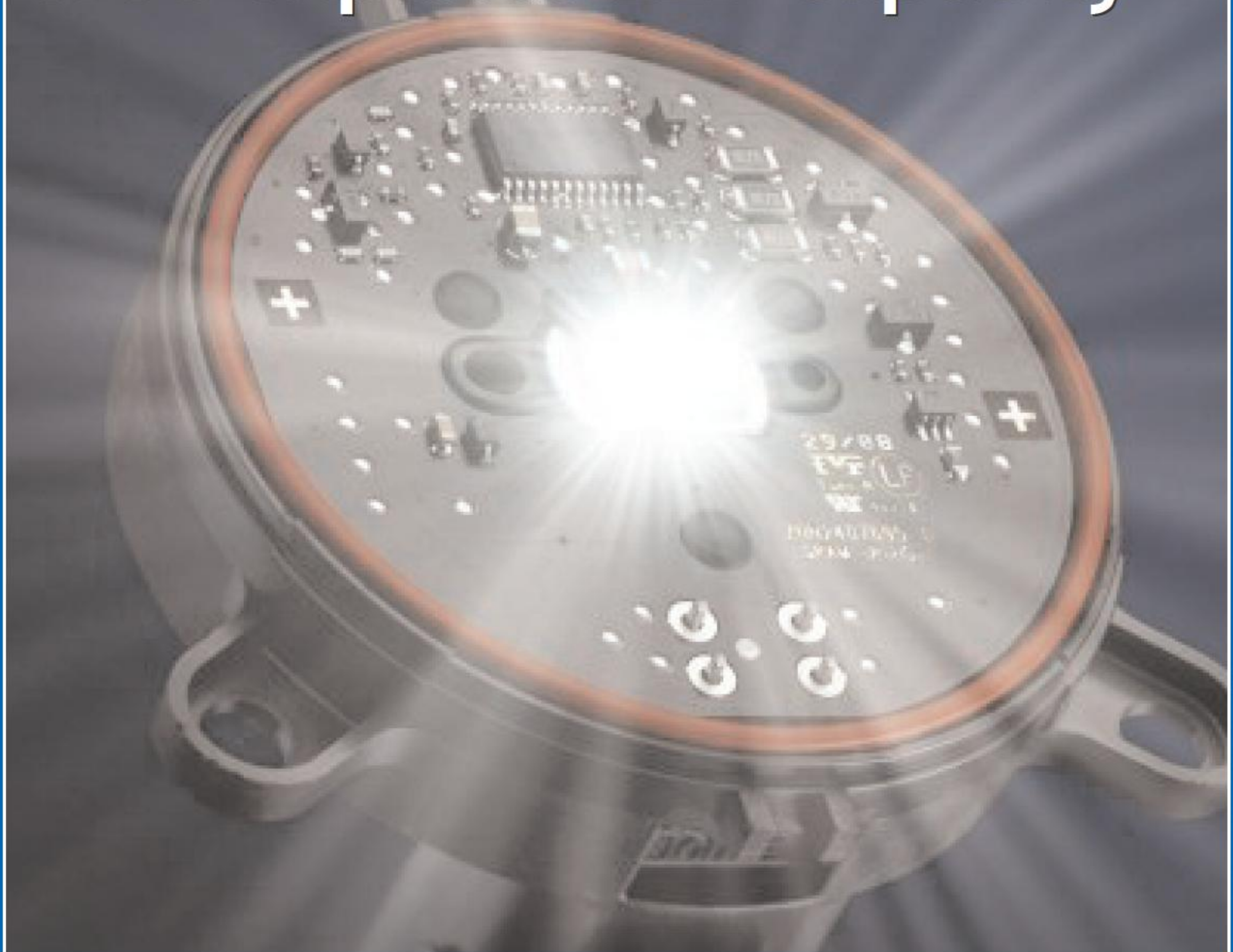


Green light from lasers Cree expands LED capacity



Anadigics foundry deal for WIN • Aviza and STS form SPTS
IQE buys substrate firm NanoGaN • News from ECOC 2009

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p20 Aixtron co-founder Holger Juergensen receives the 2009 European SEMI Award.



p38 The first quantum-dot green laser, 5.6mm in diameter, from QD Laser.



p40 Artist's impression of SMOS (Soil Moisture and Ocean Salinity) satellite — containing Modulight's lasers — on upper stage of Breeze launch vehicle.



Cover: Osram Opto Semiconductors' LEDs in Osram Automotive Lighting's new Joule JFL2 LED module, which is used in the headlamps of VW's L1 1-litre diesel-electric hybrid concept car, exhibited at September's Frankfurt International Motor Show (for possible production in 2013). **p37**

Opto applications getting 'green' light

While most firms are reporting their third-quarter 2009 results just as October turns into November (to be reported in our next issue), Cree's Q3 results (already out — see page 32) are representative of the compound semiconductor industry as a whole at the moment. Q3 revenues are up a more-than-expected 14% from last quarter as the recovery accelerates.

In the case of LED makers like Cree in particular, growth is being driven by booming demand for LEDs in the backlights of notebook PCs and TVs as well as in solid-state lighting (with, in the latter case, more universities and cities joining the Cree-instigated LED University and LED City initiatives (pages 30 & 31, respectively).

The effect on Cree is that, to meet the booming demand, it is expanding its LED-making capacity, firstly by adding 275 new staff in Durham, NC, USA by the end of 2009, and then a further 300 by the end of 2012, totalling an extra 575 (on top of its existing 3300 staff worldwide) — see page 32. After raising \$434m in a stock offering, Cree has earmarked \$150–165m for annual capital expenditure in not just its North Carolina base but also its China component packaging plant, and is on the look-out for strategic acquisitions that would enable it to stimulate the adoption of LED lighting.

Meanwhile, LED maker Lumileds has opened a Shanghai office to support solid-state lighting development (page 34). Already, Taiwan's Genius Electronic Optical is installing streetlights in mainland China in early 2010.

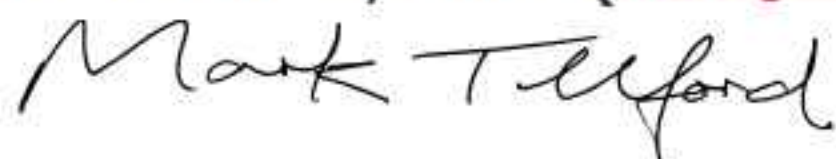
In the USA, funding from both the Department of Defense and the Department of Energy is continuing to stimulate solid-state lighting. In addition, both Lumileds and Cree are touting acceptance by the DOE of lumen maintenance test data (conforming to the LM-80 approved method) for their respective LEDs, helping luminaire manufacturers to meet the DOE's 'ENERGY STAR' performance criteria (see page 33).

Apart from backlighting, another promising display-related application of optoelectronics is projection, particularly for portable appliances such as mobile phones, where light weight and small size favor semiconductor lasers over established RGB light sources. In particular, for the green wavelength, the bulkiness of existing frequency-doubling techniques is driving development of lasers emitting directly at green wavelengths. On page 62, we overview the rapid advances that have been made in the past year in lengthening InGaN emission wavelength from blue-violet through blue-green to pure green, targeting the 532nm wavelength for RGB displays.

Most recently, Tokyo-based QD Laser has reported what it claims is the first green laser using quantum dots, albeit using frequency doubling of a 1064nm QD laser (see page 38). Measuring just 5.6mm in diameter, it also promises low power consumption through operation at high temperature without the need for cooling (due to the inherent temperature stability of quantum dot lasers).

So, optoelectronic devices are not only promising advances in 'green' technology for energy-saving LED lighting, but also green lasers for display applications that can make opto technology even more ubiquitous.

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

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

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SiC electronics needs transistor stimulus

The market for silicon carbide (SiC)-based electronic components may reach \$800m ten years from now — but only if commercial transistors based on the wide-bandgap semiconductor enter the market soon, according to a new report from analyst company Yole Développement.

In it, author Philippe Roussel suggests that SiC devices can attack a total addressable market worth \$2.6bn, part of the overall power semiconductor device market that is estimated at \$12bn.

SiC chips have made some inroads into that market already — particularly in switched-mode power supply units. But because of the high costs involved, Roussel now forecasts that, even by 2019, only 4% of the market for silicon-based discrete devices in power applications will be replaced by SiC.

Key to any market development will be the availability of a robust, commercially viable SiC transistor. Based on recent announcements

from the likes of US-based Cree, Sweden's TranSiC and the Japanese firms Rohm and Mitsubishi, Roussel is confident that next year will see the emergence of just such a device.

However, the delayed introduction of SiC transistors will likely mean that high-voltage applications will not begin to take off until 2014, Roussel predicts. "No [SiC] switch has reached large-volume production yet and car makers are still improving silicon IGBT [insulated-gate bipolar transistor] technology," he adds.

According to the same report, the merchant market for all types of SiC substrates, including n-type and semi-insulating material, was worth about \$48m in 2008. The figure does not include the captive supply, which Cree dominates with its production of high-brightness GaN LEDs. Roussel anticipates that the merchant SiC substrate market will be valued at about \$300m by 2019.

"Cree remains ahead of the competition, but its relative market share on the open market is shrinking as II-VI, SiCrystal and several new entrants are gaining momentum in the substrate battle," claimed Roussel, citing new companies such as TankeBlue in China and N-Crystals in Russia as a potential threat to the established suppliers.

Roussel's prediction of an \$800m SiC device market in 2019 also relies on substantial progress being made on wafer prices and, in particular, the epitaxy stage in device fabrication. Current progress on increasing wafer sizes is encouraging, Roussel added: "4-inch wafers are now at full production at Cree and in [the] final qualification phase at II-VI Inc, Dow Corning and Nippon Steel. 6-inch [wafers are] already announced by 2010, and will definitely accelerate the cost reduction," he concludes.

www.yole.fr

LEDs to replace halogen in European surgical market by 2014 as environmental awareness drives adoption

LED lights represented about 60% of European surgical light sales in 2009, but will completely overtake the market and represent 100% of sales by 2014 as hospitals replace halogen lights with much longer-lasting LED lights, according to the report 'European Markets for Video and High-Tech Hardware Devices 2010' from medical technology market research firm Millennium Research Group (MRG). Adoption will be accelerated in Europe, partly because European countries are more environmentally conscious than their US counterparts, the firm reckons.

As well as being more energy

efficient and durable compared to halogen lights, LEDs emit less heat, making it more comfortable for surgeons operating on patients. Surgeons can also adjust the color of LED lights according to their preference. The emergence of new LED light competitors in Europe — such as Stryker, which launched the Visum LED surgical light in August — will further accelerate market growth by increasing promotion and the push toward adoption of LEDs (already started by firms including Getinge, BERCHTOLD, and TRUMPF).

"The movement toward LED surgical lights is a boon for the

market, given the higher prices these devices are able to garner. On average, LED surgical lights are sold at a full 50% premium over halogens," says MRG senior analyst Tiffanie Demone. "Demand for LED technology is also expanding in the market for endoscopic light sources, which supply the camera head with light at the surgical site," she adds. "With the same benefits as surgical LED lights, endoscopic LED light sources will be a focus for development for more and more camera companies, which in turn will expand product variety and boost unit sales."

www.MRG.net

WiMAX subscriptions grows 74% in Q2/2009 during a slow start for LTE, while HSPA grows to 160 million

Starting from a small base, WiMAX posted the highest rate of growth of all wireless access technologies for second-quarter 2009, up 74% on the previous quarter, according to market analysts ABI Research. "The installed base of WiMAX stood at a little over three million subscriptions, but it is a sign that the battle for the 4G market is not an automatic victory for LTE [long-term evolution]," says Jake Saunders, VP for forecasting.

ABI notes that, to represent the total base of WiMAX subscribers, both 802.16d and 802.16e are included in the statistics, since many 802.16d networks will eventually be changed to 802.16e, even if they are mostly used for fixed services.

LTE subscriptions will start to trickle in during the second to third quarters of 2010, the firm says.

NTT DOCOMO had hoped to commence commercial LTE in 2009 but has since postponed its launch to 2010.

Mobile broadband subscriptions are taking off, says ABI, which estimates there will be more than 240 million subscribers by the end of 2009 and more than 1.2 billion by 2014.

Mobile data traffic is burgeoning, adds the firm. Early in 2009 mobile operators started to ramp up WCDMA 3G infrastructure equipment purchases dramatically to ensure sufficient network capacity to meet

LTE and WiMAX generate high expectations, but HSPA has meanwhile notched up almost 160 million subscriptions

demand. At almost 910 million, 3G subscriptions secured 25% of the global subscription market.

LTE and WiMAX generate high expectations, but HSPA has meanwhile notched up almost 160 million subscriptions, notes ABI. While EDGE may not have the allure of 3G or 4G, carriers are relying on it to deliver mobile Internet and messaging services where 3G coverage is inadequate. In Q2/2009 there were about 375 million EDGE subscribers.

In first-half 2009 growth rates were depressed on a regional basis around the world, but ABI anticipates that there will be steady recovery in subscriber adoption, which should provide carriers with a much needed boost in Q4/2009 and in 2010. Total subscriptions surpassed 4.15 billion in Q2/2009.






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IN BRIEF

Online store launched

RFMD has launched an online store offering new features and functionality that enhance e-commerce and streamlines selection and ordering. The store is available for ordering samples, evaluation boards, prototypes and volume production.

The store is expected to extend accessibility to existing customers worldwide while helping to service new customers in emerging markets such as Eastern Europe, India and Russia.

The online store offers the following features and benefits:

- Improved accessibility
- Seamless navigation from product attributes to purchases;
- Navigation points for browsing, filtering and sorting of products;
- Order history and status including full life-cycle of each purchase, such as delivery details, invoice and tracking numbers;
- Improved functionality
- Single sign-on 'one-stop-shop' experience;
- Self-service maintenance for additional ship-to locations;
- Purchase directly from browsing product details;
- Visibility to pricing scale detail for related package type quantities;
- Shopping cart functionality for viewing, saving, retrieving and updating; and
- Order acknowledgement e-mail when orders are submitted.

"RFMD's new online store and interactive tools enable design engineers to rapidly search for and select their RF products, accelerating our customers' prototype designs and speeding their products' time to market," says Greg Thompson, VP of sales for MPG. "The site also significantly extends the sales channel reach of our product portfolio, reduces overall order processing costs, and further streamlines our industry-leading supply chain," he claims.

www.rfmd.com

Dual-band transmit modules for ZTE's emerging-market handset

RF Micro Devices Inc of Greensboro, NC, USA says that Chinese handset maker ZTE has selected two of its dual-band transmit modules to support its S305 dual-band (GSM 900/1800MHz or 850/1900MHz) mobile handset for emerging markets.

The RF7166 and RF7167 are part of RFMD's RF71xx family of dual-band and quad-band transmit modules, the firm's first platform of products featuring its die-shrink technology. Each RF71xx product is designed to meet the front-end requirements of emerging-market handsets, including reduced solution size, improved efficiency and robust ESD protection, while also satisfying customer requirements for quality, reliability and reduced handset bill-of-material (BOM) costs.

RF71xx transmit modules are pin-to-pin compatible across the entire product family, enabling customers to produce dual-band, tri-band or quad-band GPRS or EDGE handsets from a single handset platform (claimed to be an industry first).

"Our growing representation in ZTE's handset portfolio highlights our continuing design momentum there while also underscoring our commitment to supporting their success as a leading handset supplier," says Eric Creviston, president of RFMD's Cellular Products Group (CPG).

The RF71xx family of open-market 2G transmit modules is ramping at multiple accounts in China, Taiwan and Korea and is still achieving good design activity among handset and platform providers, says RFMD.

Multiple design wins for GPS LNA module

RFMD has secured multiple high-volume design wins for its RF2815 GPS low-noise amplifier (LNA) module in support of upcoming 3G smartphones and 3G data cards. Volume production is expected to start in the December quarter, with a significant increase in volume anticipated in 2010.

RFMD says that the design wins supplement its revenue growth in power amplifiers/transmit modules and highlight the ongoing positive design activity achieved by its Switch and Signal Conditioning product line (SSCPL) since its formation in 2007. The incremental content opportunity available to SSCPL is significantly expanding RFMD's total addressable market (TAM) and bolstering customer and channel partner relationships by extending the firm's support for the entire RF front end (transceiver to antenna interface).

The RF2815 integrates a low noise-figure LNA, output SAW (surface acoustic wave) filter and supporting components in a com-

pact 3.3mm x 2.1mm x 1.0mm module. The highly integrated device is optimized for both solution size and performance and is designed for battery-powered mobile devices, such as portable navigation devices (PNDs) and GPS-enabled handsets, requiring high sensitivity.

The RF2815 is currently designed into 3G smartphones and 3G data cards manufactured by customers in China, Europe, Korea, North America and Taiwan. Design activity supports RFMD's market and customer diversification efforts and is expected to reach revenue levels of multiple millions of dollars per quarter as early as the March 2010 quarter.

Although RFMD provides GSM/GPRS, EDGE and 3G transmit modules and power amplifiers to manufacturers of handsets, smartphones and data cards, the firm expects to expand its dollar content opportunity in both the power amplifier/transmit module and the switch and signal conditioning segments in 2010.

Skyworks front-ends power LG multimedia handsets

Skyworks Solutions of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, says that it is powering several of the newest multimedia handsets from LG Electronics as the South Korean firm launches its suite of next-generation, feature-rich mobile handsets. In particular, its 3G and 4G front-end solutions are at the heart of LG's GM200, GR500 and KP500 platforms, which have enhanced touch-screen, audio, camera and messaging functionality.

Skyworks' small and efficient SKY77175 dual-band power amplifier (PA) for WCDMA/HSDPA band II (1850–1910MHz) and band V (824–849MHz) is a fully matched, 14-pad surface-mount technology (SMT) module that meets the stringent spectral linearity requirements of WCDMA transmission, high power-added efficiency (PAE) for power output to 29dBm (Band II) and 29dBm (Band V), and a low-current analog pad (VCONT) to improve efficiency for the low RF power range operation.

The SKY77340 PA module is designed in a compact form-factor for quad-band cellular handsets



Skyworks' SKY77175, SKY77340, SKY77521 and SKY77531, powering LG's next-gen multimedia handsets.

comprising GSM850/900, DCS1800, PCS1900, supporting gaussian minimum shift keying (GMSK) and linear EDGE modulation, and Class 12 GPRS multi-slot operation. Two separate HBT PA blocks supporting the GSM850/900 bands and the DCS1800/PCS1900 bands are fabricated on InGaP die. Inputs and outputs are impedance matched to 50Ω, and a custom CMOS IC provides the internal MFC function and interface circuitry.

The SKY77521 transmit and receive (Tx–Rx) front-end module (FEM) is designed in a very low-profile (1mm) compact form factor for quad-band cellular handsets comprising

GSM850/900, DCS1800 and PCS1900 operation — making it a complete transmit VCO-to-antenna and antenna-to-receive surface-acoustic wave (SAW) filter solution. The FEM also supports Class 12 GPRS multi-slot operation and EDGE polar modulation. WCDMA switch-through support is provided by three dedicated high-linearity ports.

The SKY77531 Tx/Rx integrated phase and amplitude controller (iPAC) FEM is in a low-profile compact form factor, and supports quad-band cellular handsets operating in the GSM850/900 and DCS1800/PCS1900 bands as well as Class 12 GPRS multi-slot operation. The module consists of separate GSM850/900 and DCS1800/PCS1900 PA blocks, 50Ω impedance-matched inputs and outputs, TX harmonics filtering, a high-linearity and low-insertion-loss pHEMT RF switch, and a PAC block with internal current sense resistor.

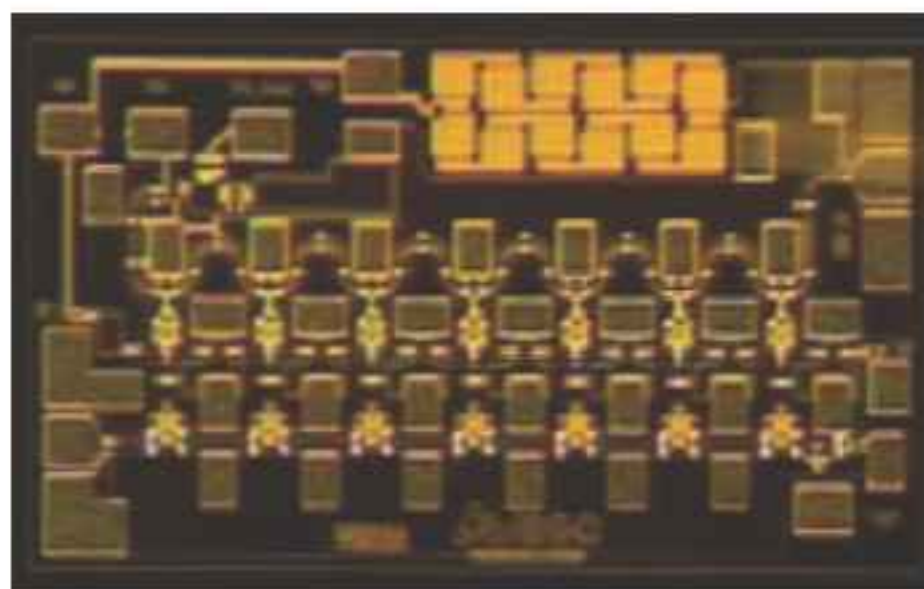
"As a valued business partner, we look forward to further enhancing our relationship with LG as they increasingly expand their global mobile communications presence," says Liam K. Griffin, Skyworks' senior VP, sales & marketing.

www.skyworksinc.com

Avago launches first 80GHz traveling wave amplifier for microwave radio and satellite VSAT applications

Avago Technologies of San Jose, CA, USA has launched what it claims is the first ultra-broadband traveling wave amplifier (TWA) for high-speed digital communications applications operating in the 30kHz to 80GHz frequency band.

The AMMC-5025 amplifier provides 8dB of small-signal gain and gain flatness of ± 0.7 dB along with input and output return loss of better than 10dB, suiting use in test & measurement equipment, radar warning receivers, wideband communications and surveillance systems, and point-to-point radios.



The AMMC-5025's 1600μm x 950μm.

The AMMC-5025 has a gain slope control feature and an adjustable gain control feature that allows more than 25dB of dynamic range. The TWA's performance features

suit use in instrumentation and MMIC applications. Moreover, with a die size of just 1.6mm by 1.0mm, the AMMC-5025 integrates easily into a wide range of RF micro-modules and subsystems, says Avago.

Features include a 50Ω match on input and output and ESD protection, 70V MM and 300V HBM. Typical performance ($V_d = 5V$, $I_{dsq} = 0.1A$) includes P-1dB of 15dBm @ 40GHz and input/output return loss of -10 dB/ -15 dB.

The AMMC-5025 is priced at \$150 each in 1000 piece quantities.

www.avagotech.com

IN BRIEF

TriQuint and Huawei partner on next-generation optical transport systems

RF product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has signed a memorandum of understanding (MOU) with Chinese telecom network provider Huawei to supply driver amplifiers and related products for new optical transport systems.

TriQuint says that, as a strategic partner, it will work closely with Huawei to develop higher-speed and wider-bandwidth networks solutions with lower power consumption for operators worldwide.

In addition to the memorandum of understanding, the product development roadmaps of both TriQuint and Huawei will be aligned, with the aim of enhancing the competitiveness of the firms' products. "Huawei is always on the look out for advanced technology that allows operators to meet network optimization challenges in reducing TCO (total cost ownership) through lower power consumption," says Qinya Hua, Huawei's manager of Transport Networks.

"TriQuint looks forward to supporting Huawei's development and deployment of next-generation 40Gb/s optical networks as well as the evolution of ultra-high-speed 100Gb/s networks," says Brian P. Balut, TriQuint's VP, Networks. "Our optical amplifiers have set a standard for high performance, efficiency and customer value that are in sync with Huawei's requirements for 'greener', high-efficiency data transport systems," he adds.

www.huawei.com

TriQuint launches cable, radio and optical networks products for broadband connectivity

At European Microwave Week in Rome, Italy (28 September to 2 October), RF product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA launched new broadband connectivity solutions for cable systems, microwave radio and optical networks.

"Network operators are seeing substantial increases in radio, optical and cable network traffic because of the growing popularity of home and mobile data applications," notes Asif Anwar, director of Strategy Analytics' GaAs and Compound Semiconductor Technologies Service. "Operators are looking for cost-effective ways to expand capacity while lowering operational expenses. Greener, more efficient systems that use less energy for amplification and cooling are especially appealing," he adds.

"TriQuint GaAs-based products are inherently more efficient and offer high linearity for those applications that require it," continues Anwar. "This places TriQuint in a good position to take advantage of a projected 10% CAGR [compound annual growth rate] for point-to-point radio products and a cable infrastructure CAGR of 14% through 2013," he adds. "The fiber-optic IC market CAGR should more than double during this period, while the emerging 40Gb/s segment will lead growth with a projected 78% CAGR through 2013."

In September, TriQuint acquired cable TV and fiber-to-the-home (FTTH) RFIC specialist TriAccess Technologies of Santa Rosa, CA. TriAccess offers a 'triple-play' line-up of highly linear amplifiers with low power consumption for internet-video-voice services. TriQuint says that demand for TriAccess products has doubled as cable and telecom companies race to enhance networks for high-speed

multimedia content delivery.

New TriQuint RFIC products developed by TriAccess (the TAT7464, TAT7466, TAT7467 and TAT7472) — which specifically meet the requirements of DOCSIS 3.0-based cable TV systems — can reduce power consumption by up to 50% and can cut overall PC board areas by up to 30%.

TriQuint's new TGA2807-SM is another DOCSIS 3.0 cable TV amplifier that can replace two conventional solutions. The firm says it can operate at much reduced power while meeting DOCSIS requirements, enabling video-on-demand, two-way data traffic and other emerging services through cable networks.

TriQuint says that it is also advancing 3G/4G wireless network infrastructure with microwave radio backhaul amplifiers, including its TGA4531. The new amplifier does the work of two narrowband devices, covering the critical 17–24GHz frequency range with a single device. Highly linear, the TGA4531 enables manufacturers to meet complex modulation requirements while reducing their overall bill of materials, the firm claims.

The lower-frequency needs of microwave radio designers are being met with the new highly linear TGA2706-SM surface-mount device, which TriQuint claims offers easy assembly while supporting the complex modulation schemes typical of 3G/4G networks.

TriQuint also enables high-speed optical networks with products such as the TGA4943-SL, which the firm claims is the first surface-mount amplifier for 40Gb/s systems. As well as offering surface-mount convenience for easier assembly, the TGA4943-SL uses only about half the power of other solutions (just 2.1W), the firm claims.

www.triquint.com/eumw

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AWR releases MMIC process design kit for WIN's H2W PH50-00 GaAs foundry process

As the latest in its series of process design kits (PDKs) for monolithic microwave integrated circuit (MMIC) designers, high-frequency electronic design automation (EDA) software tool provider AWR of El Segundo, CA, USA has released a PDK for the PH50-00 GaAs enhancement/depletion-mode pseudomorphic high-electron-mobility transistor (pHEMT) and heterojunction bipolar transistor (HBT) process (or H2W) of Taiwan's WIN Semiconductors Corp (which is reckoned to be the world's largest pure-play 6-inch gallium arsenide foundry).

WIN PH50-00 is a high-frequency, high-power MMIC process that has been in production since 2007. AWR says that, until now, PDKs and design tools have lacked the

technology needed to take full advantage of the advanced features in the process.

However, the new WIN/AWR PDK fully exploits the process along with the unique technologies in the latest version of AWR's Microwave Office software (v2009), as well as AWR's ACE automatic circuit extraction technology, AXIEM 3D planar electromagnetic simulator, and APLAC multi-rate harmonic balance (MRHB) simulator.

The WIN/AWR PP50-00 PDK can be resident in Microwave Office software simultaneously with packaging and other foundry PDKs to provide a complete module co-design environment.

"The latest WIN/AWR PDK provides customers with the most accurate models available for

pHEMT and HBT process technologies," claims Gary St. Onge, WIN's senior VP of international sales. "By facilitating our customers' design flow with advanced compound semiconductor processes as well as advanced EDA tools and flows, we bridge the gap from design concept to working product," he adds.

The new PDK's versatility is unmatched in enabling high levels of integration and performance, claims Sherry Hess, AWR's VP of marketing. "These achievements make the process exceptionally well suited for the most complex, functionally dense MMICs," she adds.

All AWR/WIN PDKs are distributed by WIN free of charge to qualifying customers.

www.winfoundry.com

Agilent announces add-on PDK with MMIC tool bar personality for UMS' pHEMT processes

Agilent Technologies Inc of Santa Clara, CA, USA has made available an add-on process design kit (PDK) with enhanced, foundry-certified features for the PH25, PH15, PPH25 and PPH15 pHEMT processes of United Monolithic Semiconductors' (UMS). UMS designs and produces RF, microwave and millimeter-wave components and ICs for the telecom, space, defense, automotive and ISM sectors at its facilities in Orsay, France and Ulm, Germany.

Providing what is claimed to be the most complete MMIC design flow available using Agilent's Advanced Design System (ADS) electronic design automation (EDA) software platform, the new MMIC tool bar personality completely revamps layout functions, adds many design automation and routing capabilities, and helps to streamline the MMIC design process.

The new MMIC tool bar personality enables the full set of ADS layout editing commands customized for UMS PDKs, including several single-button commands for converting a trace to transmission-line elements, automatic via insertion, invoking a three-dimensional (3D) layout viewer, and launching the ADS desktop design rule checker. Agilent says that these capabilities improve design efficiency by enhancing the design verification and synchronization between the ADS schematic and layout environment. Along with the industry-proven 3D planar EM technology, MMIC designers can now benefit from the MMIC design flow that ADS provides.

"This enhanced PDK will largely improve the design experience for both our internal MMIC designers and external customers," says Eric Leclerc, manager of UMS' foundry business department.

"Such upgrades will also ensure that ADS users of UMS kits have a complete front-to-back-end design flow. We intend to bring this feature to other technologies in the near future," he adds.

"This add-on PDK further strengthens our collaboration with UMS, one in which we will work to continuously bring value to our common customers through advanced PDK development," says Avery Chung, foundry program manager of Agilent's EEs of EDA division. "With ADS 2009, users will be able to extract X-parameter models of their PDK designs either directly from ADS or through Agilent instrumentation, providing them with an accurate and complete unified behavioral modeling capability and further simplifying the design process," he adds.

www.ums-gaas.com
www.agilent.com/find/eesof-foundry-ums

Anadigics and WIN announce strategic foundry relationship

A strategic agreement has been announced for Taiwan's WIN Semiconductors Corp, the world's largest pure-play gallium arsenide (GaAs) foundry, to provide GaAs-based wireless and broadband communications component maker Anadigics Inc of Warren, NJ, USA with processing services to meet demand for its radio frequency integrated circuits (RFICs).

The foundry agreement complements the continued production of devices at Anadigics' 6-inch GaAs manufacturing facility.

Anadigics says that the relationship forms the cornerstone of its new hybrid manufacturing strategy, which provides for a mix of internal and external manufacturing capabilities to ensure that demand can be met at all times.

"With this new relationship, not only will we be able to meet the

increasing customer demand, our design teams will be able to leverage a range of additional technologies," says Anadigics' CEO Mario Rivas.

WIN will deliver services that complement Anadigics' internal strengths, comments the foundry's chairman Dennis Chen. "We look forward to making our technologies available to their RF designers," he adds.

"This strategic agreement and implementation of our hybrid manufacturing strategy will ensure that we have the capacity to ramp up to meet growing product demand while ensuring we meet our own high internal standards for quality, delivery and customer satisfaction," says Russ Wagner, Anadigics' VP of operations.

www.anadigics.com

www.winfoundry.com

Anadigics opens Japan sales office

Anadigics has opened an office in Tokyo, Japan in order to support its local customers and to develop market opportunities within the local manufacturing community.

Led by Makato Takaoka (Anadigics' new country manager for Japan), the office aims to enable Anadigics to better serve its Japanese customers. "This new sales office will provide greater depth of support by offering local RF applications support and expertise for new platforms that rely on Anadigics' high-performance wireless and broadband products," says Michael Canonico, VP of worldwide sales.

With more than 25 years of Japanese market experience, Takaoka has previously held senior sales positions at ST-Ericsson Japan, NXP Semiconductor Japan, Philips Electronics Japan and Fujitsu Components Japan and overseas.



New Japan country manager Makato Takaoka.

"The establishment of a dedicated Japanese office signifies Anadigics' commitment to the Japanese marketplace, which has a rich history of wireless and broadband innovation," says Takaoka. "Japan originally offered wireless Internet through NTT DoCoMo's i-mode as early as 1999, and today we are one of the countries most committed to WiMAX service rollouts through UQ Communications," he adds. "Anadigics is now very well positioned to build on existing customer relationships while developing new opportunities for growth."

Endwave launches MMIC product line

Endwave Corp of San Jose, CA, USA has launched a range of microwave and millimeter-wave ICs for microwave radios and other high-frequency systems.

The product line consists of a variety of circuit types including amplifiers, voltage-controlled oscillators, up- and down-converters, variable-gain amplifiers, voltage variable attenuators, fixed attenuators and filters. Both bare die and QFN-packaged devices are available, over the full microwave radio-frequency range of 7–38GHz. The product line also includes devices for the new E-band (71–76GHz and 81–86GHz) frequency range.

The product line has been derived from Endwave's extensive design library, created while providing custom microwave and millimeter-wave RF modules to radio system OEMs. The devices are specially designed to meet the demands of next-generation products that require high power output, excellent linearity and low phase noise. Many of the devices also include integrated control and detection elements that provide interfaces to facilitate sophisticated micro-controller operation of both the transmit and receive chains.

"Since the founding of Endwave over 15 years ago, we have had a dedicated internal MMIC design group that has developed the numerous high-performance circuits used in our module products," says president & chief operating officer John Mikulsky. "Having shipped millions of these devices in various modules supplied to microwave radio OEMs, we are taking the opportunity to offer these desirable solutions to the market as bare die and packaged devices. We have worked with virtually every MMIC foundry in the industry to produce these circuits."

www.endwave.com

IN BRIEF

IT director appointed

M/A-COM Technology Solutions has recruited Phil Stathas as director of Information Technology, responsible for directing all IT activities throughout its global organization.

Stathas has more than 27 years of experience in the semiconductor, components and high-volume manufacturing industry. This includes nine years with M/A-COM, where he directed its management information systems activities (e.g. installing a new enterprise resource planning system for the entire company). For the past few years, Stathas has served in senior leadership IT positions at Thermo Fisher Scientific, CMGI/Modus Link Corp, and Thermo Electron.

"Phil's intricate knowledge of current and state-of-the-art technologies, coupled with his strength in leading cross-functional teams, makes him the ideal person to ensure our business systems are in pristine condition as we continue to grow our business and increase our profitability," comments M/A-COM Tech's chief financial officer Conrad Gagnon.

www.macomtech.com

M/A-COM migrates to Eyelit MES

M/A-COM Technology Solutions Inc has selected the manufacturing execution software (MES) suite of Eyelit Inc of Toronto, Canada to replace the legacy software at its two wafer fabs in Lowell, MA and Torrance, CA, USA.

Eyelit says that its MES suite will modernize M/A-COM Tech's manufacturing software infrastructure and lower the total cost of ownership and resource dependences of its older system. It also enables M/A-COM to standardize on one manufacturing software provider, simplifying its software architecture while gaining capability and flexibility. It also provides a platform to easily add equipment automation and integrate Quality Management tasks, such as OCAP, QAR, and MRB.

It took eight weeks to migrate the legacy MES data model and active WIP. M/A-COM now has a fully integrated MES, asset management and SPC solution. The new system eliminated 12 custom programs (now incorporated in the standard Eyelit model). It also added new production areas (not in the legacy MES) to the Eyelit model and preserved the MES/ERP integration with SAP.

"With our legacy MES product, we questioned the value of our support dollars and what we were getting in return," comments Charles Gagne, M/A-COM Tech's director of Wafer

Operations. "We've been an Eyelit customer, using Operator Station, PRemote and UTIL*eyes, for years... Under new ownership and direction, we were looking for strategic vendor partnerships," he adds.

"No company wants to replace its MES software in a running factory and we usually recommend more than eight weeks for a migration," says Dan Estrada, Eyelit's VP sales & business development. "In performing a manual deployment of the MES, we felt we could meet the deadline," he adds.

"Semiconductor manufacturers believe it costs millions of dollars to replace their legacy MES systems. Eyelit has demonstrated that it can deliver a proven, low-risk solution for much less, while providing our customers with greater capability and flexibility," Estrada continues. "With the pending, end-of-life support of HP AlphaServer and HP PA-RISC 9000 server platforms, many companies face a hardware upgrade. Factories running MES software and systems, such as WorkStream, PROMIS, and FACTORYworks (from Applied Materials), are all viable candidates for Eyelit's migration solution," he adds. "Companies looking to move to lower-cost software platforms, such as Linux or Windows, would also benefit."

www.eyelit.com

M/A-COM launches surface-mount broadband PIN diode switches

At European Microwave Week at the end of September, M/A-COM Tech exhibited its new family of surface-mount broadband 2-20GHz PIN diode switches — which use its proprietary, patented heterolithic microwave integrated circuit (HMIC) process — for test instrumentation, satellite and other wide-frequency-range applications.

"These new switches provide exceptional bandwidth in a small chip-scale surface-mount package, while maintaining exceptionally low insertion loss and high isola-

tion with greater than 2W power handling," claims product manager Scott Vasquez.

The compact (1.5mm x 2.2mm) MASW-002103 chip-scale package SPDT switch offers what is claimed to be the smallest broadband surface-mount symmetrical SPDT solution, with broadband performance out to 26GHz. It achieves greater than 27dB of isolation and less than 1dB of insertion loss across the 2-20GHz frequency range.

The 1.65mm x 2.06mm MASW-003103 chip-scale package SP3T

switch achieves greater than 30dB of isolation and less than 1.1dB of insertion loss across 2-20GHz, but at 25GHz can still achieve 1.4dB of insertion loss and 28dB of isolation.

