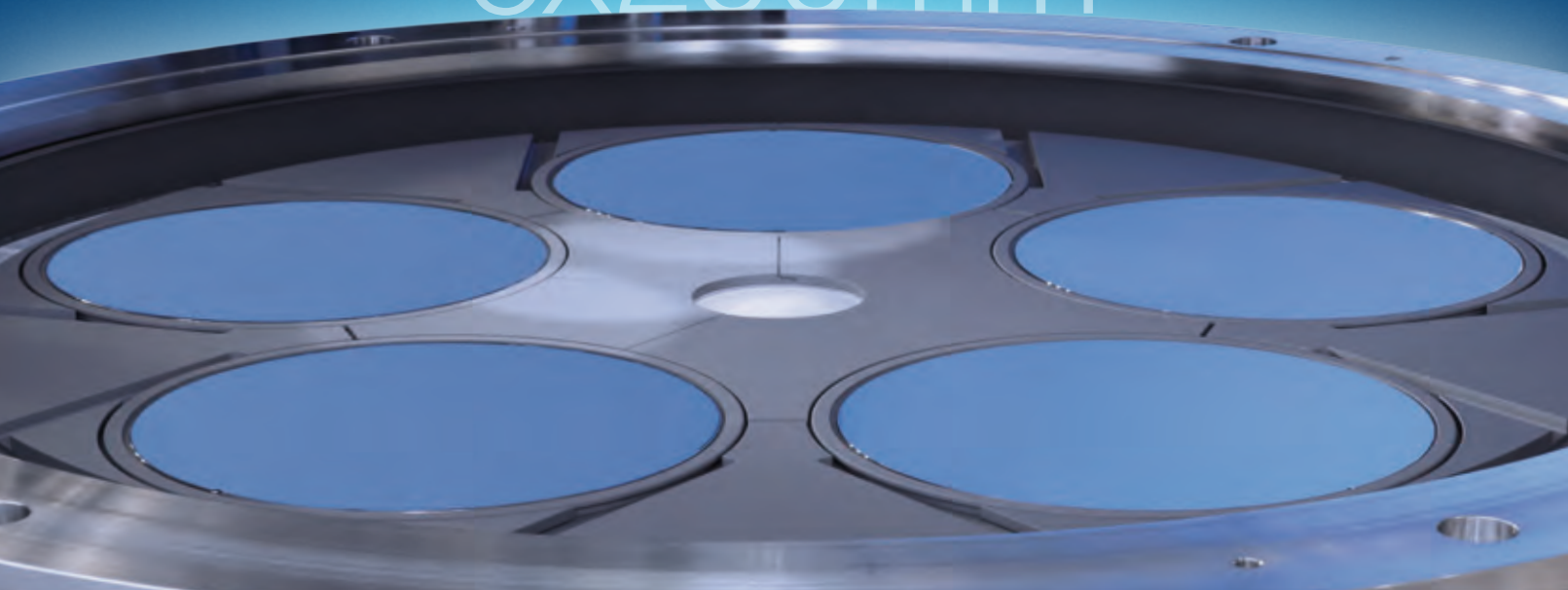


AIXTRON

200mm GaN-on-Si Batch Reactor

5x200mm



AIX G5+



AIX G5+ for GaN-on-Si

- Dedicated technology package
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- Builds on planetary technology:
Excellent and symmetric uniformities,
controlled bow behavior,
using standard Si substrates.

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C O M P O U N D S & A D V A N C E D S I L I C O N

Vol. 7 • Issue 8 • October 2012

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Osram launches direct-emitting green laser diode



SemiSouth to be closed • AkzoNobel expands Texas MO plant
Transphorm raises \$35m • CPV cell record raised to 44%

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Osram Opto achieves cyan nitride superluminescent LED

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Diamond FET with 50nm gate increases cut-off performance

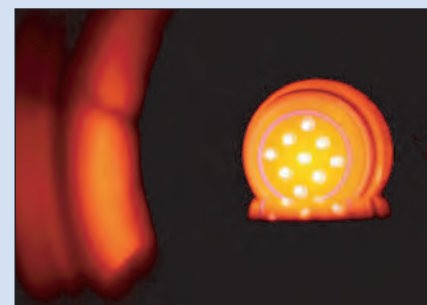
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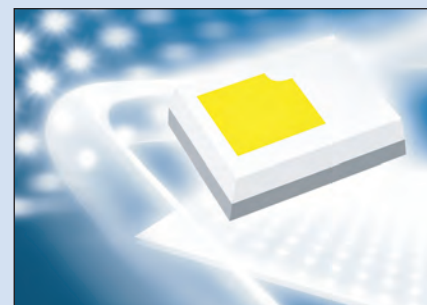
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COMPOUNDS & ADVANCED SILICON

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p35 Meaglow's hollow cathode plasma source, which is being used by Georgia State University to develop III-nitride compound semiconductor materials.



p46 Osram Opto's prototype Oslon Compact, which is claimed to be the most compact high-power LED for the automotive market.



p59 Fraunhofer ISE's Andreas Bett and Soitec Solar's Hansjörg Lerchenmüller win German Environmental Award for CPV technology achievements.



Cover: Osram Opto Semiconductors has launched its first commercial direct-emitting green laser diode. With output of 50mW at wavelengths of 515–530nm, the TO-38-packaged PL 520 InGaN green laser diode targets mini projector applications. **p48**

Green light for nitrides

For this issue's cover story we report that, after lengthy R&D (as part of Germany's 'MOLAS' project) Osram Opto Semiconductors has launched its first direct-emitting green laser diodes (see page 48). With output of up to 50mW in the wavelength range 510–530nm, the indium gallium nitride (InGaN)-based lasers are key to producing compact red–green–blue light sources for miniature projector applications (compared with the existing method of frequency doubling light from an infrared diode laser, or using lower-power green LEDs as a light source). Japanese rivals Sony and Nichia already offer lasers with output up to 100mW in this wavelength range, while University of California Santa Barbara spin-off Soraa (which currently sells white LED lighting products based on its blue GaN-on-GaN chips) is also developing direct-emitting green laser diodes. The addition of Osram as another supplier promises to speed adoption of the devices.

One of the reasons for the development of higher-power InGaN emitters is the growth of devices on semi-polar and non-polar GaN. Also in this issue (on page 72) we report UCSB's demonstration of the first nonpolar (m-plane) nitride vertical-cavity surface-emitting laser (VCSEL) diodes (rather than existing edge-emitting nonpolar GaN lasers) as well as the first observation of polarization locking in GaN VCSELs. In contrast to the random polarization of light modes from VCSELs produced on c-plane GaN, nonpolar GaN could yield arrays of GaN VCSELs that are inherently polarization-locked (advantageous for applications such as projectors, displays, sensors, detection, communications etc).

Also, on page 74 we report Osram's development of cyan-wavelength (500nm) InGaN superluminescent light-emitting diodes (which operate via stimulated emission and have the high light density and directionality of lasers but offer a broader emission spectrum for projector applications). On page 76 UCSB reports how, in addition to showing a droop as injection current increases, nitride LED luminous efficiency also droops as the temperature increases. By using semi-polar GaN rather than polar (c-plane) GaN, UCSB has reduced this thermal droop in efficiency from 40% to 4%. On page 82, we report how lithium aluminate (LiAlO_2) has been investigated as a potential low-cost substrate for the growth of nonpolar (m-plane) GaN. Also, on pages 78–79 and 80–81, we report the use of titanium dioxide (TiO_2) micro-pillars and zinc oxide (ZnO) nanorods, respectively, to boost light emission from nitride LEDs.

Regarding developments in volume production, Taiwan's biggest LED chip manufacturer Epistar has fabricated high-brightness LEDs using 150mm GaN-on-silicon epitaxial wafers from Germany's Azzurro Semiconductors. Migration from existing sapphire or silicon carbide to large-area silicon substrates promise cost reductions that could spur LED lighting adoption.

Unfortunately, regarding silicon carbide (but for microelectronic rather than optoelectronic applications), it seems that SemiSouth Laboratories Inc of Starkville, MS, USA, which designs and makes SiC devices for power management and conversion applications, is to close down, involving 90 staff lay-offs. However, rather than being driven by market conditions, this is tied up with high-voltage IC developer Power Integrations of San Jose, CA being a strategic investor. In contrast, GaN power device maker Transphorm (another UCSB spin-off) has just raised \$35m in Series E financing.

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

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- conference reports;
- event calendar and event previews;
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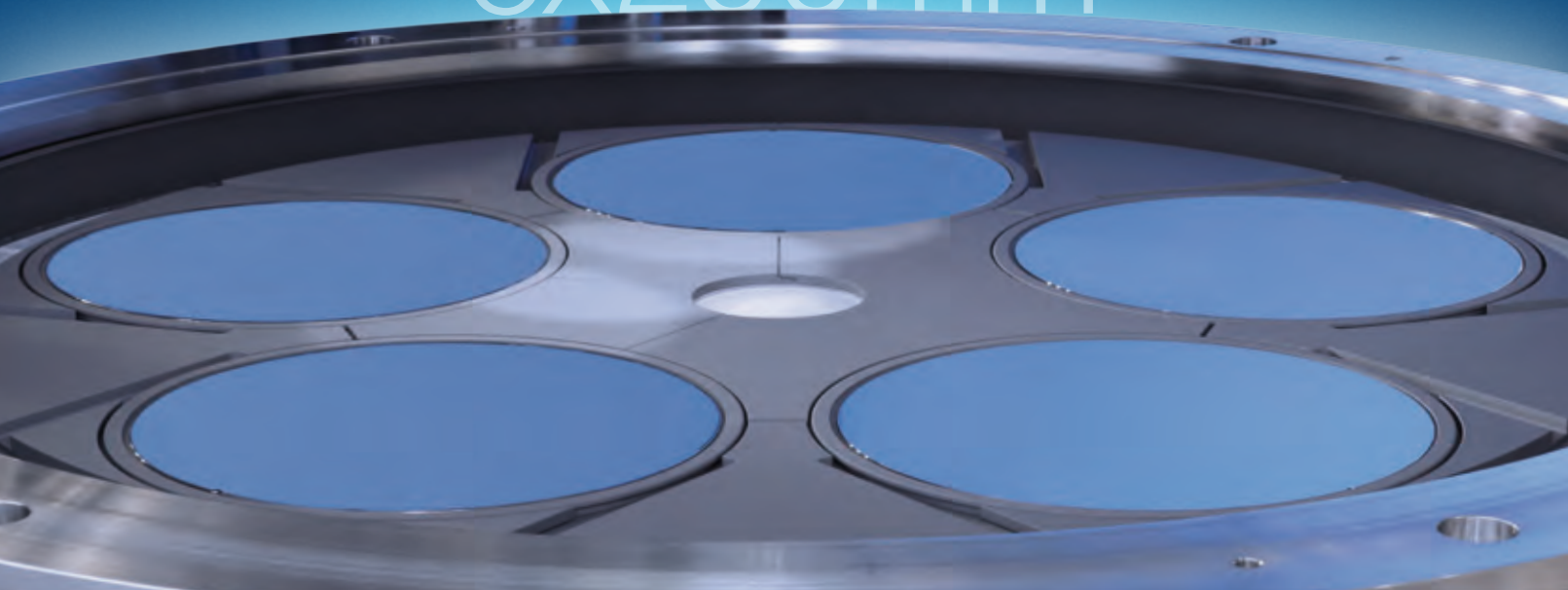
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Wireless infrastructure GaAs device revenue to grow 12% to \$348m in 2016, boosted by shrinking cell sizes

Metro and pico-cell growth to increase number of wireless base-station sectors from 2.3m in 2011 to 6.6m in 2016

Gallium arsenide (GaAs) device revenue in wireless infrastructure will rise at a CAAGR (compounded average annual growth rate) of 12% to nearly \$348m in 2016, according to the report 'Wireless Infrastructure Markets: 2011–2016' from Strategy Analytics' GaAs and Compound Semiconductor Technologies Service.

In response to increasing data consumption, operators are developing new wireless network architectures with smaller cells to support consumer demands, says the firm. These 'small cells', each with lower transmit power, will boost GaAs-based device revenues for wireless infrastructure applications. The report also forecasts that metro and pico-cell growth will

increase the number of wireless base-station sectors from 2.3 million in 2011 to 6.6 million in 2016.

"As wireless data consumption continues to skyrocket, operators and network equipment manufacturers are responding by shrinking cell sizes to boost data rates and capacity for users," says

Operators are developing new wireless network architectures with smaller cells to support consumer demands. These 'small cells', each with lower transmit power, will boost GaAs-based device revenues

Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "As a consequence, we expect growth of large macro cells used in traditional network architecture to peak next year and then slowly decline," he adds. "Offsetting this decline will be explosive growth in base stations with lower transmit power that we expect will begin around 2014."

Asif Anwar, director in the Strategy Analytics Strategic Technologies Practice (STP), added, "LDMOS [silicon] will continue to be the main technology for the RF power portion of the base station, but the deployment of small cells will lead to an increase in GaAs device revenue".

www.strategyanalytics.com

Second-quarter financial results indicate slowing microelectronics revenue growth for 2012 ...but development activity remains strong

Despite slowing revenue growth in 2012 in the microelectronics portion of the industry (based on the first-half 2012 results for many of the large manufacturers), product development activity is progressing strongly, notes The Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint 'Compound Semiconductor Industry Review April — June 2012: Microelectronics'. In advance of June's 2012 IEEE MTT-S International Microwave Symposium (IMS) in Montreal, Canada, the heavyweights of the compound semiconductor industry all announced new product developments.

The report from market research firm Strategy Analytics summarizes

technology, product, contract, financial and employment announcements in April–June 2012 from firms such as Anadigics, Hittite Microwave, TriQuint Semiconductor, Agilent, RFMD, Skyworks, WIN Semiconductors, Mitsubishi, Cree, Toshiba, Fujitsu and Sumitomo Electric, addressing commercial and military applications that use gallium arsenide (GaAs), gallium nitride (GaN), silicon carbide (SiC), silicon germanium (SiGe) and complementary metal-oxide-semiconductor (CMOS) silicon technologies.

"With a few exceptions, the revenue results for microelectronic companies have been mixed in the first half of 2012, with almost as many companies reporting declines

as are reporting revenue growth," notes Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "Barring anything unforeseen happening in the second half of the year, it appears the growth rate for the industry will finish below its historical average," he adds.

"Despite slowing revenue growth, there is no shortage of product development, with GaN, higher frequency and integrated device activities driving many of the product announcements," comments Asif Anwar, director of the Strategy Analytics Strategic Technologies Practice (STP).

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Silicon photonics market to triple in next 5 years

...but current constraints affecting cost need to be alleviated

By blending optical technology with low-cost CMOS semiconductor processing, silicon photonics has tremendous potential as a new technology, according to market research firm Yole Développement in its new report 'Silicon Photonics Market & Technologies'.

Silicon photonics is a disruptive technology that enables a new breed of monolithic optoelectronic devices, notes the firm. The goal is to deliver economic optical connectivity everywhere, from network level to intra-system level, and eventually chip-to-chip. Currently, except for the light source, all other optical functions (modulators, detection, waveguides, intelligence etc) can be embedded wafer-level at the silicon-on-insulator (SOI) substrate.

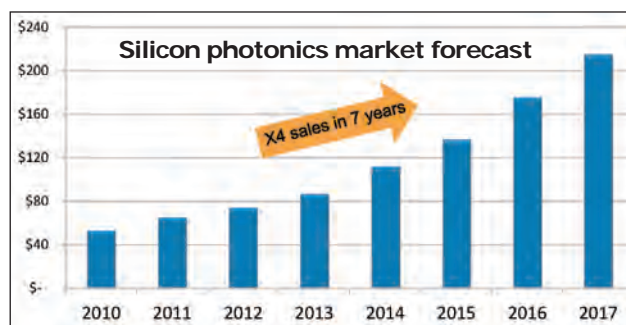
Yole notes that silicon photonics addresses different types of devices, such as:

- Individual components & sub-components: used as a single-function silicon photonics device, e.g. variable optical attenuator (VOA), mux/demux, active filters and optical switches, or as optical engines combining optics and electronics.
- Transceiver-type products: embedded optical modules, transmitters/receivers, and active optical cables (AOCs).
- Future products: e.g. hybrid packaged devices and 3DICs/integrated optoelectronic chips.

Moreover, passive optical elements (such as arrayed waveguides, optical filters, couplers, splitters, polarizer arrays) can be created with silicon photonics technologies and integrated with active elements.

In the report, Yole distinguishes between silicon photonics, CMOS photonics, hybrid silicon photonics, and III-V integrated photonics.

For a long time, silicon photonics has been constrained to R&D labs, but the first products have now shipped and an industrial infrastructure has been established step-by-step, the firm adds.



Datacoms to dominate

However, although silicon photonics can address a wide range of applications, very few firms are actually shipping products.

The potential markets are:

- Telecoms — metro and long-haul applications;
- Datacoms — data centers and campus applications;
- Consumer — connecting desktop PC devices and PCs with HDTVs;
- High-performance computing (HPC) & data centers — using AOCs or embedded modules;
- Professional/commercial video — digital signage, digital cinemas, video recording and studios;
- Metrology and sensors — measurement of time, temperature, sound, frequency, stress and range using special silicon photonics sensors;
- Medical — DNA, glucose, molecular and cellular analysis etc, using special silicon photonics sensors;
- Military/aerospace/scientific — scientific instruments at corporate and national labs (aircraft, space missile, radar, imaging, and intelligence applications).

Data communications is the biggest market and will dwarf all other silicon photonics applications, reckons Yole. Indeed, major datacom protocols are all moving to high-speed signaling and surpassing 10Gbps, where reach and signal integrity issues are surfacing for both copper and optical technologies. There is a clear trend to surpass 25Gb in datacom protocols, and this is where silicon photonics will make sense, says the firm.

Demand will be driven by the need for: low-cost, high-speed intercon-

nects supporting ever-increasing data rates at and beyond 25Gbps; and reach distance/data rates not served by vertical-cavity surface-emitting lasers (VCSELs).

Challenges ahead

However, silicon photonics still faces big industrial

and technical challenges, says Yole:

- few products currently exist;
- few companies have developed integrated product solutions;
- costs are high;
- CAE/CAD programs are almost non-existent;
- technical mismatches exist;
- there is competition with VCSEL-based alternatives; and
- high volumes are needed.

For several years now, silicon photonics projects have been under the umbrella of large-scale R&D projects to set up roadmaps, says Yole. But now, multi-wafer project (MPW) service foundries are opening, and more industrial foundry activities are being established.

However, generic technologies and production platforms are needed to achieve low cost/high volume. As the future lies in the separation of design and fabrication, the silicon photonics sector is seeking an electronics-like foundry model. The map of players involved in silicon photonics already shows a significant number of foundry services, says Yole.

Although the industry is trying to use as much as possible of the existing CMOS processes, 3D-ICs technologies will contribute to silicon photonics, especially regarding wafer bonding and 3D interconnects, the firm reckons.

Although the market is expected to grow by a factor of three in the next five years, the business could explode after 2020, as inter- and intra-chip communications could make this market grow by a factor of 10, concludes Yole.

www.yole.fr

Samsung captures record 35% share of 162 million smartphone shipments in Q3

Nokia slips outside top 3, from 14% share a year ago to 4% now

Global smartphone shipments grew 34.8% annually from 120 million units in third-quarter 2011 to 161.7 million units in third-quarter 2012, according to the report 'Global Smartphone Shipments Reach 162 Million Units in Q3 2012' from the Strategy Analytics Wireless Smartphone Strategies (WSS) service. Samsung achieved a record 35% market share. Apple held second position, while Nokia slipped outside the top three in the rankings.

"The 35% growth rate was relatively soft, as a volatile global economy and maturing penetration of smartphones among contract mobile subscribers continued to moderate demand," comments Strategy Analytics' associate director Alex Spektor.

Samsung shipped 56.9 million smartphones worldwide and captured a record 35.2% market share in Q3/2012, more than doubling from 28.1 million units (23.4% market share) in Q3/2011. "This was the largest number of units ever shipped by a smartphone vendor in a single quarter," says execu-

Smartphone vendor shipments and market share in Q3/2012.

Shipments (millions)	Q3/11	Q3/12
Samsung	28.1	56.9
Apple	17.1	26.9
Others	74.8	77.9
Total	120.0	161.7
Market share (%)	Q3/11	Q3/12
Samsung	23.4%	35.2%
Apple	14.3%	16.6%
Others	62.3%	48.2%
Growth year-on-year %	48.1%	34.8%

tive director Neil Mawston. "Despite tough competition in stores and courtrooms, Samsung continued to deliver numerous hit models, from the high-end Galaxy Note phablet to the mass-market Galaxy Y," he adds. Apple grew a healthy 57% annually and shipped 26.9 million smartphones worldwide for 16.6% market share, up from 14.3%

(17.1 million units) a year ago. "Apple had a solid quarter in the important US market and this helped to strengthen its global performance," Mawston notes.

Samsung and Apple combined now account for over half of all smartphones shipped worldwide, up from around one-third a year ago. "Volumes have polarized around those two brands," remarks senior analyst Neil Shah. "The growth of Samsung and Apple has continued to impact Nokia." Nokia shipped 6.3 million smartphones worldwide (4% market share) in

Q3/2012, dipping from 16.8 million units (14% share) in Q3/2011, and slipping outside the top three global smartphone rankings for the first time. "Nokia will need to ramp up sharply its Windows Phone volumes if it wants to recapture a top-three smartphone position in the next one to two quarters," reckons Shah.

Smartphone population tops 1 billion in Q3/2012

The number of smartphones in use worldwide surpassed the 1 billion-unit mark for the first time ever in the third-quarter 2012, according to the report 'Global Smartphone Installed Base by Operating System for 88 Countries: 2007 to 2017' from Strategy Analytics. It has taken 16 years for the smartphone industry to reach this historic milestone.

"The world's first modern smartphone, the Nokia Communicator, was introduced in 1996," notes senior analyst Scott Bicheno. "Nokia remained a dominant force in smartphones for over a decade until the arrival of Apple's iconic iPhone in 2007. The iPhone revolu-

tionized smartphone design and it catalyzed industry growth," he adds. By Q3/2011, there were 708 million smartphones in use worldwide, the market research firm estimates. "After a further year of soaring demand [surpassing 959 million in Q2/2012], the number of smartphones in use worldwide reached 1.038 billion units during Q3/2012," Bicheno continues.

Smartphone installed base (millions of units).

	Q3/11	Q2/12	Q3/12
Worldwide	708	959	1038

"We estimate one in seven of the world's population owned a smartphone in the third quarter of 2012," says Strategy Analytics' executive director Neil Mawston. "Smartphone penetration is still relatively low. Most of the world does not yet own a smartphone and there remains huge scope for future growth, particularly in emerging markets such as China, India and Africa," he reckons. "The first billion smartphones in use worldwide took 16 years to reach, but we forecast the next billion to be achieved in less than three years, by 2015."

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Anadigics launches high-output GaN power doubler line amplifier for 1GHz CATV

At the SCTE Cable-Tec Expo 2012 in Orlando, FL (17–19 October), broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA launched the ACA2428 gallium nitride (GaN) line amplifier MMIC.

Anadigics says that the GaN power doubler line amplifier uses its unique design architectures to ensure distortion-free video and audio in 1GHz CATV systems. Due to its low current consumption, the GaN line amplifier helps to save energy to enable green CATV infrastructure solutions, it is claimed.

“CATV networks are increasingly operating in a fully loaded spectrum to support high-definition television, video on demand, and high-data-rate internet,” says Tim Laverick, VP of infrastructure products. “Anadigics’ new GaN line amplifier provides a best-in-class combination of output power, linearity, bit error rate, and noise figure to ensure the highest quality of



ACA2428 GaN line amplifier MMIC.

video delivery in these network conditions,” he claims. “This level of performance is coupled with exceptional efficiency and world-class reliability and ruggedness, enabling advanced green solutions that minimize power consumption and costly truck rolls.”

The ACA2428 GaN line amplifier MMIC is optimized for 50–1000MHz frequency-band applications by delivering +58dBmV output power and 21dB gain at 1GHz. Available in a 16-lead SOIC, the it is powered through the center tap of the output impedance transformer with a single +24V supply. The ACA2428 is optimized for several CATV infrastructure applications, including output power doublers for system amplifiers and deep fiber nodes.

Anadigics notes that features of its GaN line amplifiers include: high output power; low composite triple beat (CTB), composite second order (CSO), cross modulation, and noise figure distortion characteristics for optimal performance in a fully loaded spectrum; positive slope cable equivalent; very low bit error rate (BER); and a GaN output stage incorporated to minimize the operating (bias) current.

Samples of the ACA2428 are available now for qualified programs.

Anadigics MMPAs power Samsung Galaxy Express smartphone

GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA is shipping production volumes of its ALT6181 multimode multiband power amplifier (MMPA) to Samsung Electronics for the new Galaxy Express smartphone, available soon through AT&T.

The MMPAs leverage Anadigics’ InGaP-Plus technology and patented design architectures, offering high efficiency to extend battery-life, as well as quad-band GSM/EDGE and dual-band WCDMA/LTE functionality in a single package to minimize printed circuit board (PCB) space requirements.

“Multimode multiband smartphones that provide GSM/EDGE, WCDMA, and LTE functionality

represent a growing segment of the wireless market as demand for high speed data continues to increase,” says Jerry Miller, VP of Wireless Mobile Products. “Anadigics is well positioned to capture share in this segment by leveraging our advanced technology and design expertise to provide OEMs and ODMs with highly integrated solutions that help save space, extend battery life, and reduce time-to-market,” he adds.

ALT6181 MMPAs feature an integrated voltage regulator, separate single-ended RF chains, and high-directivity RF couplers in a compact, low-profile 5mm x 7.5mm x 0.9mm package. WCDMA/LTE linearity specifications for bands 1, 5, 6, 18, 19, and 26 have been enhanced, while ensuring that

critical harmonic, noise and inter-modulation performance results in superior mobile device performance, claims the firm.

Anadigics says that the ALT6181 MMPA provides optimal WCDMA/LTE efficiency across all power levels (>40% in high-power mode and >20% in low-power mode), without the use of a DC–DC converter. The firm also claims best-in-class linearity at maximum output power, and a low quiescent current of 4mA.

The firm adds that the MMPA delivers high GSM/EDGE efficiency at all power levels and meets stringent modulation mask requirements under all conditions, while EDGE mode is optimized for the best combination of linearity and efficiency.

www.anadigics.com

TriQuint 'future proofs' HFC networks with first broadband return path amplifier for channel bonding

At the SCTE Cable-Tec Expo in Orlando, FL (17–19 October), RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA launched three new devices for CATV infrastructure and fiber-to-the-premises (FTTP) applications, including what is claimed to be the industry's first amplifier supporting return path DOCSIS 3.0 channel bonding with 5–300MHz bandwidth. This capability can ensure long-term competitiveness and help 'future proof' incumbent cable TV systems, adds the firm.

Channel bonding is a broadband data transport solution for substantially increasing two-way data throughput in cable TV networks. TriQuint says that this technology can aid cable operators in meeting current and future needs through economically scaled system upgrades. Existing silicon and previous GaAs-based solutions used for channel bonding do not match the bandwidth and output capability of TriQuint's new solution.

TriQuint's TAT3814 amplifier simplifies 5–300MHz return path system designs by integrating 36dB of gain and 20dB of automatic gain control (AGC) attenuation in a single 40-pin 6mm x 6mm surface-mount (SMT) package. The device is suited to cable modem, DOCSIS set-top gateway (DSG), set-top box (STB) as well as optical node and new combined line extender/optical node applications. With it, cable operators can offer high-speed data capabilities competing with FTTP systems, says the firm. High bandwidth helps to support cloud-based access, video-calling, peer-to-peer access and other service expansions.

"Not only does the TAT3814 help cable operators expand service offerings, it also sets the stage for

future network upgrades," says James L. Klein, TriQuint VP & general manager for Infrastructure and Defense Products. "This is truly a device that helps them reach further and faster while gaining a competitive marketplace advantage," he adds.

The TAT3814 is production-released; it is sampling now along with other CATV/FTTP products introduced for the SCTE Cable-Tec Expo.

New 12V line extender and distribution node power doublers:

TriQuint also launched two 12V infrastructure power doublers, suited to line extender output amplifier and distribution node amplifier designs. The TAT2801 provides high output and linearity for DOCSIS 3.0 Edge QAM and cable modem termination system (CMTS) applications, and has the highest linearity of the two new doublers. The TAT8801A1H is designed to meet most line extender output level requirements through its optimal performance and low power consumption.

FTTP video receiver enters full production:

The TAT6281 integrated 45–1003MHz variable-gain video receiver for FTTP launched at the 2012 ANGA Cable Show began full production in third-quarter. The TAT6281 is part of TriQuint's FTTH family, which includes the TAT6254 series 2012. TriQuint's FTTH solutions are deployed in 4 million residential and commercial locations worldwide. The TAT6281 uses the same topology as the TAT6254 family, which includes PIN diode attenuation for consistent operation. It supports low-noise analog interface to optical triplexers in single family unit (SFU) FTTP applications.

<http://expo.scte.org>

www.triquint.com

IN BRIEF

TriQuint receives employee wellness award from TechAmerica

RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has received the 2012 Corporate Wellness Award from technology trade association TechAmerica, in recognition of the firm and its human resources (HR) staff promoting internal employee wellness. TriQuint's 'Live Well' initiative gives staff and their families not only the tools and resources, but also the motivation to make good choices about their overall physical, mental and financial health, says the firm.

In addition to offering employees and their spouses biometric screenings, educational courses and a host of other programs, TriQuint partnered with TechAmerica to offer a wellness walking challenge, in which 428 active participants from TriQuint took part (the most of any firm participating). Employees from TriQuint sites around the globe formed 124 teams for the friendly eight week competition, and walked or ran more than 230 million steps collectively.

"Employees have told us that our programs have literally saved their lives," said Debbie Burke, TriQuint's VP of Human Resources. "We continue to listen to our employees' suggestions on how to make the programs more relevant to them, and the changes are really making a difference."

Burke accepted the award for TriQuint at TechAmerica's 54th annual David Packard Medal of Achievement and Innovators Award Dinner on 9 October.

www.triquint.com

IN BRIEF

Hittite reports a third consecutive quarter of growth

For third-quarter 2012, Hittite Microwave (which designs and supplies analog, digital and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems as well as instrumentation) has reported revenue of \$67.2m, down 1.4% on \$68.1m a year ago but up 2.7% on \$65.4m last quarter (the third consecutive quarter of sequential growth, after a low of \$60.2m in Q4/2011).

Of total revenue, 48.7% (\$32.8m) came from customers in the USA and 51.3% (\$34.4m) came from customers outside the USA.

Gross margin was 73.6%, down on 74.5% both a year ago and last quarter. However, although down on \$33.3m (48.8% of revenue) a year ago, operating income was \$27.6m (operating margin of 41% of revenue), up on \$26.2m (40.1% of revenue) last quarter.

Likewise, although still down 21.1% on \$22.4m a year ago, net income was \$17.7m, up 3% on \$17.2m last quarter.

During the quarter, total cash and marketable securities rose by \$17.4m, from \$375.4m to \$392.8m.

For fourth-quarter 2012, Hittite expects revenue of \$66.5–68.5m and net income of \$16.7–17.6m.

Hittite investing €4m in Irish R&D and International Operations Centre

Hittite Microwave Corp of Chelmsford, MA, USA is to create 30 new jobs by establishing two operations in Cork as part of a €4m investment; 19 new jobs will be created in R&D activities while 11 people will be employed at the firm's new International Operations Centre. The investments are supported by the Irish Government through IDA Ireland (Industrial Development Agency Ireland).

Products that will be designed at the new Cork R&D facility include components for use in telecoms and sensor systems across a variety of applications.

The International Operations Centre will manage non-US business in closer proximity to its customers in order to enhance local market presence. As part of the Centre, a global supply chain and finance team will also be located in Cork.

"This is an innovative US semiconductor company deciding that Cork is the place to carry out very significant research activities due to the presence of high-end research institutes and the availability of talent," says Richard Bruton TD, Ireland's Minister for Jobs, Enterprise and Innovation. "I am determined, through continued implementation of the Government's Action Plan for Jobs, to ensure that we continue to develop our innovation infrastructure so as to support more investments by Irish and multinational companies and create the jobs we need," he adds.

"The choice of Cork as the location for R&D activities is due to a combination of the availability of world-class engineers to contribute to the execution of the company's global R&D strategy and the proximity to the semiconductor and integrated circuit design capabilities in Tyndall Institute, University College Cork and Cork Institute of Technology," says Jason Lynch, managing director of Hittite's new Cork operation.

"Meanwhile, the new international operations centre will bring us closer to our customers and will have responsibility for growing our international business. The operation will be the point of all sales to non-US customers of existing and future Hittite Microwave products," he adds.

"In keeping with IDA Ireland's strategy to secure continued investment in R&D, Hittite Microwave will further add to Ireland's reputation as an R&D hub," comments IDA Ireland's CEO Barry O'Leary. "The company's plans to collaborate closely with a number of academic institutes including the Tyndall Institute, University College Cork, the University of Limerick, NUI-Maynooth and Cork Institute of Technology display Ireland's reputation for facilitating collaboration between industry and academia," he adds. "I wish Hittite Microwave every success with both of these new activities and offer the continued support of IDA Ireland into the future."

www.idaireland.com

Hittite promotes Gorkem Guven to vice president

Hittite Microwave has promoted Gorkem Guven to the executive role of vice president, managing various engineering, marketing and business developments organizations.

Guven joined Hittite in April 2000, and has served in roles including IC design, business development, and general management. He has

led numerous strategic technology initiatives and market penetration projects for the company. Guven has 14 years of semiconductor and industry experience.

"He is a passionate, business-savvy technologist that is expert in creating, planning and managing complex technology developments," comments chairman,

president & CEO Stephen G. Daly.

"He has a proven track record of identifying customer requirements and managing our teams to develop world-class products to satisfy those needs," he adds.

"This new position expands our executive team to support our continued growth."

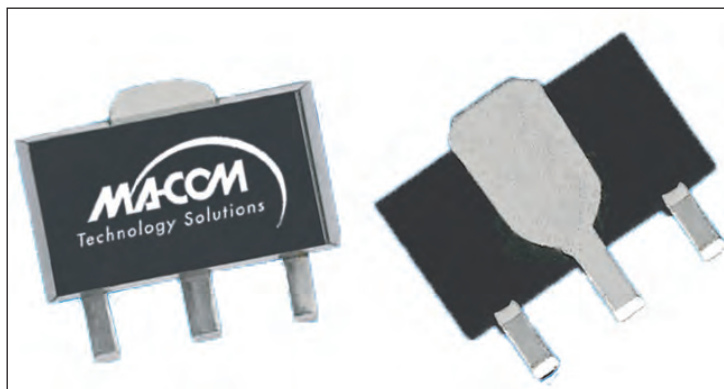
www.hittite.com

M/A-COM Tech launches broadband CATV amplifier with low distortion, high gain and low noise figure

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) has launched the MAAM-010373 monolithic microwave integrated circuit (MMIC) broadband amplifier exhibiting low distortion and high gain for CATV applications.

Housed in a lead-free surface-mount package, the amplifier employs a monolithic single-stage design featuring 75 Ω input/output impedance, which minimizes the number of external components required.

The MAAM-010373 is fabricated using a gallium arsenide pseudo-



M/A-COM Tech's MAAM-010373 MMIC broadband amplifier.

morphic high-electron-mobility transistor (GaAs pHEMT) process to realize low noise and low distortion. The process features full passivation for robust performance and reliability. Operating at

50–1100MHz frequencies, the amplifier exhibits a high gain of 22dB and low noise figure of 2.2dB.

"Customers are continually demanding more gain, improved linearity and reduced power dissipation," says

product manager Graham Board. Delivering 22dB of gain with 20dB output return loss, the MAAM-010373 suits multi-tap drop amplifier applications, he adds.

M/A-COM Tech showcases CATV amplifier line-up at Cable-Tec

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for RF, microwave and millimeter-wave applications) exhibited three amplifiers for CATV/broadband applications at the SCTE Cable-Tec Expo 2012 in Orlando, FL (17–19 October).

The MAAM-010144 is a GaAs MESFET MMIC amplifier. Configured as a pair of cascode MESFET amplifiers for optimal broadband performance, the MMIC is designed for integration in a 75 Ω push-pull circuit and exhibits low distortion.

Packaged in a TSSOP 16-lead exposed paddle package, the MAAM-010144 provides high gain of 20.5dB and +8V_{DC} bias. The CATV amplifier operates at 50–1000MHz and exhibits a gain flatness of 0.6dB and a low noise figure of 5.5dB. The device is optimized at 75 Ω with an input return loss of 18dB and an output return loss of 15dB.

The MAAM-010399 is an integrated three-stage differential variable-gain amplifier (VGA) with

an embedded voltage variable attenuator (VVA) to provide continuous power level control. The device serves as the output amplifier in a downstream EQAM (edge quadrature amplitude modulation) RF modulator. It offers very high linearity, operating off a single 6V supply, with a nominal power consumption of less than 5.5W.

Packaged in a 5mm x 7mm 40-lead PQFN package, the differential VGA is characterized in 75 Ω and designed for operation at 50–1100MHz. The MAAM-010399 simplifies the RF implementation and exceeds DOCSIS DRFI specifications with 7dB typical performance margin. Exhibiting a high gain of 28dB, it displays an input and output return loss of 20dB and an attenuation range of 25dB. The MAAM-010399 also boasts low harmonics, with 2nd and 3rd harmonics of –65dBc.

Packaged in a 4mm 20-lead QFN plastic package, the MAAM-009455 is an inter-stage or output amplifier featuring 20.5dB gain with broadband linear performance.

The MAAM-009455 targets next-generation CATV HFC, FTTx, HDTV, and EdgeQAM infrastructure applications, where high gain and low distortion are required. The device is a highly linear amplifier, with low noise figure and power dissipation. The differential amplifier uses M/A-COM Tech baluns, input and output, in order to ensure what is claimed to be best-in-class second-order performance. The amplifier also features external feedback, allowing for gain tuning.

The MAAM-009455 exhibits gain flatness of 0.5 dB typical over the 50–1000MHz operating band. Input return loss has been optimized to achieve better than 20dB across the band. Very low distortion characteristics provide what is claimed to be excellent composite second order (CSO) and composite triple beat (CTB) performance. The amplifier exceeds DOCSIS 3.0 DRFI specifications, making it a suitable output-stage solution for EdgeQAM head-end infrastructure.

www.macomtech.com

RFMD launches new CATV control components

At the SCTE Cable-TEC Expo 2012 in Orlando, FL (17–19 October), RF Micro Devices Inc of Greensboro, NC, USA unveiled two new CATV control components.

The RFS2654 is a 75Ω broadband, 6-bit serial controlled digital step attenuator with high linearity operating over a 5–2000MHz frequency range. Cable industry designers using the new digital step attenuator can adjust the gain of

high-linearity amplifier lineups over a 31.5dB range with 0.5dB step resolution. The RFS2654 also delivers ultra-fast switching speeds, solving a common problem facing step attenuators in many CATV applications says the firm.

The RFSW1012 is a high-power-handling 3V silicon on insulator (SOI) single-pole double-throw switch (SPDT), operating over a 5–6000MHz range. It delivers low

insertion loss of 0.3dB, high isolation of 48dB, and high linearity, with CTB/CSO >100dBc measured at +41dBmV/channel for 137 channels. The new SPDT also features a 2kV human body model (class 2) ESD rating on all ports and is housed in a reduced-size 2mm x 2mm 12-pin QFN package.

Both devices are suited to cable modems, CATV infrastructure, and other data network equipment.

RFMD unveils GaN-based amplifiers for cable applications

At the SCTE Cable-TEC Expo, RFMD launched multiple GaN-based CATV amplifiers, including the RFPD2940 high-power power-doubler amplifier and a new family of push-pull CATV amplifiers, led by the RFPD2870 and RFCM3080.

The RFPD2940 GaN-based CATV power-doubler amplifier delivers +63dBmV of output power without compromising the critical linearity performance requirements of CATV applications. The output power enables CATV network

operators to upgrade existing systems to wider bandwidths, enabling higher data throughput while also reducing operating expenses. The amplifier operates at 45–1000MHz, has 23dB gain at 1000MHz, features input and output return loss of –20dB, and delivers better than –73dB CTB and CSO performance. The RFPD2940 is housed in an industry-standard SOT-115J package and is available for sampling.

The RFPD2870 and RFCM3080

push-pull amplifiers are suited to drive GaN-based final-stage CATV power-doubler amplifiers. They feature 28dB gain at 1003MHz, have excellent input and output return loss (–20dB typical), and deliver low distortion levels of –68dBc CTB and –75dBc CSO. The RFPD2870 is housed in an industry-standard SOT-115 package, and the RFCM3080 is housed in a miniature 11mm x 8.5mm multi-chip-module (MCM) surface-mount package.

RFMD launches 3–5V 802.11n/ac high-linearity WiFi front-end modules

RFMD says its new high-linearity WiFi front-end modules (FEMs) provide complete integrated solution in a single FEM for WiFi systems.

Each device integrates a power amplifier (RFFM4203 for 2.4–2.5GHz; RFFM4501 for 4.9–5.85GHz), a Tx/Rx switch (SP3T in the RFFM4203; SPDT in the RFFM4501), low-noise amplifier (LNA) with bypass, and a power detector coupler for improved accuracy.

The ultra-small form factor and integrated matching minimizes layout area in the application and greatly reduces the number of external components. This simplifies the total front-end solution by reducing the bill of materials, system footprint, and manufacturability costs.

With an optimized dynamic error

vector magnitude (EVM) design, output powers for the RFFM4203 are 20.5dBm (11g/n, 5V <3% dynamic EVM), 19dBm (11n, 3.3V 2.5% dynamic EVM) and 17dBm (11ac, 3.3V 1.8% dynamic EVM). Output powers for the RFFM4501 are 20dBm (11a/n, 5V <3% dynamic EVM), 17dBm (11n, 3.3V <3% dynamic EVM) and 14dBm (11ac, 3.3V <1.8% dynamic EVM).

