance is not yet available in its production LEDs.

www.cree.com

1000lm LMR4 module outshines 26W CFLs, 100W incandescents

Cree has launched the 1000 lumen LMR4 LED module, delivering 66 lumens per watt efficiency in a fully integrated solution for downlight applications where high-quality light is essential (such as commercial, retail and residential).

Featuring Cree TrueWhite Technology, the LMR4-1000 provides higher-quality light and efficiency — using 42% less input power — than 26W compact fluorescent (CFL) bulbs, it is reckoned. It is also the only commercially available 2700K LED module to deliver 1000 lumen output at a color rendering index (CRI) of more than 90, which can replace 100W incandescent bulbs in downlight applications.



"The LMR4-1000 has the proven technology to enable our customers to quickly

and easily incorporate beautiful, energy-efficient LED lighting into the marketplace," says Scott Schwab, product line manager, Cree LED modules. "The LMR4-1000 provides high-quality light that meets the design requirements for applications such as restaurants, hotels and homes, continuing Cree's innovation in drop-in ready, integrated solutions for the LED lighting market."

The LMR4-1000 integrates driver electronics, optics and primary thermal management, making the compact module drop-in-ready. Designed to last 35,000 hours and dimmable to 5%, it is available in color temperatures of 2700, 3000, 3500 and 4000K with CRI >90.

LED fixtures designed with Cree LMR series modules could be seen at the Lightfair International event (LFI 2011) in Philadelphia, PA, USA (17–19 May) in the booths of Atlantic Lighting, DMF Lighting, Intense Lighting and Nora Lighting.

The LMR4 module is available now with standard lead times, and sample evaluation kits are available.

www.cree.com/modules

Water-resistant SMD LEDs in tall package for video screens

Cree claims that it has raised performance levels for high-brightness LEDs optimized for high-resolution indoor and outdoor video screens with two new water-resistant and higher-contrast high-brightness LEDs. The contrast offered by the LEDs extends the benefits of typical, black surface-mount LEDs used for high-definition, high-resolution LED screens and displays.

The Screen Master CLX6A-FKB delivers what is claimed to be industry-leading intensity and far-field pattern matching for high-resolution

full-color displays in a small water-resistant package. Optimized for outdoor use with both IPX6 and IPX8 ratings, the PLCC6-type LED eliminates the need for a protective cover, reducing overall systems cost and delivering higher brightness. It is said to be the first water-resistant, tall LED package, designed with dimensions that provide superior thermal performance and that make it easier for users to assemble.

The Screen Master CLVBA-FKA is Cree's first black-body RGB surface-mount LED, optimized to provide

the highest contrast ratio for indoor video screens. It has matched red-green-blue (RGB) far-field patterns, delivering a consistent viewing experience across a wide range of viewing positions and color vibrancy.

"Two years ago, Cree introduced the first water-resistant surface-mount LED," says Mike Watson, Cree's senior director of marketing, LED components. "With the CLX6A, Cree demonstrates our leadership again by introducing the industry's first water-resistant SMD LED in an easy-to-assemble, tall package."

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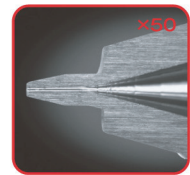
LED Packaging

CCD



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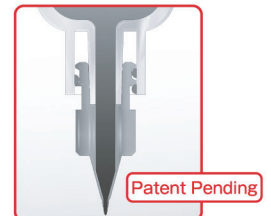
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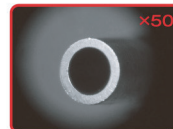
- Maintain constant flow pressure
- Maximize dispensing yield
- Alleviate bubbling



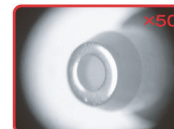
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- To minimize surface tension stiction



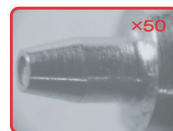
Stainless Steel Nozzle Tip



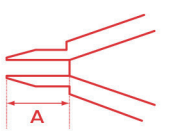
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Molex and Bridgelux launch 120V AC version of Helieon

After jointly launching their first Helieon Sustainable Light Module in March 2010, lighting firm and LED maker Bridgelux of Livermore, CA and Molex Inc of Lisle, IL, USA (a manufacturer of electronic, electrical and fiber-optic interconnection systems) have introduced the Helieon 120V AC Sustainable Light Module, a next-generation modular solid-state lighting solution that connects directly to 120V AC line voltage input. The module was showcased at Lightfair International 2011 (17–19 May) in Philadelphia.

Eliminating the need for external drivers not only simplifies the design-in process, but also enables more efficient and consistent lighting performance, say the firms. The Helieon 120V AC module is TRIAC dimmable down to less than 5% and is compatible with a wide range of commercially available dimmers, enabling it to easily interface with many typical electrical installations.

In addition to adding the electronic

driver functionality, the available product options for the module will be expanded with the introduction of a 2000 operational lumen option and the addition of a 120° viewing angle option (to complement the 24°, 32° and 50° options available). The initial product launch will include 1200 and 2000lm performance options in 3000K correlated color temperature (CCT) with 32° and 120° viewing angle options. Additional color temperature and viewing angle options will be introduced in the coming months.

“The Helieon 120V AC solution fully integrates the electronics into the module, reducing the variability found from the various driver manufacturers and providing light fixture manufacturers with a simplified design that offers all the benefits and flexibility of its predecessor [the Helieon module],” says Mike Picini, Molex’s VP, solid-state lighting.

“Due to the integration of the driver and power conversion circuitry, the

design is completely future proof, as any future improvement in LED technology can be accounted for in the driver,” he adds.

In 2010, the Helieon Sustainable Light Module was awarded the LIGHTFAIR International (LFI) ‘Most Innovative Product of the Year’ award. It is said to be the first plug-and-play sustainable solid-state lighting (SSL) system to integrate high-efficiency precision lighting with an easy-to-use socketed solution. Combining SSL technology from Bridgelux and engage-and-turn interconnect technology from Molex, the Helieon Sustainable Light Module simplifies the process of designing, building, replacing and upgrading luminaires for many lighting applications, it is claimed. “Our goal at Bridgelux is to continue reducing the complexity and cost of using LED technology for the general lighting market,” says VP of marketing Jason Posselt.

www.molex.com/link/helieon_slm.html

Bridgelux launches third-generation LED Array portfolio

Bridgelux has launched the third generation of its LED Arrays, including its LS, ES and RS product families.

The firm says the new product generation features the latest technical advances in epitaxial GaN layer growth, LED chip design and packaging technologies, increasing efficacy by up to 20% and reducing the cost per lumen by up to 30% compared with prior generations. The new Arrays offer greater system design flexibility to achieve Energy Star, Title 24, Part L and other global energy efficiency standards. The products are also configured to align with industry-standard drive currents to simplify the electronic driver selection process for new lamp and luminaire product development, enabling accelerated time to market.

Bridgelux’s product portfolio includes light output ranging from

240 to 10,000lm, continuing the expansion of what is claimed to be the industry’s broadest range of high-performance lighting-class LED light sources. The third-generation LS and ES Star Arrays are available immediately. The energy-efficient, high-flux-density sources can enable new MR-16, GU-10 and A-19 lamp applications, says the firm. In particular, the small source size of the 800–1000lm ES Star Arrays enables precision beam control for directional luminaires and PAR lamps. The new generation of ES rectangle and RS Arrays will begin shipping in third-quarter 2011.

As with the current product lines, the third-generation arrays are available in a broad range of color temperatures from 2700K to 5600K with 3 SDCM color control options to enable clean and consistent lighting installations. Additionally,

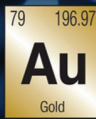
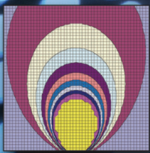
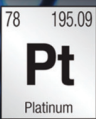
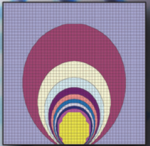
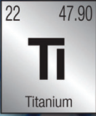
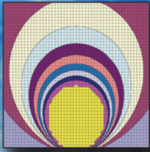
multiple color rendering index (CRI) options are now available, providing increased design flexibility for lamp and luminaire manufacturers. To enable users to easily take advantage of these performance enhancements, the new LED arrays use the same form factor as previous generations, allowing drop-in replacement and a simple upgrade path while minimizing design efforts.

“Since our first LED Array introduction in 2009, the company has increased efficacy by over 80% and reduced the cost of light by over 50%,” says Jason Posselt, VP of global marketing. “We continue to address needs for reduced design complexity, lower cost, and high-quality lighting,” he adds. “We remain confident that this is the right approach to drive rapid market adoption of solid-state lighting.”

www.bridgelux.com

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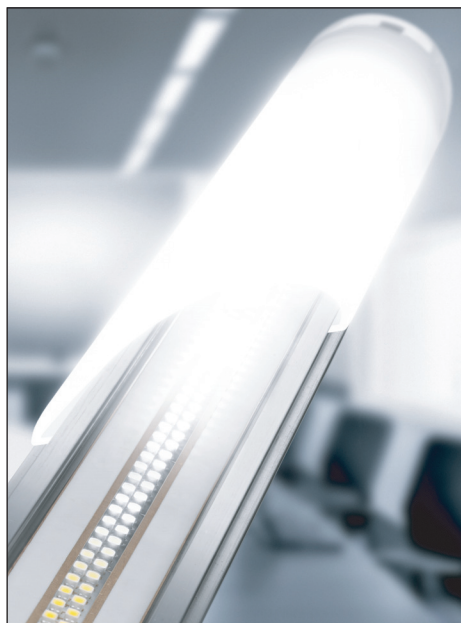
Temescal

Osram extends LED portfolio in sub-1W power range

Osram Opto Semiconductors GmbH of Regensburg, Germany has launched a new LED product family in the low-power range, starting with the DURIS E 3.

The firm says that the small dimensions and wide beam angle of the new LEDs suit applications that require uniform illumination, and the highly efficient LEDs can be used as replacements for conventional fluorescent lamps in T5 or T8 luminaires for example.

The DURIS E 3 has been designed specifically for applications that call for uniform distribution of light, high efficiency and low procurement costs. The main areas of application are hence lighting systems in industry (such as open-plan offices), production facilities, conference rooms and warehouses that have been equipped with T5 and T8 luminaires. "Bright LEDs are also recommended for smaller offers, shop lighting and signage," says Andreas Vogler, product manager SSL at Osram



Osram Opto's new DURIS E 3, which can be retrofitted as replacements for conventional T5 and T8 fluorescent lamps. Output has the appearance of a continuous strip of light.

Opto. "This new LED extends our portfolio in the low-power range."

Osram Opto claims that DURIS E 3 offers everything that is needed for uniform light. Its small size of 3mm x 1.4mm means that they can be placed very close to each other. Its beam angle of 120° ensures that in closely packed arrays the light from each LED overlaps that from its neighbor, yielding an extremely uniform distribution of light. Individual points of light can no longer be seen; instead, the impression is of a single bright strip of light.

The LED covers the entire white color spectrum with color temperatures from 3000K to 6500K, e.g. at a color temperature of 5000K it offers a color rendering index (CRI) of 72 and an efficiency of 110lm/W, suiting industrial applications.

This summer, Osram Opto will debut the next member in the new family of low-power LEDs (the DURIS E 5, providing a high luminous flux and package dimensions of 5.6mm x 3mm).

www.osram-os.com/duris

Osram sues Samsung & LG for LED patent infringement

Osram GmbH of Munich, Germany (part of the Industry Sector of Siemens, and the world's second biggest light manufacturer) has filed legal actions against Samsung group companies and LG group companies in the USA and Germany as well as an LG group company in Japan, alleging infringement of fundamental patent rights on LED technology. Osram also filed a lawsuit against LG in China.

Osram claims that Samsung and LG group companies infringe its fundamental patent rights on white and surface-mountable LEDs. The firm aims to prevent unauthorized use of its technology and seeks orders from the courts to prevent Samsung and LG from importing and selling infringing LEDs and products containing these LEDs, such as LED-backlit TV sets and computer monitors. In addition, Osram is applying for compensation.

The LED technologies protected by Osram patents relate to the electrical and thermal connection structure as well as to conversion technology, which is used to convert the blue light of the LED chip into white light.

Osram says that, by taking royalty-bearing licenses, firms worldwide have recognized the value of its patents on conversion technology.

"Our objective in taking legal actions against Samsung and LG group companies is to prevent unauthorized use of our valuable technology," says Aldo Kamper, CEO of LED-making subsidiary Osram Opto Semiconductors. "We have a considerable number of patents which we developed in the course of many years of intensive research and development work," he adds. "Competitors such as Philips/Lumileds, Cree, and Nichia have acknowledged our strong IP position by entering into cross-license agreements."

In response, Samsung LED Co Ltd has filed a patent infringement lawsuit against Osram Korea Co Ltd and two Korean sales agents (Barun Electronics and Dabo Industrial System) at the Seoul Central District Court requesting an injunction from unauthorized use of its intellectual property as well as monetary damages.

The eight patents-in-suit relate to LED chip and packaging technology used in LED light lenses and high-power applications. Samsung LED has about 700 US patents and patent applications and about 2000 Korean patents and patent applications related to LED technology.

"We are developing evidence to show that Samsung LED is not infringing any valid claim of Osram's patents, as well as evidence of Osram's unauthorized use of our patents," says Jun Sung Park, VP & head of the IP and legal affairs team.

Brilliant-Mix of white & amber LEDs yields 110lm/W, 92-CRI warm-white

Osram Opto Semiconductors GmbH of Regensburg, Germany has unveiled a new 'Brilliant-Mix' LED concept for warm-white light, which it claims achieves 30% greater luminous efficacy (110lm/W) with a high color rendering index (CRI) of more than 90.

The new intelligent color mixing concept is based on the use of Osram Opto's OSOLON SSL LEDs in EQ-White and Amber colors, which cover a broad white spectrum of 2700–4000K. Measuring just 3mm x 3mm, the LEDs are among the smallest in the 1W class and can be closely clustered, making color mixing easier and also improving the optical design at system level, claims the firm. Depending on the required luminous flux, a different number of LEDs can be combined to produce warm-white light of high quality for general illumination.

The main applications for the new concept include high-quality lighting for residential and commercial premises such as shops and offices. The high quality of light is based on the combination of a pleasant warm tone and very high color rendering properties. Osram Opto says that the high CRI ensures that colors and skin tones appear in artificial light as naturally as they do in normal daylight. Test colors R9 (saturated red) and R13 (skin colors) are crucial for the natural rendering of red and skin tones. With CRIs of 78 and 98 respectively, the LEDs have much higher values than most conventional light sources. The typical value for the general color rendering index Ra (averaged sum of test colors R1–R8) is 92 at a color temperature of 2700K.

The luminous efficacy is also very high, at more than 110lm/W. For a comparable color temperature and comparable CRI, that is 30% higher than warm-white LEDs that produce white light using the principle of phosphor conversion. Even in a retrofit lamp system, the concept can achieve 100lm/W at system



Osram's Brilliant Mix LED concept.

level, reckons Osram Opto.

To help users to select and order the appropriate LEDs, Osram Opto has developed a logistical module concept. "Planning and implementing LED lighting systems requires an immense amount of calculation, so we are relieving our customers of this tiresome task," says Christian Neugirg, business development manager SSL at Osram Opto. "Customers simply have to tell us the light color, the temperature of the board and the luminous flux they want to achieve, and our logistical module concept then works out which LEDs and how many need to be ordered to meet these requirements perfectly," he adds.

Osram Opto also offers application support for selecting the correct electronic control. Lamp and luminaire makers hence have new opportunities to create LED lighting solutions with warm-white light and high brightness levels, it says.

The Brilliant Mix concept has already been implemented by parent lighting firm Osram in its Parathom Pro Classic A 80 LED lamp and in its PrevaLED (a new LED directional light modular system).

www.osram-os.com

SPIE Technology Achievement Award for UIUC's Coleman

The awards committee of SPIE (the international society for optics and photonics) has announced its 2011 SPIE Award recipients.

James J. Coleman, the Intel Alumni Endowed Chair in Electrical and Computer Engineering & professor of Materials Science and Engineering at University of Illinois at Urbana-Champaign, is has received the SPIE Technology Achievement award in recognition of his "seminal contributions to the methods, designs, and demonstrations of selectivity grown discrete and monolithically integrated compound semiconductor lasers and photonic devices".

"I am very familiar with the large body of truly innovative and world-class research that professor Coleman has produced," says Joe C. Campbell, Lucien Carr Professor of Electrical and Computer Engineering at the University of Virginia. "His work to demonstrate the use of strained-layer materials in a new class of semiconductor lasers for optical fiber pumps resulted in a worldwide expansion of fiber-optic systems owing to the use of fiber amplifiers," he adds. "It is hard to fully describe the impact of these events on the communications technology, (and) professor Coleman's role in these events was essential and pivotal."

Coleman is a member of SPIE, and is a long-time contributor to several SPIE conferences. He served as a conference program committee member for the Active and Passive Optical Components for Communications conference for seven years.

The SPIE Technology Achievement award (which carries an honorarium of \$2000) is awarded annually to recognize outstanding technical accomplishment in optics, electro-optics, photonic engineering, or imaging. Recipients should have contributed significantly to advancing one or more of these areas with specific demonstrations or applications.

<http://sil.mntl.illinois.edu/coleman>

IN BRIEF

Luminus launches 100lm/W HB-LED for general lighting

Luminus Devices has launched the SSM-80 LED, a high-efficacy and high-brightness warm-white LED for general lighting (sampling now, with volume shipments starting in late summer).

The product is designed for indoor directional and spot lighting applications and will have an initial release in warm-white color points of 2700K, 3000K, 3500K and 4000K, at which it can achieve up to 100lm/W at 350mA and more than 1600lm at its top end rated drive condition.

"In a direct response to the demands of our general lighting customers and a rapidly growing market, the SSM-80 combines high lumens and high efficacy in a small emitting area, which enables tight beam control and provides new degrees of creativity and innovation for spot lighting applications," says Chuck DeMilo, global director of product marketing for Luminus' Lighting Business Group. "It enables lighting fixture designers to achieve light intensity levels for applications such as retail track that approach the levels of ceramic metal halide," he adds.

The SSM-80 is tested and binned at a nominal input drive condition of 1A and 12V, which makes it electrically compatible with a wide array of commercially available off-the-shelf drivers and ballasts. Other features include a thermal resistance of less than 1.0°C/W and an L70 lifetime greater than 60,000hrs.

The new LED is suited to applications including spot lighting, narrow beam down lights and focused general lighting applications where high performance and efficacy in a standard surface-mount package are needed.

www.luminus.com

Luminus and T-Opto launch single-source 6500lm LED module

Luminus Devices Inc of Billerica, MA, USA, which manufactures PhlatLight (photonic lattice) LEDs for illumination applications, and T-Opto (a division of Toyota Tsusho America Inc), which provides optically, thermally and electrically validated LED-based light engines and modules, have announced the introduction of the SoloLux high-output LED module, a high-efficacy sub-system for high-lumen general lighting applications that typically use a 175W metal halide source.

SoloLux is designed for indoor and outdoor installations requiring many thousands of lumens such as parking area, roadway, canopy, high-bay and high-ceiling downlights. The patent-pending module produces up to 6500lm from a single source, which reduces fixture cost and complexity compared with alternative solutions that use arrays of low-power LEDs, it is claimed.

"SoloLux sets a new standard for LED modules by providing the lighting community with a single-source, field-upgradeable solution with real optical punch," reckons Jim Hunter, VP & general manager for Global Commercial Markets at Luminus. "The module is based on Luminus' 'big chip' LED technology, which provides our lighting cus-

tomers with the opportunity to develop creative and differentiated high-performance fixtures," he claims. "We are seeing real innovation in the marketplace with the technology, such as indirect lighting fixtures that are low glare and eliminate multi-source shadowing."

"Field upgradeability is a real key to the strategy behind the SoloLux," comments T-Opto's general manager Michael Handerhan. "As LED performance continues to improve, fixture performance can be upgraded by replacing the chip-on-board LED with a standard screw driver," he notes. The SoloLux comes with integrated heat sinking and an electrical interface to standard ballasts, accelerating time to market, it is reckoned. "In addition, we have created reference designs for our customers, including custom optics, for targeted applications such as outdoor area lighting and high bay," Handerhan adds.

SoloLux is available in color temperatures ranging from warm to cool, and is in the process of attaining LM-79, UL1598 and ULIP66 accreditations. The LED module will be available for sampling this summer, with volume availability shortly thereafter.

www.t-opto.com

Mouser to distribute Luminus' LEDs

Luminus has announced a global distribution agreement enabling Mouser Electronics Inc of Mansfield, TX, USA to bring its LEDs quickly and efficiently to lighting design engineers and buyers worldwide. The agreement should speed to market what are claimed to be the industry's only big-chip LEDs.

Mouser says that Luminus' patented big-chip LEDs are among the brightest and most versatile solid-state light sources available, enabling the creation of innovative new products and applications.

"Demand for the solid-state lighting industry's only large-footprint LED has grown rapidly in the past 12-24 months," says Jim Hunter, Luminus' VP & general manager, Global Commercial Markets.

"Mouser is uniquely qualified to help Luminus meet this demand," he adds. "Big-chip LEDs provide Mouser's customers with a new, long-lasting, solid-state lighting solution that is ideally suited for future innovative products currently in the research and design phase."

www.mouser.com/luminusdevices

Optogan appoints international sales director

European LED chip and luminaire maker Optogan has appointed Ove Sørensen as its new director sales & business development EMEA, responsible for the development of its international sales network in Europe, Middle East and Africa.

Sørensen will be based in Landshut, Germany and will conduct the international business expansion of Optogan Group into new markets. He will also work on a worldwide distribution and trading network with solid-state lighting (SSL) manufacturers.



Ove Sørensen, the new International Sales Director at Optogan GmbH.

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. In addition to 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. Also, after founding CJSC Optogan in Russia in 2009, in May 2010 it acquired an industrial facility in St Petersburg, where it has established LED component and luminaire production lines.

Optogan says that its products have experienced an uninterrupted boom in Russia. In 2010 the firm launched its international sales activities. Due to rapidly increasing demand in global markets for LEDs 'made in Germany', Optogan Group has reinforced its activities by creating the new position of director sales & business development EMEA.

Sørensen has broad experience in international sales, marketing and management, says Markus Zeiler, Optogan Group's general manager Global Sales & Marketing. Before joining Optogan, Sørensen worked at Philips Lumileds in Eindhoven, The Netherlands, initially (from 2004) as sales manager for Great Britain, Benelux and Scandinavia, then since 2007 as sales director for Northern and Eastern Europe, contributing to the introduction of high-power LEDs into emerging markets and significantly expanding Lumileds' customer base.

Previously, Sørensen held senior sales & marketing positions at various companies, including Sales Director Government, building up a government-oriented tender business for Holland's biggest system integrator.

"Our first priority in international sales is the latest generation of chip-on-board and customized LED modules," says Zeiler. "We are also working with our SSL customers, the leading luminaire manufacturers, to build a partner network for the Russian market," he adds.

www.optogan.com



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Intense launches 20W 793nm multi-emitter pump

At Laser World of Photonics 2011 in Munich, Germany (23–26 May), Intense Ltd of North Brunswick, NJ, USA, which makes monolithic laser array products, high-power single-emitter laser diodes and electro-optical subsystems, launched prototype versions of its next-generation Series 8000 793nm high-power pump laser diode module.

The new multi-emitter pump module delivers 20W of output power from a 105 μ m-core fiber with a 0.15 or 0.22 numerical aperture (NA). It is designed to meet growing demand for laser pumps in the field of eye-safe, thulium-doped fiber-laser systems. The pump module is used in defense & aerospace applications (such as LIDAR and direct infrared counter-measures) and to replace existing diode-pumped solid-state (DPSS) technology in medical and industrial applications.

Intense says that the Series 8000 793nm standard Mini-Fiber Packages (MFP) provide a robust and cost-



Intense's new lasers.

effective solution for applications with power requirements in the 4–5W range. The same high-power chip technology used in the 793nm MFPs is now available in the new multi-emitter packages, designed

to yield a maximum optical pump power of up to 20W. The building block 4–5W laser diodes can also be supplied in free-space configuration on C-mount with a FAC-lens, or on isolation sub-mounts.

"The multi-emitter modules with the next generation of 793nm chips are an important extension of the 793nm MFP product line that incorporates a single laser diode and yield of about 4.5W fiber-coupled output power," says CEO Berthold Schmidt.

The Series 8000 793nm pump laser diode module is based on Intense's next-generation 793nm single-emitter chips, which incorporate an improved asymmetric waveguide design with narrow beam divergence and Intense's patented Quantum Well Intermixing (QWI) technology to maximize power and reliability.

The prototypes are available on a limited basis to key OEM partners, in preparation for a full product launch in 2012.

www.intenseco.com

Operating temperature performance of QC Mini Stacks extended

Intense has launched the next generation of its Hermes 650W Mini Stack.

The Mini Stack is an ultra-compact quasi-continuous-wave (QCW) stack offering maximum brightness at high operating temperatures. It incorporates new, high-power 808nm laser bars designed for extending performance across a broad range of operating temperatures. A high-brightness stack, it has an emission area of just 2.8mm x 2.8mm and generates an optical output in excess of 8kW/cm² operating with ~300 μ s pulses.

The 650W Mini Stack is designed for handheld DPSS (diode-pumped solid-state) laser systems, which require a reduced footprint/weight ratio, and improved battery life and system performance under harsh conditions. The Mini Stack has been fully qualified to military standard

MIL-STD-810F, including storage temperature cycle (-57°C to 75°C), mechanical shock (>20K shots at 1000G), and more than 250,000 shots of continuous operation. The design can be produced for standard wavelengths of 808nm and 940nm. Custom wavelengths, including multi-color options, are available.

"The Mini Stack offers more than 50% higher optical power density than common 2kW stacks that use standard bar technology," claims chief commercial officer Kevin Laughlin. "The new bar designs offer improved performance over a wider range of operating temperatures," he adds. "This, combined with a compact footprint and small emission area, makes the Mini Stack ideal for high-power end pumping of DPSS laser sources."

The standard 650W Mini Stack supports operating temperatures

from -40°C to 70°C. The new, high-temperature versions of Intense's QCW bars and stacks now meet output specifications at operating temperatures as high as 130°C. Power levels and emission areas can be custom designed for OEM requirements.

"The Mini Stack's ultra-compact form factor and high optical power density offer a real opportunity to reduce size and cost," says Laughlin. "They can dramatically improve system operating efficiency for solid-state laser manufacturers currently using flash lamps or standard diode bar pump technology. As a direct result of our latest development efforts, Intense is now in the position to provide these stacks in combination with a whole new generation of laser bars designed to operate under the most challenging environmental conditions."

Georgia Tech uses VI's 850nm VCSEL for record 25Gb/s POF link

Scientists at the Georgia Institute of Technology in Atlanta, GA, USA have demonstrated a plastic optical fiber (POF) data link using an ultra-high-speed 850nm vertical-cavity surface-emitting laser (VCSEL) from VI Systems GmbH of Berlin, Germany for error-free data transmission over 100m of 80µm-diameter core POF at a record speed of 25Gb/s. The coupling tolerances to reach error-free transmission (defined as a bit-error ratio $<10^{-12}$) were as high as $\sim 35\mu\text{m}$. Plastic optical fibers are more typically used at lower data rates from 50MB/s to 1Gb/s in automotive and home network applications and with light wavelengths near 650nm.

VI is a spin-off of the Technical University of Berlin and the A. F. Ioffe Physico-Technical Institute in St Petersburg, Russia that provides laser and photo-detector chips and modules (optical engines and optoelectronic components for communication, industrial, and consumer

applications). The firm hails Georgia Tech's achievement as a key milestone proving the applicability of advanced VCSELs for low-cost high-speed optical data transmission over 100m distances.

Optical data transmission of up to 40Gb/s has been realized using VI's high-speed photodetectors and transimpedance amplifiers (TIAs). The V40-850C chip is available in a 250µm x 250µm single die size or as a 1x4- or 1x12-channel chip array. Target applications are proprietary optical links and active optical cables (AOCs) at 40 and 100Gb/s, Fibre Channel at 14Gb/s and 28Gb/s, and Infiniband FDR (14Gb/s) and EDR (26Gb/s) applications. Product samples are available.

VI gave an update on its VCSEL and photodetector technology at the Fibre Channel Industry Association meeting in Coeur d'Alene, ID, USA (8–12 June).

www.v-i-systems.com

www.gatech.edu

Modulight launches multi-chip red laser modules

At the Laser World of Photonics show in Munich, Germany (22–26 May), laser manufacturer Modulight Inc of Tampere, Finland announced the expansion of its FiberLight product family with the addition of multi-chip red laser modules for industrial, display and medical applications.

The new products fill the gap between the butterfly-packaged single emitters and fiber-coupled laser arrays already in the FiberLight family. The modules can host up to four laser diodes, which are coupled to a single 200µm-core fiber with an NA of 0.22 and terminated with a standard SMA-905 connector. A typical configuration includes a thermistor and a thermoelectric cooler (TEC) element for temperature control and a

photodiode for power monitoring.

Wavelengths and power levels available as standard multi-chip laser module products include:

- 635nm (1W, 3-chip; 1.5W 4-chip);
- 650nm (2W 3-chip; 3W 4-chip);
- 670nm (2.5W 3-chip; 3W 4-chip);
- 680nm (2.5W 3-chip; 3W 4-chip).

"The single-emitter approach is beneficial compared to an array approach in terms of better heat management, higher power per emitter, and better brightness," says Dr Tommi Hakulinen, product engineer responsible for fiber-coupled products. "In addition, the laser diodes are wired in series, leading to a low operation current, which is often beneficial from the system design point of view."

www.modulight.com

OSA announces 2011 award winners

The Washington-based Optical Society (OSA) has announced the 18 recipients of its awards and medals for 2011. "This year's recipients have demonstrated significant contributions to the field of optics and photonics," says president Christopher Dainty.

Awards and winners include:

- The Frederic Ives Medal/Jarus W. Quinn Prize (the highest award conferred by OSA for overall distinction in optics) to Ivan P. Kaminow of University of California, Berkeley, for pioneering research in high-speed modulators, ridge waveguide lasers and wavelength-division-multiplexed optical networks (each of which has had a profound impact on modern communication systems).

- The Nick Holonyak, Jr. Award (for contributions to optics based on semiconductor-based devices and optical materials, including basic science and technological applications) to Yasuhiko Arakawa of University of Tokyo, for seminal contributions to quantum dot lasers and nanophotonic devices.

- The William F. Meggers Award (recognizing outstanding work in spectroscopy) to Steven T. Cundiff, a fellow of JILA (formerly the Joint Institute for Laboratory Astrophysics) — a joint institute of National Institute of Standards and Technology (NIST) and the University of Colorado, USA — for contributions to ultrafast spectroscopy of semiconductors (including multi-dimensional Fourier transform techniques) and contributions to the development of femtosecond frequency comb technology.

- The John Tyndall Award (recognizing contributions to fiber-optic technology, co-sponsored by the IEEE Photonics Society) to David F. Welch of Infinera in Sunnyvale, CA, USA, for his seminal contributions to photonic integrated circuits (PICs) and semiconductor lasers deployed in fiber-optic communication systems around the world.

www.osa.org

GigOptix's product revenue rises 7% in Q1 to record \$7.1m Government contract revenue hit by suspension of program support

For first-quarter 2011, 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 revenue of \$7.7m, up 45% on \$5.3m a year ago but down 6% on \$8.1m last quarter.

However, this is due to government contract revenue being down sequentially by \$0.9m to \$0.6m due to the suspension of a number of federal earmarks by the US Congress in fall 2010.

Nevertheless, product revenue is up 37% on a year ago and 7% sequentially (exceeding guidance of 5%) to a record \$7.1m, driven by increasing demand for high-speed fiber-optic communication electronic devices. "The achievement of record product revenue during the first quarter is directly attributable to successful execution on our business initiatives as we continued to focus on product development for the high-growth 40G and 100G markets," says acting chief financial officer Jeff Parsons.

On a non-GAAP, gross margin of 51% is down from 52% a year ago and 56% last quarter due to the decline in government contract revenue. Total operating expenses were \$7.2m, up from \$4.6m a year ago and \$4.5m last quarter, due mainly to a one-time cash charge of \$1.1m from the acquisition of Endwave Corp of San Jose, CA (which designs and manufactures high-frequency RF solutions and semiconductor products, particularly point-to-point (PTP) radio communication systems), a one-time non-cash charge of \$1.1m related to the issuance of warrants in conjunction with settlement of litigation with DBSI, and a non-cash charge of \$0.7m of stock-based compensation expense.

Although cut from \$1.1m a year ago, net loss of \$0.4m compares with net income of \$0.6m last quarter. Compared to a \$0.4m loss a year ago,

adjusted EBITDA of +\$45,000 is down from +\$1.2m last quarter due to one-time events. During the quarter, cash and investments fell from \$4.5m to \$4.1m. However, the drop is offset by a \$0.4m decrease in the firm's line of credit with Silicon Valley Bank, and is due mainly to the one-time expenses from the Endwave acquisition.

"We continue to work diligently with the government to release our \$4m 2011 earmarked projects and hope to reach a resolution in the near future," says chairman & CEO Dr Avi Katz.

"We continued to build momentum for our 40G TIAs and 100G MZM [Mach-Zehnder Modulator] optical driver devices by securing design wins at a number of Tier 1 customers," says Katz. "We were pleased to announce a \$750,000 purchase order for our 100G quad driver, which we expect to ship in the second and third quarters of 2011, and started shipments of the first-ever TFPS [Thin Film Polymer on Silicon] modulators, initially with the 40G DPSK TFPS MZMs for evaluation by large number of Tier 1 telecom customers," he adds. GigOptix demonstrated the industry's first production 40G DPSK TFPS MZM and 100G quad MZM driver at March's Optical Fiber Conference (OFC 2011).