The 1.5mm x 2.14mm MASW-004103 SP4T switch achieves greater than 33dB of isolation and less than 1.3dB of insertion loss across 2-20GHz, as well as 1.6dB of insertion loss and 30dB of isolation out to 24GHz.

All the switches can handle power levels up to 38dBm at 2GHz and 33dBm at 20GHz.

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Boosting frequency–breakdown trade-off for AlGaN HFETs

Japan's National Institute of Information and Communications Technology (NICT) and Fujitsu Laboratories Ltd have developed extreme high-frequency (118GHz) heterostructure field-effect transistors (HFETs) with an aluminum gallium nitride (AlGaN) back-barrier to maintain an off-state breakdown voltage of more than 110V [Norio Onojima, Japanese Journal of Applied Physics, vol.48, p094502, 2009].

Gallium nitride is considered to be a key material for producing the next generation of high-power components such as power amplifiers for radio transmission up to about 30GHz, with a leading potential application being for mobile network base-stations. This is based on high saturation velocities for electrons and high breakdown fields based on the wide bandgap of III-nitride materials (about 3x and more, compared with silicon).

Last year, a 60 μm -gate AlGaN/GaN-based HFET achieved a current-gain cutoff frequency (f_T) of 190GHz [Higashiwaki et al, Appl. Phys. Express, vol.1, p021103, 2008]. This sort of result makes III-nitrides of interest to applications beyond mobile phone, wireless networking, etc into the millimeter-wave (MMW) range of frequencies (30–300GHz, 10^{-1}mm) with applications such as point-to-point, inter-satellite and point-to-multipoint communications, as well as high-resolution radar. However, to meet the requirements of these applications, a high breakdown voltage in the off-state is needed to give an adequate maximum output power.

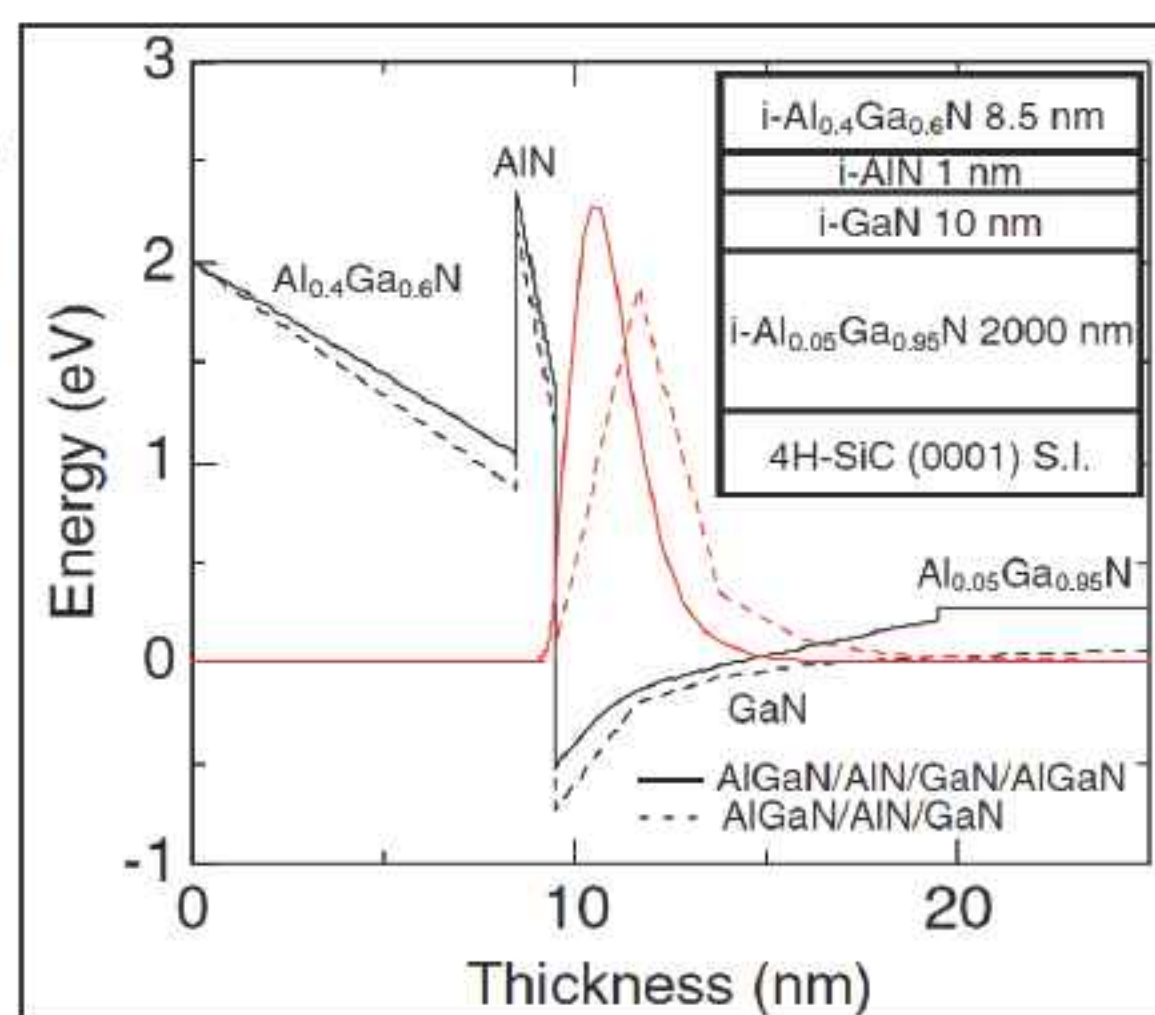


Figure 1. Conduction band diagram and calculated electron concentration distributions with and without back-barrier. Schematic of device structure inset.

The team grew its structure on a 4H-SiC substrate (Figure 1) using metal-organic chemical vapor deposition (MOCVD). The HFET includes a double-barrier arrangement (AlGaN/GaN/AlGaN) with top and back/buffer barriers constructed of AlGaN with different compositions (top 40% Al, back 5% Al). Simulations using a one-dimensional Poisson-Schrodinger solver with and without the back-barrier suggest that the two-dimensional electron gas is more efficiently confined with the back-barrier arrangement. This is attributed to the combined effects of the

conduction-band offset and the presence of a polarization-induced sheet charge.

The T-shaped gate electrode measured 50x2 μm with a 60nm gate length. The separation between the source and drain electrodes was varied from 2 μm to 5 μm . The f_T was highest with the 2 μm distance (132GHz) and fell to 118GHz for the 5 μm separation. The researchers attribute this to an increase in the access resistance. The paper comments that the change in cut-off is relatively small due to the low sheet resistance of 228 Ω/sq .

The breakdown voltage varied in the opposite direction, being highest at 5 μm source-drain separation (Figure 2). Both the 4 μm and 5 μm devices had breakdowns higher than 110V. The three-terminal breakdown voltage was defined as the drain voltage at which the increase in drain current density (I_d) was $5 \times 10^2 \text{A/mm}$ when the drain current–drain voltage characteristics were measured at a gate bias below the threshold voltage (V_{th}).

Some electroluminescence was observed during the breakdown measurements, possibly due to high-energy carrier generation under the high bias conditions. It is hoped that further study of this effect could lead to improvements in breakdown characteristics.

The researchers comment that comparison experiments with devices not having the back barrier are needed to confirm the role of the back-barrier in improving breakdown performance.

<http://jjap.ipap.jp/link?JJAP/48/094502>
Author: Mike Cooke

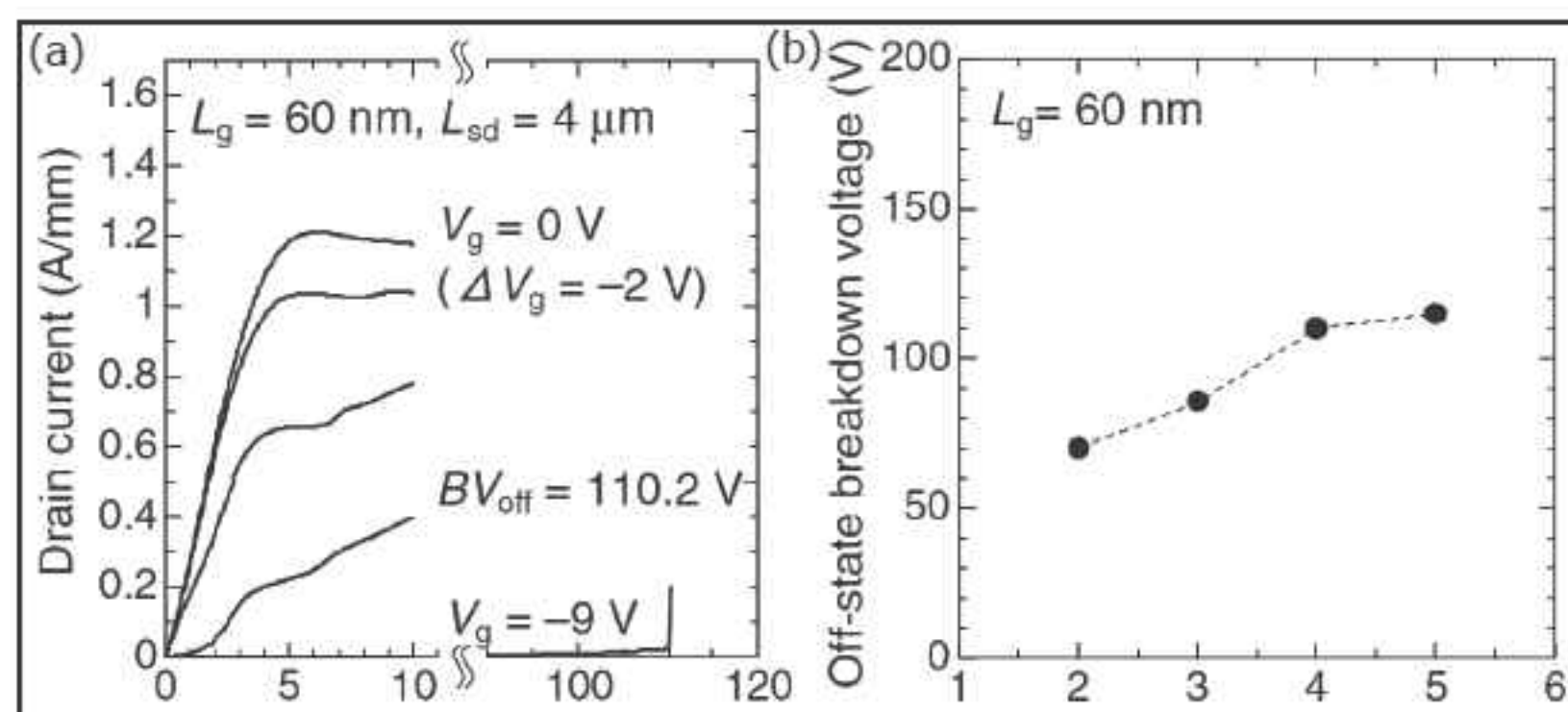


Figure 2. Drain current-voltage for 4mm source-drain distance (a); variation of breakdown with source-drain distance (b).

Wafer bonding yields Si/GaN integration

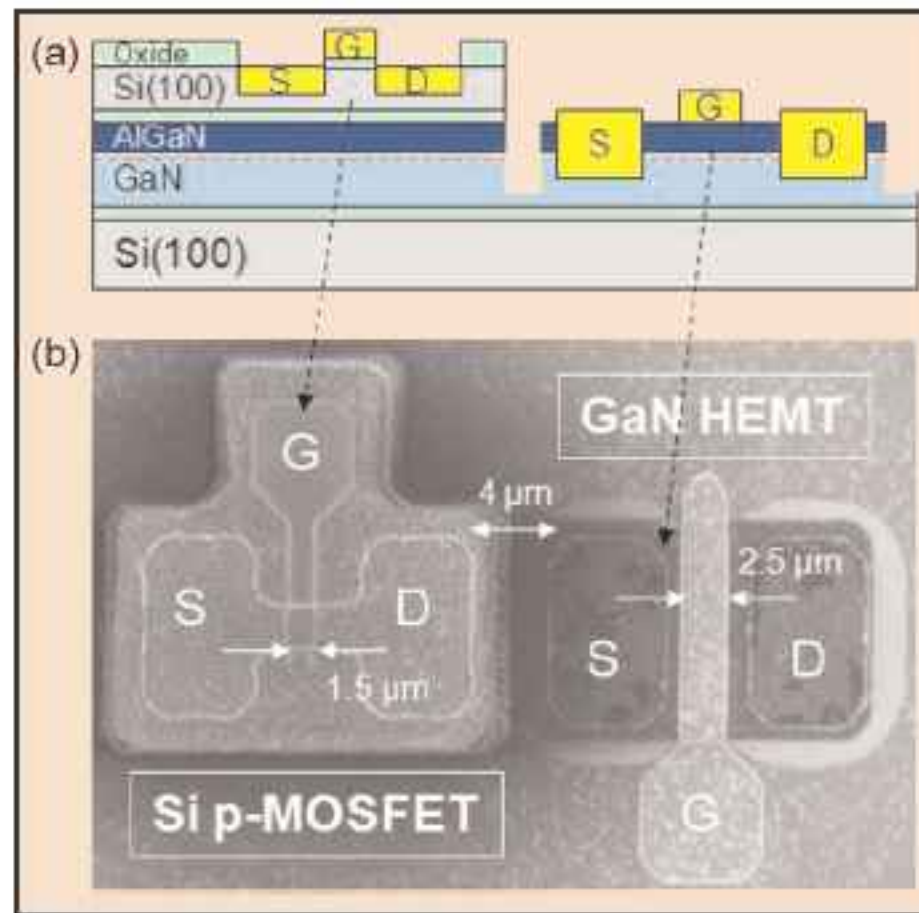
Nitronex and MIT have demonstrated the first on-wafer integration of silicon MOSFETs and gallium nitride HEMTs [Chung et al, IEEE Electron Device Letters, vol30, p1015]. The virtual substrate for the devices consists of a GaN layer sandwiched by two silicon layers, created by epitaxy, wafer bonding and etch-back.

The researchers took advantage of the high thermal stability of nitrides such as GaN to fabricate first the MOSFETs on the top layer and then to etch down to the GaN to produce the HEMTs. This allowed the heterogeneous transistors to be placed less than $5\mu\text{m}$ apart.

While silicon is the most versatile material for producing highly dense, high-frequency logic circuits, GaN is attractive for high-frequency power handling in analog/mixed-signal circuits and for its green-to-ultra-violet optoelectronic properties.

Various techniques have been used in the past to create such GaN/Si substrates, such as epitaxial growth on mis-cut Si(100) and Si(110). High-quality GaN is hard to achieve, given the lattice mismatch between materials and the high density of surface states from using mis-cut substrates. Surface states degrade device performance characteristics.

Nitronex has worked on GaN-on-Si integration and developed an MOCVD process for GaN/Si. The MIT/Nitronex virtual substrate begins (see below) with MOCVD growth of AlGaIn/GaN on a Si(111) wafer, then spin-coat deposition of hydrogen silsesquioxane (HSQ). Si(111) is not the most suitable material for producing MOSFETs.



Si pMOSFETs integrated with GaN HEMTs.

A silicon-on-insulator (SOI) substrate is then wafer bonded to the HSQ. The Si(111) wafer is removed using a sulfur hexafluoride (SF_6) deep reactive ion etch. The structure is then bonded to a Si(100) wafer with another HSQ layer. The 200nm Si(100) top layer is then separated from the SOI handle wafer. A simplification would consist of leaving the Si(111) wafer in place and just transferring the Si(100) top layer for the MOSFET devices.

The AlGaIn (26% Al) barrier layer in the HEMT was 175\AA thick. The hybrid wafers are up to 1" in diameter. The team built p-MOSFETs and used SF_6 to etch down to the nitride layers to make the HEMTs.

Gate lengths are micron-scale, while state-of-the-art silicon ICs are 32nm. MIT's Si(100) pMOSFET gate measured about $1.5\mu\text{m}$ and the GaN HEMT about $2.5\mu\text{m}$ (pictured above). The devices have good modulation of the drain current by the gate potential and low off-currents.

However, the gate length impacts the maximum output current and MOSFET performance. MIT is working on shorter-gate-length MOSFETs.

Applications of such integration are high-power integrated wireless transmitters, power gating and power conversion circuits, and in-chip optical interconnects based on nitride light emitters and silicon digital circuitry.

"GaN electronics can be used in a large array of potential applications," says MIT professor Tomás Palacios. "GaN is very attractive for high-frequency applications due to the very large current densities achievable in these transistors, as well as the large electron velocities." Transistors with an f_{max} of 300GHz have been reported and there are programs to increase this beyond 500GHz.

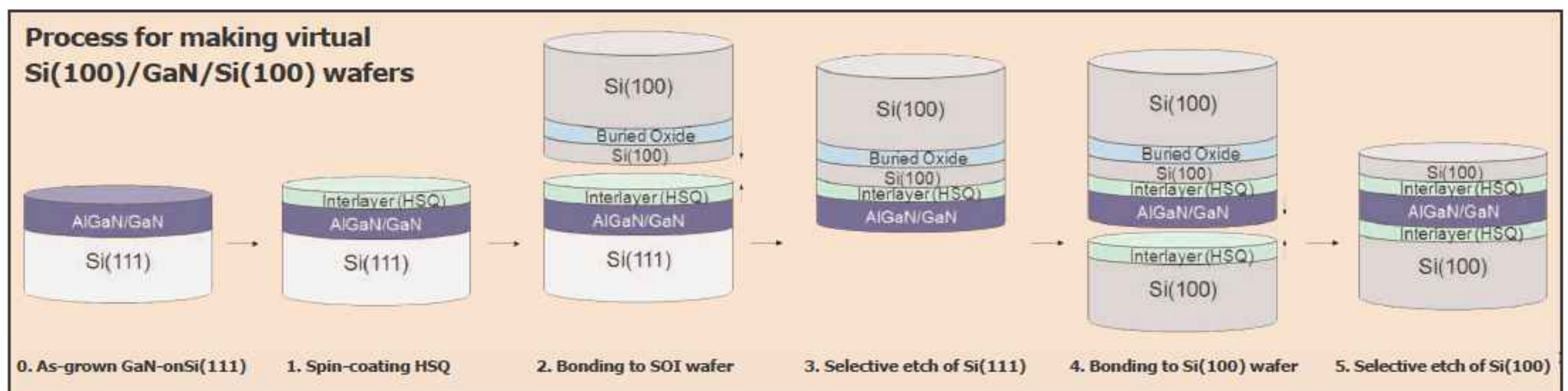
"However, other materials (InGaAs, InSb, etc) are also very promising for these applications," he adds.

"On the other hand, in other applications such as RF power amplifiers and high-voltage power electronics, GaN is clearly the best option and the performance of silicon chips could significantly improve if these devices could be seamlessly combined with silicon CMOS," he adds. "Integration of GaN and silicon would also allow the fabrication of silicon electronics in close proximity to GaN-based LEDs, lasers and MEMS to enable optical interconnections or energy-harvesting devices."

The team is developing technology for larger substrates: 4" wafers first (to be ready in 2-3 months).

<http://dx.doi.org/10.1109/LED.2009.2027914>

Author: Mike Cooke



IN BRIEF

Dow Corning boosts epitaxy capability to meet growing demand for SiC

Aixtron AG of Herzogenrath, Germany says that Dow Corning is extending its silicon carbide (SiC) epitaxy capabilities with its latest-generation Planetary Reactor platform AIX 2800G4 WW for 10x100mm and future 6x150mm SiC wafers. The reactor is planned to be commissioned in second-quarter 2010 as Dow Corning Compound Semiconductor Solutions advances its SiC devices into high-volume, low-cost manufacturing.

"After a rigorous review, we selected the Aixtron system to enable us to deliver the morphology, defect density and uniformity required by our customers," says Mark Loboda, Dow Corning Compound Semiconductor Solutions' science & technology manager. "The added capacity and capability up to 150mm will allow us to meet our customer's rapidly growing needs for high-power SiC device production," he adds.

"Building on over 10 years of experience with our SiC Hot-Wall Planetary Reactor technology, we are able to offer the proven next-generation SiC AIX 2800G4 WW epitaxial production system," says Dr Frank Wischmeyer, VP & managing director of Aixtron AB, Sweden. "The enhanced productivity of the system is due to design features such as a central water-cooled triple gas injector, improved process robustness and simplified maintenance procedures," he adds. "Based on Aixtron's proven IC [Integrated Concept] design, the AIX 2800G4 WW system shares a common platform with over 300 installed systems worldwide."

www.aixtron.com

Microsemi awarded \$2m contract

Microsemi Corp of Irvine, CA, USA, which makes analog mixed-signal ICs and high-reliability semiconductors, says that the US Congress has appropriated \$2m in funding to allow its Power Products Group in Bend, OR to develop silicon carbide-based components for data communications systems on new and upgraded Air Force platforms.

The commitment by the Air Force and Congress aims to further the development of SiC technology supporting future designs of lighter and more efficient jet fighter communications systems.

Microsemi says that SiC technology brings several advantages in

avionics applications, including increased reliability, extended battlespace coverage, point-of-use power conversion, and reduced size and cooling requirements. SiC plays a key role as battlefields become more networked and the demands for expanded bandwidth and high operation increase significantly.

"Microsemi is committed to leading the development of silicon carbide components at our Bend operations that will enable advanced communications for both defense and commercial applications," says the firm's president James J. Peterson.

www.microsemi.com

First SiC JFET in audio amplifiers

SemiSouth Laboratories of Starkville, MS, USA, which designs and makes silicon carbide (SiC) based discrete electronic power devices, says that its highly efficient, normally-off SiC JFET (junction field-effect transistor) has been adopted for the first time by a consumer electronics company for use in a new audiophile-quality power amplifier.

The new J2 power amplifier, designed by Nelson Pass, founder of amplifier specialist First Watt, features SemiSouth's SJEP120R100, a normally-off, 1200V, 100m-Ω SiC vertical JFET. Pass is also founder of Pass Laboratories.

SemiSouth believes that this is the first SiC transistor to enter production in the audio amplifier market. JFETs have traditionally been featured in rapidly growing markets such as solar inverters, as well as server and telecom power supplies. Benefits over comparable transistors include higher system efficiencies, higher switching frequencies and lower conduction losses.

"These new JFETs have a very low distortion characteristic that makes them superb for use in linear amplifiers," says Pass. "In apples-to-apples comparisons with MOSFET-type power transistors, they can achieve

10–20dB improvements in distortion performance. When a better transistor like this comes along, it can mean getting the same distortion performance with a lot less feedback, or lower distortion with the same amount of feedback. The J2 amplifier does both, and that helps make it a better sounding amplifier than the best of its predecessors," he adds.

Pass' use of SemiSouth's transistor continues to show the versatility and performance of the firm's SiC JFET technology, says Dr Jeff Casady, SemiSouth's chief technology officer & VP of business development.

SemiSouth says that SiC technology enables energy-efficient operation of power conversion and power management in telecom power supplies, inverters in solar and high-frequency welding, and future automotive electric vehicle platforms. SiC aims to make power supplies and power inverters up to 75% more energy efficient, operate at up to eight times higher frequencies, run cooler and be physically much smaller (e.g. SiC power JFETs are expected to increase the efficiency of hybrid electric vehicles and to help make them more affordable).

www.semisouth.com



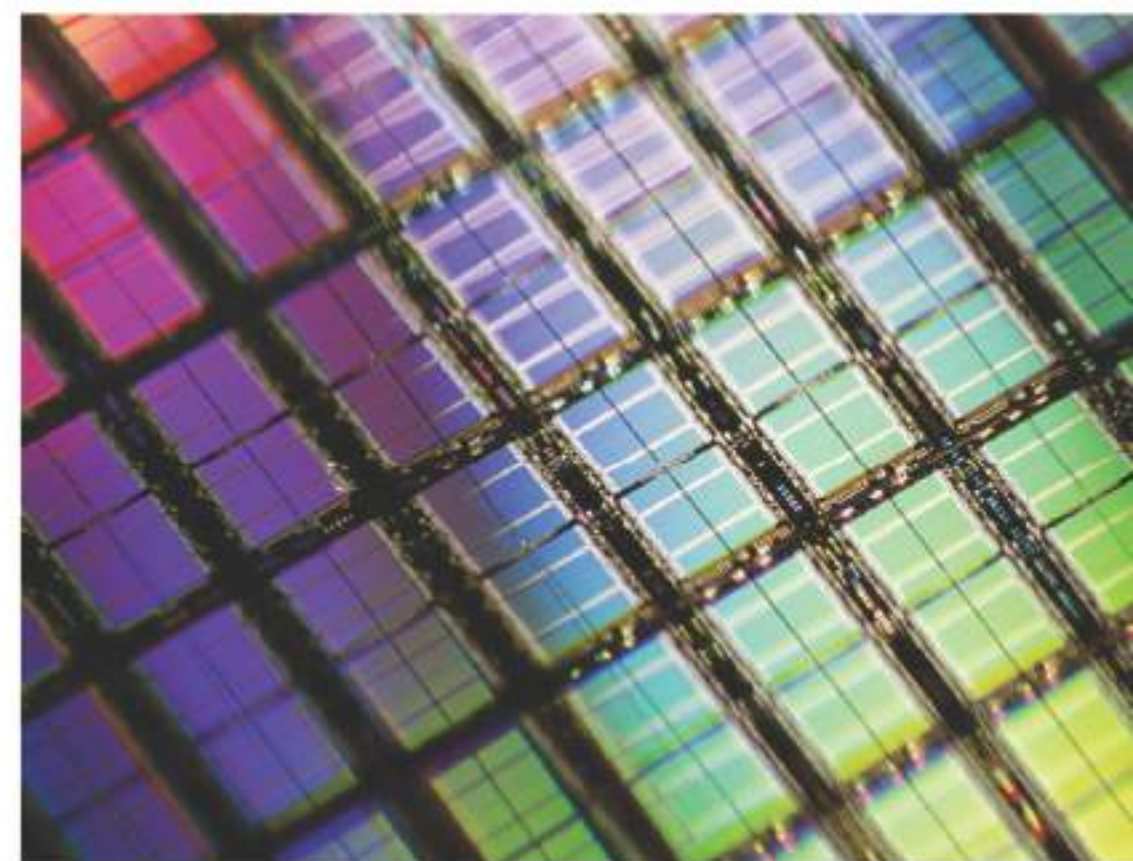
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IQE to buy GaN substrate firm NanoGaN for £3.6m

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has acquired gallium nitride substrate firm NanoGaN Ltd of Bath, UK for up to £3.6m (\$5.8m). This includes an initial consideration of £0.4m in new shares and cash, plus further consideration of up to £3.2m in shares or cash based on achieving future milestones relating to the commercialization of NanoGaN's intellectual property. Completion of the acquisition took place upon admission to trading on the AIM stock market of 5,819,134 new ordinary shares (the placing shares and the consideration shares).

NanoGaN was founded in February 2008 by CEO professor Wang Nang Wang and chief technology officer Sergei Stepanov with £250,000 (\$350,000) in seed funding from University of Bath's 'Sulis Foundation' commercialization fund. In June 2008, the firm raised £500,000 more from private investors. Funds were partly spent on a vertical hydride vapor-phase epitaxy (HVPE) reactor (built by a commercial MOCVD equipment maker according to NanoGaN's own patented design), joining an existing Aixtron 200HT MOCVD reactor.

NanoGaN has established what it claims are unique processes and intellectual property relating to GaN materials and devices. This includes its proprietary Nanocolumn Technology (invented by Wang) for producing high-quality, 2" free-standing GaN substrates, which are critical for manufacturing high-quality blue and green semiconductor lasers and ultra-high-brightness LEDs for solid-state lighting (SSL). "Nanocolumn technology provides a unique approach to overcoming the challenges facing the advancement of blue and green laser technology, high-density optical storage, and ultra-high-efficiency

solid-state lighting," claims Wang.

NanoGaN's method involves using a multiple bubbler vertical matrix showerhead HVPE reactor configuration for pendeo-epitaxial growth of a buffer layer of GaN nano-pillars, which can accommodate the lattice-mismatch-induced strain between the substrate (SiC, silicon, or sapphire) and subsequent growth of bulk GaN. Once a complete boule is grown, individual wafers can be sawn off and polished.

In June, the University of Bath's Duncan Allsopp (acting as consultant) said that NanoGaN had demonstrated reduced defect densities of 10^7cm^{-2} compared to the 10^{10}cm^{-2} typical of GaN grown on sapphire substrates.

IQE says that it has a long-standing association with NanoGaN, having been selected as a key strategic epitaxial materials partner by Wang. "We carefully selected IQE

as the ideal partner to bring our intellectual property to mass production based on its track record and its experience," says Wang.

The transaction represents a unique opportunity to commercialize NanoGaN's technology, he adds.

With development of NanoGaN's technology at an advanced stage (having entered pilot production in June), IQE will assist in completing the development of commercial products and then begin transferring the technology to its high-volume production facilities, where it is expected to begin generating sales in 2010.

IQE says that the acquisition complements and enhances its existing product portfolio by accelerating its strategic plans in emerg-

ing high-growth markets for laser projection, high-definition optical storage (including BluRay products), high-resolution laser printing, and solid-state lighting for industrial, commercial and residential lighting. NanoGaN's core technology will also be used to enhance IQE's supply of GaN products for high-power RF applications. NanoGaN also brings seven filed patents, and several innovations for which patents will be submitted.

As part of the acquisition, Wang will become chief scientific advisor to IQE's board. Wang was co-founder of Arima Optoelectronics Corp (which is listed on the Taiwan Stock Exchange) and chairman & president of Taiwan-based Quantum Optech Inc. Many of his 26 granted patents continue to be used for mass production in the optoelectronics industry, says IQE. He has also acted in advisory roles, including scientific advisor to Taiwan's government as well as to the country's ITRI (Industrial Technology Research Institute).

"This acquisition provides a perfect complement to our existing wireless and opto, and emerging solar businesses and widens our product portfolio," says IQE's CEO Dr Drew Nelson. "This acquisition of NanoGaN represents a major milestone in our technology roadmap, and enables the group to accelerate its entry into the emerging high-growth and large-volume markets for blue and green semiconductor lasers as well as the key enabling materials for low-energy LED lighting," he adds. "We now operate in a range of diverse international markets, all with powerful drivers including high-growth consumer applications and political and legislative trends towards technological solutions to address environmental challenges."

www.nanogan.com

www.iqep.com

RUSNANOPRIZE-2009 awarded to Keldysh, Cho and Riber

The 2nd International Nanotechnology Forum in Moscow — organized by RUSNANO (Russian Corporation of Nanotechnologies) — saw the award of the inaugural International Prize in Nanotechnology.

RUSNANOPRIZE is reckoned to be the first international prize awarded for not only R&D and inventions but also the introduction of nanotechnology in commercial production. It is awarded annually in one of four fields (nanoelectronics, nanomaterials, nanobiotechnologies and nanodiagnostics) to outstanding scientists and companies engaged in developing nanotechnologies.

The fund of 3 million rubles (about \$95,000) for the 2009 prize (which focuses on nanoelectronics) is shared equally between recipients professor Leonid Keldysh (a physicist at Russia's Lebedev Institute of Physics) and professor Alfred Y. Cho of Bell Laboratories in the USA.

Riber S.A. of Bezons, France, which makes MBE systems, evaporation sources and effusion cells, was also named as a recipient.

The award winners' scientific, engineering and production work is credited with laying the foundation for mass use of nano-hetero-structures in the production of telecom systems (mobile communications and the Internet), light sources (LEDs, solid-state lasers), various-purpose photo-receivers (security systems, supervision and control systems, including those used in space), high-efficiency solar radiation converters (photovoltaic generators) and sensors for intelligent control systems and robotics.

The Prize Committee is co-chaired by RUSNANO's CEO Anatoly Chubais and Nobel Prize laureate & Russian Academy of Sciences vice president Zhores Alferov.

www.rosnano.ru

Riber grows in China

Riber S.A. of Bezons, France says it received an order at the end of September from a Chinese institute for two Compact21 MBE research systems. The new systems will be used to research a new generation of compound semiconductors, says the firm.

Riber did not disclose the customer's name, but said that it already had several Riber systems, and that it wished to strengthen its R&D capacities to meet rising demand for studies in China.

Having sold about 40 systems to date in China, Riber says it sees significant development of MBE in that region. Its penetration of the China market, with 70% of MBE systems installed in the country, was further reinforced by the opening in April of a permanent sales office in Shanghai. Riber adds that it aims to continue increasing sales in China by stepping up its local workforce, especially in technical support.

www.riber.com

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RIBER

IN BRIEF

Indian Institute orders MOCVD reactor for nitride research

The Indian Institute of Science (IISc) — currently celebrating its 100th anniversary — has ordered an Aixtron AIX 200/4 RF-S R&D MOCVD reactor, for delivery in first-quarter 2010 to its new research facility for nano-engineering in Bangalore.

"Our new Aixtron system will be used to deposit uniform doped layers of aluminium, indium and gallium nitrides (AlN, InN, GaN) on 2" and 3" sapphire and silicon substrates," says Dr Srinivasan Raghavan, assistant professor at IISc's Materials Research Centre (MRC). "We intend to build the process technology for a range of advanced devices including white UHB [ultra-high-brightness] LEDs, solar cells and lasers among others (such as transistors)," he adds.

"In particular, our aim is to understand the fundamental relationships between stress evolution and defect formation during growth of these materials," Raghavan continues. "We are looking forward to working closely with Aixtron and enter into a comprehensive technical cooperation program."

The MRC was established as the Materials Research Laboratory in 1978 to pursue research and provide education in the interdisciplinary field of materials science and technology. Areas in which it is currently active include nanomaterials, electro-ceramics, electro-optic functional materials and compound semiconductors. The new centre for nanoengineering is an interdisciplinary unit that involves collaboration with faculty members from multiple departments.

<http://mrc.iisc.ernet.in>
www.aixtron.com

Aixtron co-founder Juergensen receives European SEMI award

At the SEMICON Europa Executive Summit in Dresden, Germany on 6 October, Dr Holger Juergensen, co-founder & deputy chairman of deposition equipment maker Aixtron AG, was presented with the 2009 European SEMI Award, in recognition of his personal contribution to the semiconductor industry.

Juergensen received the award for his engineering vision and business drive in the early years of developing MOCVD technology into commercial deposition equipment. Along with the other founders of Aixtron, he saw the potential of the small R&D systems they developed in the early 1980s to become today's mass-production-scale equipment. The equipment that Aixtron has since created has played a key role in the development of compound semiconductor-based devices, including LEDs, lasers, solar cells and microwave transistors.

Presenting the award, SEMI said that Juergensen had played a pivotal role in the creation of the MOCVD industry, and had also laid the essential technical foundations for further diversification into adja-



Juergensen, with SEMI's president Stan Myers (left) and SEMI Europe's president Heinz Kundert (right).

cent technologies, including organic LED (OLED) and carbon nanotubes material structures.

"I would like to recognize and underline the significance and contribution of the long-term cooperation we have enjoyed with our many valued European customers and partners in industry and research — including Gilbert Declerck of IMEC, who received this award just last year," said Juergensen. "Long-term quality partnerships are what drive innovation and make possible the success that Aixtron and our European colleagues continue to strive for globally," he added.

www.semi.org

Neo-Neon qualifies five CRIUS systems for UHB blue/green LEDs

Neo-Neon International Ltd of Guang Dong, China — said to be the largest decorative lighting manufacturer — has qualified five Aixtron Close Coupled Showerhead CRIUS MOCVD systems in 31x2" wafer configuration. Delivered at the end of 2008, the systems will be used for the development and production of ultra-high brightness (UHB) blue/green LEDs.

Since 2005, Neo-Neon has been engaged in the R&D and production of solid-state lighting technology, with its vertically integrated approach resulting in a complete supply chain from front-end (epi-

taxy, chip process) to back-end (LED packaging and applications). It is now said to be one of the world's largest manufacturers of LED-based lighting products.

"Aixtron convinced us through the quality of their engineering, processes and local support that the CRIUS system was ideal for our blue/green LED production needs," says Neo-Neon's chairman Ben Fan. "The Aixtron MOCVD systems have been installed in our new factory complex, a five-story facility at our mainland China production plant," he adds.

www.neo-neon.com

Azur qualifies Veeco MOCVD system for CPV production ramp

Azur Space Solar Power GmbH of Heilbronn, Germany has production qualified a TurboDisc Arsenic Phosphide (As/P) MOCVD system supplied by Veeco Instruments Inc of Plainview, NY, USA.

The system is the first of several Veeco MOCVD systems to be installed at Azur, and will be used to produce III-V concentrated photovoltaic (CPV) solar cells on germanium substrates for terrestrial applications.

"We selected Veeco's MOCVD systems for their ability to provide reliable large-volume production of

high-efficiency triple-junction solar cells with the lowest cost of ownership," says Azur's CEO Klaus-Dieter Rasch.

Veeco's As/P MOCVD systems feature proprietary in-situ metrology (RealTemp 200), which the firm says enables superior material quality and process efficiency from direct real-time wafer temperature control, fast gas switching for strict control of interface abruptness, and vacuum loadlock automation for highest productivity.

www.azurspace.com

Bridgelux orders Veeco MOCVD reactors for LED production ramp

Epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview NY, USA says that Bridgelux Inc of Sunnyvale, CA, which designs and makes LED-based light sources, has placed a multi-unit order for TurboDisc K465 gallium nitride (GaN) MOCVD systems to support its production ramp for interior and exterior general illumination applications.

"Bridgelux is focused on enabling mass adoption of LED-based solid-state lighting by reducing the cost of light for the general lighting market," says the LED maker's CEO Mark Swoboda. "Bridgelux is committed to the advancement of our core LED materials and process technologies. We expect Veeco to be a strategic partner for our manufacturing expansion," he adds.

"Bridgelux is an important industry player, and we are very excited



Veeco's K465 gallium nitride MOCVD system.

to secure this important new customer," says Bill Miller, senior VP, general manager of Veeco's MOCVD operations.