Applications include: WiFi (IEEE 802.11b/g/n/ac for RFFM4203 and IEEE 802.11a/n/ac for RFFM4501); ISM-band solutions (2.4–2.5GHz for RFFM4203 and 4.9–5.85GHz for RFFM4501); portable battery-powered equipment; and laptops, WiFi access points, gateways and set-top boxes.

Devices are supplied in 3mm x 3mm x 1.0mm, 16-pin laminate packages.

FEM for 868/915MHz ISM-band

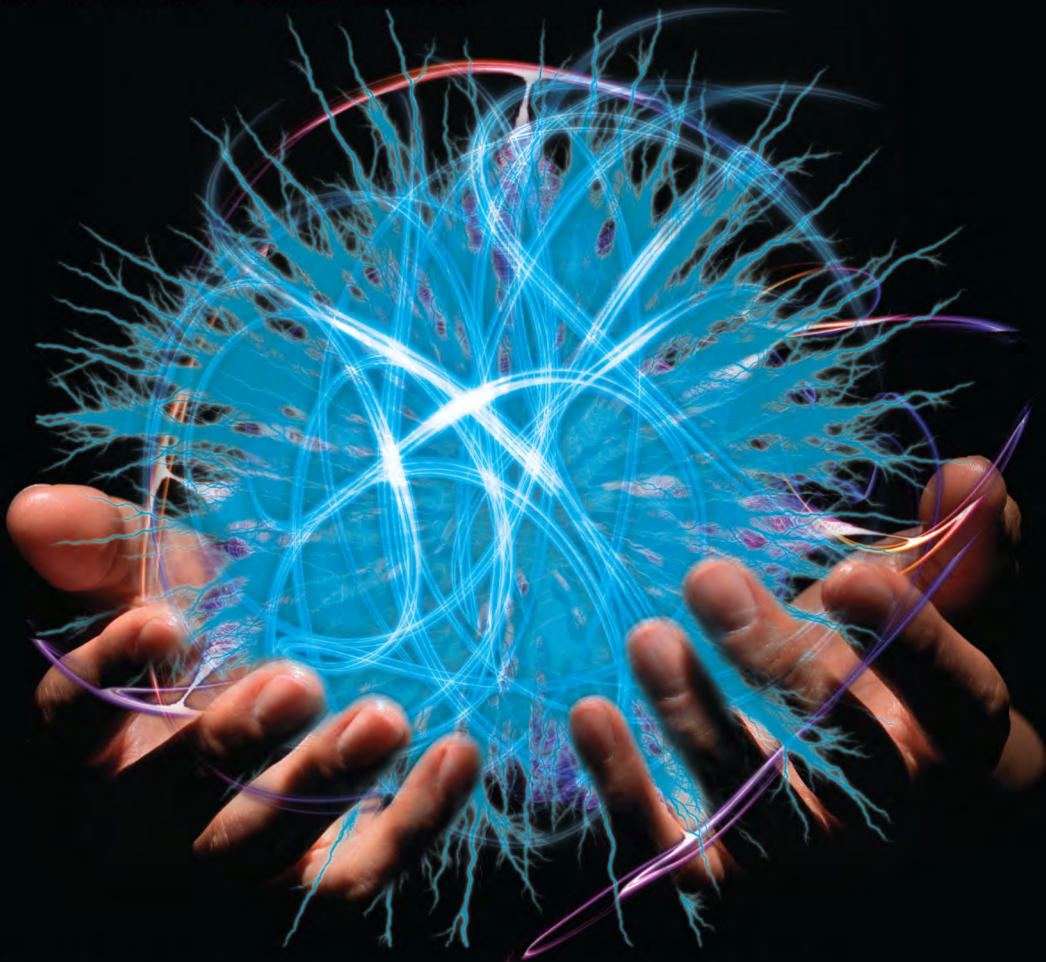
RFMD has launched the RFFM6901, a single-chip RF front-end module (FEM) for applications in the 868/915MHz ISM band as well as in wireless automatic metering, wireless alarm systems portable battery-powered equipment, and smart energy applications.

The RFFM6901 addresses the need for size reduction for portable equipment RF front-end design and reduces the number of components outside the core chipset, minimizing the footprint and assembly costs.

The 32-pin, 6mm x 6mm x 1.2mm FEM contains an integrated 1W power amplifier (PA) with nominal Tx output power of 30dBm, dual-port antenna diversity switch, low-noise amplifier (LNA) with bypass mode, and matching components.

www.rfmd.com

Hold Your Ground



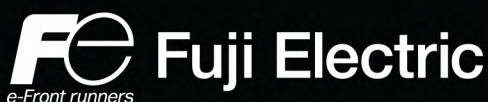
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IN BRIEF

RFMD appoints chief marketing officer

RFMD has appointed Alan Hallberg as corporate VP & chief marketing officer (CMO). Based at the firm's Silicon Valley location and reporting to president & CEO Bob Bruggeworth, he will oversee global marketing activities.

Previously, Hallberg worked in a marketing and branding capacity at technology firms including Cisco and Apple. Most recently, he was VP, global brand communications at PC maker Lenovo, where he led a two-year global re-branding and marketing effort. Hallberg graduated from Pomona College and holds a law degree from the University of Virginia.

"His extensive industry experience is well suited to growing RFMD's global marketing activities and communicating our product and technology leadership to current and new audiences," says Bruggeworth.

RFMD announces ITC lawsuit withdrawn by Peregrine

RF Micro Devices Inc of Greensboro, NC, USA says that Peregrine Semiconductor Corp of San Diego, CA, USA, a fabless provider of radio-frequency integrated circuits based on silicon-on-sapphire (SOS), has filed a motion to voluntarily withdraw the lawsuit it filed against RFMD in the US International Trade Commission (ITC) in February.

The ITC investigation was based on complaints filed by Peregrine with the ITC on 14 February and 11 May alleging that certain RFMD devices infringe patents related to silicon-on-insulator (SOI) technology for RF ICs (hence violating section 337 of the Tariff Act of 1930). The ITC investigation involved five Peregrine patents and 38 separate patent claims. Peregrine sought, among other remedies, an exclusion order preventing the importation and sale of infringing products in the USA.

RFMD believes that the decision by Peregrine to terminate the ITC proceeding is in response to devel-

opments in the case that have consistently validated RFMD's long-standing position that no infringement of Peregrine's patents occurred and that the validity of the asserted

The ITC investigation involved five Peregrine patents and 38 separate patent claims

Peregrine patents is in doubt. RFMD states that it respects the intellectual property rights of others and takes care to avoid infringements.

RFMD claims that it has a strong intellectual property portfolio relating to RFICs and switching technology that it has developed over many years, adding that it plans to continue to defend its position in the companion case filed by Peregrine in April in the US District Court for the Southern District of California.

www.rfmd.com
www.psemi.com

Peregrine appoints RFMW as global distributor

Peregrine Semiconductor Corp of San Diego, CA, USA, a fabless provider of radio-frequency (RF) integrated circuits (ICs) based on silicon-on-sapphire (SOS), and RF & microwave component distributor RFMW Ltd of San Jose, CA, USA have finalized a worldwide distribution agreement for Peregrine's UltraCMOS RFICs.

RFMW will stock, distribute and provide applications engineering support for Peregrine's broad product portfolio, including RF switches, digital step attenuators, pre-scalers, mixers, phase-locked loop (PLL) frequency synthesizers, and digitally tunable capacitors, for applications in the defense, broadband, industrial, mobile wireless device, test & measurement equipment, and wireless infrastructure markets.

"RFMW's focus on RF products, technology, and customers is a highly complementary solution to Peregrine's existing global sales network," says Dale Robinette, Peregrine's director of worldwide sales. "Partnership with RFMW gives us visibility into the very early design stages of customer projects, where our unique UltraCMOS technology process and high performance provide the most benefit," he adds.

"Peregrine Semiconductor's UltraCMOS technology enables the development of highly integrated RFICs that combine RF, mixed-signal, and digital functions on a single chip," says RFMW's president Joel Levine. "We've seen requirements in certain market segments for this type of integration while, at the same time, many of our cus-

tomers design with discrete devices such as switches, and digital attenuators. Peregrine's product portfolio satisfies the requirements of both," he adds. "Our immediate goal is to introduce customers to Peregrine's portfolio, in order to expand design-in opportunities."

"Our pan-European sales staff of focused RF specialists are eager to support customer design, prototype, and manufacturing opportunities with Peregrine's devices, which provide much needed support for current design opportunities where we've previously been unable to offer solutions," notes Peter Saxby, managing director of RFMW in Europe.

www.rfmw.com
www.psemi.com

Peregrine Semiconductor expands family of high-linearity, low-insertion loss SPDT RF switches

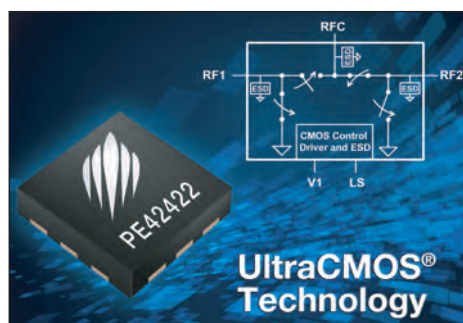
Peregrine Semiconductor Corp of San Diego, CA, USA, a fabless provider of radio-frequency (RF) integrated circuits (ICs) based on silicon-on-sapphire (SOS), has added the HaRP-technology-enhanced PE42422 to its family of high-linearity, low-insertion-loss SPDT (single-pole double-throw) RF switches.

The switch provides linearity of 115dBm IIP2, and 70dBm IIP3; low insertion loss of 0.4dB @ 3GHz, and high isolation of 28dB @ 3GHz, enabling better overall system performance it is claimed. The switch covers a wide frequency range of 100MHz–6GHz and, using a nominal +3V power-supply voltage, a typical input 0.1dB compression point of +36dBm can be achieved.

The PE42422 is available in a 12-lead, 2mm x 2mm QFN package, making it suited to not only portable wireless but also general-purpose RF switching applications, such as filter-bank switching in test equipment and base stations, adds the firm.

The 50Ω, reflective PE42422 features on-chip, low-voltage CMOS control logic and a wide operating voltage range of 2.3–5.5V, enabling it to be used in a variety of ways. ESD performance of 4kV HBM for RF pin to ground simplifies manufacturing and improves product reliability. Also, with low power consumption of 120μA (typical), the PE42422 switch helps to extend battery life in portable devices, the firm claims.

"As data rates continue to increase, RF designs are becoming more complex, and RF designers require high-linearity, low-loss switches in small packages," says Mark Schrepferman, director of marketing for Peregrine's High-Performance Solutions business unit. "By supporting frequencies up to 6GHz, with high linearity, low insertion loss, and availability in the small, 2mm x 2mm QFN package,



The new PE42422 SPDT RF switch.

the PE42422 switch meets these requirements."

For engineers wanting to evaluate the PE42422 switch, Peregrine has introduced the PE42422 Evaluation Kit (part # EK42422-01, \$95).

The PE42422 is available for \$0.83 each, in 10,000-unit quantities. Samples and volume-production quantities are available now.

www.psemi.com

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TowerJazz and UCI demo integrated 94GHz imaging transceiver with record performance in silicon

SiGe BiCMOS enables 4–10x improvement in noise equivalent temperature difference versus 65nm CMOS

Specialty foundry TowerJazz (which has fabrication plants at Tower Semiconductor Ltd in Migdal Haemek, Israel, and at its subsidiaries Jazz Semiconductor Inc in Newport Beach, CA, USA and TowerJazz Japan Ltd) says that researchers at the University of California, Irvine's (UCI's) Nanoscale Communication Integrated Circuits (NCIC) Labs have built a W-band (80–100GHz) 2x2 focal-plane array (FPA) integrated system with record NETD (noise equivalent temperature difference) performance for passive millimeter-wave imaging using TowerJazz's SiGe BiCMOS process (SBC18H2).

TowerJazz claims that this unprecedented level of integration and performance in a silicon process can reduce the cost of millimeter-wave imaging systems. These are initially being deployed in security (cameras and scanning), medical, and automotive radar applications but, with the lower cost that silicon provides, can be applied to future consumer applications.

The imaging receiver (without antenna) achieves a measured average responsivity and noise equivalent power (NEP) of 285MV/W and 8.1fW/Hz^{1/2} respectively, across the 86–106GHz bandwidth, which results in a calculated NETD of 0.48K with a 30ms integration time. This represents a 1–2 orders of magnitude improvement in NEP versus other methods and demonstrations to date, a 4–10x improvement in NETD versus, for example, 65nm CMOS. With antenna, the system NETD increases to 3K with on-chip antenna due to its low antenna efficiency in the W-band. TowerJazz claims that the work demonstrates the highest integration level of any silicon-based system in the 94GHz

imaging band, and that the responsivity achieved is orders of magnitude higher than previous work.

TowerJazz says that, due to performance improvements and lower cost, silicon technologies such as SiGe BiCMOS have been adopted as the primary platform for the development of millimeter-wave (MMW) systems for target applications such as short-range high-data-rate wireless communications, automotive radar, sensing and imaging. Within the MMW frequency range (30–300GHz), there are propagation windows located near 35, 94, 140 and 220GHz, where the atmospheric absorption is relatively low. Because passive millimeter-wave (PMMW) imaging systems are capable of operating with high performance at these frequencies, they are suitable for various applications such as remote sensing, security surveillance (e.g. concealed weapon detection at the airport), non-destructive inspection for biological tissues, and industrial process control, adds the firm. Also, the non-invasive nature of passive imaging avoids any public health concerns that are present with potentially harmful active imaging methods, such as x-ray detection used in medical and security applications.

The FPA that was designed and fabricated using TowerJazz's silicon process incorporates four Dick-type receivers representing four imaging pixels. Each receiver employs the direct-conversion architecture, consisting of an on-chip slot folded dipole antenna, a single-pole double-throw (SPDT) switch, a low-noise amplifier, a single-balanced mixer, an injection-locked frequency tripler (ILFT), an intermediate frequency (IF) variable-gain amplifier (VGA), a power detector, an active bandpass filter

and a synchronous demodulator. The LO signal is generated by a shared Ka-band phase-locked loop (PLL) and distributed symmetrically to four local ILFTs. The measured LO phase noise is –93dBc/Hz at 1MHz offset from the 96GHz carrier.

"The on-going collaboration with TowerJazz to support NCIC Labs at UCI has led to design and fabrication of 40 RF and high-speed analog ICs, and has led to the completion of several projects such as Terahertz oscillators, distributed amplifiers, and fully integrated radar-on-chip," says professor Payam Heydari, full professor of Electrical Engineering and Computer Science at UCI.

"The UCI design cleverly integrates several features needed for millimeter-wave imaging which includes on-chip frequency synthesis and local oscillator distribution. To do this at 94GHz with low phase noise is very impressive," comments TowerJazz executive director Dr David Howard. "The UCI work has shown record performance in SiGe BiCMOS as compared to other technologies such as 65nm CMOS, and demonstrates the ability to integrate millimeter-wave transmit and receive functions together," he adds. "To have such technology available, monolithically, in highly affordable 200mm wafer silicon should enable a dramatic increase in product usage and implementation, such as in the number of cameras at airports that are used for millimeter-wave imaging."

Heydari is presenting on the topic of millimeter-wave imaging at TowerJazz's 7th annual US Technical Global Symposium (TGS) at the Hyatt Regency, Irvine on 31 October – 1 November.

<http://towerjazz.com/tgs>
www.towerjazz.com
<http://ncic.eng.uci.edu>

Skyworks begins volume shipments of ZigBee front-end modules for home automation, smart energy and security applications

Skyworks Solutions Inc of Woburn, MA, USA (which manufactures high-reliability analog and mixed-signal semiconductors) has commenced volume shipments of several medium to high-power ZigBee front-end solutions for smart meters, home automation, security sensors and gateway applications.

"Skyworks is delighted to be offering best-in-class ZigBee front-end solutions that are enabling exciting consumer applications such as home monitoring, security and energy management from a smartphone," says Liam K. Griffin, executive VP & general manager of high-performance analog. "We believe we are in the early innings of what will be an enormous market opportunity as seemingly everything within the home becomes connected." The overall revenue potential of the

smart home is expected to be even higher as devices from the entertainment, health and home security sectors also become connected.

According to market analyst firms ABI and Berg Insight, the combined revenue from the smart metering, home automation and home energy management market segment is forecasted to generate more than \$44bn in 2016 (as cited in GSMA's 'Vision of Smart Home: The Role of Mobile in the Home of the Future' report). The overall revenue potential of the smart home is expected to be even higher as

The smart metering, home automation and home energy management market segment is forecasted to generate more than \$44bn in 2016

devices from the entertainment, health and home security sectors become connected, adds Skyworks.

Skyworks' SE2431L and SE2432L are fully integrated 2.4GHz RF FEMs for ZigBee/smart energy and 802.15.4 applications. The FEMs are designed for ease of use and maximum flexibility, with integrated inter-stage matching and harmonic filter, and digital controls compatible with 1.6–3.6V complementary metal oxide semiconductor levels. The RF blocks operate over a supply voltage range from 2.0 to 3.6V, allowing the devices to be used in battery-powered applications over a wide spectrum of the battery discharge curve.

Skyworks' ZigBee/smart energy front-end modules are available for both sampling and production.

www.skyworksinc.com

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IN BRIEF

Fairchild focuses on silicon carbide at electronica Europe

Fairchild Semiconductor of San Jose CA, USA, which makes silicon chips for power and mobile designs, exhibited its latest developments in silicon carbide (SiC) technology as well as over 15 power and mobile solutions at the electronica Europe 2012 show in Munich, Germany (13–16 November). The firm acquired SiC power transistor maker TranSiC AB of Kista, Sweden in April 2011.

Fairchild demonstrated its SiC bipolar junction transistor (BJT) technology, which enables higher efficiency and higher power density for applications such as solar inverters, welding systems, and mobile power.

At electronica Europe, Fairchild also conducted demonstrations in application areas such as LED lighting, automotive, power supplies, smart meters, motion control and DC–DC conversion, as well as solutions for portable applications, including portable power management and interface.

In the LED lighting demonstration, Fairchild lighting experts demonstrated a dimmable 25W PWM signal LED power supply with analog voltage (1–10V) that shows a wide input voltage range of 85 to 700 V_{AC} input for better efficiency. Featured products included the FL6961 single-stage flyback and boundary mode PFC controller; the 1550V FJAFS1510A high-voltage ESBC emitter switched bipolar/MOSFET cascode switch; the 30V FDC655 single N-channel logic level MOSFET. Also demonstrations was the FL7730 single-stage primary side regulation (PSR) controller and FL7701 smart non-isolated buck LED driver for low-power, TRIAC and analog dimming applications.

www.fairchildsemi.com
www.transic.com

SemiSouth to be closed; 90 staff to be laid off

Strategic investor Power Integrations to record \$60m charge in Q3

SemiSouth Laboratories Inc of Starkville, MS, USA, which designs and manufactures silicon carbide (SiC) devices for high-power, high-efficiency, harsh-environment power management and conversion applications, is to close down, according to a report by the Starkville Daily News.

SemiSouth was founded in 2001 by former Mississippi State University (MSU) faculty member Jeffrey Casady and current MSU electrical and computer engineering professor Michael Mazzola, and has since been housed at the Thad Cochran Research, Technology and Economic Development Park near MSU.

MSU director of university relations Sid Salter said that, while MSU does not have a formal business relationship with SemiSouth, the university assigned the technology's intellectual property rights to non-profit organization MSU Research and Technology Corp, giving the university a 2% stake. As owner of the Cochran facility, MSU has managed SemiSouth's lease of its portion of the building (yielding \$300,000 in revenue annually).

In October 2010, in order to drive the expansion of its SiC fabrication facility, Power Integrations Inc of San Jose, CA, USA (which supplies high-voltage integrated circuits for compact, energy-efficient power conversion in electronic products for AC–DC, DC–DC and LED lighting applications) made a \$30m strategic investment in SemiSouth (including an equity investment, a technology license and other financial commitments). The firms also collaborated on driving adoption of SemiSouth's SiC technology, aiming to speed the development of efficient power conversion devices for applications including solar and wind inverters as well as hybrid/electric vehicles.

In second-quarter 2011, to expand production capacity, SemiSouth installed an Aixtron AIX 2800G4 WW chemical vapor deposition (CVD) reactor in 10x100mm- and 6x150mm-wafer configuration for the production of power SiC junction field-effect transistor (JFET) and Schottky barrier diode (SBD) devices. More recently, just this March, SemiSouth announced its second major capacity expansion (worth \$18m) within 18 months, intended to add 50% more capacity to meet demand for SiC power JFETs and power diode products from the solar inverter and industrial power supply markets.

However, now, Power Integrations says that its third-quarter 2012 results will include a pre-tax charge of about \$60m from the closure of SemiSouth (resulting in a net loss). "The expected closure of SemiSouth is disappointing, but reflects the challenges and risks inherent in the quest for disruptive technologies," says Power Integrations' president & CEO Balu Balakrishnan. "Our strategic direction remains unchanged, and we continue to invest in promising technologies to expand our market opportunity within the realm of high-voltage power conversion," he adds.

MSU vice president for research David Shaw hopes a solution can be developed to retain employees among the 90 affected. "We hope we can be a resource to some of these families looking for other job opportunities," adds Jennifer Gregory, VP for tourism and development at the Greater Starkville Development Partnership.

<http://semisouth.com>
www.powerint.com
www.starkvilledailynews.com/node/11673

RFMD wins \$2.1m DARPA GaN contract to boost thermal efficiency of high-power RF amplifiers

GaN-on-SiC technology to combine with thermally enhanced diamond substrates

RF Micro Devices Inc of Greensboro, NC, USA has been awarded a \$2.1m contract from the US Defense Advanced Research Projects Agency (DARPA) to enhance the thermal efficiency of gallium nitride (GaN) circuits used in high-power radar and other military systems.

The award is in association with the Near Junction Thermal Transport (NJTT) effort of DARPA's Thermal Management Technologies (TMT) program. The goal of the NJTT initiative is to achieve a 3x or greater improvement in power handling from GaN power amplifiers through improved thermal management of the near-junction region. By combining thermally enhanced diamond substrates with RFMD's GaN-on-SiC high-power technology, RFMD expects to significantly improve power density and power handling capability.

RFMD will be working with DARPA to apply new technologies to its existing portfolio of GaN-based high-power RF amplifier products, says Jeff Shealy, VP & general manager of RFMD's Power Broadband business unit. "We expect the NJTT program will result in a new generation of higher-performing, more compact RF high-power amplifiers (HPAs) with lower operating temperature and greater RF power-per-unit area," he adds.

RFMD's partners in the program include the Georgia Institute of Technology, Stanford University, Group4 Labs, and Boeing. The firm says that Georgia Tech is recognized for its expertise in thermal testing, modeling and micro Raman thermography. Stanford University is reckoned to be the world leader in thermal measurement of the critical interface layers within a transistor die. Group4 Labs is a

pioneer in the development of diamond substrates. Boeing plans to evaluate the resulting technology to assess its projected impact on future defense systems.

RFMD has been active in GaN technology since 2000 and has production released two high-power process technologies (available through its open-foundry business model). The firm's GaN power devices have been deployed across multiple defense and commercial applications, including radar, milcom, and CATV infrastructure. RFMD also manufactures GaN-based CATV broadband amplifiers, and has shipped more than 350,000 GaN-based CATV amplifiers into the commercial market.

Previously, in September, RF front-end component maker TriQuint Semiconductor Inc of Hillsboro, OR, USA received a \$2.7m NJTT contract

We expect the NJTT program will result in a new generation of higher-performing, more compact RF HPAs with lower operating temperature and greater RF power-per-unit area

from DARPA to triple the power handling performance of GaN circuits, building on TriQuint's GaN-on-SiC technology and its RF integrated circuits in partnership with the UK's University of Bristol (for expertise in thermal testing, modeling and micro Raman thermography), Group4 Labs, and Lockheed Martin (evaluating the results for the projected impact on future defense systems).

www.rfmd.com

www.darpa.mil

IN BRIEF

AMCAD launches 1kV/30A pulse IV system for testing high-voltage fast-switching transistors

AMCAD Engineering of Limoges, France has announced an upgrade to its PIV pulse current-voltage semiconductor device analyzer family for the next generation of high-voltage fast-switching (HVFS) transistors.

HVFS transistors open the way to new targets and new designs for high-efficiency DC-DC converters, switches, hubs and servers, telecom base-stations, and automotive applications, says AMCAD. Other applications include LED drive circuits and Class D audio amplifiers.

The firm says that new HVFS transistor technology such as enhanced-mode gallium nitride (GaN) FETs and silicon carbide MOSFETs offers very fast switching frequencies capabilities that are up to 10 times higher than previous solutions, allowing designers to use lower duty cycles.

Unfortunately, until now, there were no efficient testing solutions able to highlight the capabilities of these new technologies, which can simultaneously provide high-voltage signals and short-pulse/fast-switching capabilities, says AMCAD.

"AMCAD complements its existing pulse IV system portfolio by offering a new solution with pulse width down to 400ns@1kV to help customer testing high-voltage fast-switching transistors," says general manager Tony Gasseling. Gasseling continued,

The 1kV/30A PIV HVFS measurement system was demonstrated for the first time at European Microwave Week (EuMW) in Amsterdam, The Netherlands (29-31 October).

www.amcad-engineering.fr

IN BRIEF

Cree's RF GaN transistors and Array Wireless' linear PAs deliver HD video

Cree Inc of Durham, NC and Array Wireless Inc of Carlsbad, CA (an electronics OEM specializing in microwave power amplifiers for digital communications networks) are bringing high-definition (HD) video transmission to Sunday Night Football (SNF) on NBC. The HD NFL games are broadcast using wireless video systems from Array Wireless.

Cree's GaN RF technology is deployed in Array Wireless' S-band linear power amplifier (PA) product series, enabling smaller, lighter and more efficient PAs than those based on GaAs, says the firm.

"Cree's GaN RF devices are ideal for meeting the stringent linearity requirements for wide-bandwidth HD digital transmission at high-efficiency operation," says Array Wireless' president & founder Ed Takacs. "The lighter-weight systems they enable are extremely beneficial in lowering fuel consumption and operating costs for our customers," he adds. "We migrated from GaAs devices to Cree GaN devices several years ago to offer increased transmission range while reducing our power amplifier size, weight and power consumption."

For microwave transmission of digitally modulated signals from UHF to 10GHz, Array Wireless' TruPower series linear RF amplifiers use patent-pending linearization technology to minimize distortion and provide signal quality for complex multi-carrier modulations like orthogonal frequency-division multiplexing (OFDM) while minimizing DC power consumption, heat and weight.

www.arraywireless.com
www.cree.com

ON Semiconductor joins Imec's GaN-on-Si research program

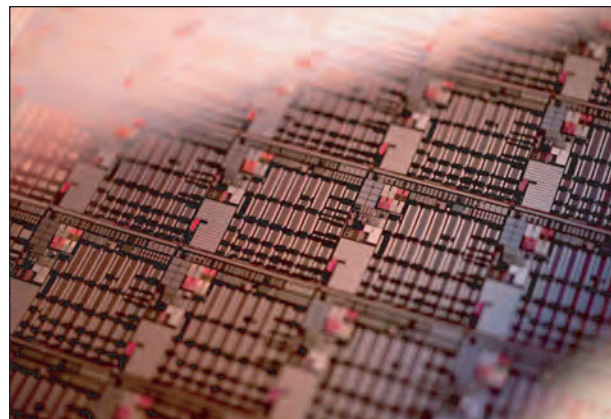
Silicon device maker targeting more energy-efficient electronics

ON Semiconductor of Phoenix, AZ, USA, which supplies silicon-based power and signal management, logic, discrete and custom devices for energy-efficient electronics, has joined the multi-partner, industrial R&D program at nanoelectronics research center Imec of Leuven, Belgium to collaborate on the development of next-generation gallium nitride on silicon (GaN-on-Si) power devices.

Since GaN is characterized by superior electron mobility, higher breakdown voltage and good thermal conductivity properties, it suits power and radio frequency (RF) devices that need high switching efficiencies, notes Imec. However, currently GaN-based power devices are too expensive for large-volume manufacturing, as they are fabricated on small-diameter wafers using non-standard production processes.

Imec's broad-scale research program is focused on developing GaN-on-Si technology on 200mm wafers, as well as reducing the cost and improving the performance of GaN devices. By bringing together leading integrated device manufacturers (IDMs), foundries, compound semiconductor companies, equipment suppliers and substrate suppliers, Imec claims to have achieved significant technical advancements.

Last year, Imec's research program produced 200mm GaN-on-Si wafers, bringing processing within reach for standard high-productivity 200mm fabs. Moreover, it developed a fabrication process compatible with standard CMOS processes and tools (the second prerequisite for cost-effective processing).



Imec's power devices on 200mm CMOS-compatible GaN-on-silicon.

"As a top 20 global semiconductor supplier with a portfolio focused on energy-efficient devices, ON Semiconductor has been researching GaN-on-silicon technologies for several years and is presently building a GaN processing line in its Oudenaarde facility in Belgium," says Hans Stork, senior VP & chief technology officer at ON Semiconductor. "Partnering with Imec will help strengthen our current market position and potentially assist us in adding a competitive leading-edge technology to our customer offerings," he adds.

"Extraordinary developments continue to emerge from our GaN-on-Si Affiliation Program, creating further inroads to drive down production costs," says Rudi Cartuyvels, VP of smart systems and energy technology at Imec. "The newest addition, of ON Semiconductor as a strategic program partner, further advances our collective expertise," he adds. "Leveraging joint efforts will help us overcome the next hurdle toward economical volume manufacturing, ultimately bringing GaN power devices to the market."

www.imec.be
www.onsemi.com

GaN Systems expands to new US office

Business development director in Michigan to target the manufacturing and automotive sectors

GaN Systems Inc of Ottawa, Ontario, Canada, which is a fabless provider of gallium nitride (GaN)-based power switching semiconductors for power conversion and control applications, has opened a new office in Ann Arbor, Michigan, and appointed Julian Styles as director of business development, leading business development in the USA.

The firm reckons the expansion in the USA will help it to impact key industries, such as manufacturing and automotive, where the need for clean technology power conver-

sion applications continues to grow.

GaN Systems will be able to better serve its clients in the USA with the addition of an "experienced, well versed executive in the electronic and automotive sectors," reckons CEO Girvan Patterson. "We have worked hard to develop viable, effective GaN applications, including making hybrid and all-electric vehicles cost effective," he adds. "Julian's broad experience and strong technical background, including electric vehicle and grid systems, will complement the existing team to meet the needs of

a growing company."

An experienced executive with over 20 years' track record of helping international companies bring new technologies to market, Styles most recently led US/Swedish company Movimento Group's entry into knowledge management for advanced automotive infotainment systems. Previously he helped lead electronics company Pi Shurlok (now Pi Innovo) to rapid growth in the USA, based around innovative products for the automotive, transport and aviation industries.

www.gansystems.com

Keithley introduces parametric curve tracing technology for characterizing high-power devices

Keithley Instruments Inc of Cleveland, OH, USA has introduced seven instrumentation, software and test fixture configurations for parametric curve tracing applications for characterizing high-power devices, including those based on silicon carbide (SiC) and gallium nitride (GaN) technology, at up to 3000V and 100A.

"Many power device developers have told us they like the dynamic range and ease of use of a traditional curve tracer, but they know they need more flexibility in configuring the measurement channels, as well as the accuracy, capability, and graphical user interface that a modern parametric analyzer offers," says staff technologist Lee Stauffer.

According to the firm, in contrast to solutions that require all instrumentation to be housed in a chassis, Keithley's seven new configurations offer the flexibility to add new measurement channels economically as users' needs evolve, with no need to return the system to the factory to install new

hardware. For example, a user could start with an entry level Parametric Curve Tracer, then add the capabilities of additional System SourceMeter instruments, such as higher voltage and/or higher current, at a later date.

Six different System SourceMeter instrument models can be mixed and matched to create the optimum combination of voltage, current and power for the user's specific needs. Keithley's TSP-Link virtual backplane technology allows users to incorporate any number of Source-Measure channels, all of which are fully and automatically synchronized with other SourceMeter instruments in the system.

All seven configurations include the latest version of Keithley's ACS (Automated Characterization Suite) Basic Edition software, which supports Keithley's newest SMUs and takes advantage of the Series 2600B's TSP-Link connection trigger model, which allows for 500ns trigger synchronization between instruments. This tighter synchronization capability maxi-

mizes the high-speed pulse-mode capabilities of the new Model 2651A and Model 2657A High Power System SourceMeter instruments.

The Windows-compatible ACS Basic Edition package provides control and analysis tools suited for high-power device characterization, including complete parametric test libraries for MOSFETs, BJTs, triacs, diodes, IGBTs, and other device types.

The software's 'trace' mode, which uses an on-screen slider control, allows users to control the level of voltage and current levels sourced interactively and to see how the power device responds in real time. The software's 'parametric' mode provides a 'fill-in-the-blanks' GUI to configure a test precisely and a comprehensive set of tools for precise parameter extraction.

All seven bundles also include all cabling and adapters required for system assembly, as well as a number of sample power devices useful for training and demonstration purposes.

www.keithley.com

Transphorm raises \$35m in Series-E financing led by Japan's INCJ

Alliance with Nihon Inter Electronics targets mass production and supply of GaN power devices

Transphorm Inc of Goleta, near Santa Barbara, CA, USA (which designs and delivers power conversion devices and modules) has announced a \$35m Series E financing round led by Innovation Network Corporation of Japan (INCJ) and Nihon Inter Electronics Company (NIEC) and joined by existing venture investors Kleiner Perkins Caufield & Byers, Foundation Capital, Google Ventures, Quantum Strategic Partners (a private investment fund run by Soros Fund Management), Lux Capital, and Bright Capital.

Established in July 2009 by Japanese government and 27 major corporations (including Sharp, Sumitomo Electric, Toshiba and General Electric Company, Japan), INCJ is a public-private partnership provides financial, technological and management support for next-generation businesses (specifically projects combining technologies and varied expertise across industries).

Transphorm was co-founded in 2007 by CEO Umesh Mishra, a professor of electrical & computer engineering at the University of California, Santa Barbara (UCSB), with backing of \$38m from Google Ventures, Kleiner Perkins Caufield & Byers, Foundation Capital and Lux Capital. The firm aims to solve the multi-billion dollar problem of power waste whenever electricity from the grid is converted into usable electric power. Existing silicon-based power converters are only 85–90% efficient, so 10% of energy is lost (e.g. as waste heat). Transphorm emerged from stealth

mode in February 2011, when it launched what it claimed to be the first complete solution to significantly reduce such power waste, based on replacing legacy silicon-based power conversion technology with high-voltage normally-off gallium nitride (GaN)-based power conversion modules.

Backed by its vertically integrated GaN development capability and intellectual property, Transphorm recently claimed that it was the first to deliver qualified high-voltage (600V) GaN products, delivering enterprise customers the most compact and energy-efficient power conversion solutions available.

The latest financing brings the total capital raised by Transphorm from all funding rounds to \$104m. "The investment from INCJ substantiates GaN as the next-generation energy efficiency technology," says Transphorm's Umesh Mishra. "The need for energy efficiency

remains paramount even as the sources of energy change," he adds. "Today's strategic financing, coupled with the earlier investments, enables scaling of this disruptive technology and helps eliminate energy waste in multiple markets from servers to solar panels, from HVACs to hybrids."

The alliance should help to bring the long-awaited practical realization, commercialization and mass production of GaN power conversion

In addition to investing, NIEC (which was established in 1957 and manufactures power management semiconductors for automotive, solar energy products, energy-efficient appliances, IT products and smartphone applications) has entered into a business alliance with Transphorm, with the aim of enabling the stable, mass production and supply of next-generation GaN power devices. The alliance should help to bring the long-awaited practical realization, commercialization and mass production of GaN power conversion solutions, the firms reckon.

"The INCJ-enabled alliance with NIEC helps Transphorm accelerate its business while maintaining its global leadership position in GaN power conversion," reckons president Primit Parikh. "Through NIEC, our customers will benefit with broader distribution channels, as well as a reputable second source for some of our packaged products," he adds.

"After a thorough evaluation process, INCJ is pleased to support Transphorm, together with NIEC, in its mission of re-defining energy efficiency with GaN," comments INCJ's executive managing director Hidetoshi Shibata. "We look forward to working with Transphorm as they continue to build energy-efficient solutions for consumers and businesses around the world."

www.transphormusa.com
www.incj.co.jp/english
www.niec.co.jp/english

Transphorm's Yifeng Wu gives plenary presentation at IWNS

On 19 October, Transphorm's Dr Yifeng Wu appeared as a plenary speaker at the International Work-

shop on Nitride Semiconductors (IWN 2012) in Sapporo, Japan, to give the invited plenary presenta-

tion 'High efficiency GaN power devices: The technology & business opportunities'.

EPC upgrades development boards featuring eGaN FETs using dedicated GaN FET gate drivers from TI

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) used in power management applications, has introduced two development boards (the EPC9003 and the EPC9006) both featuring EPC's enhancement-mode gallium nitride (eGaN) field-effect transistors (FETs).

The EPC9003 is a half-bridge configuration containing two 200V EPC2010 eGaN FETs with a 5A maximum output current using Texas Instruments' LM5114 low-side gate driver optimized for GaN devices. The EPC2010 is designed for use in applications such as solar microinverters, class D audio amplifiers, power over Ethernet (PoE), and synchronous rectification.

The EPC9006 contains two 100V EPC2007 eGaN FETs with 5A maxi-



The EPC9003 and EPC9006 development boards.

mum output current. This board uses TI's LM5113 100V half-bridge driver, optimized for GaN transistors. The LM5113 used on this board is packaged in a 2x2 BGA package, allowing for a compact power stage with the driver and two eGaN FETs. Applications for the EPC2007 eGaN FET include high-

speed DC-DC power supplies, point-of-load converters, class D audio amplifiers, hard-switched and high-frequency circuits.

Both the EPC9003 and the EPC9006 are intended to simplify the evaluation process of eGaN FETs by including all the critical components on single 2" x 1.5" boards that can be easily connected into any existing converter, says the firm. In addition, there are various probe points on the boards to facilitate simple waveform measurement and efficiency calculation. Quick Start Guides are included with both development boards for reference and ease of use.

The EPC9003 and EPC9006 development boards are priced at \$95 each, and are available for immediate delivery from Digi-Key.

www.epc-co.com

<http://digikey.com>

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ATMI expands Asian customer support with High Productivity Development Center and manufacturing facility in Korea

Groundbreaking targets high-volume production in second-half 2013

ATMI Inc of Danbury, CT, USA (which provides specialty semiconductor materials and high-purity materials handling and delivery solutions) plans to further increase its commitment to the Asia-Pacific microelectronics markets, and South Korea customers in particular, through a new manufacturing facility to be built in JangAn, Gyeonggi province, where the investment has been commemorated with a groundbreaking ceremony attended by ATMI customers and employees, officials from the Gyeonggi province and Hwaseong city governments and ATMI executives. The facility is expected to be ready for high-volume production in second-half 2013.

ATMI also announced the completion of its fifth global High Productivity Development Center (and the third in Asia), inside the facilities of the Korea Advanced Nano Fab Center (KANC) in Suwon. The center is fully operational, with customer work already underway.

"Our manufacturing investments in South Korea will strengthen our supply chain and improve our interactions with leading customers," says chairman, CEO & president Doug Neugold. "Our High Productivity Development investment will further enhance our ability to part-

ner with our customers in Asia, enabling our local customers and ATMI to work together to solve problems more quickly and comprehensively than before," he adds. "Proximity to our customers enables our teams to better collaborate on defining problems, react quickly as knowledge is gained, and move solutions to production rapidly, bringing operational efficiencies throughout our supply chain."

The new 11,000m² (118,000ft²) facility will manufacture products for semiconductor production, including: SDS (Safe Delivery Source) and VAC (Vacuum-Actuated Cylinder) gas delivery systems and materials for semiconductor and solar ion-implant applications; NOWPak liner-based liquid delivery systems used in photolithography and display applications; and advanced materials used primarily for leading-edge semiconductor thin-film deposition and surface preparation applications. Current plans project that the new facility will have about 100 staff and cost \$24m to build.

ATMI says that its existing global network of High Productivity Development

Centers in Danbury, CT and San Jose, CA, USA, Kyoto, Japan and Hsinchu, Taiwan, are designed to help customers identify and validate new chemistry solutions rapidly through quicker learning cycles, saving time and money and reducing risks. The new center in Suwon will serve the same purpose and is now equipped for research, development and applications support of new surface preparation and cleaning chemistries, and deposition materials. ATMI plans to expand R&D capabilities there for packaging materials and customized chemical development to support existing ATMI business with customers in the area.

"We have developed significant business opportunities in Asia, and our new facilities and capabilities here will deliver on these opportunities in a direct and efficient way," says Cheoroo Won, ATMI's VP/general manager for Asia. "South Korea is a logical location for investing in building capacity, as the local technical expertise and infrastructure is very strong. In addition, it allows us to more closely collaborate with our customers locally, providing access to more services and improved response times."

www.atmi.com

Shanghai Institute of Technical Physics orders Riber Compact 21 MBE system

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has received an order for a Compact 21 MBE machine from China's Shanghai Institute of Tech-

nical Physics (SITP).

SITP is a regular user of Riber MBE products specialized for the growth of thin-film layers and quantum well structures.

The new system will be used by the laboratory to increase its funda-

mental research capabilities on new III-V-based structures.

Riber reckons that the order strengthens its key in the Chinese market, which is the semiconductor industry's fastest-growing region.

www.riber.com

Riber's Q3 revenue up 33% year-on-year

Product mix shifts from Cells & Sources to MBE System sales

For the first nine months of 2012 (to the end of September), Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported revenue of €16.7m, down 10% year-on-year from €18.5m (although still more than double the €7.6m in 2010). Of total revenue, 43% came from Europe, 40% from Asia, and 17% from North America.