"Looking forward, we aim to continue capitalizing on the industry's accelerating adoption of higher-speed next-generation networking solutions with our broad and growing portfolio of industry-proven 40G and 100G solutions," says Katz.

"We continue making progress toward our goal of closing the transaction in the second quarter of 2011," says Katz regarding the Endwave acquisition. "This merger will yield a number of strategic synergies positioning GigOptix as a comprehensive one-stop supplier to an expanded Tier 1 customer base for all high-frequency wireless and high-speed optical communication needs," he adds.

"First, the products of both companies serve the increasing demand by consumers for more bandwidth and enhanced connectivity. Both GigOptix's high-speed optical communication systems and Endwave's high-frequency wireless PTP radio solutions are highly complementary and will provide common Tier 1 telecom OEM customers with a more complete end-to-end data connectivity solution," Katz continues.

"Second, both companies utilize similar semiconductor technologies, design techniques and product architectures to implement their high-frequency high-speed solutions. Our combined engineering expertise will better enable us to provide industry-leading high-speed and high-frequency RF solutions to serve customers' growing needs for faster solutions in both wireless mobile backhaul and optical networks," he adds.

"Third, both GigOptix and Endwave share many of the same large telecom OEM customers, enabling the combined company to leverage established customer relationships of each respective company, strengthening its position with all of its networking customers," Katz believes.

"Lastly, it is our expectation that this merger will strengthen our balance sheet, and is expected to result in estimated consolidated cash and liquid investments of approximately \$16m upon the transaction close, providing a solid financial platform for future growth," Katz reckons. "We believe the merger will also generate significant cost savings, including notable manufacturing cost efficiencies as well as operational cost savings," he adds. GigOptix expects most of the operational integration process to be complete early in third-quarter 2011.

"Another positive development for the company since the quarter closed was our settlement agreement with the trustees of the DBSI Liquidating Trust and DBSI Estate

► Litigation Trust,” notes Katz. “All disputes have been resolved and the trustees agreed to release all claims against GigOptix, its subsidiaries, directors and employees. The trustees also agreed to cancel and return its original GigOptix common stock warrants in exchange for two replacement warrants, both of which are not exercisable for a period of six months from the date of issuance,” he adds. “This settlement was in the best interest of GigOptix and its shareholders in that it prevented any additional legal expenses and the unnecessary use of management’s time associated with a potentially lengthy litigation,” believes Katz. “I am very pleased to have resolved this issue on a non-cash basis, which allows us to preserve our existing capital and focus our resources on driving growth and expanding our business.”

For second-quarter 2011, GigOptix expects product revenue to rise by 5% sequentially. “In terms of our government contract revenue, we continue to aggressively lobby the US Congress to reinstate the federal support of our On-Chip Integrated Photonic Polymer Transceiver program,” notes Parsons. “At this time, we are unable to determine whether our efforts will be successful, and so our revenue outlook for government contracts is difficult to forecast. We will therefore not be providing guidance on this segment,” he adds. In February, GigOptix said that it expected the program suspension to impact about \$4m of its federal funding (as part of the Department of Defense Appropriations Bill) that it expected to realize during 2011.

“Looking forward, we are focused on continuing to grow our product revenue as we build on the momentum from our 40G and 100G products and leverage our leadership position as the industry’s only pure-play semiconductor provider of high-speed communication components and sub-assemblies to drive additional growth,” Parsons concludes.

www.gigoptix.com

40G MZ modulator completes system-level tests at tier-1 transponder makers

GigOptix says that its LX8401 40G Mach-Zehnder modulator — implemented using its proprietary Thin Film Polymer on Silicon (TFPS) technology — has achieved two milestones in its product commercialization: validation of its performance by tier-1 customers in system-level tests; and completion of the demanding High Temperature Operating Lifetime (HTOL) reliability assessment (a Telcordia GR-468 requirement) without degradation in operating performance.

System-level performance tests were carried out in working transponders where results could be more easily compared with those of competing lithium niobate modulators from leading suppliers. GigOptix says the LX8401 exhibited excellent optical performance compared with the competing modulators while providing advantages in terms of smaller footprint and much lower power consumption.

The system-level tests were performed after the LX8401 had completed 2000 hours of HTOL testing (a critical milestone in the suite of Telcordia GR-468 reliability assessments that customers require for all components sold into telecom equipment). The HTOL test assesses the reliability of a modulator by stressing it at high temperature for 2000 hours while it is modulating a

1550nm laser and being driven by a high-speed electrical RF signal. This test simulates an accelerated 25-year lifetime of the product. After testing, the LX8401 showed no degradation in performance, including key parameters such as insertion loss, drive voltage, extinction ratio and bandwidth. Further reliability tests are in progress, with full Telcordia reliability assessment due to be completed by Q3/2011.

“These successful tests prove that the LX8401 modulator based on our proprietary TFPS technology demonstrates both reliable and competitive performance,” says Dr Raluca Dinu, VP & general manager of GigOptix Bothell. “Customers are demanding innovative solutions to address the growing demands of more bandwidth by consumers with smaller, faster and more power efficient solutions,” she adds. “We look forward to enabling further innovation and releasing more competitive products that leverage this technology in standalone and higher-integration architectures.”

TFPS technology enables what is claimed to be industry-leading low drive voltage (reducing power consumption by over 20% versus competing modulator technologies) in the smallest form factor available (allowing smaller 300-pin optical transponders).

LX8220 modulator sampled for 40G DQPSK

After deploying its first productized TFPS Mach-Zehnder modulator last year (LX8401, for 40G DPSK), GigOptix has expanded its range by sampling the LX8220 for the fast-growing 40G differential quadrature phase-shift keying (DQPSK) modulation market.

“By using a successful MZM production flow, we were able to bring this product to the market quickly,” says Dr Raluca Dinu, VP & general manager of GigOptix-Bothell.

The LX8220 is a small-form-factor, low-power-consumption modulator designed for 40G metro, long-haul and ultra-long-haul optical transport. TFPS technology provides what is said to be the market’s lowest-power, smallest-footprint modulator.

In a recent report on 100G and 40G components, Ovum forecasted that the 40G DQPSK DWDM market would grow at a compound annual growth rate (CAGR) of 66% to more than 68,000 units by 2015.

IN BRIEF

3S agrees strategic partnership with Brazil's Boreal for South America

3S Photonics Group of Nozay, France, which manufactures chips, optical discrete modules and passive components for the laser, sensing and telecom markets, says that Boreal Communications will serve as its sales representative in South America and, more specifically, the Brazilian market. Boreal will provide sales and support services, enabling continued distribution of 3S' products in this region.

Boreal Communications was founded in 1997 in California, USA, with offices strategically located in Campinas and São José dos Campos, in the state of São Paulo, Brazil. It started by offering services such as purchasing, marketing, consulting and sales for firms in San Francisco Bay Area. Boreal has since established an infrastructure of technical sales in Brazil to serve the market for telecoms infrastructure and for services, components, equipment and software in the whole of Latin America.

3S says that the agreement illustrates its ambition to pursue its international expansion and should contribute to its aim to grow turnover to \$100m by the end of 2012. It adds that, by working with Boreal, it both enlarges its distribution channel in South America and better serves the customer base in that specific area, participating in the rapidly growing markets of South America.

"It represents a new step on the path to fulfilling our ambition to strengthen our international position and our global growth", comments president & CEO Alexandre Krivine.

www.3Sphotonicsgroup.com
www.borealtec.com.br

M/A-COM Tech buys modulator driver and TIA designer Optomai IC firm expands fiber-optics business for high-speed 40/100G networks

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) has acquired privately held Silicon Valley-based firm Optomai Inc.

Optomai is a fabless semiconductor company that develops high-performance integrated circuits and modules for next-generation 40Gbps and 100Gbps fiber-optic networks. Its product portfolio includes high-speed optoelectronic ICs such as 40G and 100G laser modulator drivers and transimpedance amplifiers (TIAs) for both line-side and client-side applications. Its expertise in gallium arsenide and indium phosphide circuit design complements M/A-COM Tech's existing CATV/broadcast and point-to-point/infrastructure businesses, and accelerates its penetration of the rapidly growing optical communications market.

"With user demand for data driving exponential bandwidth growth, it is

paramount that our telecom and datacom customers achieve high performance with cost-per-bit efficiency," says M/A-COM Tech's CEO Chuck Bland. M/A-COM Tech says that Optomai has a business and engineering team with a proven track record in the optical communications industry. "Optomai products are designed-in as innovative, compact, and cost-effective solutions that enable high-speed 40/100G networks, and the joined teams have the expertise to further expand our fiber-optics business," he adds.

"M/A-COM Tech offers the quality brand and reputation of a top-tier IC solutions provider, and the sales channel and operational scale to make Optomai products pervasive in the marketplace," says Optomai's CEO Vivek Rajgarhia (now general manager of M/A-COM Tech's Optoelectronics business unit). "Together we will deliver significant value to our combined customer base."

www.macomtech.com
<http://optomai.com>

GigOptix signs WPG as ASIC product line distributor in the Americas

GigOptix Inc of Palo Alto, CA, USA, which designs modulator drivers, laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials, has signed WPG Americas Inc (WPGA) of San Jose, CA — said to be one of the top three IC component distributors worldwide — as its sole distributor for application-specific integrated circuits (ASICs) in the Americas.

WPGA will distribute the firm's Standard Cell, Hybrid and Structured ASICs throughout the Americas. GigOptix says that these ASIC products are particularly well suited for military/aerospace, industrial,

medical & communication markets and align well with WPGA's current line-card offerings.

"Our partnership with WPG Americas will further support our growing penetration into North, Central and South America ASIC market," says Jay de la Barre, VP of sales. "The breadth of experience and customer relationships of WPG Americas will be a great asset," he adds.

"GigOptix has a strong portfolio for the mil/aero, industrial, medical & communication markets," notes Greg Provenzano, North America VP of sales and engineering solutions.

www.gigoptix.com

GigOptix sues Optomai, former staff and M/A-COM Tech

GigOptix Inc of Palo Alto, CA, USA, which designs modulator drivers, laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials as well as polymer electro-optic modulators for 40–100Gb/s fiber-optic communications systems, has filed a lawsuit on 25 April against Silicon Valley-based firm Optomai Inc and five former GigOptix employees in Santa Clara County Superior Court.

Subsequently, on 26 April, following the announcement of the acquisition of Optomai by M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components, and subassemblies for RF, microwave and millimeter-wave applications), GigOptix amended the lawsuit to name M/A-COM Tech as an additional defendant.

The lawsuit alleges that the former GigOptix employees violated confidentiality agreements with GigOptix by retaining and misusing confidential and proprietary

information to launch a competing company.

According to the lawsuit, the former employees created Optomai in 2009 and have begun selling products that directly compete with GigOptix's products. GigOptix further alleges that its technology and intellectual property were used by Optomai to develop products in violation of California law and that it is now selling its products as the 'Optomai Optoelectronics' product line of MA-COM. GigOptix is seeking damages and injunctive relief.

"GigOptix is committed to zealously protecting its intellectual property," comments chairman of the board & CEO Dr Avi Katz. "We will take every step necessary to protect the technology we have developed and to ensure that our rights, the value we have created for our shareholders and business success are not compromised."

www.gigoptix.com
www.macomtech.com
<http://optomai.com>

M/A-COM defends against GigOptix lawsuit

M/A-COM Technology Solutions Inc says that it will vigorously defend the lawsuit filed by GigOptix Inc against M/A-COM Tech Solutions, its subsidiary Optomai Inc and five Optomai employees who previously worked at GigOptix.

Filed on 26 April in Santa Clara County Superior Court, the lawsuit requests unspecified damages and injunctive relief based on as-yet unsubstantiated breach of contract and trade secret misappropriation allegations.

M/A-COM Tech says that it is still reviewing the GigOptix complaint, but is aware of no wrongdoing on the part of M/A-COM Tech, Optomai or any of their employees in this regard, and accordingly believes that the GigOptix allegations are without merit.

"M/A-COM Tech has been pleased at the positive reaction optical networking customers have had to

The Optomai product line remains available for sampling

the Optomai acquisition, and remains committed to delivering M/A-COM Tech's full portfolio of 40/100G modulator drivers and transimpedance amplifiers to its customers," says Jihye Whang, director of strategic marketing. "We anticipate a just resolution of this matter through the legal process."

No injunction has been issued by the court hearing the case to date, nor is one expected to be issued, says M/A-COM Tech. The Optomai product line remains available for sampling and production.

IN BRIEF

Conditional listing approval from NYSE Amex for GigOptix

GigOptix has received conditional approval to list its common stock on the NYSE Amex stock exchange.

Final approval of the application is subject to certain conditions, including the closing of its merger (announced on 7 February) with Endwave Corp of San Jose, CA (which designs and makes RF and semiconductor products for the wireless mobile backhaul communications, satellite communications, electronic instruments, and defense & security markets) as well as continued compliance with other listing requirements: GigOptix's common stock must maintain a market capitalization of \$50m, a minimum price of \$2 per share, and a public float of \$15m.

GigOptix common shares will continue to trade on the Over-the-Counter Bulletin Board under the symbol 'GGOX' until all of the NYSE Amex listing conditions have been met. The firm has reserved the ticker symbol 'GIG'. Subsequent to all conditions being satisfied and the shares officially trading on the NYSE Amex, GigOptix common shares will no longer be traded on the Over-the-Counter Bulletin Board.

"We are pleased to have renewed our conditional approval, which brings us closer to our goal of listing our common stock on a national securities exchange," says chairman & CEO Dr Avi Katz. "Amex listing is an important milestone and integral part of the company's development and future growth initiatives," he adds.

"We view this listing as being beneficial to both our existing stockholders as well as Endwave's holders in that it will increase GigOptix's visibility, liquidity and suitability for a broader group of investors," Katz continues.

www.amex.com

APIC and UAlbany NanoCollege partner on 'green' computer chip technology

Collaboration to integrate optics and electronics

Photonic integrated circuits (PIC) firm APIC Corp of Culver City, CA, USA and the College of Nanoscale Science and Engineering (CNSE) of the University at Albany in Albany, NY have formed a partnership (budgeted at \$10m over the next 18 months) for the joint development and commercialization of 'green' technology to enable faster computer chips that use significantly less power.

The collaboration, which integrates APIC's expertise in photonics systems and devices with CNSE's nanoelectronics resources, will result in the creation of at least 20 high-tech jobs over the next 18 months, mostly at CNSE's Albany NanoTech Complex.

The APIC-CNSE partnership targets the development and delivery of a new generation of modules and systems using PICs that combine optical communications with silicon-based CMOS technologies. As ongoing scaling continues to shrink the bandwidth of metal wiring used to connect CMOS circuits (severely limiting speed and functionality for advanced processors and multi-core systems), optical communication is a serious contender to break this bottleneck, says CNSE.

Such PIC systems will be particularly useful in addressing the explosion in bandwidth and computing

power needs — including advanced data-centers, medical research, secure financial transactions and next-generation gaming capabilities — increasing speed by up to 60%, while reducing power consumption by as much as 90%.

"The agreement reached by the APIC Corporation and UAlbany's College of Nanoscale Science and Engineering is great news for the Capital Region and further attests to the effectiveness of our public/private economic development model," says New York State Assembly Speaker Sheldon Silver. "This is how we will create jobs, spin-off business opportunities, spur technological advancement, and rebuild our state economy. With the leadership of Dr Alain Kaloyeros, Albany Nano will remain 'the place to be' for cutting-edge nanotech R&D and commercialization," he adds.

"APIC Corporation and its commercial arm PhotonIC Corp is very excited about our partnership with the College of Nanoscale Science and Engineering, a world-class education, research, development and technology resource. Combining the unparalleled capabilities of CNSE with APIC's leading-edge photonics technology will enable advanced photonics integration with electronics and accelerate its introduction into the commercial

marketplace," says APIC's chairman & CEO Dr Raj Dutt. "This joint program will expand both CNSE's and APIC's technical workforce in Albany, NY and Culver City, CA, and pave the way for further collaboration in the future."

The partnership "further builds on the vision, support and investment of Speaker Sheldon Silver and the New York State Assembly in establishing the NanoCollege and New York State as global hubs for nanotechnology innovation, education, and economic development and growth," says CNSE's senior VP & CEO Dr. Alain E. Kaloyeros. "This collaboration will enable APIC, a recognized leader in next-generation photonics technologies, to break new ground in the development of innovative photonics integrated circuits, and put CNSE at the leading edge of systems and interconnect research, development and commercialization, while enhancing the state-of-the-art capabilities at CNSE's Albany NanoTech Complex," he adds.

The partnership between APIC and CNSE also includes the potential for further R&D initiatives in the future, which may involve the location of additional APIC employees at CNSE's Albany NanoTech Complex.

www.cnse.albany.edu
www.apichip.com

Former Verizon exec Wegleitner joins Infinera board

Infinera of Sunnyvale, CA, USA says that Mark A. Wegleitner has joined its board of directors, bringing "deep experience in telecoms technology".

Wegleitner was most recently senior VP of technology at Verizon Communications Inc until his retirement last July. Responsibilities included technology assessment, network architecture, platform development and laboratory evaluation for wire-

line and wireless communications networks.

From 2000 to 2007, Wegleitner was Verizon's chief technology officer, responsible for wireline networks. Previously, he held positions at Bell Atlantic, Bell Laboratories and AT&T. His career in telecoms spans 38 years.



"Infinera's innovative technology has already had a major impact on the telecom market... it is still in the early stages of its development as a force in the global industry," says Wegleitner.

"With his years of experience at one of the world's leading carriers, he will bring valuable insights and perspective," believes CEO Tom Fallon.

www.infinera.com

CyOptics launches 10G TOSA enabling 80km TDM and DWDM capability in SFP+ transceivers

Indium phosphide-based optical chip and component maker CyOptics Inc of Lehigh Valley, PA, USA has launched a series of 10Gbps transmit optical subassemblies (TOSAs) that address the emerging dense wavelength division multiplexing (DWDM) SFP+ transceiver market, expanding its portfolio of transmitter and receiver components for optical transceivers. The new TOSAs offer a minimum 30% reduction in power consumption versus the current-generation TOSAs.

The 1655 (40km) and 1656 (80km) series TOSAs are compatible with the 10Gbps miniature device (XMD) multi-source agreement (MSA) and integrate a high-speed electro-absorptive modulated laser (EML), a monitor photodiode and a micro thermo-electric cooler (TEC) in a small-form-factor metalized ceramic package. The TOSAs operate at data rates of up to 11.3Gbps

and are available in the full range of C-band ITU-T wavelengths.

"Network equipment manufacturers are rapidly deploying SFP+ transceivers because they provide a smaller footprint and are more cost effective than XFP transceivers," says Daryl Inniss, VP & practice leader at market research firm Ovum. "The new CyOptics TOSAs enable module manufacturers to offer a complete portfolio of SFP+ transceivers. We project 10Gbps DWDM pluggable transceivers to grow at a compounded annual growth rate of over 30% from 2010 through 2013, representing one of the fastest-growing market segments in the optical component space," he adds.

"The new CyOptics TOSAs augment the application space of the SFP+ form factor to now address all types of 10Gbps applications with the inclusion of metropolitan-area 80km

TDM and DWDM links," says CyOptics' CEO & president Ed Coringrato, who claims that the firm is first to ship such TOSA technology, which enables higher system port density and lower power consumption.

The 1655 and 1656 TOSAs exhibit the same wavelength stability as their 162x predecessors, supporting operation at 100GHz channel spacing over 20 years, with low hazard rates (~100 FIT). At a package case temperature of -5°C to +75°C the 165X series consumes a maximum of 0.45W (40km, DWDM) and 0.5W (80km, DWDM), suiting SFP+ (Class II) applications. Alternatively, for industrial-temperature applications with a case temperature of -40°C to +90°C the TOSAs consume only 0.85W (40km, DWDM) and 0.95W (80km, DWDM), a reduction of about 35% from its predecessors.

www.cyoptics.com

NeoPhotonics enters volume production of PIC-based small-form-factor DQPSK demodulator for 40Gbps

NeoPhotonics Corp of San Jose, CA, USA, which designs and makes photonic integrated circuit (PIC)-based modules and subsystems for bandwidth-intensive, high-speed communications networks, says that its PIC-based small-form-factor differential quaternary phase-shift key (DQPSK) demodulator, designed for use in 40Gbps direct detection fiber-optic transport systems, is now ramped to volume production. The small-form-factor version is under half the size of the standard-form-factor DQPSK demodulator, saving board space in high-capacity systems.

DQPSK systems use delay-line interferometers (DLIs) to coherently mix the incoming signal with a delayed sample, avoiding the need for, and cost of, an external local optical reference laser. The new DQPSK demodulator integrates two

DLIs on a single photonic chip and provides in-phase and quadrature analysis of the phase-encoded signal. To accommodate the unpredictable and varying nature of the received signals, the demodulator is designed to exhibit low sensitivity to polarization variations. NeoPhotonics introduced the small form factor version of this product in fourth-quarter 2010 and achieved general availability in first-quarter 2011.

"The deployment of 40Gbps and 100Gbps transmission technologies

To accommodate the unpredictable and varying nature of the received signals, the demodulator is designed to exhibit low sensitivity to polarization variations

on the line-side places stringent requirements on the optical performance of the components used," says chairman & CEO Tim Jenks. "For example, the level of polarization dependence in our 40Gbps DQPSK demodulator must be much less than that of our typical 10Gbps products," he adds. "By using our photonic integration technology, we are able to achieve the high levels of optical performance and quality critical for these very high-speed systems."

In addition, NeoPhotonics also currently offers a PIC-based standard form factor DQPSK demodulator for 40Gbps transmission systems and PIC-based intradyne coherent receivers (ICR) and 90° hybrid coherent mixers for both 40Gbps and 100Gbps coherent transmission systems.

www.neophotonics.com

Oclaro hit by Chinese telecom inventory correction

Second-half demand and new product ramp to drive return to profit

For its fiscal third-quarter 2011 (ended 2 April), optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has reported revenue of \$116.6m, up 15% on \$101.1m a year ago but down 3% on \$120.3m last quarter (after, as usual, taking a substantial portion of its annual price reductions on 1 January). However, this was also below guidance of \$123–131m.

Revenues from greater-than-10% customers included Huawei at 18% and Alcatel at 10%. "Revenues were impacted by inventory corrections at many of our telecom customers [with about 60% of the inventory correction being attributed to China] and by a general slowing among other telecom customers, possibly attributable to caution in the phase of macro events occurring in March," says chief financial officer Jerry Turin. "Each of these conditions will continue to impact our revenues in the June quarter, and they are likely to have a more significant impact."

Due to lower sales of component-level products and an adverse impact on overhead absorption, non-GAAP gross margin has fallen from 30% last quarter to 25% (below the expected 27–31%).

Operating expenses have continued to rise, from \$27.8m a year ago and \$34.1m last quarter to \$35m. In particular, R&D expenses have risen from \$11.3m a year ago and \$15.7m last quarter to \$17.2m.

"We slowed our investment ramp in R&D, so the March increase largely represents growth that was already in the pipeline," says Turin.

Compared with \$10.1m last quarter and \$5.8m a year ago, adjusted EBITDA was only \$1.1m (much less than the expected \$6–11m). Net loss was \$4.1m, compared with income of \$5.9m last quarter and \$2.6m a year ago. Cash, cash equivalents and restricted cash continued to fall, from \$111.6m a year ago and \$78.1m last quarter to \$75.7m, after capital expendi-

ture rose from last quarter's \$11.8m to \$14.2m.

While certain telecom customers have experienced a short-term inventory correction, Oclaro has continued to invest in its new product pipeline. "We continue to make progress in our new product introductions," comments Turin. "We hope to have product revenue traction across many of these areas in the June quarter. However we would not expect this traction to deliver either meaningful revenues within the June quarter, or margin improvement in the June quarter in the case of new products at above-average margin potential," he adds.

"We expect the slowdown to continue through our upcoming fiscal fourth quarter," says president & CEO Alain Couder. For fiscal fourth-quarter 2011 (ending 2 July), Oclaro expects further declines in revenue to \$105–115m, non-GAAP gross margin to 21–24%, and adjusted EBITDA to minus \$6.5–1.5m.

"We are now qualified with customers on several new products," notes Couder. "We are ready to ramp production for the second half of this year on those new programs."

Planned new products are expected to provide revenue growth and gross margin traction in the second half of the calendar year. We also remain confident in the second half because of the continued strong demand for broadband in the core optical market, and the increasing reliance on optical functionality throughout the network

For example, Oclaro's acquisition of high-bit-rate optical transport sub-system maker Mintera Corp of Acton, MA, USA last July is starting to bear fruit, the firm says. The 40G DPSK product inherited from them continues to grow in revenue, and this summer Oclaro expects to start selling the first 40G coherent transponder.

However, the 10G market remains a very good market, says the firm. In particular, market adoption of its tunable XFP is now obvious and has significant revenue potential, Couder adds. "We have aggressive plan to ramp our tunable XFP product in the second half [of the calendar year]."

Also, following the acquisition of Xtellus Inc of Denville, NJ, USA in December 2009, in the March quarter Oclaro started shipping wavelength selective switch (WSS) reconfigurable optical add-drop multiplexer (ROADM) products to two customers, and in the June quarter it is starting to ship not only the WSS itself but also amplifiers including the WSS. "This is very meaningful revenue potential for us in the second half of calendar year," comments Couder.

"Our planned new products are expected to provide revenue growth and gross margin traction in the second half of the calendar year," says Couder. "We also remain confident in the second half because of the continued strong demand for broadband in the core optical market, and the increasing reliance on optical functionality throughout the network," he adds.

Oclaro expects the inventory correction in the telecom market to end this summer, but Couder adds that they will continue to manage the company in a conservative way until they know for sure that the growth has come back. The revenue breakeven point is probably in the low \$120m range, he adds. "That's not a substantial ramp to get back to profitability".

www.oclaro.com

Oclaro joins EPIC's Board of Governors

Optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has joined the Governing Board of the European Photonics Industry Consortium (EPIC).

Formed in 2003, EPIC promotes sustainable growth for photonics industries and R&D organisations across Europe through initiatives to build revenues, improve access to R&D resources, and develop timely market and technology information. With 80 voting members and over 400 associate members, EPIC members have played a leading role in creating and operating the European Technology Platform, Photonics-21, as well as many influential European projects, such as LIFT for fibre-laser development and Nexpresso, which supports commercial innovation by small- and medium-size enterprises (SMEs). In 2010, the return on investment (ROI) to EPIC members exceeded 11 times investment.

The Governing Board defines the principal directions of EPIC, including focus areas, strategy, resources and membership. Oclaro joins deposition equipment maker Aixtron SE of Herzogenrath, Germany; Fraunhofer Institute for Telecommunication/Heinrich-Hertz-Institute of Berlin, Germany; epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK; and French electronics firm Sagem. EPIC's Board is presided over by IQE's CEO Dr Drew Nelson.

Oclaro has been a member of EPIC since 2004. It will be represented by chief technology officer Dr Andy Carter, who has global responsibility for technology, reporting to Oclaro's CEO Alain Couder. Prior to Oclaro, Carter held



senior technology positions within Bookham, Marconi and Plessey, where was responsible for many aspects of optoelectronic device design, applications and engineering. Carter views membership of the EPIC organization as an important element in driving innovation and leadership in photonics, and is particularly significant as Oclaro has major R&D and chip manufacturing sites in Europe.

Carter was educated at Oxford University and received a D. Phil degree for his studies of impurities in semiconductors. He is recipient of the Patterson Medal from the Institute of Physics, and the GEC Nelson Gold Medal and Prize. His home base is at Oclaro's Caswell facility in the UK, where GaAs- and InP-based devices are designed and fabricated.

www.oclaro.com
<http://epic-assoc.com>

Oclaro adds high-power laser diodes for materials processing

Optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA says that it has further strengthened two of its high-power laser diode product families by delivering new, next-generation components with improved performance, reliability and cost competitiveness.

The new products (both mounted on a passive cooler) are suited to diode-pumped solid-state (DPSS) laser pumping and direct-diode applications, and were showcased at LASER World of PHOTONICS 2011 in the New Munich Trade Fair Centre, Germany (22–26 May).

"Oclaro has the technology, packaging and manufacturing expertise to continually drive innovations in power and efficiency for our existing product families," says Bernd Meyer, leader High Power Laser Business for Oclaro. "We are now expanding the capabilities of our OPC family by delivering

higher performance across a wider wavelength range and brightness — and we've also developed a new family member for the BPM/BLM mini-cooler series," he claims.

The new BLM family member represents the industry's smallest footprint and highest-power (CW) conductively cooled product, Oclaro claims. The laser diode delivers up to 120W at the 910–1070nm wavelength range and replaces

We are now expanding the capabilities of our OPC family by delivering higher performance across a wider wavelength range and brightness, and we've also developed a new family member for the BPM/BLM mini-cooler series

micro-channel coolers in horizontal configurations for DPSS pumping and direct-diode applications. To ensure easy integration, the new BLM9xx/10xx replaces soldering or wire bonding with mechanical electrical connection and mounting.

The new OPC family member is a 60W continuous-wave (CW) low-filling-factor bar at the 875–890nm wavelength range. The new high-power laser diode will be used in Oclaro's own Prosario collimated modules, fiber-coupled packages and will also be available to Oclaro customers as a passively cooled bar.

Oclaro says that, by expanding the wavelength range of the existing OPC family, the new OPC880 enables it to enter the new and growing 880nm neodymium-YAG and neodymium-vanadate pumping market.

www.oclaro.com

JDSU demos first end-to-end 16G Fibre Channel system

At both Interop and EMC World 2011 in Las Vegas (9–12 May), JDSU of Milpitas, CA, USA participated in multiple storage network technology demonstrations.

In conjunction with Emulex Corp of Costa Mesa, CA (which provides converged networking solutions for the data center), JDSU was part of the first public demonstration of an operational end-to-end 16G Fibre Channel system, consisting of the JDSU Xgig test solution and the Emulex XE201 I/O Controller (launched at the beginning of May), showcased at both EMC World 2011 and Interop.

JDSU says that 16G Fibre Channel is a critical technology required to meet the rise in cloud computing demand and the tremendous growth of fixed and mobile voice, video and data traffic driven by social networks, remote applications, and Internet commerce. With the Xgig for Fibre Channel testing, JDSU is delivering solutions needed by storage equipment manufacturers, field service engineers, and data-center IT professionals to effectively maintain, provision, and access the next-generation

storage equipment critical to running today's businesses.

JDSU launched the 16G Fiber Channel Analyzer blade for the Xgig 5000 in December 2010, providing the market with the world's first complete 16G Fibre Channel test solution. The Xgig now offers a new 4-port blade as well as advanced Jammer and Load Tester capabilities, making it the only tool

enabling NEM storage vendors to solve difficult 16G design issues and ensure robust performance while getting products to market in the shortest possible time. Vendors can also share traces with their eco-system partners to facilitate interoperability testing as additional 16G Fibre Channel equipment comes to market.

www.jdsu.com

JDSU's Medusa Labs Test Tools suite used to demo Dell's iSCSI over DCB technology

JDSU also took part in a demonstration with Dell highlighting their latest iSCSI over DCB data center storage technology within their EqualLogic storage solution operating in a converged network environment. EqualLogic's iSCSI over DCB leverages the enhancements characterized as Data Center Bridging (DCB) technology, adding the reliability that Enterprise customers require for their data center storage needs. Dell is currently leveraging JDSU's recently released new-generation Medusa Labs

Test Tools (MLTT) 5.0 test suite to provide advanced analysis and benchmarking capabilities of storage systems characterizing the impact of sharing the bandwidth with other applications. This demonstration took place in Dell's booth at Interop.

In addition, as a member of the Ethernet Alliance, JDSU was also part of a live demonstration at Interop in the Ethernet Alliance booth, showcasing some of the latest products developed for use in next-generation data centers.

Mitsubishi launching 40G DQPSK quad PD module

Tokyo-based Mitsubishi Electric Corp has launched a compact, power-saving 40Gbps differential quadrature phase-shift keying (DQPSK) photodiode (PD) module for optical signal reception in transmission devices used to send large data volumes between metropolitan areas. The firm expects to sell about 500 units per month of the FU-387SPP.

Mitsubishi Electric says that, as optical communication networks transmit increasingly large amounts of data over long distances, needs are mounting for higher transmission speeds and densely spaced wavelength division multiplexed channels using multi-level formats such as DQPSK. Transmission devices commonly use two PD modules as a set, each comprising two

photodiodes and two transimpedance amplifiers (TIAs). However, Mitsubishi Electric's new module combines these components in a single, smaller and integrated package, with a single 3.3V voltage source for the PD bias voltage (V_{pd}) and the TIA supply voltage (V_{cc}).

The 40Gbps DQPSK quad PD module integrates four photodiodes and two TIAs in one 11.0mm x 14.9mm x 6.7mm package, contributing to the downsizing of optical transmission equipment. The energy-efficient device also features what is claimed to be industry-leading low power consumption of 0.6W at 25°C.

New surface-illuminated photodiodes also achieve low polarization-dependent loss (PDL) of 0.1dB or

less. The photodiodes have a wide detection range of 1520–1610nm (C-band/L-band), with responsivity of 0.85A/W (typical, at 1550nm wavelength). The bit-error ratio is 1.3×10^{-8} (Q=14.9dB), even after transmission over several thousand kilometers (OSNR=20dB/0.1nm, bit rate = 43Gbps). Input (for optical signals) is via an LC connector with four-tape fiber featuring a small bending loss. Output (for RF signals) is via a feedthrough with a differential signal interface.