Veeco's TurboDisc K465 GaN MOCVD system is said to be the only production-proven, fully automated MOCVD platform available on the market. The K-Series MOCVD platform includes the K465 for gallium nitride LED applications and the K475 for arsenic phosphide (As/P) LED and solar applications.

www.bridgelux.com

www.veeco.com

IN BRIEF

Optrans orders MOCVD reactor for InP optoelectronic devices

Deposition equipment maker Aixtron AG of Herzogenrath, Germany says that, in fourth-quarter 2008, Optrans Corp of Kawasaki, Japan ordered a CRIUS Close-Coupled Showerhead (CCS) MOCVD reactor, to be delivered in a multi-4" wafer configuration, for the production of indium phosphide-based optoelectronic devices including photodiodes and LEDs.

Simultaneously, Optrans will also receive an Aixtron Argus multi-channel pyrometer that allows real-time surface temperature measurement and analysis. The unique design allows monitoring of the thermometric distribution across the whole of the MOCVD growth surface in the CCS system, says Aixtron.

In March, Optrans acquired part of the InP microchip division of long-term Aixtron customer NTT-AT of Japan (including research, prototypes, patents, laboratory staff and customers). "We have considerable experience with the Aixtron CCS 19x2" wafer InP system that has given us excellent across-wafer and run-to-run uniformity at NTT-AT," says Optrans VP Dr Gako Araki. "Its ability to use all kind of precursors enables even growth at low temperature, which is beneficial for the device."

The CCS MOCVD reactor was ordered to support Optrans' annual production target of 12,500 wafers by 2010, and should suit the development and production of new-generation indium phosphide photodiode and LED product ranges, Araki adds.

www.optrans.com

www.aixtron.com

IN BRIEF

OIPT wins three-system order from Melbourne Centre for Nanofabrication

UK-based etch and deposition equipment maker Oxford Instruments Plasma Technology (OIPT) has received an order for three systems (two Plasmalab System100 ICP380 tools and a Plasmalab System100 PECVD tool) from the new Melbourne Centre for Nanofabrication (MCN) in Australia as part of a program to equip their cleanrooms for nano- and micro-scale fabrication.

MCN is the Victoria node of the Australian National Fabrication facility (ANFF), a collaborative initiative between the Australian federal government, the Victoria state government, Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), and major Victoria universities (Monash University, the University of Melbourne, Swinburne University, Deakin University, La Trobe University and RMIT University). MCN's ultimate purpose is to fill the gap in Australia for open-access, multi-scale fabrication infrastructure, spanning a range of fabrication environments and materials.

Oxford Instruments claims that the flexibility of its tools was an important criterion in MCN's choice of OIPT as a strategic partner.

OIPT also recently equipped new cleanroom facilities for California's Lawrence Berkeley National Laboratory (LBNL), the UK's Southampton University, and Saudi Arabia's King Abdullah University of Science and Technology (KAUST) — see facing page — notes the firm's sales director Mark Vosloo.

www.nano.monash.edu/mcn.html
www.oxford-instruments.com

Sumitomo Precision Products completes acquisition of Aviza

Sumitomo Precision Products Co Ltd (SPP) has finalized its acquisition of the majority of the assets of etch and deposition equipment maker Aviza Technology Inc of Scotts Valley, CA, USA. This follows completion of the process required by the US bankruptcy court with jurisdiction over Aviza's Chapter 11 filing of 9 June.

The acquisition includes the single-wafer process equipment subsidiary Aviza Technology Ltd (ATL) in Newport, Wales, UK; Aviza's Thermal Products business; and the firm's global sales & service assets and personnel, with the exception of IP related to atomic layer deposition (ALD) systems and process.

ATL and the other acquired assets will be merged with SPP's Newport-based plasma etch & deposition equipment subsidiary Surface Technology Systems plc (STS) to form SPP Process Technology Systems (SPTS). STS is just 10 miles from Aviza's UK headquarters, as both originate from Newport-based Electrotech Ltd (founded in 1968 by scientists from ITT's European research division). SPP bought STS from Electrotech in 1995. Electrotech was subsequently bought in 1996 by Plasma & Materials Technologies Inc of Chatsworth, CA, USA, which then became Trikon Technologies Inc in 1997. Trikon later merged with Aviza Technology Inc in 2005. ATL and STS will continue to operate separately during the integration process, says SPP.

In addition, a new business unit, Thermal Products Division, will be established in the USA, focused on supporting Aviza's existing vertical furnace and atmospheric-pressure chemical vapor deposition (APCVD) customers.

"SPP is excited to reunite STS and Aviza, both with common lineage from Electrotech Equipment Ltd, after so many years of separation," comments Susumu Kaminaga,

president of SPP and chairman of SPTS. "As we broaden our product line through this acquisition we feel all STS and Aviza customers in MEMS, compound semiconductor, advanced packaging, data storage and power device industries will benefit from more technology options from one supplier, with enhanced global service and support," he adds.

"We appreciate that Aviza customers have had concerns

ATL and the other acquired assets will be merged with SPP's Newport-based plasma etch & deposition equipment subsidiary Surface Technology Systems plc to form SPP Process Technology Systems... A new business unit, Thermal Products Division, will be established in the USA

about the long-term stability of the company over the past 6–9 months," says William Johnson, president of SPTS and director of Corporate Strategy for STS. "Now, through the merger of STS and Aviza, we believe we offer a technically strong and financially sound business that is focused on our customers and the enabling technologies of tomorrow," he adds.

"In addition, we look forward to providing factory-certified parts, upgrades, service, and additional systems to the thermal products customers of Aviza with the same experienced Scotts Valley team that has served them in the past under the Watkins Johnson, SVG, and Aviza brands."

www.aviza.com
www.stsystems.com

Saudi Arabia's KAUST places follow-on orders with Oxford Instruments

UK-based etch and deposition equipment maker Oxford Instruments Plasma Technology (OIPT) has received follow-on orders from the newly built King Abdullah University of Science and Technology (KAUST) in Saudi Arabia, which was inaugurated recently on 23 September.

The latest orders are for an Ionfab300 Plus ion beam etch tool and a second FlexAL atomic layer deposition (ALD) tool, bringing the total number of OI systems ordered by KAUST to 13. The tools will equip KAUST's Nanofabrication Core research facility, and add to the initial order for key OIPT systems that included several Plasmalab System100 tools for RIE and ICP etch, and PECVD, and a FlexAL tool.

"As the need for equipment in our new Nanofabrication Core Lab

increased, we decided to extend our order with Oxford Instruments," says professor Tony Eastham, KAUST's director of laboratories. "The scope and performance of OIPT tools for nano-material fabrication made them the natural choice for our requirements in etching, deposition and growth," he adds.

"Earlier this year we were extremely pleased to receive our first multiple-system order from KAUST University, and to be involved with such a large and important research institute from the start," says OIPT's sales director Mark Vosloo.

"This second order from KAUST confirms that OIPT tools are the systems of choice for this important Saudi Arabian facility," Vosloo adds.

www.kaust.edu.sa

www.oxford-instruments.com

IN BRIEF

UCSB orders OIPT FlexAL ALD tool

OIPT has received an order for a FlexAL ALD tool from University of California Santa Barbara (UCSB) for its Nanofabrication Facility.

"This system offers great flexibility for thermal and plasma-based processes with in-situ diagnostic tools to address the needs of a diverse optical and electrical device research effort," says the Department of Electrical and Computer Engineering's Brian Thibeault.

OIPT is now part of the UCSB's involvement in linking local nanotech firms into a chain that stretches across the USA, says OIPT's ALD product manager Chris Hodson. "This is our fourth plasma ALD system in the NNIN [National Nanotechnology Infrastructure Network]."

www.nanotech.ucsb.edu

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Pure CVD SiC carriers target HB-LED yield improvement

High-purity wafer carriers from component maker Morgan Technical Ceramics (MTC) will significantly improve the production yield of high-brightness LEDs, claims the firm.

Its latest carriers, designed for the high temperatures inside gallium nitride metal-organic chemical vapor deposition (MOCVD) reactors, are based on solid monolithic silicon carbide (SiC) material.

The carrier components are themselves fabricated using a CVD process, which Morgan says delivers SiC material with a purity of at least 99.999%.

The wafer carriers are typically about 17 inches in diameter, and can hold up to 40 wafers measuring between 2 and 4 inches in diameter.

Traditionally, the wafer carriers used in MOCVD reactors have been made from graphite, which is then coated with a layer of CVD SiC. According to Morgan, this can be problematic: "These coated graphite-based carriers cannot stand up to the high temperatures (1100–1200°C) required in GaN deposition for today's high-brightness blue and white LEDs," says the firm. While the traditional carriers can develop pinholes, flaking off graphite particles that may contaminate wafers in production, Morgan says that the new monolithic carriers offer better corrosion and erosion resistance.

Another advantage is gained from the better thermal conductivity of the monolithic CVD SiC: 250–300Wm⁻¹K⁻¹, versus 100–140Wm⁻¹K⁻¹ for sintered SiC

and only about 85Wm⁻¹K⁻¹ for pure graphite. "[This] results in a uniform temperature across the wafer's entire diameter, improving the GaN deposition process, and significantly increasing the yield of the target wavelength of LEDs compared to coated graphite wafer carriers," says the firm.

Also, pure monolithic SiC is very long-lived, resists warpage, and only needs to be replaced when the carrier is broken, chipped, or damaged due to handling.

A division of the Morgan Crucible Company, MTC has manufacturing sites around the globe. The CVD SiC components are fabricated at its US site in Hudson, NH, where it also produces pyrolytic boron nitride (PBN).

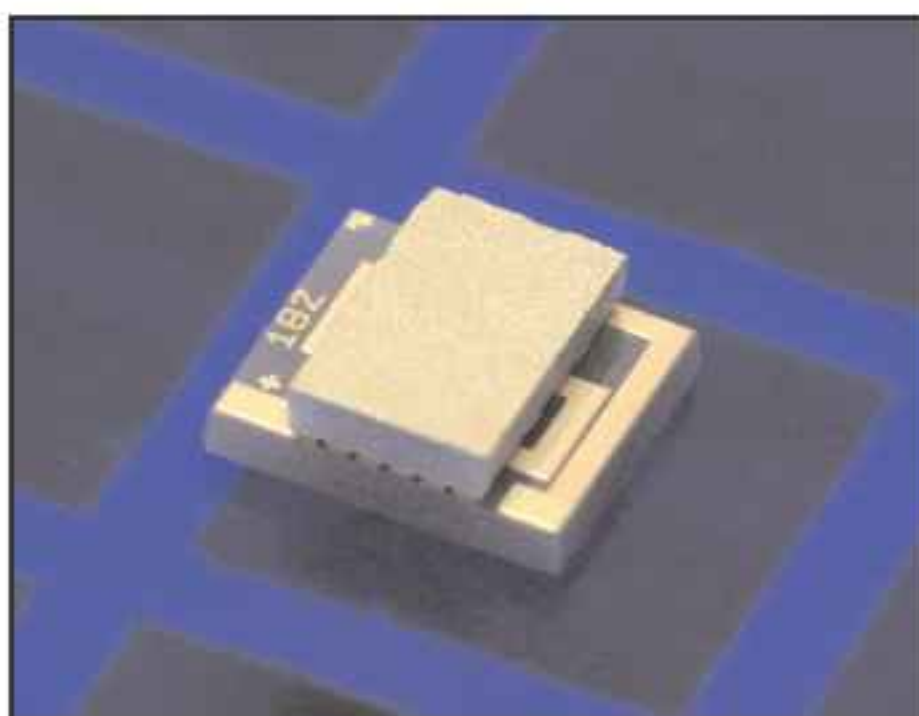
www.morgantechnicalceramics.com

Nextreme's OptoCooler HV14 passes 3000g shock test for government and aerospace electronics

Nextreme Thermal Solutions Inc of Durham, NC, USA, which designs and manufactures microscale thermal and power management products, says that its OptoCooler HV14 thermoelectric cooler module has passed the 3000g shock test as defined in the MIL-STD 883E Method 2002 Mechanical Shock standard.

MIL-STD 883E establishes uniform methods, controls, and procedures for characterizing and screening microelectronic devices suitable for use within government and aerospace electronic systems.

The standard includes basic environmental tests to determine resistance to the effects of natural elements and conditions surrounding government and space operations. The shock test is intended to determine the suitability of devices for use in electronic equipment that may be subjected to severe shocks as a result of suddenly applied forces or abrupt changes in motion.



Nextreme's OptoCooler HV14 thermoelectric cooler module.

Specifically, MIL-STD 883E calls for five shock pulses of 3000g (peak) with a pulse duration of 0.3 milliseconds in each of the orientations X1, X2, Y1, Y2, Z1, and Z2. Nextreme says that its HV14 modules showed less than a 5% change in electrical resistance as a result of the stress testing. The firm adds that the test report is available to qualified customers upon request.

"The use of thin films in conjunction with our semiconductor-based

assembly process reduces the mass of our devices substantively," says Dave Koester, VP of engineering. "Our thermoelectric coolers and power generation devices are inherently more resistant to shock and vibration than standard bulk devices while at the same time providing performance advantages," he claims.

The RoHS-compliant HV14 module is a high-voltage and high-heat-pumping thermoelectric device that is designed to operate at standard electrical power requirements. At 85°C, it operates at a maximum voltage of 2.7V and can pump 1.5W of heat in a footprint of just 3mm. The module can create a maximum temperature differential (ΔT) of up to 60°C between its hot and cold sides with a zero heat load, suiting the cooling and temperature control of optoelectronic devices such as laser diodes, avalanche photodiodes and high-brightness LEDs.

www.nextreme.com/optocooler

JPSA ships PV-5000 thin-film photovoltaic laser scribing system

J. P. Sercel Associates Inc (JPSA) of Manchester, NH, USA has shipped the first of multiple PV-5000 thin-film photovoltaic laser scribing systems for the solar industry to a US customer.

By using laser scribing technology, the robust, high-volume PV-5000 production system can rapidly and accurately produce fine scribed lines with $>30M\Omega$

isolation. Applications

include thin film, P1 front contact, P2 semiconductor, P3 back contacts, border deletion, and bulk deletion of all three layers to provide an edge isolation border.

"Our PV-5000 laser scribe sets a new benchmark with speeds, accuracies, and throughputs that have not yet been achieved for this process," claims chairman & chief technology officer Jeffrey Sercel. "With our proprietary and patent-pending laser technology, and high-precision automation experience, we developed a high-volume production system with low operat-



JPSA's PV-5000 thin-film photovoltaic laser scribing system.

ing costs that can accurately and selectively remove thin films from large glass, metal, or polymer substrates," he adds.

The PV-5000 uses JPSA's capability for designing and integrating short-wavelength lasers, high-precision motion control systems, beam homogenizer technology, and high-resolution optics to provide industrial laser scribing tools that are claimed to exceed the demanding requirements of the high-precision solar scribing industry.

www.jpsalaser.com

JDSU ships 100th Q Series UV laser for LED wafer scribing

JDSU of Milpitas, CA, USA has now shipped more than 100 Q Series UV lasers for scribing wafers used in LED manufacturing.

According to the firm, the LED wafer scribing process that uses the Q Series UV laser has become the most widely accepted method for volume LED manufacturing in recent years, because it allows LED makers to achieve increased yields and lower consumable costs.

JDSU claims that its Q Series laser offers: high energy and beam stability (to ensure consistently high yields); high pulse repetition rate and power (for high throughput); and stable laser performance

(reducing system maintenance over time).

"Growing popularity of LED-based consumer goods such as backlit TVs will continue driving demand for UV lasers," says Victor David, product line manager for JDSU's Communication & Commercial Optical Products (CCOP) business segment.

Market research firm Display-Search recently said that the penetration rate of LED backlights for LCD TVs should grow from less than 3% in 2009 to 40% in 2013 and more than 50% in 2014, surpassing CCFL backlights.

www.jdsu.com

IN BRIEF

Applied Seals adds Euro distributor

Applied Seals North America Inc of Newark, CA has signed Semiconductor Parts and Materials AG (SPM) of Schaan, Liechtenstein to distribute its perfluoroelastomer sealing components and provide local applications support throughout Europe. This follows the recent signing of BTS Baruch & Co Technologies & Supplies Ltd (BTS) as its distributor in Israel.

Applied Seals says its o-rings are integral to ultraclean manufacturing of products including compound semiconductor devices and solar cells. "Compound semiconductor manufacturers throughout Europe are seeking improved cost efficiencies, which our seals' longer lifecycles enable," claims president & general manager Dalia Vernikovsky. "Working with SPM and using our expertise in materials science, product design and applications know-how, Applied Seals is now prepared to offer European microelectronics and biotechnology companies the durable sealing technology and local support they need."

SPM has 12 years of experience providing service and spares for semiconductor customers in Germany, Austria, Italy, France, the UK, Ireland, the Netherlands, Belgium, Scandinavia and Slovakia. For quick-turnaround deliveries and service calls, it maintains product inventories, applications and technical support operations near major manufacturing centers in Germany, Italy and the UK.

Over the past 10 years, CEO Philipp Quaderer has focused on sales & market development for SPM's partner Applied Ceramics Europe AG, a supplier of custom ceramic, quartz, silicon and sapphire products for the semiconductor and photonics industries.

www.spm.li

www.appliedsealsna.com

Camtek acquiring TEM/SEM sample prep system maker SELA

Camtek Ltd of Migdal Ha'Emek, Israel, which manufactures automatic optical inspection (AOI) systems for printed circuit boards, high-density interconnect substrates, and semiconductor manufacturing and packaging, has agreed to acquire Semiconductor Engineering Laboratories Ltd (SELA).

Founded in 1992 in Yokneam, Israel, SELA develops and manufactures automated scanning electron microscope (SEM) and transmission electron microscope (TEM) sample preparation equipment for the semiconductor and optical components industries.

Camtek will pay SELA's shareholders contingent future payments of up to \$9.5m, based on SELA's revenues.

With 26 staff and revenues of \$3.8m and \$4.4m in 2008 and 2007 respectively, SELA has more

than 275 systems installed worldwide. Combined with Camtek's infrastructure in manufacturing, sales, service, R&D and facilities, this should allow Camtek to increase its revenues, shorten the time-to-market of SELA's unique products, and strengthen its presence in the semiconductor market, the firm reckons.

Most recently, SELA introduced the Xact, the first TEM sample preparation tool using adaptive ion milling (AIM) technology, which is said to enhance focused ion beam (FIB) technology by reducing the sample thickness to below 30nm over a large area with high precision and throughput and with superior image quality. Camtek says that these attributes are essential for meeting the growing market requirements for nano-scale material analysis, including much reduced turnaround times and

enhanced productivity. The trend for continuous device shrinks and material complexity increases utilization of TEM and hence the served available market for Xact, it is reckoned.

"This acquisition of SELA is directly aligned with our strategy of further enhancing Camtek's position and presence in the semiconductor market, enabling us to further expand our offering to this market," says Camtek's CEO Rafi Amit. "We intend to leverage Camtek's global infrastructure, sales and support teams, manufacturing and facilities, to service SELA's existing customer base, while targeting new customers."

The transaction is expected to be completed in fourth-quarter 2009 (subject to the fulfillment of certain closing conditions).

www.camtek.co.il

www.sela.com

Solar Metrology launches in-situ XRF tool for CIGS composition and thickness measurement

Solar Metrology of Holbrook, NY, USA says it has expanded its portfolio of SMX x-ray fluorescence (XRF) analysis tools with the launch of the System SMX-ISI, designed for film composition and thickness measurement of copper indium gallium diselenide (CIGS) photovoltaic deposition.

Solar Metrology says that its SMX metrology tool platform provides a production-ready suite of film thickness and composition measurement tools for research and process development, in-process monitoring and post-process quality control. The firm adds that XRF is an enabling technology for CIGS manufacture, delivering yield management and improvement by allowing in-situ process control.



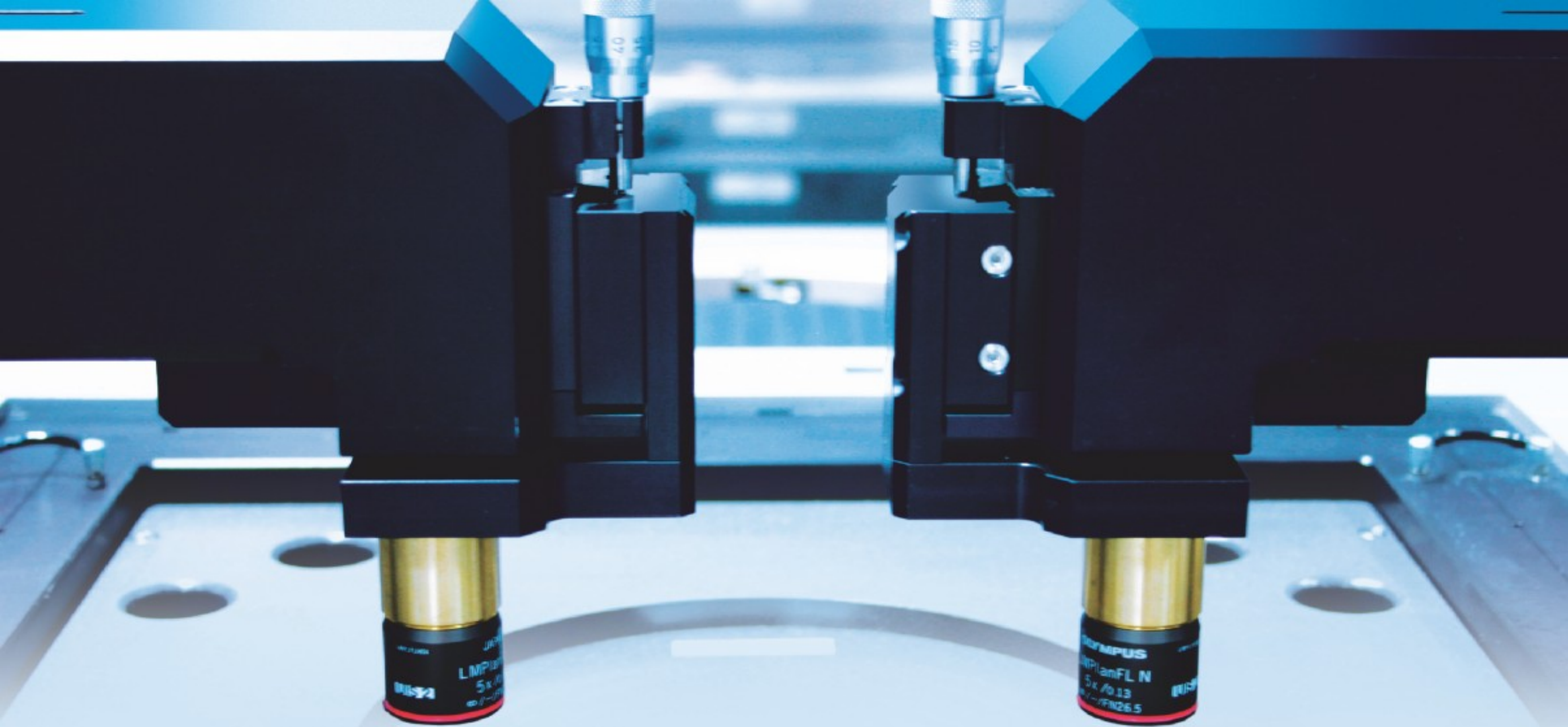
Solar Metrology's new System SMX-ISI x-ray fluorescence analysis tool for CIGS thin-film composition and thickness measurement.

The SMX-ISI in particular provides composition and thickness measurements for thin-film solar PV metal film stacks on flexible

roll-to-roll substrates such as stainless steel, aluminum and polyimide or rigid substrates such as float glass. Typical measurement applications include Mo (molybdenum) thickness and all CIGS combinations (including all CIG alloys and/or film combinations and final CIGS formulations), says the firm.

Furthermore, Solar Metrology says that the new tool is fast, flexible and easily integrated into any vacuum deposition tool or vacuum process station or point of a vacuum process line. Despite this, the SMX-ISI platform does not affect the process, since all SMX-ISI tool components reside outside vacuum to provide optimum performance and serviceability.

www.solarmetrology.com



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BluGlass wins \$4.96m grant for InGaN solar cell project

BluGlass Ltd of Sydney, Australia has been awarded \$4.96m of Commonwealth Government funding to assist with the development and commercialization of its thin-film solar cell technology. The funding is being executed between BluGlass and AusIndustry, which will provide the cash over 33 months on the basis that BluGlass matches the grant with its own expenditure.

Spun off from Macquarie University in 2005, BluGlass has developed a low-temperature process using remote-plasma chemical vapor deposition (RPCVD) to grow materials such as gallium nitride (GaN) and indium gallium nitride (InGaN) for the production of high-efficiency devices such as LEDs with significant low-cost potential and inherent scalability. In May, BluGlass said that it intended to expand its market potential with the exploration of high-efficiency group III nitride solar cells as a supplementary market for its RPCVD technology. Through its subsidiary BluSolar, BluGlass is now exploring the process' viability in photovoltaic applications.

"The Government backing is a major vote of confidence in

BluGlass's technology," says CEO Giles Bourne. "This will see Australian technology return to the forefront of solar innovation and adoption as Australia leads the way on climate change mitigation."

The 'High-Efficiency Thin-Film Solar Cell' project aims to develop a third-generation photovoltaic technology for manufacturing solar cells based on InGaN with greater efficiencies than any current solar cell at commercially competitive costs. The project sets out to reduce the cost of harnessing solar energy, resulting in more widespread adoption of solar technology, particularly by utilities as solar becomes more cost-competi-

The 'High-Efficiency Thin-Film Solar Cell' project aims to develop a third-generation photovoltaic technology for manufacturing solar cells based on InGaN with greater efficiencies than any current solar cell at commercially competitive costs

tive relative to other renewable technologies and traditional non-renewable resources.

BluGlass has secured the funding under the \$75m, four-year Climate Ready Program (one of three elements of the \$240m Clean Business Australia initiative). Climate Ready is a competitive grants program providing grants from \$50,000 up to \$5m on a matching-funding basis to support R&D, proof-of-concept and early-stage commercialization activities to develop solutions to climate change challenges.

Earlier, in July, BluGlass raised \$4.247m in share capital to enable expansion of research, development and commercialization of its

RPCVD technology for both LED and solar cell applications (allowing the commissioning of additional equipment and engineers to fast track the firm's dual-market exploration, said Bourne at the time). BluGlass says that the new government grant enhances its ability to continue with its research and commercialization program.

BluGlass recruits new chief operations & technology officer

BluGlass has recruited Dr Ian Mann as chief operations & technology officer (a new position, designed to complement the firm's technical team) in order to manage and implement its technology roadmap.

Mann's recruitment is part of BluGlass' enhanced commercialization strategy after raising capital at the end of July to dedicate more resources to expedite research, development and commercialization of its remote plasma chemical vapor deposition (RPCVD) technology. In May, BluGlass announced that it intended to expand its market potential with the exploration of high-efficiency

group III nitride solar cells as a supplementary market to LEDs for its RPCVD technology. BluGlass recently also employed two additional staff members: a postdoctoral crystal grower and an equipment engineer.

BluGlass says that Mann brings experience in transitioning R&D projects to commercialization and production. Having completed his PhD in Polymer Science in the USA, he worked in technology firms in both the USA and Australia, where he managed technology teams, developed and executed transition strategies and business plans, and facilitated

mergers and acquisitions along with establishing spin-off companies to commercialize intellectual property. His most recent role was as CEO of Bandwidth Foundry International Pty Ltd, involving activities in optoelectronics for laser projectors and commercial microfabrication services.

"Ian's industry, technical and commercial experience will greatly complement the existing skill set in the business," says CEO Giles Bourne. Mann's focus will be to ensure that BluGlass meets its technology milestones and to help guide the business to commercialization.

www.bluglass.com.au



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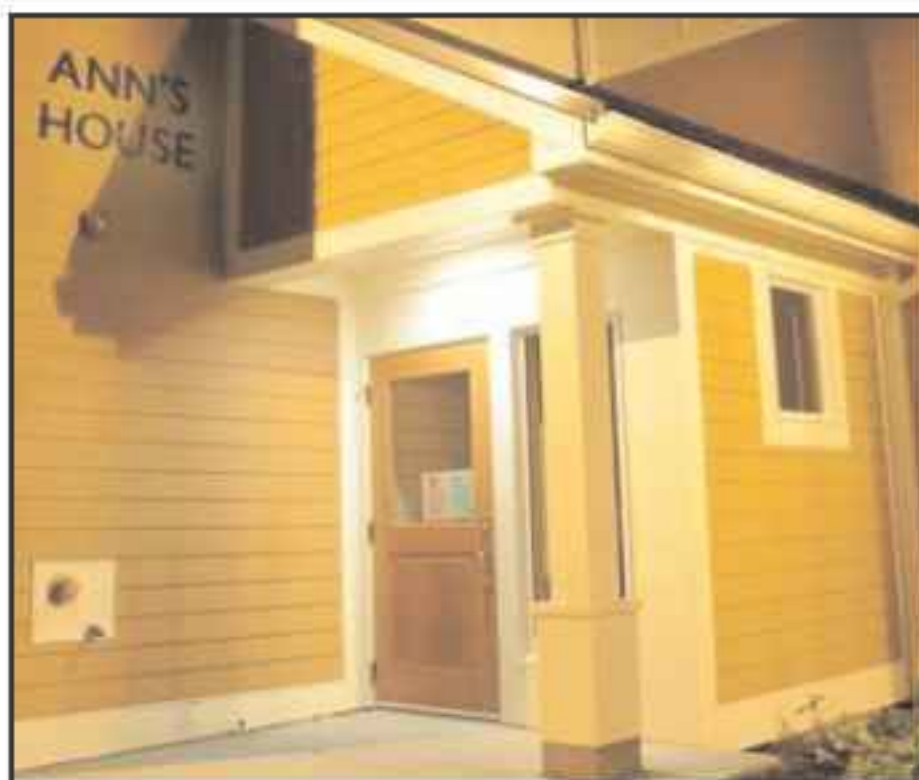
TECDIA
WWW.TECDIA.COM

Alfred University joins LED University program

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA says that Alfred University of Alfred, NY, USA has joined its LED University program.

Launched in April 2008, the LED University initiative is an international community of universities working to evaluate, deploy and promote the adoption of energy-efficient LEDs across their campuses (in areas such as offices, student housing, parking garages, walkways and streets). The aim is to save energy, protect the environment, reduce maintenance costs, and provide better light quality for improved visibility and safety. Alfred University joins inaugural participant North Carolina State University as well as University of California at Santa Barbara, the University of Arkansas, Marquette University, the University of Notre Dame, University of California, Davis, the University of Miami, the University of Alaska at Anchorage, Madison Area Technical College (MATC) and Joliet Junior College in the USA, as well as Tianjin Polytechnic University in China.

As part of its ongoing green initiatives, Alfred University has installed LED lighting throughout its newest residence hall, Ann's House. Officially opened for the Fall 2009



Entrance to Ann's House.

semester, the school's first environmentally friendly dormitory features more than 175 Cree LED lights and 18 LEDDynamics EverLED TR fluorescent tube replacements throughout the 15,000 square-foot hall.

"Ann's House was constructed as part of Alfred University's commitment to becoming a greener, more sustainable campus," explains the university's president Dr Charles M. Edmondson. "Installing Cree LEDs throughout this new dormitory will provide our students with better visibility, as well as help Alfred University significantly save on energy and maintenance costs," he adds. "The widespread use of LED lighting around our campus is certainly something we're looking at as we continue to find new ways to reduce our carbon footprint."

Intended to set a new standard in 'green' construction for the Alfred University campus, Ann's House was designed to be certified at the Silver level or above by the US Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System. In addition to the energy-efficient LED and fluorescent fixtures that light the 48 student bedrooms, hallways, lounges and stair towers, Ann's House also features LED TVs. The building is equipped with solar panels to provide about 8% of the electrical demand during daylight hours.

"It's my hope that more campuses will look at Alfred University as an example of how to successfully use LED lighting to become more energy-efficient," says John Edmond, Cree co-founder & director of advanced optoelectronics, who is also an alumnus of Alfred University.

"LED lighting can be an effective way to help commercial buildings like Ann's House gain valuable LEED points," says Cree LED programs manager Deb Lovig. "Joining Cree's LED University program makes Alfred University a model for other schools looking to deploy LED lighting."

www.leduniversity.org
www.alfred.edu

Cree's XLamp MX-6 claimed to be the first lighting-class PLCC-packaged LED

Cree Inc of Durham, NC, USA has extended its lighting-class products into PLCC LEDs with the commercial availability of the new XLamp MX-6. The firm says that the MX-6 LED offers the performance and reliability of its XLamp LEDs with enhanced light uniformity and low power consumption.

"With the addition of the XLamp MX-6 LED, we now have the most diverse family of lighting-class LEDs in the industry," claims Paul Thieken, Cree's marketing director,

LED components. "The XLamp MX-6 LED can provide better design options for indoor applications, including under-cabinet, retail displays, LED light bulbs and fluorescent replacements," he adds.

At a drive current of 350mA, the MX-6 LED provides up to 130 lumens for cool-white light and 107 lumens for warm-white light. Cree claims that it can also reduce luminaire and lamp manufacturing costs through an increased shelf life with reduced

moisture sensitivity, and the industry's smallest warm-white bins, enhancing LED-to-LED color consistency.

"The LED's performance is striking, and Cree's small bins make it easy for us to deliver a consistent product," comments Sunny Tsai, CEO of LED light bulb maker TESS.

XLamp MX-6 LEDs are available through Cree distributors in a full range of white ANSI chromaticity bins.

www.cree.com

Apecchio joins LED City program

Apecchio has become the second Italian city to join the LED City initiative, an international community of government and industry parties initiated by LED maker Cree Inc of Durham, NC, USA in December 2006 to evaluate, deploy and promote LED lighting for municipal infrastructure. Apecchio joins existing program members Raleigh, NC, Ann Arbor, MI, Austin, TX, Anchorage, AK, Indian Wells, CA, Fairview, TX and Danville, VA in the USA; Toronto and Welland in Canada; Tianjin in China; Gwangju in South Korea; and Torraca in Italy.

Apecchio says that, following its switch to LED lighting, it is saving on energy and maintenance costs, as well as improving safety for citizens with better quality lighting.

Last May, in order to comply with a regulation regarding lighting pollution, Apecchio completed its first tests on LED-lit streetlights to assess energy efficiency and lighting quality. Replacing existing fluorescent lamps in parking indicator lights and streetlights with LITEK

PROLED fixtures (featuring Cree XLamp LEDs lights) has helped to reduce energy consumption by 65%, with an estimated 70% savings in energy costs, it is claimed.

"We are committed to promoting the power of LED technology in streetlighting, as well as other functional indoor and outdoor applications," says LITEK's general manager Fabio Facchini. "Apecchio is a successful example both for the city itself and for other municipalities that are keen on saving energy and money," he adds.

"We congratulate the city Council and the community for taking a bold step in achieving significant energy savings, especially given the growing global need to conserve energy," says Cree's LED programs manager Deb Lovig.

This LED lighting project exemplifies Danville's commitment to move forward in the new economy by taking advantage of innovative opportunities.

www.ledcity.org

www.comune.apecchio.ps.it

Cree sponsors LED design contest for students in China

Cree and Beijing-based China Associate of Lighting Industry (CALI) have announced that the first Cree Cup — Creative LED Lighting Design Contest has launched in mainland China, Hong Kong, Macau and Taiwan. The contest, the first of its kind among university students in these regions, seeks to cultivate innovation and to support promising talent in LED lighting design.

"LED lighting is an important element of China's energy-efficient future," says Greg Merritt, Cree's VP of corporate marketing. "This is part of our strategy to accelerate the adoption of LED lighting."

Co-sponsored by CALI and Cree, the contest brings together executives from CALI, Cree and Shanghai Optoelectronics Trade Association (SOTA), as well as senior professors from various universities including Tsinghua University, Tongji University and Tianjin Polytechnic University, to serve as the official organizing committee.

The committee expected the contest to draw responses from about 1000 students in more than 30 universities.

www.chineselighting.org

Cree claims 111lm/W XLamp XP-G is brightest and most efficient lighting-class LED

Cree has announced commercial availability of the XLamp XP-G LED, which it claims is the brightest and most efficient lighting-class LED. The XP-G LED can produce up to 367 lumens when driven at a current of 1A, at a typical luminous efficacy of 111 lumens per Watt; making it 46% brighter and 64% more efficient than Cree's highest-performance XR-E LED, but with an 80% smaller footprint.

"Cree's XLamp XP-G cool-white LEDs set a new standard for LED performance," says David Chow, president of 4Sevens LLC. "For our

flashlights, the XLamp XP-G LED was a clear choice because of its high lumen output, unmatched efficacy and compact package size," he adds.

Cree says that this level of performance can potentially reduce the number of LEDs required, as well as the size and cost of LED fixtures. High efficacy at lower current (up to 132lm/W typical at 350mA) can lower the total power requirement for a portable or solar lighting application, which can reduce the number of solar cells or batteries needed.

"We now deliver lighting-class efficacy at 1A drive current," says Paul Thielen, Cree's director of marketing, LED components. "In addition, we have begun offering limited samples of an S2 flux bin, providing up to 400 lumens at 1A," he adds. Cree targets availability of XP-G neutral- and warm-white LED samples by the end of 2009.

The cool-white XP-G is available with order codes up to 139lm minimum at 350mA and ANSI-compliant cool-white bins (correlated color temperatures of 5000–8300K).

www.cree.com/buyxlamp

Revenue grows 14% as Cree boosts CapEx to match demand

For its first-quarter 2010 (ended 27 September 2009), Cree Inc of Durham, NC, USA has reported record revenue of \$169.1m. This is up 20% on \$140.4m a year ago and 14% on last quarter's \$148.1m (and above the \$160–166m target).

Growth was driven by higher XLamp LED sales for lighting application, higher LED chip sales (due to increased demand in notebook backlighting and lighting), and solid growth for LED lighting products as well as for GaN- & SiC-based power and RF devices. LED product revenue rose 14% sequentially to \$156m (including \$0.5m of government contract revenue), while power and RF device revenues rose 15% to \$13.1m (including \$3.6m of government contract revenue).