Most recently, following revenue for first-half 2012 of just €9.4m, this includes revenue for third-quarter 2012 of €7.3m (up 33% on €5.5m a year ago and well over double Q2's €3.2m).

By sector (for the first nine months of 2012), Services & Accessories revenue was €3.8m (almost level with €3.7m a year ago, despite the economic downturn). Revenue from Evaporation Cells & Sources was just €1.7m, down 81% from

€9.1m in 2011 (although 2011 had benefited from high sales for organic LED production). Reflecting a shift in product mix towards MBE system sales, Systems revenue nearly doubled from €5.7m to €11.2m (quadrupling from €2.8m in 2010). The number of MBE reactors billed has doubled from five to 10. "This commercial success is paving the way for gains in Riber's market shares, particularly in the research sector," says the firm.

As of end-September 2012, the order book totaled €18m (down 7% on €19.3m a year ago). By sector, Systems orders were €15.8m (up 13% on €14m in 2011). This includes 14 MBE systems to be delivered in 2012–2013. Most recently, during Q3/2012, Riber recorded two research system orders for laboratories in China and India (compared with three research systems in Q3/2011).

Orders for Cells & Sources have fallen 93% from €3.4m to just €0.2m, following the difficulties currently faced by the photovoltaic sector and during Riber's ongoing development of new ranges of organic LED (OLED) cells in anticipation of the next waves of investments. Order for Services & Accessories are level year-on-year, at €1.9m.


Riber has reiterated its full-year 2012 targets of revenue of €26–28m (down on 2011's €29m) and operating margin of 7–9%.

Kielwasser resigns as member of Supervisory board

Riber says that Jacques Kielwasser has resigned from its Supervisory Board. His position is not expected to be filled at the moment, as the number of board members is currently above the legal and statutory requirements.

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IQE's first-half profit slashed due to Q1 inventory correction

Acquisitions to boost growth in second-half 2012

After reporting interim results for first-half 2012 at the beginning of August, epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has confirmed revenue of £34.3m, down 10% on £38.3m the prior year due to an inventory correction related to market share swings at two major wireless customers during first-quarter 2012. EBITDA (earnings before interest, tax, depreciation and amortization) was £4m (down by a third, from £6.1m) and net debt has almost doubled (from £3.9m to £7.5m). However, this reflects the investment in capacity to service the growing wireless market (this major expansion program, which has spanned 2011 and 2012, will conclude in second-half 2012).

The firm has now reported detailed results, including operating profit of £0.2m (down from £3m, due mainly to the first-quarter inventory correction). Cash inflow from operations has more than halved from £5.9m to £2.8m.

"The inventory correction by two major customers concluded after the first quarter, as expected," notes chief executive Dr Drew Nelson. Sales and customer order patterns have since returned to expected levels in Q2/2012. IQE is now returning to growth, driven by demand for wireless components for a wide range of connected devices including smartphones and tablet PC technologies together with

increasing demand for the firm's range of optoelectronic products.

Also, two 'transformational' and complementary transactions position IQE for accelerating growth and cash generation, it is reckoned.

During first-half 2012, IQE issued new equity of £11.4m, including a £10.5m share placing in February to fund investing in a strategic 9% equity stake in Solar Junction Corp (SJC) of San Jose, CA, USA, which manufactures III-V multi-junction solar cells for concentrating photovoltaic (CPV) modules, as well as capital equipment to service an exclusive wafer supply contract with the firm. The investment in SJC is expected to accelerate IQE's strategy to become a leading global supplier of CPV wafers for solar power markets.

In June, IQE agreed to acquire the in-house MBE epitaxial wafer manufacturing unit of RF Micro Devices Inc of Greensboro, NC, USA. The transaction also included a seven-year supply agreement for the exclusive provision of all of RFMD's MBE wafers and for the

The second half has started well and demand has returned, as expected, with the additional benefit of our newly acquired North Carolina business from RFMD

provision of a majority of RFMD's MOCVD wafer requirements (effectively funded by future wafer discounts). IQE says that the RFMD agreement has also provided a significant step up in manufacturing capacity, bringing substantial financial and scale benefits.

"The transactions with Solar Junction and RFMD represent significant milestones in the execution of our growth strategy and will significantly enhance both our short- and long-term growth," says Nelson. "They are highly complementary, extending our critical mass and global leadership in wireless, and bringing additional capacity to service the emerging high-growth CPV market," he adds. Tool installation for Solar Junction remains on track as market demand continues to gather pace, says IQE. Also, IQE has completed full integration of the former RFMD epitaxial operation in North Carolina.

"The second half has started well and demand has returned, as expected, with the additional benefit of our newly acquired North Carolina business from RFMD," says Nelson. In addition, sales have commenced on new BiHEMT qualifications.

"Given IQE's strategic positioning and with our international capacity expansion program nearing completion, we remain confident of meeting current earnings expectations for the full year," concludes Nelson.

www.iqep.com

IQE's CEO Nelson gives keynote speech at Made in Wales Awards

On 18 October, IQE's CEO & president Dr Drew Nelson delivered a keynote speech at this year's Made in Wales Awards in Cardiff, attended by Wales' First Minister the Right Honorable Carwyn Jones AM.

Organized by Wales Business Insider, the event celebrates the best in manufacturing, design and

product development across Wales for all sizes of company.

Specifically, Made in Wales recognizes the achievements of advanced manufacturers, creative designers, manufacturing innovators, technology developers, food and drink makers, medical and life sciences companies, and manufacturers in general.

The nine awards include:

- Green Manufacturer;
- Manufacturing Innovation;
- Creative Design;
- Technology;
- Food and Drink;
- Medical and Life Sciences;
- Exporter of the Year;
- Advanced Manufacturer; and
- Manufacturer of the Year.

AkzoNobel to extend Texas TMAL unit by Q3/2013 and add TMG plant by August 2014

Metal-organic capacity expansion driven by demand from LED manufacturing

AkzoNobel of Amsterdam, The Netherlands is to boost capacity at one of its US sites in order to meet increasing demand from the semiconductor industry, particularly for the production of LEDs.

The investment (at its Battleground facility in Texas) involves extending the firm's tri-methyl-aluminium (TMAL) unit and building a new tri-methyl-gallium (TMG) plant — consolidating the plant's status as the largest of its kind in the world, claims the firm. TMAL is a feedstock for TMG, a high-purity metal-organic (HPMO) precursor used in LED wafer processing.

"The LED industry has been experiencing strong growth, well in

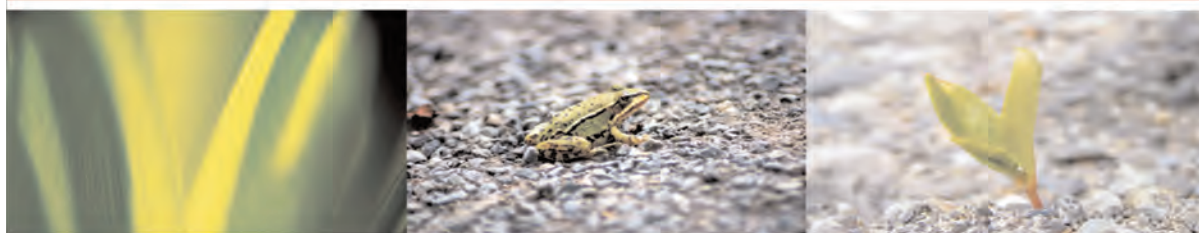
excess of 20% per annum," says Werner Fuhrmann, AkzoNobel's executive committee member responsible for Specialty Chemicals. "This investment will make production more cost-efficient and ensure that we continue supplying our customers with a highly specialized product which is playing an increasingly important role in 21st-century technology," he adds.

The investment (at its Battleground facility in Texas) involves extending the firm's TMAL unit and building a new TMG plant

AkzoNobel says that the global LED industry is projected to grow significantly over the next decade, driven by applications in displays such as PCs, laptops and tablet screens. The massive increase in the use of LEDs for general lighting is also expected to contribute strongly as — due to their low energy consumption and extended lifetime — they become the preferred source of light over incandescent bulbs and compact fluorescent lamps (CFLs).

The expanded TMAL unit is expected to be completed in third-quarter 2013. The new TMG plant should be ready in August 2014.

www.akzonobel.com



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IN BRIEF

China's HC SemiTek adds MHP version of Veeco's MaxBright GaN MOCVD system

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA says that in Q3/2012 LED maker HC SemiTek Corp of Wuhan, China (formerly Wuhan HC SemiTek Co Ltd) ordered the new high-performance (MHP) version of its TurboDisc MaxBright gallium nitride (GaN) MOCVD system, to be used for the high-volume production of mainly GaN-based blue and green LED chips for display and general lighting applications.

MaxBright MHP is designed to manufacture high-brightness LEDs, by providing as much as 20% within-wafer wavelength uniformity improvement, enhanced serviceability and a 15% increase in footprint efficiency as compared to the MaxBright, says Veeco. Higher yields are achieved from improved thermal and flow capability. The system leverages Veeco's production-proven UniForm FlowFlange technology and automation expertise by combining multiple high throughput MOCVD reactors in a modular 2- or 4-reactor cluster architecture.

"Veeco's MOCVD products offer stable process and have already helped us to successfully produce high-quality, high-brightness LEDs," says HC SemiTek's president Dr Rong Liu. "The addition of MaxBright MHPs to our manufacturing line will allow us to ramp additional production quickly, due to the seamless process transfer from our existing Veeco toolset," he adds.

www.hcsemitek.com/en
www.veeco.com

SEMI-GAS' new Samplex system automates sampling process

SEMI-GAS Systems, a division of Applied Energy Systems Inc of Malvern, PA, USA is now offering an automatic gas sampling system that eliminates operator touch time while certifying cylinders of blended gas mixtures.

SEMI-GAS says the Samplex, from its Xturion product line, saves time and money and eliminates human error while sampling any gases that can be detected using a Fourier transform infrared (FTIR) analyzer.

Samplex suits EPA protocol analysis and gas suppliers and gas companies that make EPA-approved blended mixtures. The new automated sampling system enables more efficient sampling and certification of cylinders, ensuring that certain EPA specifications and requirements, such as the EPA Traceability Protocol for Assay and Certification of Compressed Gas Calibration Standards, are being met. Samplex confirms the accuracy of constituent gases within a gas mixture, enables batch analysis, and can display up to six samples.

The sampling system features a workstation PC with LabView inter-



Samplex system.

face and a color touch-screen controller. It is capable of comparative ratio analysis in parts per million and parts per billion of multiple gases. Reports and sample certificates are generated automatically. Samplex integrates seamlessly with an MKS MultiGas FTIR analyzer.

The unit has a welded 12-gage steel mounting frame and 16-gage steel enclosure. It is 70" tall, 24" wide and 31" deep with a steel pull-out shelf for a mounted analyzer. A wireless bar-code scanner for cylinder identification is also included. Ethernet communications are also available.

www.appliedenergysystems.com

SPTS' COO Crofton appointed board chair of MEMS Industry Group

Plasma etch, deposition and thermal processing equipment maker SPTS Technologies Ltd of Newport, Wales, UK says that its executive VP & chief operating officer, Kevin T. Crofton will assume the role of Governing Council board chair for the MEMS Industry Group (MIG) for 2013.

"Kevin and SPTS have been strong supporters of MIG and MEMS Executive Congress, the annual business conference and networking event for the MEMS industry," says MIG's managing director Karen Lightman. "Kevin's experience will help to shape our strategy and direction for the coming years."

A veteran in the semiconductor capital equipment industry, Crofton brings more than two decades of manufacturing insights to the council. "Having served on the governing council in the past year, I appreciate the opportunity to play an even more active role as board chair in 2013," says Crofton. "The MIG is a tireless champion of the MEMS sector, providing a platform for the entire MEMS industry food chain to discuss challenges and opportunities and to advance the adoption of these devices throughout the world."

www.memsindustrygroup.org

Aixtron records €51.5m inventory write-down due to slower-than-expected recovery in MOCVD demand Profitability no longer expected for 2012

Aixtron SE of Herzogenrath, Germany has written down €51.5m of inventory due to a significantly slower-than-expected recovery of demand for metal-organic vapor phase deposition equipment.

The devaluation followed a comprehensive review of inventory held, which concluded that, despite the positive long-term outlook for the LED industry, the existing stock held was inappropriately high in comparison to the current subdued level of demand in the market.

These non-cash effects have led to an operating result of -€78m in third-quarter 2012 (falling back from -€16.5m in Q2) or -€113m for the first nine months of 2012.

However, Aixtron expects sequen-

tially stronger Q4 revenue, albeit considerably less than previously expected. As a result of the slower demand recovery, the firm will not report a profit for full-year 2012 (it had previously targeted profitability).

Aixtron now expects full-year revenue of €220m (versus the targeted €275m, and down 64% on 2011's €611m). Also, due mainly to the write-offs, the expected negative operating result is about €125m.

Nevertheless, for 2013 the firm's management expects an increase in demand for LED manufacturing equipment (driven by stronger projected demand in the LED lighting market) as well as a return to profitability during the year.

www.aixtron.com

Asahi Kasei orders CCS MOCVD system for next-gen opto and sensor device development

Aixtron says that in Q1/2012 Japan's Asahi Kasei Corp ordered a Close Coupled Showerhead (CCS) MOCVD system in 6x2"-wafer configuration. To be delivered in Q4/2012, the system will be used to develop next-generation arsenide-phosphide-based optoelectronic devices and antimonide-based sensor devices.

Asahi Kasei chose the system based on its flexibility for R&D purposes combined with its ability to grow on small and large wafers, says Aixtron. CCS-based processes can be easily scaled-up later for volume production.

Furthermore, the CCS concept also allows high yields with larger-area devices. Asahi Kasei has also ordered special features for its system, including an EpiTT, an ARGUS multi-channel pyrometer, and Gap Adjustment.

Through its subsidiary Asahi Kasei Microdevices Corp,

Asahi Kasei has been developing antimonide-based magnetic sensors (based on the Hall effect) for some time. Antimonide-based sensors benefit from unique material properties that result in the highest sensitivity compared with sensors made from other materials, it is reckoned.

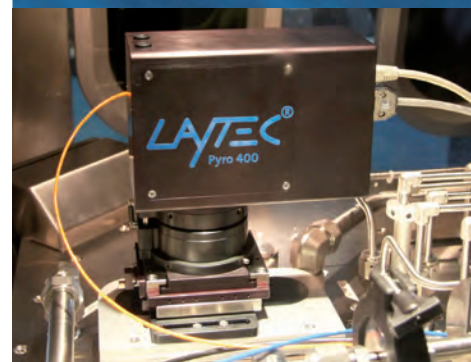
Asahi Kasei Microdevices claims to have more than 75% share of the market for Hall elements and Hall-effect ICs. The main applications of Hall elements are brushless motors used in Blu-ray/DVD drives, cooling fans for electrical equipment, current sensors for home appliances and position detection sensors used in image stabilizer systems of digital still and video cameras. Hall-effect ICs are also widely used in position and rotation detection for mobile phones, motors, industrial and automotive equipment.

www.asahi-kasei.co.jp/asahi/en

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Chalmers chooses OIPT atomic layer deposition system for nanotech research

UK-based etch and deposition system maker Oxford Instruments has been chosen by Sweden's Chalmers University of Technology to supply a FlexAL ALD (atomic layer deposition) system for installation in its cleanroom. FlexAL systems provide a range of flexibility and capability in the engineering of nanoscale structures and devices by offering remote-plasma ALD processes and thermal ALD within a single ALD system, says Oxford Instruments.

ALD allows ultra-thin films of a few nanometres to be deposited in a precisely controlled way. Its two defining characteristics — self-limiting atomic layer-by-layer growth and highly conformal coating —

offer benefits in semiconductor engineering, MEMS and other nanotechnology applications. The firm adds that its FlexAL system delivers maximum flexibility in the choice of materials and precursors, i.e. low-temperature processes enabled by plasma ALD; low damage maintained by the use of remote plasma; and controllable, repeatable processes via recipe-driven software interface.

"We have seen an increased need for very thin, high-quality films of precise thickness in our nanotechnology research," says Dr Mats Hagberg, process equipment specialist at Chalmers' Nanofabrication Laboratory.

"Introducing atomic layer deposition capability to our process laboratory will make it possible for us to take our terahertz, microwave, and quantum components research to a new level. FlexAL was the ALD system on the market that best matched our technical specification," he adds.

"The FlexAL ALD tool offers the ideal platform for research and development into many new application areas, and has the flexibility to process various materials and handle a wide range of substrates," claims Oxford Instruments' ALD product manager Chris Hodson.

www.chalmers.se

www.oxford-instruments.com

Oxford Instruments to hold scientific workshop at IISc Bangalore

In its first seminar in India, UK-based Oxford Instruments — in conjunction with host university the Indian Institute of Science (IISc) Bangalore — is holding a two-day seminar (20–21 November) covering nanoscale processing, materials characterization, surface science and cryogenic environments.

Guest speakers come from research institutions including the Lawrence Berkeley National Laboratory, California, USA and Glasgow University, UK, as well as Indian research institutes and IISc Bangalore, joined by technical experts from Oxford Instruments. Oxford Instruments' agents Aimil Ltd and Mack International are supporting the event.

Two parallel sessions will focus on Oxford Instruments' key areas of expertise: 'Thin film processing' and 'Materials characterization, surface science and cryogenic environments'. The program also includes time for all participants to network, and a networking social event on 20 November.

'Thin film processing' workshop presentation topics include:

- deep silicon etch (MEMS, ALD and silicon);
- III-V;
- deposition for compound semiconductor processing;
- plasma modelling and validation (ion densities, minimum ion energies);
- ICT etch;
- nanotechnology;
- different frequencies in plasma processing;
- plasma processing hints and tips; and
- molecular beam epitaxy (MBE).

'Materials characterization, surface science and cryogenic environments' presentation topics include:

- cryogenic environments and applications: ultra-low-temperature (<1K), superconducting magnets, software and measurement system capability;
- using Nano-manipulators for surface characterization and TEM sample preparation (including live demonstrations and hands-on training);
- characterization techniques such as EDS, thin-film analysis using

EDS including thin-film ID technique details and demonstration;

- ultra-high-vacuum scanning probe microscopy (SPM);
- electron spectroscopy for chemical analysis; and
- photoemission on heterogeneous graphene.

Tours of the Nanofabrication Cleanroom will be available during the afternoon of 20 November.

"This event will showcase our extensive capabilities to Indian scientists, while bringing together speakers and users who are at the forefront of their field," says chief executive Jonathan Flint. "India has an increasingly significant role in global scientific research and development and we have the tools and expertise to support this growth," he adds.

The seminar is free of charge, but places are limited and must be booked in advance by e-mailing: plasma-email@oxinst.com (for 'Thin film processing') and nanoscience@oxinst.com (for 'Materials characterisation, surface science and cryogenic environments').

www.iisc.ernet.in

OIPT and MIT's Microsystems Technology Laboratories announce Nanoscale Plasma Processing workshop

UK-based equipment maker Oxford Instruments Plasma Technology (OIPT), part of Oxford Instruments plc, and MIT's Microsystems Technology Laboratories (MTL) will hold a 1 day seminar addressing the latest research and technologies in plasma etch deposition and growth. The event, which will include presentations, discussions, and a networking lunch, will take place on 5 December at the MIT campus in Cambridge, MA, USA.

"We've been hosting these successful seminars worldwide for several years, most recently in The Molecular Foundry, LBNL, Caltech, USA and Shanghai, China, and we typically attract a large number of participants to each event," says Stuart Mitchell, VP sales for Oxford Instruments America Inc. "These workshops provide an ideal opportunity for academic and industrial technologists to network and share

ideas, and we are delighted to be holding this joint workshop with Microsystems Technology Laboratories."

Speakers will include professor Erwin Kessels of Technical University Eindhoven and Vince Genova of Cornell University. In addition, experts from Oxford Instruments and MTL will speak about recent process and applications developments in a number of plasma pro-

These workshops provide an ideal opportunity for academic and industrial technologists to network and share ideas

This event at MTL will allow our students and researchers to learn more about ALD and plasma processing

cessing areas.

Presentations cover a full day and currently include:

- ALD applications;
- An Overview of Plasma ALD process;
- MEMS processes;
- Nanoscale dielectric etching; and
- PECVD & TEOS.

"This event at MTL will allow our students and researchers to learn more about atomic layer deposition and plasma processing, from the experts at Oxford Instruments, while also attracting participants from the wider technical community," says Dr Vicky Diadiuk, associate director, Operations, at MTL.

The seminar is free of charge, but must be booked in advance. For booking and details, email: nancy.crouch@oxinst.com

www-mtl.mit.edu

www.oxford-instruments.com

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Tel: +44 (0)1934 837 000 Email: plasma@oxinst.com

www.oxford-instruments.com/plasma



IN BRIEF

Brewer Science launches debonder for high-temperature slide-off of thinned compound semiconductor substrates

Brewer Science Inc of Rolla, MO, USA, which provides specialty materials, integrated processes, and laboratory-scale wafer processing equipment, is introducing a new and improved thermal slide debonder that enables high-temperature slide-off of thinned compound semiconductor substrates in an R&D or low-volume production environment.

"The Cee 1300CSX debonder is designed to meet the challenges of handling thinned compound semiconductor substrates," says Wayne Farrar, director of the Equipment Business Group. "We have separated many types of exotic wafers thinned to a thickness of less than 50µm with excellent results."

The Cee 1300CSX thermal slide debonder features computerized process control and delivers accuracy, interface capabilities, and process flexibility, the firm claims. Features include:

- precision lower platen z-position control;
- programmable electronic lift pins (loading/unloading);
- compact footprint;
- flexible substrate sizes;
- constant force mode;
- data logging; and
- excess force sensing.

Along with the Cee 1300CSX thermal debonder, the firm provides a unique combination of equipment, high-temperature temporary bonding material processing capability, and process integration to deliver a seamless thin-wafer-handling solution.

www.brewerscience.com

EVG sells first ZoneBOND temporary bonding/debonding system to compound semiconductor device manufacturer

EV Group (EVG) of St Florian, Austria, a supplier of wafer bonding and lithography equipment for the MEMS (micro-electro-mechanical system), nanotechnology and semiconductor markets, has received an order for its EVG850 temporary bonding/debonding (TB/DB) systems from a "leading maker of compound semiconductor-based components". The order marks the first implementation of ZoneBOND TB/DB technology in the manufacture of compound semiconductors, whose rapid growth is being driven by the unrelenting demand for smart phones and other mobile products, says the firm.

"The compound semiconductor market has always been a front runner in driving the introduction of new temporary bonding/debonding technologies — starting from solvent-assisted debonding, tape debonding, slide-off debonding and now ZoneBOND," notes business development director Dr Thorsten Matthias. "EVG has provided TB/DB equipment to the compound semiconductor market for over 10 years. And, the introduction of ZoneBOND is a natural evolutionary step," he adds. "EVG's low-temperature debonding technology and our ZoneBOND Open Platform approach enable a standardization of processes and equipment, which provides customers with a wide choice of bonding materials for increased flexibility during thin-wafer processing."

EVG says that, since its introduction in October 2011, ZoneBOND TB/DB technology has gained a foothold in the semiconductor industry. Organizations such as the semiconductor R&D institute Fraunhofer IZM ASSID (All Silicon System Integration Dresden) have received ZoneBOND equipment for

processes and materials qualification as part of a joint development agreement with EVG. The firm says that, with a strong supply chain supported by leading materials suppliers and continuing to expand, users will continue to have increasing flexibility to choose the material adhesive that best suits their manufacturing requirements and processes.

Initially created to drive the advancement of 3D IC commercialization, EVG's ZoneBOND technology provides an approach for temporary wafer bonding, thin-wafer processing, and debonding applications — overcoming the remaining limitations associated with thin-wafer processing, it is claimed.

Benefits of ZoneBOND include: standardization of processes and equipment, the use of silicon or glass carriers; compatibility with existing field-proven adhesive platforms; and the ability to debond at room temperature with virtually no vertical force being applied to the device wafer, the firm adds.

To support grinding and backside processing at high temperatures and to allow for low-force carrier separation, ZoneBOND defines two distinctive zones on the carrier wafer surface, with strong adhesion in the perimeter (edge zone) and minimal adhesion in the center zone. As a result, only low separation force is required for carrier separation once the polymeric edge adhesive has been removed by solvent dissolution or other means.

The EZR (Edge Zone Release) and EZD (Edge Zone Debond) modules can be integrated easily in EVG's high-volume manufacturing equipment platforms such as the EVG850 TB/DB Series.

www.EVGroup.com

Meaglow's hollow cathode plasma source for Georgia State

Meaglow Ltd of Thunder Bay, Ontario, Canada — a privately held firm that produces epitaxy equipment and MBE and MOCVD accessories, as well as providing specialized thin films to research institutes and industry — says that the USA's Georgia State University (GSU) has received shipment of its patent-pending hollow cathode plasma source for the development of group III-nitride compound semiconductor materials.

The installed plasma source extends the growth processing parameter space of GSUs existing low-pressure metal-organic chemical vapor deposition reactors, upgrading the tool so that it can produce type III-nitride materials under normal low-pressure growth conditions.

Meaglow says that its plasma source fosters a unique plasma-



Meaglow's hollow cathode plasma source.

assisted gas phase and surface chemistry that provides a new path for the integration of dissimilar materials, as encountered for ternary and quaternary III-nitride alloys.

Research in Dr Nikolaus Dietz's

group at GSU will study the migration-enhanced afterglow chemistry and growth dynamics for III-nitride epilayers and nanocomposites, and support Meaglow's effort in commercializing the growth technology. Meaglow has previously applied its hollow cathode plasma source technology via its migration-enhanced afterglow technique in the deposition of high-indium-content indium gallium nitride (InGaN) and recently demonstrated a yellow LED in the so-called 'green gap'.

Meaglow says it is now focused on commercializing its hollow cathode plasma technology, and is fielding inquiries from partners interested in plasma source solutions for MBE or any surface modification to materials. Interested parties should e-mail science@meaglow.com.

www.meaglow.com

www.phy-astr.gsu.edu/dietz

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- Film Thickness Measurement System: Nanometrics 8000
- (6) Leak Detectors: (4) Balzers HLT 160 Helium; (2) Inficon UL 200 Dry
- (3) Oscilloscopes: Tektronix Models TDS 320, TDS 520 & 2465BCT
- Etching Tool: Semitool EQ11PM
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sp3 Diamond awarded patents for thermal management in semiconductor and laser applications

sp3 Diamond Technologies Inc of Santa Clara, CA, USA, a supplier of chemical vapor deposition (CVD) diamond film products, equipment and services to markets including electronics, lasers, LEDs, semiconductors and MEMS, has been awarded two patents by the US Patent and Trademark Office for its DiaMatch coefficient of thermal expansion (CTE) matched heat spreader technology. US Patent numbers 8,105,693 and 8,147,927 cover a multi-layered structure including at least one diamond layer and methods of making these multi-layered structures, respectively. The technology is suited to mounting large semiconductor chips such as high-power transistors and laser diodes where CTE matching is required.

"In 2007, we received Phase II SBIR funding from the Missile Defense Agency to develop a thermal management solution that enables the next generation of high-power lasers and semiconductors," says president & COO Dwain Aidala. "We had established solid IP in this area and began providing solutions with great potential that

target current and future high-power semiconductor and laser applications," he adds. "We are currently in the process of identifying the right thermal management or specialized material partners to further develop this technology into a fully productized offering."

Semiconductor devices require packaging with high thermal conductivity to prevent overheating and to maintain useful operation of the device, says the firm. Existing materials generally deliver good thermal characteristics but poor CTE matching, or are well-matched to most semiconductor materials but do not offer high enough thermal conductivity for today's devices. sp3's DiaMatch technology bridges this gap by offering variable CTE-matching, copper-level thermal conductivity, a choice of conductive or insulating die attach surfaces, precise edges, and no compositional variability from point to point in the material.

The new patents detail a multi-layered structure of thin diamond layers and high thermal conductivity metal layers and the methods of making the structure. The multi-

layered structure has a variable CTE, which depends on the various layer thicknesses and can be different on each side. This allows the structure to safely bond to common semiconductor materials such as silicon, silicon carbide, gallium arsenide, and gallium nitride, while providing the thermal management benefits of diamond.

"We experienced our best year ever in 2011 due in large part to two markets," says Aidala. "We saw our diamond heat spreaders adopted in multiple applications, most notably in wireless base stations where the thermal properties of diamond are paying huge dividends. In CMP pad conditioning we sold five times more CVD diamond deposition tools than the previous year. Diamond is being adopted," he adds. "While our CVD diamond equipment and our heat spreaders remain our primary focus, we see tremendous opportunity for diamond applications in the future. The potential for diamond layers in the SOI [semiconductor-on-insulator]-based process alone creates fantastic growth opportunities."

www.sp3diamondtech.com

NRL uses Kyma's GaN materials to demonstrate mid-infrared non-linear optics

Kyma Technologies Inc of Raleigh, NC, USA, which provides crystalline gallium nitride (GaN) and aluminum nitride (AlN) materials and related products and services, says that it has helped scientists at the US Naval Research Laboratory (NRL) in Washington DC to demonstrate a novel approach to making mid-infrared (mid-IR) non-linear optics (key for a number of commercial and defense applications).

Kyma says that, currently, the most prevalent approaches to non-linear mid-IR optical materials

are based on periodically poled lithium niobate and related materials, which suffer from a dramatic drop-off in performance in the wavelength region beyond 4μm. NRL's approach is dramatically different — alternating the actual crystal orientation of the semiconducting nonlinear material — to create promising structures from GaN grown by hydride vapor phase epitaxy (HVPE).

Kyma says that its HVPE GaN has very low impurity levels and low defect densities which supports a large transparency window all the

way to 7μm, a high thermal conductivity (>250W/m-K), and a high second-order nonlinear susceptibility (all important for non-linear optics applications).

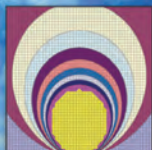
● For more information on NRL advances in this area see: 'Development of periodically oriented gallium nitride for non-linear optics' by Jennifer Hite et al, Optical Materials Express, Vol. 2, issue 9, p1203 (2012)

[http://dx.doi.org/10.1364/](http://dx.doi.org/10.1364/OME.2.001203)

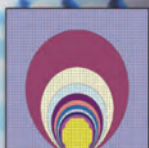
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www.nrl.navy.mil

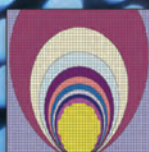
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HexaTech and Tokuyama report UV-C LEDs emitting 25mW at 265nm with IQE over 70%

HexaTech Inc of Morrisville, NC, USA has reported the results of an ongoing collaboration with development partner Tokuyama Corp of Tokyo, Japan that has demonstrated UV-C LEDs with exceptional output power and improvements in internal quantum efficiency (IQE). HexaTech reckons that the results raise the bar to what is possible with the technology, and enable commercially available high-performance, high-reliability UV-C LEDs.

HexaTech was spun off from the Department of Materials Science of North Carolina State University in 2001 to produce single-crystal aluminium nitride (AlN) substrates for both electronic and optoelectronic devices. AlN substrate material can enable long-life UV-C LEDs for disinfection applications, as well as deep UV lasers for biological threat detection and high-voltage power semiconductors for smart grid and efficient power conversion. The firm's existing product lines include single-crystal and polycrystalline AlN substrates (although long-life UV-C LEDs and high-voltage power

devices based on AlN substrates are also in development).

HexaTech says that, since their inception, UV-C LEDs have held the promise of a compact, highly efficient, long-life light source for sterilization and purification applications. The rapidly accelerating interest in LEDs for disinfection applications operating at UV-C wavelengths requires a solution with high output power, high efficiency and long lifetimes, says the firm. However, most commercially available UV-C LED products currently struggle with limited output power, efficiency and device lifetimes. A key requirement for improving these limitations is to reduce the device defect density, for which IQE is a key measure and is critically related to the underlying bulk material quality.

"As HexaTech's own device development has shown, using our high-quality, low-dislocation material, we are able to produce UV-C LEDs with record-setting reliability and lifetimes, exceeding more than 600 hours of accelerated testing, with

virtually no degradation," says HexaTech's director of device development Dr Baxter Moody.

Now, by coupling HexaTech's low-dislocation-density bulk AlN substrates with Tokuyama's hydride vapor phase epitaxy (HVPE) and device fabrication, Tokuyama was able to produce UV-C LEDs with over 25mW of output power at 265nm, and internal quantum efficiencies greater than 70%.

"This collaboration demonstrates that, when combining HexaTech's market-leading bulk substrate quality, with Tokuyama's high-quality HVPE and excellent device fabrication, breakthrough, record-setting results are possible," says HexaTech's CEO Joe Grzyb.

"Working together with HexaTech and their substrates, Tokuyama has made great improvements in the performance of our UV-C LEDs, accelerating the process for their commercial availability," comments Tokuyama's chief research engineer Toru Kinoshita.

www.tokuyama.co.jp/eng
www.hexatechinc.com

Plessey's MAGIC HB-LED products shortlisted for Elektra Awards in Solid-State Lighting Application category

UK-based Plessey Semiconductors Ltd has been shortlisted for its new MAGIC (MANufactured on GaN ICs) high-brightness LED (HB-LED) products in the Elektra Awards 2012 Solid-State Lighting Application category. The winners will be revealed on 12 December at the European Electronics Industry Awards ceremony in London.

"MAGIC technology will enable us to drive the adoption of low-power LED lighting forwards at a much greater pace as it enables HBLEDs to be manufactured in high volume using industry standard, silicon foundries at a much lower cost than current LED technologies based on

sapphire or silicon carbide," believes chief operating officer Barry Dennington.

Plessey's MAGIC HB-LED products uses gallium nitride on standard 6" silicon substrates, and will be manufactured at the firm's high-volume semiconductor production Plymouth facility. The firm's technology uses a much thinner GaN layer at only 2.5µm compared to 6–8µm in other GaN on Si technologies. This involves less deposition time so the firm can perform multiple production cycles in 24 hours to achieve higher throughputs and lower costs.

For the next-generation products, Plessey intends to integrate its MAGIC HBLED products with its EPIC sensor technology to provide smart lighting solutions.

Plessey Semiconductors also made the shortlist in the Electronics Product Category of the British Engineering Excellence Awards 2012, for its PSL350 MAGIC High Brightness LED (HB-LED) product. The winners were announced in a ceremony in London on 25 October.

www.elektraawards.co.uk/elektraawards2012/shortlist-2012
www.plesseysemiconductors.com/products/magic

Epistar migrates to GaN-on-Si based on Azzurro's 150mm technology

LED structures transferred from sapphire substrates in just 16 weeks

Gallium nitride on silicon (GaN-on-Si)-based LEDs have been fabricated using high-brightness LED structures of Epistar Corp of Taipei, Taiwan and the patented technology for 150mm GaN-on-Si substrates of Azzurro Semiconductors AG of Dresden, Germany, which makes GaN epitaxial wafers based on large-area silicon substrates.

Completion of the joint project confirmed the performance that can be reached, says Azzurro. In particular, the two firms are satisfied with the extremely short development time of just 16 weeks for transferring Epistar's existing LED structures (fabricated on sapphire substrates) to the GaN-on-Si mat-

erial system. The latest milestone takes GaN-on-Si a step further towards implementation in mass production, reckons Azzurro.

While GaN-on-Si is often associated with technological challenges that are difficult to overcome, the use of templates with Azzurro's unique strain-engineering technology enables epitaxy engineers to quickly transfer their LED structures to GaN-on-Si, says the firm. Furthermore, the patented and proprietary buffer stress management enables homogeneity improvements (<4nm wavelength homogeneity) for LED epiwafers, helping to reduce binning and to increase yield, it is claimed.

The joint project has exceeded expectations regarding speed and cost of migration, says Epistar's chairman Lee Biing-Jye. "The success helps us to utilize GaN-on-Si, which is a game changer for the industry," he adds.

"It proves our business model to offer dedicated development packages and sophisticated engineering support," states Azzurro's CEO Erwin Wolf, referring to the speed of the development. "The technology to enable the LED industry to tap into the advantages of the volume, cost-effectiveness and maturity of silicon foundries is ready with our strain-engineered templates."

www.azzurro-semiconductors.com

Soraa establishes distribution agreement with Japan's Ushio

Soraa Inc of Fremont, CA, USA, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates, says that from November its full-spectrum GaN-on-GaN LED MR16 lamps will be available via Ushio group and its subsidiaries in Japan, China, South Korea, Hong Kong, Taiwan, Singapore, and Europe. Ushio (the largest distributor of MR16 lamps in Japan) will sell Soraa's LED MR16 lamps under the brand name Superline LED, a co-branded Ushio and Soraa product.

"This agreement is an indication of what's to come for Soraa as we solidify our worldwide presence," says Soraa's CEO Eric Kim. "The partnership with Ushio allows us to introduce the company's products in several new markets, including Japan, where high quality of light is a leading consideration in purchasing replacement LED MR16 lamps."

An alternative to halogen MR16 lamps, Soraa's Vivid line of LED

MR16 lamps feature full-spectrum light; a CRI of 95 and R9 of 95 (higher than most halogen lamps); produce no UV or IR; last up to 10 times as long; use 80% less energy; run cooler; and produce a much more consistent and efficient beam. GaN-on-GaN LEDs feature high luminous efficiency and light-extraction efficiency and also claim superior heat radiation performance. This enables both large currents and high levels of illumination to be achieved for a given area, in turn enabling miniaturization of the module (difficult to attain with conventional LED chips that use sapphire or silicon substrates). Soraa's MR16 lamps are also compatible with existing halogen lamp fixtures and lighting infrastructure.

"The lighting market in Japan and many other countries has been in need of a high-quality LED replacement option for halogen lamps," says Ushio senior VP Akihiko Sugitani.

www.ushio.co.jp/en

IN BRIEF

Inventor of the Year award to Nakamura

Soraa's co-founder Dr Shuji Nakamura has received the Inventor of the Year Award from The Silicon Valley Intellectual Property Law Association (SVIPLA) for his "technological innovations, including the development of Soraa's GaN-on-GaN technology".

Nakamura, who invented high-brightness blue and white LEDs, has filed over 700 patent applications, and can claim at least 360 authorized invention patents. His development of nitride-based semiconductors is cited as "one of the most important achievements in the materials science of semiconductors in the last 30 years".

"My focus is to create efficient lighting products that do not compromise on performance, offer the highest quality available and greatly reduce energy waste," says Nakamura.

www.soraa.com

SDK to transfer GaN LED unit to TS Opto in December TS Opto to become 30:70 joint venture between SDK and Toyoda Gosei

At its latest board meeting, Tokyo-based chemical manufacturer Showa Denko K.K. (SDK) has decided to split off and transfer its gallium nitride (GaN) LED epitaxial wafer and chip production business to its subsidiary TS Opto Co Ltd (which was founded at the end of September at SDK's plant in Ichihara City, Chiba Prefecture).

In April, to strengthen the business, SDK reached a basic agreement

with fellow Japanese GaN LED maker Toyoda Gosei Co Ltd to establish a joint venture. Now, as well as transferring its GaN LED business to TS Opto (effective 1 December), SDK has decided to transfer 70% of the common shares in TS Opto to Toyoda Gosei on the same date, making TS Opto a joint venture between SDK and Toyoda Gosei.

At the time of the transfer, TS Opto will deliver 19,400 common shares

to SDK, in exchange for inheriting the rights and obligations pertaining to SDK's GaN LED business.

SDK's GaN LED business had net sales of ¥5322m in 2011. While existing sales activities will not be transferred to TS Opto, SDK itself will stop selling GaN LEDs as of the 1 December date for the business' transfer to TS Opto.

www.sdk.co.jp

www.toyoda-gosei.com

Bridgelux LED arrays light retail stores in India

LED chip and lighting array maker Bridgelux Inc of Livermore, CA, USA says that nearly 2000 LED-based luminaires, developed for Future Group using Bridgelux ES and RS LED arrays, have been installed in two new retail stores opening in India. The stores' use of LED-based technology (instead of metal halide lighting) should save 318,000kWh per year, or about 2.5 million Rupees (US\$38,000) in power costs, reckons Cree.

"The product design and lighting concept developed using Bridgelux's LED technology was a perfect match for our retail environment," says Future Group director Sunil Biyani. "Our retail lighting requirements

are very demanding. But we were sold by a combination of mock-up demonstrations and an understanding of the benefits that could be achieved with this innovative technology. We were convinced that we could enhance the quality of lighting to improve the customer experience while simultaneously reducing our operational costs," he adds.

"We selected Bridgelux LED arrays to use in our new luminaires because the Bridgelux technology gave us superior performance, in terms of lumen output, consistency, and light quality when compared to other LED light sources," comments R. Hari, chief innovation officer of

Mumbai-based Asian Retail Lighting Ltd, which manufactures luminaires and lighting systems for the retail industry. "We decided that LED arrays or chip-on-board (COB) light sources were the right technology to provide the best quality of light to attract more customers into the stores," he adds. "Arrays also gave us the design flexibility to create a broad range of new luminaires optimized to display the merchandise with the greatest appeal to the customer."

The new stores use a combination of downlights, wall washers and track lights, all designed by Asian Retail Lighting and using Bridgelux LED arrays.

www.bridgelux.com

Bridgelux on Global Cleantech 100 list for fourth consecutive year

Bridgelux has been named in the 2012 Global Cleantech 100 (produced by research and advisory firm Cleantech Group) for the fourth consecutive year. The annual Global Cleantech 100 list highlights companies from around the world in areas such as water and waste, renewable energy and energy efficiency that are considered most likely to make the most significant market impact over the next 5–10 years.

"This recognition reflects the significance of the growing market

adoption of energy-efficient solid-state lighting solutions," says Bridgelux's CEO Bill Watkins. "As we continue to make dramatic progress on our game-changing GaN-on-silicon technology, we see the cost of LED lighting becoming abundantly affordable and rapidly transforming the \$40bn global lighting industry into a \$100bn market opportunity," he adds.