Mitsubishi Electric says that, in the near future, it will market an optical signal-transmitting laser diode module to operate on the opposite end of the line from the new FU-387SPP signal-reception module.

www.MitsubishiElectric.com

Finisar accused of violating Federal Securities Laws

The Shareholders Foundation of San Diego, CA, USA says that an investigation for current long-term investors in Finisar Corp of Sunnyvale, CA, USA over possible breaches of fiduciary duties has been initiated.

An investor filed a lawsuit against Finisar over alleged violations of Federal Securities Laws on behalf of purchasers of its common stock during the period 2 December 2010 and 8 March. Meanwhile, an investigation has been announced on behalf of current long-term investors, in particular those who purchased shares prior to December and continue to hold those shares.

The investigation on behalf of current long-term investors concerns whether certain current and/or former officers and members of Finisar's board of directors and executive officers can be held liable in connection with the alleged Securities Laws violations in the lawsuit by investors who purchased stock between 2 December 2010 and 8 March 2011. According to the complaint filed in the US District Court for the Northern District of California, the plaintiff alleges that

Finisar violated the Securities Exchange Act of 1934 by issuing between 2 December 2010 and 8 March 2011 materially false and misleading statements regarding its business and financial results.

Finisar's total 12-month revenue grew from \$418.55m to \$629.88m from end-April 2007 to end-April 2010. The firm was able to go from a net loss of \$48.91m reported on 30 April 2007 to net income of \$14.13m reported on 30 April 2010. Shares traded during October 2010 at under \$20 per share

On 1 December 2010 Finisar, reported record quarterly revenues and profitability for its second quarter (ended 31 October 2010). Shares rose to almost \$30 per share. Then, on 20 December, Finisar announced a public offering of common stock. Shares continued to increase to \$43.22 on 4 March 2011.

Then, on 8 March (after the close of trading, Finisar announced its financial results for its third quarter (ended 30 January 2011), reporting revenue exceeding an annual run-rate of \$1bn. However, Finisar also disclosed that it expected

adjusted earnings of \$0.31–0.35 per share for the three months ending 30 April 2011. According to analysts, on average they had been looking for profits of about \$0.44 cents per share.

Finisar's revenue forecast for the fourth quarter of \$235–250m fell short of Wall Street expectations for \$258.6m, hence the investigation.

In its announcement of 8 March, Finisar identified a slowdown in its business in China, a 10-day shut-down for Chinese New Year, and adjustments of inventory levels by some of its telecoms customers as reasons for the shortfall.

Shares of Finisar fell from \$40.04 on 8 March to \$25 on 9 March and continued to decline to \$22.58 on 15 March. Recently, however, shares have traded at above \$25.

The Shareholders Foundation says that those who purchased Finisar shares prior to December 2010 (and presently continue to hold those shares) have certain options and should contact it at mail@shareholdersfoundation.com or call +1 (858) 779 - 1554.

www.ShareholdersFoundation.com

Finisar completes voluntary cash offer to acquire Ignis shares; to commence mandatory cash offer

Finisar Corp of Sunnyvale, CA, USA has completed its voluntary public cash offer (announced on 22 March) to acquire the outstanding shares of Norway's Ignis ASA, whose shares are listed on Oslo Stock Exchange, at a cash price of NOK8 per share.

Ignis provides optical components and network solutions for fiber-optic communications. It operates globally through four subsidiaries: Syntune in Sweden, Ignis Photonix in Denmark, SmartOptics in Norway and 71.8%-owned Fi-ra Photonics 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 modu-

lators, and WDM-based solutions enabling the building of high-capacity optical networks.

Finisar's offer was made pursuant to an offer document of 7 April. The offer period expired on 6 May, and all conditions to the completion of the offer were satisfied. Settlement with the tendering Ignis shareholders will be completed within 14 days.

The offer was accepted by holders of about 37.9 million shares of Ignis (worth NOK303m, at NOK8 per share, or about US\$55.9m in total), representing 48.1% of the firm's outstanding shares. These shares, combined with the 25.7 million shares already held by Finisar, will bring Finisar's total own-

ership to about 80.7% of the outstanding shares.

Under the Norwegian Securities Trading Act, Finisar's ownership of more than one-third of the voting shares of Ignis triggers the requirement for Finisar to make a mandatory unconditional offer for all remaining Ignis shares. Finisar says that it will proceed promptly with a mandatory offer at a cash offer price of NOK8 per share. An offer document setting forth the terms will be published and distributed to the remaining Ignis shareholders as soon as possible following review and approval by the Oslo Stock Exchange.

www.ignis.com

www.finisar.com

JDSU's March-quarter revenue falls 4.6% to \$455.4m Optical Communications inventory adjustment to limit growth

On a non-GAAP basis, for its fiscal third-quarter 2011 (ended 2 April) JDSU of Milpitas, CA, USA has reported revenue of \$455.4m, down 4.6% on \$477.2m last quarter but up 36.8% on \$332.9m a year ago (and at the high end of guidance of \$440–460m). Of total revenue, the Americas represented 46%, EMEA 28% and Asia-Pacific 26% (compared with 51%, 26% and 23%, respectively, last quarter).

Advanced Optical Technologies (AOT) revenue was \$56.8m (12.5% of total revenue), down 3.1% on \$58.6m a year ago but up 3.8% on \$54.7m last quarter. Although down on 51.5% a year ago, AOT gross margin has risen from 48% last quarter to 48.3%. While down on \$22.5m a year ago, operating income rose from \$17.7m last quarter to \$17.9m (although operating margin of 31.5% of revenue is down from 32.4% last quarter and 38.4% a year ago, and below the targeted 32–35%).

Communications Test & Measurement (CommTest) revenue was \$189.2m (41.5% of total revenue), down 18.2% on \$231.4m last quarter (showing typical seasonality) but up 29.9% on \$145.7m a year ago. CommTest gross margin has risen from 54.9% a year ago and 60.9% last quarter to 61.9% (exceeding the targeted 57–61%). Although double the \$11.5m a year ago, operating income of \$22.6m is half of last quarter's \$44.8m (as operating margin has fallen from 19.4% to 11.9% of revenue, although still up on just 7.9% a year ago).

Communications & Commercial Optical Products (CCOP) revenue was \$209.4m (46% of total revenue), up 9.6% on \$191.1m (40% of revenue) last quarter and 62.8% on \$128.6m (38.6% of revenue) a year ago.

Within CCOP, Commercial Lasers revenue was \$24.7m, up 31.9% on \$18.7m a year ago and up 8.8% on \$22.7m last quarter due to demand for solid-state lasers for semiconductor, LED and micro-machining use.

However, Optical Communications revenue was \$184.7m (up 9.7% on \$168.4m last quarter and 68.1% on \$109.9m a year ago), with strength in ROADMs (growing 20% sequentially to 35% of optical revenue), circuit packs (with Super Transport Blade revenue growing over 37%) and tunable XFPs (growing more than 35% to 13% of optical revenue). Products introduced within the last 2 years accounted for 65% of optical revenue and are driving market share growth, says JDSU. In addition, the quarterly decline in average selling price (ASP) was a lower-than-expected 3.9%.

CCOP gross margin has risen from just 28.2% a year ago and 34.4% last quarter to 34.6% (including Commercial Lasers rising from 41.3% through 45.5% to 46.8%, and Optical Communications level with last quarter's 32.9% after rising from just 26% a year ago). CCOP operating income has risen from just \$12.6m a year ago and \$34m last quarter to \$39.6m (with operating margin rising from 9.8% to 17.8% then 18.9% of revenue). This is within CCOP's target model of operating margin of 16–20% at quarterly revenue of \$190m or more.

Overall company gross margin was 47.6%, down from 48.8% last quarter (due to segment mix) but still up on 44.1% a year ago (due to better margins in CCOP and CommTest). Operating expenses have risen from \$124.6m a year ago and \$159.8m last quarter to \$161.9m (35.6% of revenue), due mainly to higher payroll taxes and the weaker dollar. Operating margin was 12.1%, down from 15.3% last quarter but up on 6.6% a year ago.

Net income was \$51m, down from \$67m last quarter but more than double the \$23.2m a year ago. After generating \$52.9m of cash from operations and after capital expenditure of \$34.2m (up from \$28.3m last quarter), during the quarter total cash and investments rose from \$655.3m to \$700.5m.

"In fiscal Q3 JDSU reported strong financial results with year-over-year operating income growth of nearly 150%, as our strategy to operate as a diversified technology company provides the ability to navigate fluctuations that may occur in any one business segment and continues to positively differentiate JDSU's performance," says president & CEO Tom Waechter. "We benefited again this quarter from the strong mix of new products as the result of our collaborative innovation initiative, evidenced by market share gains in our optical communications and test & measurement businesses," he adds.

For fiscal Q4/2011 (ending 2 July), JDSU expects non-GAAP revenue of \$455–475m (up 4.4% sequentially). In particular, revenue is expected to grow 6–13% for CommTest but fall 2–4% for both AOT and CCOP. The firm is seeing a slowdown in Optical Communications demand as some customers reduce inventory levels. However, inventory adjustments are expected to have only a near-term impact, and end-market drivers remain strong.

Capital expenditure should be 4–5% of revenue (as JDSU invests in expanding manufacturing and test capacity for AOT and optical communications). Operating expenses are expected to rise by \$4–5m (mainly for increased investment in R&D and selling costs). Operating margin should be 11.5–13.5% (with CommTest rising to 14–17% due to higher revenue, AOT falling to 28–30% due to lower revenue, and CCOP falling by about 1 percentage point due to increased R&D investment).

Assuming corporate gross margin of 49%, JDSU targets operating income of 14–17% at quarterly revenue of \$460m or more (comprising operating income and quarterly revenue, respectively, of 16–20% and \$190m for CCOP, 20–23% and \$215m for CommTest, and 32–35% and \$55m for AOT).

www.jdsu.com

**Source
Materials**

Laser

LPE

VPE

InAs

InSb

VCSEL

MOCVD

PIN

GaAs

APD

Polycrystal

Solar Cell

HBT

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ISO9001:2000, Certificate No.: FM 26963
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Emcore quarterly revenue falls 2% year-on-year

Transition to new products to drive margin rebound

For its fiscal second-quarter 2011 (to end-March), Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components, subsystems and systems for the fiber-optics and solar power markets, has reported revenue of \$47.2m, down 2% on \$48.2m a year ago and 9% on \$52.1m last quarter.

Fiber Optics revenue was \$30m (64% of total revenue). This is down about 1% on \$30.2m a year ago (despite Telecom business seeing revenue double for 40–100G tunable lasers and ITLAs, and Broadband business continuing to experience robust demand for cable TV equipment, particularly video transport products). It is also down 4.5% on last quarter's \$31.8m (due mainly to the discontinuation of some legacy products and lower revenue with an Asian customer).

Photovoltaics revenue was \$17.2m (36% of total revenue), down 4% on \$18m a year ago and 17% on last quarter's record \$20.3m (due mainly to completion of a few major programs in space solar power generation products over the last couple of quarters delivering record revenues in the September and December quarters).

Gross margin has fallen further, from 32.7% a year ago and 24.3% last quarter to 22.4%, due mainly to Photovoltaics gross margin falling from 46.6% a year ago and 33.3% last quarter to 30.2%. Fiber Optics gross margin has fallen from 24.4% a year ago and 18.4% last quarter to 18% (due to lower revenue and a \$1.2m inventory reserve related to the end-of-life legacy product, offset partially by better product margin — otherwise Fiber Optics gross margin would have been 22%).

Net loss has continued to rise, from \$1.7m a year ago and \$3.6m last quarter to \$5.2m, despite a \$2.6m litigation settlement gain related to a patent infringement

award associated with the Fiber Optics segment. However, net loss included \$0.6m from the first non-operating expense related to Suncore Photovoltaics (the firm's CPV component- and system-making joint venture with San'an Optoelectronics Co Ltd in Xiamen, China). After excluding certain non-cash and other adjustments, adjusted EBITDA was a loss of -\$2.3m, compared with a profit of +\$843,000 last quarter and +\$3.3m a year ago.

During the quarter, cash and cash equivalents and restricted cash fell from \$25.4m to \$17m, driven mainly by being significantly back-end loaded on shipment, the pay-down of payables, and the firm's first capital contribution of \$4m to Suncore, partially offset by the \$2.6m litigation settlement gain.

In April, Emcore announced a private placement of 4.4 million shares of common stock (4.9% of its total shares outstanding) at \$2.19 per share, yielding \$9.6m.

Net proceeds will be used primarily for capital expenditure and increases in working capital necessary to support a production ramp up in the second half of calendar 2011 for the firm's Tunable XFP product line (which a few telecom customers are qualifying as a replacement for 300-pin transponders in metro and long-haul applications).

During the quarter, order backlog fell from \$57.3m to \$50.5m. Photovoltaics backlog fell from \$36.1m to \$26.4m. In contrast, Fiber Optics backlog rose from

\$21.2m to \$24.1m, driven mainly by Tunable Laser business, which continues to gain strong traction in the 40G and 100G markets.

Since the end of the quarter, Emcore has seen strong bookings in both Fiber Optics and Photovoltaics, boosting order backlog significantly. In particular, on 5 May Emcore received its second-highest-value contract ever (a third long-term purchase agreement with Space System/Loral, worth "tens of millions of dollars", to deliver satellite solar cells over the next couple of years). Loral was Emcore's first ever Space Solar customer, and Emcore continues to be its sole supplier for solar cells and panels. "We are in active discussion on a long-term purchase arrangement with another major aerospace customer, even though we are today already a primary supplier to them," says Weinswig.

"Because of the significant investment in new products, we are seeing some very positive traction in the Fiber Optics business," says president & CEO Dr Hong Hou. For fiscal third-quarter 2011 (to end June), Emcore expects revenue to rise to \$48–50m, driven mainly by 10% growth in Fiber Optics, despite revenue for legacy products falling off by more than \$1m (due partly to revenue from the Tunable XFP growing to about \$1m, after two design wins from top-5 telecom equipment manufacturers, as well as good growth for video transport products). Photovoltaic revenue will be a little flat. However, although revenues in any given quarter are lumpy and program-specific, the Space Solar business will continue to experience year-on-year growth, believes chief financial officer Mark Weinswig.

"We are continuing to move into the end-of-life stage on a few products. We expect to see another \$2–3m reduction in these products from this evolution," says Weinswig. ►

Because of the significant investment in new products, we are seeing some very positive traction in the Fiber Optics business, says president & CEO Dr Hong Hou

► “We expect future revenues from the new products will be more than enough to offset the decline of the legacy product,” he adds.

“The Telecom and Datacom division is experiencing a product mix shift as customers begin to move towards newer technology platforms,” continues Weinswig. “This evolution will cause margins in this division to improve when our new products begin to ramp in the latter part of this year.” Due to the better product mix, Emcore aims to increase Fiber Optics gross margin to 25–35% within the next few quarters.

Regarding terrestrial concentrating photovoltaics (CPV), the Suncore joint venture is currently manufacturing Emcore’s Gen-III CPV system in a temporary facility in Xiamen. After gaining a certification at the end of April, Gen-III products are now officially qualified for the Chinese terrestrial solar market. “We do not expect running

at this volume without automation for the module assembly to be very cost competitive,” says Hou. Losses from it will hence continue, but at slightly lower levels (less than \$500,000), for the next few quarters until Suncore’s permanent 200MW per annum CPV module-making facility in Huainan City is up and running (after receiving its business license and relevant regulatory approvals in January, construction began in February and should be completed by mid-July, with production starting in September for shipments by the end of this calendar year). Currently, Suncore has a firm order backlog of 5MW (worth about \$5m), to be delivered by mid-2012, plus an order for another 10MW (\$10m) to be finalized in the next month or so, says Hou. “From the first calendar quarter 2012, this joint venture should be at break-even or generating a slight profit,” he reckons.

www.emcore.com

IN BRIEF

Multi-year PV supply deal with SS/L

Emcore has entered into a long-term supply agreement to make multi-junction solar cells for the commercial satellite programs of Space Systems/Loral (SS/L). The multi-year contract is Emcore’s second largest award ever.

“Emcore has been a highly reliable partner in helping us deliver some of the world’s most powerful satellites to our customers,” says Vivian Mackintosh, VP of Materiel at Space Systems/Loral. “Emcore has delivered more than 800,000 solar cells to Space Systems/Loral over the past decade, and this agreement further strengthens our successful long-term relationship,” says chief operating officer Christopher Larocca.

www.ssloral.com

Emcore launches 1550nm CATV transmitter platform

Emcore has added to its 1550nm CATV fiber-optic transmitter product portfolio by launching the Medallion 6000 platform at the booth of distributor EQ Photonics GmbH at the ANGA Cable Show in Cologne, Germany (3–5 May).

The firm says that, to support the evolving and diverse requirements for extended bandwidth CATV, RF over glass (RFoG), RF overlay for passive optical networks (PON), and concurrent SAT-IF transport networks, the Medallion 6000 transmitter has been designed specifically for performance, flexibility and with a full suite of enhanced features.

The Medallion 6000 series of externally modulated transmitters is housed in a 1RU rack mount housing, and supports operational bandwidths up to 2.8GHz, adjustable SBS suppression capabilities of 20dBm and beyond, and optional electronic dispersion compensation. Transmitters with up to two output ports of 10dBm each

are made possible with Emcore’s high-power, narrow-linewidth, CW (continuous wave) laser technology at the core. When deployed with one or more Emcore optical amplifiers, fiber launch powers exceeding 20dBm are possible.

The Medallion 6000 series can deliver high-quality video with full quadrature amplitude modulation (QAM) loading to 1GHz, spanning from shorter-reach RFoG and FTTH (fiber-to-the-home) applications, to over 100km for long haul.

Monitoring and configuration is supported via a convenient front panel display, an RS-232 port, and Ethernet port with SNMP, Telnet, and Web interface. The platform is mechanically designed for flexibility and space efficiency, including universal rack mount features, modular front panel design for private label convenience, and optional front and rear port placement. Dual, redundant and field replaceable fans and power supplies are standard.

“These new transmitters are ideal for extending traditional CATV systems such as head-end consolidation and broadcast transport,” says Grant Olecko, product marketing director at Emcore Broadband. “Additionally, new RF overlay FTTH and RFoG projects in countries around the world are representing a significant and growing market opportunity. Emcore is well positioned to take advantage of this worldwide trend with our advanced portfolio of broadband solutions,” he reckons. “Network providers are demanding high-quality and economical delivery of video to their customers, while extending capacity and improving network management intelligence. The enhanced features and cost-effective designs leveraged from Emcore’s long-established experience in 1550nm transmitter technology meet the demanding needs of today’s networks.”

www.angacable.com

CPV ready to compete in solar market

Annual installations to pass 1000MW by 2015

While the concentrating photovoltaic (CPV) market remains a fraction of the world's total installed solar base, at a mere 28MW of the total 33,000MW, CPV technology is finally gaining momentum with multiple utility-scale project announcements over the past year, says the report 'Concentrating Photovoltaics 2011: Technology, Costs and Markets' from GTM Research (the research arm of Greentech Media), which examines the recent gains and obstacles remaining for the fast-growing solar technology. This growing pipeline of CPV projects represents a vote of confidence from solar developers for a technology that, to date, has been marginalized because it was considered unproven and risky, says the firm.

"Developers choosing a solar technology for a large power plant focus on two factors: cost per kilowatt-hour (kWh), and bankability," says

report co-author Brett Prior, senior analyst at GTM Research. "CPV's promise has been a lower cost/kWh, but it has been hamstrung by a lack of bankability, as the technology's track record is much shorter and its performance warranties were not backed by strong corporate parents," he adds.

Currently, three CPV technology providers are at the head of the market — Amonix,

CPV's promise has been a lower cost/kWh, but it has been hamstrung by a lack of bankability, as the technology's track record is much shorter and its performance warranties were not backed by strong corporate parents

Concentrix Solar, and SolFocus—accounting for 96% of global projects in operation, construction or development (with signed power purchase agreements). Each has boosted their respective viability over the past two years by attracting strong strategic partners. The report examines the most prominent of these partnerships.

"These relationships will be key in generating additional demand for CPV projects," says Prior. "They bring credibility to the technology, and will help future plants to secure project finance from the major banks."

GTM Research forecasts that annual CPV installations will surpass 1000MW per year by 2015, predicated upon CPV firms successfully achieving their cost reduction roadmaps and reducing the installed cost of a CPV system by more than 30% over the next 4 years.

www.gtmresearch.com

DOE offers \$90.6m loan guarantee to Cogentrix 30MW Colorado project using Amonix CPV systems

US Energy Secretary Steven Chu has announced the offer of a conditional commitment for a \$90.6m loan guarantee to Cogentrix of Alamosa LLC. The loan guarantee will support construction of the Alamosa Solar Generating Project, a 30MW net capacity high-concentration solar photovoltaic (HCPV) generation project in south-central Colorado near the city of Alamosa.

Founded in 1983, power generation project developer Cogentrix Energy LLC of Charlotte, NC (a subsidiary of The Goldman Sachs Group Inc) estimates that the project will create about 75 construction jobs and 10 operations jobs. The project will source over 80% of its components from the US.

"Colorado has long been a leader in the development and deployment of renewable energy," says Chu. "By deploying an innovative, com-

mercially ready technology at utility scale, the Alamosa Solar Generating Project is increasing the generation of clean, renewable power, creating jobs and strengthening the US economy," he adds.

"With this significant financial commitment, Cogentrix will have the tools to finish construction on one of the largest and most innovative photovoltaic solar power plants in the country — as well as create a significant number of jobs in the San Luis Valley," says Senator Mark Udall. "This new solar facility will further solidify Colorado's lead in clean energy, create good-paying jobs, and provide a much-needed economic boost for the San Luis Valley and all of Colorado," adds Senator Michael Bennet.

The proposed facility will use HCPV systems designed and made by Amonix Inc of Seal Beach, CA,

USA consisting of concentrating optics and multi-junction III-V solar cell panels controlled by a dual-axis tracking system that rotates and tilts the cells throughout the day so the surface of the panel maintains an optimal angle with respect to the sun. According to the project sponsor, the multi-junction solar cells are nearly 40% efficient, or about double that of more traditional PV panels used in areas with high amounts of direct sunlight, such as Alamosa County.

The Alamosa Solar Generating Project will sell all of its electricity output to Public Service Company of Colorado. It will produce about 75,000MW-hrs of renewable energy per year (enough to power more than 6500 homes) and will avoid the emissions of over 43,000 tons of carbon dioxide per year.

www.cogentrix.com

Solfocus 420kW plant completed at water reclamation facility

A 420kW concentrator photovoltaic (CPV) power plant has been completed at the City Coachella Water Reclamation Plant in California using 55 SF-1100S tracking CPV systems made by SolFocus Inc of Mountain View, CA, USA. The installation will offset 40% of the reclamation plant's daytime energy consumption.

According to the US Environmental Protection Agency, energy costs can account for 30% of the total operation and maintenance costs of wastewater treatment plants, which account for about 3% of the electric load in the USA. Demand for electricity at such plants is expected to grow by 20% over the next 15 years, according to the EPA's 'Wastewater Management Fact Sheet'.

The installation was developed by Johnson Controls (which delivers products, services and solutions for increased energy efficiency in buildings) and California-based renewable energy firm Solar Power Partners Inc (SPP), which develops, owns and operates distributed solar energy facilities on continental USA and Hawaii and sells solar-generated electricity through power purchase agreements (PPAs).

The plant has been built on disturbed land which had limited potential use until the City of Coachella envisioned employing the land for renewable power generation, which would help the city to reduce operating costs and its carbon footprint. Using an innovative financing structure, the City leased the land to SPP, which financed and

owns the project, and will operate the plant, selling electricity to the Water Reclamation Plant under a long-term power purchase agreement. The project was originated by Johnson Controls, which also designed and constructed the facility under contract with SPP. The plant is connected to the regional electrical grid serviced by the Imperial Irrigation District (IID).

"IID's Solar Solutions Program serves as a powerful tool to government entities, like the City of Coachella, in helping to meet environmental goals and reducing long-term costs," says John Pierre Menvielle, VP of the IID board of directors.

"This project exemplifies how smart public policies are encouraging the deployment of solar projects," notes SolFocus' CEO Mark Crowley. "Under Senate Bill 1, the 'Go Solar California' initiative laid the foundation for programs like IID's Public Benefits Charge to fund solar incentive programs," he adds.

"As a recipient of the California Association of Sanitation Agencies' 2009 Capital Improvement Award for another water treatment plant's solar project, we are thrilled to bring this highly innovative and leading-edge solution to Coachella's Water Reclamation Plant and to be working with the City to help them with their energy and environmental goals," says Solar Power Partners' CEO Bob Powell.

www.solfocus.com

www.solarpowerpartners.com

www.johnsoncontrols.com



SolFocus' CPV panels at the Coachella Water Reclamation Plant.

IN BRIEF

Isofoton launches CPV systems

At the GENERA 2011 International Energy & Environment Trade Fair in Madrid, Spain (11-13 May), Isofoton S.A. of Malaga, Spain — which was spun off from the Polytechnic University of Madrid in 1981, and has been developing III-V-based concentrating photovoltaic (CPV) systems since 2001 — unveiled its new ISF panel product line, consisting of three CPV solar modules that can be customized according to the installation architecture and aesthetics desired.

The product range is distributed in 3kW kits and includes ISF-245 and ISF-250 modules (formed of 60 cells) and the ISF-215 module (formed of 54 cells). Isofoton says that the product range ensures optimum energy output due to its micro-textured glass composition.

Isofoton also presented its ISOTRACKER product line, which provides integral solutions with dual- or single-axis trackers (depending on the project requirements). The main advantage of the dual-axis ISOTRACKER products are their high energy output (up to 42% more than static installations, depending on environmental conditions and the solar resources, the firm claims).

Isofoton says that its most innovative launch is the ISO-TRACKER HCPV, which combines its new high-concentration GEN2 modules and trackers developed by INDRA. The product range uses Isofoton's high-concentration technology, which enables it to obtain higher energy output in high-irradiation locations. This topic was discussed during a conference session on 'High Concentration Photovoltaic Systems'.

Also at the trade fair, Isofoton exhibited Nessuno, a solar boat powered by photovoltaic cells.

www.isofofon.com

IN BRIEF

Chevron starts operation of 1MW CPV solar field

Coal and metal mining firm Chevron Mining Inc (CMI), a subsidiary of Chevron Corp of Englewood, CO, USA and sister company Chevron Technology Ventures (CTV, a division of Chevron USA), has started operation of one of the USA's largest concentrating photovoltaic (CPV) solar facilities. The installation, located on the tailing site of CMI's molybdenum mine in Questa, NM, will demonstrate and evaluate an emerging solar technology and a practical use of previously impacted land.

The Questa solar field covers about 20 acres and includes 173 solar trackers, each 18ft x 21ft. The field includes CPV systems made by Soitec Group of Bernin, France (via its CPV system making division Concentrix Solar GmbH of Freiburg im Breisgau, Germany) and has the capacity to generate about 1MW of power (enough for about 300 New Mexico homes). Output will be sold to Kit Carson Electric Cooperative through a power purchase agreement.

"Chevron is one of the first companies in the US to demonstrate CPV on this scale," claims CTV president Des King. "We're fortunate that we have property in a part of the world with a solar resource that is expected to be most conducive to this type of technology," he adds. CPV technology uses lenses to collect and focus direct sunlight onto layers of high-efficiency photovoltaic cell, and is expected to work best in areas like northern New Mexico that have higher direct solar radiation. "This project goes a long way in demonstrating the unique solar resource we have in this part of New Mexico," comments Questa's mayor Esther Garcia.

www.chevron.com

Soitec contracts with SDG&E raise system supply by 125MW to 155MW

San Diego Gas & Electric (SDG&E) of San Diego, CA, USA has signed two additional 25-year contracts with subsidiaries of Soitec Solar Development LLC (part of Soitec of Bernin, France) for a total of 125MW of solar power (to be generated in the utility's service territory), using Soitec's Concentrix concentrator photovoltaic (CPV) technology with modules made in a Soitec factory to be built in the San Diego area.

The new agreements are separate from the three San Diego contracts that the firms signed in April for 30MW of CPV-generated power. Combined, the five contracts represent five separate projects capable of generating a total of 155MW (enough energy to supply more than 60,000 homes). The projects will be located in San Diego County near SDG&E electric substations.

"Our projects with Soitec will bring local jobs to the community and will help us to meet our renewable energy goals," says James P. Avery, SDG&E's senior VP of power supply.

"We are very confident in our choice of technology and in Soitec's plans for a solar panel manufacturing facility in the San Diego region," he adds.

"These new contracts with SDG&E reinforce Soitec's decision to build its new manufacturing site in the San Diego area, and confirms the importance of the US market for our company," says Soitec's CEO & chairman André-Jacques Auberton-Hervé.

Soitec's new manufacturing facility will have an annual production capacity of 200MW and supply all of SDG&E's projects with Concentrix CPV technology. At full capacity, the facility should generate up to 450 direct jobs and over 1000 indirect jobs. The location should be named this summer, with completion within 18 months of construction start.

The power contracts require approval from the California Public Utilities Commission.

www.sdge.com

www.soitec.com

OPEL turnkey CPV installation for waste-water treatment facility

OPEL Solar International Inc of Toronto, Ontario, Canada is to provide a 95kW turnkey high-concentration photovoltaic (HCPV) solar installation for the municipally owned waste-water treatment facility of the town of Newtown, CT, USA.

Newtown is receiving a grant of \$325,000, covering part of the cost of installation from a competitive bid grant awarded by the State's Connecticut Clean Energy Fund (CCFEF).

The installation will include OPEL's TF-800 single-axis trackers and US-made PV panels from Grape Solar Inc. OPEL says that the use of its single-axis trackers results in higher energy production for each PV panel, providing much lower cost per kWh than conventional fixed-panel solar

systems. For the Newtown Facility, the tracker system increases the project's energy production by about 28%. OPEL Solar was selected through a competitive public bid process with the Town of Newtown.

"This installation serves to validate our decision to pursue the municipal market in order to benefit the public with clean solar energy," says OPEL's CEO Leon M. Pierhal. "The TF800 trackers contributed positively to the town's receipt of this significant grant award," he believes. "The increased energy output from our trackers provides a great match to other facilities similar to Newtown's waste water treatment plant," Pierhal adds.

www.opelinc.com

OPEL Solar proposes new directors

OPEL Solar International Inc of Toronto, Ontario, Canada, which makes high-concentration photovoltaic (HCPV) panels (and both roof- and ground-based solar tracker systems), announced a realignment of its board of directors.

Denis Colbourne, a director since September 2006, chairman of the board from 2008 to 2010, and a member of the Compensation Committee and the Audit Committee, will be retiring from the board at the upcoming Annual General Meeting of Shareholders (AGM) at the Toronto Hilton Hotel on 21 June. The firm says that his years of board and operational experience in the industry — including with Spectalis, SiGe Semiconductor, International Datacasting, Wi-LAN and Nortel Semiconductors — have been of vital importance to its growth. He will continue his involvement with OPEL in an advisory role, to be called upon for his expertise from time to time, under a consultancy agreement.

President & CEO Leon M. Pierhal, chairman Lawrence R. Kunkel, and director Dr Samuel Peralta will continue in their current capacities. The board is proposing two nominees (Christopher Grasset and Tristram Collins) for election as directors at the AGM. Proxy material will be mailed to shareholders on 20 May.

Grasset J.D. has over 35 years of experience in the high-tech sector. He is currently VP, business affairs for Covalon Technologies and a member of the Law Society of Upper Canada. Building on his background in communications and IT, he co-founded the technology business law firm Grasset/Fleisher LLP (subsequently merged with a major law firm) and the consultancy firm KBE International, focused on knowledge-based enterprises. Grasset has been an advisor to international organizations including the Sprinkles Global Health Initiative at the Hospital for Sick Children in Toronto and UNICEF. His 'Crossing the Pond' initiative was an

international technology business development program of Canada's Department of Foreign Affairs and International Trade. He has published articles on technology business, policy, law, tax and related issues, and has chaired conferences on subjects including international transactions and financing, and intellectual property and technology transfer.

Collins has over 25 years of business experience. He holds an MBA from the Amos Tuck School of Business Administration and an AB from Dartmouth College. Currently president of Grassmere Acquisition Corp and president & CEO of Great Point Holdings LLC, his recent focus has been on the financing and management of high-growth firms, exemplified by AcuStream LLC and Sustainable Building Innovations. Previously, he was a director and senior managing executive at Nassau Broadcasting Partners L.P. He was also previously an investment banking executive with over \$85bn of transaction experience. At Citigroup Global Markets, he was a managing director and sector head specializing in broadcasting and media, where he managed global relationships, transactions and mergers and acquisition (M&A) advisory assignments, including \$6bn of Viacom financings. He also held senior executive positions at Merrill Lynch & Co, where he helped execute Infinity Broadcasting's \$3.2bn initial public offering (IPO).

"Their integrity and experience will be invaluable to the strategic

growth of OPEL," reckons OPEL's chairman Lawrence R. Kunkel. "Both candidates bring strong knowledge-based and high-value transactional expertise to the board and will provide solid support to the management team while OPEL continues its vision for expanding the vertical and geographic reach of its photovoltaic business, and for realizing optimum value from its proprietary Planar Optoelectronic Technology (POET) semiconductor device manufacturing platform and associated intellectual property portfolio [of subsidiary ODIS Inc of Shelton, CT, USA]," he adds.