On a non-GAAP basis, gross margin has risen from 36.1% a year ago and 40.3% last quarter to 44.1%. This is above the targeted 40% due to: extra cost leverage from high factory utilization and increased production scale; better-than-planned yield; a more stable pricing environment for LED chips and LED components; and the continued progress in the power and RF product lines.

Non-GAAP net income was \$27.4m, up from \$16.3m last quarter and more than double the \$13.2m a year ago.

Operating cash flow has risen from just \$43m last quarter to \$61.2m. So, despite capital expenditure rising from \$14.7m to \$20.4m, free cash flow (operating cash flow minus capital expenditure) has still risen from just \$28.3m last quarter to \$40.8m.

Cash and investments almost doubled during the quarter from \$447.2m to \$888.5m, but this was due mainly to the secondary common stock offering in September, which raised a net \$434.2m (intended mainly for capital expenditure to support accelerated growth, with the remainder for general corporate purposes including working capital and potential strategic investments).

"Both revenue and profits exceeded our targets due to solid factory execution and strong demand," says chairman & CEO Chuck Swoboda. "We are benefitting from continued LED lighting adoption and high factory utilization and are well positioned for solid growth in Q2," he adds.

Cree is still capacity limited in most product lines. However, the proportion of products migrated to 4" silicon carbide substrates should rise from more than 70% now to almost all by the end of December (while yield should also improve).

So, for fiscal second-quarter 2010 (ending 27 December 2009), Cree still expects revenue to rise 6–12% to \$180–190m, driven by higher LED component sales for lighting applications and higher LED lighting product sales, followed by some growth in LED chips to support notebook and TV backlighting and incremental growth in power and RF device sales. Cree also expects non-GAAP gross margin to be steady at 44% and non-GAAP net income to rise further to \$29–32m.

"As a result of the recent equity offering, we have the balance sheet to invest in the growth of our business," says Swoboda. Quarterly capital expenditure was \$32m in fiscal Q1 (above the \$25–30m forecast) and should rise to \$50–60m over the next few quarters. Cree has earmarked \$150–165m for capital expenditure in fiscal 2010 to expand LED chip fab capacity in Durham and to more than double LED component packaging capacity in China (allowing growth in fiscal second-half 2010 to match growth in the first half).

Swoboda says that, after raising cash reserves to \$888m, Cree is also in a good position to consider potential strategic acquisitions that could help it to accelerate the adoption of LED lighting.

Cree to add 575 jobs as it expands manufacturing capacity

To aid the expansion of manufacturing capacity for LED chips as well as other staffing needs, Cree aims to add 275 jobs in Durham by the end of 2009, and a further 300 in North Carolina by the end of 2012. Cree currently has about 3300 full-time workers, including 1500 in Durham.

Cree said in August that it was adding staff as it boosts production at plants in Durham and China.

Cree has also started the manu-

facture and assembly of LED lighting products with Flextronics in Mecklenburg County, NC. Initial products made at the facility include the ENERGY STAR-qualified LR6 recessed LED downlight and the award-winning LR24 LED troffer replacement. Cree's line of LED lights, including recessed downlights and troffer replacements, began production in August.

"We are seeing tremendous growth for LED lighting," said

Cree's CEO Chuck Swoboda. "Energy-efficient lighting has its roots right here in North Carolina, and Cree is proud to be bringing more green jobs to our state." North Carolina governor Beverly Perdue was present as Swoboda announced the staff increase.

Swoboda adds that Cree is likely to also have to expand its back-end assembly & packaging operations in Asia.

www.CreeLEDLighting.com

Lumileds publishes LM-80 lumen maintenance test report data online for use by luminaire manufacturers

Lumileds claims that it is the first power LED maker to openly publish LM-80 test report data for use by luminaire manufacturers evaluating the merits of using different LEDs in their solid-state lighting solutions. The firm says that the data for its white LUXEON Rebel power LEDs clearly demonstrates that lumen maintenance performance exceeds ENERGY STAR requirements by a wide margin as well as documenting lumen maintenance performance under various conditions.

Lumileds' LM-80 test reports adhere to and are published in accordance with the Illuminating Engineering Society (IES) LM-80-08 standard.

"Using our LM-80 reports helps system designers meet ENERGY STAR eligibility criteria and optimize solutions for a desired lumen maintenance level," says Steve Barlow, Lumileds' executive VP of sales & marketing. "These reports are just

one of the many tools we make available in order to simplify the development and production of LED luminaires, and we encourage other manufacturers to follow our lead to help simplify and accelerate solid-state lighting market development," he adds.

The lumen maintenance performance of LEDs varies significantly from manufacturer to manufacturer due to differences in materials and manufacturing processes. Lumileds has been studying the factors that affect power LED lumen maintenance in an ongoing effort to improve performance and more accurately describe lumen maintenance behavior for the lighting community.

"Reliance on generic LED lumen maintenance statements that are adopted by luminaire manufacturers is destined to lead to disappointment with LED solutions," says Rudi Hechfellner, Lumileds' director of applications. To design appropriately

for optimum lumen maintenance, Lumileds recommends that luminaire manufacturers and the lighting industry do the following:

- understand the specific lumen maintenance behavior of the LEDs that they have selected;
- disregard generic statements about LED lumen maintenance performance and ask for information that is appropriate for the anticipated current and temperature conditions.

The IES LM-80-08 standard describes the testing methodology and the test report format that LED makers must follow. It does not make any assessment of the data or statements of appropriateness for any particular application. Other industry programs, such as ENERGY STAR, establish performance criteria that can be determined from published LM-80 test reports.

www.philipslumileds.com/pdfs/DR03.pdf

Cree claims the most lighting-class LEDs for designing ENERGY STAR-compliant LED fixtures

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA claims that it has the most lighting-class LEDs meeting the US Department of Energy (DOE) ENERGY STAR performance criteria, offering fixture manufacturers benefits when designing with the firm's XLamp XR-E, XP-E or MC-E white LEDs.

The DOE's 'ENERGY STAR Manufacturer's Guide for Qualifying Solid-State Lighting Luminaires' requires that LED fixture manufacturers seeking ENERGY STAR Category A approval test their luminaires for a minimum of 6000 hours (about 9 months) to demonstrate the product's long-term lumen maintenance. In lieu of performing this lengthy and costly testing procedure, the

DOE will accept an LED manufacturer's lumen maintenance data if the LEDs are tested to the Illuminating Engineering Society (IES) approved method for 'Measuring Lumen Maintenance of LED Light Sources', LM-80-08.

The DOE accepts Cree's IES LM-80 test data for its XLamp XR-E, XP-E and MC-E LEDs. This test data can be submitted by luminaire manufacturers (along with the appropriate LM-79 optical and electrical data) to the DOE for ENERGY STAR approval of both 25,000-hour residential and 35,000-hour commercial lighting products.

"Customers can avoid expensive and prolonged fixture testing by designing-in XLamp XR-E, XP-E or MC-E LEDs," says Paul Thieken,

Cree's director of marketing, LED components. "XLamp LEDs were also the first to be binned to ANSI C78.377A chromaticity back in 2007 and feature excellent white-point stability — further simplifying the design of LED fixtures to meet ENERGY STAR requirements," he adds.

In addition, Cree's lighting-class XLamp XP LEDs became UL-recognized on 4 August (registration file OOQA2.E326295). Due to the glass lens, Cree's XLamp XR family and MC-E LEDs are considered enclosures by UL and do not require registration.

Information on Cree's LM-80 testing methodology can be found in the recently published Lumen Maintenance Application Note.

www.cree.com/LM80

IN BRIEF

Lumileds opens Shanghai office to support solid-state lighting development

LED maker Philips Lumileds of San Jose, CA, USA has opened a new office in Shanghai that is being staffed with an applications team and market specialists to provide direct and local access to support the growing number of firms in China developing solid-state lighting (SSL) solutions.

Lumileds says that, by providing optical, thermal and electrical LED design expertise, it will further support rapid development and market entry for new LUXEON LED-based products.

"No company has a longer history of working with power LEDs than Philips Lumileds and, through application assistance for our customers, we continue to support the overall SSL market expansion," says Steve Barlow, executive VP of sales & marketing.

"We appreciate the continued investment in people and resources that Philips Lumileds is bringing to the China SSL market and industry," comments Wu Ling, secretary of the China Solid State Lighting Alliance (CSA).

The new office complements an engineering and design center operated by Lumileds' partner Future Lighting Solutions. Using optical, thermal and mechanical design and test equipment, Lumileds says that the staff can help to reduce development times, provide technical knowledge and training, and help customers deliver more reliable and efficient lighting solutions. Lumileds also maintains customer application support teams in San Jose and in Eindhoven, The Netherlands.

www.philipslumileds.com

GSEO to use LUXEON Rebels in LED street lighting throughout China

Taiwan's Genius Electronic Optical Co Ltd (GSEO) is developing new solid-state street lights and street light modules incorporating LUXEON Rebel LEDs from Philips Lumileds Lighting Co of San Jose, CA, USA, for use on roadways throughout China. The first installations are expected in early 2010.

Established in 1990, GSEO is also developing solid-state lighting solutions including tunnel lights and flood lights. With experience in injection mold design and production, GSEO specializes in high-precision optical component design, development and manufacturing, enabling it to offer a complete design and manufacturing process.

Lumileds says that GSEO's LED specification for its most advanced street lights prioritized reliability, efficacy, ease of integration and thermal capabilities — the primary factors that allow a lower total cost of ownership and lower energy consumption compared with conventional light sources.

Lumileds adds that the proven reliability of its power LED allowed

GSEO to create a design that delivers 70 lumens per watt, minimize the number of LEDs required, and minimize or eliminate the visual disturbance of glare. The LED maker uses a patented thermal design that, it says, ensures the lifetime performance of its LUXEON Rebel. The cooling system is guaranteed for the life of the product.

"The solutions that GSEO is developing can bring great benefit to the cities that adopt and implement the new street lights," says Alvin Tse, Lumileds' VP Asia Pacific Sales.

"GSEO's approach to creating new solutions is to choose the highest-quality LEDs and to implement an optimized system design to ensure that the new luminaire is the best overall solution for its designated application," says Calvin Chen, director of GSEO's LED Lighting unit. "The result is a high-quality, long-life street light with uniform light distribution," he claims. "GSEO intends to provide its solution using Philips LUXEON Rebel LEDs to municipalities and organizations globally."

www.gseo.com

Funding opportunity released for 2010 SBIR Phase I projects

The US Department of Energy has released the 2010 Small Business Innovation Research (SBIR) Phase I funding opportunity, which includes topics related to its Solid-State Lighting (SSL) program.

The SBIR program aims to increase the participation of small businesses in federal R&D. Phase I projects evaluate the scientific or technical merit and feasibility of ideas with commercial potential.

The 2010 SBIR topic area related to solid-state lighting has three main areas of interest — two of which are focused on transitional technology and one focused on supporting technology:

- Transitional Technology for LEDs;
- Transitional Technology for organic LEDs (OLEDs);
- Supporting technologies for off-grid SSL applications.

The deadline for the receipt of Phase I grant applications (via Grants.gov) is 20 November. Grants will be made in fiscal year 2010

www.science.doe.gov/sbir

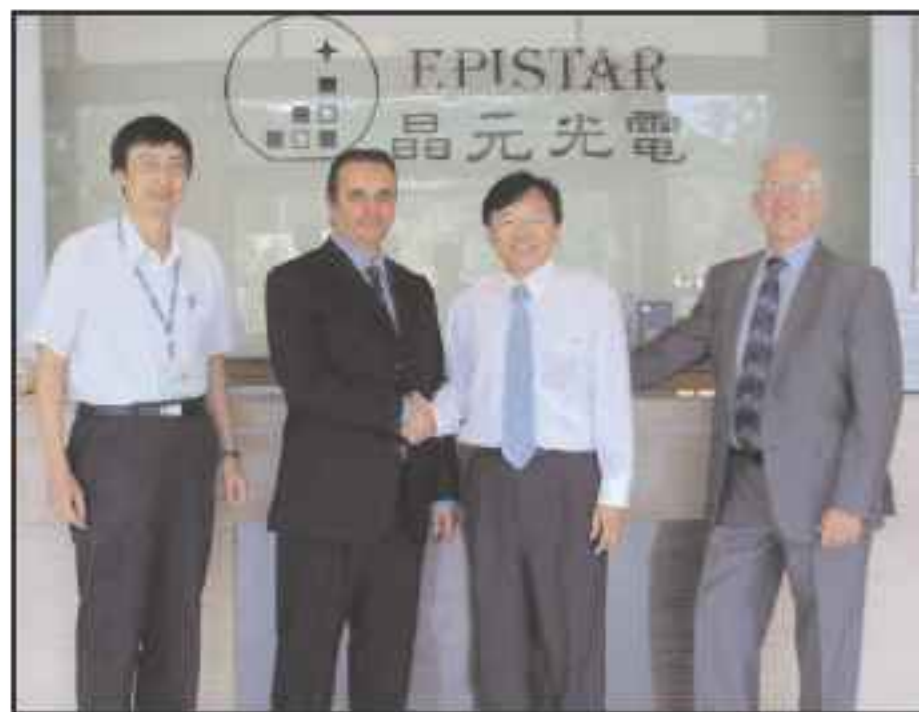
The deadline for the receipt of Phase I grant applications (via Grants.gov) is 20 November. Grants will be made in fiscal year 2010.

Epistar and Lynk Labs sign equity investment & licensing agreement to develop AC LED technology

Taiwan's largest LED epiwafer and chip maker, Epistar Corp of the Hsinchu Science-based Industrial Park, has entered into a strategic equity investment and license agreement with Lynk Labs Inc of Elgin, IL, USA, which supplies AC LED device, light engine and power supply technology.

Lynk Labs has been building an LED technology patent and product portfolio since 2002, focusing on AC LED technology. The portfolio includes fundamental core AC LED circuits that can be integrated at the chip level as well as drive methods and product- or system-level solutions. With over 50 patents filed to date and its first US patent (no. 7,489,086, 'AC light emitting diode and AC LED drive methods and apparatus') granted early this year, Lynk says that it will soon be announcing more patent approvals in major international markets.

In March, Epistar announced plans to enter the AC LED market with



Epistar senior R&D scientist T.P. Chen, Lynk Labs CEO Mike Miskin, Epistar chairman B.J. Lee, and Lynk Labs VP Bob Kottritsch.

single-chip AC LED technology. The firm has been developing AC LED chips since 2004 and has also filed more than 10 patent applications in related fields. Last year, Epistar obtained a patent license from Taiwan's Industrial Technology Research Institute (ITRI), which is also developing chip-level AC LED technology.

Through the strategic partnership,

Epistar and Lynk aim to share and leverage technology and expertise from both firms to develop new AC LED technology, as well as IP and products including single-chip and system-level solutions for the lighting industry.

"Having access to Epistar's chip-level design and manufacturing expertise will allow us to advance AC LED technology as well as accelerate its adoption into all areas of lighting where AC LEDs can deliver an advantage," reckons Lynk Labs' president/CEO Mike Miskin.

AC LED technology-based products continue to show advantages over DC in many applications when integrated into the AC power infrastructure, says Epistar. "AC LED technology creates a new era in the industry and Lynk Labs has been the pioneer driving AC LEDs into the market for many years now," adds Epistar's chairman Dr B.J. Lee.

www.epistar.com.tw

www.lynkylabs.com

DARPA awards Energy Focus additional \$0.5m SBIR extension grant to develop LED lighting for Navy ships

Energy-efficient lighting technology firm Energy Focus Inc of Solon, OH, USA has been awarded a \$0.5m Small Business Innovation Research (SBIR) extension grant from the US Defense Advanced Research Projects Agency (DARPA) to develop and produce solid-state lighting fixtures for general use on Navy ships. The new fixtures will replace 50W and 110W water-tight incandescent fixtures currently in use. Energy Focus will hence be able to offer energy-efficient, long-life LED lighting alternatives to replace both incandescent and fluorescent systems across the entire US Navy fleet.

Utilizing its proprietary ultra-low-distortion solid-state power supply technology, the fixtures will be developed over the next 11 months.

Beyond efficiency, life, and maintenance specifications, the fixtures must meet the Navy's new stringent requirements for LED systems, which include light output, shock and vibration, corrosion, EMC and EMI compliance. "The SSL lights developed under this grant will save a significant amount of energy and maintenance," says Energy Focus' CTO Roger Buelow. "As an example, using only 26W, a new LED fixture saves 76% (or 84W) over the incandescent fixture it replaces," he

The DoD has now awarded Energy Focus \$1.9m to develop energy-efficient LED lighting for the US Navy

adds. "In addition, we fully expect that bulb replacement will become a thing of the past with the LEDs' projected lifetime of up to 50,000 hours or more."

"With the addition of this \$0.5m grant, the Department of Defense has now awarded Energy Focus \$1.9m to develop energy-efficient LED lighting for the US Navy," says the firm's CEO Joe Kaveski.

"Energy Focus' incandescent replacement LED technology will go beyond military applications, saving energy for the country as a whole in broad commercial applications, providing energy-efficient, mercury-free, long-life alternatives to the incandescent bulbs which the US is phasing out beginning in 2012."

www.energyfocusinc.com

Osram's stack-chip DRAGON doubles IR LED power

Osram Opto Semiconductors GmbH of Regensburg, Germany says that ThinFilm chip-in-stack technology enables its new infrared Platinum DRAGON LED to generate optical output power of nearly 1W from a drive current of 1A in a surface area of just 1mm² (almost twice the output of the standard chips that have been used up to now), creating a high-radiance solution for automotive, industrial and consumer applications where space is limited.

The firm says that the increased output of the new LED is based on a special ThinFilm chip with not one but two p-n junctions that have been grown on top of each other. This stack technology achieves almost twice the optical output power compared to conventional IR ThinFilm chips, says Osram Opto.

"We were able to bring the infrared Stack DRAGON to market quickly thanks to our experience in developing the stack technology for our lasers," says Harry Feltges, marketing manager for Infrared Components. "Its package is the same as the one used for the other



The stack-chip IR Platinum DRAGON LED gives high radiance from a small surface.

IR DRAGON components, so existing designs can be used without modification," he adds. The forward voltage of 2.9V at 1A enables the use of standard LED drivers that operate in this voltage range. The LED emits at a wavelength of 850nm and is a compromise between the maximum spectral sensitivity for CCD and CMOS cameras and the suppressed visibility for the human eye.

With its high optical output from a small surface area, the infrared Platinum DRAGON is suited to lighting solutions where space is an important factor, says Osram Opto.

In addition, the viewing angle and radiant intensity can be varied using standard secondary optics. The firm says that preferred applications are those that require high radiance so that small optics can be used. For example, night-vision systems, sensor-based electronic pedestrian protection systems and pre-crash sensors in vehicles can be made much more compact because fewer IR LEDs are needed to provide the same optical output. In industrial applications, stack-chip IR Platinum DRAGON LEDs can be used in illumination units for CCTV cameras or in systems for automatic number plate recognition (ANPR).

Another potential application is 3D camera technology, which will be used increasingly in consumer devices such as gaming consoles and TVs for gesture recognition, says Osram Opto. The high modulation frequencies of the light source (typically 20–50MHz) required for these applications can be easily achieved with the new stack-chip IR Platinum DRAGON LED, adds the firm.

OSLON LEDs send student message to International Space Station

After partnering with the Schulich School of Engineering at Canada's University of Calgary, Osram Opto Semiconductors GmbH of Regensburg, Germany helped a team of 600 students send an LED-illuminated message of support to Schulich graduate & Canadian astronaut Bob Thirsk and his crewmates, who are on a six-month mission aboard the International Space Station, as it passed 300km (186 miles) overhead on the night of 19 September.

Through its project 'Lift up Your Eyes', the Schulich School of Engineering also wanted to demonstrate their gratitude for Thirsk's dedication to higher education.

"Through the use of LED technology, we wanted to collaborate with students to recognize one of the best role models we could have," says the Schulich School of Engineering's dean Elizabeth Cannon. "We are tremendously grateful for Osram Opto Semiconductors' generosity and adventurous spirit, in their support of our students in making sure they could be successful in this engineering student event."

Using Osram's donation of 300 units (boards), each containing four new OSLON high-brightness LEDs, the students delivered their message with an estimated total brightness of 400 lumens per board (totaling about 120,000 lumens). Each board uses two 9V

batteries and contains a simple switch allowing the students to manually flash the LEDs to send a signal to the space station.

"We provided LED units which can be arranged in a multitude of ways, enabling the students to send their unique, illuminated message," said Tom Shottes, president & CEO of Osram Opto Semiconductors Inc in Santa Clara, CA, USA.

Osram Opto says that the support given to the Schulich School of Engineering furthers its commitment to the educational community. The firm supports the educational community through the donation of products, expertise and engineering support.

www.osram-os.com

LEDs light the way ahead for VW

At the Frankfurt International Motor Show (IAA) in Germany (17–27 September), Volkswagen presented its L1 1-litre diesel-electric hybrid concept car (for possible production in 2013), which is built of aluminum and carbon fiber, weighs just 380kg, and has fuel consumption of 189 miles per gallon. In particular, the L1 has front headlights equipped with new Joule JFL2 LED modules (developed by Germany's Osram Automotive Lighting in collaboration with Regensburg-based LED maker Osram Opto Semiconductors GmbH) plus matching reflectors designed by Volkswagen (enabling legally compliant headlights to be implemented).

Dimmable LED light sources provide both the dipped and main beam functions and consume far less energy than conventional headlamps, Osram says. Each headlight (which is only 5cm high) has three Joule JFL2 LED modules: two provide the main low or dipped beam — compliant with the Economic Commission for Europe (ECE) — and one provides the high beam.

"Compact and efficient LED sources will be mandatory for low-consumption and electric vehicles in the future in order to achieve the car industry's CO₂ objectives," says Thomas Reiners, Osram's director of Application Technology for special lighting. "A dipped-beam headlight with these light sources will use less than 15W and therefore save 40W of power input per vehicle side compared with a halogen solution," he adds.

With a power input of only 19W per dipped beam, the car's lighting is far more energy efficient than conventional headlights, in which mostly 55W halogen lamps are used, says Osram. Even xenon lamps (with an input of just 35W) use 20% more energy on dipped lights (95% of night-time driving) than two Joule JFL2 LED modules.

"Energy efficiency and ease of integration were good reasons to



VW's L1 concept car.

rely on LED solutions for headlights," says Volkswagen lighting engineer Henning Kiel. "They can bring about significant benefits both for end customers as well as during headlamp and vehicle production," adds Christian Meier, Osram product manager Joule LED systems.

With a lifetime that normally exceeds that of a vehicle plus considerable robustness against shocks and vibration, LED-based lamps are far less maintenance intensive than conventional lamps, Osram claims. Joule JFL2 LED modules will be introduced in production for other vehicles in early 2010 and can then be included in new vehicle models across multiple platforms.

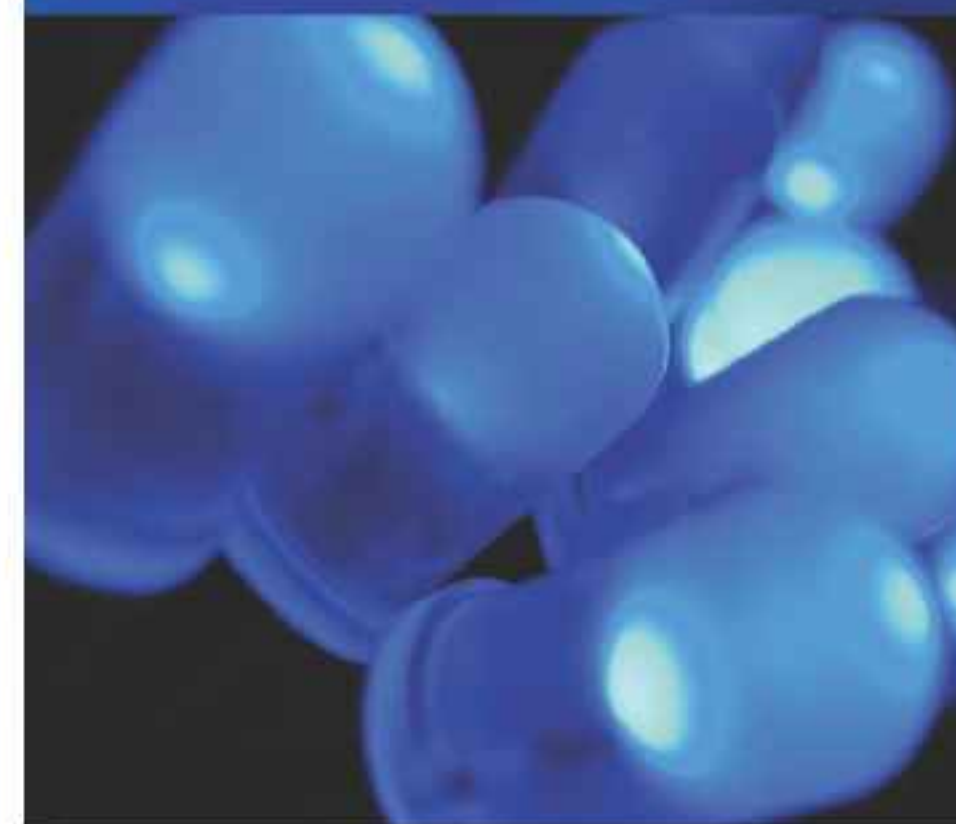
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QD Laser claims first quantum dot pure-green laser

In collaboration with professor Yasuhiko Arakawa (head of the University of Tokyo's Institute for Nano Quantum Information Electronics), Tokyo-based QD Laser Inc has developed what it claims is the first green laser using quantum dot (QD) semiconductor crystals (exhibited at CEATEC JAPAN 2009 at Makuhari Messe in Chiba, 6-10 October).

With a compact 5.6mm diameter (Figure 1) as well as the capability of low power consumption by operating at up to 60°C without the need for cooling, the QD green laser suits use in mobile projectors that can be mounted on cell phones or laptop PCs, says the firm.

There is currently great demand for low-power-consumption, compact projector sources that can be mounted on mobile devices, such as cell phones and laptop PCs. But using an LED light source requires the projector to be refocused each time the distance to the screen changes. In contrast, using a laser enables focus-free operation, as well as reduced power consumption (key for use in battery-operated devices).

For a focus-free compact mobile projector, three lasers (red, blue, and green) are needed. However, until now, a green laser had not existed that combines the features of being compact (for practical use) with low power consumption, as well as allowing mass production at a lower cost.

QD Laser has now applied distributed feedback (DFB) laser technology — commonly used in high-reliability optical communications — to create a quantum dot laser with a wavelength of 1064nm. The beam of photons is subsequently filtered through a nonlinear optical crystal in which the process of second-harmonic generation (SHG) leads to two photons being re-emitted as one photon with twice the energy (i.e. frequency) and hence half the wavelength (532nm).



Figure 1. The 5.6mm-diameter quantum dot green laser. Because the quantum dot green laser can operate at 2V DC at temperatures up to 60°C without cooling and can be packaged in a 5.6mm-diameter TO-56 can (a generic package for laser diodes), QD Laser says that it meets the optimal power consumption and dimension requirements for

The 1064nm quantum dot laser converts electricity to light very efficiently, resulting in a reduction in power consumption, claims the firm. Also, by adopting DFB technology, which has been field proven in optical communications products, QD Laser says that it has simplified the structure for stable optical coupling to SHG (a complicated process that so far has required complex control mechanisms). In addition, because the quantum dot green laser can be produced on a gallium arsenide substrate, it is cost-competitive with alternative technologies, it is reckoned.

a compact mobile projector. Also, because it enables high-speed video modulation of 500MHz or higher, it enables display of HDTV-class images even in compact mobile projectors. By combining the quantum dot laser with a red-green-blue (RGB) laser source that is already equipped with red and blue lasers, along with a micro-electro-mechanical systems (MEMS) scanner (Figure 2), ultra-small size and large screen size as well as low power consumption can be realized, it is claimed.

According to Insight Media, the compact mobile projector market should reach 32 million units in 2012. In addition to compact mobile projectors, expected applications include head-mounted displays and head-up displays for automobiles.

QD Laser says that it will start shipping samples of the laser source module in December, and aims to launch commercial products in mid-2010.

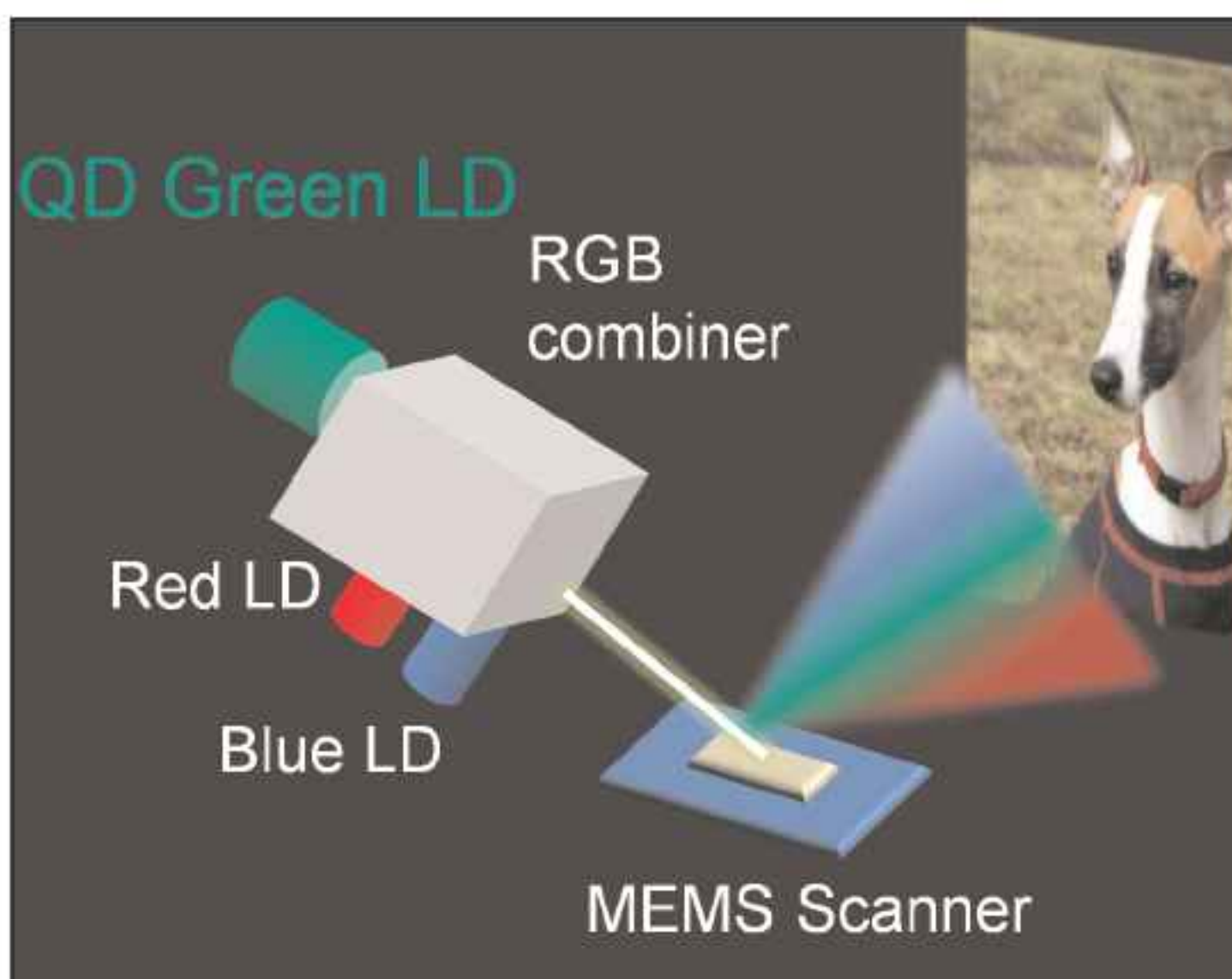
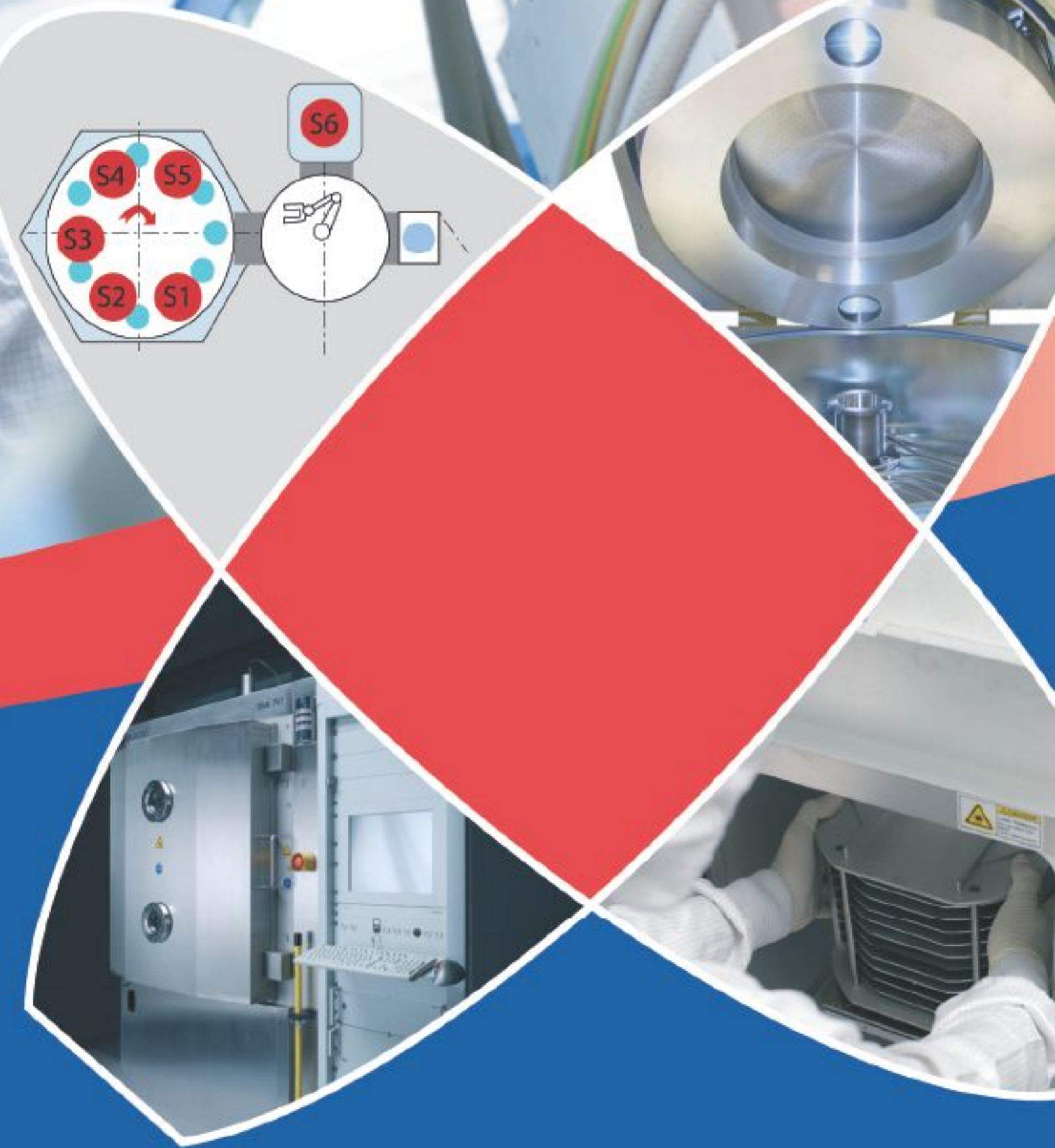


Figure 2. QD green laser structure and example application. www.qdlaser.com

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Modulight lasers to be launched on ESA's SMOS Satellite

Laser manufacturer Modulight Inc of Tampere, Finland has supplied fiber-pigtailed laser diodes to the European Space Agency (ESA) for its Soil Moisture and Ocean Salinity (SMOS) satellite mission, launched on 2 November.

The lasers are a part of the optical harness of the MIRAS (Microwave Imaging Radiometer using Aperture Synthesis) instrument in the satellite.

By using MIRAS, SMOS will provide global information on surface soil moisture every three days within an accuracy of 4% at a spatial resolution of 50km (comparable to detecting one teaspoonful of water mixed into a handful of soil).

In parallel, SMOS will also observe ocean salinity down to 0.1psu (practical salinity unit) for a 30 day average over an area of 200km x 200km (about the same as detecting 0.1g of salt in a liter of water).

The MIRAS Optical Harness (MOHA) was designed and manufactured by the former Contraves Space (now RUAG Space). Modulight supplied more than 70 lasers for the instrument, which controls the synchronization of the distributed



Artist's impression of SMOS atop the upper stage of Breeze launch vehicle.

microwave antenna elements of the satellite and hence the whole remote sensing functionality.

Data from SMOS should result in a better understanding of the water cycle and, in particular, the exchange processes between the Earth's surfaces and the atmosphere. This should help to improve weather and climate models, as well as having practical applications in areas such as agriculture and water resource management.

"We delivered the first ever communication lasers to space application for a mission critical function on a science satellite," claims Modulight's president & CEO Dr Petteri Uusimaa.

www.esa.int/esaEO/SEMDR7YRA0G

UK/Ireland distributor appointed
Modulight has signed a distribution agreement with Pro-Lite Technology of Cranfield, UK, a specialist distributor serving the laser and optical radiation measurement communities in the UK and Republic of Ireland.

Pro-Lite will supply Modulight products ranging from the design and manufacturing of high-power laser diodes to OEM-based optical sub-systems and turnkey laser systems for medical, industrial, display, and communications applications. Modulight says that it works in close co-operation with customers, offering customized products and volume production capabilities.

"We have a customer base in that market, and Pro-Lite's expertise complements very well the support we can offer," says Uusimaa. "By working together with Pro-Lite, we expect a significant increase in our market share in UK," he adds.