The list is derived from Cleantech Group's own research combined with the weighted qualitative judgments of hundreds of nominations

and the viewpoints of a global panel of 75 cleantech experts. To qualify for the list, companies must be independent, for-profit, cleantech companies that are not listed on any major stock exchange. This year 8285 firms were nominated from 85 countries. These companies were weighted and scored to create a short list of 236 firms presented to the panel for final input, resulting in 100 companies from 13 countries.

www.cleantech.com

[/global-cleantech-100](http://global-cleantech-100)

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Cree's quarterly sales up 17% year-on-year to record \$316m

Profits rise again as spending is controlled while lighting drives growth

For fiscal first-quarter 2013 (ended 23 September 2012), Cree Inc of Durham, NC, USA has reported record revenue of \$315.8m, up 3% on \$306.8m last quarter and 17% on \$269m a year ago (and in the middle of the \$305-325m targeted range, with LED, Lighting and Power & RF revenues all in line with the firm's forecast).

Although Power & RF product revenue fell 4% from last quarter's \$21m to \$20.1m, LED product revenue rose 1.4% from \$185m to \$187.6m. Lighting product revenue was \$108.1m, up 7% on \$101m last quarter due to continued good growth from both agent and direct sales channels. In fiscal Q3/2012, Cree transitioned to new agents during the integration with Ruud Lighting Inc of Racine, WI, USA (acquired in August 2011), causing greater-than-expected disruption to the project pipeline. However, last quarter saw a recovery in revenue via momentum with sales agents.

On a non-GAAP basis, gross margin has risen from 36.3% last quarter to 37.5% (up slightly on 37.4% a year ago, and above the targeted 37%). Again, it was driven by a combination of factory cost reductions, slightly higher factory utilization, product mix and lower-cost new products. By sector, gross margins were 40.2% for LED products, 31.6% for Lighting products, and 51.8% for Power & RF products.

Operating expenses have fallen from \$81.4m last quarter to \$80.9m (\$1m less than targeted due to lower R&D spending). Hence, although still down from 12.2% a year ago, operating margin has continued to recover, from 9.8% last quarter to 11.9%.

"We continue to closely manage inventory across our factories, while working to respond to short lead-time expectations in both LED and lighting markets," says chairman & CEO Chuck Swoboda. Overall, inventory was reduced by \$9.2m to \$179.7m (representing 81 days, down from

85 days), due mainly to a reduction in work-in-process inventories.

Net income has continued to rise, to \$31.8m, up on \$29.2m last quarter and up 13% on \$28.1m a year ago.

"We started the year strong in our fiscal first quarter with record revenue and non-GAAP earnings per share at the high end of our target range due to improvement in gross margins and lower-than-targeted operating expenses," summarizes Swoboda. "Our results are beginning to demonstrate the enormous leverage we have in our fully integrated vertical lighting model as we continue to increase performance and reduce costs in LED components," he adds. "We are seeing the positive impact these gains have on our LED and Lighting businesses."

Cash flow from operations grew again, from \$72m last quarter to \$86m. Capital expenditure has been cut again, from \$25m to \$18m (\$13m in property, plant and equipment additions, plus \$5m related to patents). "The last several quarters have demonstrated our ability to convert R&D investments into innovations that result in strong free cash flow [of \$68m, up from \$47m last quarter]," says Swoboda. "This is a different model than most other companies in the LED or lighting industry today, and our balance sheet gives us the ability to continue to invest in growing our business and the market for LED lighting."

During the quarter, due to good working capital management, focused capital spending and higher profitability, cash and investments rose by \$71.8m, from \$745m to \$816.3m.

"Overall, company backlog is ahead of this point last quarter, with

lighting and LEDs trending higher and Power & RF at similar levels," says Swoboda. "We are focused on using new product innovation to drive growth through share gains against traditional technologies and opening new applications for LED lighting," he adds. During the quarter, Cree launched the XLamp XP-E2 LED (delivering higher lumens per watt and more lumens per dollar to lower system costs); announced THE EDGE High Output LED luminaires delivering performance and saving improvements for area and flood light applications; and introduced a new 10-year warranty covering the industry's broadest range of products. "We continue to be encouraged by our progress in LED lighting, but the macroeconomic environment is a headwind on our growth outlook and our customers' outlook," Swoboda cautions.

For its fiscal second-quarter 2013 (to end-December 2012), Cree expects revenue to grow to \$320-340m, comprising solid growth in lighting, LED product sales flat to slightly higher, and Power & RF sales flat to slightly higher. Non-GAAP gross margin should rise to 38.5% (building on momentum from the last several quarters by delivering higher revenues from a similar fixed cost base and a higher mix of lower-cost new products). However, operating expenses should rise by \$5m, due partly to increased sales & marketing to support the higher revenue as well as new product promotion. Nevertheless, net income should be \$31-36m.

"For fiscal 2013, we are continuing to actively manage our capital spending," says interim chief financial officer Michael E. McDevitt. "In the near term, we target similar levels of investment as Q1 to support our strategic priorities to lead the market, drive adoption of LED lighting, accelerate cost reductions and support incremental capacity as needed."

www.cree.com

We continue to closely manage inventory across our factories, while working to respond to short lead-time expectations

Cree color LEDs double lumens-per-dollar performance

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has announced the commercial availability of XLamp XB-D color LEDs and XLamp XM-L multi-color LEDs, providing lighting manufacturers with discrete and multi-color LED options to more cost-effectively address a wider spectrum of applications such as architectural, vehicle and display lighting.

XLamp XB-D color LEDs extend the double lumens-per-dollar performance of the XB package to color LEDs, delivering up to 40% higher maximum light output than XP-E color LEDs. Cree says that the combination of performance and the small size of XB-D color LEDs enables better color mixing and lower system cost through fewer LEDs. Now available in color as well as existing white color temperatures ranging from 2700K to 6200K, users can support a full range of color in the single XB footprint.



Cree's XBD and XML color LEDs.

XLamp XM-L color LEDs are claimed to be the brightest and smallest multi-colored LED of their power class, delivering red, green, royal blue and white in one LED at twice the lumens-per-dollar of the MC-E color LED. The XM-L color LED is 60% smaller than the MC-E LED, reducing the distance between LED die, to create a small optical source for what is claimed to be

excellent optical control, efficient color mixing and simplified design. "The smaller and brighter XM-L color LED allows us to improve system performance and lower system cost," comments Michael Johnson, VP of engineering at LED lighting fixture designer and manufacturer The Black Tank Inc of Amesbury, MA, USA.

XLamp XB-D color LEDs deliver output of up to 1416mW for royal blue, 92 lumens for blue, 198 lumens for green, 210 lumens for red and 261 lumens for red-orange, all at a drive current of 1A in the 2.45mm x 2.45mm footprint.

XLamp XM-L color LEDs deliver up to 89 lumens for royal blue, 214 lumens for green, 229 lumens for red and 272 lumens for white at 1A in the 5mm x 5mm footprint.

Cree XLamp XB-D and XM-L color LED samples are available now, and production quantities are available with standard lead times.

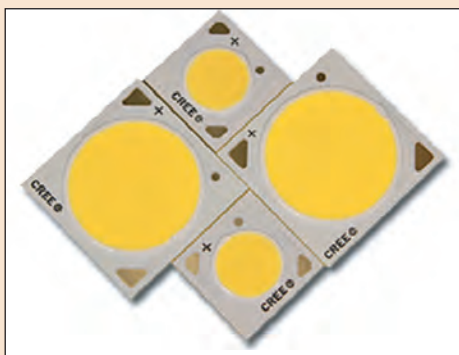
www.cree.com/xlamp
<http://theblacktank.com>

Cree introduces new lighting-class LED arrays

Cree has introduced its new CXA LED arrays, with LEDs that deliver system-level performance ranging from 500 to 5000 lumens output and up to 146 LED lumens per watt efficacy, enabling applications ranging from LED replacement lamps to commercial downlights.

CXA LED arrays are available in EasyWhite color temperatures, which provide color consistency for designs that use only one LED. The arrays are designed to be used as a single component in an LED design — emulating the single-filament appearance of traditional lighting products — offering simplified design, manufacturing and inventory management, and enabling lighting manufacturers to shorten time to market and reduce manufacturing costs, adds the firm.

"We switched to Cree's new CXA1507 LED array because it



Cree's family of CXA LED arrays.

delivers higher performance over other LED arrays," says Jason Lee, president of Gama Illuminer. "The easy-to-use package of the CXA1507 LED array with well-designed features and small optical source made design and manufacturing simple."

The new CXA family offers four CXA LED arrays (CXA1507, CXA1512, CXA2520 and CXA2530) delivering different lumen levels in

two packages and optical sizes (minimum 80 and 90 CRI available).

"The CXA1512 LED array can deliver over 1900 lumens at 120 lumens per watt in a very small 9mm optical source size," says Mike Watson, Cree's senior director marketing, LEDs. "Other LED arrays may come close to this level of performance, but not in this small of a form factor," he adds.

"The CXA1512's small size is critical for enabling low system cost in a wide range of lighting applications, from narrow-beam spotlights to wide-area lights."

Samples of XLamp CXA LED arrays are available now, and production quantities are available with standard lead times. The arrays were displayed at the Hong Kong International Lighting Fair (27–30 October).

www.cree.com/cxa

Optogan's X10 LED modules enter mass production

European LED chip and luminaire maker Optogan Group has started mass production of its X10 modules in St. Petersburg, Russia. "The opening of the X10 production line, with a production capacity of 40,000 units per month, will make LED technology accessible to a wider range of customers in the near future," said executive VP Vladislav Bougrov at the opening ceremony.

Based on the concepts of scalability, flexibility and lean processing, the X10 modular chip-on-board (COB) solution significantly reduces the manufacturing costs of energy-efficient light sources based on LEDs, the firm claims.

A unique feature of the X10 is the combination of small size, module efficiency over 110lm/W, optimal price and convenient size for mounting, adds the firm. Optogan has already produced modules consisting of 72 items that can be easily divided into LED elements of smaller sizes and power. The X10 concept offers the maximum possible variety, starting with a single unit of 10W. The biggest X10 module can provide maximum luminous flux of nearly 80,000lm, while the power consumption is only 720W. Due to the various sizes and forms of the elements, X10 can be used



Executive VP Vladislav Bugrov (on the right) and production manager Oleg Arshinov (left) at the opening ceremony.



Optogan's X10 LED module consisting of 72 items.

for applications such as halogen lamp analogs, light fittings, single designer lamps, fixtures with reflectors, as well as high-power industrial or street lights, the firm says. The ceramic base and product material selection is based on long-life performance by design, it adds.

Optogan's X10 patented design was co-developed with the Russian Innovation Center 'Skolkovo'. The X10 pilot sample was introduced in 2011 and has been exhibited at events such as Light & Building in Frankfurt-am-Main and Strategies in Light Europe in Munich, Germany. "Thanks to the material and technical base of the Innovation Centre Skolkovo, our breakthrough technology does not stagnate in the laboratory, and only after a year goes to the mass market," notes Bougrov.

Optogan's X10 module is a new generation of integrated solutions like LED chip-on-board, which the firm claims are the main focus of technology development in the LED industry. Optogan aims to "make the transition from a single breakthrough LED, which is already implemented in the technology chip-on-board, to the integrated lighting system, including the assembly of LEDs on a single substrate, the circuit elements and the power control (driver), as well as the primary optics," says Bugrov. "Full integration, in particular, will significantly reduce the cost of the production process, significantly decreasing the price of LED light sources in the future," he adds.

Optogan's DSF lighting illuminates renovated sports field in Malta

Optogan has supplied DSF (Dynamic Sport Field) Lighting to the renovated Luxol Sport field in Pembroke, Malta, which was officially opened on 14 September.

DSF offers intensity of 280 lux compared with the 96 lux of the old, traditional lighting. Also, the light can be controlled and dynamically changed from orientation (10%), to training (50–70%) to game play (100%), and can illuminate just one half of the pitch. Due to the various lighting options available, DSF lighting can reduce energy usage from 35.2KWh to 27.2KWh in the case of LUXOL. This can be cut

further if the system is used dynamically.

"Dynamically using the LED DSF Lighting will reduce electricity cost enormously," says Pieter Bregman, project manager of The LightShop in B'Kara, Malta. "As the electricity prices are on the rise in Malta, savings made with this lighting system per year at Luxol Sports Club will pay back the new LED DSF lighting system in approximately five years time."

The DSF system has no 'light spill', so light is only directed to where it is needed. Also, unlike traditional metal halide lighting, LED lights

can be switched on and off and on again without having to wait for them to cool down first.

"DSF doesn't have to be only used for football fields, but is also excellent for many other purposes, like tennis, hockey, smaller play fields, as well as hotel chains having playing fields to control the spill of light and moreover, reducing the electricity bill," says Optogan's director of sales & business development Ove Sørensen. "The DSF lighting is a very multi-functional product for lighting up areas, big or small".

www.optogan.com

Cree introduces 10-year LED lighting warranty

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has introduced a 10-year limited warranty on nearly all new Cree commercial LED lighting fixtures.

Cree claims that, through more than 20 years of experience in commercial LED development, it brings an unprecedented level of expertise to all components of the LED lighting design and development process, enabling this level of warranty.

"With leading LED research and development, a strong financial balance sheet and some of the industry's longest-running field LED lighting installations, the new 10-year limited warranty underscores Cree's commitment to the long-term performance and reliability of our products," says Ty Mitchell, executive VP, lighting, Cree.

Cree's new 10-year warranty covers nearly all Cree globally available commercial-grade indoor and outdoor fixtures, which can be installed in restaurants, offices, hospitals, grocery stores, shopping malls, schools and universities, auto dealerships, roadways, parking facilities, gas stations and many other commercial spaces around the world.

www.cree.com/lighting/products/warranty

Town upgrades high-pressure sodium lamps to LED luminaires

The Town of Oyster Bay, New York is installing LEDway street lights made by Cree as part of a town-wide upgrade of its high-pressure sodium (HPS) lights to LED lighting. To date, 2500 Cree LEDway street lights have been installed out of the 4000 planned. The town received a \$2m Energy Efficiency Conservation Block Grant (EECBG) from the US Department of Energy to fund the installation along 750 miles of roadway in Oyster Bay.

"LED lights have made huge strides regarding energy savings and life span," says Oyster Bay town supervisor John Venditto. "These new LED lights will save 50% of the amount of energy consumed by the previous high-pressure sodium bulbs. By replacing 10% of the existing HPS street lights within the town, the town stands to save \$200,000 annually on our electric bill and maintenance costs."

Maintenance costs should be reduced dramatically as the LEDway luminaires are designed to provide a 100,000 hour lifetime compared to the 5–7 year life span of the HPS street lights previously installed.

"Cree's LEDway street lights are helping to drive the adoption of LED lighting for municipalities like Oyster Bay that need to address rising energy and maintenance costs," says Christopher Ruud, VP global sales, Cree lighting.

www.CreeLEDLighting.com



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Osram launches Oslon LX for subcompact auto market

Osram Opto Semiconductors GmbH of Regensburg, Germany says that, with the Oslon LX, it is offering a new LED for widespread application in the automotive sector.

The focus is on the essential functions of brightness and quality, making the new white LEDs affordable even for installation in subcompact vehicles, the firm reckons. Oslon LX LEDs can be used mainly for daytime running lights (DRLs) and fog lights, providing visual and technical enhancements to automobiles from high-end down to the entry level segment.

Osram Opto notes that experience has shown it always takes time before the price of high-tech applications fall to such an extent that they are practical for the mass market. The firm reckons it has now reached this threshold in LED automotive lighting. The new Oslon LX LED is based on the marriage between tried and tested package and converter technologies and



Osram's Oslon LX LED.

new chip technology (UX:3) that offers high light output.

The firm says it has focused the Oslon LX LED on the essential objective of producing a large amount of light at an affordable price, suiting applications in which high light output and high energy efficiency are crucial factors — such as fog lights and daytime running lights. Low-beam and high-beam applications are also possible, but with a combination of several Oslon LX LEDs.

At a junction temperature of 25°C (in the chip), the LED produces 125

lumens from a drive current of 350mA. At a higher operating temperature of about 100°C, it achieves a luminous flux of 100lm. The maximum drive current is 1000mA. The typical correlated color temperature (CCT) is 6500K.

The LED's lens has a beam angle of 120°. It hence meets the established standard for reflector solutions in automobiles, and the systems used in the compact and subcompact segments can be retained. Also, the package is very compact, measuring only 3mm x 3mm, with a solder pad design that is identical to the other Oslon automotive components.

"The combination of high quality and low price means that LED designs can be introduced in many more vehicle classes," says marketing manager Michael Martens.

The Oslon LX is being unveiled at electronica 2012 in Munich, Germany (13–16 November).

www.osram-os.com

Osram unveils smallest LED format for automotive lighting

Osram Opto has unveiled the prototype of its Oslon Compact, which it claims to be the most compact high-power LED for the automotive market. Due to the flexible arrangement of the small LEDs, it will be easier and more cost-effective to create unique, signature headlight designs, claims the firm. A prototype was unveiled at the SIA-Vision conference in Versailles, France (9–10 October).

Despite their high efficiency, luminous intensity and durability, LEDs have faced a major challenge as light sources in headlights, in that different LEDs must be used for different areas to achieve a uniform arrangement of the light-emitting surfaces, notes Osram. Sophisticated designs hence involved much effort and high cost.

The small size of the Compact — combined with its high light output — enables a single LED type to be

used as the default light source for all automotive forward-lighting applications, the firm claims. Light points in the headlight can be placed in any arrangement, and customized designs can be developed to give different vehicles a unique appearance. The LEDs can also be grouped very close to each other, so they can even be used for light-guide solutions and adaptive frontlighting systems (AFS).

The compact design has been achieved by reduction to the bare essentials, says Osram. The entire LED package is not much larger than the chip's actual light-emitting surface. The platform is Osram Opto's UX:3 chip technology, which provides high luminous efficacy even at high currents. The prototype measures only 1.5mm x 1.9mm and produces 200lm from 700mA. The clear white light from the chips is achieved through

Osram's C2 technology, which converts blue light with the aid of ceramic conversion.

"The development of the Oslon Compact is a direct response to changing market requirements in the automotive sector. There is a need now for high-power LEDs that are more compact and more cost-effective," says Peter Knittl, director Marketing Automotive. "We have been able to adapt the reliable chip and package technologies that have proved so successful in the Oslon Black Flat and Ostar Headlamp Pro LEDs to fit this smaller design," he adds. "The introduction of this space-saving solution makes a huge contribution to the spread of LED technology in the forward lighting sector and makes efficient and durable lighting solutions available as standard for more vehicle models."

www.osram-os.com

Osram's Duris E 5 LEDs chosen by FuturoLighting

LED lighting solutions specialist FuturoLighting of Piestany, Slovakia (a certified partner in Osram's 'LED Light for you' network) has launched its Catherina2 ceiling fixture, a new solution for widespread use in interior lighting (architectural, retail or residential lighting).

Incorporating Duris E 5 LEDs from Osram Opto Semiconductors GmbH of Regensburg, Germany (a mid-power LED specially developed for applications requiring high-output, homogenous planar light), Catherina2 has dimensions of 300mm x 300mm x 55mm, power consumption of about 25VA and gives out around 1600lm in near-Lambertian light distribution. The luminaire is optionally available with a motion sensor and emergency module and has a long operational lifetime.

A smart sensor module detects movement and distinguishes between day and night. This functionality was developed for hotel corridors and rooms where light activation is only required when customers are present in order to decrease facility power consumption. Based on customer requirements, Catherina2 can be equipped with a new emergency module (currently under development) based on Li-ion battery technology. FuturoLighting says that, due to Osram's LED technology, Catherina2 offers high efficiency with minimal power requirements, a life expectancy of over 50,000 hours and requires no maintenance other than normal dusting/cleaning during the whole product life.

The Duris E 5 LED is suitable for a particularly homogenous distribution of light in panel lights, says Osram. With a color temperature of 4000K and a color-rendering index (CRI) of 85, the LEDs generate a light color that is similar to daylight (particularly important for Catherina2's areas of application — offices and retail lighting). Duris E 5 LEDs are claimed to be among the most efficient LEDs on the market in their performance class (mid-power),

achieving 110lm/W (at 4000K and 120mA). Since their launch in October 2011, output has risen by 25%. They now also achieve lumen maintenance figures in accordance with the IESNA LM-80-08 standard. These results are said to be a key factor in the Energy Star certification of LED lamps and luminaires in the USA and also are increasingly being

demanded worldwide as a standardized test method for lumen maintenance.

"The excellent price/performance ratio of this LED is prompting more and more manufacturers to convert their product designs to LED technology," claims Osram Opto product manager Andreas Vogler.

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Osram Opto launches direct-emitting green laser diodes

Output of 50mW at 515–530nm targets projector applications

Osram Opto Semiconductors GmbH of Regensburg, Germany says that it is now offering its first direct-emitting green diode lasers. The two compact indium gallium nitride (InGaN) laser diodes have optical output powers of 30mW and 50mW, respectively (at 25°C), as well as high beam quality, which is key to the development of miniature projectors for mobile devices such as smartphones and cameras, adds the firm. Other applications include projection units for laser shows, point lasers and line lasers.

Direct green diode lasers are a key step toward powerful pico projectors, eliminating the laborious method of producing green light by doubling the frequency of an infrared laser. The new technology also enables high color rendering and contrast to be achieved, says Osram Opto.

The new PL 520 laser diode's wavelength range of 515–530nm produces the appropriate green colour for projection applications, the firm notes. Optical output is 50mW and efficiency is typically 5–6% at present. In addition, the PL 515 laser diode offers an output of 30mW in the wavelength range 510–530nm. With a TO-38 package diameter of just 3.8mm the lasers can enable the dimensions of projection units to be reduced considerably. "The commercial breakthrough for compact laser projectors is closer than ever



The PL 520 green direct-emitting laser diode for projection applications.

before," reckons Stephan Haneder, marketing manager for Consumer Lasers at Osram Opto.

The firm says that the lasers have high beam quality — i.e. an extremely narrow beam that spreads out only slightly due to its small divergence angle. In the case of pico projectors, which project the laser light with a micro-electro-mechanical system (MEMS) mirror without any other optics, the size of the light point determines the image resolution. The beam quality is hence particularly important. Both laser diodes therefore operate in single mode (emitting just a single transverse oscillation mode).

Osram Opto says direct-emitting lasers can be better modulated than other laser types, such as frequency-doubled infrared lasers. This is an key property for MEMS-based projectors, in which the color components per pixel result from the emission time of the laser

diode. There is also no need to adjust the focus of the projection image, which is always sharp, even on curved surfaces.

The single-mode lasers open up new possibilities as light sources for laser shows, says Osram Opto, as their high beam quality enables extremely fine structures to be displayed even over large distances. The projectors also benefit from the high thermal stability and small size of the lasers.

Green diode lasers are also suitable as point or line lasers for measuring distances, for example. The human eye is most sensitive in the green spectrum, offering another advantage over red laser light. For the same laser output, and hence the same laser safety class, green light is perceived more easily by the eye than the red light that is usually used. Hence distance meters (such as those used by builders) can be used over larger distances.

Osram Opto says that its green laser was developed as part of the research project 'MOLAS' (technologies for ultra-compact and mobile laser projection systems), sponsored by the German Ministry for Education and Research and involving technologies for ultra-compact and mobile laser projection systems. In 2010, researchers at the firm received the Karl-Heinz-Beckurts Award for development work on the green laser.

www.osram-os.com

Advanced Photonix appoints non-executive chairman

Advanced Photonix Inc of Ann Arbor, MI, USA (which designs and makes silicon, InP- and GaAs- based APD, PIN, and FILTRODE photodetectors, HSOR high-speed optical receivers, and T-Ray terahertz instrumentation) has separated the roles of chairman of the board and CEO, and appointed Donald C. Pastor as non-executive chairman.

Pastor became an independent director in July 2005 and is now chairman of the Compensation Committee as well as serving on the Audit Committee. He now takes a greater role in monitoring implementation of the board's business strategies, in developing enhanced reporting mechanisms, and in communications between the board

and principal executive officers. Richard Kurtz (CEO since February 2003 and president since June 2006) will still oversee daily operations.

"This change will allow the management team to devote their full attention to meeting the day-to-day needs of our customers in our growing markets," says Pastor.

www.advancedphotonix.com



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Daylight launches modular mid-infrared laser source with overall tuning range of 6000nm

Daylight Solutions Inc of San Diego, CA, USA, which makes mid-infrared molecular detection, spectroscopic imaging and high-power illumination systems based on quantum cascade lasers (QCLs), has launched the MIRcat ultra-broadly tunable mid-infrared laser system, providing scientific researchers with what is claimed to be the widest single-box tuning range commercially available.

Building on the field-proven performance of the firm's broadly tunable Über Tuner series of ECQCL (external-cavity quantum cascade lasers), MIRcat incorporates up to four tunable laser modules into a single, sealed laser head. The system switches between these modules to provide a single, high-quality output beam with an overall tuning range of up to $\sim 800\text{cm}^{-1}$ ($\sim 6000\text{nm}$), providing a highly flexible, modular approach to optimizing coverage within the mid-IR region of wavelengths ($\sim 4\text{--}12\mu\text{m}$).

Uniquely available in either pulsed or continuous wave (CW) variants,



A broadly tunable laser from Daylight.

MIRcat deliver what is described as uncompromised performance across application-critical parameters such as: high output power



Daylight's tunable QCL controller.

(typically hundreds of milliwatts peak power pulsed or tens of milliwatts CW), superb beam pointing stability, high mode quality, and narrow line-widths.

The modular design allows users to optimize mid-infrared wavelength coverage by selecting two, three or four widely tunable laser modules, optimized for their application and budget.

According to the firm, MIRcat's performance brings new capabilities to a broad range of applications, including molecular spectroscopy, stand-off explosive detection, hyperspectral imaging and microscopy. "Solid-, liquid-, and gas-phase spectroscopy and imaging measurements are now easier, faster and more cost-effective than ever before," claims president & chief operating officer Paul Larson. "MIRcat will also future-proof our customers' research by allowing them to add or swap modules as their requirements change over time," he adds.

www.daylightsolutions.com

IPG Photonics appoints Veeco's CEO to board

High-power fiber-laser and amplifier manufacturer IPG Photonics Corp of Oxford, MA, USA says that John R. Peeler, chairman & CEO of epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA, has joined its board of directors.

The addition of Peeler, who will serve on IPG's Compensation Committee, temporarily expands IPG's board to 10 members until the 2013 annual meeting of shareholders.

"The addition of John will further diversify the outstanding talents and wide-range of experience of our current board," says founder & CEO Dr Valentin Gapontsev.

"John has deep experience in managing high-growth technology companies and a wealth of knowl-



John Peeler.

edge about the service needs of customers in demanding markets, including semiconductor capital equipment," he adds.

"We look forward to working with John as we con-

tinue to expand the presence of our products and technology around the world."

IPG also says that William F. Krupke Ph.D. will not stand for re-election at the 2013 annual meeting. "I also want to thank Dr Krupke for his 12 years of service, guidance and dedication to the company and its stockholders,"

says Gapontsev.

Peeler joined Veeco as CEO in July 2007 and was named chairman in May 2012. He spent his early career in engineering, marketing and product development in the communications test equipment industry. He became president & CEO of TTC in 1992 and, through organic growth and a series of acquisitions, he grew the firm into the largest global provider of field service communications test products. TTC evolved into Acterna, which was acquired by JDSU in 2005. Peeler earned a B.S. and Masters Degree in Electrical Engineering and graduated with high distinction from the University of Virginia.

www.ipgphotonics.com

www.veeco.com

Berthold Leibinger Zukunftspreis awarded to Sony's Osamu Kumagai for data storage lasers

On 14 September at a ceremony in Ditzingen, the not-for-profit Berthold Leibinger Stiftung organization presented its biennial Zukunftspreis and Innovationspreis awards.

The Zukunftspreis recognizes outstanding milestones in research, in this case concerning the application or generation of laser light. The Berthold Leibinger Stiftung jury selects the winner independently from applications and recommendations. The Berthold Leibinger Zukunftspreis 2012 (worth €30,000) was awarded to Dr Osamu Kumagai, senior VP of Japan's Sony Corp. This year's ten-



Osamu Kumagai.

strong jury cited his achievements in the development of technologies for the mass production of laser diodes as well as pioneering decisions in the development of multi-wavelength laser diodes for the backwards compatibility of three generations of optical data storage disc drives.

The Innovationspreis honors scientists and developers who innovations in the application or gener-

ation of laser light. After shortlisting eight finalists on 16 May, the Berthold Leibinger Stiftung jury selected the three prizewinners for the Berthold Leibinger Innovationspreis 2012. At the award ceremony, the first prize (worth €30,000) was presented to Dr Tso Yee Fan and Dr Antonio Sanchez-Rubio of Massachusetts Institut of Technology and Dr Bien Chann, who co-founded laser manufacturing spin-off TeraDiode Inc, of Littleton, MA, USA, for their work on 'Dense Wavelength Multiplexing of High Power Diode Lasers'.

www.leibinger-stiftung.de/en/activities/research-innovation-prize.html

IQE's III-V-on-Si laser materials enable next-generation hard disk drive technology

Tyndall, Semprius and Seagate combine GaAs laser with silicon substrate using micro-transfer printing

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK says it has produced epitaxial wafers combining the optical properties of compound semiconductors with the electronic properties of silicon to produce high-power lasers that enable increased storage density for next-generation hard disk drives.

In the last 20 years, through research and technological innovation, typical storage capacities for consumer disk drives have increased by 100,000 times from around 20MB to 2TB, notes IQE. In order to maintain such increases in capacity while maintaining the same footprint, the next generation of disk drives need to be capable of storing more than 1Tb of data per square inch.

Such high-density storage is made possible through heat-assisted magnetic recording (HAMR), where the heat source is a semiconductor laser device emitting 10mW or more of optical power.

Work published in the September edition of Nature Photonics volume 6 (2012) p612 (doi: 10.1038/nphoton.2012.204) describes the achievement by Tyndall National Institute (University College Cork), Semprius Inc and Seagate Technology in combining a high-power gallium arsenide laser structure with a silicon substrate using Semprius' proprietary micro-transfer print technology to print epitaxial layers produced by IQE using MOCVD at its Cardiff manufacturing facility ('Wafer-scale integration of group III-V lasers on silicon using transfer printing of epitaxial layers', Justice et al).

Specifically, the researchers used an elastomeric stamp to selectively release and transfer epitaxial coupons of GaAs to realize III-V lasers on a silicon substrate. Low-threshold continuous-wave (cw) lasing at a wavelength of 824nm has been achieved from Fabry-Pérot ridge waveguide lasers

operating at temperatures up to 100°C. Single- and multi-transverse mode devices emit total optical powers of >60mW and support modulation bandwidths of >3GHz.

The fabrication strategy opens up a route to the low-cost integration of III-V photonic devices and circuits on silicon and other substrates. In particular, says IQE, the demonstrated level of optoelectronic integration should allow HAMR to meet growing demand in the high-performance, high-capacity and low-cost storage markets.

"Programs such as this demonstrate how we successfully combine our high-volume manufacturing capabilities with leading-edge research to support our partners through all stages from development through to production," says Andrew Joel, commercial director for IQE's optoelectronics division.

www.nature.com/nphoton/journal/v6/n9/abs/nphoton.2012.204.html
www.iqep.com

Infinera's revenue grows 20% in Q3/2012

For third-quarter 2012, Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has reported revenue of \$112.2m, up 20% on \$93.5m last quarter and 8% on \$104m on a year ago.

On a non-GAAP basis (excluding non-cash stock-based compensation expenses) gross margin has rebounded from the low of 37% last quarter to 39%, although this is still down on 41% a year ago. Net loss was \$7.8m, cut from \$18.6m last quarter and \$9.2m a year ago.

"The DTN-X [a 100G converged WDM/OTN switching platform] is

experiencing strong traction around the world," says president & CEO Tom Fallon. "We now have 16 purchase commitments, representing five new customers and 11 existing customers. These commitments come from customers in North America, Europe and Asia Pacific and include commitments from all of our vertical markets," he adds.

"The DTN-X is in full deployment across the globe and, as forecasted, we began recognizing revenue from this platform in the third quarter."

"We are at the beginning of what we believe will be an expansive market opportunity for 100G that will extend over many years," says

Fallon. "We are pleased with the very strong initial support for the DTN-X," he adds. "Customers appreciate the superior scale, efficiency, reliability, simplicity and lower total cost of ownership offered by the DTN-X," Fallon believes, "and we are very optimistic about the outlook for its continued adoption."

"We are also seeing continued wins with our DTN platform, with three new DTN customers in the quarter," Fallon continues. "Our Digital Optical Network portfolio now delivers the same ease-of-use and quality across multiple applications in multiple markets."

www.infinera.com

Infinera demonstrates DTN-X 100G platform at SCTE Cable-Tec

In the Infinera Express truck at the SCTE Cable-Tec Expo in Orlando, FL (17–19 October), Infinera featured live demonstrations of its DTN-X, which is claimed to be the industry's first multi-terabit packet-optical transport platform.

Now being deployed worldwide, the DTN-X is said to be the first to deliver 500Gb/s super-channels based on PICs and the FlexCoherent Processor, scaling transport capacity without scaling operational complexity. Infinera's PICs combine multiple optical subsystems on a single integrated circuit and result in fewer fiber connections, less space, and less power compared

with conventional systems based on discrete components, says the firm. The DTN-X increases network efficiency with 5 Terabits of integrated OTN switching per bay, resulting in more efficient utilization of the 100Gb/s waves compared with conventional WDM architectures that do not allow sub-lambda grooming and switching, the firm adds. Infinera's Bandwidth Virtualization simplifies service deployment, enabling cable operators to deploy networks in days and services in minutes, thereby lowering operational costs.

At Cable-Tec Expo's technical workshops, Gaylord Hart, director

of the MSO market segment at Infinera, moderated the panel 'The Kilowatts Are Coming! Act Now or Be Overpowered'. Presenters, including Infinera's technical marketing manager Thomas Neel, discussed increasing energy efficiencies in cable networks as services expand and network bandwidth requirements continue to double every 12–18 months.

Infinera's solutions are widely deployed by major US MSOs in national backbone, regional, and metro applications. The firm says that it currently has DTN-X purchase commitments from cable operators.

Infinera and Verizon report record real-time polarization-mode dispersion compensation

Infinera and Verizon have reported record real-time polarization-mode dispersion (PMD) tolerance measurement results, using coherent optical transmission based on 500Gb/s PICs (Journal of Lightwave Technology, vol 30, issue 17, p2907).

By surmounting the problems of PMD, coherent transmission promises to enable higher communication

rates without penalty from this common fiber impairment. Infinera says that, taking advantage of the signal processing built into the 500Gb/s coherent modem, performance could be analyzed for both first-order and second-order PMD. Moreover, the combination of high amounts of PMD and fast polarization transients could be

tracked with near-perfect precision.

"Our team, with Verizon, was able to demonstrate a coherent optical transmission that can handle large PMD values with our commercially available 500Gb/s PIC," says Dave Welch, co-founder, executive VP & chief strategy officer. "System vendors in the industry today are having a difficult time achieving this."

NeoPhotonics appoints former JDSU president to board

NeoPhotonics Corp of San Jose, CA, a vertically integrated designer and manufacturer of both indium phosphide (InP) and silica-on-silicon photonic integrated circuit (PIC)-based modules and subsystems for bandwidth-intensive, high-speed communications networks, has appointed Charles J. (Jay) Abbe to its board of directors as well as its Audit Committee.

Abbe served as president, chief operating officer and director of JDS Uniphase Corp from February 2000 until his retirement in June 2001. In 1996, he joined Optical Coating Laboratory Inc (OCLI) as VP & general manager of its principal operating unit. He was promoted to president & chief operating officer in November 1997 and to CEO in April 1998 and, during his tenure, OCLI's market capitalization increased from \$125m in 1996 to \$1.3bn in late 1999. The firm was acquired by JDS Uniphase for \$2.8bn in February 2000.



New board member Jay Abbe.

From 1990 to 1996, Abbe served in positions of increasing responsibility (including senior VP, electronics sector) at Raychem Corp. He practiced business consulting with McKinsey & Company in San Francisco from 1971 to 1989, serving the last seven years as a senior partner. Abbe began his career with the US Air Force Rocket Propulsion Laboratory in Edwards, CA.

Abbe also served as a director of publicly traded optical communications firm Opnext Inc from January 2009 until Opnext's acquisition by Oclaro Inc in July 2012, and has served as a director of semiconductor capital equipment company Cymer Inc since 2002.

"NeoPhotonics has become a

leading vendor of integrated components for high-speed applications and coherent networks through the advancement of its photonic integrated circuit technology," comments Abbe. "This company has an impressive core technology that offers tremendous potential for systems manufacturers and carriers to continue driving down their costs of delivery of bandwidth and flexible services in wireless and wireline networks," he adds.

"Jay has a tremendous amount of experience in technology strategy and in telecom network business growth," notes CEO & chairman Tim Jenks. "His personal achievements and insights for business expansion in these areas can bring an important new dimension to the board."

Abbe earned a Master of Business Administration degree from Stanford University as well as Master of Science and Bachelor of Science degrees in chemical engineering from Cornell University.

NeoPhotonics launches embedded optical time-domain reflectometer capability for passive optical network transceivers

NeoPhotonics has launched an optical line terminal (OLT) transceiver with embedded optical time-domain reflectometer (eOTDR) for Gigabit passive optical networks (GPON) in an SFP form factor and for use in fiber-to-the-home (FTTH) networks.

The eOTDR OLT transceiver was designed in collaboration with leading broadband access network equipment manufacturers and is designed to offer FTTH operators a cost-effective way to monitor their fiber infrastructure during network operation.

The transceiver represents the latest addition to NeoPhotonics' PON transceiver portfolio, which includes modules such as the mode coupling receiver (MCR) OLT — announced in September during the European Conference on Optical Communications (ECOC 2012) in

Amsterdam, The Netherlands — as well as a full range of GPON, GEAPON (Gigabit Ethernet PON) and 10G PON transceivers.

The new eOTDR OLT SFP is designed to enable customers to provide an integrated fiber monitoring solution

instead of the current standalone test & measurement approach, says chairman & CEO Tim Jenks. It is also designed to lower the overall cost of FTTH network rollout and operation, he adds.

FTTH has become a key wireline broadband access technology, and PON represents one of the most

Telecom carriers around the world are integrating fault location and management into operating systems to minimize traffic outages

widely deployed network architectures, says NeoPhotonics. In their continuous drive to reduce network operations costs, telecoms carriers around the world are integrating fault location and management into their operating systems to minimize traffic outages and revenue loss, the firm adds.

These practices are already common in high-bandwidth links at the core of the network, but with data rates growing in broadband access networks, the need is growing to do the same at the edge of the network. NeoPhotonics says that its eOTDR OLT is designed to address that need as its monitoring functions can be integrated with the network management system, allowing a continuous view of the access fiber infrastructure.

www.neophotonics.com

Oclaro reports preliminary post-merger quarterly revenue below guidance

Integration of Opnext to boost next quarter

For its first fiscal-quarter 2013 (to 29 September 2012), optical communications and laser component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has reported preliminary revenue of about \$149m, below the low end of its guidance of \$154–168m issued on 31 July.

On 23 July, the merger closed between Oclaro and optical component, module and subsystem maker Opnext Inc of Fremont, CA, USA. The first fiscal quarter includes revenue from the former Opnext subsequent to the close of the merger.

Oclaro says that certain principal factors that contributed to the lower-than-expected revenue include:

- continued challenging market conditions in the segments of the optical communications space that Oclaro serves;
- slower-than-expected recovery of customer share of certain products to pre-flood levels, including certain data communications products; and
- slower-than-expected ramp of new products, in particular certain customer-qualified new 40G and 100G products.

“Following the merger, our integration activities are on track to execute our synergies, and our customer relationships are strong,” notes chairman & CEO Alain Couder. “We expect these factors to strengthen our future performance and expect revenues to be up in the December quarter,” he adds.

Oclaro cautions that its anticipated revenue results are preliminary and based on the best information currently available, and are subject to completion of its financial statements for fiscal first-quarter 2013.

www.oclaro.com

Finisar launches first wavelength-tunable XFP-RF optical transmitter for cable access networks

Finisar Corp has launched what is claimed to be the first 1GHz RF-modulated, widely tunable optical transmitter in a small-form-factor module for cable operators' access networks.

The XFP-RF transmitter can be designed into existing broadband optical platforms to double the density and halve the power consumption of transmitters in hybrid fiber coaxial (HFC) networks. It can also be plugged directly into next-generation cable modem termination systems and QAM modulators with optical ports, saving space and power. Finisar showcased its wavelength-tunable XFP-RF transmitter in a demonstration at the SCTE Cable-Tec Expo in Orlando, FL (17–19 October).

Consumer demands for video and bandwidth services continue to rise. As a result, cable operators are deploying dense wavelength-division multiplexing (DWDM) in their access networks to dramatically increase the bandwidth available over their existing fiber

infrastructure. Finisar's XFP-RF optical transmitter module introduces wide-band wavelength tuning to HFC networks, allowing the cable operator to tune it to 80 different DWDM wavelengths across the entire C-band in less than 500ms. Tunability eliminates the need for an inventory of transmitters at fixed wavelengths and eases the provisioning of complex DWDM networks. Wavelength-tunability also enables future, innovative architectures that can route services by managing the wavelengths of the HFC transmitters.

The XFP-RF transmitter uses Finisar's high-volume XFP manufacturing process being used for today's wavelength-tunable 10Gb/s digital transceivers. It can be fully loaded from 50MHz to 1GHz with a reach up to 40km, and has operational bandwidth up to 1.2GHz to accommodate frequency expansions in the cable access network. The performance is distance-agnostic, so a single transmitter can be deployed for redundant

paths to a node or to multiple nodes in a tapped architecture where the distance can vary greatly.