OPEL also announced the grant of additional incentive stock options under its stock option plan to its directors to purchase up to an aggregate of 600,000 common shares (representing 0.65% of its outstanding voting shares). The stock options are exercisable at a price of CA\$1.21 per share (the closing price on 10 May 2011), expiring 11 May 2021.

There are currently 8,179,000 options outstanding and 92,183,256 voting shares outstanding. The options will vest and be exercisable on the basis of 25% on the date of grant and 25% every six months thereafter. The options were granted subject to provisions of the stock option plan, which was approved by shareholders in June 2009, and subject to the TSX Venture Exchange policies and the applicable securities laws.

www.opelinc.com

OPEL Solar director Slomka resigns

OPEL Solar International Inc announced the resignation on 30 April of David Slomka as a director for personal reasons. Slomka had served on the board since June 2007 and was also chairman of the Compensation Committee.

The board aims to fill the vacancy at its next scheduled

meeting. The board says that it continues to be confident in its strategy for both its solar business (including greater vertical integration, development of its brown-field initiative and its solar systems rollout in North America and China) and its Planar Optoelectronic Technology (POET) device development program.

First Solar's sales drop 7% in Q1

For first-quarter 2011, First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement and construction (EPC) services, has reported revenue of \$567.3m, down slightly on \$568m a year ago (due to lower average selling prices) but down 7% on \$610m last quarter, due to: (i) the allocation of modules to systems projects in order to meet the project contractual delivery schedule; (ii) seven fewer production days; and (iii) a full quarter impact of the pricing change implemented in December.

Net income was \$116m (\$1.33 per diluted share), down from \$156m (\$1.80 per diluted share) last quarter (driven mainly by lower net sales and gross margin) and \$172.3m (\$2.00 per diluted share) a year ago (driven mainly by reduced average selling prices and higher expenses, partially offset by increased module production and lower module cost per watt).

"Despite European market uncertainties, First Solar has good visibility into our demand for 2011," says

CEO Rob Gillette. "We continue to execute our cost roadmaps, invest in new module capacity, build our project pipeline, and develop promising new markets around the world."

In late February, First Solar reduced the top end of its guidance for net sales in 2011 from the \$3.7–3.9bn forecast of mid-December to \$3.7–3.8bn (up 46% on 2010's \$2,564m). However, it increased 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).

Now, while maintaining its late February revenue guidance, the firm has cut back its guidance for operating income to \$900–970m. Also, while maintaining its earnings guidance, it expects lower manufacturing start-up expenses of \$50–60m and lower factory ramp costs of \$10–15m. First Solar is maintaining its original mid-December forecast for total capital spending of \$1–1.1bn, but has cut its guidance for operating cash flow from \$1.0–1.1bn to \$0.8–1bn.

First Solar hits 4GW: second German fab making modules a month early

First Solar has now made 4GW of modules since it began commercial production in 2002. This is enough electricity to power about 2 million households, displacing over 2.5 million metric tons of CO₂ emissions a year (equivalent to taking 500,000 cars off the road).

The firm also says its second factory in Frankfurt an der Oder, Germany has begun producing solar modules 1 month ahead of schedule. The four new production lines are still expected to ramp to full production during third-quarter 2011, bringing annual capacity at the two Frankfurt factories to over 500MW.

First Solar also has manufacturing sites in Perrysburg, OH, USA and Kulim, Malaysia, as well as new plants under construction in Mesa, AZ, USA and Vietnam. It recently completed the production ramp of its two newest plants in Malaysia.

www.firstsolar.com

Constellation acquires 30MW CdTe solar project from Belectric

Constellation Energy of Baltimore, MD, USA has acquired a 30MW DC (25MW AC) solar generation project in Sacramento, CA, from utility-grade photovoltaic (PV) power plant developer Belectric Inc of Newark, CA, USA (the North American arm of Belectric, which is ranked the world's largest systems integrator, with 330MW of PV power plants installed in 2010).

The system will consist of about 381,000 cadmium telluride (CdTe) thin-film PV panels made by First Solar, ground-mounted at multiple sites near the city of Sacramento. Constellation will own and operate the system and sell the electricity generated from it to the Sacramento Municipal Utility District

(SMUD, the USA's sixth largest publicly owned utility) under ten, 20-year power purchase agreements. The project is expected to be commercially operational by the end of 2011.

The transaction was arranged by finance and investment firm Smart Energy Capital LLC of White Plains, NY, which is focused exclusively on the North American solar photovoltaic industry.

"This utility-scale generation project is an attractive opportunity for Constellation Energy to grow its existing solar portfolio," says Andrew Good, senior VP of corporate strategy & development. The project will help to provide a long-term source of emissions-free

electricity to more than half a million customers in SMUD's service territory, he adds.

The project is among the first to be installed under SMUD's feed-in tariff program, says Belectric Inc's president & chief operating officer David Taggart. "For the past 18 months, the Belectric team has worked closely with SMUD, Sacramento County and local land owners to develop this project, which clearly demonstrates the competitiveness of Belectric's integrated thin-film PV system design," he adds.

With this latest acquisition, Constellation Energy now owns and operates about 95MW of solar installations either completed or under construction in the USA.

First Solar & China Power reach international cooperation agreement

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe) as well as providing engineering, procurement and construction (EPC) services, has signed a strategic cooperation framework agreement with China Power International New Energy Holding Ltd (CPINE), a subsidiary of China Power New Energy Development Company Ltd (CPNE), to collaborate on PV projects in China, the USA and other international markets.

Liu Genyu (China Power International Holding Ltd's new energy development supervisor, CPNE CEO and CPINE general manager) and TK Kallenbach (president of First Solar's Components Business Group) signed the agreement at a ceremony in Beijing with Madame Li Xiaolin (chairwoman of China Power International Holding Ltd, CPNE and CPINE).

First Solar and CPINE will initially explore collaboration on solar PV projects in China and identify project investment opportunities for CPINE in the USA and other global solar markets, leveraging CPINE's role as a renewable energy developer in China (including its planned

2GW of solar in China by 2020) and First Solar's expertise as a global solar PV technology firm (including its 2.4GW pipeline in North America).

"This cooperation leverages our advantages in the domestic solar power industry, and helps First Solar further expand its business presence in China," says Li. "In addition, we are happy to explore other cooperation opportunities in different areas and through different methods with First Solar, working together to further expand in the global market," she adds.

CPINE is one of the premier state-owned clean-energy companies in China, says Kallenbach, although CPNE is incorporated in Bermuda with limited liability, and its shares are listed on the Main Board of The Stock Exchange of Hong Kong Ltd. "Both China and the US are important markets with vast potential for sustainable solar energy, and this agreement can serve as a model for US-China collaboration on renewable energy," he adds. "Our agreement with CPINE also includes the potential to expand to other international markets, which could open up tremendous opportunities."

www.firstsolar.com

IN BRIEF

First Solar's modules receive UK MCS certification

First Solar Inc of Tempe, AZ, USA says that its Series 3 CdTe PV modules FS-370 to FS-385 have received accreditation under the UK Microgeneration Certification Scheme (MCS), opening the door to their use in systems that benefit from the UK's feed-in tariff.

The MCS accreditation is an internationally recognized quality assurance scheme which validates the quality and reliability of approved products that satisfy rigorous standards. Product certification involves type testing of products and an assessment of the manufacturing processes, materials, procedures, and staff training.

"MCS is a key prerequisite to serving the UK market," says TK Kallenbach, head of First Solar's Components Business Group. "Installers and products that carry the MCS mark provide end-customers with assurance that their PV systems comply with rigorous international standards."

www.microgenerationcertification.org

First Solar and juwi solar sponsor road cycling team

First Solar and juwi solar Inc (JSI) of Boulder, CO are co-sponsoring a US amateur road cycling team in an effort to promote awareness for sustainable solar energy in communities throughout the country.

JSI develops, designs, engineers, constructs and operates utility-scale solar energy generation facilities (1MW and larger) in North America, and has constructed three of the 10 largest PV facilities in the USA. JSI is majority-owned by German parent firm juwi Holding AG, whose solar subsidiaries have built more than 1500 solar PV project worldwide (totaling 700MW of installed capacity).



The juwi/First Solar Elite Cycling Team.

Based in Boulder, the juwi/First Solar Elite Cycling Team consists of 10 elite cyclists, including two-time national champion Michael Olheiser. Team members are competing in

events from New York to California, including the Redlands Bicycle Classic on 31 March – 3 April, which took place near First Solar's proposed Stateline and Desert Sunlight solar projects. The combined capacity will be 850MW, enough to power 250,000 homes (displacing about 465,000 metric tons of CO₂ annually, equivalent to removing 92,000 cars from the road).

www.solarcycling.org

www.juwisolar.com

Phoenix inaugurates 18MW of CdTe solar parks on former German military airbase

Together with its financing partner KGAL GmbH & Co KG, in a ceremony on 20 May attended by guests from politics and the business community, photovoltaic system integrator Phoenix Solar AG of Sulzemoos near Munich, Germany (which is listed on the TecDAX exchange) inaugurated two solar parks in Jocksdorf and Preschen located on a former military airbase in Neiß-Malxetal, Brandenburg, Germany. The plants are separated by a 3km-long runway and hence belong to different neighbouring municipalities.

Both solar parks will use Xantrex GT500 PV inverters together with cadmium telluride (CdTe) thin-film photovoltaic modules made by First Solar Inc of Tempe, AZ, USA, which in June 2005 reached its first agreement to supply what was then called Phoenix SonnenStrom AG. In particular, the Jocksdorf plant (built in 22 weeks and commissioned in May 2010) uses 55,360 FS-275 modules and 50,092 FS-277 modules, and the Preschen plant (built in 12 weeks and commissioned in December 2010) uses 129,600 FS-277 modules.

Favorable irradiation of an annual average 1050 kilowatt hours per square metre makes the region in the east of Germany well suited to the construction of photovoltaic power plants, says Phoenix. Collectively, the two solar parks will supply electricity to more than 4300 four-person households and save about 10,000 tons of CO₂ annually.

"Brandenburg is already sourcing 15.6% of its primary energy requirements from renewable energies. This brings annual savings on CO₂ to almost 10 million tons," remarked Brandenburg's Environment Minister Anita Tack at the ceremony. "Brandenburg is viewed as a role model for an ambitious energy and climate protection policy, and has made it possible to convince entrepreneurs, investors and scientists to translate their



Aerial view of Jocksdorf and Preschen solar parks. Source: Phoenix Solar.

ideas into reality here in particular," she adds. "In the meantime, a branch of industry has successfully developed on this basis, with more than 12,000 jobs, 3000 of which are in the photovoltaic sector alone," Tack states.

Also, district administrator Harald Altekrüger, mayor Eberhard Müller, Dr Klaus Wolf of KGAL and Ralph Schneider of Phoenix Solar underscored the special features of both projects and gave an insight into the development, construction, expected electricity yields, and the significance of the solar parks for the region.



From left to right: Phoenix Solar's Ralph Schneider, Point 36's Hans-Joachim Wilhelm, Brandenburg Environment Minister Anita Tack, Neiß-Malxetal mayor Eberhard Müller and KGAL board member Klaus Wolf open the solar parks.

KGAL commissioned Phoenix to build the solar parks and has incorporated them into a fund for institutional investors. "We have been realising projects with Phoenix Solar for our investors for many years now," notes KGAL board member Dr Klaus Wolf.

Phoenix was responsible for the turnkey construction of both power plants in the capacity of engineering, procurement and construction (EPC) contractor. As the solar power plants had to be built on a military conversion site of just under 60 hectares (about 150 acres), Phoenix's first task was to remove all munition

remains before it could start with the installation. "We will continue our work in the region," says

Ralph Schneider, executive VP of Solar Energy Investments at Phoenix. At the end of the operating lives of the solar parks (now fixed for 20 years) the conversion of the site will enable it to be used for urban development.

www.firstsolar.com
www.phoenixsolar-group.com

Abound partners with Italian system integrators DW Europe and Thesan

Abound Solar Inc of Loveland, CO, USA has announced a partnership and distributorship with DW Europe of Rome, Italy, a commercial solar and building-integrated photovoltaic (BIPV) system integrator. The firms will work together to install solutions based on Abound's cadmium telluride (CdTe) thin-film PV modules on commercially scaled projects.

Last December, Abound closed a \$400m loan guarantee from the US Department of Energy (DOE) to fund expansion of its manufacturing capacity, which will help to cater for demand for its solar products in Italy, Germany, India and North America, as well as spurring new growth in employment.

Abound has also announced a partnership and distributorship with Thesan of Chiusa di San Michele, Italy, a designer and manufacturer of solutions for the renewable energy and energy-efficiency industries

and a solar system integrator for commercial-scale applications. The firms will work together to provide functional and economic solutions based on Abound's thin-film modules and the design of Thesan's racking system 'Around You', which can reduce labor costs associated with module installation by up to 57%.

"The combination of thin-film technology, high performance in a low-cost module and our experience with Energy Account regulations in the growing Italian photovoltaic market allows us to deliver strong financial returns to our customers," claims Thesan's CEO Aimone Balbo.

DW Europe and Thesan are some of Abound's preferred system integrators, says senior VP of sales & marketing Julian Hawkins. As leaders in the Italian market, they are an opportunity for Abound to expand in the Mediterranean, he adds.

www.abound.com

Sunovia and EPIR settle lawsuit

Sunovia Energy Technologies Inc of Sarasota, FL and EPIR Technologies Inc of Bolingbrook, IL, USA and its affiliates have settled the litigation between them that arose last August.

The settlement provides that Sunovia and EPIR will share equally in revenues from the jointly developed solar patent 12/261,827 published in 2010. Also, each firm will return to the other certain shares issued in the course of their venture, and the contracts between them relating to the joint development of cadmium telluride solar technology are terminated without further obligation on the part of either firm.

"It is important to Sunovia to resolve this dispute and move ahead with its LED outdoor lighting business [EvoLucia Inc]," says CEO Art Buckland. "If the solar technology can be developed and commercialized, our shareholders will share equally in those gains. Meanwhile,

both Sunovia and EPIR can move forward with their respective businesses without the ongoing cost and risk of this litigation," he adds.

"We are eager to move ahead with other projects and to eliminate the distraction from our primary business and the expense the lawsuit creates for our company and shareholders," comments EPIR's CEO Dr Siva Sivananthan (director of the Microphysics Laboratory at the University of Illinois at Chicago), who founded EPIR in 1998 to develop infrared materials for the US military and to research IR imaging technology based on mercury cadmium telluride (HgCdTe, or MCT). The same technology forms the basis for EPIR's development of solar cells. "Both companies have worked very hard to come to a resolution that is fair for all," he adds.

www.epir.com

www.sunoviaenergy.com

H.C. Starck's targets on show

With increasing global interest in safe and sustainable energy sources promising a bright future for US-based thin-film PV production, H.C. Starck of Newton, MA, USA (which supplies refractory metals and technical ceramics) reckons that a local presence coupled with global reach is critical to efficiently and effectively meet the rapidly increasing demand for sputtering targets. With almost 3000 staff at more than 30 locations worldwide including in the USA, Asia and Europe, the firm — which exhibited at the Society of Vacuum Coaters Technical Conference (SVC TechCon 2011) in Chicago in April — says it offers local support to customers.

Responding to the demand to lower cost-per-watt, H.C. Starck's Fabricated Products Group of Euclid, OH, USA has developed sputtering targets with what is claimed to be superior sputtering performance for thin-film PV (TFPV) applications. This has been achieved using thin-film materials labs equipped with sputtering tools and supporting equipment for testing film characteristics, together with in-house prototyping and modeling.

For copper indium gallium diselenide (CIGS), amorphous silicon (a-Si) and cadmium telluride (CdTe) thin-film photovoltaics, H.C. Starck makes custom rotary and planar sputter targets from molybdenum- and nickel-based alloys along with its other core competency materials: tantalum, niobium and tungsten. The most demanding requirements of target users in LCD display, large-area coating and solar cell applications are met by using extrusion technology.

H.C. Starck produces molybdenum rotary targets with inside diameters of 125mm (monolithic) and 135mm (bonded) up to the largest rotary targets. Tantalum, niobium, nickel-vanadium and other materials come in planar or rotary form.

www.hcstarck.com

Sulfurcell renamed Soltecture

Sulfurcell GmbH of Berlin, Germany, which makes both sulfur-based CIGS and selenium-based CIGSe 'CIS' thin-film photovoltaic (PV) solar modules, has renamed itself Soltecture GmbH.

"The renaming is a logical step that takes the evolution of our company into account," says CEO & founder Dr Nikolaus Meyer. "The new name 'Soltecture' gets to the heart of our core competencies and stands for superior performance in solar, technology, and architecture," he adds. "We are signaling and underlining the development of the company from module manufacturer to a provider of optimum integrated PV system solutions."

Sulfurcell was spun off 10 years ago from the Hahn-Meitner-Institut (now the Helmholtz Centre Berlin for Materials and Energy). In 2002 it raised €9m from private investors, followed in 2003 by R&D grants of €7m from the Senate of Berlin. The firm subsequently set up pilot production of thin-film PV modules based on a copper indium sulphide (CIS) photovoltaic absorbing layer, making its first shipments in 2005.

In July 2008, the firm raised €85m in an equity financing round involving Intel Capital and the BEU fund (which is supported by Vattenfall Europe and Gaz de France Suez). Funding was used to construct production facilities and to expand R&D.

More recently, Soltecture added gallium to copper indium sulphide to produce modules with a CIGS

absorbing layer (yielding higher conversion efficiency). Also, since the end of 2008, Soltecture has been working on second-generation technology, which deploys an absorbing layer based not on sulfur but on selenium (CIGSe), yielding even higher efficiency. CIGS and CIGSe modules are produced with the same equipment, but some new, specially developed equipment is also used just for the CIGSe coating stage of the process.

Last July, Soltecture produced the first prototypes of large-format solar modules based on CIGSe with energy conversion efficiency of more than 10%. This new product line was unveiled at the 25th European PV Solar Energy Conference and Exhibition (EU PVSEC 2010) in Valencia, Spain last September as modules measuring 1.25m x 0.65m (0.8m²) with an aperture efficiency of 10.7% and a peak output of 86.8W (confirmed by the German technical inspection agency TÜV Rheinland). In mid-February, this was raised to 12.6% and 94W. Record efficiency of 13.0% followed just weeks later.

This January, Sulfurcell raised a further €18.8m (\$25m) in an equity financing round led by Intel Capital and joined by other existing investors. This boosted total funding to €110m. The latest funding is going towards the acquisition of additional equipment for the firm's fully automated manufacturing facility as well as ongoing R&D work for its CIGSe technology.

Annual production capacity for the CIGS product line is 20MW, while the CIGSe line is being ramped up from 5MW to 15MW (three fabrication lines), making 35MW in total.

During continuing shift operation (24/7) within just three months of the start of CIGSe production, a yield of more than 80% was achieved (i.e. over four out of five modules produced are meeting the required specifications). Soltecture says that the rapid increase in yields in mass production and the marginal deviance in module power (90W ± 3W) confirm process stability, which is widely recognized as a challenge in thin-film module production.

In the next 10–16 months, the firm aims to boost module efficiency to more than 14% and production yield to more than 90%. Based on quality control and a background of series production readiness, sales and distribution of the new modules have already begun.

Soltecture says that it now offers standardized solutions for the integration of thin-film modules for constructions such as roofs, factories, and modern facades. "With their engineering expertise and years of experience in solar technology, our engineers constantly develop new PV solutions that are perfectly adjusted for solar architecture," says executive director & chief sales officer Henrik Kruepper. "We offer our clients solar integration from one source."

www.soltecture.com

China's first CIGS solar integrated power circuit

At the 6th Asia Solar Photovoltaic Industry Exhibition in Shanghai in May, the exhibits included China's first CIGS solar integrated power circuit, developed by Henan Yanyuan Photovoltaic Technology Co Ltd with support from Peking University (PKU).

According to Henan Yanyuan and PKU, people are familiar with solar collectors and solar cells but are often unaware of the combination

of the two: the solar integrated power circuit.

"The application of CIGS solar cells is going to be the development trend in the solar industry," said PKU School of Physics professor Gan Zizhao (an academican of the Chinese Academy of Sciences). "It reduces pollution and costs compared with the old material, which is mainly silicon. Moreover,

it's cheaper and more efficient".

Zizhao added that the PKU research team had independent intellectual property of this technology but, compared with countries like the USA and Germany, they are still at an intermediate level, having a long way to reduce the gap. However, there are large potential markets in China.

<http://english.pku.edu.cn>

Swiss team claims record 18.7% efficiency for flexible CIGS photovoltaic cells

A Swiss research team at Empa's Laboratory for Thin Film and Photovoltaics, led by Ayodhya N. Tiwari, has raised its energy conversion efficiency record for copper indium gallium (di)selenide (CIGS) flexible solar cells from 17.6% (achieved in June 2010) to 18.7%. The measurements have been independently certified by the Fraunhofer Institute for Solar Energy Systems in Freiburg, Germany.

"The new record value for flexible CIGS solar cells of 18.7% nearly closes the 'efficiency gap' to solar cells based on polycrystalline silicon (Si) wafers or CIGS thin film cells on glass," says Tiwari. "Flexible and lightweight CIGS solar cells with efficiencies comparable to the 'best-in-class' will have excellent potential to bring about a paradigm shift and to enable low-cost solar electricity in the near future," he adds.

According to the team, an advantage of flexible high-performance CIGS solar cells is the potential to lower manufacturing costs through roll-to-roll processing while at the same time offering a much higher efficiency than those currently on the market. Such lightweight and flexible solar modules offer additional cost benefits in terms of transportation, installation, and structural frames for the modules, i.e. they significantly reduce the 'balance of system' costs.

Working with FLISOM, a start-up company that is scaling up and commercializing the technology, Empa's team has made progress in low-temperature growth of CIGS layers yielding flexible CIGS cells that are more efficient, up from a record value of 14.1% in 2005 to the new record of 18.7% for any type of flexible solar cell grown on polymer or metal foil. The improvements in cell efficiency were made possible through a reduction in recombination losses by improving the structural properties of the CIGS layer and the proprietary



Flexible thin film CIGS solar cell on polymer substrate developed at Empa (Copyright: Empa).

low-temperature deposition process for growing the layers, as well as in-situ doping with Na during the final stage. With these results, polymer films have for the first time proven to be superior to metal foils as a carrier substrate for achieving highest efficiency, claims the team.

Record efficiencies of up to 17.5% on steel foils covered with impurity diffusion barriers have so far been achieved with CIGS growth processes at temperatures exceeding 550°C. However, when applied to steel foil without any diffusion barrier, the proprietary low-temperature CIGS deposition process

developed by Empa and FLISOM for polymer films easily matched the performance achieved with the high-temperature procedure, resulting in an efficiency of 17.7%.

The results suggest that commonly used barrier coatings for detrimental impurities on metal foils would not be required.

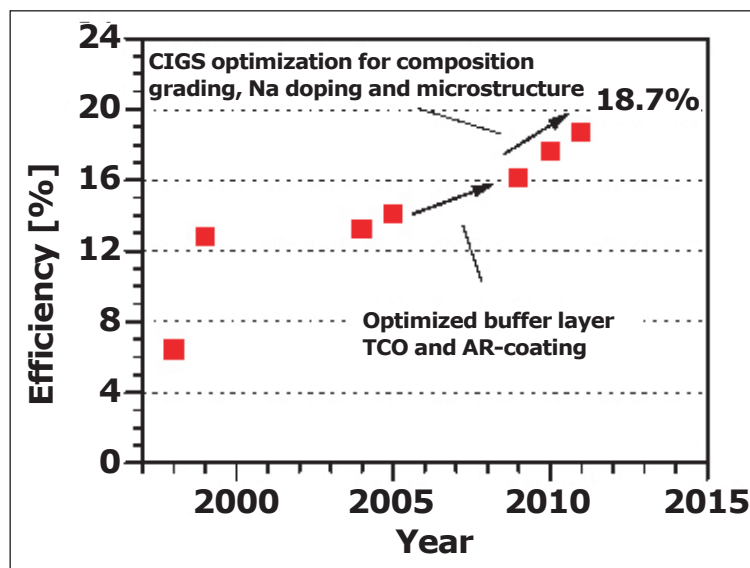
"Our results clearly show the advantages of the low-temperature CIGS deposition process for achieving highest-efficiency

flexible solar cells on polymer as well as metal foils," says Tiwari.

"What we see here is the result of an in-depth understanding of the material properties of layers and interfaces combined with an innovative process development in a systematic manner," says Empa director Gian-Luca Bon. "Next, we need to transfer these innovations to industry for large-scale production of low-cost solar modules to take off." Empa is currently working with FLISOM to further develop manufacturing processes and to scale up production.

The projects were supported by the Swiss National Science Foundation (SNSF), the Commission for Technology and Innovation (CTI), the Swiss Federal Office of Energy (SFOE), and EU Framework Programmes as well as by the Swiss firms W.Blösch AG and FLISOM.

www.empa.ch



Improvement in energy conversion efficiency of flexible CIGS solar cells on polymer film.

Nanosolar to supply up to 1GW of CIGS PV panels to European installers Belectric, EDF and Plain Energy

Nanosolar Inc of San Jose, CA, USA, which makes copper indium gallium diselenide (CIGS) thin-film photovoltaic panels (using the industry's first roll-to-roll solar cell printing factory, together with a panel-assembly plant in Luckenwalde, Germany), has signed long-term supply agreements for up to 1GW of Nanosolar Utility Panel supply with Belectric of Koltzheim, Germany; EDF Energies Nouvelles of Paris, France; and Plain Energy of Munich, Germany.

Nanosolar says that, as some of the largest and most experienced installers of thin-film panels in Europe, these long-term strategic partners will use its Nanosolar Utility Panel to expand their solar power plant developments. Each supply agreement ranges from a 3–6 year term, and in total may account for up to 1GW of committed module deliveries as Nanosolar achieves its volume and cost targets. Each of the three firms has

worked closely with Nanosolar as a strategic partner since 2008.

"Nanosolar's commitment to quality, customer relationships, and targeting one of the world's lowest cost solar panels makes it an ideal partner to help us tap into the world's fastest-growing renewable energy markets," says EDF Energies Nouvelles' CEO David Corchia. "Through this partnership with Nanosolar, we look forward to achieving a very competitive levelized cost of energy for our solar installations."

Nanosolar says that it combines proprietary technology with advanced system design and manufacturing processes to reduce both panel and balance-of-system costs. Leveraging what it claims are competitive CIGS solar cell and panel efficiencies in combination with its proprietary printing techniques, Nanosolar reckons that it can become the lowest-cost panel manufacturer at hundreds of

megawatts of production (versus gigawatts) within the next several years.

Nanosolar's roll-to-roll printing process combines low capital expenditure and high throughput, resulting in a low fixed-cost portion of the production cost per watt. Combined with a panel design that uses less overall materials for production and installation, this should enable the firm to surpass the \$0.60 per Watt cost threshold within the next several years, it is reckoned. Nanosolar will reach an annual production capacity of 115MW by fall 2011, and expects to at least double capacity each year thereafter.

"Nanosolar's industrial printing approach to manufacturing its utility-scale panel, combined with its lower balance-of-systems costs, will allow solar to be cost competitive with fossil fuels," says Belectric's CEO Bernhard Beck.

www.nanosolar.com

Thin-film PV firm Stion named top 50 startup at TiEcon

Stion Corp of San Jose, CA, USA, which manufactures nanostructure-based thin-film photovoltaic panels, has been chosen as a winner of the TiE50 Award honoring start-ups in a variety of industries.

Stion was recognized at TiEcon 2011 in the Santa Clara Convention Center on 13–14 May. TiEcon is said to be the world's largest conference for entrepreneurs, attracting thousands of entrepreneurs, venture capitalists, and industry executives.

This year, the TiE50 program screened 1619 companies worldwide, through a multi-tier screening and judging process. "Stion was clearly ranked amongst the best of the breed by a team of 60 highly accomplished and experienced judges. These experts included globally recognized venture capital-

ists, CEO's, academia, and serial entrepreneurs," says TiEcon 2011 chairman Vish Mishra, president of TiE Silicon Valley. "Being recognized as a TiE50 winner is a true testament to their entrepreneurial spirit and world-class caliber," he adds.

Founded in 2006 as Nstructures, Stion raised \$15m in June 2007 in a Series B financing round led by Lightspeed Venture Partners and joined by General Catalyst Partners along with previous investors Khosla Ventures and Braemar Energy Ventures. In June 2010, VentureTech Alliance — an affiliate of Taiwan Semiconductor Manufacturing Company Ltd (TSMC) of Hsinchu, Taiwan (the world's largest pure-play silicon foundry) — invested \$50m to take a 21% stake in Stion.

Stion also agreed to license and transfer its thin-film CIGSS (copper

indium gallium sulfur-selenide) technology to TSMC, in exchange for TSMC providing a certain quantity of solar modules to Stion using the technology. TSMC and Stion also agreed to work together to enhance the thin-film technology through joint development. Stion is currently building its first mass-production facility in Hattiesburg, MS.

"TiE50 companies this year again represented an extraordinary set of ideas, innovation, and business opportunities. Since its inception two years ago, 94% of TiE50 companies have been funded, attracting over \$20bn in investments," says TiE50 2011 chair Ram K. Reddy. "We plan to feature our finalists and winners through various channels and outreach programs during the year," adds Reddy.

www.stion.com

ZSW deposits CIGS cells on polymer film in single roll-to-roll system

German institute exceeds 10% efficiency using web coating

ZSW (Zentrum für Sonnenenergie- und Wasserstoff-Forschung — or Center for Solar Energy and Hydrogen Research — Baden-Württemberg) in Stuttgart, Germany claims that it has achieved a breakthrough in the development of efficient roll-to-roll web coating of copper indium gallium diselenide (CIGS) thin-film photovoltaic modules on plastic film.

By using lightweight, flexible substrates, the range of applications of thin-film solar cells can be increased significantly, says ZSW. Specifically, flexible thin-film solar cells on plastic film can enable many new areas of application where it is important for the cells to be both lightweight and flexible, such as solar cells on T-shirts and jackets, and modules on cars and light aircraft. It can also be advantageous to bond the solar foil to a glass substrate, since such modules would weigh half as much as standard modules (which are typically framed using two glass panels), suiting roofs that are not capable of bearing heavy loads.

However, until now, the manufacture of flexible thin-film modules has been difficult, labour intensive and time consuming, since every single layer is deposited individually in a separate system.

ZSW has been developing CIGS thin-film solar cells from the roll since 2010, using a 12m web-coating system in one of their technical labs. A temperature-resistant polyimide plastic polymer film — 0.0025cm (25µm) thick and 30cm wide — is used as the substrate. The institute had already completed the most important production steps in one go, using a continuously running system. The next phase was to complete all steps in the same system, making the manufacturing process considerably more efficient. ZSW has now combined

these steps in a single system.

"The unique feature of this web-coating system is that all coating steps take place simultaneously in the same vacuum," explains professor Michael Powalla, ZSW board member and head of the Photovoltaics Division. "While the back contact is applied at one end of the system by means of cathode sputtering, the co-evaporation of the CIGS absorber and the deposition of the transparent front contact layer are located elsewhere in the system," he adds.

In the current development stage, the molybdenum (Mo) back contact, the four elements for the CIGS absorber, and the zinc oxide window layers can be deposited. The development and integration of a new buffer layer is still in progress. Monolithic cell interconnection will also be fully integrated at a later point in time. The goal is to produce fully integrated solar modules with even greater efficiency. ZSW has already developed CIGS thin-film photovoltaics to series production maturity in collaboration with industrial partner Würth Solar GmbH of Schwäbisch-Hall, Germany. Mass production could help to create a new generation of affordable, flexible modules, says ZSW.

The cells have already achieved a solar energy conversion efficiency of 10.2% using the web-coating system. However, using research processes, ZSW has previously produced a small, 0.5cm² cell with a record conversion efficiency of 20.3% for a thin-film solar cell.

Development of the web-coating system by ZSW has been supported financially by the Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU) via the CISROLL investment project.

www.zsw-bw.de

IN BRIEF

Sono-Tek launches ultrasonic spray system for CIGS

Sono-Tek Corp of Milton, NY, USA has launched a new ultrasonic spray system for inline copper indium gallium diselenide (CIGS) photovoltaic cell manufacturing. The high-speed reciprocating HyperSonic system is scalable to high-volume production. The firm claims its ultrasonic systems such as the HyperSonic represent lower capital investments and cost savings compared with vacuum-based systems.

Sono-Tek says that non-vacuum deposition methods are becoming more popular in thin-film PV manufacturing as alternatives to chemical vapor deposition (CVD) and sputtering. It also notes that such methods require smaller capital investments compared to vacuum deposition.

Sono-Tek also states that its ultrasonic systems offer up to 95% transfer efficiency of rare-element CIGS suspensions.

Sono-Tek says that its ultrasonic nozzles use high-frequency vibrations to break up agglomerations in solution and hence assure spray uniformity during coating. This is particularly valuable when depositing cadmium-based suspensions, where such agglomerations can result in the non-uniform distribution of particles and a lower cell efficiency.

The Hypersonic system provides independent control of drop size, flow rate and deposition. Sono-Tek states that such features contribute to high uniformity and the ability to optimize morphology characteristics.