"Modulight's proven range of application-specific products and customer focus make them an ideal partner," comments Pro-Lite partner Ian Stansfield.

www.pro-lite.co.uk

www.modulight.com

DILAS appoints materials processing expert to sales staff

DILAS Industrial Laser Systems of Mainz, Germany (a division of high-power diode laser maker DILAS Diodenlaser GmbH) of Mainz, Germany has appointed Steffen Reinl to its sales team, responsible for supporting all sales channels.

As well as a Master's Degree in mechanical engineering in 1997 from the University of Applied Studies in Darmstadt (specializing in materials processing with diode lasers), Reinl has a track record of 12 years in laser materials processing, including industry insight that should benefit the company, it is reckoned.

"Reinl brings extensive expertise in the field of materials processing," says Dr Marcel Marchiano, presi-

dent & CEO of the parent firm. "With a solid reputation and technical experience; he is a great asset," he adds.

After starting his career at DILAS Diodenlaser GmbH (where he was in charge of the applications laboratory), in 2001 Reinl co-founded semiconductor industrial laser manufacturer Optotools GmbH, and was responsible for product management as well as sales & marketing for a wide range of industrial applications.



Steffen Reinl.

Since 2003 he has focused on laser materials processing, primarily in the welding of plastics.

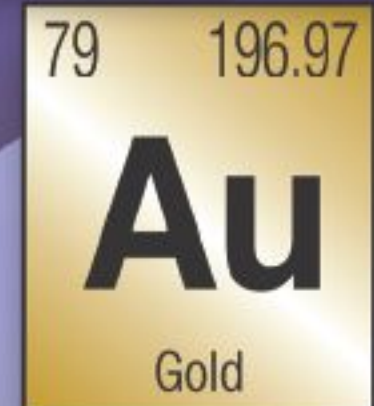
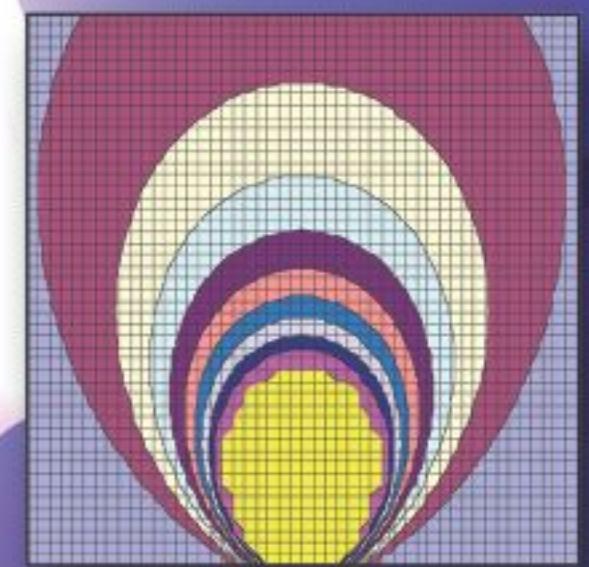
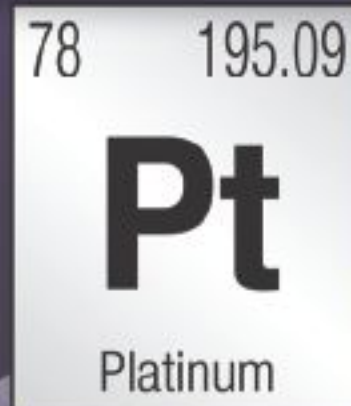
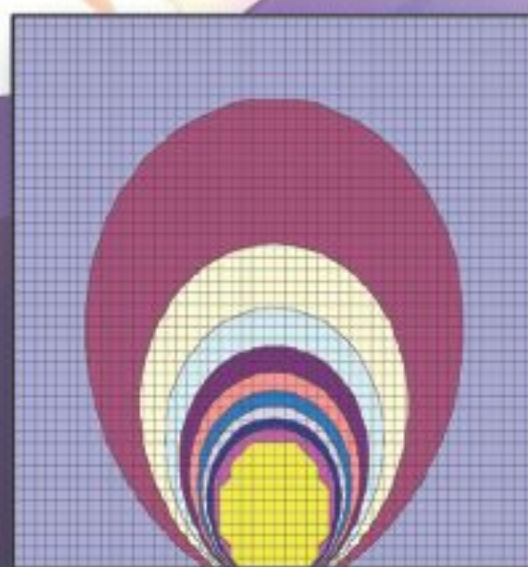
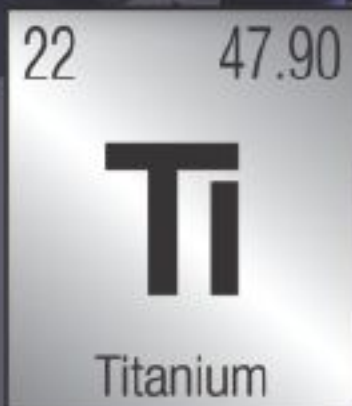
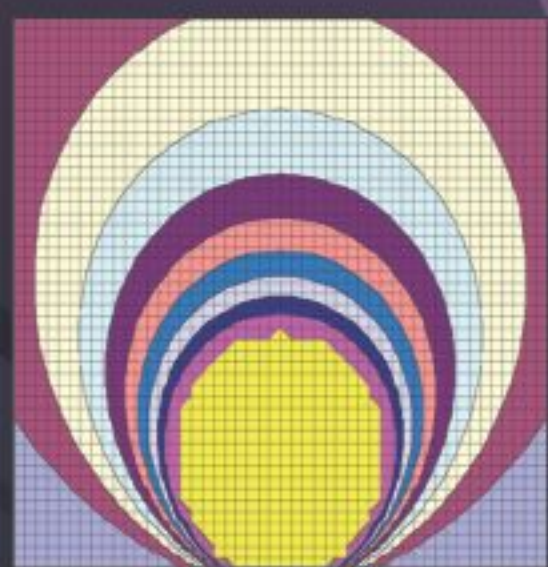
● In October, DILAS celebrated its 15-year anniversary of providing diode laser solutions and customer service on a global scale.

Founded in 1994 with just nine people, the firm now has more than 200 staff in manufacturing and R&D facilities in Europe, North America and Asia.

DILAS has maintained its focus on delivering diode laser technology. The firm says that its solid growth is founded on a customer base that spans medical, diode-pumped solid-state laser, defense, graphic arts and materials processing.

www.dilas-ils.com

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3S unveils 600mW submarine 980nm pump laser module

At the 35th European Conference and Exhibition on Optical Communication (ECOC 2009) in Vienna, Austria (21–23 September), 3S Photonics of Nozay, France unveiled its next-generation 1996 SGP Series 980nm-wavelength submarine-grade pump modules.

Capable of providing 600mW of ex-fiber optical power, 3S claims that the 1996 SGP Series is the most powerful 980nm pump laser module available for submarine optical networking applications. Its performance and reliability enable cost-effective designs for the deployment of next-generation 10 and 40Gb/s optical amplifiers into the submerged repeaters distributed along the submarine inter-continental cables, the firm claims.

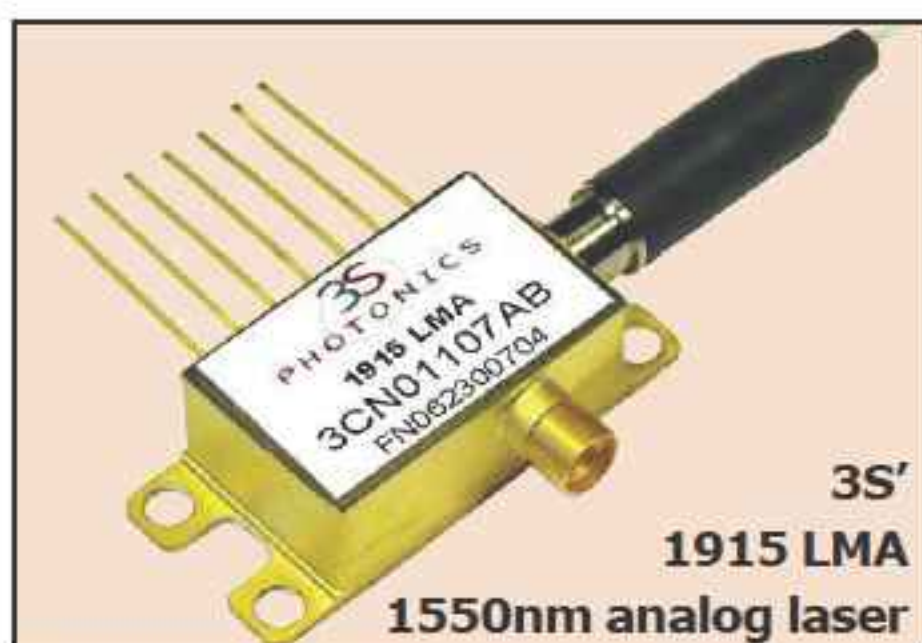
The pump module complements 3S' current-generation 1994 SGP high-power pump (which has been under field deployment for more than three years) and addresses demands for increased power.

"New submarine systems will require much higher power levels and NEC has actively been collaborating with 3S Photonics for the successful development and manufacturing of next-generation submarine cable systems," says Osamu Harada, general manager of NEC's Submarine Networks division.

The 1996 SGP Series' performance and ability to meet demanding submarine reliability requirements has been enabled by a development program launched by 3S, technical results of which have already been published in various proceedings.

Optimized chip structures enable a reduction in internal losses to a record $0.55\text{--}0.60\text{cm}^{-1}$ while maintaining high external efficiencies. New designs also maintain low junction temperature and injection current density. The results translate to completion of the initial aims of raising operating power above 600mW at the module level while meeting stringent reliability requirements.

Construction of the pump modules is based on the double-lens coupling



platform, the reliability of which has been proven through more than 20,000 active components being field deployed worldwide over more than a decade without any failures. Long-term aging tests have demonstrated typical expected end of life (EOL) power drifts of less than 2% over a 25-year lifetime.

The platform is the most deployed in the world, so 3S can refer to its submarine experience without needing to consolidate reliability information captured from a terrestrial platform, says Yannick Bailly, VP marketing & product management. "Terrestrial information does not take into account the extended warranty periods requested by submarine customers and the imperative obligation of traceability for the product lifetime," he adds.

3S says its long-term strength in high-reliability products relies on assembly technology and processes, an extensive set of quality checks (from kitting up to the final control before shipping), plus dedicated chip and module pedigree reviews. "These are the key elements to guarantee to our customers the quality and reliability levels required by the submarine community," says Michel Privat, chief operating officer & VP sales. "This new product enlarges our product portfolio for submarine applications and strengthens our position of strategic supplier with regard to submarine system makers." 3S' submarine-grade product portfolio extends beyond 980nm pump modules and includes a full range of FBG-based filters and monitoring PIN photodiodes fitted in an ultra-compact package.

At ECOC, Orange Labs presented the performance of prototypes — tested within the European project ALPHA (Architectures for flexible Photonic Home and Access networks) — of 3S' 1915 LMA Series of next-generation directly modulated 1550nm high-bandwidth analog laser modules, which are optimized for the OFDM/ QAM high-spectral-efficiency formats.

Powered by 3S' in-house 1550nm analog DFB laser chip (optimized for direct modulation), the 1915 LMA has been developed for the project EPOD — Enhanced PON (passive optical networks) using the OFDM modulation format — which is sponsored by France's National Research Agency (ANR) and is led by Orange Labs (the French telecom provider's R&D division). Academic partners include LISIF (Laboratories of Electronics and Electromagnetism — L2E of the Paris region) and a team from XLIM (a research institute of the University of Limoges and CNRS).

The module has high ex-fiber optical output power ($>10\text{mW}$) and a low RIN ($<-160\text{dB/Hz}$ at up to 18GHz), enabling analog signal transmission over a bandwidth of 10MHz to 20GHz over 20km of single-mode fiber.

Using an industry-standard butterfly package with GPO connector as RF input, the module is intended for the distribution and/or transmission of radio-type signals via broadband fiber links such as radio-over-fiber (RoF), RF over glass (RFoG) or fiber-to-the-antenna (FTTA).

"When directly modulated with the OFDM technique — the one implemented in xDSL transmission — the 1915 LMA represents a perfect transmitter candidate for the next-generation of broadband optical access networks, meeting all the stringent requirements set by the convergence of metro and access, i.e. low cost, mature technology, high bit rate and extended reach," claims Yannick Bailly, VP marketing & product management.

www.ict-alpha.eu

www.3Sphotonics.com

JDSU in production with tunable chip

Optoelectronic component maker JDSU of Milpitas, CA, USA has launched two new products for fiber-optic communications networks.

The firm has released its tunable XFP transceiver into volume production (after announcing the product in March), while it also says that a new GaAs-based pump laser package fabricated using a simplified manufacturing process has met crucial Telcordia qualification standards.

JDSU's announcements were timed to coincide with the European Conference on Optical Communications (ECOC) in Vienna, Austria.

The XFP transceiver is based on a tunable source fabricated using an InP process that integrates the laser with a semiconductor optical amplifier and a Mach-Zehnder modulator. The chip-integration approach delivers a module that is just one-sixth the size of previous generations of tunable transceivers.

JDSU's design was the subject of recent patent litigation with rival component maker Oclaro (formerly Bookham), which had also developed a tunable transceiver. That case was won by JDSU in April, with Oclaro ordered to pay royalties

of up to \$1m per year to JDSU.

JDSU has also modified the tunable technology to create a different component that is suitable for ultra-long-haul networks. Incorporated into a 300-pin transponder design, the laser's continuous-wave output is fed into an external lithium niobate modulator — an older technology — instead of a semiconductor modulator.

"The DWDM market is looking for multiple supplier solutions that provide lower-cost, lower-power consumption and a smaller footprint to support the carrier dilemma of single-digit revenue growth but double-digit traffic growth," comments Daryl Inniss, VP & practice leader of components at market analyst firm Ovum. "It's great to see that JDSU has extended its tunable XFP technology to support 300-pin [multi-source agreement] transponders, as this should help provide lower-power and lower-cost options to the market."

Meanwhile, JDSU believes that a new approach to making 980nm lasers, which are used to pump the erbium-doped amplifiers (EDFAs) that boost optical signals in long-

haul networks, will provide energy savings to network equipment firms.

Toby Strite, marketing director of Optical Components and Integrated Modules for JDSU's CCOP business segment (responsible for the pump lasers), reckons that the increasing consumer demand for network applications has put a focus on the energy requirements of optical modules used in those networks. "JDSU's new 980nm pump laser is a low-cost solution that can help operators reduce the amount of power needed to support these increasing demands, which is especially critical in today's economic environment," he said.

According to the firm, the new SP Platform pump lasers are reliable enough to operate at 45°C, rather than at room temperature, which means that system cooling requirements are reduced significantly.

The laser packages are designed to fit into existing modules, for direct replacement of older pump components, and a new manufacturing process is said by JDSU to have reduced customer lead times by half.

www.jdsu.com

JDSU qualifies 980nm pump laser package for telecom networks

JDSU has met the Telcordia qualification requirements for its new SP Platform 980nm pump laser package, which is designed to help network equipment manufacturers (NEMs) lower costs and power consumption in optical networks. JDSU will also be able to reduce lead times for the new product by 50% compared to older designs, based on its simplified and lean manufacturing process.

The erbium-doped fiber amplifier (EDFA) is a key optical component that regenerates weakened network signals traveling long distances over agile optical networks (AON). Service providers are deploying AONs to provide flexible network

infrastructures that can meet increasing consumer demand for the voice, video and data applications that are driving higher internet traffic levels.

"As NEMs focus on supporting an increased amount of network capacity, the energy requirements of modules that support the infrastructure can skyrocket," says Strite.

Key benefits of the SP include:

- next-generation terrestrial package based on proprietary JDSU technology;
- reliable chip technology that can operate at 45°C, which can reduce system cooling requirements by up to 60% compared to the previous 25°C chip temperature standard;

- a lean production that reduces product lead time by 50%; and
- the same form, fit and function of previous product for convenient replacement of existing designs.

As light is transmitted through AONs, signal degradation occurs over distances of 60–100km. EDFAs are placed throughout networks to regenerate weakened signals. They rely on an optical fiber that is 'doped' with erbium, which efficiently converts pump laser energy to replicate signal light in a 1550nm band. 980nm pump lasers are preferred due to their low noise amplification, low power consumption, reliability, and competitive price.

CIP launches monolithically integrated reflective SOA-EAM for DWDM networks

At the 35th European Conference and Exhibition on Optical Communication (ECOC 2009) in Vienna, Austria (21–23 September), CIP Technologies of Martlesham Heath, Ipswich, UK (which manufactures photonic hybrid integrated circuits and indium phosphide-based optoelectronic chips, devices, arrays and modules) has launched the R-SOA-EAM-1550, which monolithically integrates a semiconductor optical amplifier with a reflective electro-absorption modulator to combine high optical gain with high-speed modulation capability.

CIP says that the R-SOA-EAM-1550 offers high output power, low power consumption, and low sensitivity to input polarization, making it suitable for dense wavelength division multiplexing (DWDM) transmission at speeds of 10Gb/s over fiber-optic links of up to 80km. The device is 'colorless', and a single device may be used across the entire C-band.



CIP's packaged R-SOA-EAM-1550 for DWDM networks.

"Using colorless modulators with remote DWDM light sources is becoming a viable alternative to expensive tunable lasers in WDM-PON [passive optical network] and metro applications," says chief technology officer David Smith. "This level of device performance represents a breakthrough that will simplify and cost-reduce future deployments," he reckons.

The R-SOA-EAM-1550 also incorporates standardized design



Monolithic chip inside CIP's R-SOA-EAM-1550.

features to make it compatible with the CIP HyBoard photonic integration platform. "This new device is an important addition to the toolkit of optical devices that will be integrated in the future," says Smith.

CIP's optical systems manager Dr Alistair Poustie presented a paper related to the R-SOA-EAM-1550 in session 8.6 of the ECOC conference.

www.ciphotonics.com

Opnext demos 100Gb/s CFP and launches 40Gb/s modules

Optical component, module and subsystem maker Opnext Inc of Fremont, CA, USA announced two new additions to its 40Gb/s product portfolio in response to customer demand for longer-reach and smaller-size 40Gb/s solutions: DQPSK (differential quadrature phase shift keying) modules for dense wavelength division multiplexing (DWDM) transmission and compact VSR (very short reach) modules for client applications.

DQPSK technology offers enhanced performance with improved optical signal-to-noise ratio (OSNR) characteristics and 50GHz channel spacing. Opnext claims that its DQPSK technology offers improved performance, simplified network design and lower manufacturing cost to network equipment manufacturers.

The new 40Gb/s VSR-2000-3R2 300-pin MSA (multi-source agreement) transceiver introduces a compact size and reduced power dissipation to the firm's 40Gb/s module portfolio. The SFF (small form factor) optical module has a 3.5-inch x 4.5-inch footprint. System applications are migrating toward higher-density 40Gb/s platforms, which require the smaller size and lower power that the 40Gb/s SFF solution can provide, says the firm.

At ECOC 2009, Opnext is also showcasing its CFP MSA-compliant module for 100GBASE-LR4 in a live demonstration. The CFP MSA defines the form factor of a hot-swappable optical transceiver supporting 40 Gigabit and 100 Gigabit Ethernet (GbE) and uses an transceiver electrical interface

consisting of multiple 10Gb/s lanes. The 100GbE CFP optical module demonstrated at ECOC transmits and receives via four parallel wavelengths at 25Gb/s each, as per the IEEE 802.3ba 100GbE project.

"Network equipment vendors are introducing higher-bandwidth switching and routing solutions, flexible DWDM platforms, with extended-reach requirements and more challenging thermal environments," says Tadayuki Kanno, president of Opnext's module business unit.

"Opnext's 100GbE CFP, new 40G solution DQPSK MSA module and 40Gb/s SFF VSR deliver the cost and power savings necessary to meet next-generation network requirements," he adds.

www.opnext.com

Sumitomo Electric unveils 40 Gigabit Ethernet CFP optical transceiver module for 10km transmission

At the 35th European Conference and Exhibition on Optical Communication (ECOC 2009) in Vienna, Austria (21–23 September), Tokyo-based optical component, module and subsystem maker Sumitomo Electric Industries Ltd (SEI) expanded its optical transceiver portfolio with the introduction of what it claims is the first 40 Gigabit Ethernet (40GbE) CFP transceiver module for 10km transmission.

The transceiver complies with the 40GbE standard under discussion by the IEEE802 committee, which has been working on the next-generation standard of 40 and 100 Gigabit Ethernet in order to respond to the anticipated shortage of transmission capacity in 2010 due to the



SEI's 40GbE CFP transceiver for 10km transmission.

rapid growth of Internet services.

In parallel, Sumitomo Electric — together with fellow optical component, module and subsystem makers Finisar Corp of Sunnyvale, CA, USA, Opnext Inc of Eatontown, NJ, USA — established the multi-source

agreement (MSA) for the next-generation CFP form factor, which was announced in March at the Optical Fiber Communication Conference & Exposition (OFC 2009) in San Diego.

To meet these demands, Sumitomo Electric developed the 40GbE CFP transceiver for 10km transmission by using a high-speed four-wavelength CWDM laser diode, through the application of its own low-power-consumption drive technology and high-density mounting technology.

Sumitomo Electric has started shipping 40G CFP samples. Mass production is planned for second-quarter 2010 at subsidiary Sumitomo Electric Device Innovations.

<http://global-sei.com>

Nokia Siemens deploys Mintera's Adaptive-DPSK 40G DWDM module

Mintera Corp of Acton, MA, USA, which makes high-bit-rate optical transport sub-systems, says that Nokia Siemens Network's updated hiT 7300 transport product now incorporates its MI 4000XM Adaptive-DPSK module, which is in full deployment supporting 40Gb/s services.

"It is a very reliable component, enabling simple upgrading of high-capacity DWDM [dense wavelength division multiplexing] systems to 40Gb/s line speed," says Uwe Fischer, head of Nokia Siemens Networks' DWDM business line, of the Mintera module.

"Mintera greatly values the opportunity of working with Nokia Siemens Networks as a lead customer," says the module supplier's president & CEO Terry Unter. "The commercial deployment of our combined products demonstrates the strength of performance and quality of Mintera's MI 4000XM." Adaptive-DPSK provides the most cost-effective, longest-reach solution

suitable for the majority of 40Gb/s applications worldwide, he claims.

"This is just the first of many 40Gb/s network deployments for the hiT 7300 using Mintera's MI 4000XM, with substantial Adaptive-DPSK deployment volumes expected for the next several years," Fischer continues.

The patent-pending Adaptive-DPSK technology incorporated in the MI 4000XM DWDM module enables 40Gb/s transport on 50GHz channel-spaced systems and transmission over agile reconfigurable optical add-drop multiplexer (ROADM) networks without compromising critical ultra-long-haul (ULH) reach. The unit conforms to the industry-standard footprint and incorporates an electrical mux/demux for compatibility with any 40Gb/s framer. The module has a 300-pin MSA connector with support for the appropriate I2C commands, enabling simple hardware and software integration.

www.mintera.com

IN BRIEF

Oplink is Tellabs' Supplier of the Year

At the Supplier Alliance Day of network provider Tellabs in Naperville, IL, component, module and subsystem maker Oplink Communications Inc of Fremont, CA, USA became the first optical supplier to be presented with Tellabs' 2009 Supplier of the Year award.

Oplink won the award based on exemplary performance in all of Tellabs' key metrics for evaluating preferred suppliers: technology, quality, responsiveness, delivery, and total cost management.

"With this encouragement, we will invest even more resources in our OMS [optical manufacturing solutions] capabilities, to provide timely, cost-effective and high-performance solutions," said Oplink's president & CEO Joe Liu.

Tellabs was Oplink's second biggest customer in the quarter to end June (18% of revenue, behind only Huawei at 23%).

www.oplink.com

Photonic integrated circuit expert named IET Fellow

Digital optical network system maker Infinera Corp of Sunnyvale, CA, USA says that Dr Radhakrishnan (Radha) Nagarajan, its senior director of Optical Component Technology, has been named a Fellow of the Institute of Engineering and Technology (IET) in recognition of his pioneering work in photonic integrated circuit design.

Infinera says that Nagarajan is one of the key architects in the development of its large-scale InP-based photonic integrated circuits (PICs). He is also a fellow of the Optical Society America (OSA) and a fellow of the Institute of Electrical and Electronics Engineers (IEEE).

The firm's commercial PICs integrate more than 50 optical components on a single chip less than 5mm across. Meanwhile, its next-generation devices have demonstrated monolithic integration levels of well over 400 components. The devices are at the heart of Infinera's Digital Optical Networks architecture,



Radha Nagarajan. Infinera has won 62 customers worldwide, including some of the largest service providers. Nagarajan has been a member of the engineering team developing PICs since the firm was founded in 2001.

The IET has 150,000 members in 127 countries. Fellowship is awarded to members who have demonstrated superior individual responsibility, sustained achievement and significant professionalism during their careers. Applicants must clearly demonstrate successful leadership or outstanding service to the profession over an extended period.

Nagarajan says the Fellowship is

which has delivered improvements in density, scalability, reliability, and power consumption, the firm claims.

also recognition for Infinera's PIC engineering team. "It has been a pleasure working in such an environment, from the days when there were two dozen of us in one building, up to and including the present, when Infinera is a company with nearly 1000 people."

Nagarajan has a degree in Electrical Engineering from the National University of Singapore, a Masters in Electronic Engineering from the University of Tokyo, and a PhD from the University of California at Santa Barbara (UCSB). After further work as a research faculty at UCSB, he joined optical components manufacturer SDL, where in 2000 his team won the Photonics Circle of Excellence award for the design of a high-power, single-mode pump module for EDFA applications. In 2006, he was awarded the IEEE/LEOS Aron Kressel award in recognition of work on the development and manufacturing of large-scale PICs.

Infinera revenue rebounds by 21% to \$83.4m

For third-quarter 2009, Infinera, a vertically integrated manufacturer of digital optical network systems incorporating its own InP-based photonic integrated circuits (PICs), has reported revenue of \$83.4m, rebounding by 21% from \$68.9m last quarter and back up on a year ago (by 3% from \$80.9m). International revenue grew for the fourth quarter in a row, reaching 37% of revenue.

On a non-GAAP basis, gross margin was 38%, up from 31% last quarter (though still down from 42% a year ago). Net loss has been cut from \$18.2m last quarter to \$3.1m, although this is still down on break-even a year ago.

"We continued our positive revenue growth trajectory and our new customer win momentum with the addition of four customers to our roster [bringing the customer count to 66]," says president & CEO

Jagdeep Singh. With the addition of incumbent service providers Telefonica and Teliasonera, Infinera's tier-1 carrier customer count is now six, of which three (NTT Communications, Deutsche Telekom and Telefonica) are among the top five in the world. The firm also won a new eight-figure opportunity with another major internet content provider.

Infinera has also diversified its customer base, cutting its reliance on any one account. Three clients accounted for 10% or more of revenue, and the largest was an existing cable MSO customer. Level 3 was just less than 10% of revenue.

"Our ability to grow our revenue and expand our customer base in the current environment validates that customers are investing in the optical network again," Singh says.

"We have expanded our total addressable market with the addi-

tion of submarine and metro edge products," he adds.

With the launch in October of its ATN metro edge product, Infinera now addresses all major categories in the \$8bn DWDM space, including submarine, ultra-long haul, long-haul, regional, metro core and metro access. To date, the firm has six wins for its new ATN platform, including the recently announced ATN deployment at Deltacom.

Also, in September Infinera strengthened its technology resources with the addition of an experienced engineering team in its new Ottawa development center. The firm says that the team has deep expertise in signal processing and complex modulation schemes (important building blocks for the next generation of optical transport products).

www.infinera.com

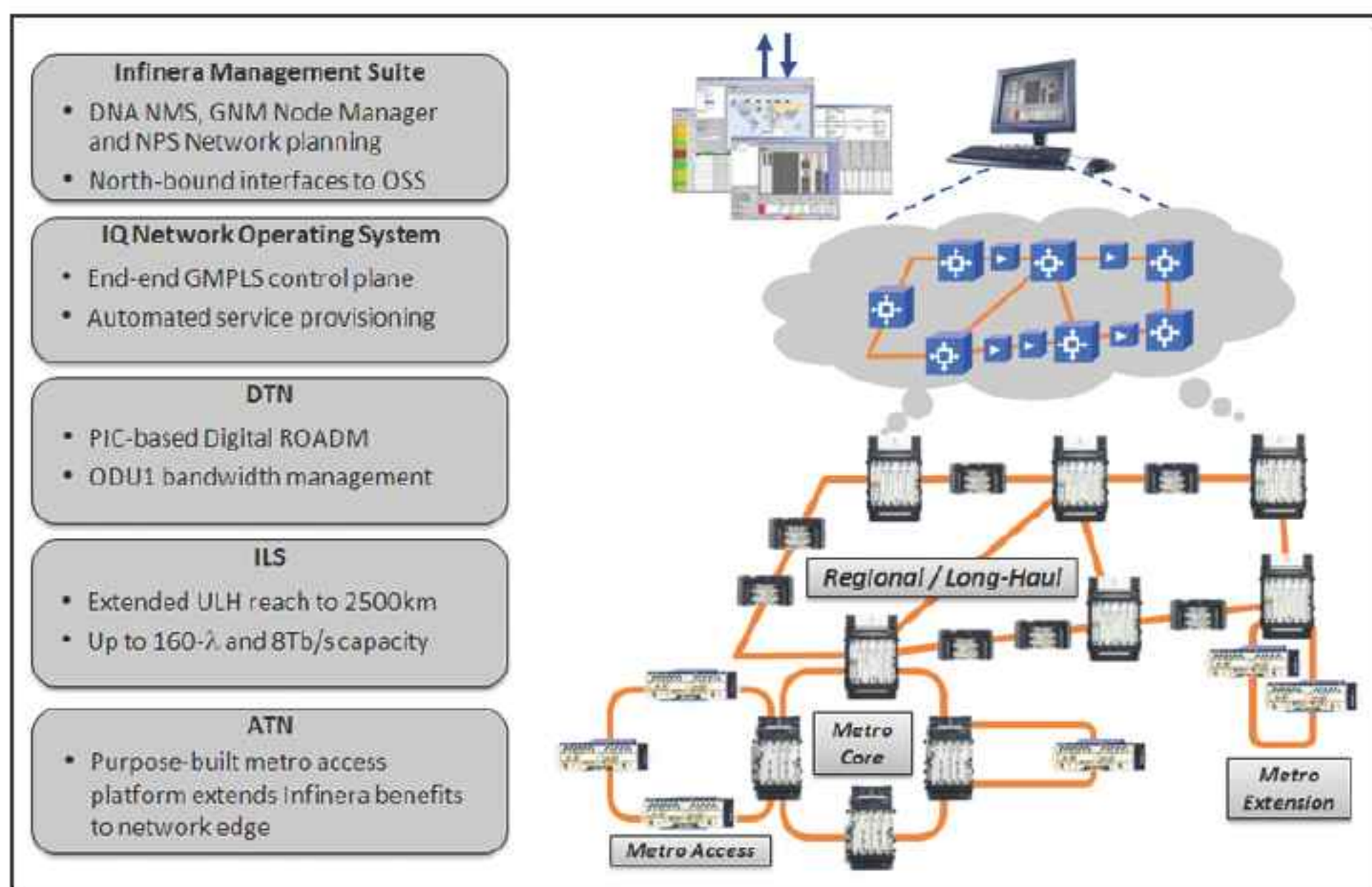
Infinera launches metro WDM edge platform

In a live demonstration at the Supercomm 2009 trade show in Chicago, IL, USA (21–23 October), Infinera of Sunnyvale, CA, USA unveiled its compact and flexible ATN metro WDM edge platform.

The firm says that the new system brings the benefits of its Digital Optical Network architecture to the edge of the network, offering service providers with a seamless end-to-end managed WDM solution.

“Our customers have embraced the simplicity, efficiency and speed of the Digital Optical Network,” says CEO Jagdeep Singh. “They have asked us for solutions to extend the Infinera benefits deeper into their metro network.” Together with the introduction of its submarine solution last month, Infinera says that it now provides end-to-end optical networks capability. The firm's products are now carrying live traffic in all segments of the DWDM market: metro, regional/long-haul, and submarine.

The ATN is designed to offer seamless integration with an Infinera DTN network via a common network management system, enabling end-to-end service provisioning and visibility. The firm says that, by eliminating back-to-back transponders at network interconnection points, an ATN/DTN network delivers savings in capital expenditure, while extending ease of operation to the metro edge. An ATN network, in combination with a DTN network, can offer end-to-end integrated optical transport network (OTN) bandwidth management for traffic transiting the network, leveraging Infinera's integrated digital bandwidth management. The ATN also provides a high-density platform for standalone metro C/DWDM applications, including data-center connectivity, commercial services extension and broadband backhaul. Infinera also says that the ease of operation and powerful management software provide robust network management options from the smallest to



New metro access platform expands Infinera's coverage to the network edge.

the largest networks, enabling operators to minimize network operational expenditure.

As a compact, metro optical transport platform, the ATN delivers up to 40 DWDM or 8 CWDM wavelengths on a single fiber pair. Implementing flexible service interface modules (SIMs) with all line-side and client-side interfaces pluggable, the ATN offers flexible configurations to simplify and accelerate network deployment. The ATN has been designed to offer what is claimed to be best-in-class density and power consumption in a small form factor. It is designed to support all metro transport services, including Ethernet, SAN, SONET/SDH, OTN and video services.

Infinera's digital architecture has brought new efficiency to core optical networks: the firm's Bandwidth Virtualization ensures that bandwidth resources in the core network can be allocated to carry any available service between any points on the network, increasing network flexibility and utilization rates, and minimizing stranded bandwidth. By interconnecting ATN and DTN networks, the ATN extends those efficiency and flexibility benefits to the metro edge.

Infinera has already won six customers for the new platform, including telecom carriers, cable operators, and Internet content providers. For example, Deltacom, a provider of integrated communications services already operates a long-haul DTN network across the southeastern USA, has deployed the ATN in several of its metro markets.

According to market analyst firm Ovum, worldwide revenue in the metro DWDM market in 2008 was \$3.6bn, with a forecast average annual growth rate of 13% over the next six years. Infinera says that the ATN's launch enables it to address the full metro market. “Infinera's ATN metro platform effectively doubles Infinera's addressable market while also strengthening its value proposition,” says Dana Cooperson, Ovum's VP for Network Infrastructure. “In-house development of the platform promises capital and expense efficiencies from tight coupling of the ATN and DTN in critical areas like service and network management and physical interworking, but the platform stands on its own as well,” she adds.

www.infinera.com

IN BRIEF

Spectrolab records 41.6% CPV efficiency

In late August, Boeing Company subsidiary Spectrolab of Sylmar, CA, USA reported a record conversion efficiency for a terrestrial concentrator photovoltaic (CPV) cell of 41.6%, as tested by the US Department of Energy's National Renewable Energy Laboratory (NREL) in June.

This surpasses the prior record of 41.1% reported in January by the Fraunhofer Institute for Solar Energy Systems (FhG-ISE) in Freiburg, Germany, which followed 40.8% achieved by NREL in August 2008 and 40.7% by Spectrolab in December 2006.

Produced in February 2008, the new cell is an advanced version of the lattice-matched triple-junction photovoltaic technology already produced in high volume for space and terrestrial applications at Spectrolab. It incorporates several improvements in wafer processing to reduce how much of the cell's area is shadowed by its metal contact grid and to improve series resistance, raising the cell's overall efficiency.

The new cell will be incorporated quickly into Spectrolab's production line, says president David Lillington. "This milestone underscores our emphasis on realizing the highest-efficiency cells in high-volume production," he adds.

Spectrolab claims that its cells power 60% of satellites orbiting the Earth. But, after making investments to meet rising demand from terrestrial CPV system makers, it expects an annual capacity of 300MW in 2010.

"Over the past decade, Spectrolab's efforts developing terrestrial solar cell efficiency have achieved an average improvement of approximately one percentage point per year, and we expect to continue that," adds Lillington.

www.spectrolab.com

First nitride/Si tandem solar PV cell

RoseStreet Labs Energy (RSLE) of Phoenix, AZ, USA has unveiled two developments towards solar power that use nitride semiconductor technology. One development is a nitride semiconductor photovoltaic (PV) device combined with a standard silicon solar cell; the other uses nitride thin-film semiconductors to generate hydrogen electrochemically from sunlight.

RSLE works with indium gallium nitride (InGaN) combinations. These materials are also used extensively with aluminum to create light-emitting and laser diodes covering the spectrum from green to ultraviolet light. By varying the In-Ga proportions the bandgap of the material can be varied from less than 1eV up to around 3eV. These energies cover the greater part of the solar spectrum (Figure 1).

Semiconductor materials are relatively transparent to photon energies below their band gap energy. By combining layers of semiconductor materials in tandem, one can arrange to extract energy from light more efficiently, gathering the high-energy photons first and then lower down the less energetic light, which is not absorbed by the wider-bandgap material above.

The standard silicon PV technology is based on that material's bandgap energy of about 1eV. One can use silicon to extract energy from photons above this energy; however, much of the energy is then lost with each photo-generated electron only delivering the useful energy of the bandgap with the rest of the photon's energy being lost as heat.

Ultimately, RSLE is targeting 25–30% efficiencies with the first cells off the production line, versus 10–20% for commercial silicon PV cells (although about 22.5% is claimed by Sunpower of San Jose, CA for its crystalline silicon solar cell), depending on cost and technology. Production devices based on RSLE's technology are expected in fourth-quarter 2010.