“Finisar has combined its high-volume small-form-factor module capabilities, wavelength-tunable laser technology, and its extensive experience in CATV transmitters to advance optics for the next evolution of cable access networks,” says Shawn Esser, director of product marketing for CATV products. “As cable operators continue to deploy more optics to segment their networks, our wavelength-tunable XFP-RF transmitter saves valuable space, reduces energy requirements and improves their operational flexibility,” he adds. “The XFP-RF transmitter deployed in existing optical platforms today is designed to be able to be re-deployed in next-generation infrastructure equipment designed with optical ports to future-proof cable operators' investment.”

www.finisar.com

<http://expo.scte.org>

ATK awards Emcore \$5m solar panel contract for AMOS-6 telecom satellite

Emcore has been awarded a solar panel manufacturing contract by aerospace, defense and commercial products firm ATK of Arlington, VA, USA for the AMOS-6 commercial telecoms satellite (planned for launch in early 2015). Solar panels populated with Emcore's most advanced ZTJ triple-junction solar cells will power the AMOS-6 spacecraft, which is manufactured by Israel Aerospace Industries (IAI).

Operated by Spacecom, AMOS-6 is to be co-located at the 4°W orbital position with the AMOS-2 and -3 satellites. It will provide steerable Ku-band with Pan-European and Middle East coverage, and a Ka-band beam for broadband services in Africa and Europe. The AMOS satellite fleet, beginning with the AMOS-1 in 1996, provides broadcasting and communications services to DTH (direct-to-home) television operators, TV broadcasters and programmers, government

and corporate organizations, and VSAT network operators.

ATK will adapt its space-proven modular PUMA array, from GPS IIF and Orbital's Star2 GEO line, to provide power to AMOS-6, according to Dave Messner, VP & general manager of ATK Deployables business in Goleta, CA, USA. "We look forward to delivering over 10kW of end-of-life power using Emcore's solar cell technology," he adds.

"The manufacture of the AMOS-6 solar panels will reinforce our heritage in the telecom satellite business and allow us to pursue future opportunities in that market," reckons Brad Clevenger, general manager of Emcore's Photovoltaics Division. In December 2011, ATK contracted Emcore to provide solar panels for a cargo delivery spacecraft for Orbital Sciences Corp's Commercial Resupply Services (CRS) missions to the International Space Station.

www.atk.com

IN BRIEF

Emcore closes public offering to raise \$9.5m

On 3 October, Emcore Corp of Albuquerque, NM, USA, which makes components, subsystems and systems for the fiber-optic and solar power markets, closed its underwritten public offering of 1,593,400 shares of common stock (announced on 27 September) at \$5.46 per share.

The offering was increased from what was previously announced due to demand from investors.

In addition, the underwriter took up its option to purchase 239,010 additional shares. This boosted the total to 1,832,410 shares, increasing the net proceeds raised from \$8.265m to \$9.5m.

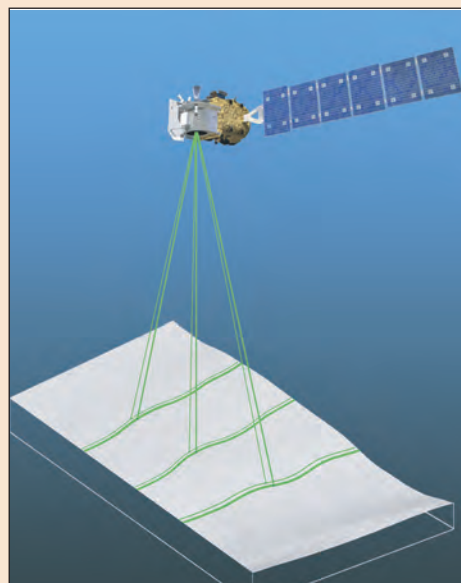
Emcore plans to use the proceeds for general corporate purposes.

www.emcore.com

Orbital Sciences awards Emcore solar panel contract for NASA's 2016 Ice, Cloud and land Elevation Satellite-2 spacecraft mission

Emcore Corp of Albuquerque, NM, USA, which makes components, subsystems and systems for the fiber-optic and solar power markets, has been awarded a solar panel manufacturing contract by Orbital Sciences Corp for the spacecraft it is making for NASA's Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) mission, which is targeted for launch in early 2016. Solar panels populated with Emcore's most advanced ZTJ triple-junction solar cells will power the spacecraft.

ICESat-2 builds on measurements taken by NASA's original ICESat mission. ICESat was the benchmark Earth Observing System mission for measuring ice-sheet mass balance, cloud and aerosol heights, as well as land topography and vegetation characteristics. Data from ICESat,



Artist's impression of ICESat-2.

which was in orbit from 2003 to 2010, revealed thinning of the world's ice sheets. ICESat-2 will

use precision laser-ranging techniques to measure the topography of the Greenland and Antarctic ice sheets and the thickness of sea ice.

"This award for ICESat-2 continues the strong partnership between Orbital Sciences Corp and Emcore," says Brad Clevenger, general manager of Emcore's Photovoltaics Group.

Emcore claims to be the world's largest manufacturer of highly efficient radiation-hard solar cells for space power applications. With a beginning-of-life (BOL) conversion efficiency nearing 30% and the option for a patented, onboard monolithic bypass diode, the firm's multi-junction solar cells can provide the highest available power to interplanetary spacecraft and earth-orbiting satellites, it adds.

<http://icesat.gsfc.nasa.gov/icesat2>

Concentrated photovoltaic market to double in 2012

Installations to reach 1.2GW by 2016

According to the report 'The World Market for Concentrated PV (CPV) – 2012' by market analyst firm IMS Research, the CPV market will double in 2012 to almost 90MW, with revenue predicted to grow by more than 60% to \$325m. Also, installations should grow rapidly over the next five years to almost 1.2GW by 2016.

Despite strong competition from conventional PV systems, there is still an attractive market for CPV in its target regions, says the firm. "CPV suppliers are being forced to continually decrease costs in order to compete with the rapidly falling cost of PV systems," says report co-author and IMS Research analyst Jemma Davies. "The technology is still relatively new and faces bankability issues. Despite this, CPV suppliers have made significant progress in the USA market, with a forecast 13% share of the target market in 2012, rising to a predicted 27% by 2016," she adds.

While the technology will remain niche, in the long-term the outlook for CPV remains positive.

Installations are forecast to capture an 18% share of the target market (ground-mount systems with a direct normal irradiance (DNI) above 6kWh/m²/day) by 2016, says the report.

High-concentration PV (HCPV) systems are forecast to dominate the market in 2012. However, low-concentration PV (LCPV) installations are forecast to accelerate over the next five years, capturing a 20% share of the CPV market by 2016.

"Currently, LCPV suppliers have not entered the market aggressively," says report co-author Sam Wilkinson. "However, with recognised companies such as SunPower poised to install a significant amount from 2013, these products are set to gain market share as a result," adds Wilkinson.

The most attractive markets for CPV will be the USA and Central America as well as Middle East and Africa (excluding South Africa), which will see CPV capturing up to a 27% share of the high-DNI target markets by 2016. In particular, regions such as South West USA, Chile, Saudi Arabia and Morocco are predicted to see high growth, since conditions in these regions are suited to CPV.

The report profiles over 30 CPV suppliers, but in 2011 the market was dominated by the top five suppliers (comprising almost 90% of installations). Amonix was the largest supplier. However, since the closure of its operations earlier this year — and as the number of suppliers commercializing their products increases — the competitive landscape is expected to shift considerably. Suppliers such as Soitec and SolFocus are expected to gain market share in 2012.

www.imsresearch.com

Solar Junction sets CPV cell efficiency record of 44%

Firm's own world record raised from 43.5%, set in April 2011

Solar Junction of San Jose, CA, USA, which manufactures III-V multi-junction solar cells for concentrated photovoltaics (CPV), has raised its own world record for the energy conversion efficiency of a commercial-ready production solar cell, from 43.5% at 418 suns (achieved in April 2011) to 44% at 947 suns now, as verified by the US National Renewable Energy Laboratory (NREL).

Founded in 2007 with investors including New Enterprise Associates, Draper Fisher Jurvetson and Advanced Technology Ventures, Solar Junction says that its cells, which incorporate proprietary adjustable-spectrum lattice-matched (A-SLAM) materials technology, enable it to more optimally

partition the solar spectrum for maximum efficiency and greater reliability.

"Breaking our own world record cements Solar Junction as an innovator and leader in the multi-junction cell space," reckons VP technology Vijit Sabnis. "We continue to push technological boundaries to further drive CPV costs down."

Solar Junction's announcement follows a \$19.2m investment round in February, a 5MW order in May from CPV system maker SolFocus Inc of Mountain View, CA, USA, and several industry awards. Earlier this year, Solar Junction and epitaxial wafer supplier IQE plc of Cardiff, Wales, UK signed an investment and manufacturing agreement to

ramp Solar Junction's SJ3 solar cell product to high volumes.

In addition, Solar Junction is commissioning a 6"-wafer fabrication facility, partially funded by a US Department of Energy (DOE) contract awarded in April for SUNPATH (Scaling Up Nascent PV At Home). The Silicon Valley-based project is part of the DOE's SunShot Program, which aims to increase PV manufacturing in the US through investments in technologies that are sustainable with competitive cost and high performance.

SunShot investments are designed to help achieve \$1/Watt by 2020. Solar Junction's shipments for SUNPATH are due to begin in first-quarter 2013.

www.sj-solar.com

Altatech launches multi-chamber CVD system for thin-film PV material deposition

Altatech of Montbonnot Saint Martin, near Grenoble, France (which in January became a subsidiary of Soitec), has introduced a multi-chamber chemical vapor deposition (CVD) system that enables the development of photovoltaic (PV) cell designs using thin-film deposition of amorphous silicon and other materials. By performing all deposition processes within a single system, the AltaCVD Solarlab tool reduces cycle times and materials consumption in fabricating advanced single-junction, tandem-junction and triple-junction PV cells, says the firm.

Using the AltaCVD Solarlab, users can deposit transparent conducting oxide (TCO) films that deliver the superior optical characteristics, high doping mobility and smooth,

defect-free surfaces needed to optimize cell efficiency, the firm claims.

"Extending our core CVD technology for use in solar cell development presents an additional market opportunity for us," says Altatech's general manager Jean-Luc Delcarri. "Reducing the amount of material used in cells and improving photovoltaic conversion performance will be the keys to growth in the next few years," he adds.

The new CVD system leverages Altatech's patented chamber architecture and deposition technology, which enables the use of new precursor gases to achieve extremely high film uniformity and tightly controlled stoichiometry, says the firm. These capabilities have been production-proven on the firm's AltaCVD platform, which has been

used in both engineering and volume manufacturing of advanced semiconductor devices since 2008.

The AltaCVD Solarlab system has the versatility to perform standard thermal CVD processing as well as plasma-enhanced CVD and atomic-layer deposition (ALD). These processes can be run over temperatures of 100–800°C to create photosensitive films that can maximize the efficiency of PV cells in converting sunlight to electricity. In addition, the system can handle a variety of substrates, including transparent glass and both round or square silicon wafers with thicknesses ranging from 150µm to several centimeters.

Soitec aims to begin shipping AltaCVD Solarlab by the end of 2012.

www.altatech-sc.com

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- Crucible Weighing/Mixing and Transfer System: Tronrud HGC-Cleanroom 4-Station (2009)
- (71) Crystal Growth Pullers: (50) PVA Tepla (All 2008); (21) Kayex/Hamco
- (2) Ingot Coding Marking Labeling Machines: Goodtech Tiara-CML (2009)
- (13) CNC Horiz. Bandsaws: Meyer Burger (4) KVP 830/BS 830 (2008-2009); (9) BS 830 (2008)
- (2) Automated Block Handling Centres (2008)
- (2) Automated Gluing Centres: Artech Lime-Robot-Senter (2008)
- (17) Wire Saws: Applied Materials/HTC 500SD-B/5 (All 2008)
- (3) Process Wash Plants: Edwards CME Automated 5-Station (All 2008)
- (6) Wafer Lines: Tronrud Engineering Mono (All 2008)

Heroya #4, Norway Location also includes:

- (2) Crucible Cleanroom Mixing/Weighing Systems: Tronrud Engineering HGXXB (Both 2008)

Heroya Plants #3 & #4 Private Treaty Sales "Two" Complete 325 MW/yr State of the Art Crystalline Poly Silicon Wafer Manufacturing Facilities

156mm x 156mm x w/180 micron thickness

Offered in their Entirety or Piecemeal

Located in Heroya, Norway

Both Heroya Plants #3 & #4 Include:

- (2) Crucible Coating Systems: Artech Anlegg-1 (2007-2008)
 - (4) Crucible Baking Furnaces: C.H. Evenson 07-086m01 (All 2008)
 - (10) Silicon Crystallization Vacuum Melting Furnaces: ALD SMC1000 1600A°C
 - (6) Ingot Band Saws: Meyer Burger BS 801 (All 2008)
 - (2) Automated Block Centres: Artech, Each with ABB IRB6600 Rail Mounted 7-Axis Robot (2008), (5) Abwood CNC Grinders with GE Fanuc Controls (All 2008)
 - (2) Automated Gluing Cells: Artech Lime-Robot-Senter (Both 2007)
 - (32) Wire Saws: Meyer Burger DS 268 (All 2008)
 - (4) Process Wash Plants: Edwards CME Automated 5-Station (2007-2008)
 - (6) Wafer Lines: Tronrud Engineering (All 2008)
- Heroya #3, Norway Location also includes:
- Crucible Cleanroom Mixing/Weighing System: Tronrud Engineering HGXXB (2008)
 - Ingot Band Saw: MB Wafertec BS 806 Large Capacity (2009)
 - Wire Saw Bricking Machine: MB Wafertec BM 860 Brick Master (2011)

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IN BRIEF

5N Plus wins DLA materials contract

5N Plus Inc of Montreal, Canada, a producer of specialty metal and chemical products, says its 66.67%-owned subsidiary Sylarus Technologies LLC in St. George, UT, USA has been awarded a US\$1.32m contract by the US Defense Logistics Agency (DLA) to upgrade part of the National Defense Stockpile (NDS) high-purity germanium metal inventory to unfinished Ge substrates for multifunction solar cells in National Security Space (NSS) use.

Sylarus is the sole US domestic space-qualified Ge substrate supplier to NSS customers, and is one of only two NSS-qualified suppliers worldwide. The award brings the total Sylarus US Government contract award value to over US\$10m.

5N Plus says the DLA award is strategic in nature as Sylarus becomes part of the US NDS for strategic materials, with the potential for follow-on business both as a strategic metal supplier and NDS inventory manager.

www.5nplus.com

Soitec completes delivery of 5MW of CPV systems to Italy

Soitec of Bernin, France has completed delivery on a total of 5MW of its Concentrix concentrating photovoltaic (CPV) systems (of which 3.3MWp was recognized as revenue in second-quarter 2012) to seven solar power plants throughout Italy. This follows Soitec's announcement in June that it had completed construction of a solar facility in the Catania province in Sicily. These system deliveries to multiple customers expand Soitec's solar system installations to more than 10MW worldwide.

"Our proven CPV technology provides the highest power-generating efficiency, making it a perfect match for Italy's solar initiatives," claims José Bériot, VP solar projects development of Soitec's Solar Energy division. "With Soitec's high-quality modules being very well received in Italy and with our office in Rome providing direct customer support and developing new business opportunities, we are building momentum in the growing Italian market for renewable-energy solutions," he adds.

"We are committed to have a competitive offering in Italy and we

are currently looking into integrating more and more local content," Bériot says. "Soitec's industrial manufacturing capacity and supply chain in Europe, with its fully automated solar-module factory in Freiburg, Germany, has proven to be a reliable and flexible infrastructure to ensure competitiveness and security of supply in Europe."

Soitec claims that its CPV technology combines the industry's highest power-generating efficiency of up to 30% with low installation and maintenance costs, making it the most cost-efficient solution for high-volume power generation in regions such as Italy with high direct normal irradiation (DNI). Using high-performance optics, high-efficiency cells and precise tracking to maximize power generation, the CPV systems deliver advantages not available with other solar technology approaches, the firm adds. Each system produces a high, constant power output curve to match peak-load demands – a key performance need for power utilities.

www.soitec.com

OPEL appoints VP of technology as consultant on POET

OPEL Technologies Inc of Toronto, Ontario, Canada — which makes high-concentration photovoltaic (HCPV) panels and solar tracker systems through its subsidiary OPEL Solar Inc — has appointed Lee Shepherd as VP of technology. He joins OPEL as a consultant through his firm IT Millwrights Corp of Kanata, Ontario.

Shepherd brings expertise to assist the special committee of the board, which was established in August to drive monetization efforts of the POET platform technology of OPEL's US affiliate OPEL Defense Integrated Systems (ODIS Inc) of Shelton, CT. In contrast,

OPEL is in the process of divesting its solar operations.

The POET process enables monolithic fabrication of gallium arsenide integrated circuits containing both electronic and optical elements on a single wafer. III-V devices developed by ODIS include infrared sensor arrays and ultra-low-power random access memory.

"OPEL has revitalized the company's direction so that the core component of the strategy is to continue developing the POET platform," says Peter Copetti, executive director of the board. "Shepherd joins our team to provide his guidance on POET's roadmap and

assisting in ultimately marketing the technology as expeditiously as possible," he adds.

Shepherd has over 25 years of experience in business, technical, and military leadership roles. He spent the last 18 years in the telecoms/IT industry, serving in technical, management, product architecture, engineering program management, technical sales, merger & acquisition leadership, and entrepreneurial roles.

Shepherd entered into a consulting agreement with OPEL whereby his company will provide consulting services for one year.

www.opeltechinc.com

Environmental Award for Fraunhofer ISE's Bett and Soitec's Lerchenmüller for CPV technology achievements

Dr Andreas Bett, deputy director of the Fraunhofer Institute for Solar Energy Systems ISE, and Hansjörg Lerchenmüller, CEO of Soitec Solar (a division of Soitec of Bernin, France) — both based in Freiburg, Germany — have been named as recipients of the German Environmental Award 2012 for their achievements in research and industry related to concentrator photovoltaic (CPV) technology. Originally developed by Fraunhofer ISE, the technology was brought to market by Soitec Solar.

Awarded each October by the Deutsche Bundes-stiftung Umwelt (DBU) foundation, the €500,000 award (Europe's largest environmental prize) was to be presented this year by the German President Joachim Gauck on 28 October in Leipzig. Entrepreneur Günther Cramer, co-founder & supervisory board chairman of SMA Solar Technology AG of Kassel, Germany, shares this year's prize. "With their pioneering technological developments and personal commitment," the prize-winners have "set worldwide standards in photovoltaics and thus significantly advanced the field at a global level," says DBU secretary general Dr Fritz Brickwedde.

For many years now, research and industry have been working on solar energy systems and components, making them increasingly efficient and hence more competitive. Aside from conventional silicon technology, other cell technologies suitable for specific applications have been brought to market. These include CPV technology, in which a Fresnel lens in each module concentrates the sunlight by a factor of 500 onto small (3mm-wide), high-efficiency multi-junction semiconductor solar cells. With modules with a two-axis tracking system that follows the path of sun, almost twice the incident sunlight can be converted into electricity compared to conventional silicon technology. Concentrator power plants have a modular construction



Bett (left) and Lerchenmüller (right).

and are hence freely scalable. CPV technology is hence targeted particularly at use in large power plants ranging from a few to several hundred megawatts in regions with a large amount of direct solar irradiation. Currently, in sun-rich regions such as South Africa or the USA, thousands of industrially produced CPV modules are therefore being used in large power plants.

"A cost-effective optical lens concentrates the sunlight and allows the economical use of the comparative costly semiconductors used in this system," says Dr Andreas Bett, division director 'Materials – Solar Cells and Technology' and deputy director of Fraunhofer ISE (which, with 1200 staff, is Europe's largest solar energy research institute). "Depending on the concentration factor, only one five-hundredth to one-thousandth of the semiconductor material is required, yet still improving the efficiency of the solar cell," he adds.

Decisive for the efficient and economical operation of large CPV power plants is the interplay between components. This plays a role in module construction, the connection of the modules as well as for the entire system technology and process control. "The efficiency of a concentrator module manufactured by Soitec Solar is currently about 30%," says Lerchenmüller. "At the same time, we are using cost-effective materials," he adds. "Exactly this combination of low material costs and high efficiency is the key to keeping electricity production

costs down." In 2009, Bett and his team achieved record efficiency of 41.1% for a III-V multi-junction solar cell under laboratory conditions. Both Bett and Lerchenmüller see further potential for increasing the efficiency of solar cells and modules.

At Fraunhofer ISE, in a research team with more than 50 scientists, Bett is working to increase the efficiency of multi-junction solar cells. In the Concentrator Technology & Evaluation Center (ConTEC) they also work on optimizing the construction of the CPV module. Soitec is working on expanding the installed capacity of CPV power plants worldwide. With Soitec's Freiburg subsidiary Soitec Solar GmbH, Lerchenmüller has contributed to the industrial implementation, commercialization and international expansion of the concentrator technology. The firm transferred the concept of the CPV module to industry. Soitec Solar has also established a 70MWp automated production line for CPV modules in Freiburg. In addition, a module factory with 280MWp production capacity is currently being constructed in San Diego, CA, USA.

"Andreas Bett and Hansjörg Lerchenmüller were key contributors to develop this very innovative, reliable and efficient CPV technology," says Gaetan Borgers, executive VP of Soitec's Solar Energy Division. "Today, Soitec operates in Freiburg one of the world's most modern production lines for manufacturing CPV modules. We already have more than 10MWp installed around the world," he adds.

Fraunhofer ISE director professor Eicke R. Weber comments that the German Environmental Award "sends a clear signal and emphasizes the significance that innovations in photovoltaics have for the future global energy supply".

www.dbu.de

www.soitec.com

www.ise.fraunhofer.de

First Solar launches global power plant Operations Center

First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services, has launched a new global Operations Center, a centralized monitoring and control center where power plants in First Solar's operations and maintenance (O&M) program can be monitored, operated and connected to utility and customer networks.

The Operations Center combines First Solar's power prediction and analytical capabilities with its diagnostics and plant controls in order to maximize power output and minimize maintenance costs for its customers, and to enable the world's largest solar photovoltaic (PV) power plants to integrate seamlessly with the electrical grid and contribute to grid stability.

Located in Mesa, AZ, USA, the second-generation center is fully compliant with North American Electric Reliability Corporation (NERC) standards and is designed to be scalable to accommodate the global fleet of PV power plants in First Solar's O&M program. The firm currently operates 14 customer plants with 460MW of peak generating capacity, which will increase to 23 plants with 850MW of capacity by year-end and 27 plants with 2200MW of capacity in 2013.

The center aims to maximize power plant availability and reduces costs for customers by preventing potential problems from occurring and quickly fixing those that do. It collects and processes a wide range of real-time power plant data, including electrical performance, equipment status and weather data, which are monitored and analyzed against key performance and operational parameters. Automated data analysis detects issues in the plants and automatically dis-



First Solar's new Operations Center aims to maximize power plant availability and reduce costs by preventing or fixing problems quickly and efficiently.

patches maintenance crews to resolve them, and proprietary algorithms developed using years of O&M data enable the system to predict potential issues and schedule preventive maintenance before a problem occurs, says the firm.

A key feature of First Solar's power plant design is its plant controls, which manage grid reliability and stability and can be controlled remotely from the operations center. Features include ramp-rate control, which limits how fast a power plant's output increases or decreases in order to minimize grid disruption; ride-through capability, which enables a power plant to operate through faults and other grid disturbances; active power control, which can be used to modulate power output; and frequency droop control, which enables a power plant to provide critical grid support when grid frequency is changing. Such tools have become increasingly important as more solar generating capacity is connected to the grid, says First Solar.

"Our years of experience and

investment have enabled us to build a proprietary system that allows us to optimize our customers' power plants to produce the maximum amount of energy and revenue under their power purchase agreements while minimizing costs and risk," says Bob Callery, VP of O&M. "The vast quantity of data we gather also gives us invaluable insight into the real-world performance of our products and supports the continuous improvement of our power plants."

"Predictability and reliability have become increasingly critical to utilities and grid operators as large-scale renewable power plants are connected to the grid," says Mahesh Morjaria, VP of Global Grid Integration at First Solar. "First Solar has invested considerable time and resources to ensure our power plants integrate seamlessly into the grid and provide features that not only avoid disruptions, but also can help to actively mitigate disruptions elsewhere on the grid," he adds.

www.firstsolar.com.

PJB & First Solar to development projects in Indonesia

First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services, and PT Pembangkitan Jawa Bali Services (PJB Services) of Jakarta, Indonesia have signed a memorandum of understanding (MOU) to collaborate on the delivery of 100MW of utility-scale solar power plants in Indonesia in order to address the growing energy demand in the country.

"Indonesia has an increasingly urgent need for reliable, cost-effective energy resources," says Won Park, First Solar's senior manager of business development & sales in Southeast Asia. "This MOU underscores First Solar's belief that the Indonesian market has great potential as a sustainable market where solar power can be a meaningful part of the energy mix," he adds. "Solar PV electricity can help Indonesia meet its fast-growing power needs while reducing its dependence on fossil fuels," comments PJB Services' president Bernadus Sudarmanta.



First Solar modules in ground-mounted solar power plant.

The MOU is the first for First Solar in Indonesia and one of several related to its strategy of forging strategic alliances in fast-growing, sustainable energy markets worldwide. It also represents the first foray into the development of utility-scale photovoltaic power plants for PJB Services, which was established in 2001 with a 95% shareholding owned by PT Pembangkitan Jawa Bali (PT PJB) and 5% owned by the Foundation for Education and Welfare of PT PJB, which is a

subsidiary of Perusahaan Listrik Negara (PLN). It initially focused only on plant maintenance, but has since engaged in providing services for the operation and maintenance of conventional power plants in Indonesia. PJB Services also has representa-

tion in Singapore, Malaysia, Kuwait, China and Saudi Arabia.

The MOU represents an initial step in the collaboration between the two firms toward the development, engineering, procurement, construction, operation and maintenance of an approximately 100MW pipeline for solar PV power plants (including PV hybrid solutions) using First Solar's PV modules and related system services and components.

www.pjbservices.com

www.firstsolar.com

First Solar wins manufacturing category at inaugural Malaysia Greentech Awards

At the inaugural Malaysia Greentech Awards ceremony at the Kuala Lumpur Convention Centre on 12 October, First Solar Inc was recognized as the Gold Award winner in the manufacturing category. First Solar Malaysia earned the award for its "continuous commitment to excellence in green technology manufacturing practices and infusing elements of sustainability and nature preservation into its operations".

As a highlight of the third International Greentech & Eco Products Exhibition & Conference Malaysia (IGEM), the Greentech Awards program is an initiative to showcase the best-in-class examples of creativity and innovation among

public and private sector players. Conferred by the Ministry of Energy, Green Technology and Water Malaysia in cooperation with Malaysian Green Technology Company, the awards recognize the most innovative renewable energy leaders in Malaysia.

The award "reflects the hard work and dedication of our entire team in Kulim to continuously reduce costs and our environmental impact across the entire solar value chain," says First Solar Malaysia's managing director P'ng Soo Hong. "First Solar has the smallest carbon footprint and the lowest manufacturing cost in the photovoltaic industry," he claims.

First Solar Malaysia actively par-

ticipates in the Economic Transformation Programme (ETP) via two National Key Economic Areas (NKEA); the Oil, Gas and Energy NKEA and the Electronics and Electrical NKEA. In line with the ETP's vision, First Solar's solar module cost-reduction roadmap aims to achieve cost-competitive parity with conventional fossil fuel and to build up the nation's solar capacity.

The Greentech Awards have been introduced to acknowledge the best green technology leaders in Malaysia as well as to identify future green technology ideas and initiatives that can help to transform green business in Malaysia and worldwide.

www.firstsolar.com

IN BRIEF

Millionth module installed at MidAmerican's Topaz project

First Solar Inc of Tempe, AZ, which manufactures thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services, and energy services provider MidAmerican Solar of Phoenix, AZ (a subsidiary of MidAmerican Renewables) say that earlier in October the 1 millionth solar module was installed at the Topaz Solar Farms project in San Luis Obispo County, CA, USA. This comes less than six months after installation of the first module on 16 May.

Construction of the plant began in late 2011 and is expected to be complete by early 2015. The project currently employs more than 800 workers at the site and is expected to provide about 400 construction jobs on average during its three-year construction period. It should generate nearly \$417m in local economic impact, mostly during construction.

On completion, the plant will produce 550MWAC of power from nearly nine million PV modules (making Topaz the largest solar project under construction in the world). It will provide enough energy to power about 160,000 California homes, displacing about 377,000 metric tons of carbon dioxide per year (equivalent to taking 73,000 cars off the road). Pacific Gas and Electric Company (PG&E) will purchase the electricity from the plant under a 25-year power purchase agreement, helping California to meet its mandate to generate 33% of its power from renewable sources by 2020.

www.firstsolar.com

www.midamericanrenewablesllc.com

First Solar appoints MD & VP of business development, China

First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic (PV) modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services, has appointed Bruce Yung as managing director & VP of business development for China, based at the firm's office in Beijing and reporting to Jim Brown, executive VP of global business development.

Yung has 25 years of experience in the energy industry throughout Asia and Europe. Most recently, he was managing director of China Renewable Energy Investment Ltd, a renewable energy firm focused on China. Prior to that, he held senior positions in business development, mergers & acquisitions, asset management and strategy with global energy companies such as British Petroleum, Entergy Power Group and British Gas.

"Bruce's extensive and diverse global experience across the energy industry will be a valuable asset to First Solar and our customers as we continue to grow and invest in the Chinese market," says Brown. "His first-hand knowledge of the entire power life-cycle, from development to operation, will help us to expand the market for utility-scale solar PV power plants in China and to deliver value to Chinese solar power producers."

Yung earned BS and PhD degrees in chemical engineering from the University of Birmingham and an MBA from Henley Management College in the UK. He is currently vice chairman of the Energy Committee at the American Chamber of Commerce in Hong Kong and co-chair of the Renewable Energy Chapter of the Independent Power Producers Forum.

www.firstsolar.com

Western Australia's first large-scale solar project officially opened

Perth-based Verve Energy (the leading electricity producer in Western Australia), GE Energy Financial Services of Stamford, CT, USA and First Solar have opened the 10MW Greenough River Solar Farm near Geraldton, Western Australia. Joined by Western Australia's Energy Minister Peter Collier, landholders, community members and contractors, the opening follows more than one year of planning, design, construction and testing, and marks Australia's first large-scale photovoltaic (PV) solar project.

"With this landmark project now complete, partners Verve Energy and GE Energy Financial Services are now evaluating the possibility of expanding the plant to up to 40MW to satisfy growing demand for renewable energy," says Verve Energy's CEO Jason Waters.

The 10MW project should generate enough solar energy to power 3000 homes and displace 20,000 tonnes of greenhouse gases annually. The output will be purchased by WA Water Corp to help offset the energy requirements of its Southern Seawater Desalination Plant.

As well as supplying over 150,000 of its PV modules and engineering, procurement & construction services for the plant, First Solar will provide operations and maintenance services for the next 15 years.

Western Australian state-owned power utility, Verve Energy, and GE Energy Financial Services each own 50% of the Greenough River Solar Farm, with the WA Government having provided A\$20m in funding, including A\$10m from the WA Royalties for Regions program.

www.greenoughsolarfarm.com.au

First Solar partners on 50MW_{DC} of projects in Rajasthan

First Solar Inc of Tempe, AZ, USA, project developer Kiran Energy Solar Power Pvt Ltd of Mumbai, India and Mahindra Solar One Pvt Ltd (a joint venture between Kiran Energy and Mumbai-based conglomerate Mahindra) have completed an agreement for the supply of First Solar's cadmium telluride (CdTe) thin-film photovoltaic (PV) modules for two solar power plants totalling 50MW_{DC} to be constructed in India's Rajasthan state.

The two adjacent projects (collectively one of India's largest PV installations upon completion) are part of the second batch of utility-scale solar projects concluded under India's Jawaharlal Nehru National Solar Mission (NSM), which aims to install 20,000MW of new solar electricity generating capacity by 2022.

First Solar will supply more than 585,000 of its modules for the two projects of 30MW_{DC} and 20MW_{DC}. Construction on both projects is expected to begin this year and be completed in first-quarter 2013.

"We are pleased they [Kiran and Mahindra Solar One] selected our technology as the best solution for the high ambient temperatures and diffuse sunlight conditions here," says Sujoy Ghosh, First Solar's India country head.

"Kiran Energy, as well as our joint venture Mahindra Solar One, will own the largest solar power plant aggregation in a single location in India," notes Pramoda Karkal, chief operating officer of Kiran Energy, which has a total of 75MW under operation/construction and has a pipeline of solar PV projects in India.

Together, the side-by-side projects are expected to produce an average of more than 85,000 megawatt-hours of electricity per year (equivalent to the electricity needs of more than 97,000 average Indian households) and displace more than 80,000 metric tons of CO₂ annually, based on the national averages.

www.mahindra.com

www.firstsolar.com

First Solar to build four New Mexico solar projects totalling 20MW for PNM

First Solar is to construct four solar power plants totaling 20MW_{AC} of generating capacity for PNM Resources Inc.

First Solar will provide engineering, procurement & construction (EPC) services, using its cadmium telluride (CdTe) thin-film photovoltaic (PV) modules. The four projects are expected to create a total of up to 450 construction jobs at peak. The plants could be in service by the end of 2013, although the schedule is dependent on project approval by the New Mexico Public Regulation Commission, whose decision is expected in Q4/2012. PNM has the option to expand the agreement to a total of 22MW_{AC}.

The four solar plants will generate enough energy to power up to 7000 average New Mexico homes, displacing about 31,000 metric tons of CO₂ annually (equivalent to taking 6000 cars off the road).

The new solar projects are in addition to five projects totaling 22MW that First Solar completed for PNM in 2011.

"Our advanced technology and unparalleled experience designing and building solar power plants will help ensure PNM's customers enjoy many years of clean, reliable solar electricity," says Jim Tyler, First Solar's VP of engineering, procurement & construction.

www.pnmresources.com

IN BRIEF

PV module to power Himalayan villages

First Solar and Sir Ratan Tata Trust are collaborating on a pilot project to provide safe drinking water and irrigation to rural communities in India's northern Uttarakhand state.

Many remote villages of the middle Himalayas lack basic infrastructure. In Uttarakhand, even villages connected to the electrical grid receive only erratic supply. Without electric pumps, collecting water from springs and carrying it to villages can take 3–4 hours each day.

Through its charitable giving program, First Solar is working with the trust to develop a pilot project using its modules to help off-grid villages receive energy for essential needs such as safe drinking water and irrigation. The project aims to develop an integrated solution that is low-maintenance and simple for the communities to install, maintain and use.

Managed under the Trust's Central Himalayan program (Himmothan Pariyojana) by the Himmothan Society, the project will consist of two solar plants to be built in the Chureddhar and Chham (Gunogi) districts, Tehri Garhwal, Uttarakhand. The project could be replicated across hundreds of villages throughout India.

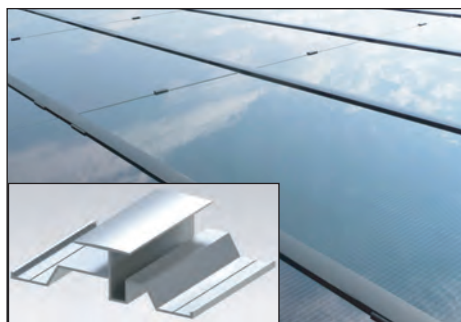
"We thank First Solar for partnering with us for the installation of this system, which will help us meet our community development goals," says Sir Ratan Tata Trust's development manager Ganesh Neelam.

First Solar will donate 100 modules to the pilot project, which will combine the modules with water pumps to move water from spring sources into storage tanks, benefiting 65 households, with a population of 530 individuals, in the two villages.

Calyxo launches lightweight system for fast assembly of PV modules without frames on trapezoidal sheet roofs

Cadmium telluride (CdTe)-based thin-film photovoltaic module maker Calyxo GmbH of Bitterfeld/ Wolfen-Thalheim, Germany has developed a new assembly system especially for the installation of modules without frames on trapezoidal sheet roofs. Made of durable aluminium, the MX1 insertion system allows the quick and safe assembly of Calyxo CX3 modules on-site. However, using the system (designed especially for fixing glass/glass laminates), modules without frames made by other manufacturers (with a maximum thickness of 6.8mm) can also be fixed on trapezoidal sheet roofs.

Installing CX3 modules using the MX1 assembly system loads the roof with less than 20kg/m², allowing assembly of PV power plants even on less load-bearing roofs, says Calyxo. Due to the insertion technol-



The Calyxo's MX1 assembly system for trapezoidal sheet roofs.

ogy, the modules can be installed without using any tools, as neither clamping nor screwing is required. Besides saving time, the concept is also gentle on the modules, says the firm. Due to the floating module installation, the thermal surface expansion of the profiles is uncoupled from the complete system.

Together with the black CX3 modules, compact, optically attractive

roof areas can be created that fit optimally into the architecture of a building, says Calyxo. At a customer's request, the system can be delivered in a black anodized design, as standard; Calyxo delivers the profiles in a mill finish design.

While the MX1 system is installed directly on trapezoidal roofs, the MX2 offers an assembly system especially designed for slanted roofs, which offers all the above-mentioned advantages but is assembled in cross connection.

The MX assembly systems are now available Europe-wide. Calyxo says that, with the MX assembly systems, it is extending its capabilities as an engineering, procurement & construction (EPC) supplier for efficient PV power plants, now offering an intelligent assembly system for proven and tested CX3 modules.

www.calyxo.com

IN BRIEF

UL certifies First Solar PV modules for 1000V systems

First Solar's thin-film Series 3 solar modules have been listed by UL (Underwriters Laboratories) as meeting standards UL1703 and ULC1703 for use in PV systems up to 1000V (the voltage typical for utility-scale PV power plants). The firm's modules were previously UL listed as meeting those standards for use in PV systems up to 600V.

"First Solar is pleased that UL has validated the quality and safety of our modules, which are the first thin-film PV modules to receive this certification," says Tom Kuster, First Solar's VP of product management & system technology.

www.ul.com

First Solar to construct 13MW plant for Dubai Electricity & Water Authority

First Solar Inc of Tempe, AZ, USA has been selected by state-owned company Dubai Electricity & Water Authority (DEWA) to construct a 13MW_{DC} solar plant in Seih Al Dahal, about 50km south of Dubai in the United Arab Emirates. First Solar will provide CdTe thin-film PV modules and engineering, procurement & construction (EPC) services.

The plant is the first phase of the landmark Mohammad Bin Rashid Al Maktoum Solar Park (named after the leader of the Emirate of Dubai), an AED12bn project that will cover 48 square kilometers and produce 1000MW of energy for the nation's capital using both PV and solar thermal technology.

"The PV plant installation is a key step in the implementation of the energy diversification strategy adopted by the Supreme Council of Energy," says HE Saeed Mohammed

Al Tayer, MD & CEO of DEWA. "The strategy is based on Dubai's growing energy requirements and aims to maintain security of supply," he adds.

The project illustrates First Solar's strategy to provide solar power plants in sustainable markets, says CEO Jim Hughes.

The plant should generate 22 million kilowatt hours of electricity per year, enough to supply over 500 local households annually and displacing more than 14,000 metric tons of CO₂ (equivalent to removing 1600 cars from the road).

The solar park will be implemented by Dubai's Supreme Council of Energy (SCE) and managed and operated by DEWA as part of the Dubai Integrated Energy Strategy 2030.

First Solar recently opened an office in Dubai and is establishing an office in Saudi Arabia as well.

www.firstsolar.com



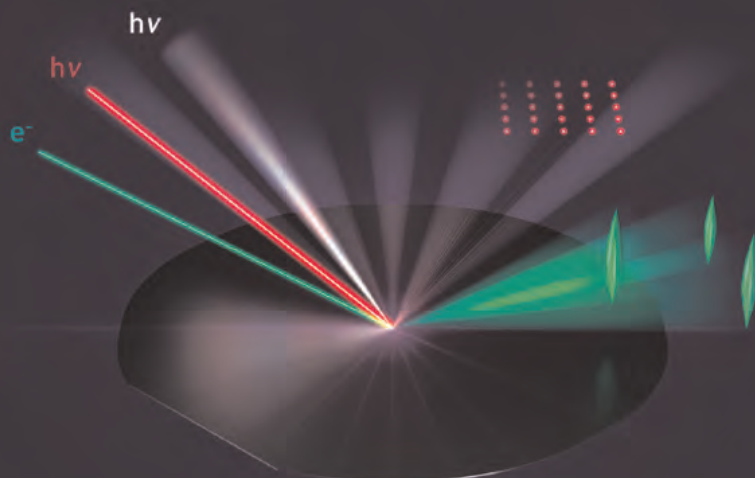
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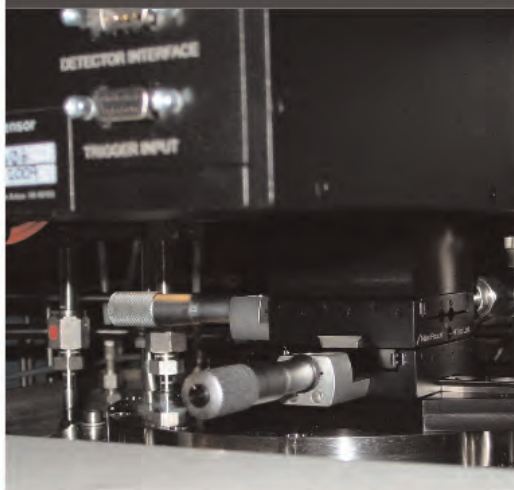
Real-Time Process Monitoring for MOCVD, MBE, Sputtering, and Thin-Film PV Deposition



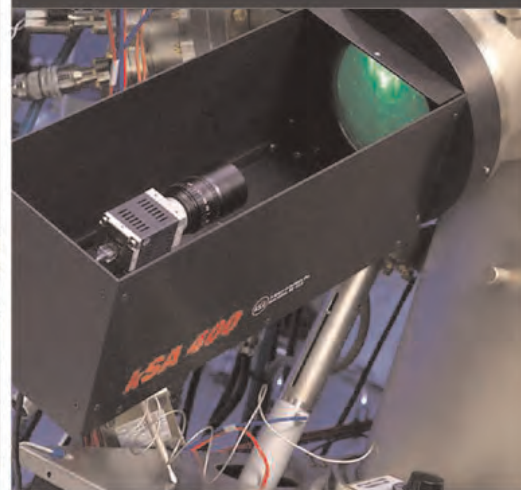
kSA BandiT Wafer Temperature



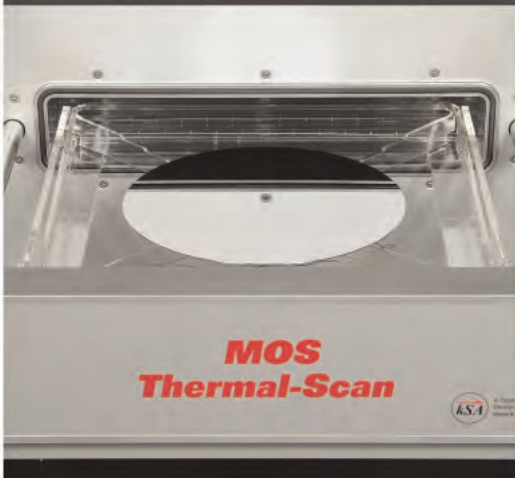
kSA MOS and kSA Mini-MOS Thin-Film Stress



kSA 400 Analytical RHEED



kSA MOS Ultra-Scan and Thermal-Scan Stress Mapping



kSA Rate Rat Pro Thickness & Deposition Rate



kSA BandiT PV Process Tuning



Solar Frontier consolidating production at 60MW MP2 plant into Kunitomi Plant

MP2 being evaluated for production of specialized solar modules

Tokyo-based Solar Frontier (a subsidiary of Japanese energy business Showa Shell Sekiyu) — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — is suspending production at its 60MW 'MP2' solar module manufacturing plant in Miyazaki prefecture in southwestern Japan as its 900MW flagship Kunitomi plant continues to demonstrate improved performance.