The HyperSonic system is available in 61, 97 or 122cm coverage. It includes product sensing capability, and the system can be retrofitted with existing conveyor systems for high-volume lines.

www.sono-tek.com

Odersun's CIS PV modules to be integrated into Franzen's solar façades

After announced a cooperation agreement with Lithodecor on solar façades in late March, Odersun AG of Berlin, Germany, which designs and makes customer-specific flexible thin-film solar modules using proprietary CISCuT (copper indium disulfide on copper tape) reel-to-reel manufacturing technology, is to cooperate on building-integrated photovoltaics (BIPV) with FranzenGroup of Kottenheim, Germany, a planner and constructor of façade and solar systems focusing on the integration of solar components into curtain-wall-type, rear-ventilated façades.

FranzenGroup works in the field of open system curtain wall façades and is said to have the necessary cross-disciplinary expertise for integrating photovoltaics into buildings. With more than 40 years in the façade business and involvement in the solar sector since 2005, Franzen says that it combines (under one roof) all the necessary skills for both aesthetic and functional installation and layout of fully integrated façade systems. In particular, façade experts at FranzenGroup have detailed knowledge of Odersun's customized solar products and offer both the electrical layout



Solar façades using building-integrated photovoltaics.

of the integrated solar system and its professional installation.

In addition, FranzenGroup subsidiary Franzen Ingenieur- und Montagebau GmbH offers consulting services for the planning of solar-integrated façades as early as in the planning and design phase. Architects, specialist planners and builders are accompanied from design through to implementation.

"Franzen combines, when it comes to the handling of our new types of solar components, a decisive, and until now rare, combination of skills, namely experience in façade construction and in the design of solar systems," comments Odersun's CEO Dr Hein van der Zeeuw. "The constructional and artistic integration of solar in build-

ings can only be successful when the necessary systems and the decisive experience and competence in planning and installation are combined with suitable materials," he adds.

The cooperation between Odersun and Franzen forms another link in the chain between manufacturer, system supplier, and planning and installation. "As a classical installation company, we were one of the first businesses to turn to the integrated use of solar energy in buildings," claims FranzenGroup managing director Jürgen Krämer. "It was clear to us that there was a dynamic movement toward the incorporation of new technologies for sustainable energy supply within the building," he adds. "With the new components from Odersun, we can now combine both skills and offer solar façades, which also meet the requirements of aesthetic integration."

<http://franzengroup-solar.net>

Odersun publishes online configuration software for solar modules

Odersun has published a software tool for designing individually fitted solar modules.

The 'Solarmodule-Designer' configuration software addresses architects and planners in search of customizable photovoltaic elements, enabling the user to create solar modules optimized for individual building projects and systems. Size, form, appearance as well as build-up and materials can be modified in detail to fit applications such as solar-integrated roofs and façades. Despite its unique diversity of adjustable

parameters, the tool is intuitive and easy to use, claims Odersun.

"The customized manufacturing of solar modules still is, after all, a new and often extremely technical area," says chief sales & marketing officer Uwe Hering. "This configuration software was purpose-built to allow users to experience the unique capabilities of Odersun's customized products in an easy, appealing and yet technically accurate way," he adds.

A special feature is the export function with its detailed PDF summary of the parameters cho-

sen and an additional CAD version of the user's individually designed solar module for download. Solar-module-Designer is free of charge and can be accessed online via www.solarmodule-designer.odersun.com.

The respective App for the iPad 2 will follow within a short time. Visitors at the Intersolar Europe 2011 show in Munich, Germany (8–10 June) had the opportunity to test the software using a touch screen table. The application was developed by Plural | Kilian Krug, Markus Lerner (Berlin).

www.odersun.com

Ruukki claims first fully integrated solar panel façade

Rautaruukki Oyj of Helsinki, Finland (which supplies metal-based components, systems and integrated systems to the construction and engineering industries under the trade name Ruukki) claims that it is the first company to develop a photovoltaic system that has been fully integrated into a solar façade. The electricity generated can either be used to meet the building's own needs or be fed into the grid.

Based on copper indium gallium diselenide (CIGS) thin-film technology, the solar panel façade has been designed for application in buildings of a high architectural standard that comply with increasingly stricter environmental regulations, says the firm. Developed and patented by Ruukki, the system is fully integrated into the façade and is claimed to be the most cost-effective method on the market for making a fully glazed façade that generates energy from the sun. The system enables power to be produced even in areas with no direct sunlight (since the technology can also use sun rays in cloudy weather), and in snowy areas and next to water it increases output from reflected rays.

In the façade of an average-sized office building in Finland, for example, Ruukki's solar panel façade can produce 18,000kWh of electricity a year (enough to meet the annual needs of a medium-sized, electrically heated small-family home). Output and capacity can be increased according to the area available and the capacity required.

"The unique concept in Ruukki's solar power system is that it is fully integrated into the façade of the building, both functionally and visually," says architect Laura Paunila at Ruukki. "The almost completely black fully glazed façade enables solutions of a high architectural standard," she adds. No visible fastenings have been used and, due to their even colouring, the modules are more aesthetically pleasing



The solar panel façade is based on solar panels made from glazed PV modules and Ruukki's steel rain-screen panel system.

than crystalline silicon solar panels, reckons the firm.

A solar panel façade is suited not only to office and commercial construction but also to residential and commercial construction, says the firm. The system does not limit choice of base materials or type of building, and the façade can be installed in new-build and renovation construction and on different bases, it adds.

The system is based on modular solar panels made from glazed PV modules and Ruukki's steel rain-screen panel system. The modules are almost black in color. They can be combined with Ruukki's other façade products and are part of its Design Palette range, which allow the size and shape of the other components in the façade to be freely defined.

A solar panel façade has a similar structure to Ruukki's Liberta rain-screen panel façade and is installed just like an ordinary Ruukki façade. Delivery includes all the components and supplies required at the site. Also, the cabling system has been pre-designed, so on-site installation is both fast and easy, claims the firm.

www.ruukki.com

TechPrecision wins \$400,000 order from new Tier-1 customer

TechPrecision Corp of Center Valley, PA, USA, a manufacturer of precision, large-scale fabricated and machined metal components and systems with customers in the alternative energy, cleantech, medical, nuclear, defense, aerospace and other commercial industries, has received an order worth about \$400,000 from a new Tier-1 customer for equipment which is used in the production of thin-film copper indium gallium diselenide (CIGS) photovoltaic (solar) panels. This represents the fourth new strategic tier-1 customer signed by TechPrecision since the beginning of its fiscal 2011.

"At the beginning of fiscal year 2011 we established a goal of signing four new Tier-1 customers," says TechPrecision's CEO James Molinaro. "This engagement further diversifies our customer base, particularly in the alternative energy vertical, and also increases our penetration in the rapidly growing solar energy market. This CIGS product complements our existing multi-crystalline and mono-crystalline solutions, and market trends indicate that CIGS technology will displace traditional thin-film technology in the next few years."

"Ranor's history of producing high-precision components with similar performance requirements gave us a distinct advantage to capture this business," says TechPrecision's director of business development Bill Hogenauer. "\$641m was invested in US solar companies in the first quarter of 2011 (according to the Cleantech Group) and CIGS technology is a significant advance in thin-film photovoltaic materials. TechPrecision, with this strategic Tier-1 customer, will position itself as a leading supplier in the rapidly growing CIGS market."

The initial order is expected to ship by fiscal third-quarter 2012.

www.techprecision.com

Tellurium doping opens up tunnel junction for GaInP/GaAs solar cells

Korean researchers develop tellurium as an alternative to silicon for doping to high n-type carrier concentrations in GaAs-based PVs.

Korea's Advanced Nano Fab Center and Hanbat National University have been investigating the use of tellurium (Te) doping in tunnel junctions for tandem solar cells that use gallium indium phosphide and arsenide (GaInP/GaAs) structures [Ho Kwan Kang et al, *Semicond. Sci. Technol.*, vol26, p075009, 2011]. Efficiencies of up to 28% were achieved in tandem solar cells grown on p-GaAs substrates with Te-doped junctions. By comparison, a Si-doped comparison device achieved only 11% efficiency

Tellurium provides n-type carriers in GaAs crystal structures. More usually silicon (Si) doping is used for this. One advantage of using Te is lower diffusion, allowing more abrupt structures to be achieved. Also, higher carrier concentrations can be achieved — up to $2 \times 10^{19}/\text{cm}^3$ — compared with the $5 \times 10^{18}/\text{cm}^3$ limit of silicon; this limit exists because, at higher Si doping levels, significant self-compensation sets in.

The results from devices grown on p-GaAs substrates are encouraging for proposed triple-junction formats combining the GaInP/GaAs tandem cell with germanium PV devices (GaInP/GaAs/Ge). The process would start with p-Ge substrates, followed by in-situ diffusion of n-type dopant in an epitaxial deposition chamber to form an n-p Ge junction. Then further layers would be applied to create the III-V cells.

The team concludes: "Our work, thus, suggests that the GaAs tunnel junction with Te doping can be utilized to improve the device performance of GaAs-based

multi-junction solar cells, although further research work on heavily Te-doped GaAs layers is required to optimize the carrier concentration and crystalline quality".

The research started with optimization of the Te-doping in GaAs by varying the growth temperature and precursor flow rates. Metal-organic chemical vapor deposition (MOCVD) was used to grow epitaxial structures on GaAs wafers that were miscut 2° in the $\langle 111 \rangle$ plane. Such miscutting can lead to better crystal quality in grown epilayers. Trimethyl-gallium (TMGa) and arsine (AsH_3) were the precursors for the epitaxial GaAs with hydrogen used as carrier gas. The tellurium doping was supplied by diethyl-tellurium (DETe).

Tunnel-junction structures (Figure 1) with Te- and Si-doping were compared in performance. The p-side of the junction was provided through carbon-doping; the other n- and p-type layers were provided by Si- and zinc-doping, respectively. The tunnel junctions were grown at 550°C , minimizing dopant diffusion and segregation effects. Other layers were grown at 680°C .

The Te-doping in the tunnel junction provided much higher current densities (Figure 2) for a given voltage. The tunnel-junction diode structures were used in GaInP/GaAs tandem solar cells grown on n- and p-GaAs substrates. Low-resistance contact metallization schemes were used: AuGe/Ni/Au for the n-side and Ti/Pt/Au for the p-side. A double-layer anti-reflection coating of SiO_2 (600nm)/ SiN_x (500nm) was also applied to minimize optical losses. ▶

n-GaAs	30nm	$(3 \times 10^{19}/\text{cm}^3)$	n-GaAs	30nm	$(3 \times 10^{19}/\text{cm}^3)$
n-GaAs	500nm	$(10^{18}/\text{cm}^3)$	n-GaAs	500nm	$(10^{18}/\text{cm}^3)$
n- $\text{Al}_{0.5}\text{In}_{0.5}\text{P}$	50nm	$(10^{19}/\text{cm}^3)$	n- $\text{Al}_{0.5}\text{In}_{0.5}\text{P}$	50nm	$(10^{19}/\text{cm}^3)$
TJ n-GaAs(Te)	20nm	$(4 \times 10^{19}/\text{cm}^3)$	TJ n-GaAs(Si)	20nm	$(9 \times 10^{18}/\text{cm}^3)$
TJ p-GaAs(C)	10nm	$(1 \times 10^{20}/\text{cm}^3)$	TJ p-GaAs(C)	10nm	$(1 \times 10^{20}/\text{cm}^3)$
p- $\text{Al}_{0.5}\text{In}_{0.5}\text{P}$	30nm	$(7 \times 10^{17}/\text{cm}^3)$	p- $\text{Al}_{0.5}\text{In}_{0.5}\text{P}$	30nm	$(7 \times 10^{17}/\text{cm}^3)$
p- $\text{Ga}_{0.5}\text{In}_{0.5}\text{P}$	300nm	$(2 \times 10^{18}/\text{cm}^3)$	p- $\text{Ga}_{0.5}\text{In}_{0.5}\text{P}$	300nm	$(2 \times 10^{18}/\text{cm}^3)$
p-GaAs	200nm	$(2 \times 10^{18}/\text{cm}^3)$	p-GaAs	200nm	$(2 \times 10^{18}/\text{cm}^3)$
p-GaAs substrate	$350\mu\text{m}$	$(10^{19}/\text{cm}^3)$	p-GaAs substrate	$350\mu\text{m}$	$(10^{19}/\text{cm}^3)$

Figure 1. Schematic structures of the tunnel-junction diodes: (left) Te/C and (right) Si/C junction.

► The extracted device parameters were determined under air-mass 1.5 global (AM1.5G) solar illumination (Table 1). Te-doped tunnel junctions showed poor performance (7% efficiency, compared with 26% for Si-doped junction) on n-type GaAs substrates with cross-sectional transmission electron microscopy (TEM) investigation showing non-uniform Te-doped layers attributed 'probably' to the formation of micro-precipitates of gallium telluride (Ga_2Te_3). The researchers thus recommend a lower level of Te-doping in this case, giving lower resulting carrier densities.

By contrast, on p-GaAs wafers the Te-doped tunnel junction resulted in much better performance compared with Si-doping (28% efficiency vs 11%). The researchers believe that the Si-doped device could have suffered significant out-diffusion of Si into other layers, "especially into the C-doped GaAs layer". The result of such diffusion would be increased tunneling resistance, degrading solar cell performance. "However, the exact mechanism is under investigation," the researchers say.

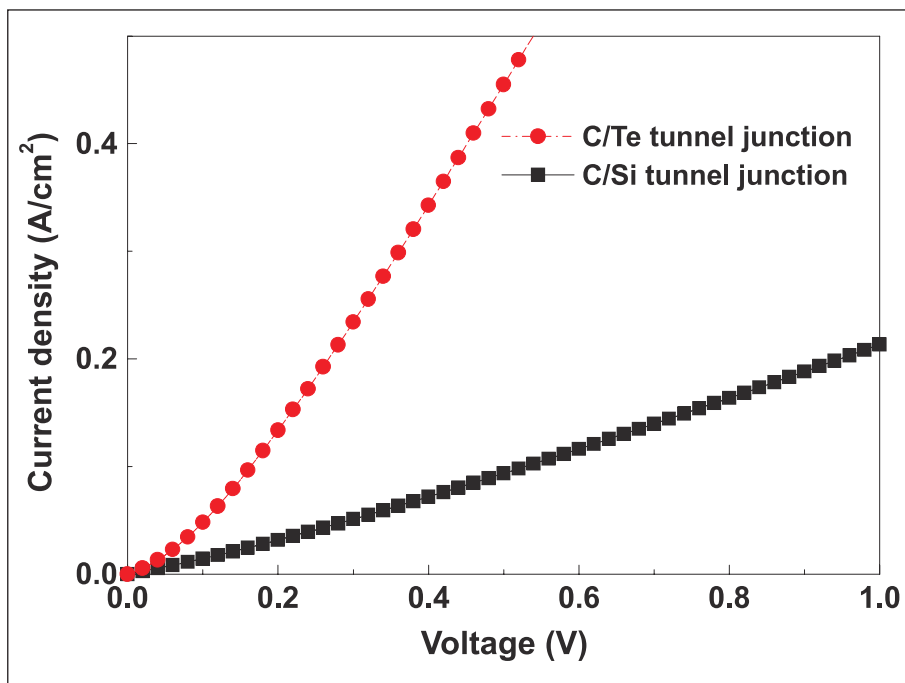


Figure 2. Current–voltage (I–V) curves for the tunnel-junction diodes.

<http://dx.doi.org/10.1088/0268-1242/26/7/075009>

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

Table 1. Summary of measured solar cell performance.

Solar cells with the GaAs tunnel junction			J_{sc} (mA/cm ²)	V_{oc} (V)	Fill Factor (%)	Efficiency (%)
n-tunnel (/cm ³)	p-tunnel (/cm ³)	Substrate				
Si: 9×10^{18}	C: 1×10^{20}	n-type	12.39 (± 0.02)	2.40 (± 0.02)	83.76 (± 0.41)	25.53 (± 0.04)
Te: 4×10^{19}	C: 1×10^{20}	n-type	8.88 (± 0.04)	2.15 (± 0.02)	35.81 (± 0.23)	7.17 (± 0.03)
Te: 1×10^{19}	C: 1×10^{20}	p-type	14.13 (± 0.08)	2.34 (± 0.01)	85.08 (± 0.51)	28.03 (± 0.02)
Si: 9×10^{18}	C: 1×10^{20}	p-type	13.12 (± 0.05)	1.47 (± 0.02)	36.81 (± 0.18)	10.51 (± 0.05)

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Re-grown source–drain III-V MOSFETs demonstrate higher drain current

Tokyo Institute of Technology achieves drain current of $1.3\text{mA}/\mu\text{m}$ for InGaAs CMOS field-effect transistors.

The Tokyo Institute of Technology says that it has increased the maximum drain current of indium gallium arsenide (InGaAs) complementary metal–oxide–semiconductor (CMOS) field-effect transistors (FETs) to more than $1.3\text{mA}/\mu\text{m}$ [Ryousuke Terao et al, Appl. Phys. Express, vol4, p054201, 2011].

Researchers have been working to achieve saturation drain currents of $2\text{mA}/\mu\text{m}$ for future scaled CMOS devices and moving from silicon to high-mobility III-V channels such as InGaAs has been developed as an option to achieve this. Earlier this year, a Taiwan National Tsing Hua University/National Taiwan University group reported a drain current of $1.23\text{mA}/\mu\text{m}$ — “to our knowledge, the present maximum drain current”, the Tokyo researchers comment.

The Tokyo researchers achieved their improved drain current by increasing the carrier concentration in the source–drain regions through using metal-organic chemical vapor deposition (MOCVD) re-growth rather than ion implantation to create highly silicon-doped InGaAs. The maximum carrier concentrations of ion-implanted InGaAs is about $10^{19}/\text{cm}^3$. Using re-growth, this can be increased about 3x.

The epitaxial layers for the latest Tokyo device (Figure 1) were grown on p-type indium phosphide (InP) substrates using MOCVD. The InGaAs channel layer was not doped (intrinsic/i-) to avoid resistance effects arising from ionized impurity scattering. The channel was covered with a thin 5nm i-InP layer to separate the carrier distribution from the oxide interface, avoiding further resistance effects from interface roughness and charge traps. The 300nm i-InAlAs layer below the channel further confined the channel carrier distribution.

A ‘dummy gate’ structure consisting of silicon dioxide was then formed on the top InP layer with lengths in the range 150nm to $6\mu\text{m}$, with a channel width of $20\mu\text{m}$. The purpose of the dummy gate was to allow wet etch of the InP and InGaAs layers in the source–drain regions, using hydrochloric acid in water and citric acid in hydrogen peroxide, respectively. The InGaAs etch also undercut the dummy gate on both sides — about 25nm for deep submicron channels (thus 150nm dummy gate gives 100nm channel) and

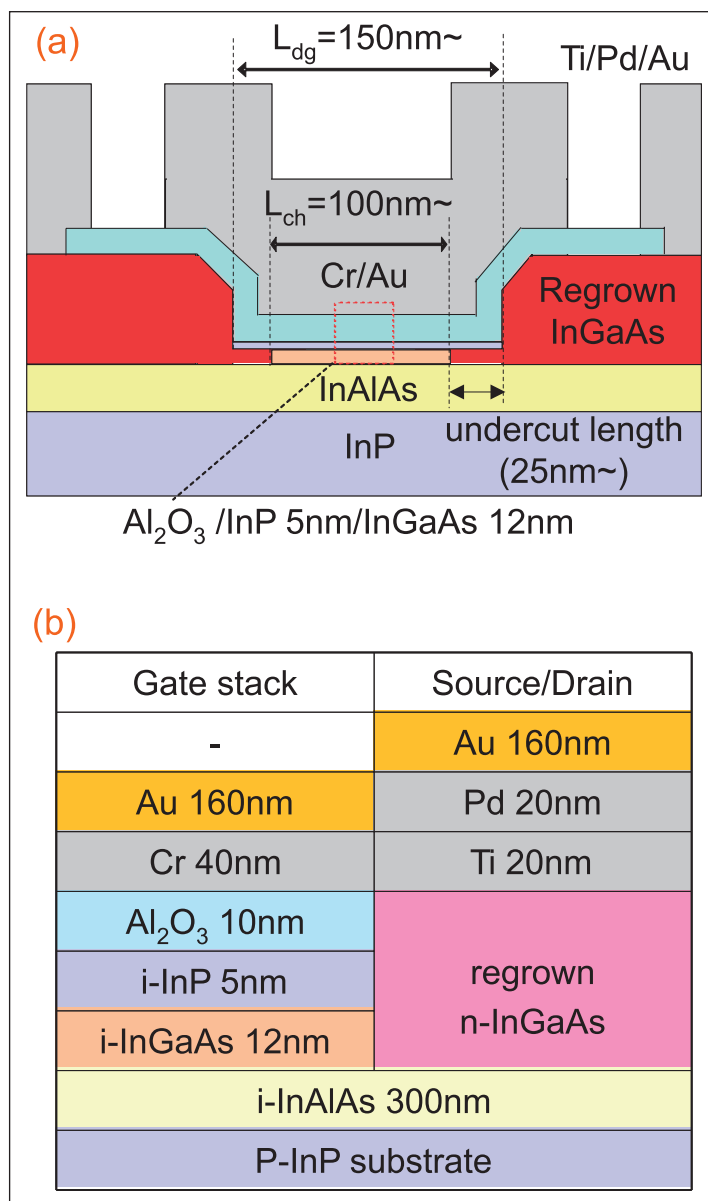


Figure 1. (a) Schematic and (b) layer profile at the gate stack and source/drain structure of the fabricated re-grown source/drain MOSFET.

45nm for micron-scale channels.

The wet etch was followed by an InAlAs surface treatment with a more dilute hydrochloric acid solution (1:5 rather than 3:1).

▶ The source–drain regions were then formed from silicon-doped InGaAs regrown using MOCVD. A dummy sample of regrown n-InGaAs on InAlAs/semi-insulating InP was found to have a carrier concentration of $2.9 \times 10^{19}/\text{cm}^3$ and a mobility of $1490 \text{cm}^2/\text{V}\cdot\text{s}$. “Thus, the re-grown source/drain process seems to be a good technique for heavy doping,” comment the researchers.

The devices were then isolated and the dummy gate was removed using buffered hydrofluoric acid. Atomic layer deposition (ALD) was used to apply aluminum oxide (Al_2O_3) gate insulator/dielectric. The wafer was then annealed at 400°C in nitrogen.

The gate electrode metals were then formed and annealed (350°C in nitrogen), followed by etch of the Al_2O_3 and deposition of the source–drain metal.

For the shortest channel length of 100nm , the maximum drain current of $1.34\text{mA}/\mu\text{m}$ was obtained with drain bias 1V and gate potential 3V . The gate leakage under these bias conditions was $2.6 \times 10^6 \text{mA}/\mu\text{m}$, a factor of more than 10^5 smaller than the drain current. The peak transconductance of $817 \mu\text{S}/\mu\text{m}$ was obtained at drain bias 0.65V . The threshold was -0.3V , so the device is partially ‘on’ at 0V (depletion mode, normally-on).

The total series resistance of the MOSFET was $0.5\text{k}\Omega\text{-}\mu\text{m}$, “which is slightly worse than other reported values”, the researchers comment. The poor series resistance is thought to arise from “high contact resistance of the metal/semiconductor junction”. From transmission line method (TLM) measurements, the researchers estimate that $0.38\text{k}\Omega\text{-}\mu\text{m}$ of the total series resistance arose from contact

One possible reason for the improvement is thought to be a reduction in the dielectric/semiconductor interface trap density as a result of surface cleaning, sulfide treatment, TMA pre-treatments, and annealing before the Al_2O_3 gate dielectric deposition. Comparing the performance of devices with different channel lengths, the researchers note “a good trend of increasing output performance with scaling of the channel length, although we also have room to improve the characteristics by using thinner Al_2O_3 ”

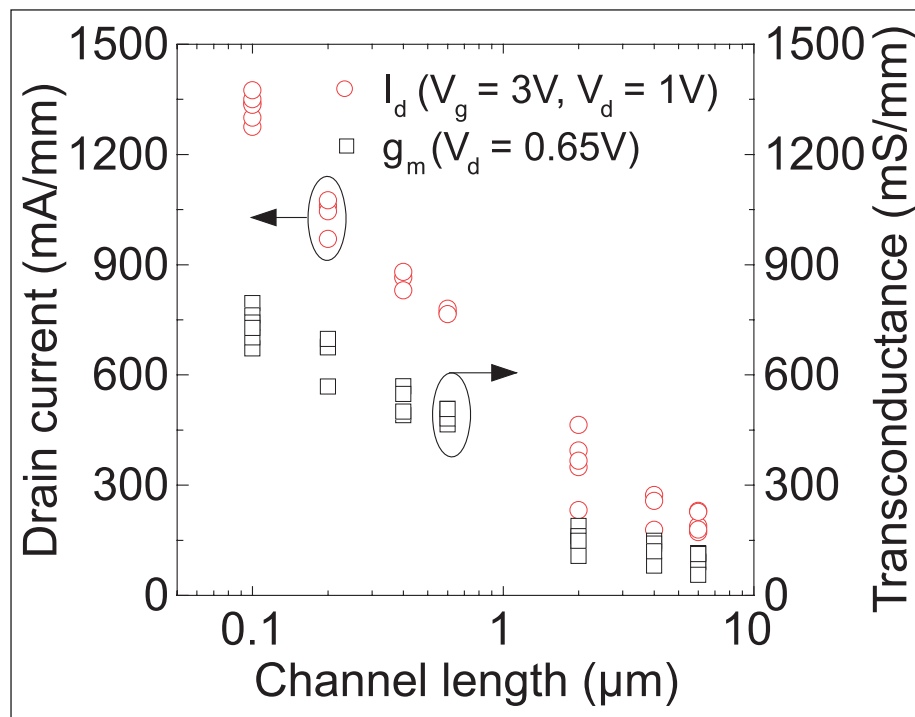


Figure 2. Channel length dependence of drain current (I_d) at drain bias (V_d) 1V and gate potential (V_g) 3V , and peak transconductance (g_m) at V_d 0.65V .

resistance, with the remainder being due to sheet resistance. Subtracting the series resistance gave an intrinsic transconductance figure of $1330 \mu\text{S}/\mu\text{m}$. The researchers thus hoped for improved performance from improving the metal/semiconductor contact properties.

The estimated peak channel mobility was $3100 \text{cm}^2/\text{V}\cdot\text{s}$. The subthreshold swing at a drain voltage of 10mV was $184\text{mV}/\text{dec}$ and at 0.65V it was $195\text{mV}/\text{dec}$. While these are a way off from the theoretical limit of $60\text{mV}/\text{dec}$ of planar MOSFET structures, the researchers comment: “This value is a dramatic improvement compared with our previous device (nearly $1\text{V}/\text{decade}$)”. One possible reason for the improvement is thought to be a reduction in the dielectric/semiconductor interface trap density as a result of surface cleaning, sulfide treatment, trimethyl-aluminum (TMA) pre-treatments, and annealing before the Al_2O_3 gate dielectric deposition.

Comparing the performance of devices with different channel lengths (Figure 2), the researchers note “a good trend of increasing output performance with scaling of the channel length, although we also have room to improve the characteristics by using thinner Al_2O_3 ”. There was some degradation of drain current and threshold fluctuation that seem to be associated with charge trapping; further work is needed to analyze and suppress these effects.

The researchers conclude that their results “indicate that the [metal-organic vapor phase epitaxy] MOVPE [i.e. MOCVD] re-growth process has superior capabilities for high-current operation”.

<http://apex.jsap.jp/link?APEX/4/054201>

Author: Mike Cooke

Dynamic improvement for nitride semiconductor power switching

HRL Laboratories reduces dynamic degradation of ON-resistance in 1200V normally-off GaN-on-silicon FET to just 1.2x at 350V.

HR L Laboratories of Malibu, CA, USA has achieved low dynamic ON-resistance in a nitride semiconductor field-effect transistor with normally-OFF behavior and high breakdown voltage [Rongming Chu et al, IEEE Electron Device Letters, published online 22 March 2011]. The researchers comment: "This is the first time a 1200V normally-OFF GaN-on-Si FET with low dynamic R_{on} is reported."

HRL defined its dynamic ON-resistance as being the value attained 5 μ s after switching from OFF to ON. In its best device, HRL achieved a degradation of the ON-resistance of only 1.2x at 350V bias and 1.6x at 600V.

For power switching, the dynamic behavior needs to maintain the good performance achieved in static tests. The ON-resistance can often be degraded in high-voltage power switching from the OFF- to ON-state in nitride transistors due to field-assisted electron

trapping in the region between the gate and the drain.

In microwave nitride devices, passivation and field plates have been used to overcome this problem by reducing the effects of charge trap states. This is one reason that HRL used multiple field-plate structures to control the electric fields in its device that was designed (Figure 1) to operate at voltages much higher than those of microwave devices.

The $\sim 4\mu\text{m}$ AlGaIn epi-structures were grown on 3-inch (75mm) (111)-oriented silicon substrates using metal-organic vapor phase deposition (MOCVD). The ohmic source-drain electrodes consisted of annealed titanium/aluminum metal stacks.

The gate formation was begun with a fluorine/chlorine plasma treatment to deplete the channel electrons, providing the normally-OFF characteristic. The researchers see 'normally-OFF' operation as being

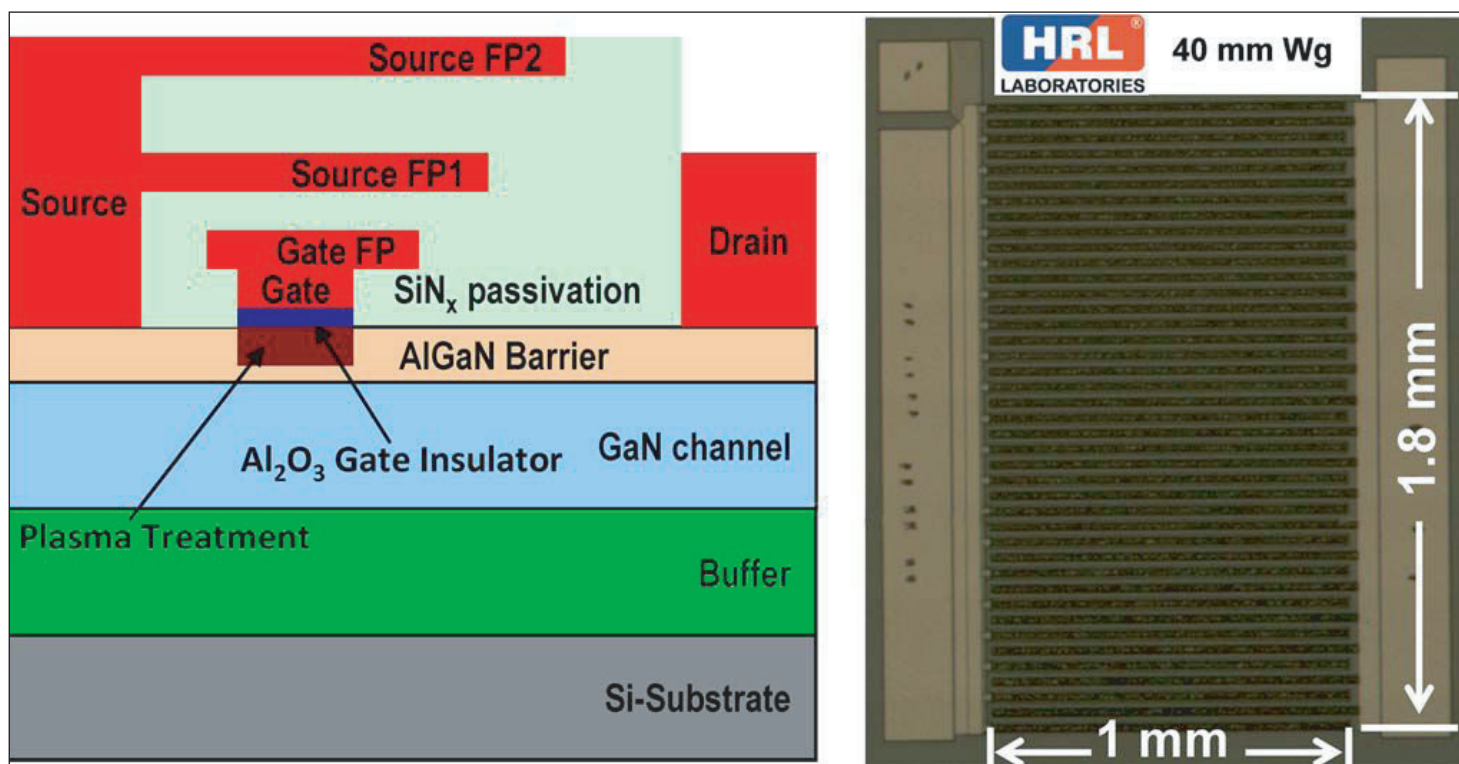


Figure 1. Cross-section schematic of device structure (left) and (right) microscopy top-view photo of GaN-on-Si FET.

particularly important for safe power switching device technology.

Fluorine is the main factor in providing the depletion and shifting the threshold voltage to positive values. Chlorine has been found to improve transconductance and reduce threshold hysteresis.

The hysteresis factor is caused by charge traps that occur near insulator-semiconductor interfaces, particularly in III-V devices. When there is a large gate bias swing expected in operation, hysteresis must be minimized for stable operation.

HRL's device has a gate dielectric/insulator of Al_2O_3 , applied using atomic layer deposition (ALD). The $1\mu\text{m}$ -length gate was completed with a nickel-gold electrode.

A silicon nitride passivation layer was grown using plasma-enhance chemical vapor deposition (PECVD), then the field plates were added — one to the gate and two to the source electrode.