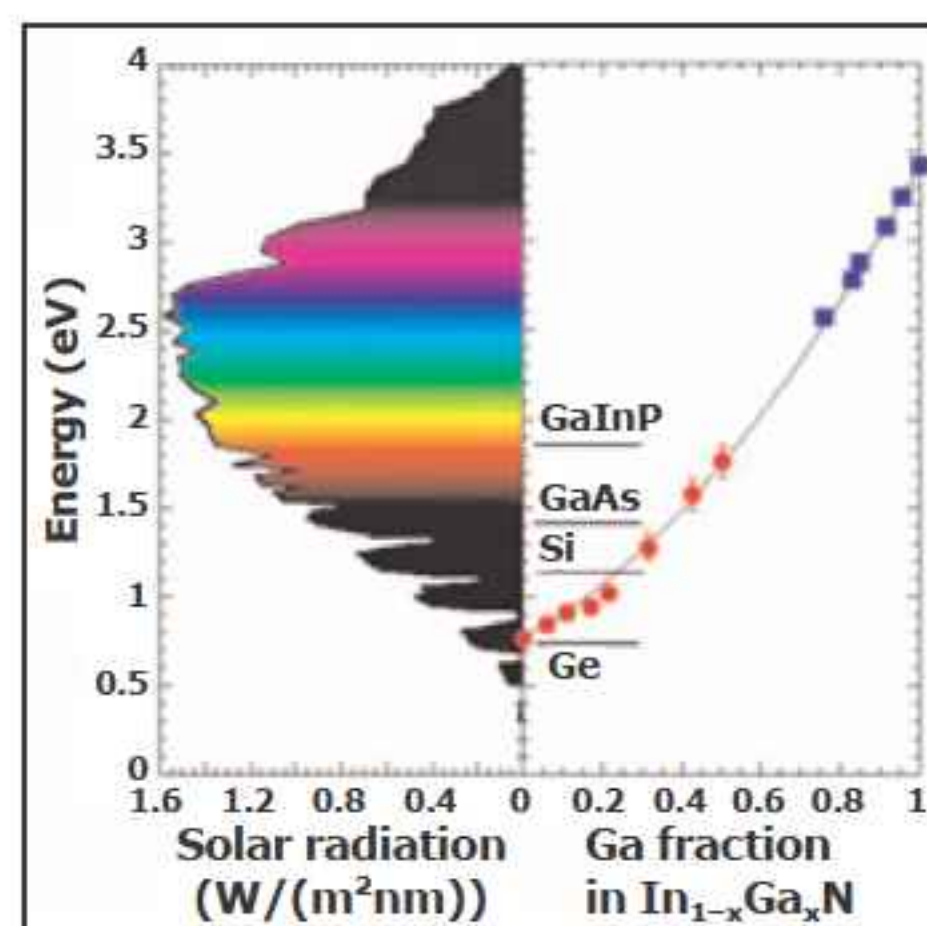


Figure 1. InGaN absorption spectrum as In/Ga proportions are varied.

"We are quite excited about this new hybrid solar cell that marries low-cost nitride thin film with the massive infrastructure of silicon solar cells," says RSLE's CEO Bob Forcier. "Our target market for this hybrid device is the high performance sector for photovoltaics which we estimate to be over 1% of the \$34bn solar cell global market. This high performance market is especially sensitive to applications which have constrained areas such as industrial rooftops and mobile devices."

The photo-electrochemical cell (Figure 2) immerses a nitride-thin-film PV device in an aqueous solution with the potential to generate hydrogen with about 10% efficiency. This depends on the control of the bandgap energy allowed by using the III-nitride semiconductor system.

www.RSLEnergy.com

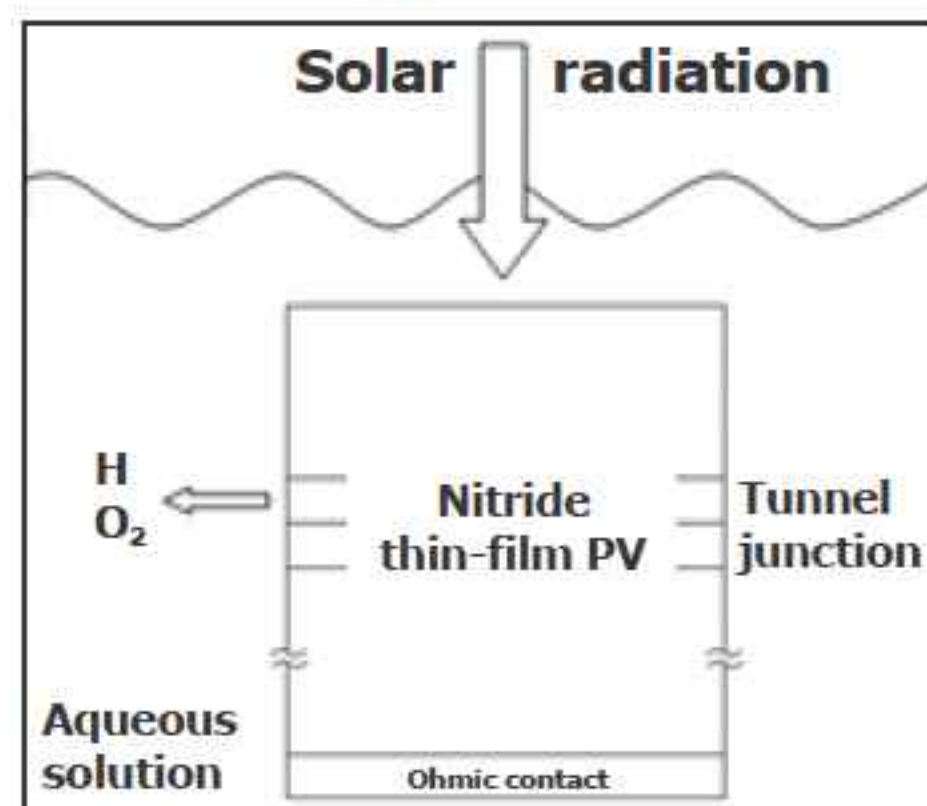


Figure 2. Photo-electrochemical cell.

IMEC GaAs/Ge stacks promise solar cell efficiency hike

A team from the IMEC semiconductor research institute in Leuven, Belgium has found a new way to stack materials that promises to improve the efficiency of multi-junction solar cells.

Researchers from the institute presented details of the method at the 24th European Photovoltaic Solar Energy Conference (EU PVSEC), which took place in Hamburg, Germany (21–25 September).

The first demonstration of the technology is a GaAs/germanium dual-junction cell. In it, the GaAs-based top cell has an efficiency of 23.4%, close to the state-of-the-art figure. The IMEC researchers have taken this cell and transferred it onto a germanium cell.

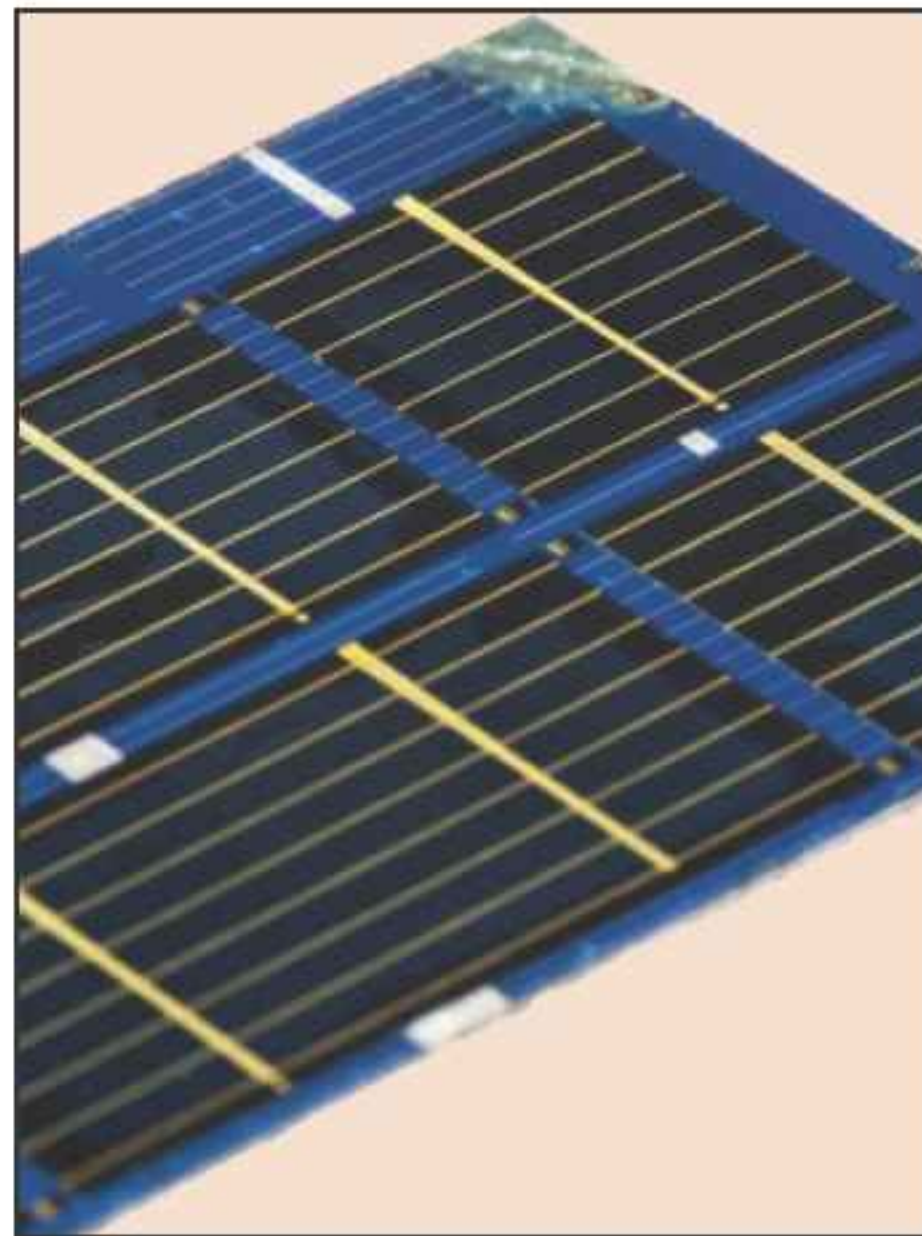
Normally in multi-junction stacks the top cell is grown epitaxially on the other cells, using a metamorphic approach to reduce defects in the monolithic stack. However, the growth processes needed to achieve this are complicated, with IMEC offering the promise of a simpler manufacturing method.

In IMEC's first mechanical stack, the germanium bottom cell has a 'potential' efficiency of as much as 3.5%, which it says is higher than is typically seen for the Ge bottom cell of a monolithically stacked triple-junction InGaP/(In)GaAs/Ge cell.

As a result, IMEC believes that its new mechanical stacking method could deliver triple-junction cells that are 1–2% more efficient than today's state-of-the-art monolithic triple-junction solar cells, which typically operate at 35–40% under concentrated sunlight.

Giovanni Flamand, IMEC's team manager, reckons that the institution aims to show the first triple-junction cell based on the new stacking method by the start of next year.

As well as offering enhanced efficiencies, Flamand and colleagues say that the new approach will also



IMEC's stacked GaAs/Ge solar cell.

improve the 'spectral robustness' of multi-junction cells, converting a larger part of the solar spectrum into electrical energy.

Dr Jef Poortmans, the director of IMEC's photovoltaics program, admits that mechanical stacks are more complex to handle and interconnect than monolithic alternatives, but added: "They definitely offer a way to increase the conversion efficiency and energy yield of high-efficiency solar cells. And they also enable an efficient way to try and use new combinations of materials."

● Another IMEC team has adapted a completely different stacking process, this time using copper metallization, to improve silicon-based solar cells.

Also presented in Hamburg, the large-area cells with copper-plated contacts showed a conversion efficiency of 18.4%. Using copper instead of silver should reduce cell manufacturing costs and make the process more sustainable, said IMEC.

www.photovoltaic-conference.com
www2.imec.be/imec_com/stacked-solar-cells.php

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QuantaSol licenses Houston's dilute-nitride IP to boost conversion efficiency in its quantum-well solar cells

Solar cell developer QuantaSol Ltd of Kingston-upon-Thames, UK, which designs and manufactures strain-balanced quantum-well solar cells, is to exploit dilute-nitride materials in a bid to improve the conversion efficiency of its multi-junction devices.

The company has just signed an exclusive licensing deal with the University of Houston in Texas, and will exploit materials and processing technology described in patents awarded to Alex Freundlich from the university.

For example, Freundlich's US patent 6,372,980, awarded in April 2002, describes a two-terminal tandem solar cell in which the quantum wells in the structure are adapted to extend the photo-absorption range further into the infrared spectrum.

In the patent's claims, Freundlich mentions the possible use of InGaAsN, GaAsN and InAsPN alloys

in the quantum wells that convert sunlight hitting the cell into electric current.

"We've already tested the benefits of using Houston's dilute nitride materials in the way we engineer quantum wells in our cells," said Keith Barnham, the researcher at Imperial College, London who is the co-founder & chief scientific officer at QuantaSol. "The exclusive worldwide licence is a strategic move to ensure we maintain our performance advantage, and we will work with our colleagues in Houston to develop the techniques further in commercial production in 2010."

QuantaSol's own research team produced a record-breaking single-junction cell earlier this year, measured at 28.3% efficiency by a team at the Fraunhofer Institute for Solar Energy Systems.

Next year, the firm (which was spun out of Imperial College in June 2007) is aiming to manufac-

ture triple-junction cells for the emerging concentrator photovoltaics (CPV) market.

As well as helping to improve cell efficiencies, QuantaSol says that the use of dilute-nitride materials will allow it to reduce the number of quantum-well layers in each junction of the multi-junction cells — making for a simpler, lower-cost manufacturing process and thinner cells.

Chris Shannon, who was recently installed as QuantaSol's new CEO following the departure of Kevin Arthur, said that the deal with Houston (the first major collaboration announced by the company) will assist in the drive towards volume cell production in 2010: "It indicates just how close the company is getting to being able to produce very efficient devices in production quantities."

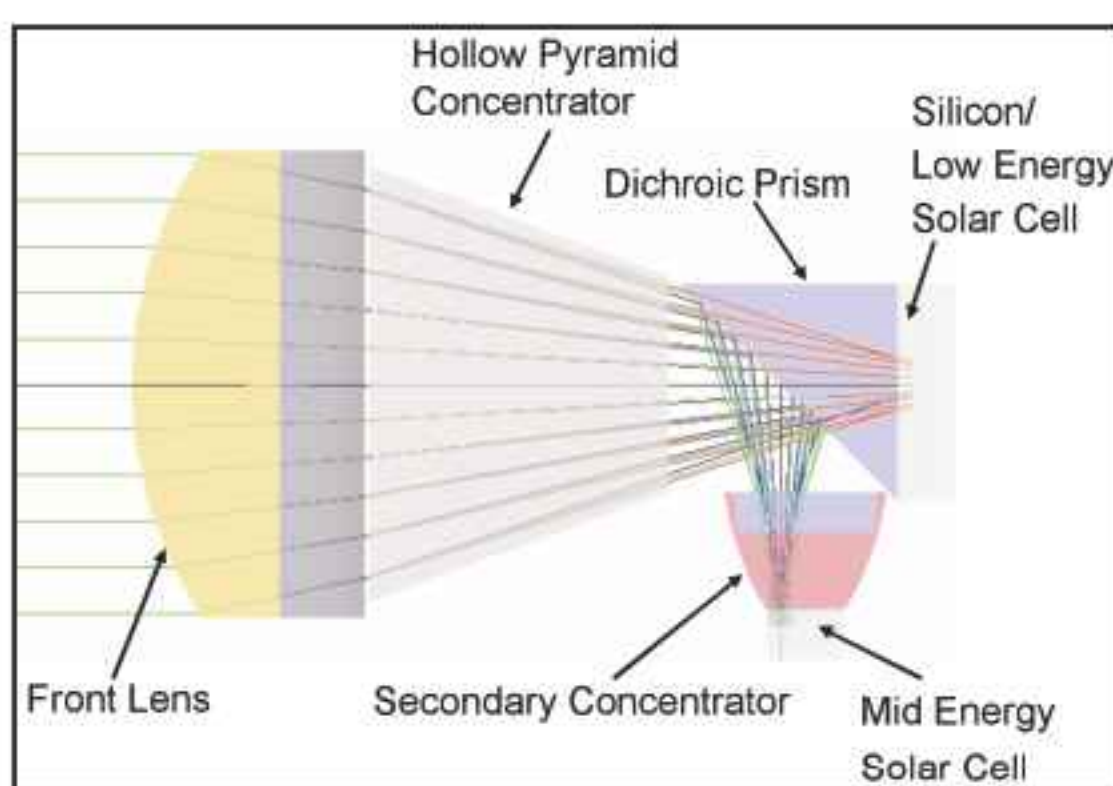
www.quantasol.com

www.cam.uh.edu

DARPA awards Energy Focus \$3.1m to develop spectrum-splitting solar module

Energy Focus Inc of Solon, OH, USA, which provides LED lighting and fiber-optic products, has entered into a \$3.1m, two-year contract with the DuPont-University of Delaware VHESC (Very High Efficiency Solar Cell) consortium as part of solar research funded by the US Defense Advanced Research Projects Agency (DARPA) to enable low-cost photovoltaics.

"Energy Focus' role on the VHESC program during the initial phase of the effort helped pave the way for the developments to date," claims the firm's chief technology officer Roger Buelow. "A key part of our company's vision is to be able to provide distributed, low-cost energy that enables buildings to be completely off grid," adds CEO Joe Kaveski.



Solar module using the VHESC optical spectrum-splitting approach.

DARPA recently began the second two-year phase of a four-year program with the VHESC consortium to raise the system power efficiency of a new class of solar modules to 40% and to deliver manufacturable engineering prototype modules.

The modules under development by the VHESC team use an optical 'spectrum splitting' system that directs light from the sun into different paths corresponding to the color of the light, and concentrates the light onto photovoltaic cells that cover different segments of the solar spectrum. The technology could boost rooftop power three-fold over silicon, it is said.

DARPA is developing the VHESC solar module technology for compact renewable energy to power both permanent and mobile bases, as well as to reduce the logistical burden of supplying energy (e.g. batteries and fuel) to the US military in the field.

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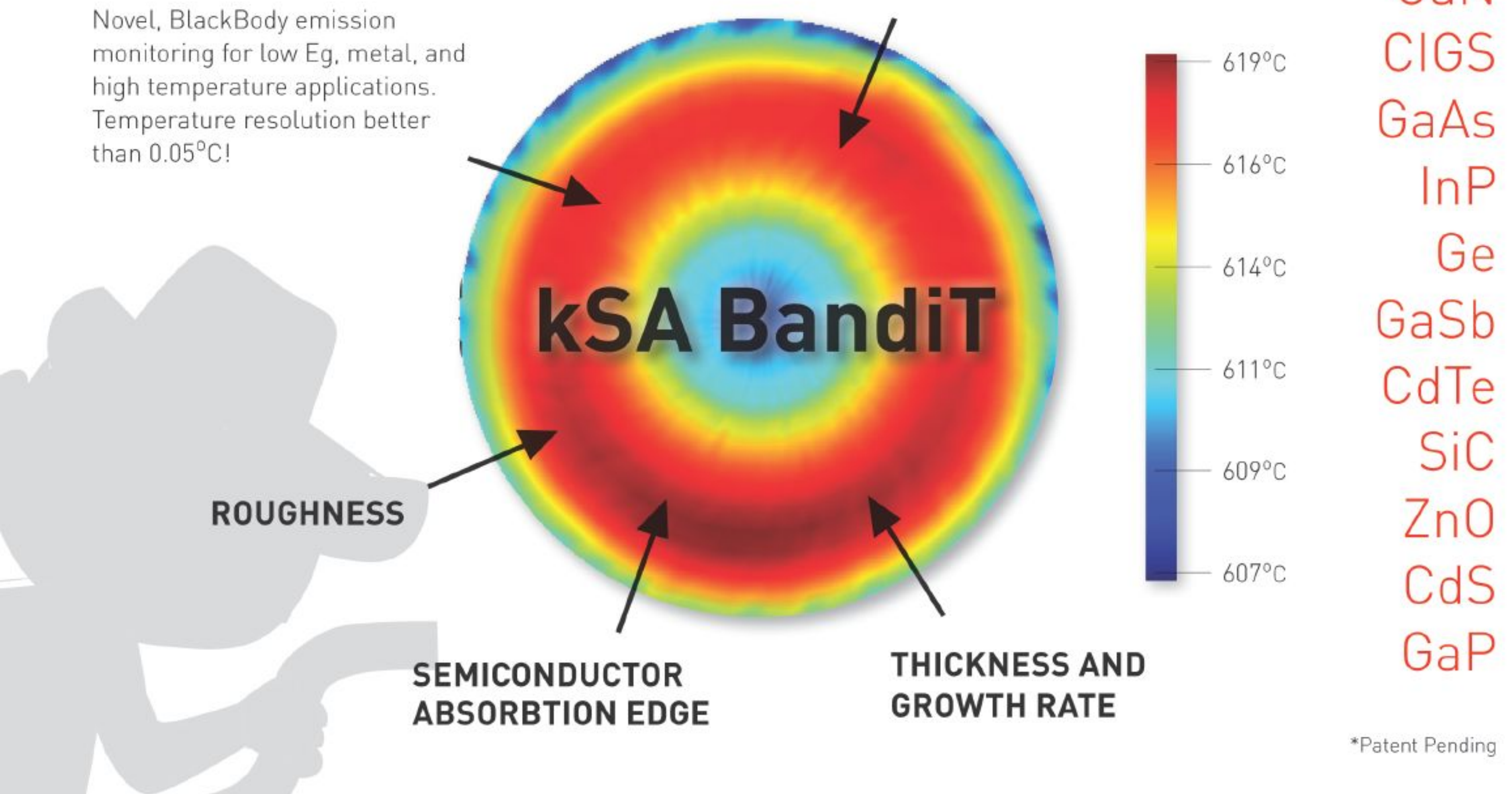
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SolFocus to supply 8.5MWp of CPVs to Portuguese utility

Concentrator photovoltaic (CPV) system maker SolFocus Inc of Mountain View, CA, USA says that, in partnership with Portuguese group Dreen Europe, it has agreed to install 8.5MW of peak power (MWp) CPV systems at the facilities of utility firm Águas de Portugal (ADP).

The deal is part of ADP Group's plan to invest over Euros 830m by 2014 in renewable energy projects, with a goal of covering 3% of the electricity needs and avoiding the import of 4 million barrels of oil and the emission of 724,000 tons of carbon dioxide (CO₂).

SolFocus is partnering on the project with developer Dreen Europe Re-energy. A test array was installed this year in one of Dreen's Europe facilities to allow the utility to gain experience and understanding of SolFocus' CPV technology. Project deployment will begin in

early 2010 for the first 2MW, with the balance deployed in phases over the next four years.

"As global delegates consider climate goals at the upcoming Copenhagen climate discussions, this agreement comes at a critical time for delivering low-cost solar energy to progressive markets like Portugal," says SolFocus CEO & president Mark Crowley.

The firm's CPV systems are claimed to have a solar conversion efficiency of more than 25%. "Now one of the largest CPV projects in Europe, this project puts Portugal on a steep trajectory of driving energy costs down at a very rapid rate," Crowley adds.

"Investing in new and disruptive technologies such as SolFocus CPV is key to driving the global initiative for higher renewable energy usage," comments ADP board member Antonio Branco.

SolFocus' CPV design uses a system of reflective optics (curved mirrors) to concentrate sunlight 650 times onto highly efficient gallium arsenide-based solar cells (on germanium substrates) that have high solar energy conversion efficiency (approaching 40%, more than twice that of traditional silicon solar cells). Like its smaller SF-1000S system (approved by the CEC last September), the firm's second product (the SF-1100S, launched last November) uses about a thousandth of the active solar cell material compared to traditional silicon-based PV panels, but boosts panel conversion efficiency from 18% to more than 25%. The firm says that, in high solar regions such as Portugal, such efficiency can accelerate the trajectory for solar energy to reach grid parity with fossil fuels.

www.solfocus.com

OPEL announces US manufacturing for solar trackers

OPEL International Inc of Shelton, CT, USA and Toronto, Canada, which makes high-concentration photovoltaic (HCPV) panels (as well as both roof- and ground-based dual- and single-axis solar trackers for mounting them), has formally announced US manufacturing for two of its utility-scale high-performance solar trackers, which were developed in conjunction with tracker partner FEiNA in Spain and launched by OPEL Inc subsidiary OPEL Solar Inc.

The first single-axis tracker, the SF-70 H1, is designed for ground-mounted, utility-scale applications and can deliver more than 10,000W of power when equipped with conventional silicon flat-plate panels. The second single-axis tracker, the SF-40 H1, is designed for both ground-mount and roof-top applications, and is capable of delivering more than 6000W of power when equipped with conventional silicon flat panels.

Both trackers can be assembled and equipped with solar panels in less than 4 hours by a crew of three individuals without the need for special tooling, cranes or welding. In addition to their light weight and ease of installation, the SF-70 and SF-40 trackers are capable of reversing tracking direction during the beginning and end periods of the day. This eliminates mutual shadowing between trackers and increases the amount of power that can be deployed.

"The major benefit of these trackers in the OPEL product line to the end user is the possibility of increasing the amount of kilowatt-hours that can be produced per unit of area," says Frank Middleton, OPEL Solar's VP of marketing. "This is particularly attractive when dealing with limited real estate availability such as in roof top applications," he adds.

Each OPEL tracker can increase the power production of a photo-

voltaic (PV) array by as much as 30%, depending on the location. "The ease of installation, combined with the increase in power production, makes the SF-70 H1 and the SF-40 H1 very attractive alternatives to fixed mounting installations because they can reduce the pay-back time of a solar power investment significantly," Middleton adds.

Both trackers will now be made in the USA, using OPEL Solar's existing manufacturing infrastructure. Local production will result in reduced delivery times to the end markets as well as more attractive pricing. "Even more vital, manufacturing the SF-70 H1 and the SF-40 H1 in the USA allows OPEL Solar Inc to continue to bring life to the 'green economy' and to create jobs for Americans, as promoted by President Obama with his support of the pending clean energy and climate change legislation," OPEL International Inc's CEO Robert Pico.

www.opelinc.com

OPEL and BETASOL complete third 110kW phase of 440kW HCPV solar farm

Together with Spanish partner BETASOL (which builds utility-grade solar farm installations for subsequent sale to investor groups), OPEL Solar Inc (a subsidiary of OPEL International Inc of Shelton, CT and Toronto, ON, Canada) has completed the third 110kW phase of its utility-grade photovoltaic power plant in the Tarragona region of north Spain. The solar farm is one of the first operable solar grid fields in the world using OPEL's high-concentration photovoltaic (HCPV) panel technology.

This brings the plant's installed electricity-generating capacity to 330kW of the targeted 440kW. The second phase was completed only in mid-August and the first phase between last December and early this July. The balance of the installation was due to take place by the end of third-quarter 2009. When fully completed, the plant will supply electricity to over 350 households.

OPEL Solar continues to host customer visits to the solar farm. "The reaction of customers to OPEL's HCPV technology has been nothing but positive," says CEO Robert Pico. "HCPV delivers scalable electric power to the grid." Visitors can witness this firsthand, he adds.

OPEL built the installation with its Mk-I HCPV panels (which concentrate light from the sun more than 500 times) mounted on dual-axis trackers which, combined, result in higher power production per unit of land than silicon or thin-film flat panels, with the potential to boost PV yields by up to 40%, the firm claims. OPEL also reckons that the conversion efficiency is up to twice that of silicon flat-plate solar panels and more than three times that of thin-film solar panels.

www.opelinc.com

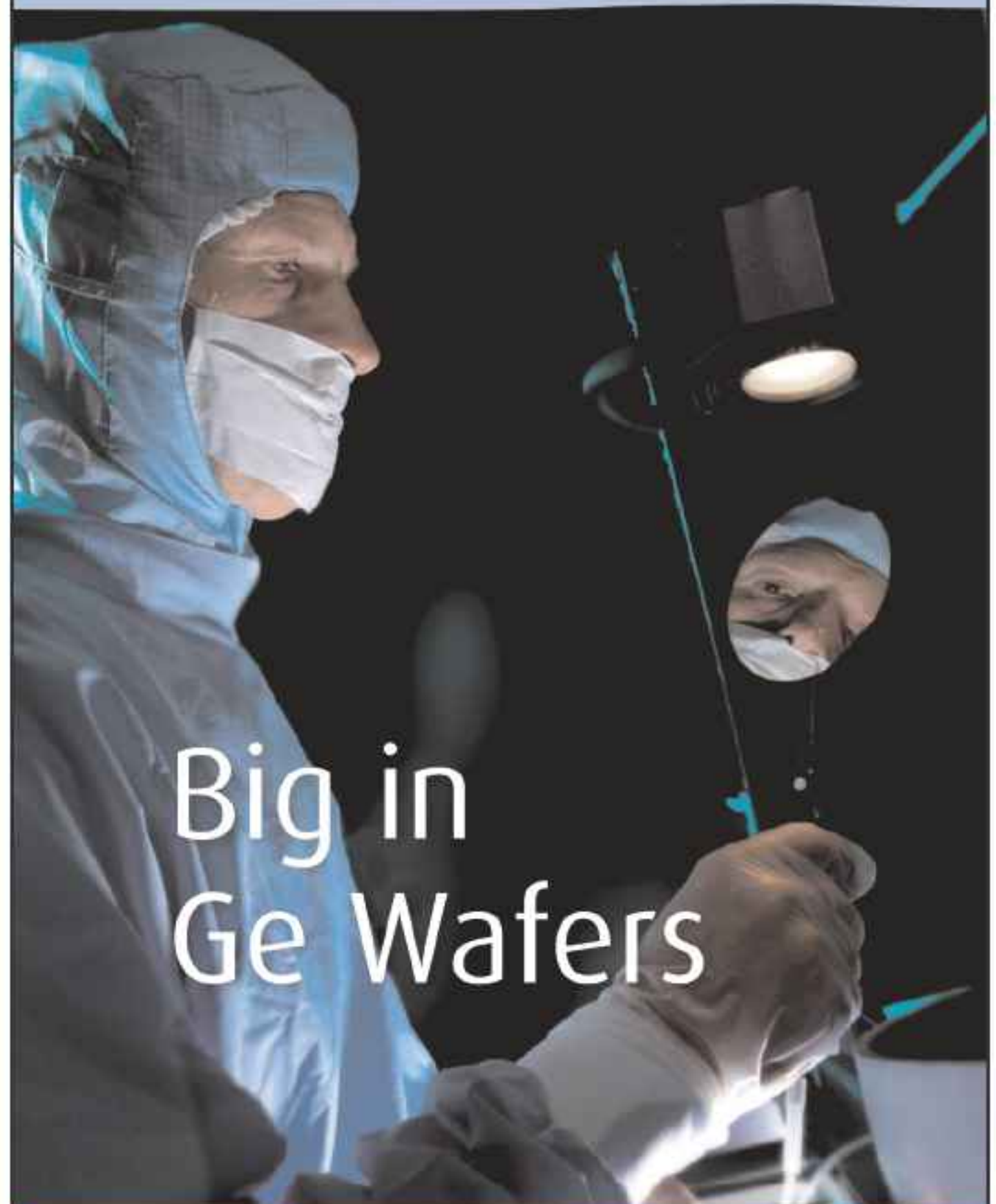
Arima EcoEnergy completes installation of 300kWp CPV system for ISFOC in Spain

In early August, Taiwanese GaAs high-concentration photovoltaic (HCPV) module maker Arima EcoEnergy Technologies (ArimaEco) said that it had completed the installation of a 300kWp concentration PV (CPV) power-generating system for Spain-based Instituto de Sistemas Fotovoltaicos de Concentración S. A. (ISFOC).

In November 2007, ArimaEco and six other companies together won a contract from ISFOC for a CPV power-generating project with a total installation capacity of 1.3MWp.

ArimaEco began shipping CPV modules to ISFOC in March. The firm has installed software for the system and undertook testing in late August. The system was handed over to ISFOC in September.

www.arimaeco.com



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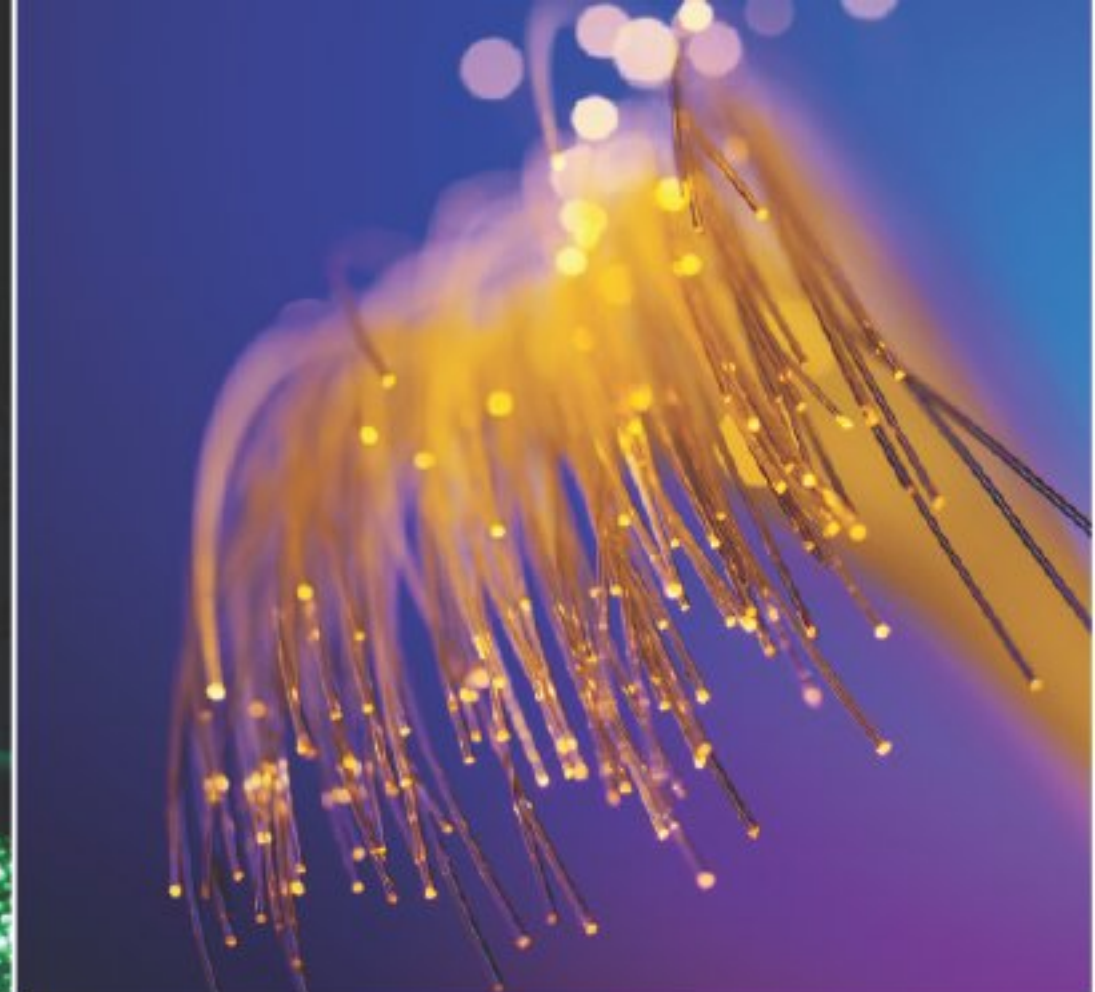
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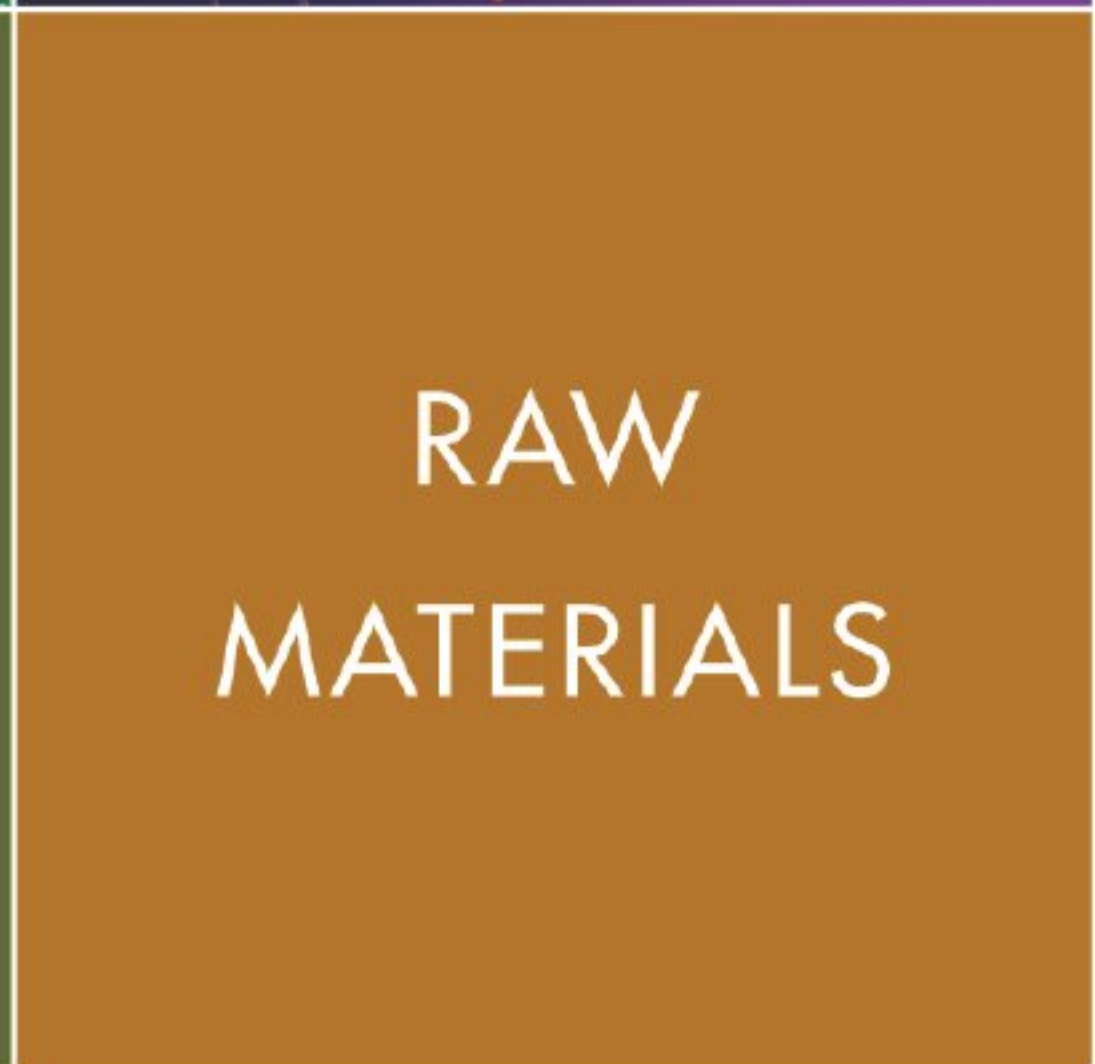
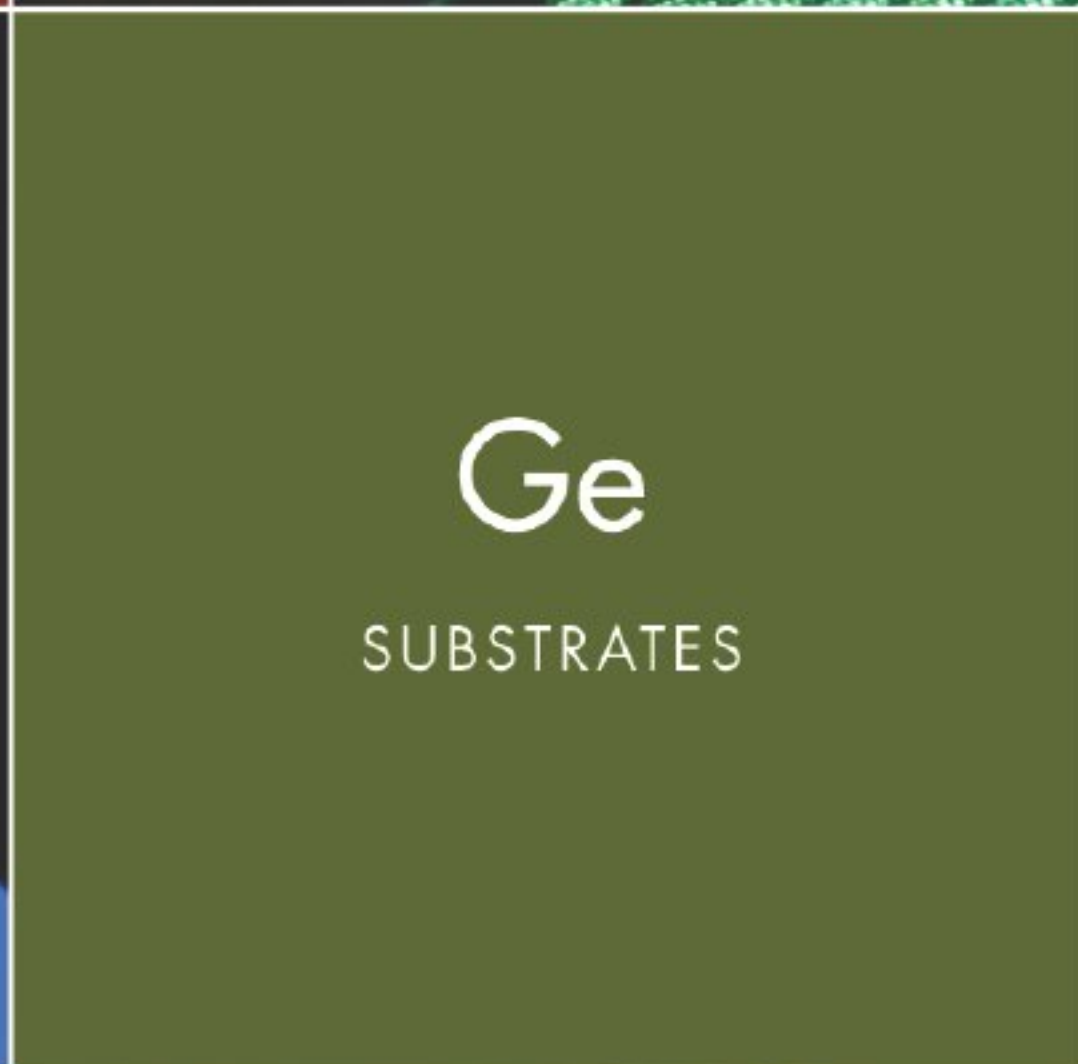
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IN BRIEF

BTU launches CdTe PV processing platform

BTU International of North Billerica, MA, USA, which supplies thermal processing equipment and processes for alternative energy and electronics manufacturing (PCB assembly and semiconductor packaging), has launched Perseas, a product platform designed specifically for processing cadmium telluride (CdTe) thin-film photovoltaic cells.