The firm is evaluating the role MP2 will play in opportunities to produce specialized solar products currently in development. The gigawatt-scale Kunitomi plant in Miyazaki began commercial production in February 2011 and all lines at the plant were operational by July 2011. It now produces CIS solar modules with efficiencies of 13–14%, delivering more kilowatt-hours per Watt than competing technologies such as crystalline silicon modules.



Solar Frontier's Kunitomi manufacturing plant.

The MP2 plant, which provided much of the knowledge base for the design efficiencies of the Kunitomi plant, has operated since 2009. It is currently being evaluated for future opportunities to produce specialized solar modules being developed at Solar Frontier's Atsugi Research Center for new and unique applications.

Employees will transfer their skills from MP2 to the Kunitomi plant and

to sales engineering roles. "They are a great resource of knowledge and expertise that will continue to help Solar Frontier grow," says president Shigeaki Kameda.

"The Kunitomi plant is the largest solar module manufacturing facility in Japan, and Solar Frontier is the only solar panel manufacturer in the world with production exclusively in Japan," says Kameda.

"With the heightened demand for solar in Japan, Solar Frontier is extremely well positioned with its combination of local manufacturing and skilled staff," he reckons.

"The knowledge base we have in our MP2 staff will contribute to Solar Frontier's progress beyond R&D and manufacturing," says senior VP Atsuhiko Hirano.

www.solar-frontier.com

Solar Frontier's production plant receives ISO 14001 and OHSAS 18001 certifications

Solar Frontier says that its gigawatt-scale Kunitomi solar panel production plant has received ISO 14001 and OHSAS 18001 certifications after passing stringent audit processes.

As one of the foremost environmental management systems standards worldwide, ISO 14001 is designed to provide assurance to company management and employees as well as external stakeholders that environmental impact is being measured and improved. ISO 14001 sets standards of stewardship for the environment that also help to reduce the cost of waste management, save in the consumption of energy and materials, and lower distribution costs.

OHSAS 18001 is a British stan-

dard for occupational health & safety management systems that is also recognized globally. It helps organizations to reduce risks to personnel and put the right health & safety measures in place. The standard also helps firms to find ways to improve and maintain occupational health & safety systems.

These ISO and OHSAS standards are routinely required in numerous applications and projects involving solar energy, and by attaining these certifications Solar Frontier's modules qualify to be included in such applications and projects. Both certifications are compulsory for projects in Italy to be eligible for the country's feed-in tariff, in accordance with Italy's 4th and 5th Conto Energia. Other countries

such as the UK, France and Mexico are considering similar requirements.

ISO 14001 and OHSAS 18001 are also an essential part of Solar Frontier's commitment to ensuring minimum impact on the environment and maximum safety of its employees.

Solar Frontier also meets appropriate standards set by Japan Electrical Safety and Environment Technology (JET), International Electrotechnical Commission (IEC), Underwriters Laboratories (UL), and the EU Restrictions on Hazardous Substances (RoHS) directive. Certifications for salt and ammonia resistance performed by TUV Rheinland confirm the modules' suitability for installation in coastal and agricultural areas.

Solar Frontier completes 80MWp delivery to EDF Renewable Energy's Catalina Solar Project

Tokyo-based Solar Frontier K.K. (a subsidiary of Japanese energy business Showa Shell Sekiyu K.K.) — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic (PV) solar modules — says that 80MWp of its modules have been delivered to the world's largest CIS thin-film solar power generation project. The modules will be part of the 143.2MWp Catalina Solar Project installation in Kern County, CA, developed, built and owned by renewable energy project developer EDF Renewable Energy (formerly enXco) of San Diego, CA, USA (an EDF Energies Nouvelles Company).

The project's first phase of about 50MWp should go online by the end of 2012, while the remainder is targeted for completion by June 2013. The plant will generate enough energy to power the equivalent of about 35,000 homes and will offset about 74,000 metric tons of greenhouse-gas emissions annually.

"This year, Solar Frontier will approach a cumulative total of a gigawatt of installations worldwide from the time of its founding," says Charles Pimentel, chief operating



Solar Frontier's CIS PV panels being installed.

officer of Solar Frontier Americas Inc of Santa Clara, CA. "With CIS demonstrating advantages from desert to tropical to sub-zero climates, our modules are especially well suited to the range of conditions here in California, where their higher kilowatt-hour production in real conditions ensures improved project economics," he claims, as Solar Frontier continues its growth in the Americas markets.

Solar Frontier delivered its modules to the Catalina project site in 623 shipping containers. Securing the modules on a custom-designed steel-resin pallet with reusable

plastic corner pieces, the firm has increased the module-container density of worldwide shipments by 130% and cut its logistics carbon footprint by more than 10%, while lowering its module breakage rate to what is claimed to be a record 0.002%. The new packaging solution ensures that there is also no more than 5m³ of on-site waste per megawatt-peak of modules shipped, helping customers to install projects with minimum ecological impact, the firm adds.

Solar Frontier's solar panels are manufactured at gigawatt-scale production facilities in Miyazaki Prefecture, Japan and meet JET, IEC, UL, RoHS and California Energy Commission standards. These standards, and collaboration with integrators, installers and energy providers such as Belectric, Juwi and Granite Construction, ensure quality, durability and reliability, claims the firm. The modules are available from 140W to 160W classes, operating with up to 13.0% efficiency and 14.1% aperture efficiency.

www.edf-re.com/projects/detail/catalina_solar_project
www.solar-frontier.com

Solar Frontier's CIS PV modules selected by Iberdrola for 1.5MWp of 5MW utility-scale project in Mexico

Solar Frontier and Iberdrola Ingeniería & Construcción Mexico S.A. de C.V. have announced completion of the delivery of 1.5 megawatt peak (MWp) of modules to a 5MW Iberdrola plant in Cerro Prieto, Mexico.

The Cerro Prieto project is owned by the state-owned electric utility company CFE, and will be the largest PV installation in Mexico when it goes into production by the end of 2012. The project is the first for Solar Frontier in the rapidly growing Central and South American market.

Iberdrola is combining Solar Frontier technology with competing technology in the project. Solar Frontier says that the hot climate and mounting on mono-axial trackers will be an opportunity to show the advantages of its CIS technology's lower temperature coefficient (valued for better performance in hotter conditions compared to crystalline silicon).

Iberdrola Ingeniería & Construcción Mexico S.A. de C.V. belongs to the Spanish group Iberdrola (one of the world's largest energy suppliers, with extensive experience

in renewable energy). Its goal by 2020 is to produce 20% less CO₂ per kWh than the overall European electricity sector.

"This is a significant opportunity for Solar Frontier to strengthen its position in the regions served by Iberdrola to Iberdrola's high standards," says Wolfgang Lange, managing director of Solar Frontier Europe in Munich, Germany. "We are demonstrating to our most discriminating customers that CIS technology delivers more kWh over the lifetime of a project for a lower cost," he adds.

Saint-Gobain signs MOU to build and operate CIGS PV module manufacturing facility in Saudi Arabia

Saint-Gobain of Courbevoie, France (which designs, makes and distributes building materials and electronic materials), represented by Jean-Pierre Floris (senior VP & president of the Innovative Materials Sector) has signed a memorandum of understanding (MOU) with HRH Prince Faisal Bin Salman Bin Abdulaziz Al Saud to establish a solar energy firm in Saudi Arabia. The signing ceremony was held in Torgau, Germany, where Saint-Gobain's Avancis affiliate has its thin-film photovoltaic (PV) module manufacturing plant.

Saint-Gobain will provide technical assistance and engineering expertise to build and operate a copper indium gallium diselenide (CIGS) thin-film PV module manufacturing facility in Saudi Arabia. The project is part of a larger program that includes the construction of solar

power plants in the Kingdom.

The firm says that the strategic alliance will lay the foundation for other businesses in the field of solar, and will accelerate the development of solar power plants equipped with modules made in Saudi Arabia using Avancis CIGS technology.

Fully aligned with the strategic priorities of K.A.CARE (the King Abdullah City for Atomic and Renewable Energy), the program should enable the development of a competitive manufacturing base in the Kingdom. K.A.CARE was established in April 2010 by Royal Decree and is in charge of developing nuclear and renewable energy in the Kingdom. It aims to install 41GWp of solar power by 2032, of which 16GWp should be contributed by PV power generation.

"The cost of the electricity pro-

duced in this way will have a very strong local content," says Floris.

HRH Prince Faisal reckons that the Kingdom will benefit in two different ways as a result of the partnership. "On the one hand, it is going to result in an alternative and efficient way of producing electricity and on other hand, the introduction of very innovative technology to the Kingdom of Saudi-Arabia will be the outcome."

Based on depositing CIGS thin films on a glass substrate, the technology developed by Avancis avoids using traditional crystalline silicon, enabling low production costs, like other thin-film based techniques, while its electrical efficiency (over 12% industrially and up to 20% in laboratory) is comparable to the higher yields produced by polycrystalline silicon modules, says the firm.

www.saint-gobain.de/en

InnoLas' laser scribes installed at Korean CIGS PV fab

InnoLas Systems GmbH says that it recently installed P1, P2 and P3 scribes at a 100MW copper indium gallium diselenide (CIGS) photovoltaic cell fabrication plant in Korea, showing that the firm's laser technology for P2 scribing of thin-film solar cells is gaining global acceptance. So far this year InnoLas has delivered P2 laser scribes for structuring CIGS semiconductors to four different customers. The laser patterning tools support 250MW of production volume worldwide.

"The current installations are a further step in the successful roll-out of our laser scribe systems for thin-film solar cells," says CEO Richard Grundmüller. "Not only for the processing of CIGS but also for other semiconductors, e.g. CdTe [cadmium telluride] cells," he adds. "Up to September this year we have already developed, built and installed P1, P2 and P3 scribing



Innolas' Impala wafer scribing system.

systems for a fab capacity of 300MW."

InnoLas also offers laser systems for R&D applications. The firm has received an order for a multi-functional laser tool, tailored to the rigorous requirements in modern photovoltaic development labs. This system can process any individual pattern, either from the film side or from the glass side, with

multiple wavelengths. All layers (P1, P2 and P3) can be laser scribed, and the processing side and process parameters are selected through simple menu commands. Mechanical scribing (P2, P3) is available on the same system. Features include integrated in-situ metrology,

giving 100% control over scribe performance and enabling the user to optimize process parameters on the fly.

InnoLas exhibited its laser scribing systems at the 27th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC 2012) trade show in Frankfurt-am-Main, Germany (24-28 September).

www.innolas.com

centrotherm photovoltaics submits reorganization plan to court

Creditor approval targeted for return to fully independent operation

After filing for Chapter 11-type insolvency protection in July, centrotherm photovoltaics AG of Blaubeuren, Germany, which provides equipment and turnkey production lines for manufacturing both crystalline silicon solar cells and copper indium gallium diselenide (CIGS) thin-film solar modules, has submitted its reorganization plan to the District Court of Ulm. After being examined by the court, the insolvency plan will be presented to creditors, who will then decide whether to accept it in a separate discussion and voting meeting.

"Our aim is to maintain centrotherm as an independent company," says the company's own administrator Tobias Hoefer. "Ultimately,

this would benefit everyone involved in the process."

If the plan is accepted by the creditors and confirmed by the court, the proceedings can then be terminated, in line with the regulations of the German Act Relating to the Further Simplification of the Reorganization of Companies (ESUG) and Section 270b of the German Insolvency Directive (InsO). centrotherm photovoltaics says it could then operate again on the market as a reorganized company on a fully independent basis.

The same applies for the subsidiaries centrotherm thermal solutions GmbH & Co KG and centrotherm SiTec GmbH, which are currently engaged in their own proceedings and for whom insol-

vency plans have also been submitted to the court.

The court has appointed professor Martin Hörmann, a lawyer from legal firm Anchor Rechtsanwälte, as centrotherm photovoltaics AG's administrator. Anchor Rechtsanwälte lawyer Alexander Reus has been appointed administrator for centrotherm thermal solutions GmbH & Co. KG and centrotherm SiTec GmbH.

Insolvency creditors of the companies named can register their receivables to the court-appointed administrator by 5 November to participate in the continuation of the process and to enable them to decide on approval of the insolvency plans.

www.centrotherm-pv.com

XsunX completes CIGSolar deposition system assembly

Expansion into new CIGSolar marketing and technology demonstration facility on fast-track completion schedule

XsunX Inc of Aliso Viejo, CA, USA, which is developing hybrid copper indium gallium (di)selenide thin-film (CIGS) photovoltaic (TFPV) cell technologies and 'CIGSolar' manufacturing processes, was due to complete assembly of its CIGSolar TFPV cell evaporation system in October. The firm has implemented a fast-track completion schedule to expedite its technology demonstration and marketing efforts.

In July, XsunX announced that it had received equity financing through Ironridge Energy Co, an institutional investor financing small-cap public companies in the energy sector. The funding is enabling XsunX to focus on assembling and configuring a demonstration of the CIGSolar TFPV cell evaporation system while also establishing technology marketing operations in its new facility in

Irvine, CA. "We are pleased to have had the opportunity to help facilitate the development of XsunX's unique TFPV cell evaporation system," says Ironridge's managing director John C. Kirkland. "The CIGSolar system offers the potential to improve operating efficiencies for the TFPV industry," he adds.

"We have been anxious to launch the start-up, testing and calibration of our patent-pending CIGSolar technology so that we can begin customer demonstrations as quickly as possible," says XsunX's CEO Tom Djokovich. "The industry's obvious need and the focus of our CIGSolar TFPV cell evaporation technology is to provide cost reductions and an opportunity to restore operating margins for manufacturers," he adds. "How to achieve these goals has been an elusive challenge for the industry, but we believe that

CIGSolar's new approach is the right solution to this challenge."

The firm says that its method, unlike other CIGS manufacturing technology, uses individual thin stainless-steel substrates sized to match silicon cells to be used as an alternative to silicon cells in existing or new solar module assembly lines. Another improvement is the use of multi-small-area thermal co-evaporation technology to better control the complex management of the CIGS layer deposition process. This provides a more precise deposition environment, the firm claims. Together, these improvements help to avoid performance losses experienced when cells are either cut from rolls of CIGS material or mismatched electrically in monolithic large-area deposition assemblies.

www.xsunx.com

Arsenide nanowires on graphite and graphene

Researchers in Norway devise a new production template for solar cells, LEDs and self-powered consumer devices.

Researchers at Norwegian University of Science and Technology (NTNU) have succeeded in growing gallium arsenide (GaAs) and indium arsenide (InAs) compound semiconductor crystal nanowires (NWs) on graphitic substrates such as few-layer graphene [A. Mazid Munshi et al, Nano Lett., published online 13 August 2012]. The researchers see this as a breakthrough, since earlier attempts to grow semiconductor crystal thin films on graphene and other graphitic substrates have thus far failed.

The NTNU spin-out Crayonano AS has already patented the technology developed by a team under the leadership of the company's founders, NTNU professors Helge Weman and Bjørn-Ove Fimland.

"We do not see this as a new product," Weman says. "This is a template for a new production method for semiconductor devices. We expect solar cells and LEDs to be first in line when future applications are planned."

Crayonano sees application potential for self-powered nanomachines and advanced 3D integrated circuits built on graphene and semiconductor nanowires, enabling smaller and more efficient electronics with self-powered consumer devices integrated into everything from clothes to notepads, along with more traditional uses

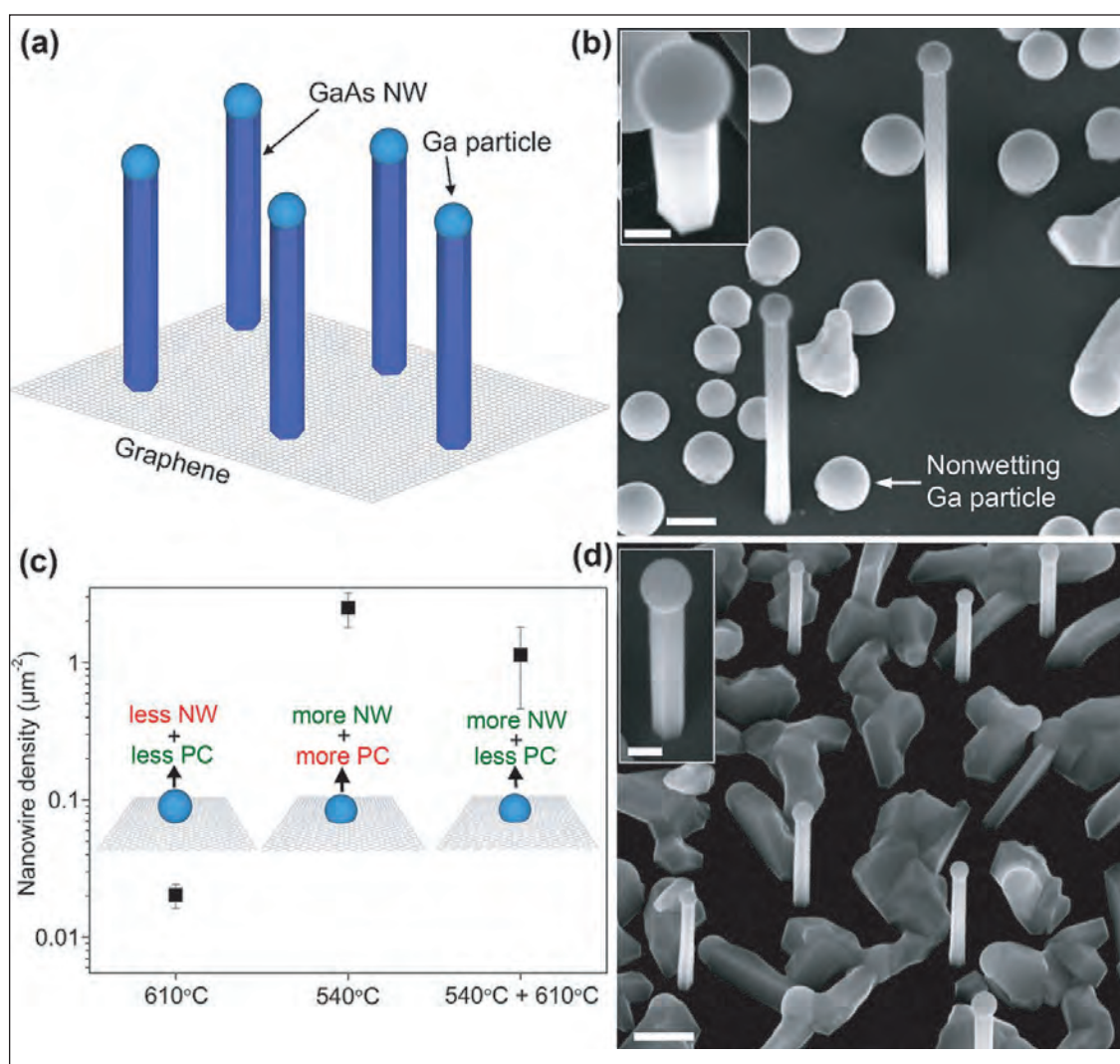


Figure 1. (a) Schematic of self-catalyzed GaAs nanowires on graphitic surface.

(b) SEM image of nanowires grown on graphite. Inset, near top-view image.

(c) Variation in average nanowire density with growth temperature. Insets:

schematic of contact angles of Ga catalyst droplet at different temperatures. (d) SEM image of nanowires grown on graphite by two-temperature growth. Inset: tilted-view image of one nanowire. Scale bars are 200nm in main figures and 100nm in insets.

in cell phones, tablets and exercise accessories.

The paper adds: "We anticipate this particular GaAs nanowire/graphene hybrid to be promising for flexible and low-cost solar cells."

The researchers also analyzed the ways in which compound semiconductor crystals can accommodate themselves to the underlying graphite/graphene

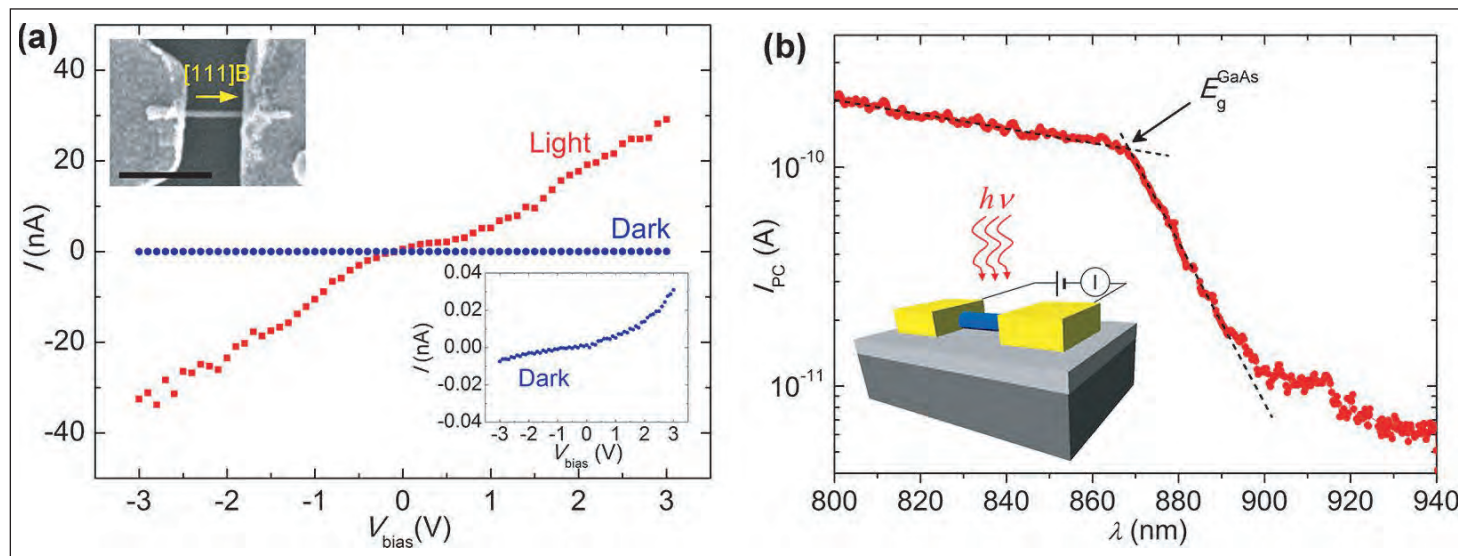


Figure 2. Photocurrent response of a single GaAs nanowire photodetector. (a) I–V curves of a single GaAs nanowire photodetector. Blue circles are measured dark current; red squares are measured photocurrent. Photocurrent was measured using an 800nm laser line with estimated power density of $\sim 2.5\text{ kW/cm}^2$. Bottom inset: dark current with enlarged y-axis. Top inset: SEM image of photodetector. Scale bar 500nm. (b) Wavelength dependence of photocurrent for nanowire at applied bias of 50mV. From crossing of black dashed lines, absorption edge was estimated to be $\sim 869\text{ nm}$ (1.427 eV), denoted by black arrow. Inset: schematic of fabricated nanowire photodetector.

hexagonal chickenwire structure. They found that their grown material fitted well with their theoretical concepts. In particular, growth of nanowires accommodates a larger mismatch in lattice parameters, compared with thin films of semiconductor.

The vertical GaAs nanowires (Figure 2) were grown on graphitic and few-layer graphene surfaces using self-catalyzed vapor-liquid-solid molecular beam epitaxy (MBE). The flux of the source gases needs to be optimized to increase the number of nanowires (NWs) and decrease the occurrence of parasitic crystals (PCs). In particular, it was found that a reduced temperature of 540°C was needed in the nucleation phase to form GaAs droplets with reduced contact angle that seems to favor the growth of nanowires. The nucleation was followed by a higher-temperature growth step at 610°C that reduced the number of PCs. The nucleation phase lasted 10 seconds and the higher-temperature growth step was five minutes long.

The graphene-based nanowires were grown on graphene produced through epitaxy on silicon carbide (SiC) substrates. The researchers have also grown InAs NWs on graphite.

High-resolution transmission electron microscopy (HR-TEM) showed zincblende (ZB) and wurzite (WZ) crystal structure sections of the NWs, with ZB predominant. However, in the lower sections a mixture of segments are found that the researchers attribute to “a combination of catalyst droplet shape change due to the two-temperature transition and strain relaxation in the nanowire due to the growth on a lattice-mismatched substrate”.

The researchers say that there is a need to control the nucleation introduced by external manipulation to allow increased nanowire density and further reduction of parasitic crystallites. Ultimately, they want to find a method for positioning the vertical semiconductor nanowires on graphene for device applications, rather than depending on random initiation of the NW growth.

The researchers used GaAs NWs produced on graphite to create photodetectors (Figure 2). The contacts consisted of gold. In dark-mode, the resistance was more than $1\text{ G}\Omega$. With laser illumination, the current increases by three orders of magnitude. Due to the high surface charge density of the unpassivated NWs, the researchers believe that the majority of the photocurrent arises from the metal-semiconductor contact region. The calculated responsivity is $\sim 30\text{ mA/W}$, “which is three orders of magnitude larger than previously reported for a single GaAs nanowire.”

The good optoelectronic performance of these devices is taken as an indication of the high purity of the wires with no apparent contamination from the graphite substrate. A sharp absorption edge occurs at a wavelength around 869 nm with a width of about 30 nm (50 meV), which is comparable to the performance of intrinsic crystalline GaAs.

The researchers conclude: “These results convey that GaAs nanowires grown on graphite are at least of similar optoelectronic quality as the ones grown on GaAs substrates, and hence can be equally useful for nanowire optoelectronic applications.”■

<http://pubs.acs.org/doi/suppl/10.1021/nl3018115>

Author: Mike Cooke

First nonpolar nitride semiconductor VCSELs

...and first observation of polarization locking in GaN VCSELs, reports University of California, Santa Barbara.

University of California, Santa Barbara (UCSB) has demonstrated for the first time nonpolar m-plane (10 $\bar{1}0$) nitride semiconductor vertical-cavity surface-emitting laser (VCSEL) diodes [Casey Holder et al, Appl. Phys. Express, vol5, p092104, 2012].

The VCSEL structure is attractive based on its generally lower threshold current, single-longitudinal mode operation, wafer-level testing, circular and low-divergence output beams, and the ability to form densely packed, two-dimensional arrays. Until recently, VCSEL development has been focused on arsenide and phosphide compound semiconductor material systems.

Producing VCSELs in nitride semiconductor materials would yield shorter-wavelength devices. Already, c-plane violet and blue nitride VCSELs have been produced that emit in continuous-wave (cw) operation at room temperature. The more challenging green part of the spectrum has been achieved with pulsed operation at room temperature. These shorter-wavelength devices could find application in displays, high-density optical data storage, high-resolution printing, and biosensing.

Nitride semiconductor materials have large polarization fields that arise both spontaneously and through strain-dependent effects on the crystal structure. These fields reduce light emission efficiency, for example by related electric fields reducing the overlap between electrons and holes flowing through the device.

In the m-plane crystal orientation, these fields are perpendicular to the current path and hence avoid the overlap problem. However, m-plane material epitaxial growth is less established than c-plane, which has been developed intensely for the past two decades. This means that m-plane nitrides will tend to have higher defect levels, and defects reduce light-emission efficiency.

The material for the VCSELs was grown using atmospheric-pressure metal-organic chemical vapor deposition (AP-MOCVD) on Mitsubishi Chemical free-standing m-plane gallium nitride (GaN) offcut $\sim 1^\circ$ in the negative c-direction (Figure 1). The active region consisted of five 7nm 10%-indium gallium nitride (InGaN) wells with 5nm GaN barriers. The electron-blocking layer consisted of 15nm p-type 20%-aluminium gallium nitride (p-AlGaN).

To enable separation of the substrate from the device layers, a sacrificial region of three 7nm 12%-InGaN wells with 5nm GaN barriers was embedded in the n-GaN buffer region. This region was used to create photoelectrons during a selective chemical etch process. Also, in the n-GaN buffer, 15nm of 30%-AlGaN region was placed ~ 50 nm above the sacrificial region to define the 7.5-wavelength cavity and to prevent holes from the etch process reaching the sidewalls of the device.

The device regions were created with a mesa etch that was then covered with silicon nitride to protect the active-region sidewalls during the photoelectrochemical

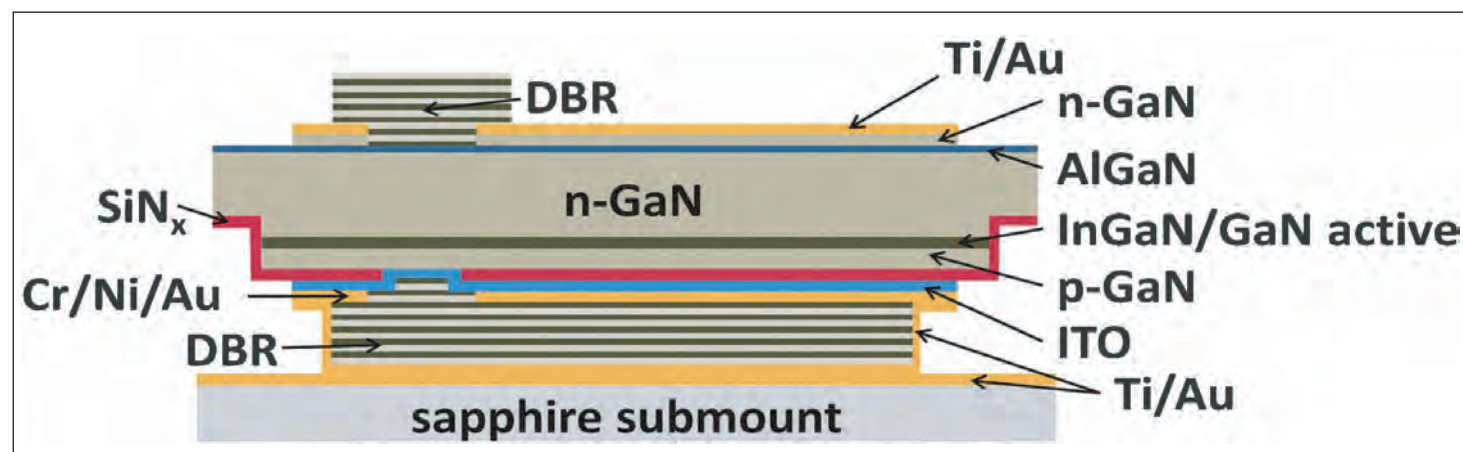


Figure 1. Cross-sectional schematic of nonpolar m-plane GaN VCSEL with flip-chip design and dielectric mirrors.

(PEC) etch removal of the substrate. Current apertures with a diameter of 7–10 μm were also defined in the SiN material. Indium tin oxide (ITO) transparent conductor (50nm thick, or about a quarter of a wavelength) was applied to the p-GaN top layer using electron cyclotron resonance (ECR) sputtering.

The metal ring p-contact was followed by dielectric layers of silicon dioxide and tantalum pentoxide to create a 13-period distributed Bragg reflector ($\text{SiO}_2/\text{Ta}_2\text{O}_5$ DBR).

The PEC was prepared with a second mesa etch to expose the sacrificial undercut layer. The sample was flip-bonded to a gold-coated sapphire submount. A 405nm laser light source was used to create photo-electrons in the sacrificial layer to allow selective etching during exposure to potassium hydroxide (KOH) solution, removing the free-standing GaN substrate.

A metal ring n-contact was then formed, aligned with the p-contact aperture. A further PEC used the n-AlGaIn layer as etch stop. The n-aperture was then coated with a 10-period $\text{SiO}_2/\text{Ta}_2\text{O}_5$ DBR.

When operated, the VCSELs tend to have bright spots smaller than the full aperture diameter, which could be due to inhomogeneity in the cavity as a result of interface roughness or local cavity-length variations. This effect has been seen in other nitride-based VCSELs. Under pulsed operation (30ns, 0.03% duty cycle), the peak output was 19.5 μW with a threshold current of 70mA.

"The high threshold current may be due to excessive optical loss in the cavity or leakage currents caused by cracking during the bonding process," the researchers comment. The team is investigating how to reduce the optical loss of the cavity and has alternate designs that would reduce the parameter to 30% of its present value.

Spectral analysis with 0.3%-duty-cycle pulse operation at 100mA current gave a single peak at 411.9nm wavelength with a full-width half maximum (FWHM) of 0.25nm, which is close to the resolution limit of the measuring equipment. The distance between cavity modes is estimated to be 15nm, so a FWHM of 0.25nm gives only one mode within the gain bandwidth.

The polarization ratio of the emitted light increased with current. In the sequence 60mA, 80mA, 100mA and 120mA, the ratios were 0.13, 0.15, 0.62 and 0.72, respectively. The researchers point out that their measurements were carried out on-wafer with no special measures to eliminate spontaneous emission or light scattering. They estimate that at 120mA the spontaneous emission is around 25% of the total.

"Higher stimulated emission power and more sophisticated measurements will result in a significant increase in the polarization ratio, as spontaneous emission becomes a smaller fraction of the total light collected and collection of scattered light is reduced," they write.

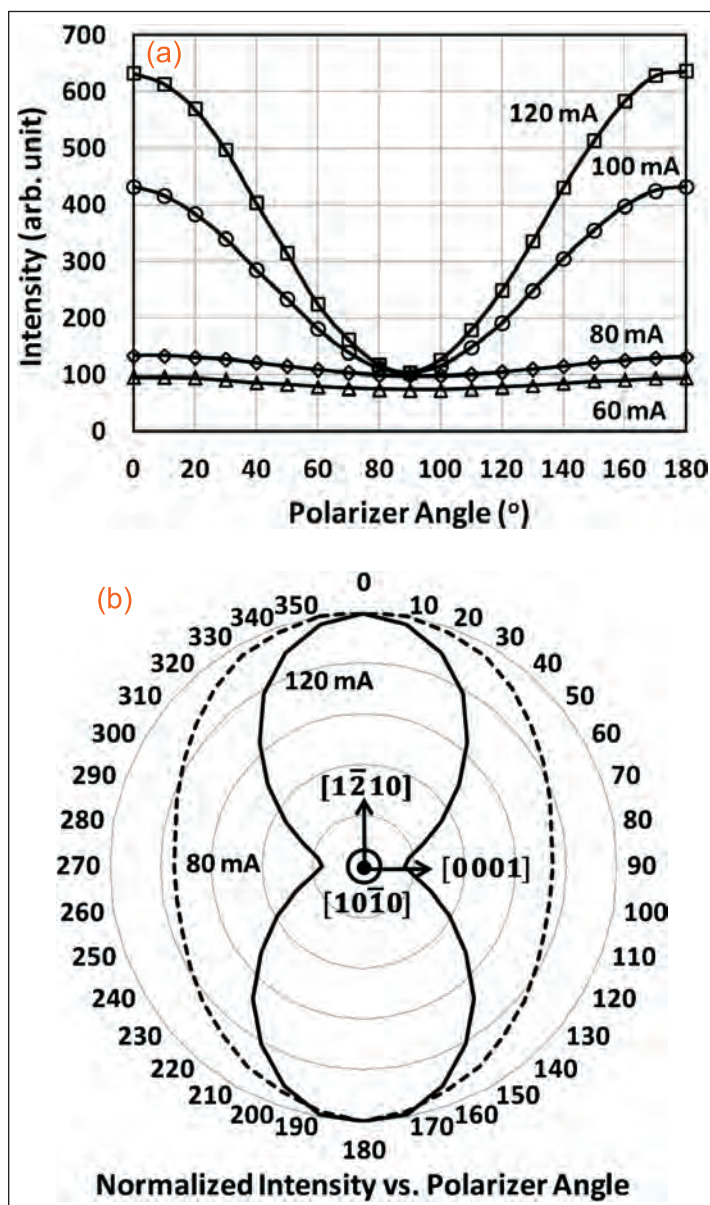


Figure 2. (a) Normalized light intensity versus polarizer angle at various currents above and below threshold. (b) Normalized light intensity versus polarizer angle well above and near threshold, plotted in radial coordinates.

The laser emission is found to polarize along the $[1\bar{2}10]$ a-direction of the underlying wurtzite crystal structure. The researchers comment: "This is in agreement with observations of anisotropic gain in edge-emitting nonpolar GaN lasers and is believed to be the first observation of polarization locking in GaN VCSELs. This unique feature could be used to fabricate arrays of GaN VCSELs which are inherently polarization-locked and may be attractive for a variety of applications, including displays, sensors, pico-projectors, coherent detection systems, and communications."

VCSELs produced using c-plane materials have random polarization of emitted light modes. ■

<http://apex.jsap.jp/link?APEX/5/092104>

Author: Mike Cooke

Osram Opto achieves cyan nitride semiconductor superluminescent LED

InGaN device outputs more than 4mW of 500nm-wavelength light, promising application to projectors.

Germany's Osram Opto Semiconductors GmbH has achieved super-luminescent light emission at wavelengths as long as 500nm in an indium gallium nitride (InGaN) diode [Fabian Kopp et al, Appl. Phys. Express, vol5, p082105, 2012]. Previously, InGaN super-luminescent light-emitting diodes (SLEDs) have been hindered at longer wavelengths due to low gain in the indium-rich active regions of these devices.

The researchers see SLEDs as an attractive option for projector applications. SLEDs combine the high light density and directionality of laser diodes with the broader emission spectrum of LEDs. The SLED operation uses stimulated emission effects to increase light output, but the devices are designed to avoid laser threshold.

For full-color operation one needs red, green and blue devices. At present, there are no SLEDs reported for the green spectral region (520–570nm). Although shorter-wavelength SLEDs have been achieved, as one increases the indium content to narrow the bandgap to access longer wavelengths, the gain of the material degrades due to deterioration in material quality. Fluctuations in indium concentration broaden the gain spectrum and reduce the peak gain.

Osram produced a SLED by curving the cavity of an edge-emitting device structure, similar to that of laser diodes (Figure 1). The purpose of the curving was to allow the rear facet to be highly reflecting for double-

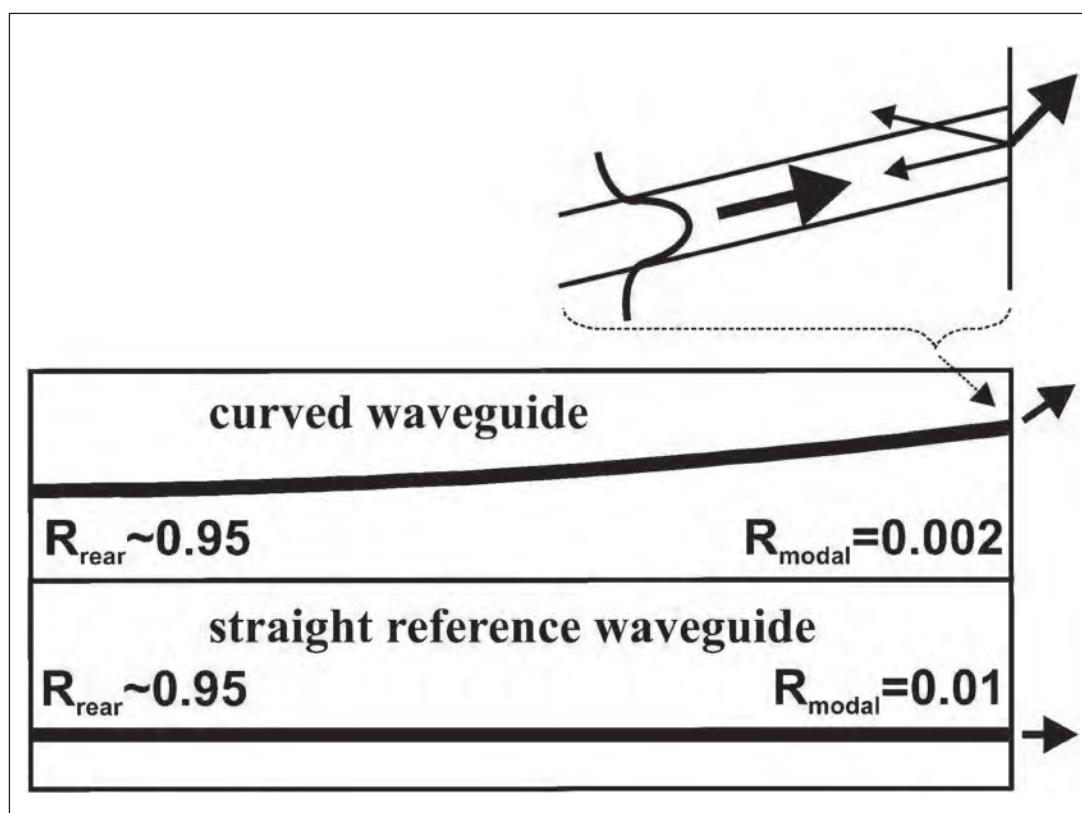


Figure 1. Detailed drawing of planar waveguide with tilted facet and incident waveguide mode (top), curved waveguide with perpendicular rear and tilted out-couple facet (middle), and a straight reference waveguide (bottom).

pass amplification of the light by stimulated emission, while at the same time to allow the out-couple facet to be slightly tilted, reducing its modal reflectivity to avoid lasing. Double-pass amplification effectively squares the gain of a single pass.