The completed devices had a gate width of 40mm and an active area of 1.8mm^2 . The dies were attached to transistor outline TO-257 metal packages. The source terminal and silicon substrate were bonded to the metal can, while the gate and drain electrode were bonded to the input and output leads.

Process control monitor (PCM) devices were also processed on the wafers. A low threshold hysteresis of 0.1V was measured in these devices, indicating a low interface charge trap density.

Within a gate bias range from -3V up to $+3.5\text{V}$, the maximum drain current at 5V drain bias was $0.18\text{A}/\text{mm}$ and the gate leakage was of the order of $10\text{nA}/\text{mm}$. The researchers see low gate leakage as being important for high breakdown voltage, reduced power wastage, and simplified gate drive design.

HRL defined the threshold voltage (V_{th}) as being the gate potential at which the drain current reaches $1\mu\text{A}/\text{mm}$ at 5V drain bias. In these terms, some 600 PCM devices were tested and found to have 0.64V threshold on average with standard deviation 0.04V . The researchers comment: "The good uniformity of the

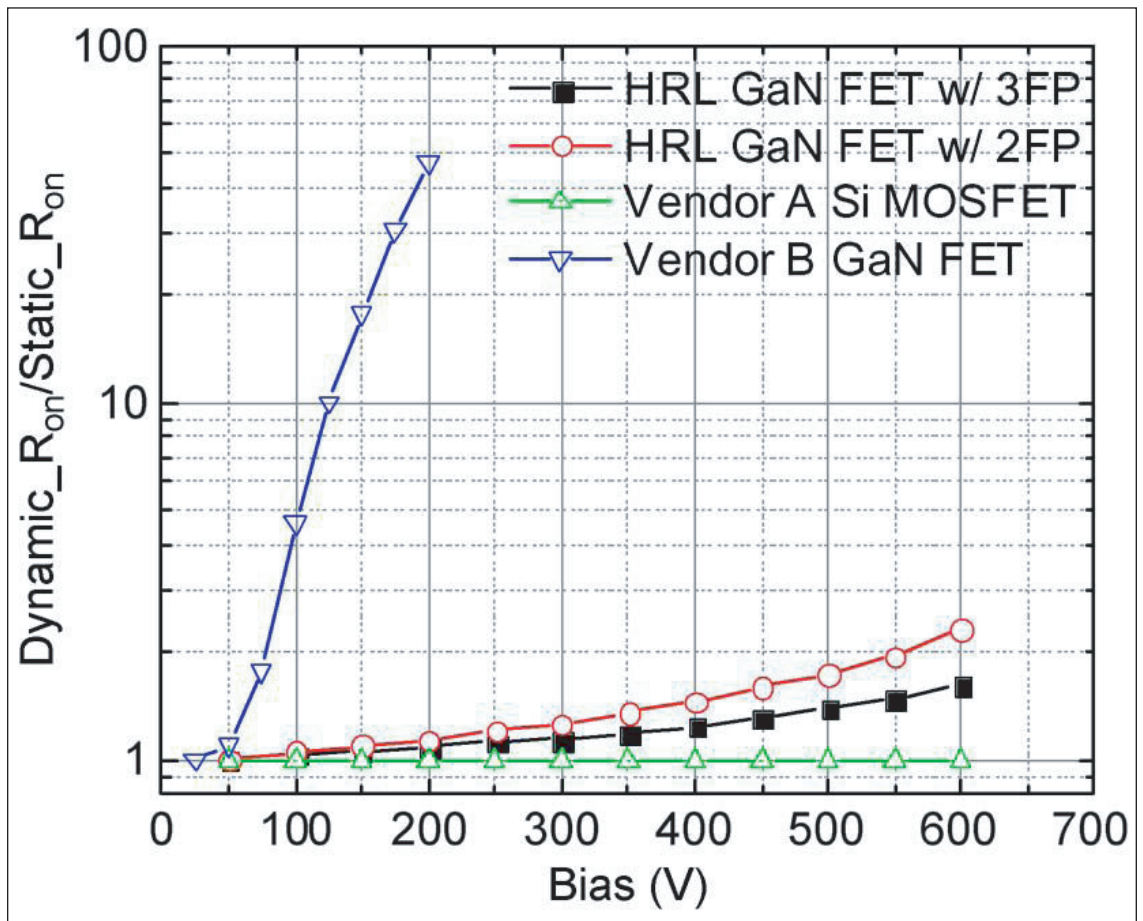


Figure 2. Ratio between dynamic ON-resistance and static ON-resistance at varied operating biases for different devices.

V_{th} of the PCM devices suggests the feasibility of constructing normally-OFF FETs with large gate width, as well as the manufacturability of our device fabrication process."

The static ON-resistance of a packaged device was 0.5Ω or $9\text{m}\Omega\text{-cm}^2$ at a gate potential of 3V and a drain current of 2A . The catastrophic breakdown at zero gate potential (OFF) was 1200V . The researchers comment: "The low R_{on} and high breakdown achieved with this device make it a very competitive candidate for high-voltage power-switching applications."

HRL compared its device (Figure 2) with varying numbers of field plates, along with commercial silicon superjunction power MOSFET and nitride FET devices. The silicon device showed no dynamic degradation of ON-resistance. The HRL FET with three field plates suffered some degradation of $1.2\times$ at 350V bias and $1.6\times$ at 600V . The researchers comment: "This is, to our knowledge, the best dynamic R_{on} performance achieved for a normally-OFF GaN FET on Si substrate."

The HRL team believes that further optimization of the field-plate configuration and epilayer quality could improve these dynamic characteristics towards a degradation-free level. ■

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Author: Mike Cooke

Nitride HEMTs with record 245GHz cut-off frequency

Oxygen plasma treatment reduces gate leakage current more than 100-fold in GaN-based high-electron-mobility transistor.

Researchers based in the USA have produced gallium nitride (GaN) semiconductor high-electron-mobility transistors (HEMTs) with indium aluminum nitride (InAlN) barriers that achieve cut-off frequencies (f_T) of 245GHz [Dong Seup Lee et al, IEEE Electron Device Letters, published online 29 April, 2011].

The scientists from Massachusetts Institute of Technology, IQE RF LLC and University of Notre Dame thus claim "the highest f_T ever reported in GaN transistors... These results demonstrate the great potential of InAlN/GaN HEMTs for millimeter- and sub-millimeter-wave applications."

The record performance was achieved thanks to an oxygen (O_2) plasma treatment that reduces gate leakage currents by more than two orders of magnitude. "In addition, the RF transconductance (g_m) collapse is reduced in the O_2 -treated devices, which results in a significant improvement in the f_T ," the researchers say.

The epitaxial structures for the HEMTs were grown on silicon carbide substrates using metal-organic chemical vapor deposition (MOCVD). The 45Å barrier layer of $In_{0.17}Al_{0.83}N$ was lattice matched with the underlying GaN buffer layer with a very thin 10Å AlN interlayer. Hall measurements on this epitaxial material gave a two-dimensional electron density of $1.5 \times 10^{13}/cm^2$ with a mobility of $1670 cm^2/V\cdot s$ and sheet resistance $250 \Omega/square$.

The use of lattice-matched material promises improved device reliability behavior long term, compared with the more usual GaN HEMTs with aluminum gallium nitride (AlGaN) barriers. A further attractive feature is a strong spontaneous polarization field in InAlN, inducing a high sheet charge density even with barriers thinner than 10nm.

Very thin barriers are needed to avoid complicated gate recessing etch processes where the barrier is thinned in the gate region to bring the electrode closer to the channel. Such recessing requires increasing etch accuracy as devices are scaled to the smaller dimensions needed for high-frequency performance. Nitride semiconductor technologists also avoid etch processes where possible, due to their potential to damage device performance.

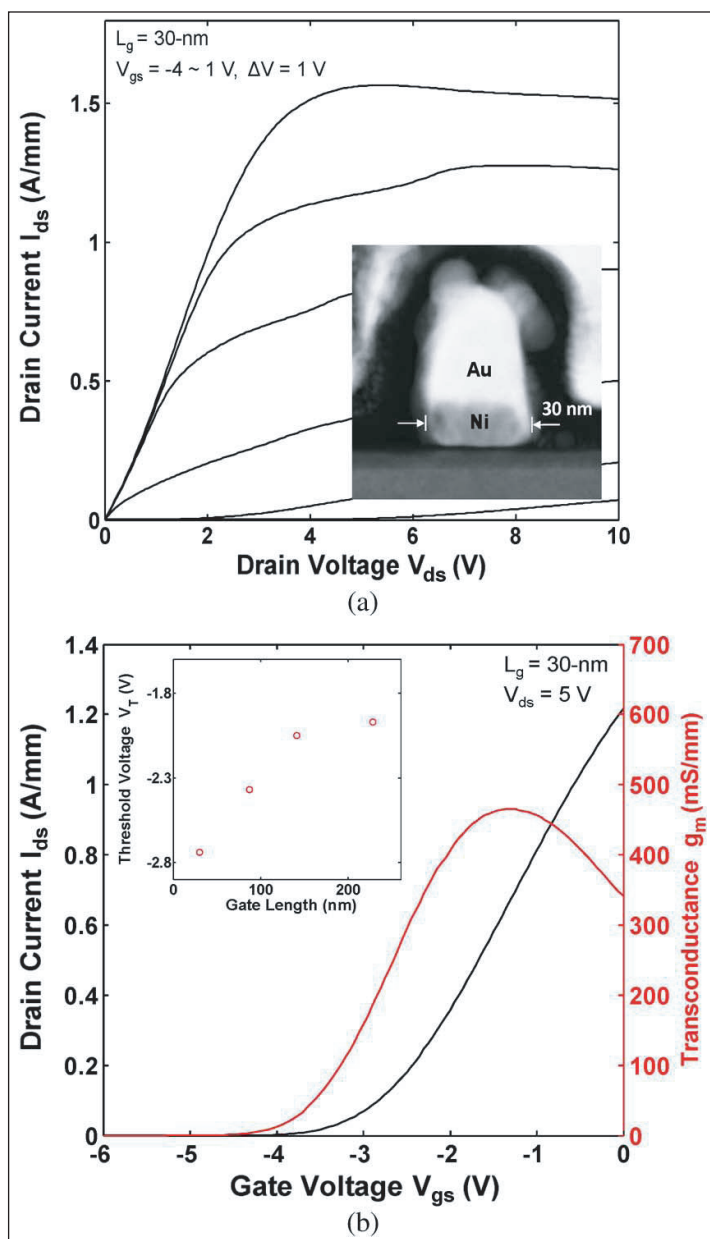


Figure 1. (a) Current-voltage (I - V) characteristics of an InAlN/GaN HEMT (gate length 30nm and width $50 \mu m$). Inset: transmission electron micrograph of 30nm-long gate. (b) Corresponding transfer curve at drain bias 5V. Inset: threshold voltage change depending on gate length. DC measurements were conducted by using one finger of device.

Device fabrication from the InAlN/GaN/SiC epitaxial material consisted of mesa isolation, deposition of titanium-aluminum-nickel-gold ohmic source-drain contacts, and annealing at $850^\circ C$ for 30 seconds in nitrogen.

▶ The gate deposition process was begun with the oxygen plasma treatment and then electron-beam lithography to define a rectangular gate opening on the oxidized layer. The gate electrode consisted of nickel-gold. The access region of the device was cleared of oxide with a buffered etch.

The device was passivated with aluminum oxide (Al_2O_3) using atomic layer deposition (ALD). The produced HEMTs had gate lengths as short as 30nm.

The researchers comment: "It should be noted that this fabrication technology results in very short gate-length devices but high gate resistance. Although the high gate resistance will not allow the practical use of these devices in RF applications, the simple gate geometry allows the careful study of the frequency limitations of InAlN/GaN transistors."

The DC characteristics (Figure 1) of the 30nm device include a maximum drain current of 1.57A/mm at a gate potential of 1V, and peak extrinsic transconductance (g_m) of 467mS/mm. The transconductance value was affected by unoptimized contacts and short-channel effects. The g_m value of a device with 140nm gate length produced on the same wafer was 509mS/mm.

The research team comments: "Even with the thin barrier thickness ($45 + 10\text{\AA}$), the short-channel effects cannot be ignored as the gate length decreases below about 50nm."

A further short-channel effect was a decrease in the threshold voltage with gate lengths less than 100nm (inset Figure 1). "A thinner barrier or the use of InGaN or AlGaN back barriers is necessary to completely suppress short-channel effects in highly scaled devices with sub-50nm gate lengths," the researchers say.

RF measurements, leading to the cut-off frequency of 245GHz (250GHz according to Gummel's method), give a very poor maximum oscillation frequency (f_{MAX}) of only 13GHz due to the high resistance of the rectangular gate structure. The researchers believe that significantly improved results would result from use of mushroom-shaped gate structures or multi-finger devices with rectangular gates. They warn, "It is important, however, to carefully design them to minimize their parasitic capacitances and the potential degradation in f_T ."

The researchers also compared performance of devices with and without oxygen plasma treatment (Figure 2). The main difference found is a suppression of gate leakage current by more than two orders of magnitude in devices with the oxygen plasma treatment. This effect is attributed to the insulating effect of the thin oxide layer resulting from the plasma exposure. Another effect of the oxide layer is a slight decrease in the threshold voltage due to the increased distance between the gate and channel. Neither the mobility nor the sheet resistance are affected by plasma treatment.

The researchers also carried out small-signal equivalent circuit analysis, finding that the f_T improvement is due

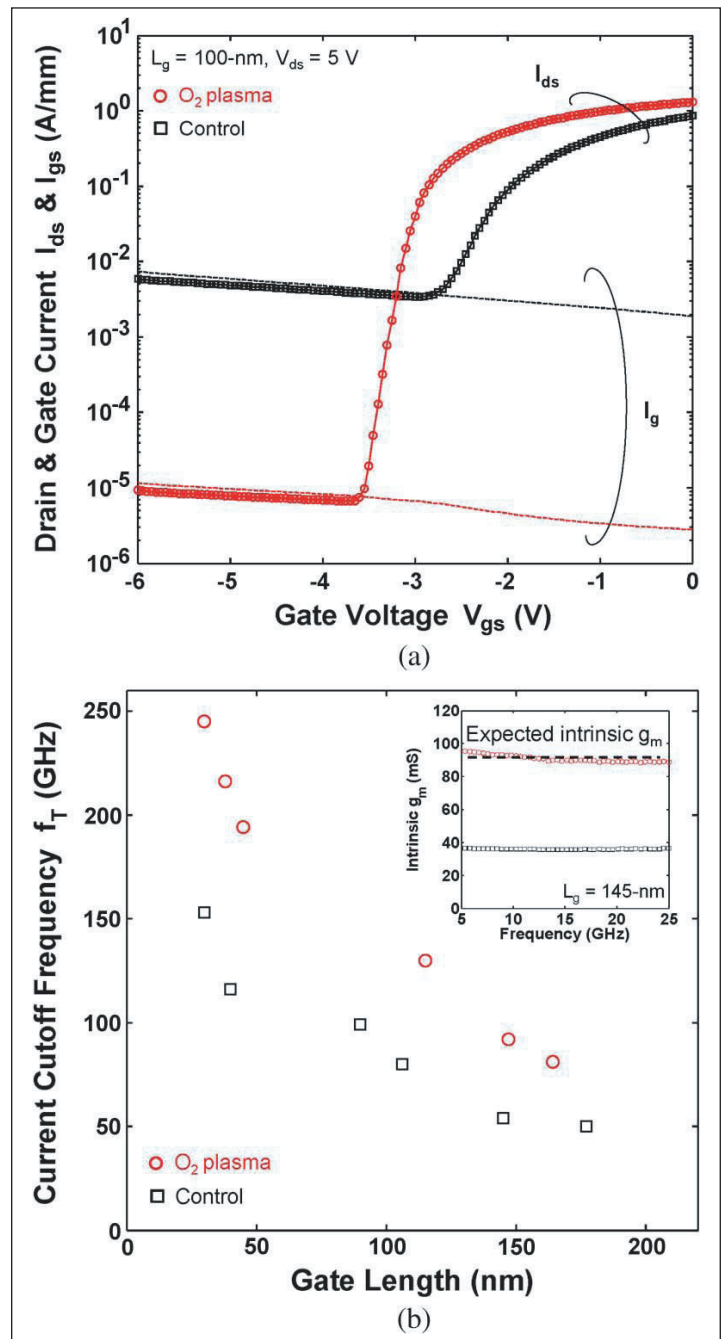


Figure 2. Effects of oxygen plasma treatment on (a) DC and (b) RF characteristics in InAlN/GaN HEMTs. Inset: intrinsic RF g_m at bias point of maximum f_T .

mainly to the higher RF peak transconductance of the plasma-treated devices. The exact mechanism for this reduced transconductance collapse at high frequency "is still under investigation".

The MIT/IQE/Notre Dame work received financial support from the US Defense Advanced Research Projects Agency (DARPA) Nitride Electronic NeXt-Generation Technology (NEXT) program, the Office of Naval Research (ONR) Defense University Research Instrumentation Program (DURIP), and the National Science Foundation (NSF) CAREER Award. ■

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UCSB reports N-polar HEMT power density record

UCSB has fabricated an N-polar AlGaN/GaN high-electron-mobility transistor that matches the power density of devices using Ga-polar material on sapphire.

A University of California Santa Barbara (UCSB) research team has achieved a new world record for output power density of N-polar aluminum gallium nitride/gallium nitride (AlGaN/GaN) high-electron-mobility transistors [Seshadri Kolluri et al, IEEE Electron Device Letters, vol32, p635, published online 15 April 2011].

The headline performance figure for the device was 12.1W/mm output power density at 4GHz operation and 50V drain bias (Table 1). The researchers comment: "To the best of our knowledge, the device reported in this letter showed the highest output power density for an N-polar GaN HEMT, and also matched the highest output power density for a Ga-polar device grown on a sapphire substrate".

However, the researchers note that Ga-polar AlGaN/GaN HEMTs grown on SiC presently show significantly better output power density (more than 40W/mm). These Ga-polar HEMTs, developed by Cree Santa Barbara Technology Center, used multiple field plates to massage the electric field distribution in the device layers. The use of SiC allows much better heat dissipation since it has a much higher thermal conductivity than sapphire. Devices with Ga-polar AlGaN/GaN structures are seen as having much potential for power amplification of microwave frequencies ranging from L-band (40–60GHz) to W-band (75–110GHz).

Advantages of reversing the polarity of the nitride semiconductor layers to being N-polar include lower contact resistance. "Development of N-polar MOCVD HEMTs on SiC substrates is expected to reduce the limitations due to self-heating and improve the large-signal performance of the devices significantly," the researchers add. Much of the work in this direction has been carried out at UCSB.

The researchers put particular stress on their use in the new devices of silicon nitride passivation and recessed gate structures with integrated slant field plates "to prevent dc to RF dispersion and improve the breakdown voltage". Further features include reduced

Table 1. Comparison of 4GHz large-signal performance of different GaN HEMTs. All results from UCSB work, except for Cree Santa Barbara Technology Center (MOCVD Ga-face on SiC substrate). The latest UCSB work is MOCVD N-face/sapphire.

Device	Substrate	V _{DS} (V)	P _{Out} (W/mm)	PAE (%)
MOCVD N-face	Sapphire	50	12.1	55
MBE N-face	SiC	40	8.1	54
MOCVD Ga-face	Sapphire	50	12	58
	SiC	135	41.6	60
MBE Ga-face	SiC	42	13.7	55

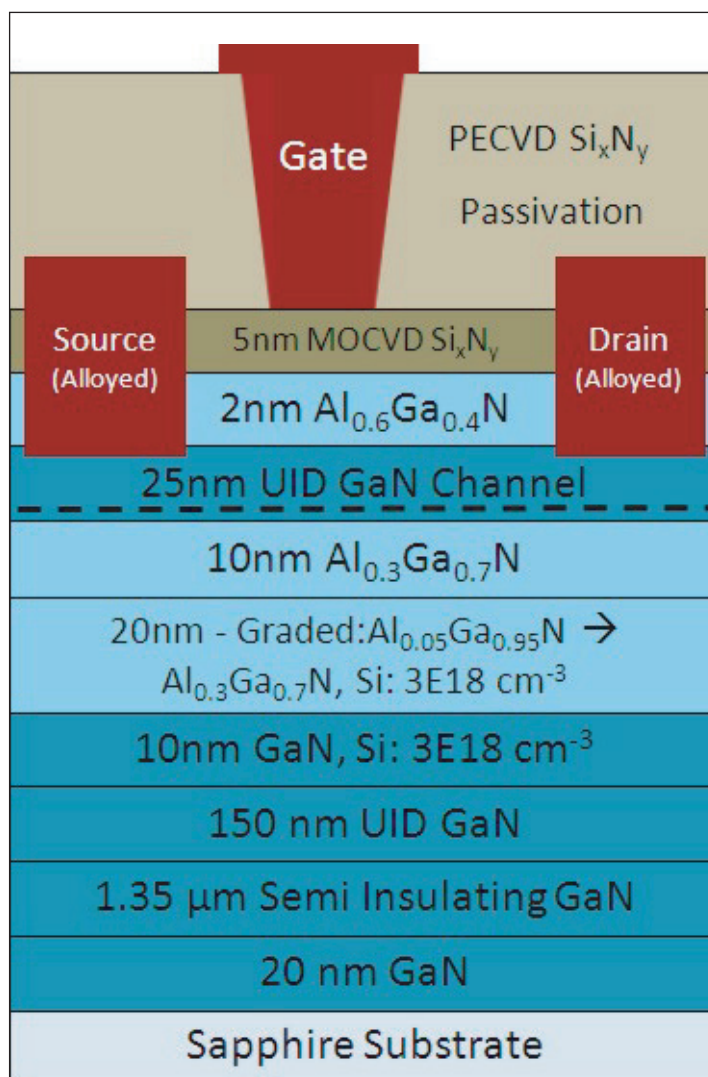


Figure 1. Schematic cross section of UCSB's MOCVD-grown N-polar AlGaN/GaN HEMT device.

source-to-drain spacing (reduced parasitic resistance) and increased output bias voltage.

The structure (Figure 1) was grown using metal-organic chemical vapor deposition (MOCVD) with trimethyl-gallium/aluminum (TMGa/TMAI) and ammonia as precursors on (0001) sapphire mis-oriented 4° toward the a-sapphire-plane. The researchers comment: "Growth on a misoriented substrate was essential to achieve smooth, high-quality N-polar films".

The N-polar film was initiated by exposing the sapphire surface to ammonia at high temperature. The semi-insulating GaN layer was achieved through iron-doping using bis-cyclopentadienyl-iron ((Cp)₂Fe).

Ohmic source-drain contacts were titanium/aluminium/nickel/gold (Ti/Al/Ni/Au) annealed at 870°C in nitrogen. These electrodes reached through the cap layers, making contact with the GaN channel layer.

A boron trichloride/chlorine reactive ion etch (RIE) created the transistor mesa structure, which was then passivated with silicon nitride applied using plasma-enhanced CVD (PECVD).

A timed gate recess etch was performed using carbon tetrafluoride/oxygen plasma. The gate metal structure was nickel/gold/nickel (Ni/Au/Ni). The nominal gate length was 0.7µm with a gate-drain spacing of 0.8µm. The gate width was 2µm x 50µm.

The channel direction was aligned with the direction of the growth steps that result from use of the mis-cut sapphire substrate. The reason for this is that that conductivity was found to be greatest in this direction

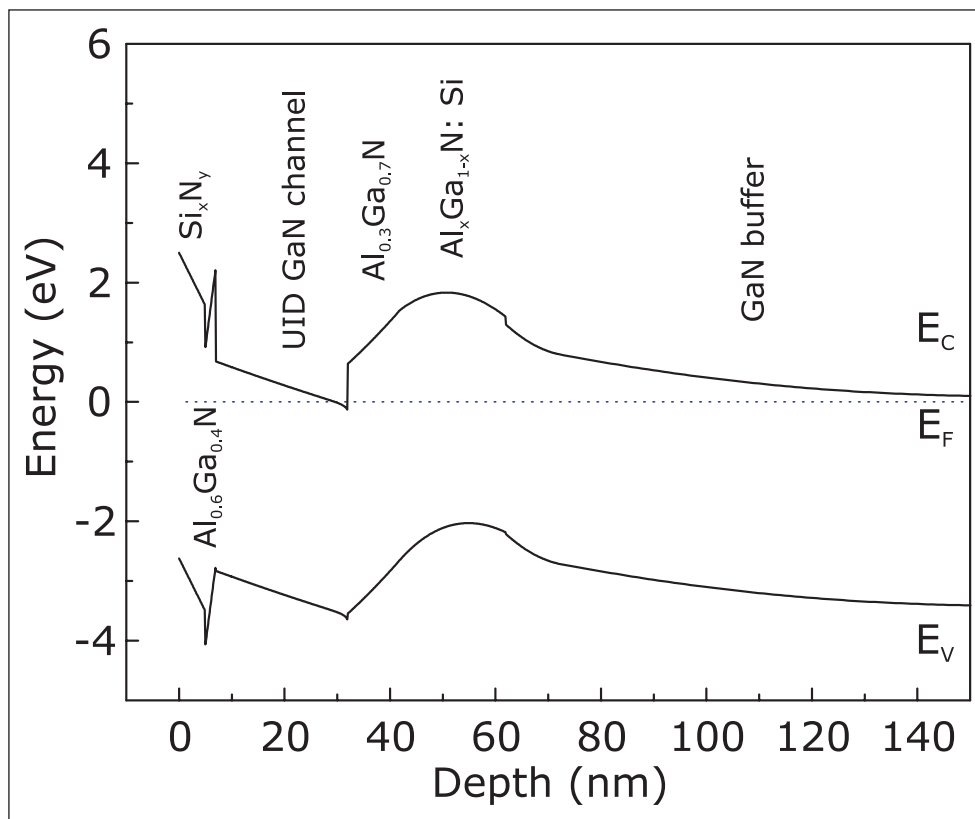


Figure 2. Simulated band diagram of device.

in Hall-effect measurements on the epitaxial material.

Further performance specifications include cut-off (f_T) and maximum oscillation (f_{MAX}) frequencies of 16GHz and 40GHz, respectively, at a drain bias of 17V. The three-terminal breakdown voltage (leakage current 1mA/mm) with gate biased at pinch-off was found to be in excess of 170V.

The UCSB work is supported in part by the US Office of Naval Research (ONR) Millimeter-wave Initiative for Nitride Electronics (MINE) project. ■

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Stepping up EBL in laser diode internal quantum efficiency

'Simple yet efficient structural design change' by Georgia Tech yields reduced threshold and increased slope efficiency.

Researchers at Georgia Institute of Technology (GaTech) have used a stepped electron-blocking layer design for indium gallium nitride (InGaN) semiconductor laser diodes (LDs) to increase internal quantum efficiency (IQE) to 0.92, compared with 0.6 found for an unstepped layer [Yun Zhang et al, J. Appl. Phys., vol109, p083115, 2011]. The effects of the improvement in IQE were reduced threshold current densities for lasing (from 4.6kA/cm² down to 2.5kA/cm²) and increased slope efficiency (from 0.72W/A up to 1.03W/A).

The researchers comment: "This simple yet efficient structural design change provides an effective way to achieve high-performance InGaN-based LDs with higher optical-output power and lower electric-power consumption."

Electron-blocking layers (EBLs) are used to confine

the electron and hole carriers to the active region of light-emitting devices in the hope of increasing internal quantum efficiency. In nitride semiconductor devices, the EBL often consists of a layer of aluminum gallium nitride (AlGaN), which has a wider bandgap than gallium nitride (GaN).

The EBL is deposited on the last barrier of the multi-quantum well (MQW) of the light-emitting device. The interface between the EBL and last barrier is usually strained, giving rise to polarization electric fields that are unusually strong in nitride semiconductors. These polarization fields lead to free-electron accumulation at the interface that degrades internal quantum efficiency of light emission.

To combat this effect, GaTech researchers produced two laser diode structures that differ in the EBL region: structure A had a conventional magnesium-doped

Layers	Material:doping	Thickness (nm)
p-contact	GaN:Mg ⁺⁺	20
p-injection	GaN:Mg	30
p-cladding super lattice 90 pairs	GaN/Al _{0.16} Ga _{0.84} N:Mg	450
p-waveguide	GaN:Mg	100
EBL		28.8
Active region		49.2
n-waveguide	GaN:Si	100
n-cladding super lattice 150 pairs	GaN/Al _{0.16} Ga _{0.84} N:Si	750
Buffer	GaN:Si	2000
Substrate	c-plane GaN	

EBL structure A	
Al _{0.18} Ga _{0.82} N:Mg	20
GaN barrier:undoped	8.8

or

EBL structure B	
Al _{0.18} Ga _{0.82} N:Mg	20
Al _{0.09} Ga _{0.91} N:Mg	4.4
Al _{0.04} Ga _{0.96} N:Mg	4.4

Active region	
In _{0.10} Ga _{0.90} N:undoped	3.5
GaN:undoped	8.8
In _{0.10} Ga _{0.90} N:undoped	3.5
GaN:undoped	8.8
In _{0.10} Ga _{0.90} N:undoped	3.5
GaN:undoped	8.8
In _{0.10} Ga _{0.90} N:undoped	3.5
GaN:undoped	8.8

Figure 1. Compositions and thicknesses of laser diode structures.

p-Al_{0.16}Ga_{0.84}N layer on top of the last undoped 8.8nm GaN barrier of the active region; structure B also had a magnesium-doped p-Al_{0.16}Ga_{0.84}N, but the GaN barrier was replaced by two 4.4nm layers of p-AlGaN with stepped Al-content (Figure 1). The full epitaxial structures were grown using metal-organic chemical vapor deposition (MOCVD) on c-plane free-standing GaN substrates.

LDs using epitaxial materials A and B were fabricated in the same process run to avoid fabrication-related performance variation. Ridge devices were formed with end facets that had distributed-Bragg-reflector (DBR) mirrors with reflectivities of 27% and 99%.

Optical output power-current density measurements on devices with 8 μ m x 750 μ m ridges in pulsed operation (0.1% duty cycle, pulse width 1 μ s, repetition rate 1kHz), avoiding self heating effects, gave threshold current densities of 4.6kA/cm² and 2.5kA/cm² for structures A and B, respectively. The slope efficiencies were 0.72W/A for structure A, and 1.03W/A for structure B. The researchers also report that continuous-wave (cw) laser operation was achieved at room temperature for both structures.

By comparing devices with different cavity lengths, the researchers found the IQE and internal loss for devices based on epitaxial materials A and B. The IQEs were 0.6 and 0.92 for structures A and B, respectively. The loss values were roughly similar at 10/cm for structure A and 9/cm for structure B.

Spectral investigations showed variation of the peak wavelength with a red-shift at high temperatures (Figure 2). The staircase pattern for the peak wavelength of structure A is attributed to mode-hopping, where the stimulated emission switches from one longitudinal mode of the cavity to another as the temperature varies. Structure B has a smoother curve without mode hopping. The researchers comment: "The results suggest that the step-graded EBL design may offer a better thermal stability in the lasing wavelength." Mode hopping in structure B was also suppressed at high injection current (and thus for high optical-output power operation).

The shift in threshold current with temperature was also measured (Figure 3) to find the characteristic temperatures (T_0) of the devices. The researchers comment: "It is noted that T_0 of 210K on the abrupt EBL LDs is one of the highest values reported on InGaN-based violet-blue LDs. For the step-graded EBL LDs, T_0 of 180K is also measured, which is comparable to typical

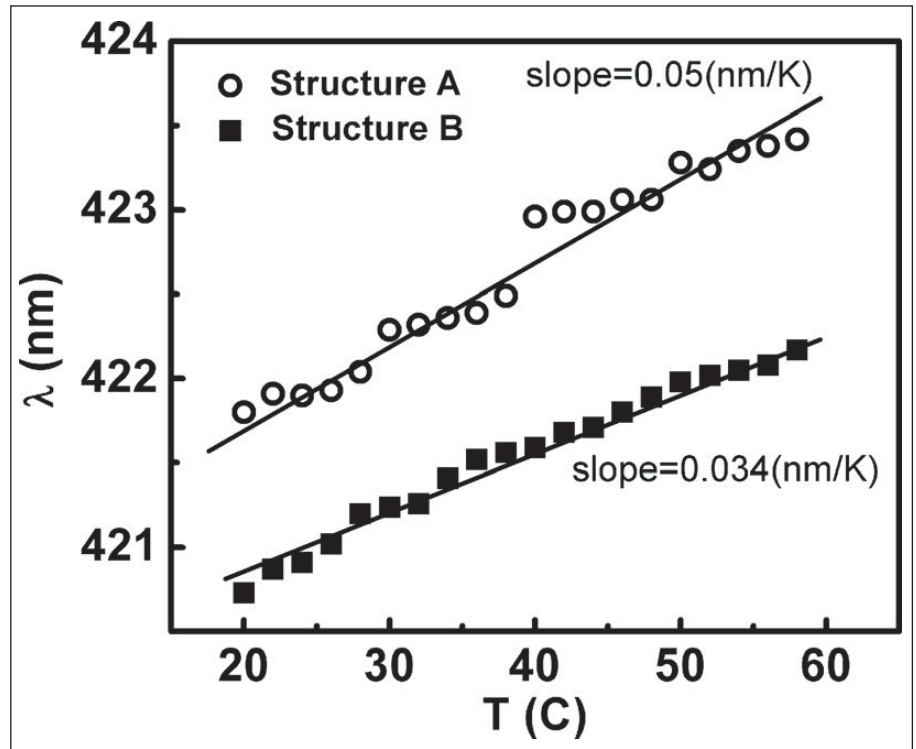


Figure 2. Temperature dependence of peak wavelength for the LD structures A and B under pulsed-current operation from 20°C to 58°C.