Perseas is a modular platform featuring configurations with various throughputs and process capabilities, and is therefore scalable from R&D to pilot- and production-sized units. The Perseas-CA is designed for the chlorine annealing process, while the Perseas-CF is for contact formation. Perseas is also compatible with both glass and web substrates.

"Based on the tremendous market growth forecasted for this segment and the ambitious plans of our thin-film customers, we decided to design and introduce a robust and scalable product platform," says Jan-Paul van Maaren, BTU's VP of marketing. "We expect the market growth to be driven by both new entrants to the market and the rapid scale up of established producers. The Perseas platform is a solution for customers in both stages in their growth plans," he adds.

At the Solar Power International 2009 exhibition in Anaheim, CA (27-29 October), BTU show-cased Perseas, together with its other photovoltaic process solutions, including equipment for copper indium gallium diselenide (CIGS) thin-film PVs and silicon PVs (metallization furnaces and in-line diffusion systems).

www.btu.com

Enbridge buys First Solar PV plant

Energy distributor Enbridge Inc of Toronto, Canada has agreed to acquire a 20MW solar energy project being developed and constructed near Sarnia, Ontario by First Solar of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe). First Solar's CdTe PV technology has already been deployed in 1000MW of installations in the US and Europe.

With about 6000 staff, Enbridge owns and operates Canada's largest natural gas distribution company, providing distribution services in Ontario, Quebec, New Brunswick and New York State, as well as operating the world's longest crude oil and liquids transportation system, but is expanding into renewable energy.

"As society and governments increasingly accept green energy, we believe that solar energy represents meaningful opportunities for long-term growth," says Enbridge's president & CEO Patrick D. Daniel. "The Sarnia Solar Project is right in the sweet spot of Enbridge's renewable energy strategy. It has risk and return characteristics which are fully consistent with Enbridge's low-risk business model, and similar to our crude oil pipeline business," he adds. "At the same time it represents a further step towards our corporate goal of a neutral environmental footprint."

In 2009, Enbridge's investment in solar energy is about CDN\$100m. "We plan to continue to invest in further renewable energy investments which have similar risk and return characteristics, including potential additional investments in Ontario," continues Daniel.

The Sarnia Solar Project is due to be completed by the end of 2009 and will be the largest solar plant in operation in Canada and one of the largest in North America, with 337,200 modules covering a total surface area of 250,615m². At 20MW, it should generate 30 million kWh of power (enough for 3200 homes) and help to save the equivalent of 6600 tonnes of CO₂ per year.

"Enbridge's investment underscores the fact that large-scale solar photovoltaic power generation is becoming a reality," says First Solar's president Bruce Sohn. "This agreement is the first that realizes the value of the OptiSolar project development pipeline that we acquired in April," he adds. "First Solar's project development and engineering, procurement and construction capabilities have enabled us to complete over 65% of the 20MW project in less than three months." The firm did not recognize revenue from the project in its fiscal third quarter (ended 26 September).

First Solar is building the plant under a fixed-price engineering, procurement and construction contract. It will also provide operations and maintenance services under a long-term contract. The plant's power output will be sold to the Ontario Power Authority pursuant to a 20-year power purchase agreement under the terms of the Ontario Government's Renewable Energy Standard Offer Program. Enbridge says that it may also participate with First Solar in future solar energy projects at the Sarnia site.

"Ontario's Green Energy Act demonstrates the commitment of Ontario Premier Dalton McGuinty and the Honourable George Smitherman, Deputy Premier and Minister of Energy and Infrastructure, to a diversified portfolio of green energy solutions," says Daniel. "We already own and operate the 190MW Enbridge Ontario Wind Project in Bruce County, Ontario, the second largest in Canada, and we welcome the opportunity to help create additional environmentally preferred energy solutions and to support a diversified, interconnected and stable supply of green energy in Ontario," he adds. The Sarnia project complements Enbridge's four existing wind energy projects, which have a combined capacity of 260MW.

www.enbridge.com

www.firstsolar.com

Sunovia boosts open-circuit voltage for CdTe PVs by 45%

Researchers working on thin-film cadmium telluride (CdTe) solar cells say that they have set a new world record for the open-circuit voltage of these types of device.

If confirmed, the advance could increase significantly the power output possible with CdTe cells, helping to make them more competitive with traditional energy sources.

The research team, which comprises engineers from Florida-based Sunovia and its Illinois-based partner EPIR Technologies, said that its single-junction CdTe cells showed an open-circuit voltage of 1.34V. In a two-junction configuration, that figure of merit increased to 1.75V.

"[These] single-junction and two-junction devices exceeded the highest open-circuit voltage values ever reported publicly by research institutions on thin film CdTe solar cells by over 45%," they claim.

However, the companies make no reference to any pending publication of their research in a peer-reviewed journal, or any verification of the result by an accredited test lab such as the National Renewable Energy Laboratory (NREL). Until then, their claims will inevitably attract some skepticism.

Nevertheless, the open-circuit voltage is an important figure of merit because the amount of electric power that a cell can generate follows Ohm's law. The claimed 45% increase could, in theory, lead to an equivalent increase in output power — assuming that other cell characteristics remain constant.

Michael Carmody, EPIR's director of photovoltaic materials development, says that the increased voltage will ultimately make CdTe cells competitive with multi-junction devices based on III-V materials —

currently by far the most efficient cells in volume production,

"The company's two-junction II-VI-on-silicon design will reach production efficiencies [of] over 35%," Carmody predicted, adding that the production cost would be only a small fraction of that for three-junction III-V solar cells. "Three-junction II-VI-on-silicon cells will have even higher production efficiencies without much added cost."

Sunovia's plan to use silicon substrate material is at odds with the method favored by First Solar, the company that currently dominates the CdTe solar scene. First Solar uses glass substrates and its latest figures claim an average module conversion efficiency of just under 11%.

www.sunoviaenergy.com

www.epir.com

Solar demand sustains 5N's growth

For its fiscal first quarter (ended 31 August 2009), 5N Plus Inc of Montreal, Quebec, Canada has reported revenue of CDN\$16.1m, up 14.4% on CDN\$14m a year ago.

5N Plus draws its name from the purity of its products (99.999%, or five nines, and above), which include metals such as tellurium, cadmium, selenium, zinc and antimony. It also produces related II-VI and III-V compounds like cadmium telluride (CdTe) and cadmium sulphide (CdS) as precursors for the growth of crystals for electronic applications, including infra-red detectors and lenses for night vision systems, gamma ray detectors for nuclear imaging in medicine, thermoelectric modules for cooling, and thin-film photovoltaic cells for solar panels.

Results reflect continuing strong demand for solar-grade products but a weakening of sales of all other products as a result of a more challenging economic environment, says president & CEO Jacques L'Ecuyer. "The strong demand for our solar-

grade products enabled us to increase our supply commitments to our main customer in this market and extend the duration of such commitments [as announced on 24 June]. The decrease in sales of other products reduced our profitability, which was also negatively impacted by the significant acquisition related charges for uncompleted acquisition projects."

Earnings before interest, taxes, depreciation and amortization (EBITDA) fell from \$6m a year ago to \$5m. Net earnings were \$3m, down from \$4.1m a year ago.

The backlog of orders expected to translate into sales over the following 12 months stood at a record \$57m, up 6.2% on \$53.6m a year ago.

Despite a challenging economic environment, 5N's balance sheet continued to strengthen during the quarter. The firm is well positioned to execute its growth plan, which calls for investments aimed at diversifying its product offering, says L'Ecuyer.

www.5nplus.com

IN BRIEF

First Solar added to S&P 500 Index

The common stock of First Solar of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on CdTe, has been added to the S&P 500 Index.

The firm claims to be the first pure-play renewable energy firm to be added to the index.

Specifically, it has been added to the S&P 500 GICS (Global Industry Classification Standard) Electrical Components & Equipment Sub-Industry of the Industrials sector.

● In September, First Solar entered into a \$300m senior secured revolving credit facility with a syndicate of nine leading financial institutions. The facility, which was oversubscribed, has a three-year term and will be used for general corporate purposes, including issuing letters of credit.

www.firstsolar.com

IN BRIEF

Ascent Solar signs 67MW multi-year supply agreement with TurtleEnergy

Ascent Solar has signed a multi-year direct supply agreement with PV system integrator TurtleEnergy LLC of Linden, NJ.

"Ascent Solar is well positioned to reduce the cost of PV systems and enable introduction of innovative product solutions to the marketplace with its lightweight, flexible and high-efficiency PV modules," says TurtleEnergy's founder John Millard.

"Under our development agreement with Ascent Solar, we have gained considerable experience working with its product over the past ten months and are now pleased to become a customer as we plan to be the first solar systems integrator to come to market using our leading-edge approach using these materials," Millard adds.

In November, Ascent and TurtleEnergy signed a cooperation agreement focusing on the development of building-integrated photovoltaic (BIPV) roofing materials for the US market.

Ascent Solar expects to deliver up to 67MW of its flexible CIGS photovoltaic modules during the five-year contract. It is scheduled to begin shipping products to TurtleEnergy early next year.

"This order will help establish Ascent Solar in one of the fastest-growing markets in the United States," says president & CEO Farhad Moghadam. "We are focused on enabling companies like TurtleEnergy to address new market opportunities, add value to existing lines of business, and set a higher performance standard for flexible PV," adds Moghadam.

www.turtleenergy.com

Ascent Solar closes \$32.9m public offering and private placement

Ascent Solar has closed its public offering of about 4.6 million shares of common stock (announced on 30 September).

The firm has also closed its \$5m concurrent private placement of 769,000 shares by its largest shareholder, Norsk Hydro Produksjon AS (a subsidiary of Norsk Hydro ASA of Oslo, Norway, one of the world's leading suppliers of aluminum). Norsk Hydro is interested in building-integrated photovoltaic (BIPV) systems. Previously, in October 2008, Norsk Hydro had raised its stake in Ascent from 23% to about 35%.

Both the public offering and private placement are priced at \$6.50 per share. Net proceeds are \$32.9m.

As of June, Ascent had a \$34m deficit, according to a filing with the US Securities and Exchange Commission (SEC). The stock prospectus

cautioned that the firm expects to incur net losses "for the foreseeable future". However, CEO Farhad Moghadam reckons that, by second-half 2010, it will be in a positive-cash-flow position. Key to profitability is to boost cash flow by increasing production.

In addition to general corporate purposes, net proceeds from the offering are therefore expected to be used for an expansion of Ascent's production capacity in 2010. The existing commercial production line at its former headquarters in Littleton, CO is rated at 1.5MW. However, in March the firm opened a further 30MW high-volume production line (for start-up early next year). The projected cost of the facility is about \$65m for land, building improvements and equipment.

www.ascentsolar.com

Energy Technologies to collaborate on systems for soft-walled military shelters

Ascent Solar has signed a cooperation agreement with Energy Technologies Inc of Mansfield, OH.

Since 1992, Energy Technologies has provided products for power production, conditioning, and control in the military, government, industrial, medical and telecoms sectors.

The collaboration will focus on the development of hybrid solar power generation systems for rapidly deployable tactical soft-walled shelters for the US military.

Using its existing 1.5MW commercial production line at its former headquarters in Littleton, CO, Ascent Solar has supplied Energy Technologies with products for a military shelter that has been used in demonstrations to potential military customers.

Energy Technologies also showcased Ascent's 2m-long modules on a soft-walled shelter at two expositions: Modern Day Marine in Quantico, VA (29 September) and the 2009

Association of the US Army Annual Meeting & Exposition in Washington DC (1 October).

Ascent intends to supply Energy Technologies with modules for subsequent 2010 demonstration projects from its upcoming 30MW high-volume production line at its new headquarters in Thornton, CO (opened in March).

"Ascent Solar's flexible, lightweight PV modules work well with our hybrid military power systems and are now being integrated into ETI's tactical soft-walled shelter," says Energy Technologies' VP sales Tim Lowe.

"Our material is well suited for integration into various portable and tactical solar-powered solutions for the military," says Ascent's president & CEO Farhad Moghadam. "Working with experienced specialty integrators like Energy Technologies has helped expand our development and penetration into this exclusive market," he adds.

SoloPower recruits VP of product development and sales manager

As it nears volume manufacturing and commercialization of copper indium gallium diselenide (CIGS) thin-film photovoltaic cells and modules in 2010, SoloPower Inc of San Jose, CA, USA, has recruited Arthur Rudin as VP of product development and Robert Muhn as general manager of sales.

In mid-September, SoloPower raised almost \$200m in venture capital to ramp up manufacturing at a 100MW plant (using a roll-to-roll process that layers CIGS cells onto a flexible substrate by electroplating rather than sputtering).

Rudin will draw on his 30 years of photovoltaic industry experience to guide the next stage of SoloPower's CIGS product development.

He started his career at Shell Solar Industries (formerly Siemens Solar and ARCO Solar) and was subsequently director of engineering at the Solar Energy Solutions Group of SHARP Electronics Corp and VP of product development and systems engineering at Solar Integrated

Technologies (a subsidiary of Energy Conversion Devices).

Rudin has been involved in standards development via the US National Renewable Energy Laboratory and the Institute of Electrical and Electronic Engineers. He has also held positions with the National Electric Code committee at Sandia National Laboratory, the North American Board of Certified Energy Practitioners, SolarTech Committee, and the PV Assistance Center Board.

Muhn joins SoloPower from Kyocera Solar, where he was responsible for sales to the grid-connected, off-grid industrial and rural electrification markets in the Americas and Australia.

He previously worked at AstroPower and Siemens Solar/ARCO Solar, and as a subcontractor to Sandia National Labs and the Department of Energy (developing programs focused on productive uses of renewable energies in developing countries).

www.SoloPower.com

CIS PV maker Odersun expands board with sales & marketing officer

Odersun AG of Frankfurt (Oder), Germany, which designs and makes flexible thin-film solar cells and modules using proprietary CISCuT (copper indium disulfide on copper tape) reel-to-reel manufacturing, has appointed Uwe Hering as chief sales & marketing officer.

Implementation of the chief sales & marketing function at board level underlines the importance of sales and product marketing to Odersun's development, says the firm.

Hering has a master's degree in electrical engineering and brings experience of sales, business development and product marketing in the semiconductor industry. He has worked internationally in various executive positions, most recently



for CoreOptics, where he set up international sales and product marketing activities and led cross-national teams.

"We will benefit significantly from Uwe Hering's experience and understanding in developing new markets and his knowledge of introducing innovative technologies in customized products," reckons CEO Dr Hein van der Zeeuw.

"Odersun has a unique technology, which enables a customized range of products in the solar market," says Hering.

www.odersun.com

IN BRIEF

Solarion hits 13.4% efficiency for CIGS on plastic substrate

Solarion AG of Leipzig, Germany has achieved record conversion efficiency of 13.4% for a flexible copper indium gallium diselenide (CIGS) solar cell on a plastic substrate, produced on an industrial roll-to-roll system. The cells do not employ anti-reflective coating.

The result has been verified by Germany's Fraunhofer Institute for Solar Energy Systems (ISE).

Founded in 2000, Solarion in 2002 established the first European pilot-line for the manufacturing of flexible and highly efficient CIGS thin-film cells on a flexible carrier material.

"Our proprietary ion beam technology for the production of flexible solar cells not only uses less raw materials and energy, but also reaches high conversion efficiencies," says chief technology officer Alexander Braun. The result is also the highest efficiency for any thin-film solar cell on a flexible polymer substrate from a roll-to-roll process, regardless of the absorber material

The patented ion beam process for producing the CIGS absorber allows the reduction of process temperature and thus the use of a flexible polymer substrate. "The combination of a low-cost polymer substrate, the ion beam technology and a roll-to-roll production process allows us to reduce manufacturing costs significantly," says CEO Karsten Otte.

The flexibility and efficiency opens up new large-volume applications, the firm claims (e.g. direct integration into building systems for roofing and facade solutions. Modules with flexible CIGS cells can also be used for standard solar applications.

Mass-manufacturing of CIGS PV modules is planned for next year.

www.solarion.de

Fujitsu develops first millimeter-wave GaN transceiver amplifier chipset

Fujitsu targets using gallium nitride transistors to provide more compact and higher-quality high-capacity wireless transmission equipment.

At the European Microwave Integrated Circuits Conference (EuMIC) in Rome, Italy (28–29 September), Fujitsu Laboratories Ltd of Kawasaki, Japan announced the development of what is claimed to be the first gallium nitride (GaN) high-electron-mobility transistor (HEMT)-based transceiver amplifier chipset for broadband wireless transmission equipment operating in the millimeter bandwidth (70–100GHz), for which widespread usage is expected to grow.

The new transceiver amplifier chipset (Figure 1) features a GaN HEMT-based transmitter amplifier that achieves what is claimed to be record power output of 350mW plus a high-sensitivity receiver amplifier with record signal gain of 310 operating in the W-band (75–110GHz) with a low noise figure of 3.8dB.

Compared to gallium arsenide (GaAs)-based technology, power output of the new millimeter-band GaN HEMT-based amplifier chipset is expected to be increased about four-fold (4x) and noise figure reduced by 40%, while transmission ranges are expected to be extended about three-fold (3x). Used as an alternative to fiber-optic cabling, the new transceiver amplifier can help to bridge what Fujitsu calls the digital divide for wireless communications, by making communications equipment for trunk lines and ultra-high-speed fixed wireless access higher in quality and more compact (ultimately making wireless broadband more practical).

To accommodate demands for greater bandwidth on the Internet, cell-phone networks and other networks, fiber-optic cabling is being laid throughout Japan to create a high-capacity trunk-line system. However, this is problematic in heavily built-up areas, or areas with difficult topography, which has sparked interest in high-bandwidth wireless that is capable of data transmission capacities and speeds of 10Gb/s — on a par with fiber-optic cabling — as a way to bridge the digital divide.

The millimeter-wave band (70-100GHz) can be an effective band for wireless communications running faster than 10Gb/s, as it is readily available and appropriate for long-distance transmissions. Fujitsu Laboratories has tested millimeter-band transmitters and receivers at speeds of 10Gb/s using impulse radio (which emits a broadband pulse signal that varies over a very short period, and uses a filter to extract only the

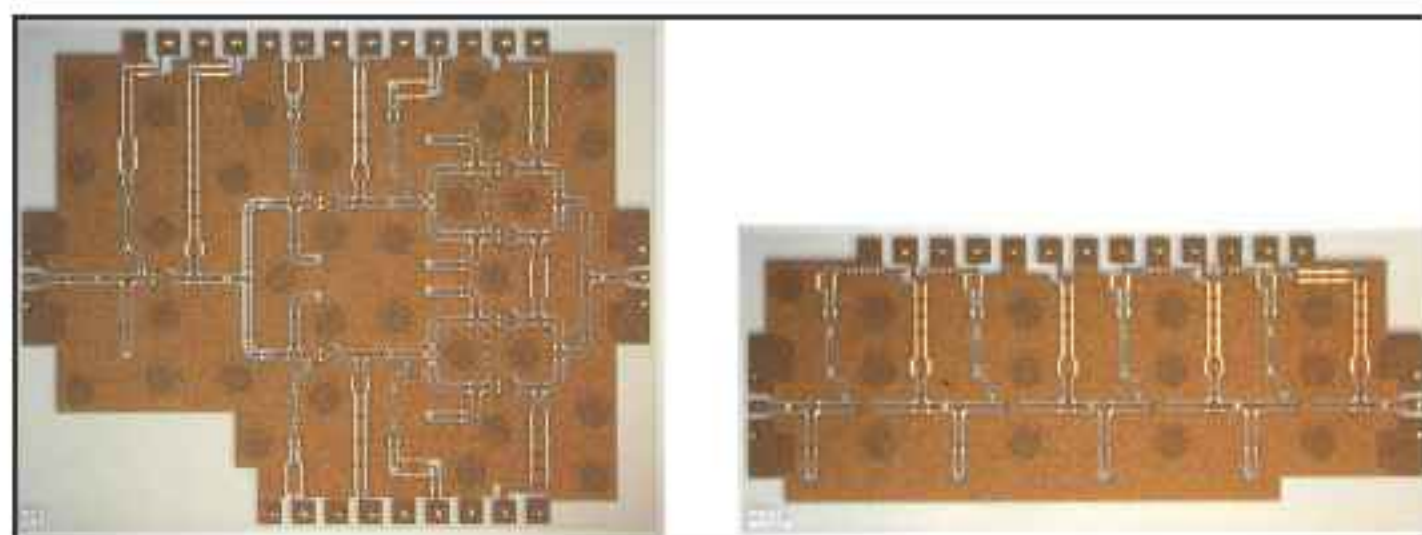


Figure 1: Chipset with GaN-based high-output transmitter amplifier and high-sensitivity receiver amplifier.

usable frequency component for transmission). However, for this to be practical and widely used, transmission distances would need to be extended from several kilometers to several tens of kilometers. One way to achieve this would be through higher-output amplifiers. But higher outputs cause increased power leakage from the transmitter to the receiver, which can overload the inputs of circuits using existing technologies based on gallium arsenide and indium phosphide (InP), resulting in breakdown. There has hence been a desire to develop GaN-based receiver amplifiers, as they can tolerate higher inputs and have excellent reception sensitivity.

To satisfy the above requirements for W-band signals, the transceiver amplifier needs to address the following issues:

1. Compared to conventional GaAs HEMT devices, the wide-bandgap characteristics of GaN HEMT devices enable breakdown voltages that are ten times greater (10x), allowing them to tolerate higher voltages. However, because the parasitic capacitance of transistors worsens with high-frequency signals of 70GHz or higher, the signal amplification rate to magnify weak incoming signals — to enable them to be identified —

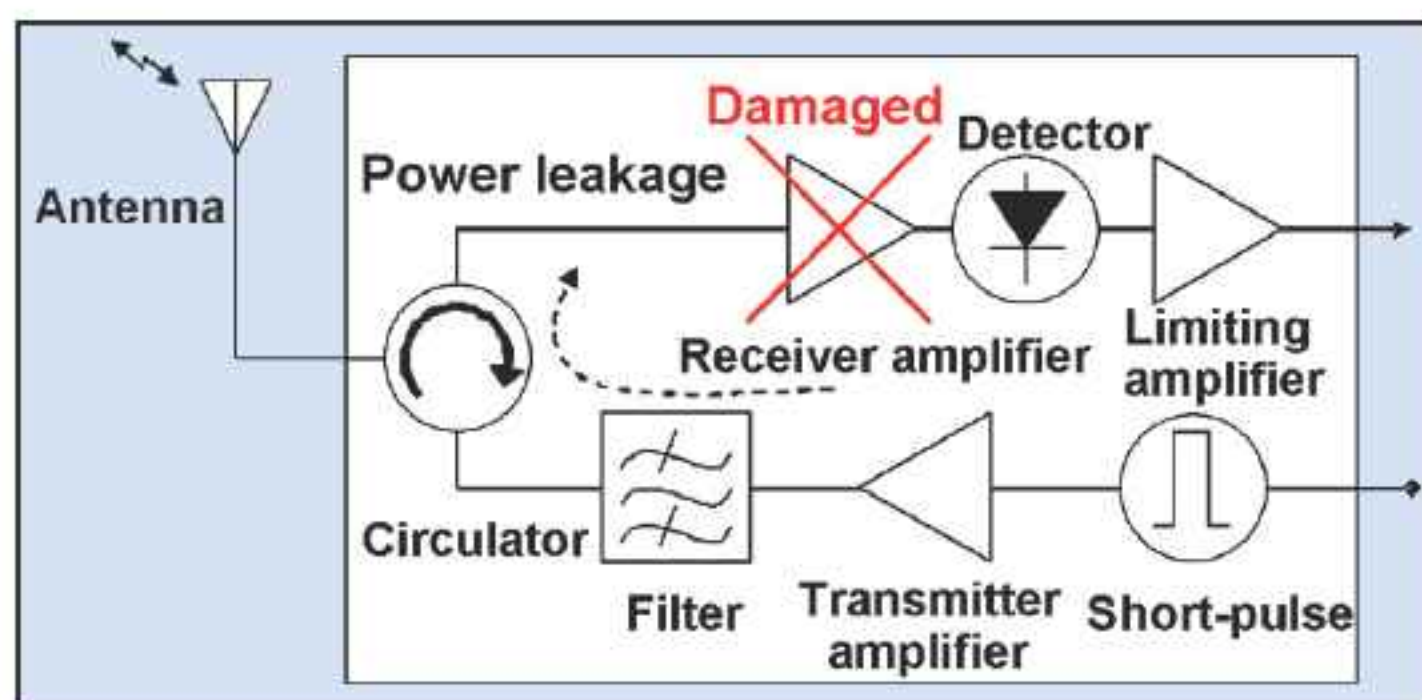


Figure 2: Impulse radio millimeter-wave transceiver.

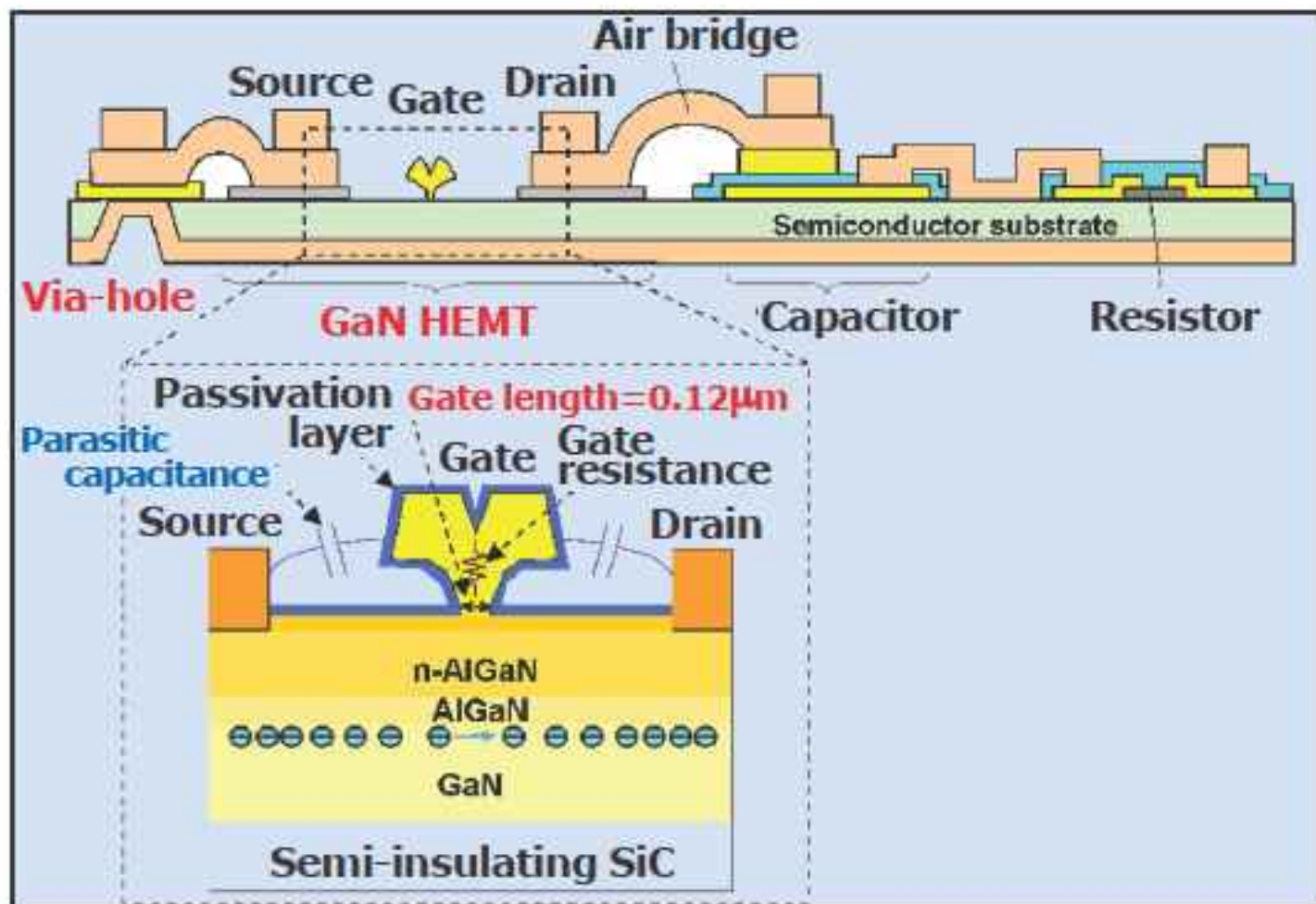


Figure 3: Cross section of high breakdown-voltage millimeter-wave GaN HEMT.

is insufficient, as the incoming signals become buried in noise.

2. At frequencies above 70GHz, the signal wavelength is roughly the same length as the chip size, which produces signal interference that is more prominent, between signal paths and circuits. This makes it difficult to create an integrated circuit featuring good signal amplification and low noise, due to the fact that oscillation of the circuit itself can result in malfunctions caused by unnecessary power-coupling between the signal paths.

Fujitsu says that it has addressed the above issues through the following technologies:

1. In 2006, Fujitsu Laboratories developed a GaN HEMT structure with gate lengths of just 0.12μm, allowing for both high breakdown voltage and good high-frequency performance. By tuning this gate structure and adjusting the thickness of the protective layer, parasitic capacitance was reduced, and the increased signal gain further improved noise characteristics (Figure 3).

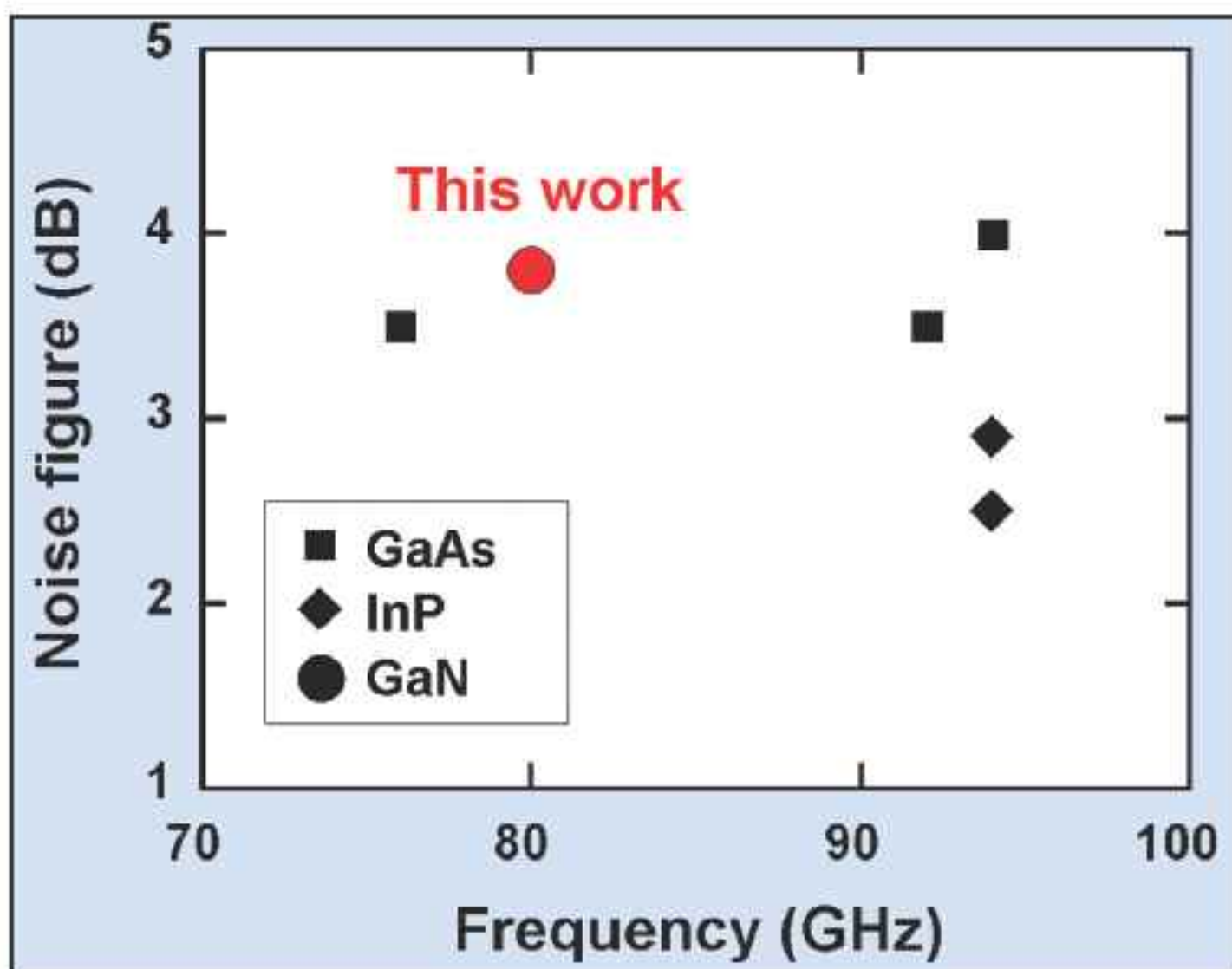


Figure 5: Comparison of millimeter-wave receiver amplifier performance (first report for GaN-based).