The epitaxial material was grown on sapphire using metal-organic chemical vapor deposition (MOCVD). The InGaN quantum well light-emitting region was sandwiched between p- and n-type aluminium gallium nitride cladding and GaN waveguide regions. Ridge waveguides were formed that were 1200µm long and 2µm wide. The end facets had dielectric layers applied to give reflectivities of 95% (rear) and 1% (out-couple).

Two forms were given to the waveguide: in one, a traditional straight waveguide was formed with both facets perpendicular to the axis of the cavity; in the other, the waveguide was curved with a radius of around 34mm. The rear facet in the latter device was perpendicular to the light path, while the out-couple facet was tilted by around 2° . The tilting gave a calculated modal reflectivity of 0.2%.

The straight light-emitting device had an apparent threshold for lasing at $\sim 400\text{mA}$ and showed a super-linear output power current characteristic. By contrast, the curved cavity device showed an exponential output power characteristic that is a typical behavior for SLEDs.

The straight cavity device also had a narrower spectral peak around 501nm with full-width at half maximum (FWHM) of less than 1nm (Figure 2). The curved-cavity SLED had a peak at $\sim 500\text{nm}$ with a much broader FWHM of 4.4nm when the output power was more than 4mW ($\sim 450\text{mA}$). At a higher current of 460mA, spectral modulation of the emission spectrum occurs, "because the higher gain compensates the low modal reflectivity of the tilted out-couple facet".

The researchers found a blue-shift trend for the curved SLED at increasing current densities of $0.5\text{kA}/\text{cm}^2$, $1\text{kA}/\text{cm}^2$ and $20\text{kA}/\text{cm}^2$, of 526nm, 513nm, and 500nm, respectively. The $1\text{kA}/\text{cm}^2$ ($\sim 24\text{mA}/(1200\mu\text{m} \times 2\mu\text{m})$) level is the threshold current density of a good laser diode. The blue-shift is seen as the result of screening of the original polarization field of the InGaN structure, which red-shifts the emission spectrum, by increasing densities

of free carriers at high currents.

The super-luminescent property of the emission was confirmed by the increase in degree of polarization of the light from 88% at 50mA to 98% at 450mA. ■

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Author: Mike Cooke

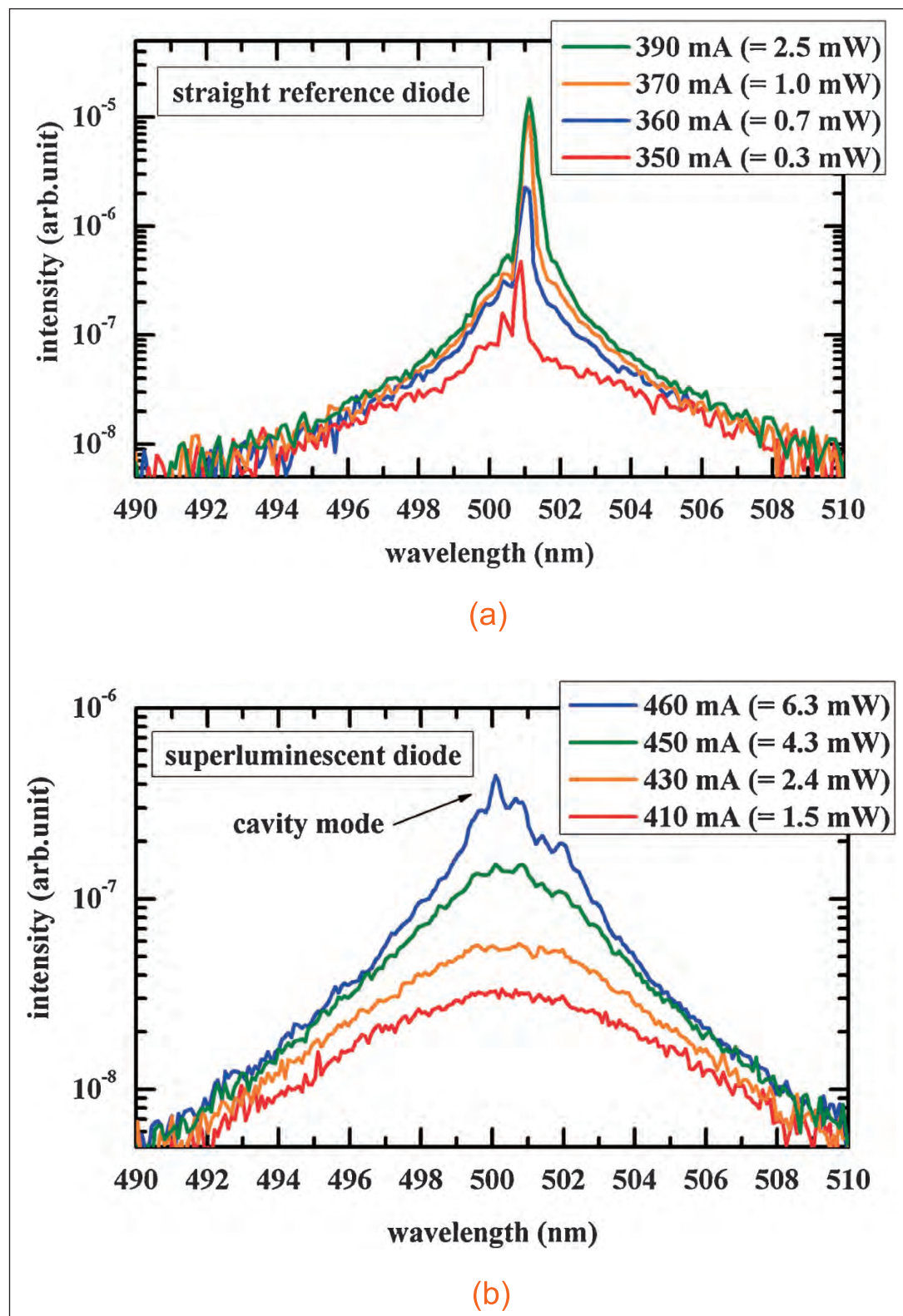


Figure 2. Emission spectra for (a) the straight reference diode and (b) the superluminescent diode at several currents driven in pulsed mode at a pulse width of $1\mu\text{s}$, a duty cycle of 1%, and a temperature of 25°C .

Thermal droop improved in semi-polar nitride LEDs

UCSB reports characteristic temperature of almost 900K for (20 $\bar{2}$ 1)-oriented semi-polar nitride LED.

Researchers from University of California, Santa Barbara (UCSB) have measured thermal droop for the first time in semi-polar nitride semiconductor light-emitting diodes (LEDs) [Chih-Chien Pan et al, Appl. Phys. Express, vol5, p102103, 2012]. In line with previous experiments on efficiency droop, the researchers found improved thermal stability for the semi-polar devices, compared with traditional polar c-plane LEDs.

Nitride-based LEDs show efficiency degradation at high current (current droop) and high temperatures (thermal droop). These behaviors limit the performance of nitride LEDs for applications such as automotive headlights, interior/exterior lighting, and full-color displays.

UCSB has developed LEDs on semi-polar nitride materials with (20 $\bar{2}$ 1) crystal orientation. Their previous work has achieved current droops of just 4% at 100A/cm² current density from a peak external quantum efficiency (EQE) of 50%. For conventional c-plane LEDs the comparative current droop is of the order 40% at the same current density.

The researchers used on-axis free-standing (20 $\bar{2}$ 1) GaN substrates from Mitsubishi Chemical to produce epitaxial material through metal-organic chemical vapor deposition (MOCVD). LEDs were produced (Figure 1) that were mounted on ceramic plates and tested in a customized integrating sphere fitted with a thermoelectric cooler (TEC). Pulse operating conditions were used to avoid uncontrolled self-heating effects. The pulse length varied between 30ms and 10 seconds.

The external quantum efficiency of the devices gradually declined with increasing temperature. A lower EQE was seen compared with the previous experiments on devices that were encapsulated in silicone. The researchers believe the decline with temperature is due to the effects of non-radiative recombination, Auger recombination and carrier leakage.

The maximum EQE occurs at around 40A/cm² current density. The thermal droop was given as the decrease in EQE between 20°C and 100°C as a fraction of the EQE at 20°C (Figure 3). For 1A/cm² current density the thermal droop was 22.5%, and at 100A/cm² 9.7%. The droop was less than 10% for current densities greater than 20A/cm². The high thermal droop at lower current densities is attributed to the more temperature-

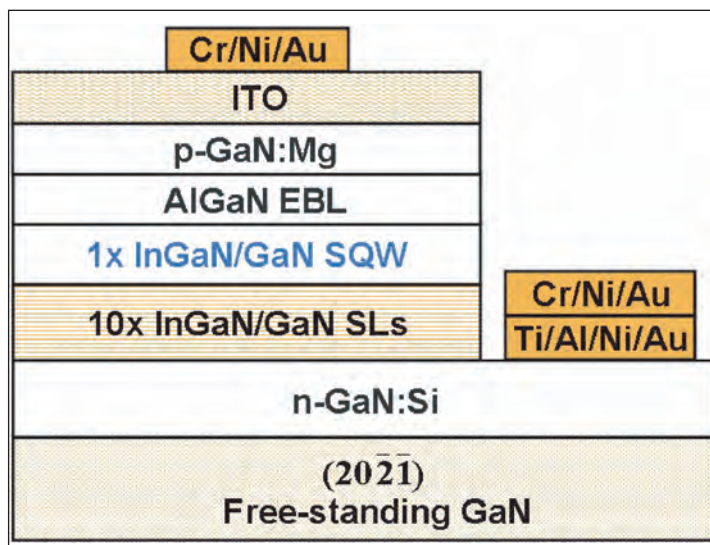


Figure 1. LED structure on semi-polar (20 $\bar{2}$ 1) free-standing GaN.

dependent Shockley–Read–Hall (SRH) mechanism of non-radiative recombination through states in the bandgap. Thermal droop in c-plane LEDs is typically more than 20% at 100A/cm².

The researchers also used their results to extract a characteristic temperature relative to performance at 293K (20°C). Conventional c-plane devices have a T_c around 170K, but the UCSB semi-polar devices had a

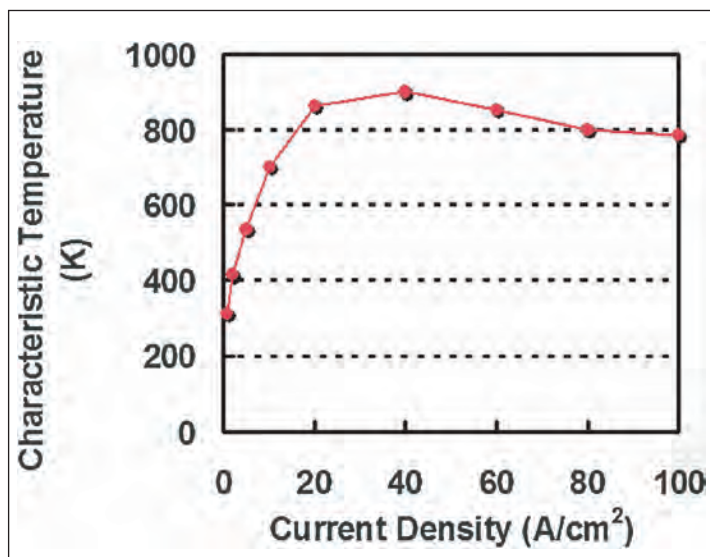


Figure 2. Characteristic temperature as function of current density for UCSB semi-polar SQW blue LED.

T_c of almost 900K (see Figure 2), both values being determined at $40\text{A}/\text{cm}^2$. The researchers comment that higher values of T_c show improved output power stability as a function of temperature for the semi-polar devices.

The researchers also investigated junction temperature under DC operating conditions. At $100\text{A}/\text{cm}^2$, the junction temperature was around 68°C , according to the dependence of forward voltage on temperature. An infrared camera gave a similar figure of around 64°C .

The researchers see the improved performance over c-plane devices as coming from the material being relatively free of indium fluctuations. Such fluctuations in c-plane devices cause carrier localization and band filling. These lead to pockets of increased carrier densities where Auger recombination and carrier leakage can eat away at radiation efficiency and reduce the effective active region volume.

The UCSB structure uses a thick 12nm single quantum well (SQW), rather the more usual multi-quantum wells of 2nm or 3nm.

The researchers comment: "In our semi-polar (2021) LEDs, polarization-related electric fields are significantly reduced; an SQW active region eliminates carrier non-uniformity issues. Additionally, the thick high-quality homogeneous InGaN layer grown at a relatively high growth temperature reduces the effects of potential fluctuations and lowers the average carrier density. The result is a much larger effective active

region volume than that of conventional c-plane LEDs. This reduces the effects of Auger recombination and carrier leakage by reducing the carrier density, resulting in a device with a low efficiency droop."

These same factors are also thought to improve the thermal droop behavior. ■

<http://apex.jsap.jp/link?APEX/5/102103>

Author: Mike Cooke

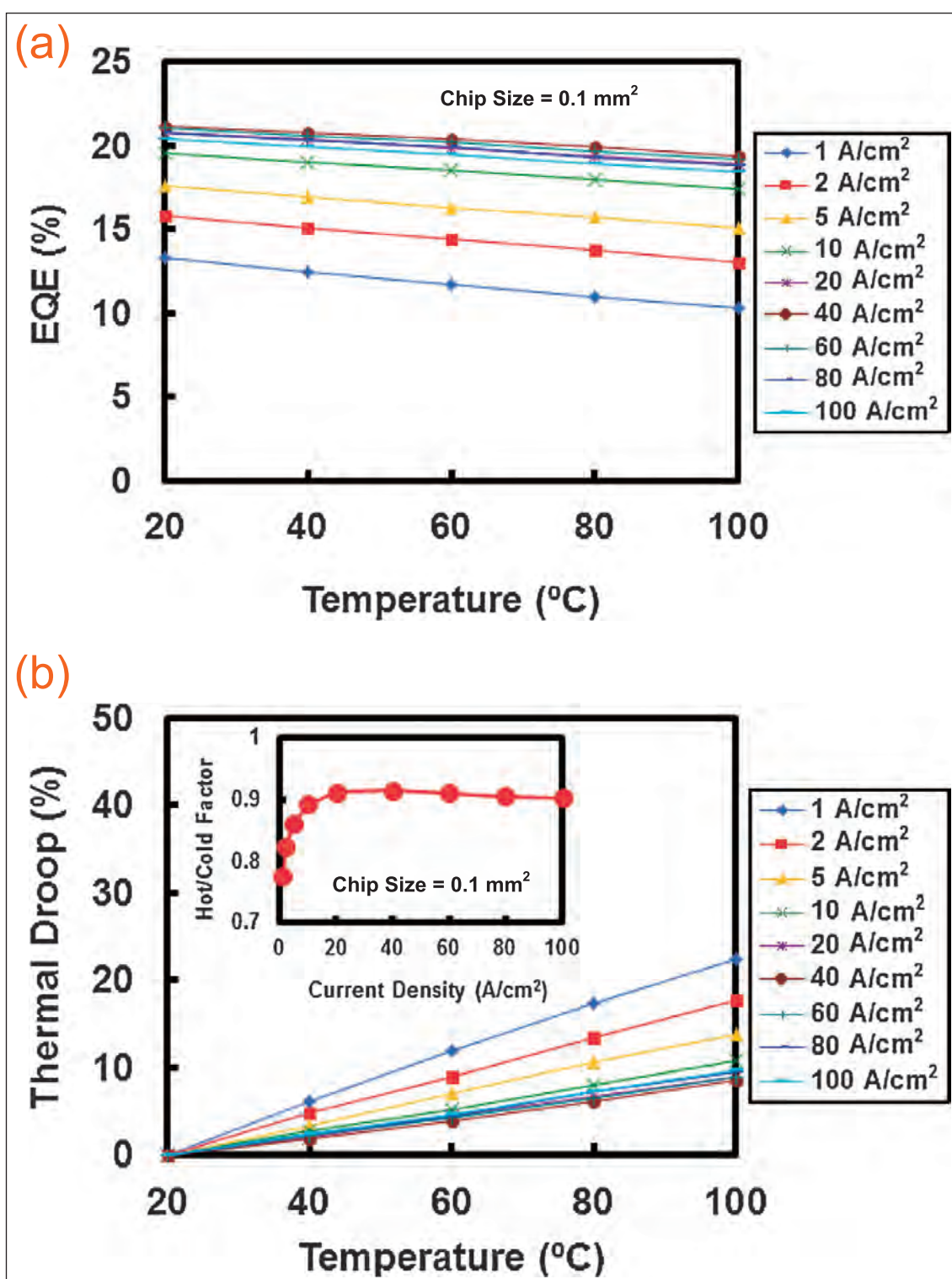


Figure 3. Current-density-dependent (a) EQE, and (b) thermal droop as a function of temperature for UCSB semi-polar SQW blue LED. Inset: Hot/cold factor as a function of current density, comparing EQEs at 100°C and 20°C .

Tuning micro-pillars to increase light extraction from nitride LEDs

Up to 100% increase in output seen without impacting electrical performance.

Rensselaer Polytechnic Institute (RPI) and Samsung Electronics have used tapered micro-pillars of titanium dioxide (TiO_2) to increase light extraction from nitride semiconductor light-emitting diodes (LEDs) by up to 100% [Ming Ma et al, Appl. Phys. Lett., vol101, p141105, 2012].

Light extraction is a problem in nitride LEDs because there is a large difference in refractive index between gallium nitride (GaN, refractive index ~ 2.5) surfaces and air (refractive index 1). This difference restricts the escape cone for light to just 24° (Figure 1a).

The light extraction can be enhanced through surface texturing with micro-pillars. With vertical sidewalls these pillars can give a certain amount of enhancement (Figure 1b), but even better performance could be achieved with a tuned tapering (Figure 1c).

Surface texturing of GaN is limited by the crystal structure to certain angles of taper and shapes (e.g. pyramids with angles around 58°).

The RPI/Samsung approach is to use a layer of TiO_2 for which the taper angle can be changed through different etch conditions. This material was chosen because it was matched in refractive index to GaN at the target wavelength of 445nm.

A 500nm TiO_2 film was sputtered onto the 'n-type' side of 445nm-wavelength gallium indium nitride (GaInN) LED epitaxial material. In fact, the researchers left some undoped GaN above the n-GaN contact layer to protect the active region during subsequent etch processes.

A photomask was applied, followed by inductively coupled plasma reactive-ion etch (ICP-RIE) to create pillars in the TiO_2 . Tri-fluoro-methane (CHF_3) was used for anisotropic etch, along with O_2 for isotropic etch. The mix of gases allows control of the taper angle.

The range of taper angles that were possible included the optimum suggested in previous ray-tracing simulations carried out by the researchers. The pillars were

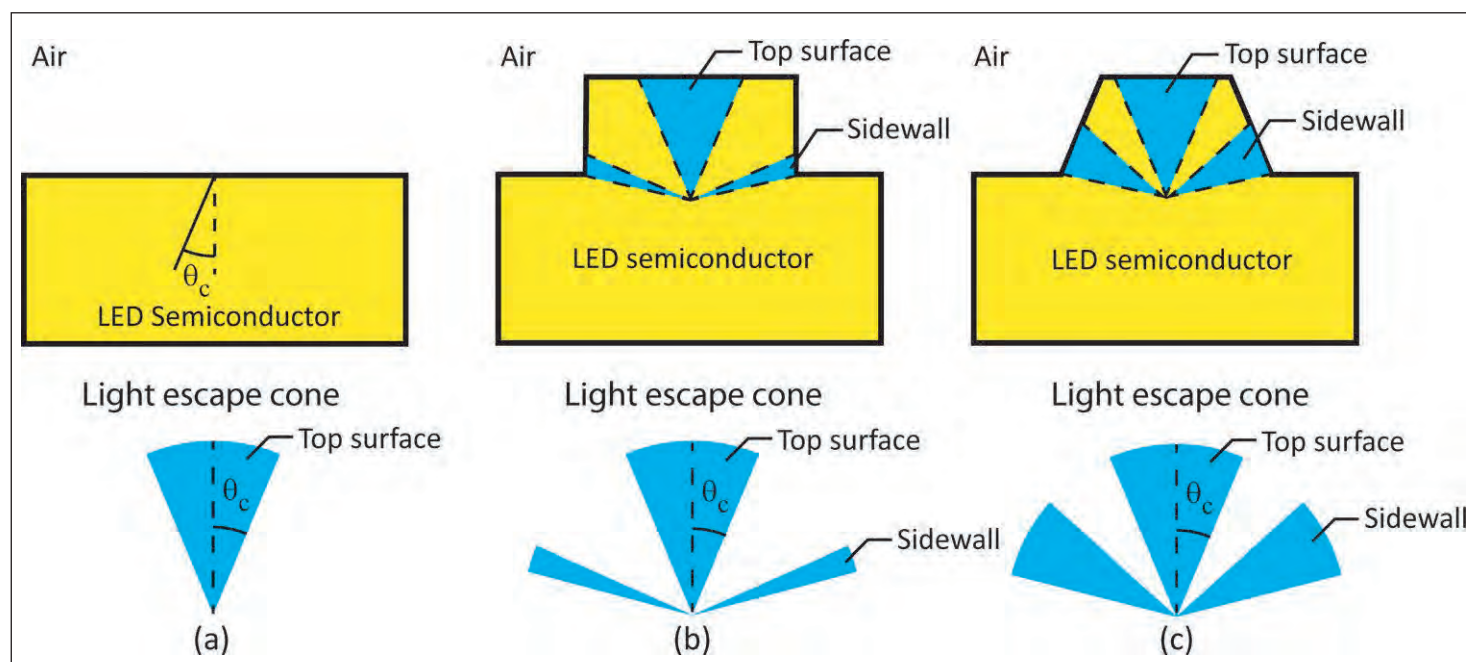


Figure 1. Schematic diagrams of light extraction from (a) rectangular-parallelepiped-shaped LED with no surface features, (b) rectangular-parallelepiped-shaped LED with a micro-pillar with vertical sidewalls, and (c) rectangular-parallelepiped-shaped LED with a micro-pillar with tapered sidewalls.

4–5 μm in diameter, around 3 μm high, and separated by about 1 μm .

The material was processed into 1mm x 1mm square LEDs. The chips were flipped so that the n-type side was the one through which light was emitted. Therefore, no metal electrodes were deposited on that side to avoid blocking light output.

The light from devices with vertical micro-pillars showed a 68% increase in output power over planar LEDs produced for comparison purposes (Figure 2). The largest enhancement of 100% was seen for tapered micro-pillar LEDs with parameter 1.4 (35–36° angle to GaN surface plane), close to the value found in the ray-tracing simulations. The taper parameter for vertical micro-pillars was 0 (90°).

The addition of micro-pillars was found not to impact current-voltage behavior of the LED, and thus the production process did not adversely impact power consumption performance. The angular spread of the emission was wider for the devices with micro-pillars and actually dipped for the direction normal to the plane of the LED.

A range of organizations funded the research: Samsung LED, the Korean Ministry of Knowledge Economy and the Korea Institute for Advancement of Technology through International Collaborative R&D Program, the US National Science Foundation (NSF), Sandia National

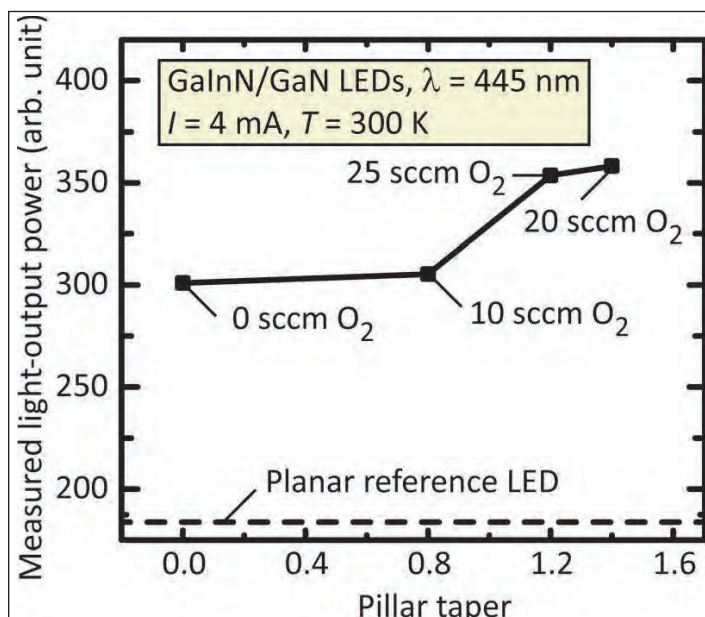


Figure 2. Measured light-output power as a function of the pillar taper for GaInN LED patterned with array of TiO₂ micro-pillars. For comparison, planar reference LED performance is also shown.

Laboratories, the US Department of Energy, Magnolia Optical Technologies, and Raydex Technology Inc. ■

<http://link.aip.org/link/doi/10.1063/1.4756797>

Author: Mike Cooke

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Improving nitride LEDs with ZnO nanorods on rear surface

Simple low-temperature solution-based process increases output power by up to 15%.

Researchers in Korea and India have used zinc oxide (ZnO) nanorods on the rear side to improve light output from nitride semiconductor light-emitting diodes (LEDs) grown on c-plane sapphire [Joo Jin et al, Jpn. J. Appl. Phys., vol51, p102101, 2012]. The researchers were based at Chonbuk National University, Republic of Korea, and Sona College of Technology, India.

Researchers around the world are seeking ways to improve nitride LEDs for high-brightness lighting applications at low production and operation cost. One factor that limits external quantum efficiency (EQE) is poor light extraction due to the large refractive index difference between nitride semiconductor and air, resulting in a narrow escape cone of around 23° . A number of techniques have been tried for improving light extraction, but they tend to involve expensive processes or they damage the underlying performance of the LED.

One way that has been tried is to use ZnO nanorods on the transparent top p-electrode, where 50% improved light output was achieved with a metal-organic chemical vapor deposition. However, the high-temperature process damaged the p-electrode, reducing electrical performance. Some researchers have tried low-temperature deposition using aqueous solutions, but these needed time- and energy-consuming multi-processing steps.

The Korea/India LEDs were constructed from epitaxial material produced through metal-organic chemical vapor deposition (MOCVD) on c-plane sapphire. The

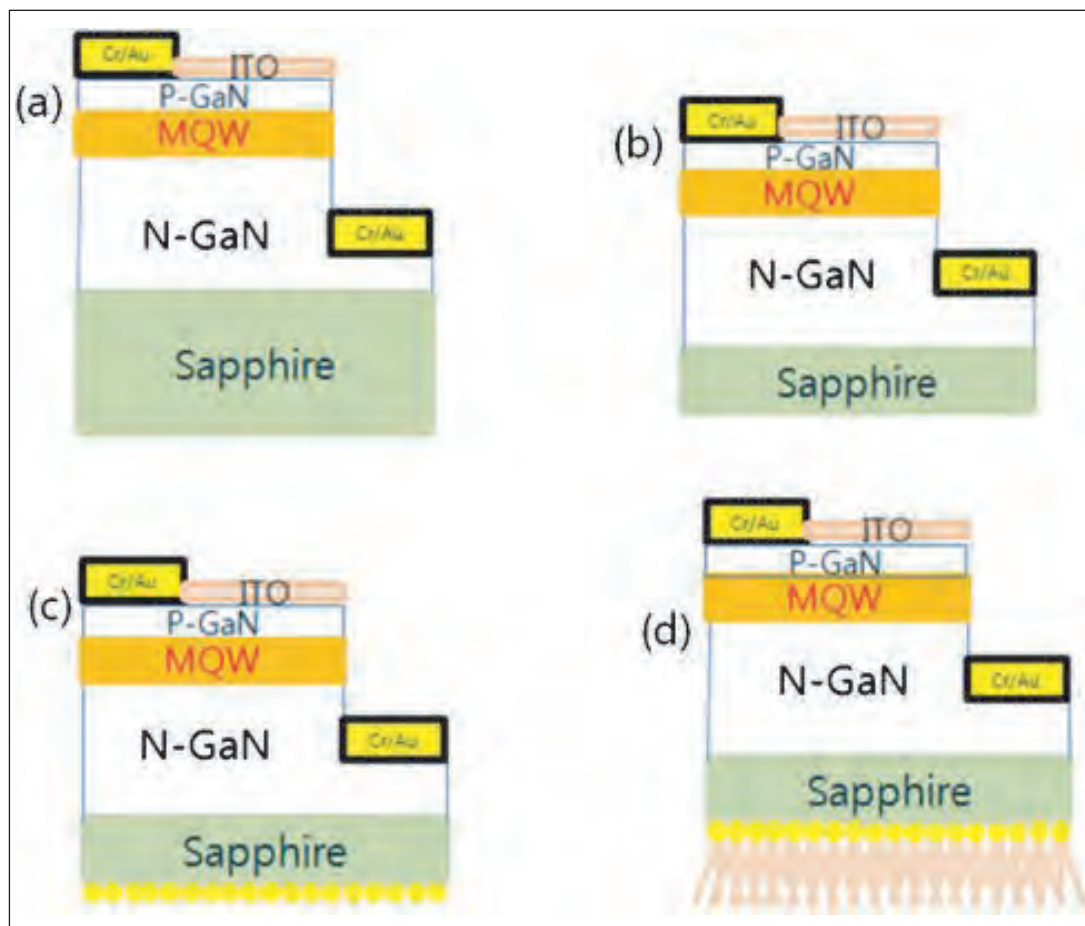


Figure 1. Schematic of process for growing ZnO nanorods on rear side of PBSS: (a) basic LED structure, (b) sapphire polishing, (c) ZnO seed deposition, and (d) growth of ZnO nanorods.

The enhanced optical output power of the LEDs with ZnO nanorods is due to the high level of heat dissipation through the nanorods due to both the high thermal conductivity of ZnO and the high surface/volume ratio of nanorod arrays

multi-quantum well (MQW) active region consisted of five indium gallium nitride (InGaN) wells in gallium nitride (GaN) barriers. The blue emission wavelength was $\sim 460\text{nm}$.

The epitaxial material was subjected to an inductively coupled etch, producing $254\mu\text{m} \times 584\mu\text{m}$ mesa regions. The raised p-electrode was covered with 200nm indium tin oxide (ITO) transparent conductor.

Chromium and gold (Cr/Au) were used for contact metals.

The sapphire substrate was prepared for the ZnO deposition by polishing (Figure 1). The polished bottom sapphire surface (PBSS) was then seeded with ZnO by spin coating. The ZnO seeds were then developed into nanorods using solution growth. The time of exposure to solution was varied to give different samples: A for 0 hours (conventional LED), B for 0.5 hours, C for 1 hour, D for 2 hours, and E for 3 hours.

The resulting nanorods are randomly oriented on the sapphire surface with constant diameters but length varying with the length of exposure to the solution: ~370nm for sample B, ~650nm for C, ~900 for D, and ~1300nm for E. The effect of the nanorods on 460nm light is to increase reflectance to almost 18% for sample E. There is almost no effect on forward voltage, which is in the range 3.40–3.43V for all LEDs at 20mA. Also, at 20mA, the light output from sample D was 15% higher than that without nanorods (Figure 2).

The researchers comment: "Compared with the conventional LED the optical output power of the LEDs with ZnO nanorods was enhanced, indicating that more light escapes from the rear side of the LEDs through ZnO nanorods."

The light output with the even longer ZnO nanorods of sample E was less, at only 9% higher than the conventional LED. "The decline in light output power after a critical nanorod length can be attributed to the light loss occurring via absorption and appearance of air-voids in the interlayer between the nanorod arrays and silver paste," the researchers write.

The researchers believe that the enhanced optical output power of the LEDs with ZnO nanorods is due to the high level of heat dissipation through the nanorods due to both the high thermal conductivity of ZnO and the high surface/volume ratio of nanorod arrays, along with the increased probability of light emission in all directions with reduced absorption.

The angular properties of the emission were also

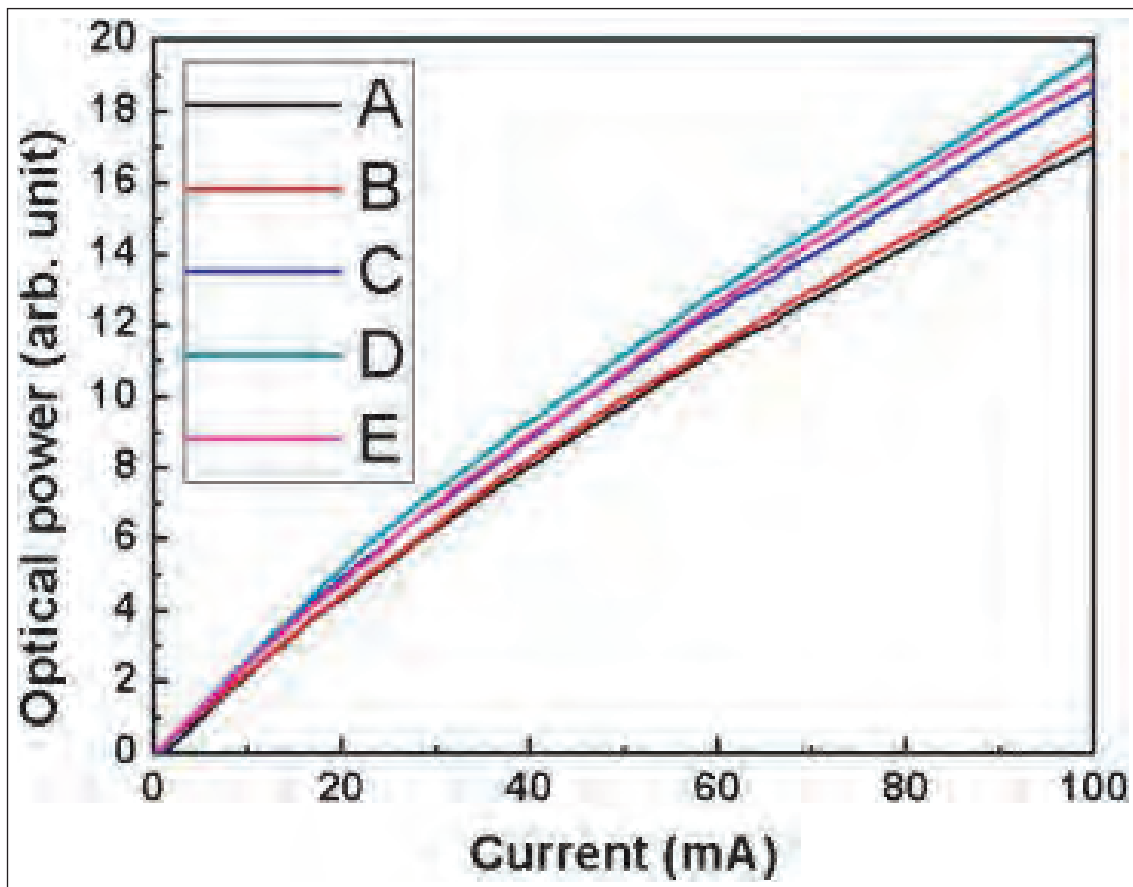


Figure 2. Light output power of LEDs with and without ZnO nanorods.

Table 1. Comparison of thermal conductivity of relevant materials.

Materials	Thermal conductivity (W/m-K)
ZnO	1.47
Air	0.032
Silver paste	2–25
Sapphire	0.35

measured. The divergence angles to half maximum emission intensity at 20mA were 157°, 162°, 162°, 169° and 153° for samples A to E, respectively. The broader emission with nanorods can be attributed to waveguiding and scattering effects of the inclined nanorods.

The low divergence for LED E was explained as being due to the appearance of air voids in the interlayer between ZnO nanorods and silver paste used to make thermal connection with the packaging structure.

The thermal resistances of the connection with the silver paste were 40.5°C/W, 38.7°C/W, 35.9°C/W, 25.1°C/W and 29.4°C/W for samples A to E, respectively. The samples with nanorods benefitted from the high thermal conductivity of ZnO (Table 1). The up-tick for LED E can again be attributed to air voids/discontinuity between the nanorods and silver paste. ■

<http://jjap.jsap.jp/link?JJAP/51/102101>

Author: Mike Cooke

Lithium aluminate substrate for low-cost nonpolar gallium nitride

A new study clarifies the nitridation process used to create the nucleation layer, reports [Mike Cooke](#).

Researchers based in Germany and the Netherlands have been studying the potential for growing nonpolar gallium nitride (GaN) on lithium aluminate (LiAlO_2 , or LAO) [Kwang-Ru Wang et al, Appl. Phys. Express, vol5, p105501, 2012].

In particular, the initial nitridation process that is used before the growth of GaN was analyzed using x-ray reflectivity (XRR) and cross-sectional high-resolution transmission electron microscopy (HRTEM). It was found that the nitridation produced a single-crystal aluminium nitride (AlN) layer without any detectable misfit dislocations. Such a layer forms a good base for further growth of nonpolar m-plane GaN.

The researchers were variously associated with Paul-Drude-Institut für Festkörperelektronik, RWTH Aachen, PANalytical B.V., and Aixtron SE.

Nonpolar GaN is of much interest for the production of high-efficiency light-emitting diodes. In normal polar c-plane GaN, large electric fields result from the large polarization fields in the c-direction. These fields interfere with the recombination process that produces light, reducing efficiency.

Unfortunately, high-quality m-plane GaN is difficult to produce because of large lattice mismatches with the well established substrates, leading to defects and dislocations. The substrates with the smallest lattice mismatch, such as silicon carbide (SiC) or free-standing GaN (FS-GaN), are usually very expensive.

Michael Heuken of RWTH Aachen and Aixtron comments: "2-inch LiAlO_2 substrates can be very low cost, as less energy is needed to make them compared even with sapphire (Al_2O_3). Further cost savings arise because LiAlO_2 (LAO) is softer than Al_2O_3 , reducing the consumption of cutting/lapping materials, and of time and money during manufacturing of the substrate.

Another advantage of LiAlO_2 is that lift-off — i.e. separation of the GaN film from the substrate — can be practically automatic, without any further processing. The researchers find that thick nitride semiconductor

layers often peel off or separate when the wafer is vacuumed off the wafer holder in the metal-organic chemical vapor deposition (MOCVD) chamber. This automatic lift-off is very attractive for lower-cost FS-GaN substrates from films grown on LiAlO_2 , avoiding laser or etch processes that are expensive and time consuming.

Gamma-phase (γ -phase) 2-inch wafers of LiAlO_2 substrate have been commercially available for almost ten years at prices less than 10% of 2-inch m-plane SiC or less than 30% of 5mm x 10mm pieces of free-standing m-plane GaN.

Further, according to Heuken, "the supply of 6-inch SiC wafers could become limited due to strategic (military) purposes for which it has been developed in

The supply of 6" SiC wafers could become limited due to strategic (military) purposes for which it has been developed in the USA. Presently, 2" m-plane free-standing GaN wafers are not available in the market...

This may change, since technology moves very fast in this field

the USA. Presently, 2-inch m-plane free-standing GaN wafers are not available in the market." Kwang-Ru Wang of Paul-Drude-Institut adds that "this may change, since technology moves very fast in this field. Also 2-inch m-plane SiC wafers, although theoretically available, are difficult to buy."

Heuken adds: "The quality of nonpolar m-plane GaN grown on LiAlO_2 is not presently as good as m-plane GaN on FS-GaN." Wang adds: "However, our TEM data show that part of the reason for this is attributable to the quality of the LiAlO_2 substrate."

The researchers found that most of the planar defects (i.e. stacking faults) found in nonpolar GaN grown on LAO is related to surface morphology and is not related to lattice mismatch or strain relief.

Data	Lattice Constant (Å)		Thermal Expansion Coefficient (1/K)		
Materials	a-axis	c-axis	a-axis	c-axis	Reference
γ -LiAlO ₂	5.1698	6.2779	6.5×10^{-6}	14.9×10^{-6}	J. Cryst. Growth, vol291, p485, 2006
α -GaN	3.189	5.182	5.59×10^{-6}	7.75×10^{-6}	The Blue Laser Diode: The Complete Story, Springer-Verlag, Berlin 2010.
α -Al ₂ O ₃	4.758	12.991	7.5×10^{-6}	8.5×10^{-6}	

f: lattice mismatch

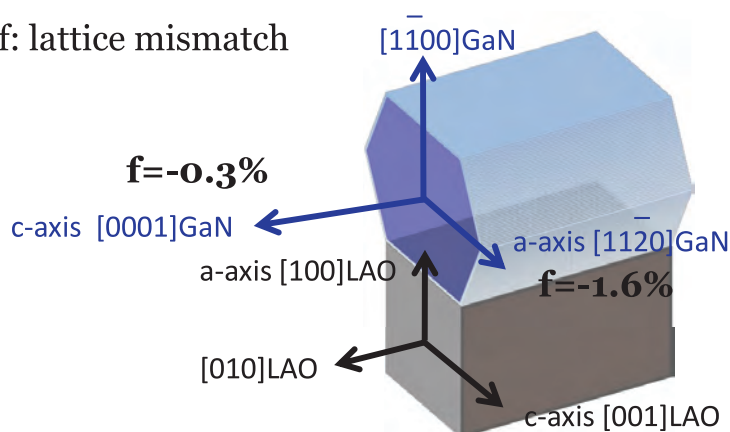


Figure 1. Lattice constant and thermal expansion coefficient of LiAlO₂ versus α -GaN and α -Al₂O₃ and (bottom) crystal orientations of GaN and LAO (LiAlO₂).