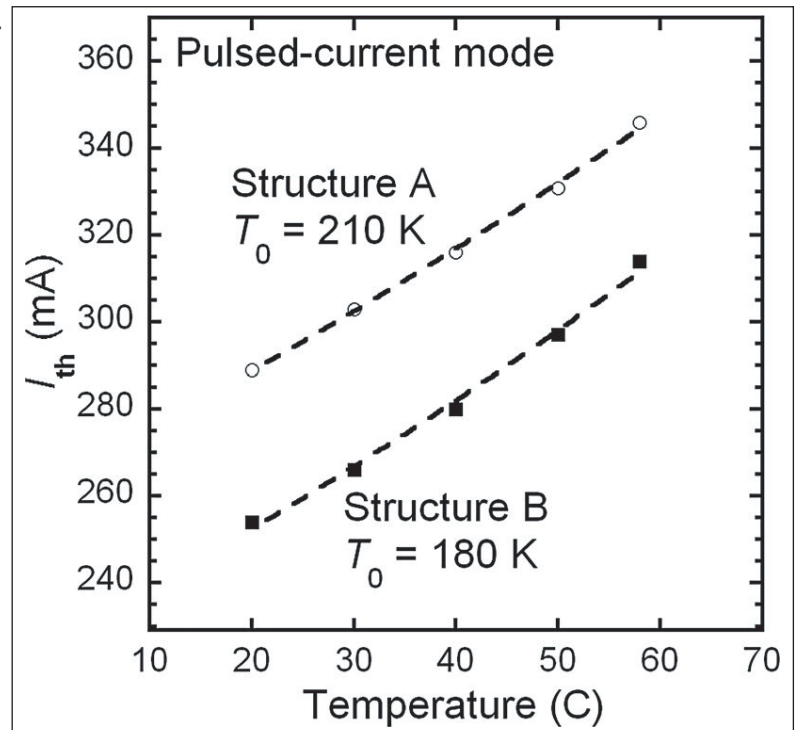


Figure 3. Temperature dependence of the threshold currents for structures A and B in pulsed-current mode at 20–58°C.

values reported on other InGaN-based violet-blue LDs (140–190K)". A high value of T_0 indicates less shift in the threshold with a given change in temperature.

The research at GaTech benefited from DARPA Visible InGaN Injection Lasers (VIGIL) program funding. ■

<http://link.aip.org/link/doi/10.1063/1.3581080>

Author: Mike Cooke

Simulating way to improved deep ultraviolet LEDs

Taiwan research suggests that thicker barrier layers at p-type end of multi-quantum-well structure could boost DUV LED power by 45%.

Researchers at Taiwan National Changhua University of Education and LED chip maker Epistar Corp have carried out simulations that suggest that deep-ultraviolet (DUV) LEDs could benefit from using multi-quantum well (MQWs) structures with barrier thicknesses that vary through the structure [Miao-Chan Tsai et al, Appl. Phys. Lett., vol98, p111114, 2011]. In particular, having thicker barrier layers towards the p-type end of the simulated device increased the light output power by 45% at 20mA injection current.

In the past few years, a number of research groups have reported deep-ultraviolet (less than 300nm wavelength) LEDs, based on the aluminum gallium nitride (AlGaN) semiconductor material system. The output powers are generally low (less than 1mW or even 1μW at wavelengths less than 250nm) and there is much interest in increasing the efficiency of devices.

The main application in the short term would be the replacement of mercury lamps, which are inefficient, unreliable, short-lived and environmentally undesirable (particularly in terms of disposal). The first application in line for conversion to these devices is thought to be disinfection lamps, since UV light of these wavelengths disrupts biological structures, killing microbes etc. Further possible applications include gas sensing, medicine, and biochemical analysis.

As a basis for their work, the Taiwan researchers used a previously published actual device structure (Figure 1) developed by Japan's Institute of Physical and Chemical Research (RIKEN) and Saitama University [Hideki Hirayama et al, Appl. Phys. Lett., vol91, p071901, 2007, <http://link.aip.org/link/doi/10.1063/1.2770662>]. These devices were 300μm square and emitted 261nm-wavelength radiation.

		Reference	A	B
p-contact	p-GaN	10nm	10nm	10nm
p-contact	p-Al _{0.72} Ga _{0.28} N	10nm	10nm	10nm
Electron blocking layer	p-Al _{0.94} Ga _{0.06} N	15nm	15nm	15nm
Barrier	Al _{0.72} Ga _{0.28} N	7nm	7nm	7nm
Active layer barrier 4	Al _{0.72} Ga _{0.28} N	4nm	2nm	6nm
Active layer well 3	Al _{0.55} Ga _{0.45} N	2nm	2nm	2nm
Active layer barrier 3	Al _{0.72} Ga _{0.28} N	4nm	3nm	5nm
Active layer well 2	Al _{0.55} Ga _{0.45} N	2nm	2nm	2nm
Active layer barrier 2	Al _{0.72} Ga _{0.28} N	4nm	5nm	3nm
Active layer well 1	Al _{0.55} Ga _{0.45} N	2nm	2nm	2nm
Active layer barrier 1	Al _{0.72} Ga _{0.28} N	4nm	6nm	2nm
Buffer	n-Al _{0.72} Ga _{0.28} N	1.7μm	1.7μm	1.7μm

Figure 1. Basic device structure with triple quantum well active region from Japanese research, and the graded barrier structures modeled by the Taiwan team.

The research team has previously found that decreasing the barrier thicknesses towards the p-contact end of a multi-quantum well (MQW) active layer improved hole injection for a blue-emitting indium gallium nitride LED structure in simulation. Sufficient hole injection is a challenge for all nitride semiconductor light-emitting devices due to the high activation of magnesium (Mg) doping (reducing hole carrier densities in p-type materials).

For deep-UV emission (less than 300nm), the Taiwan researchers produced simulations of variations of the RIKEN/Saitama LED, varying the barrier thicknesses from 6nm to 2nm. 'Structure A' decreased the barriers from n-type to the p-type region, while 'structure B' increased the barrier thickness in the same direction (Figure 1). The work was also checked by a reference simulation with constant 4nm barriers, as in the RIKEN/Saitama device.

Simulations suggest the hole concentration is very low (about two factors of ten down from the electron density)

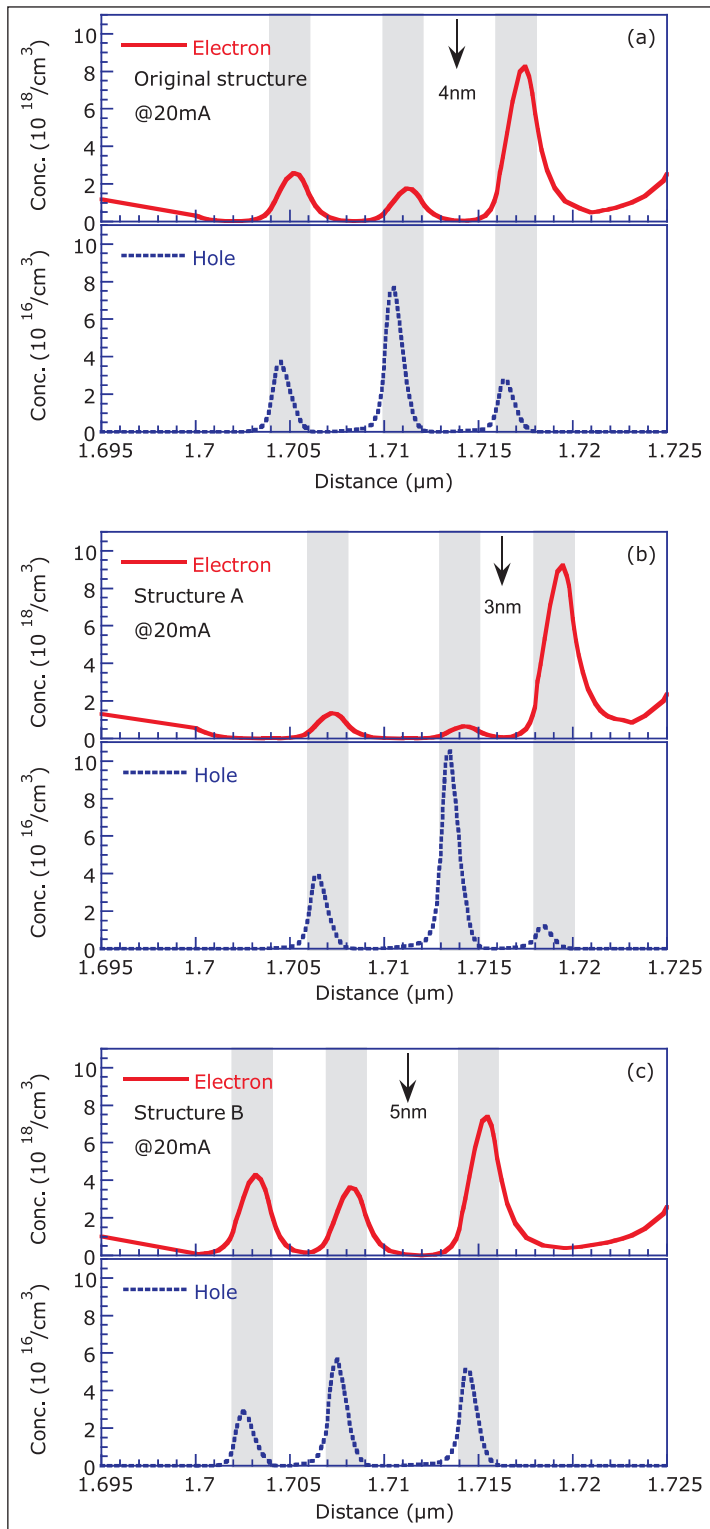


Figure 2. Electron and hole concentrations of (a) original structure, (b) structure A, and (c) structure B around the active region at 20mA. Note that the scale of the hole concentration axis is two orders of magnitude smaller than that for the electrons.

in the active layer for the three structures considered (Figure 2). This is due to the low hole concentration in the p-AlGaIn layers, along with valence-band offsets between p-type layers, making it hard for holes from the p-GaN layer to reach into the light-emitting region. The p-GaN layer has a higher hole concentration due

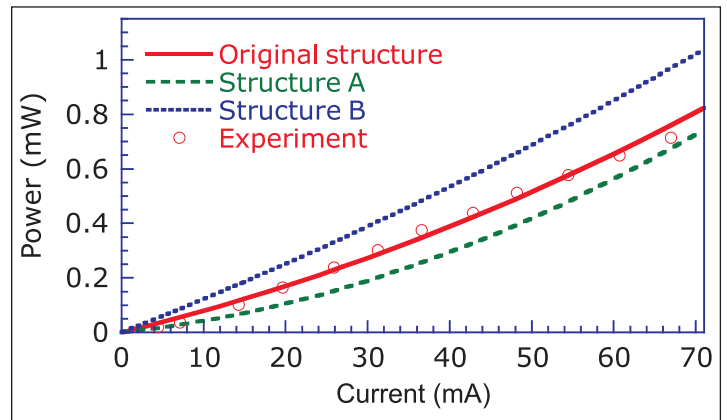


Figure 3. Output power as a function of current for original structure, structure A, and structure B. The open circles are the experimental data of the original structure produced by Japanese researchers.

to the lower activation energy of the Mg doping. The electron-blocking layer (EBL) is also inefficient at completely blocking electrons from entering and recombining (generally non-radiatively) in the p-type regions.

The low hole density in the active layers means that there are a large number of electrons that do not recombine. Negative outcomes from this include serious electron leakage, more non-radiative recombination, self-heating problems, and poor output power.

The obvious solution might appear to be to thin the barrier towards the p-end of the device, allowing in more holes (structure A). However, the Taiwan simulations suggest that while the hole concentration in the middle well increases, it does not match up with the electron distribution, which is concentrated towards the p-end of the active region.

The counter-intuitive structure B leads to a more balanced hole (and electron) distribution. The researchers attribute this to a smaller electrostatic field and smoother energy-band profile in the thicker barrier at the p-end.

Further simulation work consisted in determining the amount of non-radiative electron-hole recombination (Shockley-Read-Hall mechanism). They found that the radiative recombination in structure A was 50% that of the reference device, while structure B radiation rates were increased 56%.

Bringing all the work together, the researchers calculated light output versus current for the three structures and compared their results with the Japanese experiments to demonstrate the reliability of the simulations (Figure 3). At 20mA, the structure B emitted 45% more power than the reference device.

The researchers used Crosslight Software's APSYS, Advanced Physical Models of Semiconductor Devices, simulator. ■

<http://link.aip.org/link/doi/10.1063/1.3567786>

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Author: Mike Cooke

Sapphire patterning boosts green LED light generation and extraction

Effect of reducing total internal reflection and improving crystal quality gives a 3.4x enhancement in external quantum efficiency, says RPI.

Researchers from Rensselaer Polytechnic Institute (RPI) in the USA and SCIVAX Corp of Japan have used patterned sapphire substrates to improve efficiency of green (520–570nm wavelength) light-emitting diode (LED) indium gallium nitride (InGaN) semiconductor structures [Yufeng Li et al, Appl. Phys. Lett., vol98, p151102, 2011].

Patterning of sapphire substrates has previously been used to reduce the total internal reflection of light (due to the refractive index differences of materials) back into nitride semiconductor devices, increasing light extraction. However, another effect of patterning can also be to improve the crystal quality of epitaxial nitride semiconductor layers. One way to do this is to deposit a silicon dioxide mask to block threading dislocations and create regions of low-defect material (epitaxial layer overgrowth/ELOG).

Direct patterning of sapphire substrates has also been suggested as a way to reduce threading dislocations in epitaxial layers, and was recently used by researchers in Taiwan to enhance the performance of nitride semiconductor photovoltaic devices [www.semiconductor-today.com/news_items/2011/MAR/NCKU_250311.html].

The RPI/SCIVAX researchers used nano-imprint lithography (NIL) with a silicon patterned stamp to produce patterning in a resin layer on the initially planar sapphire substrates. Reactive ion etch (RIE) then transferred the patterning of the resin layer, cutting into the sapphire itself to create a hexagonal array of cylindrical holes of 250nm diameter and 450nm period. The etch depth was 125nm.

Vertical-flow metal-organic chemical vapor deposition

p-GaN	magnesium-doped	0.2 μ m
p-Al _{0.18} Ga _{0.82} N	electron blocking	10nm
Ga _{1-x} In _x N/GaN	8xquantum well	3nm/20nm
n-GaN	silicon-doped	6 μ m
low temp. GaN	buffer	

Figure 1. Schematic of epitaxial nitride layers grown on patterned and unpatterned sapphire substrates. The grown devices had indium content of 10–20%, determined through x-ray diffraction.

(MOCVD) was used to grow the nitride semiconductor layers on these patterned sapphire substrates (Figure 1).

Patterning was found to improve the crystal quality of the nitride semiconductor material through reducing threading dislocation densities in the quantum wells of the LEDs

Patterning was found to improve the crystal quality of the nitride semiconductor material through reducing threading dislocation (TDs) densities (Figure 2) in the quantum wells of the LEDs where the light is produced.

Threading dislocations emanating from the bottom of the cylinders (T3) are thought to be terminated by air voids that tend to form during the growth process.

Another TD reduction process is thought to be confinement to the growth plane of those emanating from the cylinder sidewalls (T2). "Only TDs originating in the

Table 1. LED characteristics for devices grown on patterned and unpatterned sapphire (reference). Output power is partial, being measured from the sapphire side of the unencapsulated nanopatterned substrate LED die.

	Current mA	Current density A/cm ²	Output power mW	Wavelength nm	Linewidth nm
patterned	30	33	2.3	537	42
patterned	100	110	5.2	523	42
reference	30	33	0.88	541	46
reference	100	110	1.8	527	46

unetched portions of the substrate (T1) propagate toward the active region," the researchers comment.

The researchers estimate from transmission electron microscopy (TEM) that the threading dislocation density is $3.6 \times 10^8/\text{cm}^2$ for patterned substrate growth, reduced 44% compared with $6.4 \times 10^8/\text{cm}^2$ for the unpatterned substrates. X-ray diffraction (XRD) linewidths were also reduced to 427arcsec from 524arcsec, again suggesting improved crystal quality for the patterned over the unpatterned material, respectively.

The internal quantum efficiency (IQE) was estimated using photoluminescence (PL) at both 7K and room temperature with excitation from a laser at 408nm (so the non-active layers are not excited). The maximum IQE for the patterned material was 22%, while the unpatterned reference only managed 9.7% (Figure 3a). This gives the patterned material an advantage of more than 2x.

Electroluminescence tests (Table 1) on $350\mu\text{m} \times 350\mu\text{m}$ LEDs (without encapsulation) provided further information on external quantum efficiency (EQE) through the substrate side (Figure 3b) and thus the light extraction efficiency (LEE). The maximum EQE was 8.5% at $0.5\text{A}/\text{cm}^2$ for the patterned device, which is a 3.4x advantage compared with the 2.5% at $0.8\text{A}/\text{cm}^2$ achieved for the reference.

By studying the angular distribution of the light output power and interference effects, the researchers estimate an LEE enhancement of 1.58x from the reduction of total internal reflection of light due to the patterning. ■

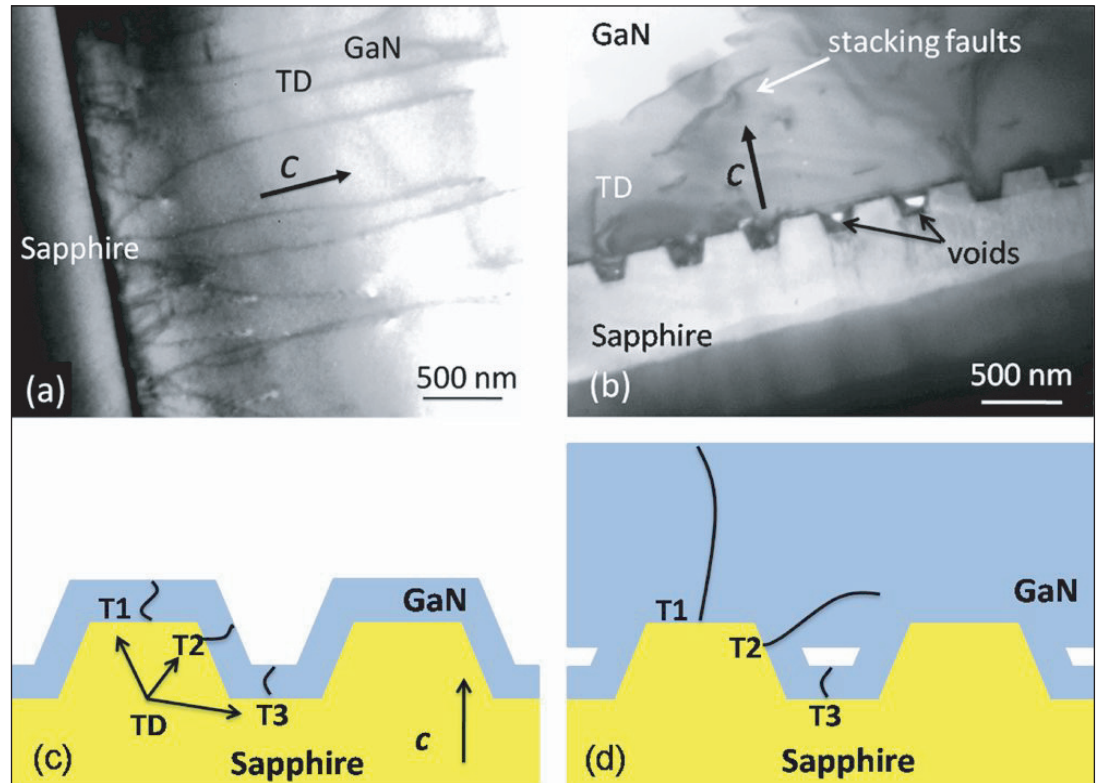


Figure 2. Cross-section TEM of the epitaxial GaN/sapphire interface on planar (a) and nanopatterned (b) sapphire. Schematics showing early (c) and late (d) phases of threading dislocation (T1, T2, T3) formation on nanopatterned substrates.

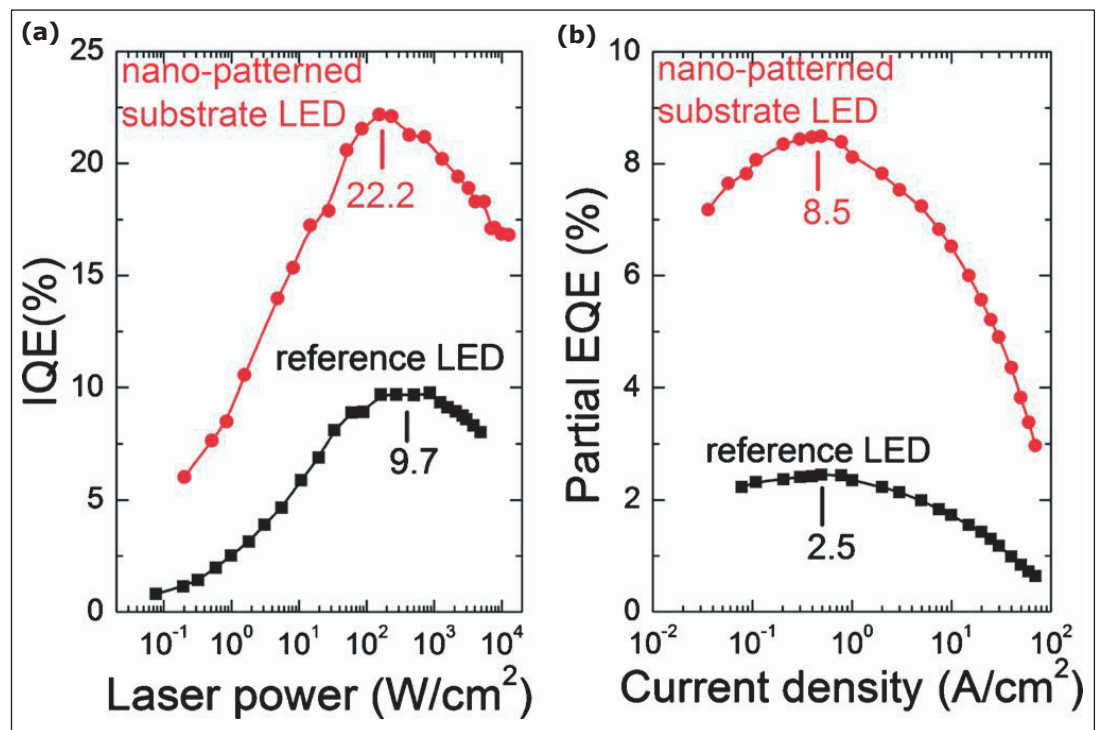


Figure 3. (a) Internal quantum efficiency (IQE) as a function of excitation power density, and (b) external quantum efficiency (EQE) as a function of current density for nanopatterned substrate (circles) and reference (squares) LED.

<http://link.aip.org/link/doi/10.1063/1.3579255>

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

Indirect Auger impact on nitride LED droop

Mike Cooke reports on the theory and experimental support from European research. Meanwhile, a US-Korean collaboration has made some observations on real-life internal quantum efficiency dependence on carrier density that does not fit the simple models generally used.

University of California Santa Barbara (UCSB) theorists say that they have cracked the nitride semiconductor light-emitting diode (LED) lighting performance problem commonly referred to as 'efficiency droop' [Emmanouil Kioupakis et al, *Appl. Phys. Lett.*, vol98, p161107, 2011].

UCSB believes that this research "will help engineers develop a new generation of high-performance, energy-efficient lighting that could replace incandescent and fluorescent bulbs." LEDs have already begun to encroach on sectors of the lighting industry such as for traffic signals, where the benefits of high efficiency and long lifetimes are balanced against the somewhat higher initial costs. However, the efficiency droop problem needs to be overcome — reducing the number of LEDs in a unit and hence cost — for more general application.

Nitride semiconductor LEDs use layers of indium gallium nitride (InGaN) alloy of InN and GaN compounds to form wells in which electrons and holes recombine to create light. It has been found that such devices have an increasing efficiency up to a certain current. Unfortunately, at currents beyond this peak the efficiency drops, often dramatically.

There has been much debate on the mechanism for this unwanted efficiency droop. Although the droop behavior has been attributed by some to Auger recombination, others comment that the size of this effect should be small.

Auger recombination usually involves two carriers recombining and transferring their energy to a third carrier rather than producing light (Figure 1(c)). Since the process involves three carriers it requires a high carrier density and hence would tend to kick in at higher current densities. However, atom-level calculations of simple 'direct' Auger recombination have suggested that the effect should be small in nitride semiconductors.

The two other recombination mechanisms (and, at low current/carrier densities, the main, recombination mechanisms) are Shockley-Read-Hall (SRH) and light emission (Figures 1(a) and (b), respectively).

In an ideal world, all the recombination would occur via light emission, at least for optoelectronic applications.

Phonon and alloy scattering


The theorists at UCSB have been working on indirect Auger processes for some time using varieties of density functional theory as an explanation for droop. In 2009, almost the same team proposed a resonant 'interband' Auger effect with an excited conduction band to account for the droop [Kris T. Delaney et al, *Appl. Phys. Lett.*, vol94, p191109, 2009].

The new processes involve electron-phonon coupling, alloy scattering or Coulomb scattering by charged defects (Figure 1(d)). Phonons are the quantum description of lattice vibrations. The electron-phonon coupling is particularly strong in nitride semiconductors. Alloy scattering occurs because the crystal structure of InGaN is not uniform.

It is a particular problem with growth of high-indium-concentration InGaN that one finds regions of high and low content because of phase separation effects. In fact, the resulting localized states can even lead in some cases to higher-than-expected light emission.

According to UCSB, the effects from phonon coupling and alloy scattering are significant enough to account for the discrepancy between the observed degree of droop and that predicted by other theoretical studies, which only accounted for direct Auger processes (Figure 2).

The effect increases at smaller band gaps, explaining the 'green gap' difficulty in producing longer-wavelength nitride semiconductor LEDs. According to the UCSB team, the Coulomb scattering term "is not important in nitride devices."

In nitride LEDs, "these indirect processes form the dominant contribution to the Auger recombination rate," says Emmanouil Kioupakis, a postdoctoral researcher at UC Santa Barbara and lead author of the new UCSB paper. The paper comments: "The cumulative effect of these contributions to the Auger coefficient amounts to a sizeable value that agrees with experiment and can explain the efficiency droop in LEDs." 

It is hoped that, by understanding the causes of efficiency droop, techniques might be found to eliminate or ameliorate the effect. "Identifying the root cause of the problem is an indispensable first step toward devising solutions," comments professor Chris Van de Walle of the Materials Department at UCSB, who heads the research group that carried out the work. The paper concludes: "This knowledge is the first step to addressing the efficiency loss and the engineering of high-power and high-efficiency nitride light emitters."

Although the Auger effect is 'intrinsic', meaning LED droop cannot be eliminated entirely, the researchers believe it could be minimized by using thicker quantum wells in LEDs or by growing devices along non-polar or semi-polar growth directions in order to keep carrier densities low.

"With Auger recombination now established as the culprit, we can focus on creative approaches to suppress or circumvent this loss mechanism," Van de Walle adds.

The UCSB work was supported by the US Department of Energy funded Center for Energy Efficient Materials and by UCSB's Solid State Lighting and Energy Center.

Experimental support

Following the UCSB work, Fraunhofer Institute for Applied Solid State Physics IAF and Ecole Polytechnique Fédérale de Lausanne claim to have measured a third-order charge carrier recombination coefficient for InGaN quantum wells in agreement with the theoretical predictions for phonon- and alloy-disorder-assisted Auger scattering [W. G. Scheibenzuber et al, *J. Appl. Phys.*, vol109, p093106. 2011].

Relaxation oscillations and turn-on delay measurements were made on (Al,In)GaN laser diodes that emit $\sim 415\text{nm}$ light (violet, photon energy $\sim 3\text{eV}$). These results were fitted to a rate-equation model with charge-density-dependent recombination rates with linear, quadratic and cubic terms (Table 1). These three terms are associated with SRH, spontaneous light emission and Auger recombination. This is often called the 'ABC model', since the recombination rate is represented as $An + Bn^2 + Cn^3$, where n represents the carrier density.

The Fraunhofer-Lausanne model also includes charge-carrier leakage as a separate term. The researchers used optical

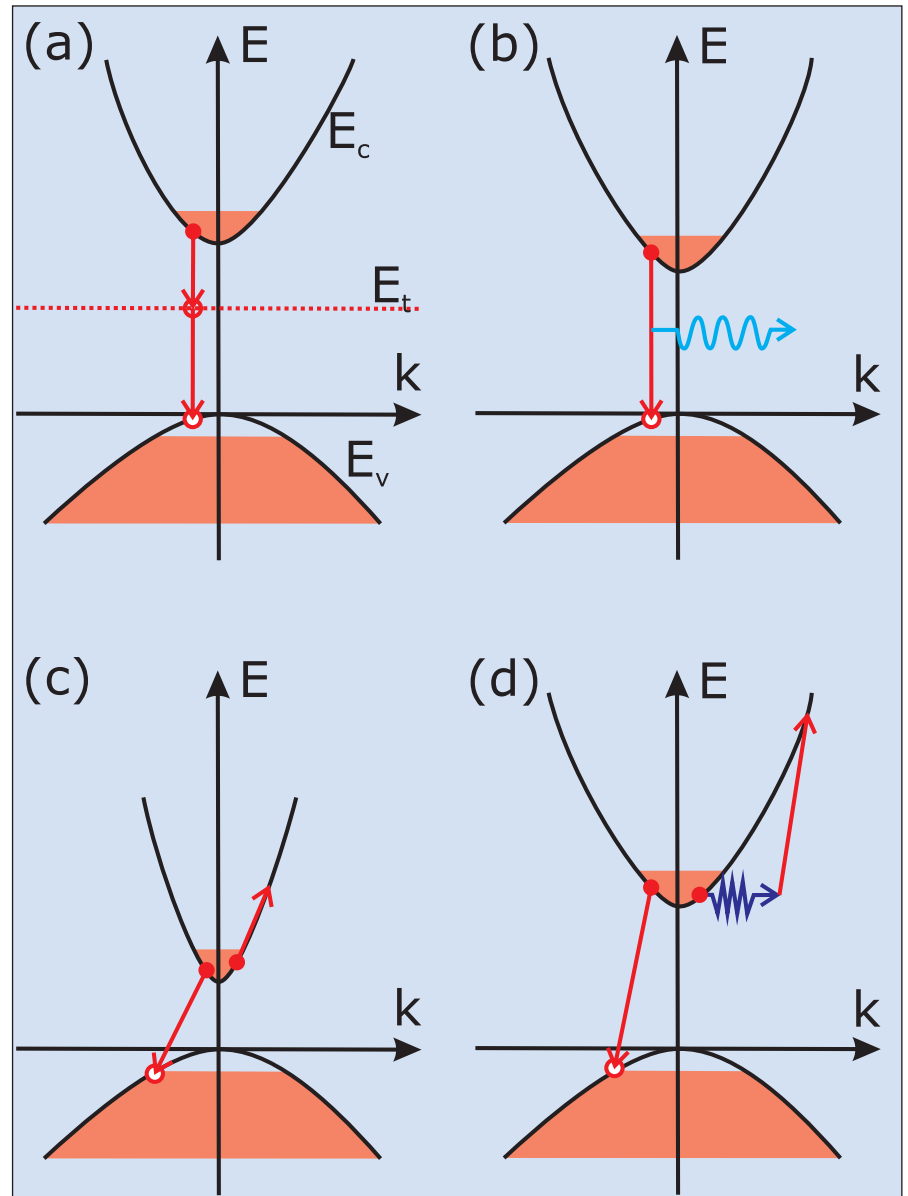


Figure 1. Schematic wavevector–energy (k – E) diagrams of the recombination mechanisms. (a) The Shockley–Read–Hall (SRH) indirect recombination mechanism occurs through transitions to and from localized energy states in the energy bandgap. (b) The direct recombination of electron and hole states results in the desired photon emission. (c) The direct Auger recombination process shown involves two electrons and a hole (eeh). One can also have processes with two holes and an electron (hhe). (d) Indirect Auger recombination, where the process is assisted by scattering mechanisms such as electron–phonon coupling, alloy disorder, or Coulomb scattering by charged defects.

Table 1. Coefficients measured by Fraunhofer–Lausanne researchers.

Symbol	Associated mechanism	Coefficient
A	Shockley–Read–Hall (SRH)	$(4.2 \pm 0.4) \times 10^7 / \text{s}$
B	Spontaneous emission	$(3 \pm 1) \times 10^{-12} \text{cm}^3 / \text{s}$
C	Auger	$(4.5 \pm 0.9) \times 10^{-31} \text{cm}^6 / \text{s}$

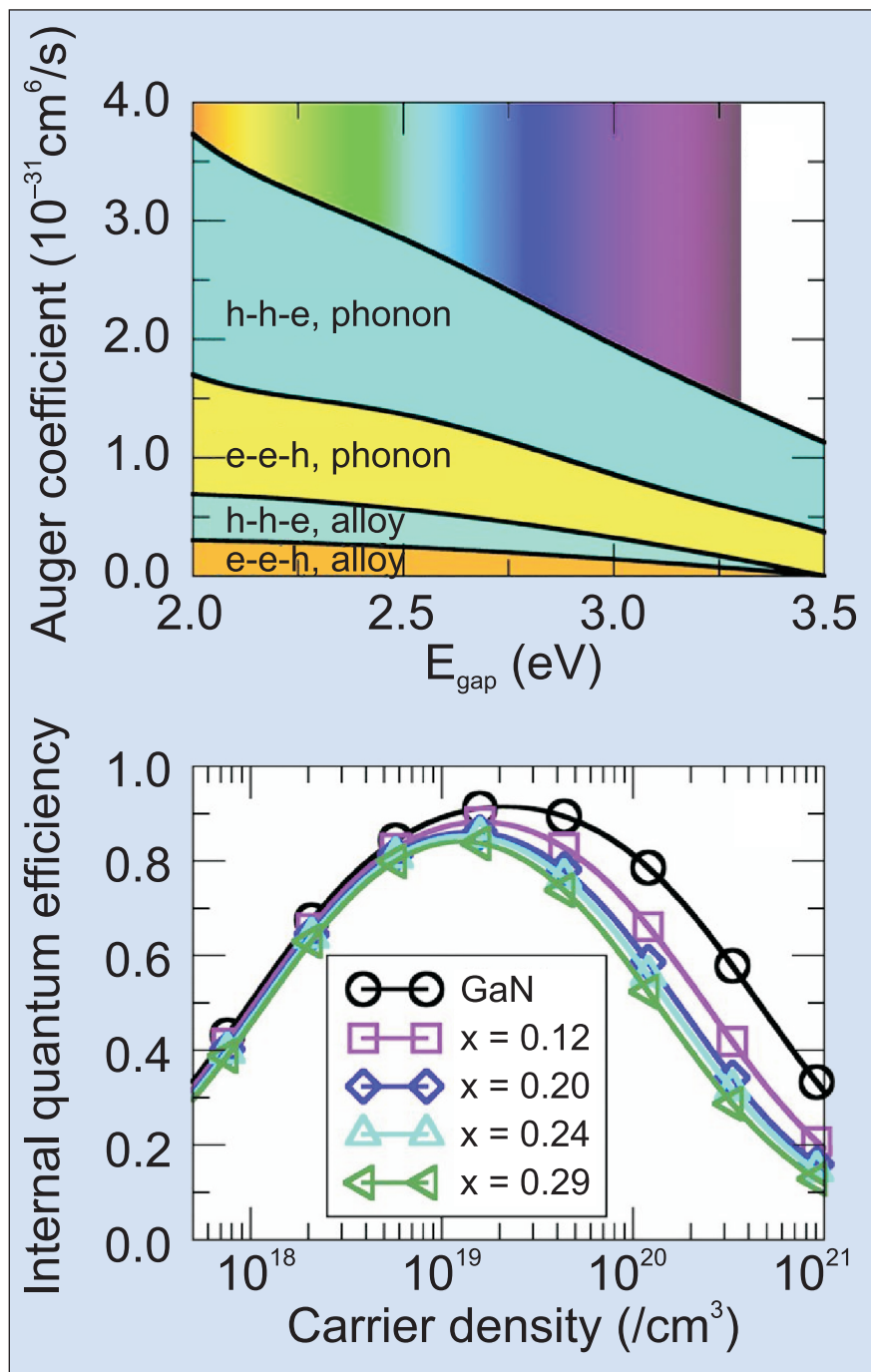


Figure 2. (a) UCSB predicted contributions of phonon- and alloy-assisted electron-electron-hole (e-e-h) and hole-hole-electron (h-h-e) processes to Auger coefficient of InGaN as a function of bandgap of active layer material. (b) LED internal quantum efficiency as function of carrier density for varying InGaN alloy composition.

gain spectroscopy to find the injection efficiency and thus to separate charge-carrier leakage from carrier recombination contributions. The spectra were found using the Hakki-Paoli method of electrically driving the laser diodes below threshold and measuring the gain. The researchers found a relatively low injection efficiency of $\sim 68\%$, blamed on a deficient electron-blocking layer leading to significant electron overshoot into the p-type layers. Other groups have managed to create laser diodes with injection efficiencies close to 100%.

The research team comments on the relation of their results to the UCSB theoretical work: "The numerical value of the C-coefficient determined in this work agrees within a factor of two with a recent theoretical study of alloy-disorder- and phonon-assisted Auger scattering by Kioupakis et al, who found a value of about $2 \times 10^{-31} \text{ cm}^6/\text{s}$ for bulk InGaN with a bandgap of 3eV."

The team admits that they do not have 'direct evidence', but they do say that this agreement with the UCSB theory "indicates that the mechanism we observe is in fact related to the indirect Auger effect."

"The advantage of our method is the clear differentiation between injection and recombination, and it is clearly shown that there is a considerable nonradiative recombination term that goes (at least) with n^3 and is not related to charge-carrier leakage," they conclude.

The Fraunhofer-Lausanne research was funded by the European Community's Seventh Framework Programme (FP7/2007-2013, Future and Emerging Technologies – FET) under the Blue Femtosecond Laser Implemented with Group-III Nitrides (FEMTOBLUE) project.

Symmetry of ABC model

Researchers based in the USA and Korea have recently pointed out that the simple ABC model is inadequate to describe the behavior of most LEDs [Qi Dai et al, Appl. Phys. Lett., vol98, p033506, 2011]. In particular, if the ABC model is correct, then the internal quantum efficiency (IQE) plotted against carrier concentration with a logarithmic scale should present symmetric curves about the peak.

As one might expect, real life is more complicated, with LEDs showing both positive and negative asymmetry. The researchers from Rensselaer Polytechnic Institute (RPI), Sandia National Laboratories and Samsung LED comment that such asymmetry requires a fourth-power or higher-power contribution to the recombination rate.

The US-Korean team found a left-asymmetry in two LEDs that it grew and tested (Figure 3), suggesting a positive higher-order contribution. The researchers also note that some IQE vs carrier density plots seen in the literature are skewed to the right, indicating negative higher-order contributions. According to the US-Korean researchers, this could be due to either carrier leakage or polarization field effects (proposed by

RPI as an explanation for droop over a number of years).

Of course, simply adding extra parameters to improve a fit is not satisfactory — as the mathematician John Von Neumann apparently once commented: “With four parameters I can fit an elephant, and with five I can make him wiggle his trunk.”

However, it seems clear that a simple association of the linear, quadratic and cubic terms with SRH, radiative and Auger recombination, respectively, is inadequate.

A further aspect to consider is that these simple associations give only the ‘leading’ behavior for these recombination mechanisms.

For example, one of the devices grown and tested by the US–Korean group had a significant non-radiative quadratic contribution with only about 44.5% of the ‘B’ term contributing to radiation.

Professor E. Fred Schubert of RPI comments: “The efficiency droop is a unique phenomenon that is associated with GaN-based LEDs. It does not occur in other semiconductor materials. It has been our view that the origin of the efficiency droop lies in the unique properties of the III-V nitride material system. Two properties that are uniquely associated with the GaN material family are:

- the large polarization fields inherent to the III-V nitride family;
- the large asymmetry in transport characteristics between electrons and holes.

“It has been shown that these two unique properties can result in (i) electron leakage or (ii) insufficient injection of holes (both are the two sides of the same coin).

“Our experiments reported in the literature have demonstrated that the efficiency droop is fully consistent with carrier leakage out of the active region and insufficient hole injection. We showed that the simple ABC model is inadequate to comprehensively describe recombination in GaInN LEDs. An additional term, which we attributed to transport effects, is needed to adequately describe recombination in LEDs.” ■

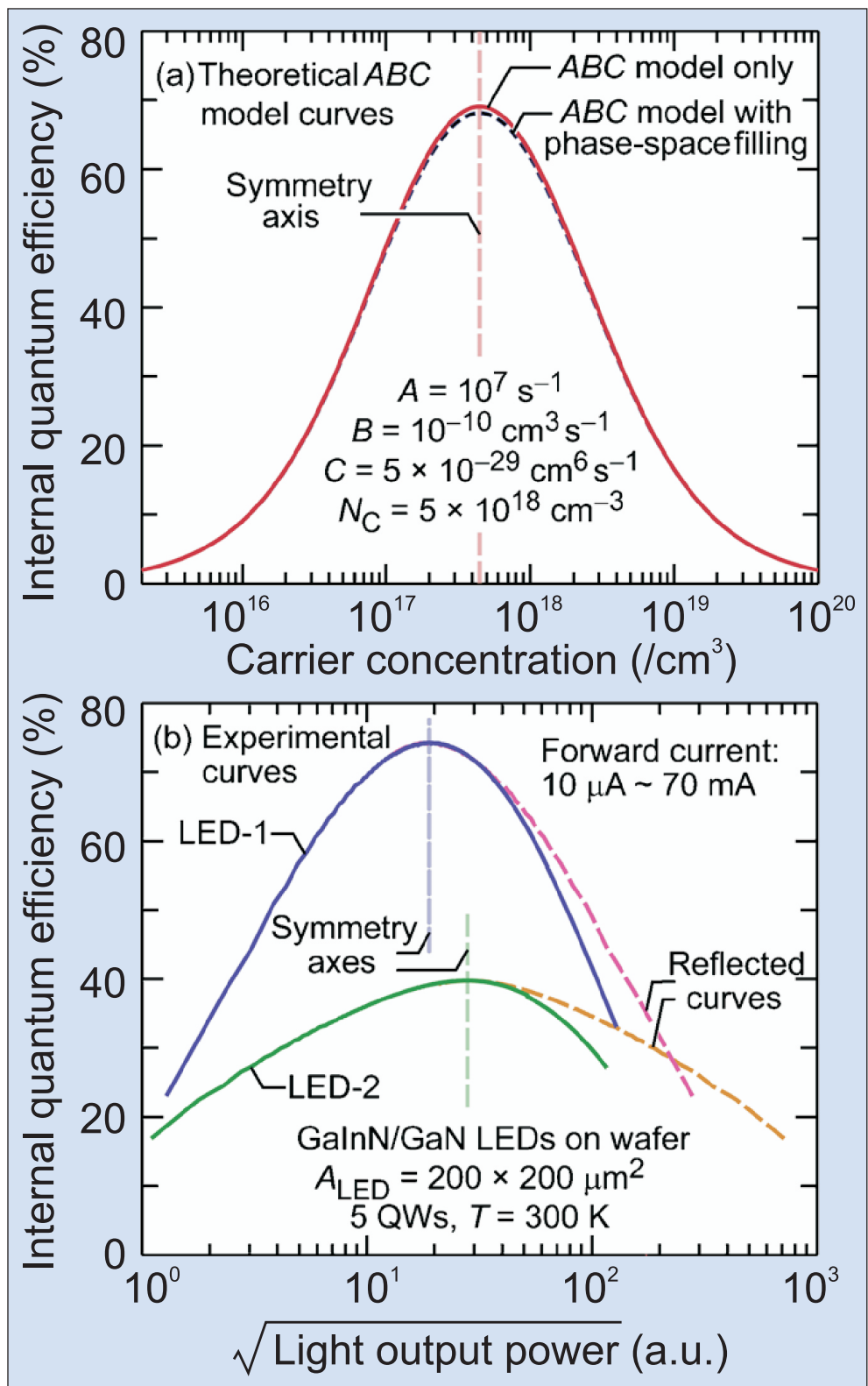


Figure 3. (a) Theoretical IQE-vs- n curves based on the ABC model (without and with phase-space filling) showing even symmetry. (b) Experimental IQE curve showing asymmetry, where carrier density is assumed to be proportional to the square root of light output power (since emission is due to ‘B’ quadratic term). Experimental curves are skewed to the left.

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

Developments in the market for UHP hydrogen purifiers

Long treated as the Cinderella material of semiconductor processing, with limited usage in silicon semiconductor, LCD and GaAs manufacture, hydrogen and in particular ultra-high-purity hydrogen is becoming an increasingly important ingredient in new and high-growth areas of semiconductor processing technologies, says **Noel Leeson** of Power & Energy Inc.

The dramatic growth in LED production since 2008 has attracted much scrutiny and many articles have been written about the growth in metal-organic chemical vapor deposition (MOCVD) tool demand, the challenges faced by the substrate makers, and the rush to expand the production capacity of inorganometallic chemicals and of high-purity NH_3 , a critical gallium nitride (GaN) precursor.

Less well publicized has been the need to improve the supply of UHP hydrogen (the gas that transports all the organometallic chemicals into the MOCVD reaction chambers). For the highest-performance GaN devices, for example, the need to eliminate oxygen from GaN epitaxial layers means that typically the hydrogen

must reliably and consistently contain $\ll 1$ ppb (parts per billion) of both oxygen and H_2O impurities. As supplied, hydrogen typically contains far higher levels of impurities when it is delivered to the fab, so GaN epitaxy processors must purify the hydrogen on-site.

Since the early days of the MOCVD industry, most processors have used H_2 purifiers that work by diffusion through a hot palladium membrane (Figure 1). Each MOCVD tool would typically have been equipped with its own palladium (Pd) purifier.

Modern GaN epi plants typically operate many MOCVD tools, and facilities engineers are increasingly adopting a centralized purification model, where several purifiers are installed in parallel to supply a group of

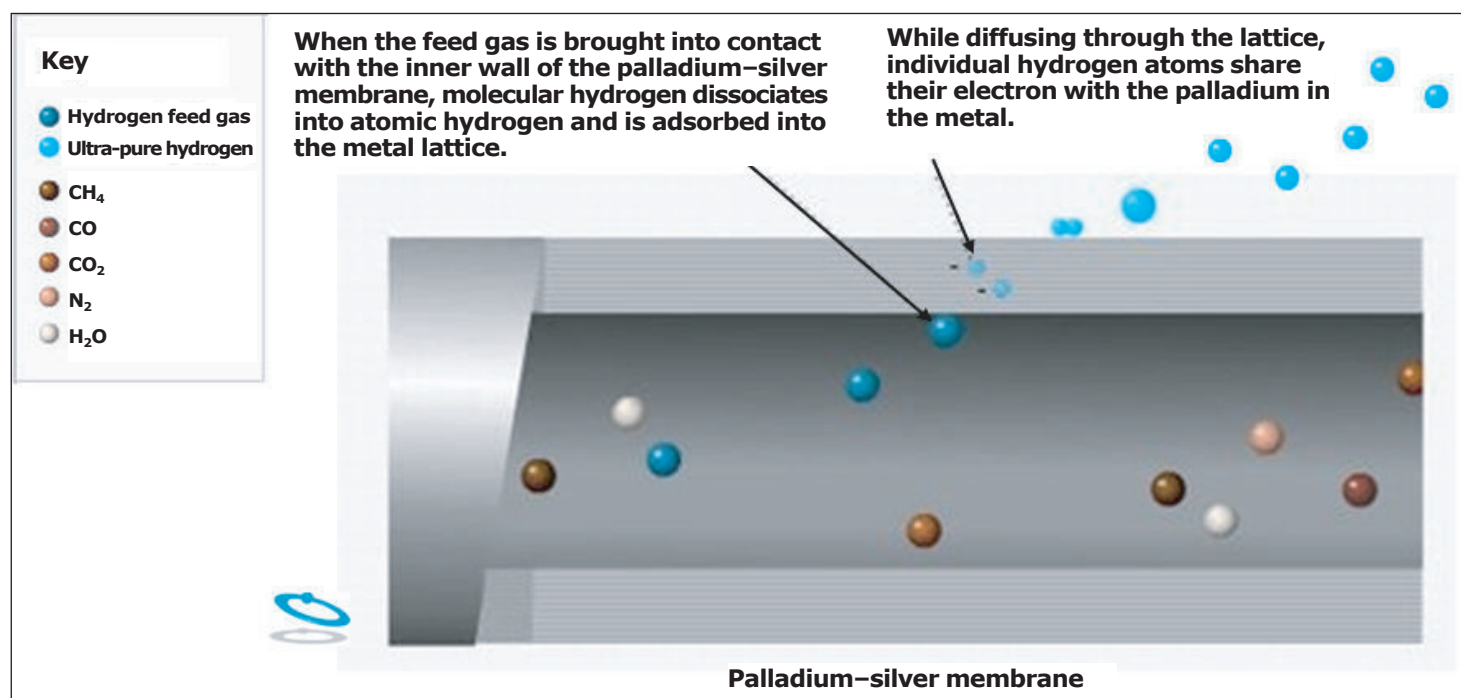


Fig 1. Principle of palladium purification of hydrogen.

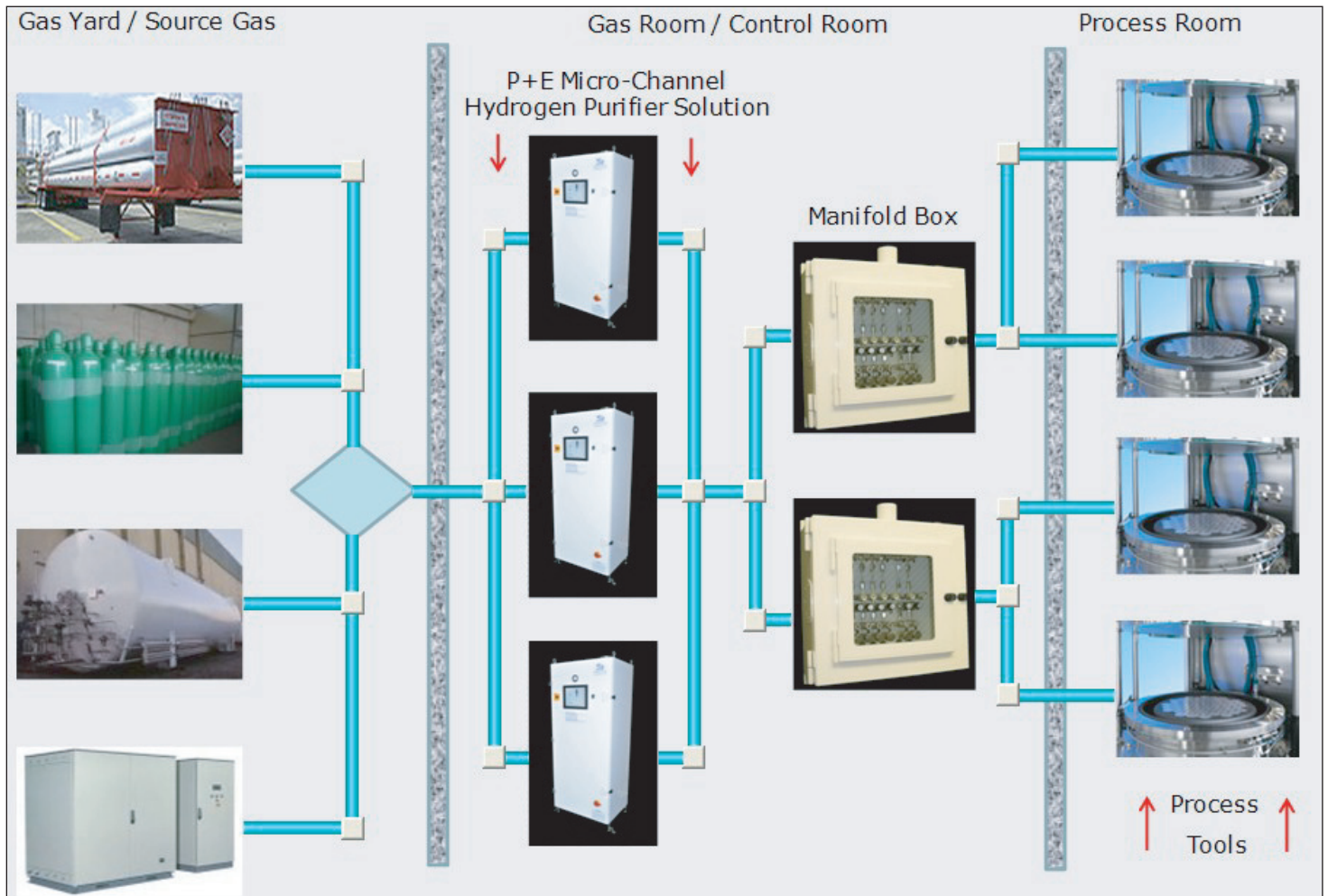


Fig 2. Centralized purification layout.

tools or even an entire fab. This approach allows a facilities manager to build redundancy into the purifier system design by installing an additional stand-by purifier (Figure 2), increasing reliability and uptime while reducing capital and operating costs by making use of larger capacity purifiers. With this philosophy, facilities managers are also able to pace purification capacity additions to match the tool installation and production ramp of the fab, thereby optimizing cash flow. Pd purifiers capable of purifying hydrogen from 97% to 99.9999999% are now available with nominal flow capacities of up to $160\text{NM}^3/\text{Hr}$, a capacity unthinkable a couple of years ago.

While there are alternatives to Pd for the purification of hydrogen, Pd remains the technology of choice, as it is the only technology that provides absolute purification, i.e. only H_2 can diffuse across the Pd membrane. All other technologies work by adsorbing some proportion of the impurities from the H_2 stream and struggle to contain the impurity spikes to which all hydrogen systems are prone, particularly those fed by H_2 of variable consistency such as the H_2 supplied in much of China, India and other parts of Asia. Given the high cost of an impurity excursion in terms of lost epi-wafers, down-time for tool clean-up, and the cost for

Modern GaN epi facilities typically operate many MOCVD tools...

Pd purifiers capable of purifying hydrogen from 97% to 99.9999999% are now available with nominal flow capacities of up to $160\text{NM}^3/\text{Hr}$, a capacity unthinkable a couple of years ago

replacement of contaminated MOCVD chemistry, few facilities managers are willing to give up the security provided by palladium. Also, with the lower unit costs achieved through the adoption of the centralized purification model, there is little economic incentive for a facilities manager to take a risk on an alternative technology.

Pd purifiers use either the traditional 'outside-in' approach to purification or the more modern 'inside-out' micro-channel technology (Figure 3). Each approach has its advocates, but currently only inside-out micro-channel technology purifiers are available in nominal capacities of greater than $60\text{NM}^3/\text{hr}$.

In addition to the demand from LED production, thin-film silicon photovoltaic (PV) cell production processes require large volumes of UHP hydrogen. China-based producers are increasingly turning to Pd technology to

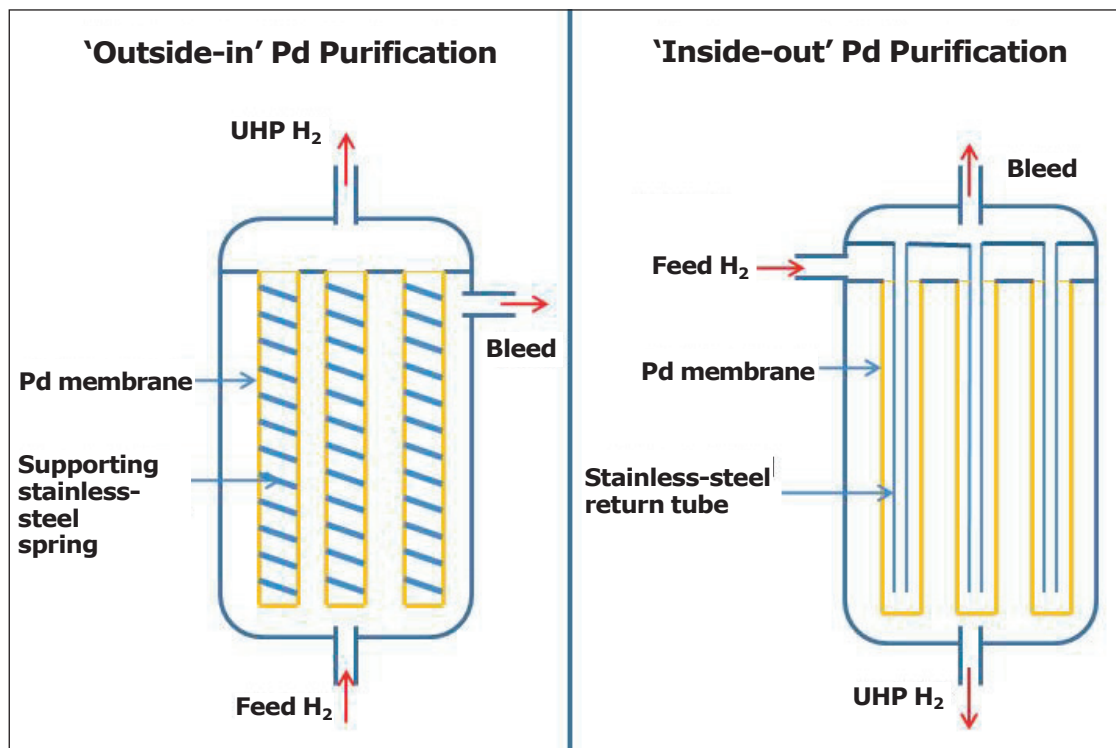


Fig 3. 'Outside-in' and 'inside-out' purification schematic designs.

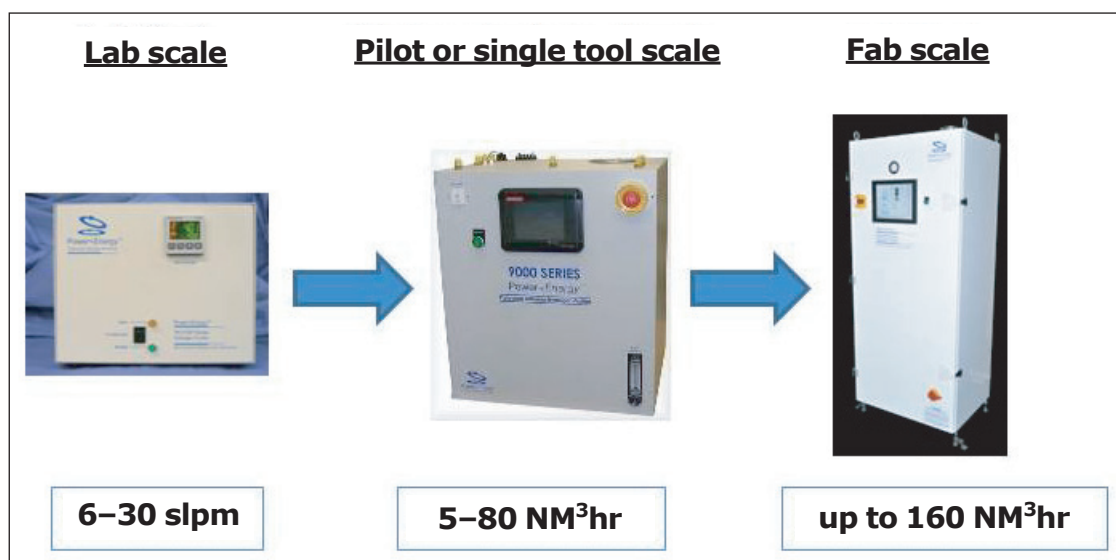


Fig 4. 'Lab to fab' using identical purification elements.

protect their processes from variability in quality of the the local hydrogen supply. For these thin-film processes, N₂ and O₂ are particularly unwelcome impurities. Unlike other purification technologies, Pd purifiers can reliably maintain sub-ppb impurity levels even in the face of large spikes of contamination possible from routine operations such as tube trailer change-over or from leaking fittings.

The expectations for growth of power semiconductor devices are also high, driven by the exploding growth in wired and wireless data transmission capacity, increasing adoption of non-traditional grid-linked electricity generation, and the general growth in electric vehicles. Power devices can be based on silicon technology but

increasingly devices are being designed on gallium nitride (GaN) or silicon carbide (SiC) epiwafers. Like GaN, SiC epi is grown using an MOCVD process but, in addition to removing oxygen, nitrogen must be controlled to < 1ppb. Pd once again is the ideal technology to consistently achieve the demanding hydrogen purity needed by SiC producers. Inside-out micro-channel purifiers employ identical membrane elements in all sizes of purifier. Researchers and producers can eliminate one source of variation by using consistent hydro-

gen purification at all stages of technology deployment, from R&D through pilot operations into mass production (Figure 4).

As we approach the sub-20nm generation of silicon semiconductor processing, tolerance for impurities in silicon epi layers and in the super-thin gate structures is also decreasing, continuing the requirement for employing UHP hydrogen in these critical process steps.

The surging demand in traditional and new applications for UHP hydrogen, coupled with the move to centralized purification systems, is driving growth and change in the market for hydrogen purifiers. Manufacturers are responding by increasing the capacity of Pd purifiers from 60NM³/hr up to 160NM³/hr and higher, thereby allowing a semiconductor manufacturer to reduce unit costs and ensure process uptime while guaranteeing that only the highest-purity hydrogen consistently reaches the process chamber. ■

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Fax: +1 503 693 8275
www.sesmi.com

TECDIA Inc

(see section 16 for full contact details)

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www.camchem.co.uk

The Fox Group Inc

(see section 3 for full contact details)

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5 Deposition materials

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Fax: +44 (0)1223 352444
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Tel: +1 978 557 1700
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6 Deposition equipment

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E-mail: sales@microchem.com

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(see section 8 for full contact details)

Praxair Electronics

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Veeco Instruments Inc

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9 Materials & metals

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11 Process monitoring and control

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13 Characterization equipment

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SUSS MicroTec Test Systems

228 Suss Drive,
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VT 05677,
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Fax: +1 802 244 7853

www.suss.com

15 Assembly/packaging materials

ePAK International Inc

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Tel: +1 512 231 8083
Fax: +1 512 231 8183

www.epak.com

Gel-Pak

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USA

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Fax: +1 510 576 2282

www.gelpak.com

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(see section 3 for full contact details)

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Fax: +1 716 833 2926

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16 Assembly/packaging equipment

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Fax: +41 329257115

www.ismeca.com

Kulicke & Soffa Industries

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Fax: +1 215 784 6001

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www.quikcpak.com

18 Chip foundry

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www.compoundsemi.co.uk

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www.ums-gaas.com

19 Facility equipment

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Crosslight Software Inc

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22 Used equipment

Class One Equipment Inc

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24 Consulting

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25 Resources

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www.semiconductor2k.com

21–24 June 2011

LED Tech Korea 2011 & Optical Expo 2011

Seoul, Korea

E-mail: led2100@naver.com

www.korealed.org

28 June 2011

3rd Concentrated Photovoltaics Summit US

San Diego, CA, USA

www.cpvtoday.com

3–8 July 2011

13th International Conference on the Formation of Semiconductor Interfaces (ICFSI-13): From semiconductors to nanoscience and applications in biology

Prague, Czech Republic

E-mail: icfsi13@fzu.cz

<http://pc220.fzu.cz/icfsi13/icfsi-13-1.html>

6–7 July 2011

UK Semiconductors 2011

Endcliffe Village, University of Sheffield, UK

E-mail: info@uksemiconductors.com

www.uksemiconductors.com

10–15 July 2011

9th International Conference on Nitride Semiconductors (ICNS-9)

SECC, Glasgow, Scotland, UK

www.icns9.org

12–15 July 2011

SEMICON West 2010, including Intersolar North America

San Francisco, CA, USA

E-mail: registration@xpressreg.net

www.semiconwest.org

18–22 July 2011

26th International Conference on Defects in Semiconductors (ICDS-26)

Hotel Grand Chancellor, Christchurch, New Zealand

E-mail: icds2011@tcc.co.nz

www.icds2011.com

27–29 July 2011

PV Japan 2011

Makuhari Messe, Japan

E-mail: pvj@semi.org

www.pvjapan.org/en

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28 August – 2 September 2011

ISES Solar World Congress (SWC 2011)

Kassel, Germany

E-mail: info@swc2011.org

www.swc2011.org

5–8 September 2011

NUSOD 2011 (11th International Conference on Numerical Simulation of Optoelectronic Devices)

Rome, Italy

www.nusod.org/2011

5–9 September 2011

26th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC)

CCH Congress Centre and International Fair, Hamburg, Germany

E-mail: pv.conference@wip-munich.de

www.photovoltaic-conference.com

6–9 September 2011

13th China International Optoelectronic Exposition (CIOE 2011)

Shenzhen Convention & Exhibition Center, China

E-mail: shirly@cioe.cn

www.cioe.cn/html/list_543.html

11–16 September 2011

International Conference on Silicon Carbide and Related Materials (ICSCRM 2011)

Renaissance Cleveland Hotel, Cleveland, OH, USA

E-mail: Barbara.L.Kakiris@nasa.gov

www.icscrm2011.org Neudeck@nasa.gov

12–16 September 2011

Solid-State Device Research – 41st European Conference (ESSDERC-2011) and Solid-State Circuits Research – 37th European Conference (ESSCIRC-2011)

Helsinki, Finland

www.esscirc.org

14–16 September 2011

8th IEEE International Conference on Group IV Photonics (GFP 2011)

The Royal Society, London, UK

www.photonicsconferences.org/GFP2011

19–22 September 2011

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Clarion Congress Hotel, Prague, Czech Republic

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http://spie.org/security-defence-europe.xml

http://spie.org/remote-sensing-europe.xml

19–22 September 2011

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http://spie.org/photomask.xml

21–23 September 2011

SOLARCON Korea 2011

COEX, Seoul, Korea

E-mail: jkim@semi.org

www.solarconkorea.org/SOLARKOREA-EN

27–29 September 2011

LED professional Symposium + Expo 2011

Bregenz, Austria

E-mail: symposium@led-professional.com

www.led-professional-symposium.com

28–30 September 2011

LED Japan Conference & Expo/ Strategies in Light

Pacifico Yokohama, Japan

E-mail: Lubah@pennwell.com

www.sil-ledjapan.com

2–7 October 2011

36th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2011)

Hyatt Regency Hotel, Houston, TX, USA

E-mail: daniel@rice.edu

www.irmmw-thz2011.org

4–6 October 2011

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www.sileurope.com

4–8 October 2011

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