Christof Mauder based at RTWH Aachen comments: "The most important origin of defects in nonpolar nitride layers is the lattice mismatch between substrate and the epitaxial layers, leading to the formation of planar stacking faults, which are detrimental to device performance. Therefore, low mismatch is a prerequisite for the growth of high-quality nonpolar m-plane GaN thin films." However, the lattice mismatch for LiAlO₂ is less than 1.7% and hence much lower than the leading alternatives such as sapphire or SiC."

Wang adds: "Our research is important because of the challenge of quality improvement, and reproducibility is directly related to the surface sensitivity of LiAlO₂ substrate during the process, as we've identified."

Dr Achim Trampert, the leader of the project at Paul-Drude-Institute, comments: "The diameter of the LiAlO₂ substrates, as well as the quality, needs to be improved significantly."

Once this happens and processes are developed for reproducibly growing high-quality m-plane GaN on the resulting substrates, market demand should increase. In addition, since neither 2-inch m-plane SiC nor 2-inch m-plane GaN substrates are really available on the market currently, the research may open up another achievable and low-cost way in making real 2-inch, or even larger, free-standing, nonpolar GaN substrates. With improved quality of the substrates,

it is hoped that full structure, high-performance, nonpolar GaN light-emitters will be realized soon on LiAlO₂.

One headache for scientists and engineers is that LiAlO₂ decomposes at elevated temperature and in hydrogen environments. High-quality GaN needs to be grown at higher temperature than other III-V materials such as gallium arsenide (GaAs).

Wang comments: "Before our detailed studies, people could only follow their own empirical rules about whether to perform or not substrate pre-treatments [M.D. Reed et al, J. Cryst. Growth, vol274, p14, 2005; Chengxiang Liu et al, J. Cryst. Growth, vol298, p228, 2007]. It was anybody's guess whether pre-treatment would be good or bad for subsequent GaN growth as it dominates the crystal orientation (c- or m-plane) and phase purity of thin films."

"Our detailed investigations clearly demonstrate that precise control of the nitridation pre-treatment process plays a key role in creating a pure phase, high-quality m-plane GaN thin film reproducibly on this novel alternative oxide substrate with high potential for future high-performance optoelectronics applications. Our study should also guide people who cannot precisely control their initial processes, allowing them to check if their nitridated layer is a pure phase m-plane AlN layer. We see the creation of such an initial layer as

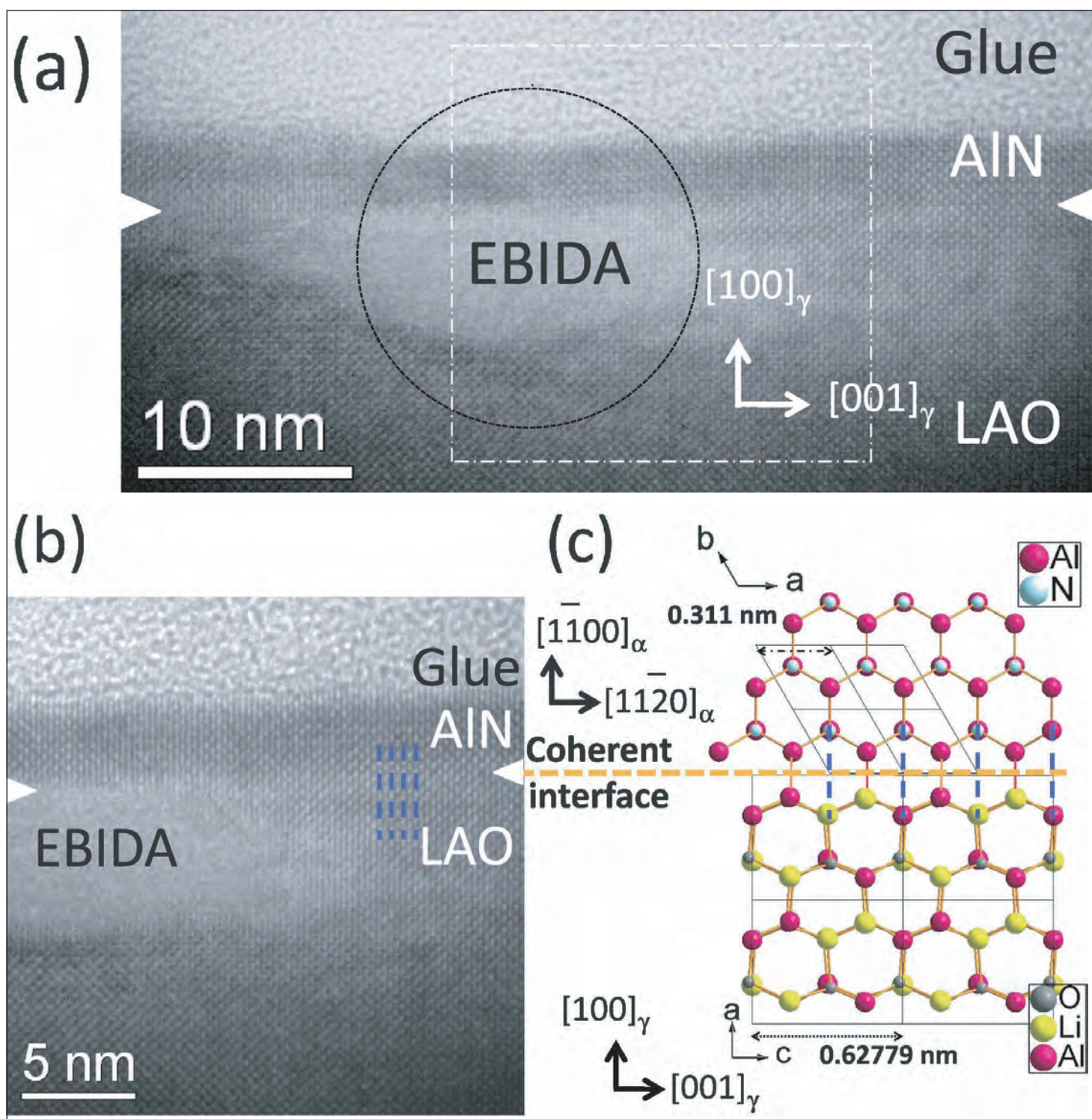


Figure 2. (a) HRTEM image of the heterointerfaces along γ -LAO[010] zone axis for sample with 5-minute nitridation process. (b) HRTEM image of central area indicated by rectangle in (a) with the vertical dashed lines representing the coherent AIN/ γ -LAO heterointerface. (c) Ball-and-stick model of the AIN/ γ -LAO heterointerface projected along the γ -AIN[0001] and γ -LAO[010] zone axes.

being key to successful growth of high-quality m-plane nitride semiconductors on this substrate."

The researchers began their growth process by cleaning their γ -LiAlO₂ before loading it into the metal-organic chemical vapor phase epitaxy (MOVPE) reactor. Two substrates were processed — one was subjected to a flow of ammonia at 300mbar pressure and 900°C temperature for two minutes and the other

for 5 minutes. After nitridation, a layer of 1.2 μ m m-plane GaN was grown in a three-step process.

XRR and HRTEM (Figure 2) analysis determined that the longer nitridation process resulted in a single ~2nm layer of m-plane AIN. This sample also was free of misfit dislocations in a region investigated using HRTEM. By contrast, nitridation of sapphire leads to layers of AIN with dislocations due to plastic relaxation

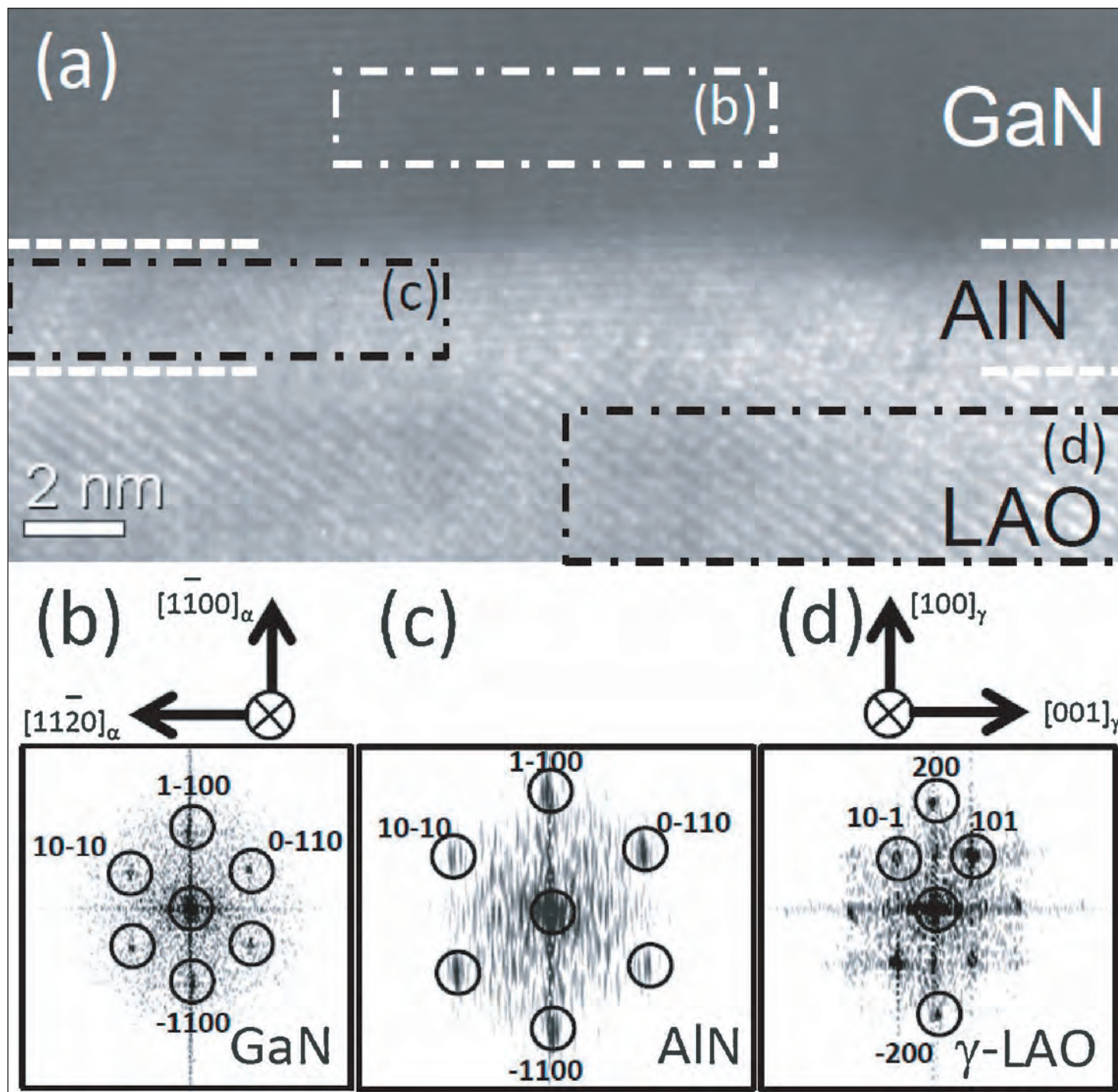


Figure 3. (a) HRTEM image of GaN/AlN/ γ -LAO double heterointerface prepared with 2-minute nitridation process. (b–d) Fast Fourier transform (FFT) patterns for GaN, AlN, and γ -LAO, respectively. Crystal orientation of the NH_3 -induced AlN layer is exactly the same as that of the following m-GaN, which indicates that nitridation-induced, monocrystalline layer is epitaxial m-AlN. Crystal orientations of GaN and γ -LAO are indicated in (b) and (d), respectively.

of strain as a result of the much larger mismatch of lattice parameters.

In terms of the interface with the overlying GaN, the quality on top of the 2-minute nitrided film seems better, according to x-ray rocking curves and atomic force microscopy (AFM). The $(1\bar{1}00)$ x-ray rocking curves of the m-GaN films were as low as 361 arcsecs and 2566 arcsecs, respectively, parallel and perpendicular to the $[0001]$ direction.

The researchers comment: "The achieved x-ray values are similar to values observed in much thicker m-GaN samples, which are grown by hydride vapor phase epitaxy [HVPE] using lateral epitaxy overgrowth on γ -LAO and m-plane 6H-SiC substrates [B. A. Haskell et al, Appl. Phys. Lett. vol86, p111917, 2005]."

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Author: Mike Cooke

First ammonia MBE nitride HEMTs on silicon

Singapore researchers achieve drastic reduction in buffer leakage and increase in on/off ratio compared with plasma-assisted MBE.

Singapore's Nanyang Technological University has made a first demonstration of nitride semiconductor high-electron-mobility transistors (HEMT) grown on silicon substrates using ammonia molecular beam epitaxy (MBE) rather than the usual metal-organic chemical vapor deposition (MOCVD) or plasma-assisted MBE [Nethaji Dharmarasu et al, Appl. Phys. Express, vol5, p091003, 2012].

While MOCVD has the attraction of high growth rates, MBE methods offers more control of growth parameters and sharper interfaces between layers. Also in situ monitoring of MBE gives growth process control at the monolayer level.

With the rise of commercial interest in growing nitride semiconductors on silicon as opposed expensive silicon carbide or thermally insulating sapphire, further advantages of MBE include lower growth temperature allowing better management of differences in thermal coefficients of expansion. Also, the ultra-high vacuum used for MBE minimizes hydrogen incorporation that impacts the effectiveness of magnesium doping for p-type nitride layers.

The use of ammonia rather than plasma-assisted MBE increases growth rate and the process parameter window for high quality, more uniform material growth. In HEMT applications, the resulting material has lower buffer leakage due to growth in nitrogen-rich rather than metal-rich conditions, giving a high-resistance buffer layers. Thus current flow is restricted to the two-dimensional electron gas that forms near barrier/channel interfaces.

The epitaxial structures were grown on 100mm-diameter high-resistivity (more than $10,000\Omega\cdot\text{cm}$) silicon oriented in the (111) direction preferred for nitride semiconductor growth. The layers consisted of 50nm aluminium nitride (AlN) nucleation, 200nm gallium nitride (GaN) and 200nm AlN stress mitigation, variable thickness GaN buffer/channel, 28nm AlGaN (25% Al) barrier, and 2nm GaN cap (Figure 1).

The ammonia molecular beam epitaxy process was optimized with the help of reflection high-energy electron diffraction (RHEED) patterns. The temperature was varied with 750°C used for pre-deposition clean, 800°C for AlN growth and 920°C for GaN growth. Also, the growth rate for the stress mitigation layers was tuned to speed the transition from 3D to 2D lateral

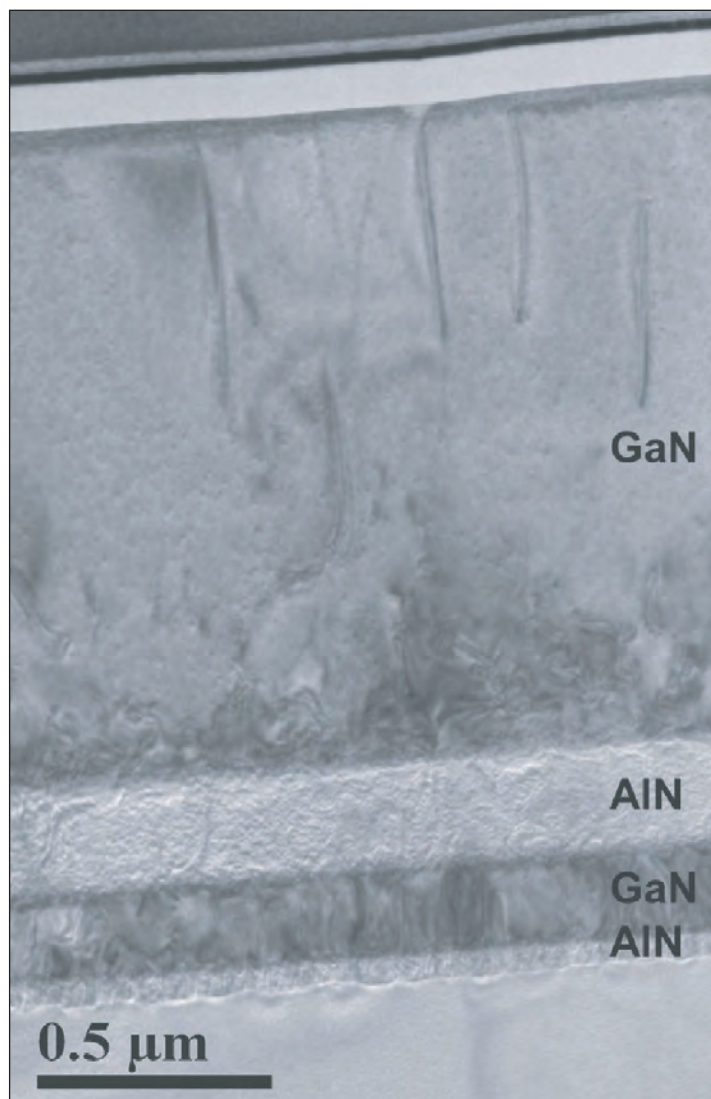


Figure 1: High resolution transmission electron micrograph (HR-TEM) cross-section of GaN/AlN/GaN/AlN/Si(111) structure.

growth that suppresses defect propagation. An additional improvement from higher growth rates was compressive stress in the GaN layer that balanced thermal-expansion-mismatch-induced tensile stress during cooling. The result was a crack-free buffer layer.

The material was subjected to Hall-effect measurements giving a room temperature (300K) mobility for the two-dimensional electron gas at the AlGaN/GaN interface of $1350\text{cm}^2/\text{V}\cdot\text{s}$ and carrier density of $1.2 \times 10^{13}/\text{cm}^2$. The average sheet resistance was

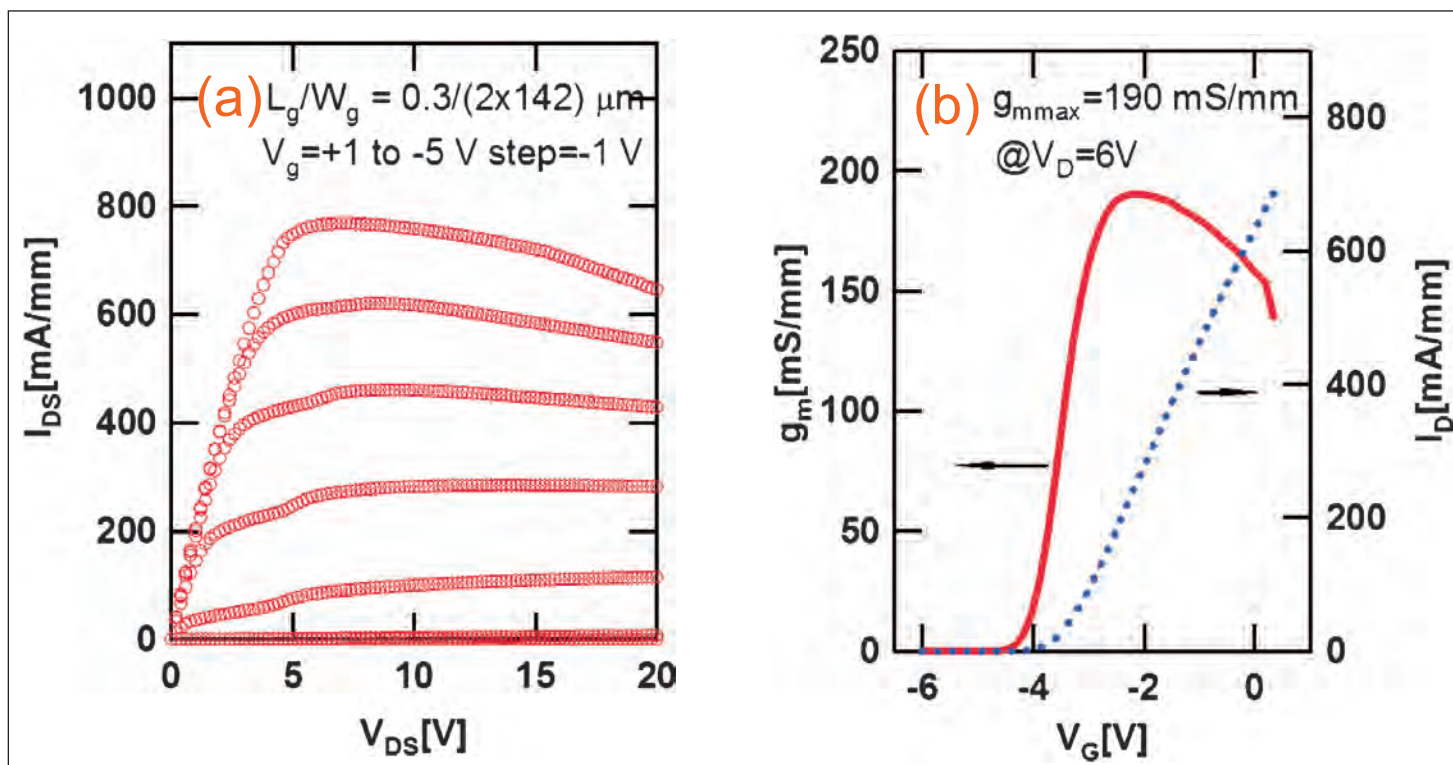


Figure 2: (a) Drain current–voltage characteristics and (b) extrinsic transconductance versus gate potential transfer characteristics of 0.3μm-gate-length AlGaIn/GaN HEMTs.

368Ω/square. At 90K, the mobility reached 4290cm²/V-s. By contrast, the carrier density was relatively insensitive to temperature variation over the range 90–400K.

The researchers also assessed buffer leakage. A 1.7μm buffer showed the lowest current of 2.6x10⁻⁴mA/mm at 20V bias, giving an on/off current ratio of 7.3x10⁶. Similar HEMT structures grown using plasma-assisted MBE had buffer leakage values of

1mA/mm and on/off current ratios of 400.

The researchers characterized a nickel-gold T-gate device with gate length and width of 0.3μm and 2x142μm respectively (Figure 2). The maximum drain current was 768mA/mm at 1V gate potential and the peak extrinsic transconductance 190mS/mm at 6V drain bias. The threshold voltage was -4.53V. ■

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Diamond field-effect transistor with 50nm gate increases cut-off performance

RF performance in diamond field-effect transistors has been demonstrated for the first time at short gate-length.

University of Glasgow and Université Paris researchers have demonstrated for the first time RF performance of 50nm gate-length diamond field-effect transistors (FETs) [Stephen A. O. Russell et al, IEEE Electron Device Letters, published online 30 August 2012]. The extrinsic cut-off frequency of 53GHz is believed to be the highest reported for diamond-based transistors.

Diamond has many attractive qualities for high-power devices (Table 1) such as wide bandgap (5.47eV) and high thermal conductivity (more than 20W/cm.K). The high intrinsic carrier mobility (more than 3000cm²/V-s) also suggests high-frequency application.

The researchers used 4.7mm squares pieces of homoepitaxial diamond supplied by Element Six. The material was treated with a surface clean in aqua regia and then sulfuric/nitric acid before hydrogen termination was achieved using a plasma treatment.

Photolithography patterning of the 50nm gate-length device involved a gold sacrificial layer used to protect the hydrogen termination in some regions of the diamond surface. The aluminium gate electrode consisted of a two-finger arrangement with a width of 2x25µm. Oxygen plasma was used to remove the hydrogen ter-

mination in selected regions and to provide electrical isolation of individual unpassivated devices.

DC measurements gave a maximum drain current of 225mA/mm at -10V drain bias and zero gate potential. A gate voltage sweep between -2V and +4V showed good transistor action, but the maximum drain current at zero gate potential was then reduced to 170mA/mm. The maximum drain current overall was 295mA/mm at -2V gate potential. More negative gate biasing led to irreversible degradation of drain current performance. The degradation is attributed to "sensitivity of the hydrogen-terminated surface during processing".

The gate leakage was 0.02mA/mm. The peak extrinsic transconductance was 78mS/mm at +0.2V gate and -8V drain biasing. The low transconductance value "can be attributed to a process-associated increase in access resistance at this reduced gate dimension".

Frequency performance measurements were carried out between 1 and 30GHz resulting in a de-embedded extrinsic cut-off (f_T) of 53GHz and maximum oscillation (f_{MAX}) of 27GHz. Open and short on-wafer structures were used to correct for the parasitic effects of the

	Si	SiC-4H	GaN	Diamond
Band gap (eV)	1.1	3.2	3.44	5.5
Breakdown field (MV/cm)	0.3	3	5	20
Electron mobility (cm ² /Vs)	1450	900	440	4500
Hole mobility (cm ² /Vs)	480	120	200	3800
Thermal conductivity (W/cm.K)	1.5	5	1.5-3	24
Johnson's Figure of Merit	1	410	280	8200
Keyes' Figure of Merit	1	5.1	1.8	32
Baligas Figure of Merit	1	290	910	17200

Table 1. Material properties and figures of merit (normalized to silicon) at room temperature. The numbers under diamond are those recently reported by E6 for electronic-grade CVD diamond.

coplanar waveguides used to deliver the RF signals.

The researchers used extracted parasitic behaviors to estimate an intrinsic cut-off of 90GHz. The researchers attribute the reduction to an extrinsic value of 53GHz as being due to a substantial increase in output conductance that perhaps is due to short-channel effects and/or increased interface state density at the diamond surface.

The intrinsic maximum oscillation frequency was put at 43GHz, compared with the extrinsic 27GHz. The researchers comment: "Employing a T-gate structure to minimize the lateral gate resistance across the width of the device would reduce gate resistance and greatly improve f_{MAX} in these devices. However, a comparatively low value for output resistance will still limit f_{MAX} at this gate length."

Diamond Microwave Devices Ltd (DMD) was also involved in the supply of diamond material for the research, along with Element Six. DMD is developing diamond semiconductor materials and processing technology with the aim of creating the next generation of high-power, high-frequency semiconductor devices, with applications in microwave power amplifiers and transmitters that are used in civil and defense systems.

Element Six (E6) is an independently managed synthetic diamond supermaterials company. Element Six is part

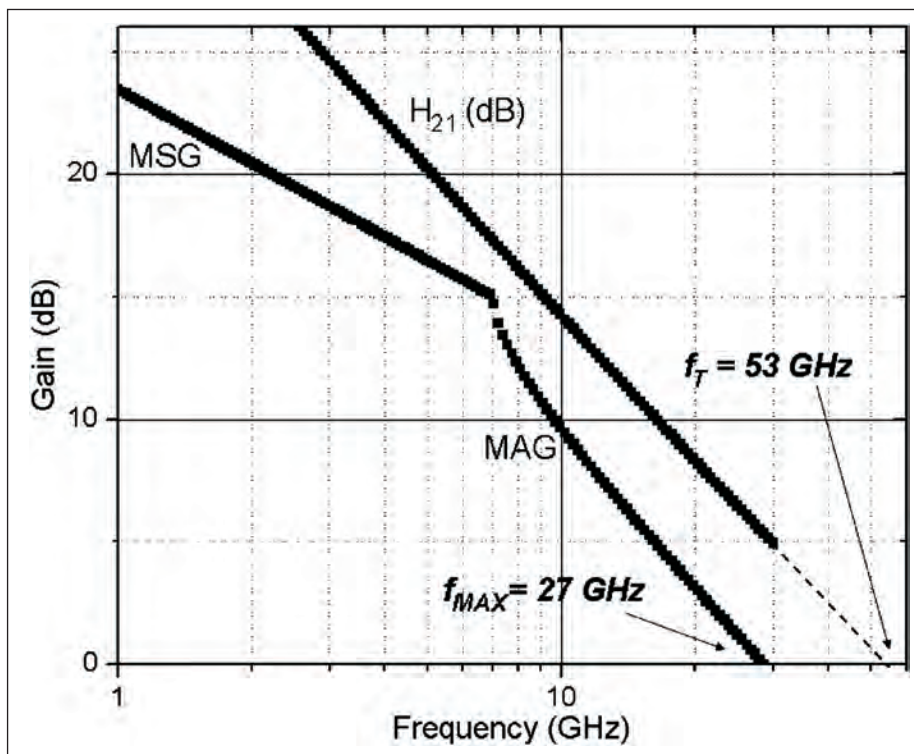


Figure 1. RF measurements for a 50nm gate-length FET showing extracted extrinsic f_T of 53GHz and f_{MAX} of 27GHz.

of the De Beers Family of Companies and is co-owned by Belgium's Umicore materials group. ■

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6291745>

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(see section 6 for full contact details)

Power + Energy Inc

(see section 10 for full contact details)

SAMCO International Inc

532 Weddell Drive,
Sunnyvale, CA, USA

Tel: +1 408 734 0459

Fax: +1 408 734 0961

www.samcointl.com

**SPP Process Technology
Systems Ltd**

Imperial Park, Newport NP10 8UJ,
Wales, UK

Tel: +44 (0)1633 652400

Fax: +44 (0)1633 652405

www.spp-pts.com

Veeco Instruments Inc

(see section 6 for full contact details)

9 Materials & metals

Goodfellow Cambridge Ltd

Ermine Business Park, Huntingdon,
Cambridgeshire PE29 6WR, UK

Tel: +44 (0) 1480 424800

Fax: +44 (0) 1480 424900

www.goodfellow.com



Goodfellow supplies small quantities of metals and materials for research, development, prototyping and specialised manufacturing operations.

10 Gas and liquid handling equipment

Air Products and Chemicals Inc

(see section 7 for full contact details)

Cambridge Fluid Systems

12 Trafalgar Way, Bar Hill,
Cambridge CB3 8SQ, UK

Tel: +44 (0)1954 786800

Fax: +44 (0)1954 786818

www.cambridge-fluid.com

CS CLEAN SYSTEMS AG

Fraunhoferstrasse 4,
Ismaning, 85737,
Germany

Tel: +49 89 96 24 00 0

Fax: +49 89 96 24 00 122

www.cscleansystems.com

Power + Energy Inc

106 Railroad Drive,
Ivyland, PA 18974, USA

Tel: +1 215 942-4600

Fax: +1 215 942-9300

www.powerandenergy.com

SAES Pure Gas Inc

4175 Santa Fe Road,
San Luis Obispo, CA 93401,
USA

Tel: +1 805 541 9299

Fax: +1 805 541 9399

www.saesgetters.com

11 Process monitoring and control

k-Space Associates Inc

2182 Bishop Circle
East, Dexter,
MI 48130, USA

Tel: +1 734 426 7977

Fax: +1 734 426 7955

www.k-space.com



k-Space Associates Inc specializes in in-situ, real-time thin-film process monitoring tools for MBE, MOCVD, PVD, and thermal evaporation. Applications and materials include the research and production line monitoring of compound semiconductor-based electronic, optoelectronic, and photovoltaic devices.

KLA-Tencor

One Technology Dr,
1-22211, Milpitas,
CA 95035,
USA
Tel: +1 408 875 3000
Fax: +1 408 875 4144
www.kla-tencor.com

LayTec AG

Seesener Str.
10-13,
10709 Berlin,
Germany
Tel: +49 30 39 800 80 0
Fax: +49 30 3180 8237
www.laytec.de



LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

Optical Reference Systems Ltd

OpTIC Technium,
St Asaph Business Park,
St Asaph, LL17 0JD,
UK
Tel: +44 (0)1745 535 188
Fax: +44 (0)1745 535 186
www.ors-ltd.com

WEP

(Ingenieurbüro Wolff
für Elektronik- und
Programmentwicklungen)
Bregstrasse 90, D-78120
Furtwangen im Schwarzwald,
Germany
Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

12 Inspection equipment

Bruker AXS GmbH

Oestliche Rheinbrueckenstrasse 49,
Karlsruhe, 76187,
Germany
Tel: +49 (0)721 595 2888
Fax: +49 (0)721 595 4587
www.bruker-axs.de

13 Characterization equipment

J.A. Woollam Co. Inc.

645 M Street Suite 102,
Lincoln, NE 68508, USA
Tel: +1 402 477 7501
Fax: +1 402 477 8214
www.jawoollam.com

Lake Shore Cryotronics Inc

575 McCorkle Boulevard,
Westerville, OH 43082,
USA
Tel: +1 614 891 2244
Fax: +1 614 818 1600
www.lakeshore.com

14 Chip test equipment

Keithley Instruments Inc

28775 Aurora Road,
Cleveland, OH 44139,
USA
Tel: +1 440.248.0400
Fax: +1 440.248.6168
www.keithley.com

SUSS MicroTec Test Systems

228 Suss Drive,
Waterbury Center, VT 05677,
USA
Tel: +1 800 685 7877
Fax: +1 802 244 7853
www.suss.com

15 Assembly/packaging materials

ePAK International Inc

4926 Spicewood Springs Road,
Austin, TX 78759, USA
Tel: +1 512 231 8083
Fax: +1 512 231 8183
www.epak.com

Gel-Pak

31398 Huntwood Avenue,
Hayward, CA 94544, USA
Tel: +1 510 576 2220
Fax: +1 510 576 2282
www.gelpak.com

Wafer World Inc

(see section 3 for full contact details)

Williams Advanced Materials

2978 Main Street,
Buffalo, NY 14214, USA
Tel: +1 716 837 1000
Fax: +1 716 833 2926
www.williams-adv.com

16 Assembly/packaging equipment

Ismeca Europe Semiconductor SA

Helvetie 283, La Chaux-de-Fonds,
2301, Switzerland
Tel: +41 329257111
Fax: +41 329257115
www.ismeca.com

Kulicke & Soffa Industries

1005 Virginia Drive,
Fort Washington, PA 19034, USA
Tel: +1 215 784 6000
Fax: +1 215 784 6001
www.kns.com

Palomar Technologies Inc

2728 Loker Avenue West,
Carlsbad, CA 92010, USA
Tel: +1 760 931 3600
Fax: +1 760 931 5191
www.PalomarTechnologies.com

TECDIA Inc

2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054, USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com

17 Assembly/packaging foundry

Quik-Pak

10987 Via Frontera,
San Diego, CA 92127, USA
Tel: +1 858 674 4676
Fax: +1 8586 74 4681
www.quikicpak.com

18 Chip foundry

Compound Semiconductor Technologies Ltd

Block 7, Kelvin Campus,
West of Scotland, Glasgow,
Scotland G20 0TH,
UK

Tel: +44 141 579 3000

Fax: +44 141 579 3040

www.compoundsemi.co.uk

United Monolithic Semiconductors

Route departementale 128,
BP46, Orsay, 91401,
France

Tel: +33 1 69 33 04 72

Fax: +33 169 33 02 92

www.ums-gaas.com

19 Facility equipment

MEI, LLC

3474 18th Avenue SE,
Albany, OR 97322-7014,
USA

Tel: +1 541 917 3626

Fax: +1 541 917 3623

www.marlerenterprises.net

20 Facility consumables

W.L. Gore & Associates

401 Airport Rd,
Elkton, MD 21921-4236,
USA

Tel: +1 410 392 4440

Fax: +1 410 506 8749

www.gore.com

21 Computer hardware & software

Ansoft Corp

4 Station Square, Suite 200,
Pittsburgh, PA 15219,
USA

Tel: +1 412 261 3200

Fax: +1 412 471 9427

www.ansoft.com

Crosslight Software Inc

121-3989 Henning Dr.,
Burnaby, BC, V5C 6P8,
Canada

Tel: +1 604 320 1704

Fax: +1 604 320 1734

www.crosslight.com

Semiconductor Technology Research Inc

10404 Patterson Ave., Suite 108,
Richmond, VA 23238,
USA

Tel: +1 804 740 8314

Fax: +1 804 740 3814

www.semitech.us

22 Used equipment

Class One Equipment Inc

5302 Snapfinger Woods Drive,
Decatur, GA 30035,
USA

Tel: +1 770 808 8708

Fax: +1 770 808 8308

www.ClassOneEquipment.com

Brumley South Inc

422 North Broad Street,
Mooresville,
NC 28115,
USA

Tel: +1 704 664 9251

Fax: +1 704 664 9246

www.brumleysouth.com

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www.mw-zander.com

24 Consulting

Fishbone Consulting SARL

8 Rue de la Grange aux Moines,
78460 Choisel,
France

Tel: + 33 (0)1 30 47 29 03

E-mail: jean-luc.ledys@neuf.fr

25 Resources

SEMI Global Headquarters

3081 Zanker Road,
San Jose, CA 95134, USA

Tel: +1 408 943 6900

Fax: +1 408 428 9600

www.semi.org

Yole Développement

45 rue Sainte Geneviève,
69006 Lyon,
France

Tel: +33 472 83 01 86

www.yole.fr

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5–7 November 2012

9th China International Exhibition and Forum on Solid State Lighting (China SSL 2012)

Guangzhou, China

E-mail: Chinassl.forum@gmail.com

www.[exhibition.sslchina.org/eng](http://www.exhibition.sslchina.org/eng)

21–22 November 2012

Forum LED Europe

Grande Halle de la Villette, Paris, France

E-mail: info@forumled.com

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

28 November – 2 December 2012

2012 MRS Fall Meeting & Exhibit

Boston, MA, USA

E-mail: info@mrs.org

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

29 November 2012

LED Market: Updates & Forecasts seminar (EuroLED kicker event)

Birmingham Science Park Aston, UK

E-mail: info@euroled.org.uk

www.[euroled.org.uk](http://www.euroled.org.uk)

6–7 December 2012

DGKK (German Association for Crystal Growth) Workshop 2012

Erlangen, Germany

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

10–12 December 2012

IEEE International Electron Devices Meeting (IEDM 2012)

Hilton San Francisco, CA, USA

E-mail: iedm@his.com

www.[ieee-iedm.org](http://www.ieee-iedm.org)

2–7 January 2013

SPIE Photonics West 2013

Moscone Center San Francisco, CA, USA

E-mail: customerservice@spie.org

http://spie.org/photonics-west.xml

12–14 February 2013

Strategies in Light 2013 Conference & Expo

Santa Clara Convention Center, CA, USA

E-mail: Tcarli@pennwell.com

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

24–28 February 2013

SPIE Advanced Lithography 2013

San Jose Convention Center and Marriott, CA, USA

http://spie.org/advanced-lithography.xml

17–23 March 2013

Optical Fiber Communication Conference & Exposition (OFC 2013)

Anaheim, CA, USA

E-mail: info@ofcconference.org

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

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17–18 March 2013

China Semiconductor Technology International Conference (CSTIC 2013)

Kerry Hotel Pudong, Shanghai, China

E-mail: kwu@semi.org

<http://semiconchina.semi.org/cstic>

19–21 March 2013

SEMICON China 2013

Shanghai New International Expo Centre (SNIEC), China

E-mail: semichina@semi.org

www.semiconchina.org

19–21 March 2013

LASER World of PHOTONICS CHINA

Shanghai New International Expo Centre (SNIEC), China

E-mail: laser@mimi-shanghai.com

www.world-of-photonics.net/en/laser-china/start

29 April – 3 May 2013

SPIE Defense, Security, and Sensing 2013

Baltimore Convention Center, Maryland, USA

<http://spie.org/defense-security-sensing.xml>

12–17 May 2013

223rd Electrochemical Society (ECS) Meeting

Toronto, Ontario, Canada

E-mail: meetings@electrochem.org

www.electrochem.org/meetings/biannual/fut_mtgs.htm

13 May 2013

JEDEC's 28th Annual ROCS (Reliability of Compound Semiconductors) Workshop

Hilton New Orleans Riverside, New Orleans, LA, USA

E-mail: ptanner@jedec.org

www.jedec.org/home/gaas

13 May 2013

2013 CS MANTECH: International Conference on Compound Semiconductor Manufacturing Technology

Hilton New Orleans Riverside, New Orleans, LA, USA

E-mail: csmantech@csmantech.org

www.csmantech.org

2–5 June 2013

15th European Workshop on Metalorganic Vapour Phase Epitaxy (EWMOVPE 2013)

Technology Centre in Aachen, Germany

Abstract deadline: 22 February 2013

E-mail: ewmovpe2013@jara.org

www.jara.org/index.php?id=606

17–20 June 2013

LASER World of PHOTONICS 2013

Munich, Germany

E-mail: info@world-of-photonics.net

www.world-of-photonics.net/en

24–25 June 2013

euroLED 2013

The ICC, Birmingham, UK

E-mail: info@euroled

www.euroLED.org.uk

9–11 July 2013

SEMICON West 2013

San Francisco, CA, USA

E-mail: semiconwest@xpressreg.net

<http://semiconwest.org>

4–10 August 2013

15th Summer School on Crystal Growth (ISSCG-15)

Gdansk, Poland

www.ptwk.org.pl/pol/documents/ISSCG-15-1.pdf

<http://science24.com/event/isscg15>

11–16 August 2013

17th International Conference on Crystal Growth and Epitaxy (ICCGE-17)

Warsaw, Poland

E-mail: sarzyn@unipress.waw.pl

www.ptwk.org.pl/pol/documents/ICCGE-17-1.pdf

<http://science24.com/event/iccge17>

23–26 September 2013

5th International Conference on One dimensionnal Nanomaterials (ICON 2013)

Annecy, France

E-mail: icon2013@grenoble.cnrs.fr

www.icon2013.fr

21–24 October 2013

Solar Power International (SPI '13)

McCormick Place, Chicago, IL, USA

E-mail: plangdon@solarenergytradeshows.com

www.solarpowerinternational.com

27 October – 1 November 2013

224th Electrochemical Society (ECS) Meeting

San Francisco, CA

E-mail: meetings@electrochem.org

www.electrochem.org/meetings/biannual/fut_mtgs.htm

9–11 December 2013

IEEE International Electron Devices Meeting (IEDM 2013)

Hilton Washington and Towers, Washington DC, USA

E-mail: iedm@his.com

www.ieee.org/conference/iedm

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