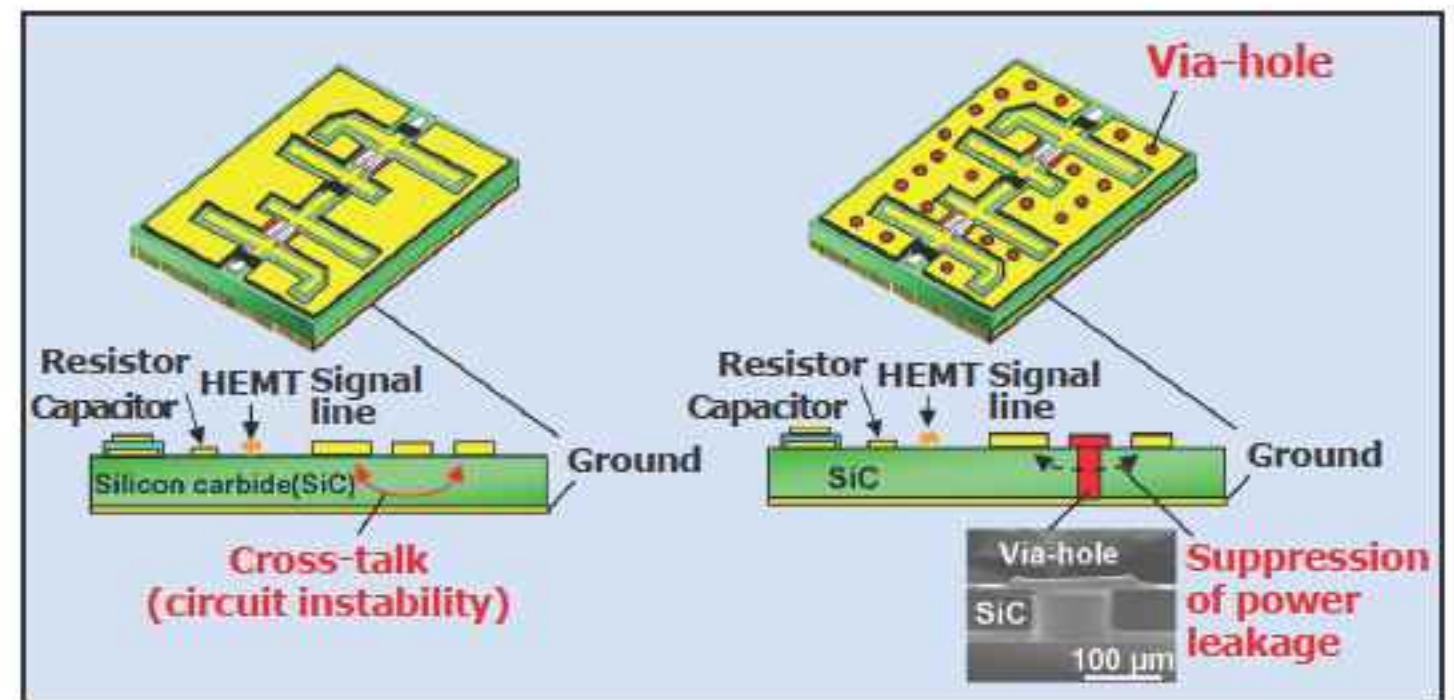


Figure 4: Stabilization technology for millimeter-wave circuits.

2. As the output of GaN HEMTs is higher than existing devices, signal interference (caused by unnecessary signal emissions from signal circuitry) between signal paths and circuits is more prominent in GaN HEMTs. By laying contact conductors around the signal circuitry while employing a 3D electromagnetic field analysis to optimize the placement of via-holes that penetrate the top and bottom of the chip relative to signal paths and circuits, and by developing design technology that shields against unnecessary signal radiation — and applying all of these for the first time in GaN HEMT circuitry — signal interference has been suppressed (Figure 4). These millimeter-wave circuit stabilization technologies realize a circuit that features high output and high signal-gain while being able to operate stably, free from malfunctions caused by circuit oscillations.

The new receiver-amplifier operates in the W-band with a signal gain rate of 25dB (310x) and a noise figure of 3.8dB — both records for a GaN-based IC (Figure 5). Fujitsu says that the amplifier unit's receiver performance is on a par with those using GaAs-based technology but, because it obviates the need for a protective circuit, the performance of the transceiver as a whole can be expected to improve (Figure 6).

Fujitsu says that it aims to continue improving the performance and expanding the frequency band for GaN circuits featuring high breakdown-voltages, in order to enable wireless equipment that can be used as an alternative to fiber-optic networks. ■

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

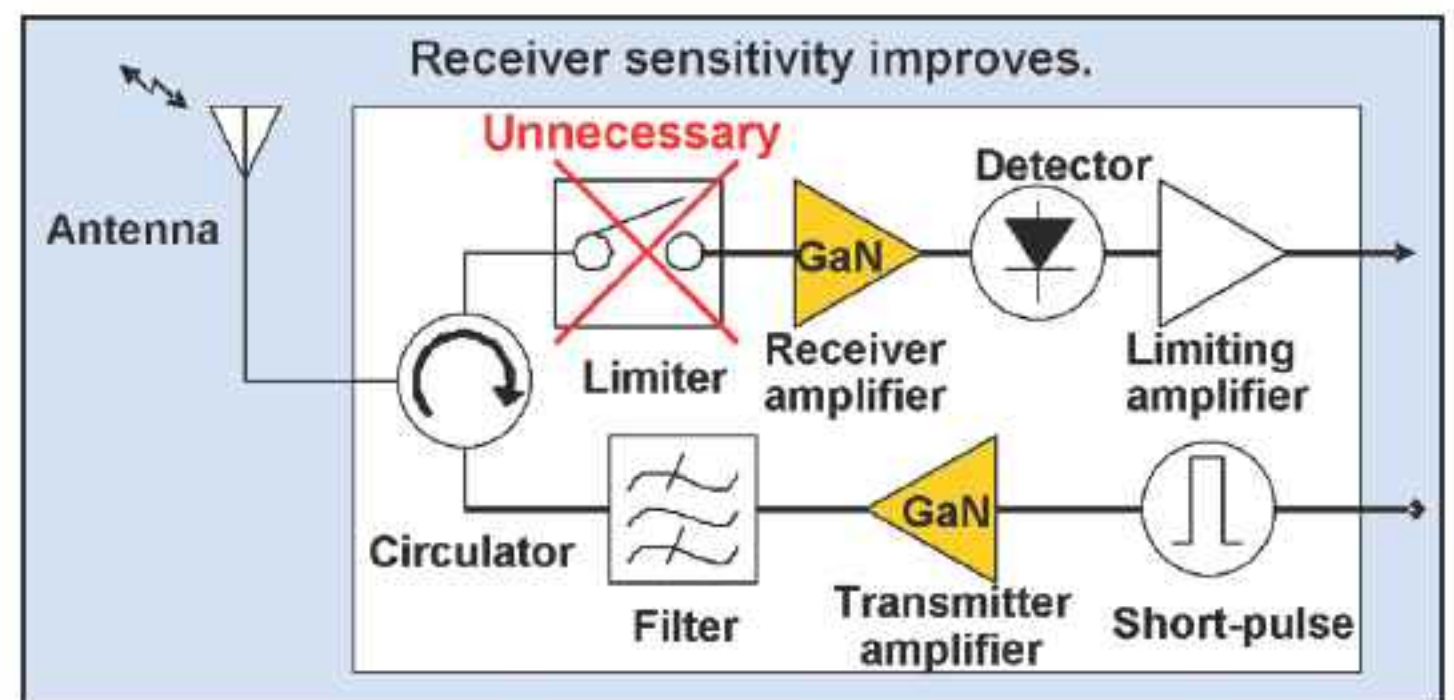


Figure 6: Structure of high-performance impulse radio millimeter-wave transceiver.

Getting a green light from lasers

This year has seen significant steps towards filling the 'green gap' for semiconductor light emission, particularly for lasers. A number of groups have published papers describing various approaches to producing green lasers in the III-nitride material system by using indium gallium nitride (InGaN) based active layers. Mike Cooke reports.

While producing red and blue laser light from semiconductors is relatively simple, producing green lasers has been much harder. Laser diodes (LDs) based on II-VI compound semiconductor materials were demonstrated in the 1990s, but these devices are unreliable under the high currents required to produce lasing.

A green light source is needed to produce full-color RGB projection systems. Green lasers are also used in medical and industrial applications. At present, while compact direct red and blue semiconductor laser diodes are available, green laser light (520–570nm) in commercial laser-diode-based systems, such as overhead projectors, is produced using conversion from sources that emit light at another frequency.

A common technique is to use second-harmonic generation (SHG) from non-linear optics materials to combine photon energies, doubling the light frequency to create a green wavelength. Such conversion techniques naturally waste energy and add bulk to products. Creating a direct green laser diode would enable smaller full-color projectors (e.g. in a mobile phone format) to be produced, hopefully at lower cost.

InGaN layers

With the development of blue-violet-ultraviolet LEDs and laser diodes based on the III-nitride system, starting in the 1990s until the present, it is natural to look to the possibility of extending the wavelength (reducing the frequency) of this material system into the green gap. This involves narrowing the energy bandgap from gallium nitride's bandgap of about 3.4eV (corresponding to the ultraviolet wavelength 365nm) by introducing indium (i.e. $\text{In}_x\text{Ga}_{1-x}\text{N}$). However, to get into the green range (520–570nm) requires significant amounts of indium, and growing such layers with the high quality that is needed is extremely difficult. Thermal stability and parasitic chemical reactions have been highlighted as particular problems in growing such layers.

In the past, various techniques have been used to improve material quality, which is particularly important for the active layer, where indium concentrations have to exceed 20% to achieve suitable energy bandgaps to produce green light. One factor that reduces control is the formation of indium-rich clusters.

Further problems arise from the crystal orientation. Normally LDs are grown on GaN, where the surface consists of the c-plane (0001), but then large spontaneous and piezoelectric (i.e. strain-dependent) polarization fields arise from the different effective charges (ionicity) of the group III elements (Ga, Al, In) and nitrogen in the wurtzite lattice. Such large polarization fields shift the energy band levels of the carriers in heterostructures through quantum-confined Stark effects (QCSEs) and also make it difficult to set up the electrical conditions needed for lasing by separating the electron and hole wave-functions, even at high carrier current densities. Wave-function separation reduces the rate at which electrons and holes recombine radiatively, increasing the weight of non-radiative mechanisms.

One approach is to use m-plane $\{10\bar{1}0\}$ GaN, which results in non-polar electronic structures. Violet m-plane GaN LDs were reported in 2007. Among the problems arising from the use of c-plane GaN has been low slope efficiency. Devices using m-plane substrates demonstrate better slope efficiency than those grown on c-plane GaN, meaning that more of the extra power delivered beyond the threshold becomes laser light. It is also desirable for the threshold of turn-on of lasing to be achieved at as low current and voltage as possible. Further orientations with non-polar or semi-polar characteristics include $\{10\bar{1}\bar{1}\}$ and $\{11\bar{2}2\}$ planes.

The different orientations also have an effect on the layers grown above, including the active InGaN layers. For example, thermally induced defects of In diffusion at high concentration are common on c-plane substrates, while on m-plane material stacking faults tend to arise.

GaN substrate

One problem with producing specialist orientation GaN substrates is that the infrastructure is geared around producing c-plane, for example through metal-organic chemical vapor deposition (MOCVD) on sapphire or silicon carbide substrates. For other orientations researchers often have to look to different techniques for GaN growth such as molecular beam

epitaxy (MBE) or hydride vapor phase epitaxy (HVPE), which is a fairly old epitaxial process (dating back to the 1960s) with a relatively high growth rate. Nitrides can be grown with a rate of 100–200 $\mu\text{m}/\text{hour}$ using HVPE. This compares with tens of microns/hour for MOCVD, and 1 $\mu\text{m}/\text{hour}$ for MBE.

An HVPE machine (Figure 1) consists of a hot-wall reactor (MOCVD uses a cold-wall reactor) and a series of gas supplies: Ga, which is heated and positioned upstream of the substrate; hydrogen chloride (HCl) gas flowing over this precursor will form gallium trichloride (GaCl_3); ammonia (NH_3) is used as nitrogen precursor; and hydrogen and nitrogen are used as carrier gases. The same process can be used to deposit AlN buffer layers, with Al replacing Ga.

Japan's Sumitomo Electric Industries is one of the companies using HVPE to produce non-standard-orientation GaN. In particular, a semi-polar $\{20\bar{2}1\}$ GaN substrate has been used to achieve CW operation of 520nm green InGaN-based LDs [1]. Sumitomo has even produced LDs on semi-polar $\{20\bar{2}1\}$ GaN substrates that achieve 531nm wavelengths in pulsed-mode operation [2].

Sumitomo's $\{20\bar{2}1\}$ GaN material has a threading dislocation (TD) density less than $1 \times 10^6/\text{cm}^2$. The resulting substrates were n-type with sufficiently low resistivity (0.01 Ωcm) for the use of back-side ohmic contacts. Using $\{20\bar{2}1\}$ GaN material increases the homogeneity of the InGaN structures, resulting in narrower spontaneous spectra compared with other attempts at creating green LDs.

CW operation was achieved through improvements in the epitaxial structure enabled by the use of lattice-matched quaternary InAlGaN cladding layers and of a ridge waveguide, compared with the gain guiding used in Sumitomo's previous pulsed laser. The lattice matching improves crystal quality. The cladding was also optimized for optical confinement properties.

The epitaxy was performed using MOCVD of: n-type GaN, an n-type InAlGaN cladding layer, an n-type InGaN waveguide, an InGaN MQW active region,

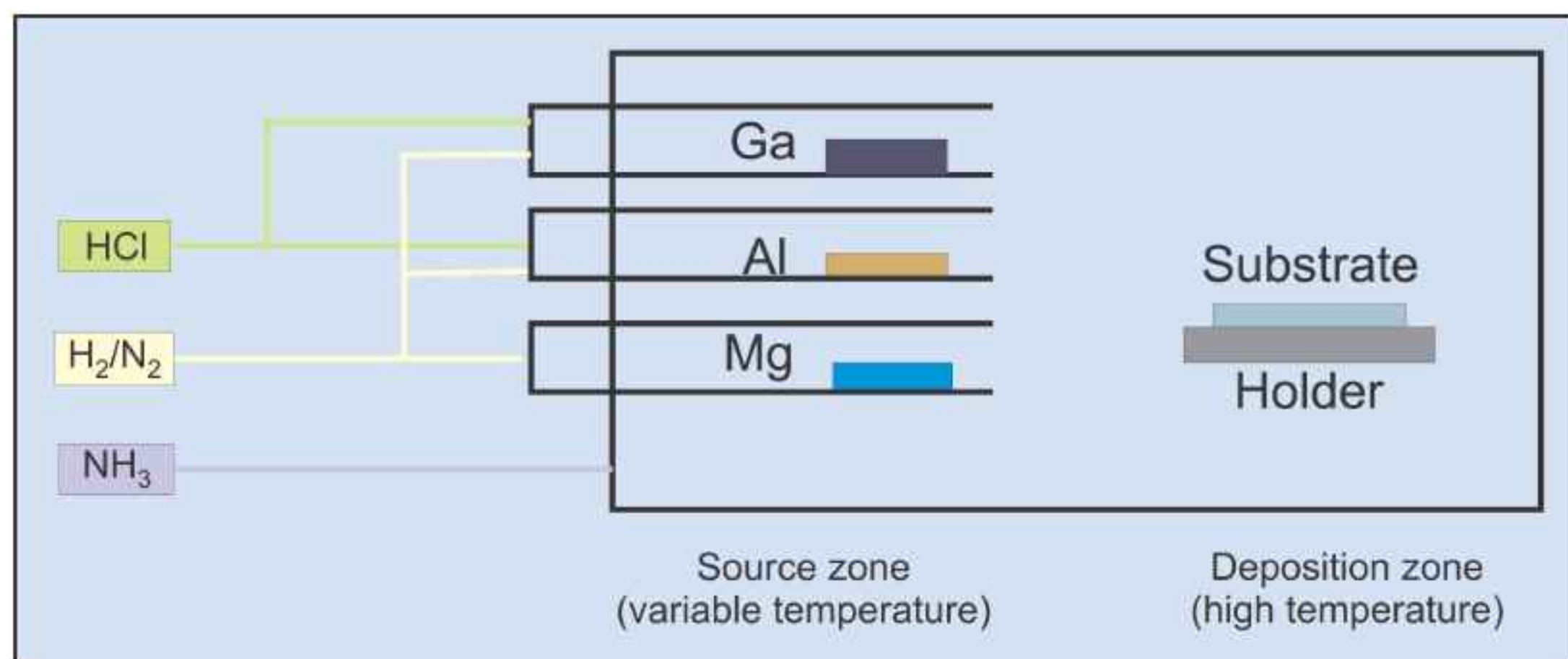


Figure 1. Schematic of hydride vapor phase epitaxy (HVPE) reactor.

a p-type AlGaIn electron-blocking layer, a p-type InGaIn waveguide, a p-type InAlGaIn cladding layer, and a p-type GaN top contact.

The threshold conditions for the continuous wave (CW) device were: current 95mA, current density 7.9kA/cm², and voltage 9.4V. The slope efficiency was 0.1W/A. The wavelength at 110mA is about 520nm and this is maintained up to 2.5mW output power (about 120mA). The researchers see the reduction in threshold voltage from 16V to 9.4V in moving from Sumitomo's earlier pulsed device to the more recent CW operation as being enabled by optimization with an improved doping profile, adjustment of the epitaxial layer structure to the green region, and better crystalline quality of both the InAlGaIn cladding and the active layers.

A different angle

Another team that is working on m-plane material is Shuji Nakamura's group at University of California Santa Barbara (UCSB), which has reported on a blue-green laser diode (LD) based on a miscut substrate [3]. Nakamura is responsible for much of the development and commercialization of GaN as a light-emitting material for electronics as part of Nichia Corp in Japan in the late 1980s and all through the 1990s until he became a professor at UCSB in 1999. Also involved in the research is a scientist from Mitsubishi Chemical's Optoelectronics Laboratory, Kenji Fujito, who has worked on HVPE of high-quality non-polar m-plane GaN substrates [4].

Although the UCSB work has only reached 481nm so far, the researchers point to improved performance by using miscut non-polar substrates in terms of lasing threshold currents and slope efficiency, which suggests that moving to longer wavelengths should be 'easy' and a possible route to realizing high-power green laser diodes.

For the UCSB LDs, the m-plane GaN substrate was miscut about 1° in the $[000\bar{1}]$ (-c) direction. Miscutting of substrates is commonly used to improve or manipulate material quality on a wide range of substrates. [5].

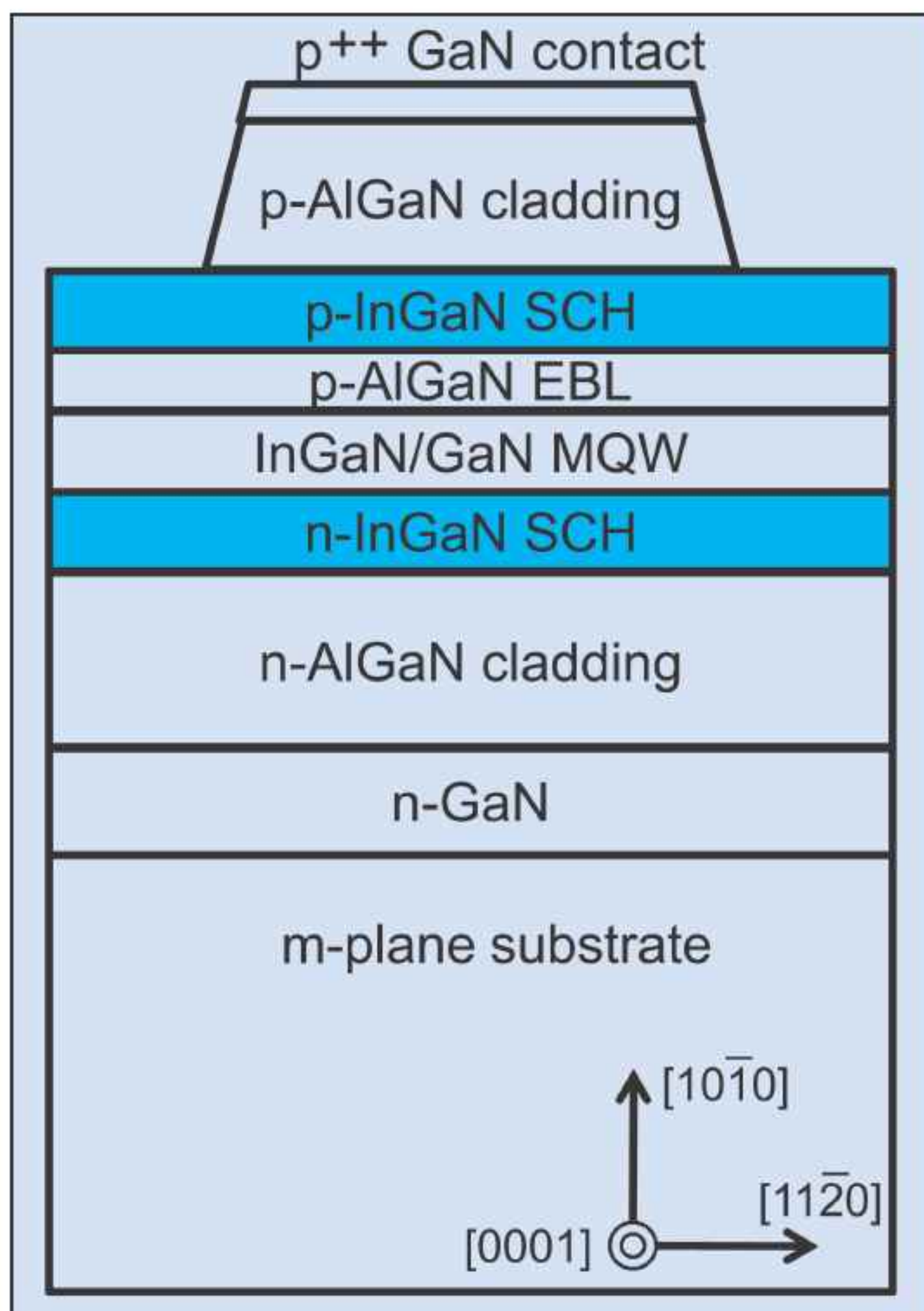


Figure 2. Schematic of laser diode structure used by UCSB. SCH = separate confinement heterostructure. EBL = electron blocking layer.

UCSB used MOCVD to grow the laser diode. The active layer was a three-period multi-quantum well (10nm undoped $\text{In}_{0.03}\text{Ga}_{0.97}\text{N}$ barriers, 3nm InGaN wells with $\sim 26\%$ In, estimated through high-resolution x-ray diffraction). Electron-blocking layers (EBLs) and separate-confinement heterostructures (SCHs) were also used (Figure 2).

Ridge lasers pointing in the c-direction were formed using normal photolithography and etch processes. Nomarski and fluorescence optical microscopy of laser diode surfaces grown on nominal on-axis and miscut substrates showed a significantly smoother surface, without 'hillocks', for

Using m-plane substrates from Mitsubishi is Rohm. Scientists at Rohm's Kyoto R&D headquarters extended the wavelength for continuous wave (CW) operation of indium gallium nitride (InGaN) laser diodes... the 499.8nm CW lasing wavelength was the longest reported for such devices at that time

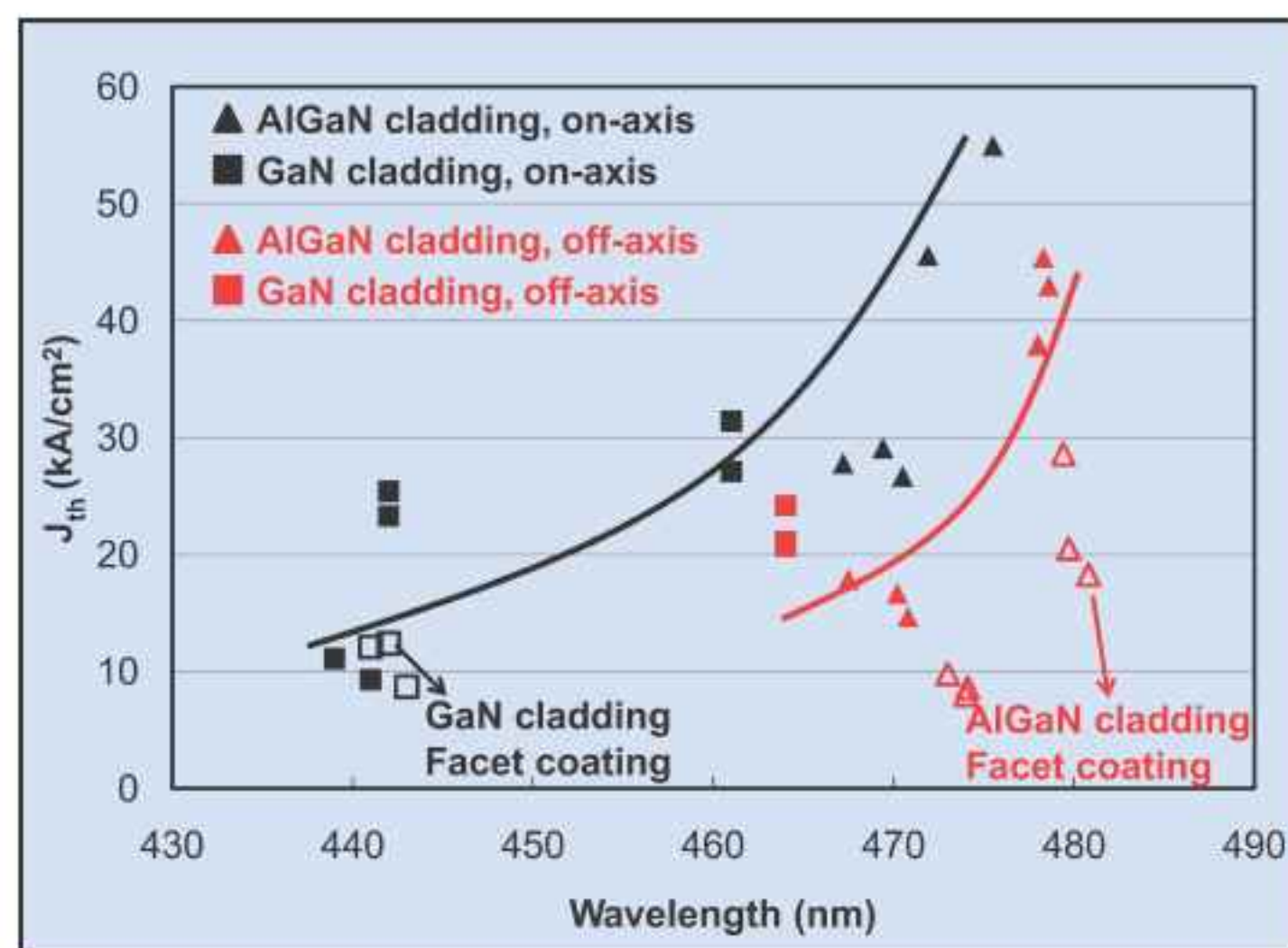


Figure 3. Dependence of threshold current density on lasing wavelength for various laser diodes produced by UCSB using on-axis and 1° towards $[000\bar{1}]$ direction misoriented substrates.

the laser diode grown on the miscut substrate. Also, photoluminescence was much more homogeneous for the miscut substrate device.

A comparison of $2 \times 500 \mu\text{m}$ laser diodes with uncoated facets in pulsed operation (1% duty cycle) shows a lower threshold current (153mA, compared with 413mA for nominal on-axis device) for the miscut substrate. Further, less blue shift was seen in moving from spontaneous emission to laser emission ($\sim 483\text{nm}$ spontaneous wavelength for both miscut and nominal, 471nm for miscut lasing, 461nm for on-axis lasing). These properties are attributed to larger indium fluctuations in the on-axis samples. A clarification of the mechanisms is promised in a future publication from the group.

The threshold current density tends to increase with wavelength (Figure 3), but with the miscut devices generally reporting a lower value. The longest lasing wavelength found was 481nm (10nm away from the spontaneous photoluminescence wavelength at 491nm) from a coated facet device in pulsed operation (1% duty cycle).

Non-polar route

Also using m-plane substrates from Mitsubishi is Rohm. Scientists at Rohm's Kyoto R&D headquarters extended the wavelength for continuous wave (CW) operation of indium gallium nitride (InGaN) laser diodes (LDs) [6]. The Rohm researchers claimed in February that the 499.8nm CW lasing wavelength was the longest reported for such devices at that time.

The Rohm team grew the LDs on freestanding m-plane wurtzite GaN substrates using low-pressure MOCVD. By growing in the m-plane direction, rather than the more usual c-plane, the devices avoid large polarization electric fields.

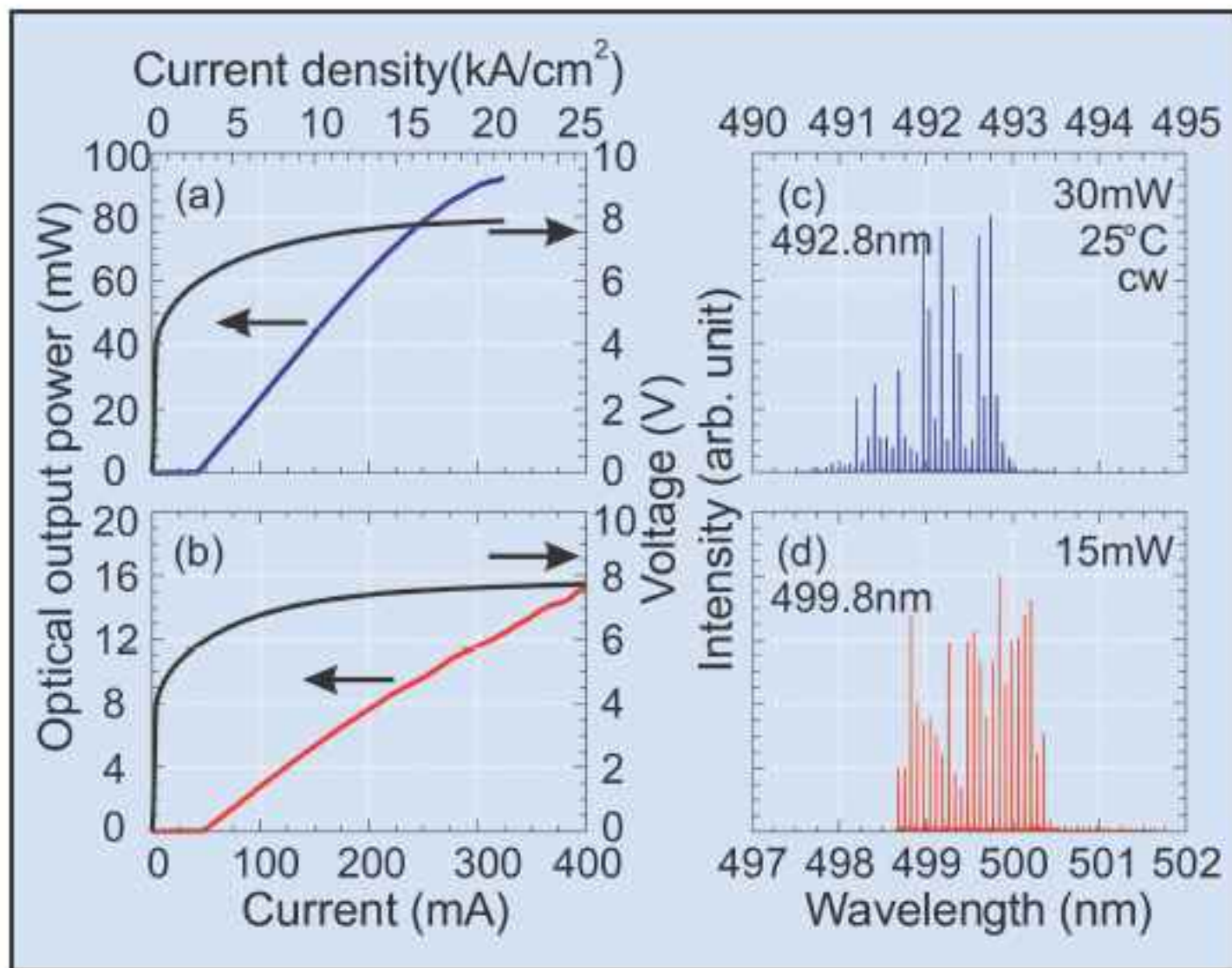


Figure 4. Output power (L-I, left scale) and voltage (V-I, right) performance with respect to current for the two Rohm InGaN devices – 70% reflective front mirror LD70 (a) and 97% reflective LD97 (b) – with respective spectra (c and d).

The Rohm LD structures consisted of layers, in sequence, of n-type GaN, n-type AlGaIn (cladding), n-type InGaIn (waveguide), a two-period InGaIn multi-quantum well (active), p-type AlGaIn (electron blocking), p-type InGaIn (waveguide), p-type AlGaIn (cladding), and p-type GaN (contact). Ridged stripes were etched out to form the laser structures (bottom width 2.5 μ m). A ZrO₂ insulator was used. The cavities were 600 μ m in length. Cleaving along the c-plane was used to form the mirror facets. Sputtered dielectric was used to create front and back mirrors. The back mirror was 99% reflective, but two different reflectivities were used for the front mirror (70% and 97%) to investigate the role of self-heating in LD performance.

For comparison, devices with similar threshold currents were chosen for detailed testing (Figure 4). The device with a 70% front mirror (LD70) had a threshold current of 42mA (density 2.8kA/cm²), threshold voltage of 5.9V and slope efficiency for producing laser emission of 0.4W/A. The figures for LD97 were 46mA (3.1kA/cm², 5.9V, and 0.05W/A, respectively. The maximum output powers for LD70 and LD97 were 92mW and 15mW. These come in well above the typical 5mW output of c-plane blue-green LDs. Spectral measurements showed the peak wavelengths of LD70 (operated at 30mW) and LD97 (15mW) to be 492.8nm and 499.8nm, respectively. Many sharp peaks are seen in the spectra.

By comparing the wavelength shift from CW and pulsed operation, the researchers determined that self-heating effects lead to a red-shift of the emission. Band-filling effects – when, with increasing numbers of carriers in the active region, the electrons and holes become more separated in energy – would lead to higher-energy photons, and hence to a blue-shift in the spectrum.

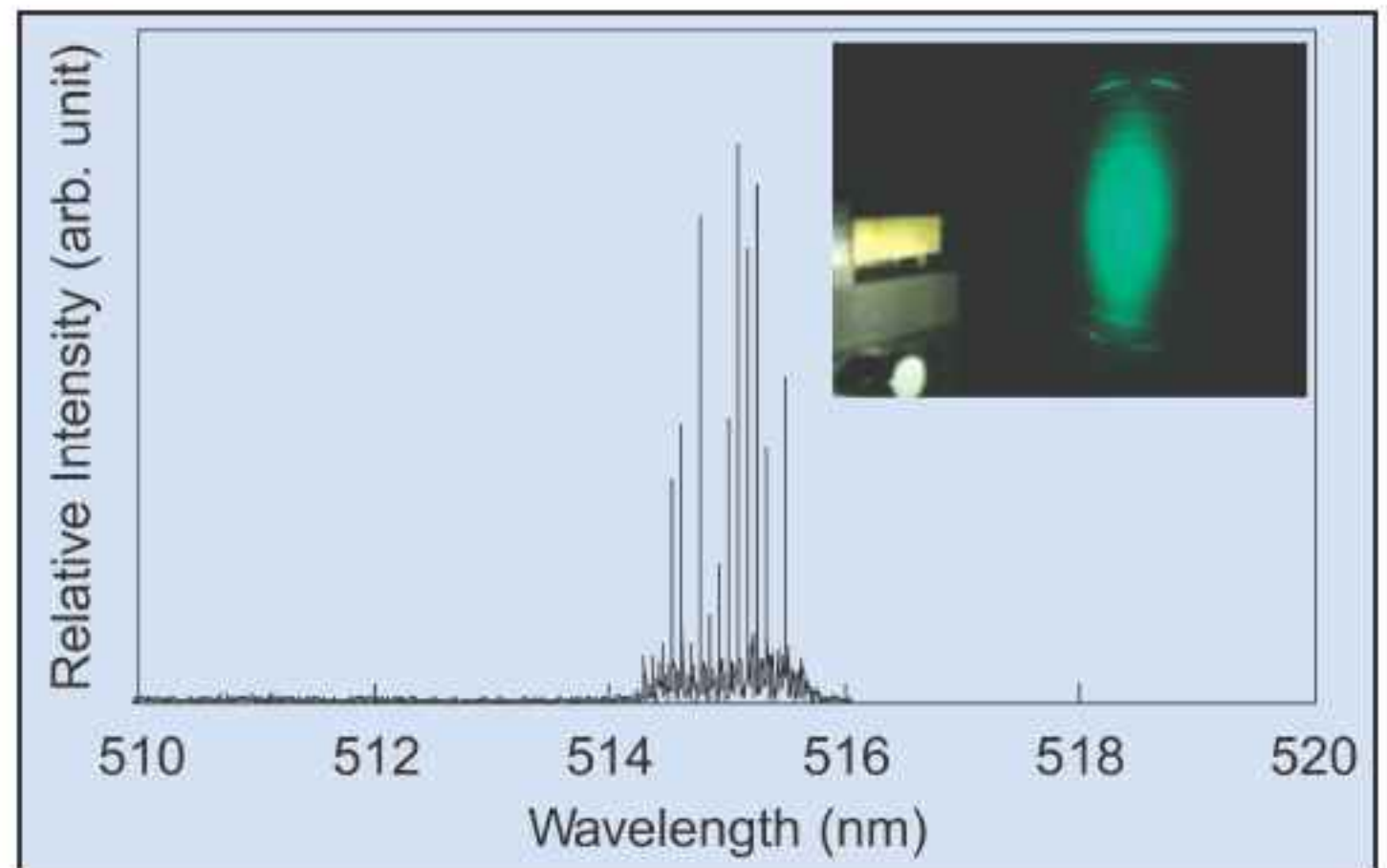


Figure 5. Lasing spectra of the 515nm LD with an output power of 5mW under CW operation at 25°C.

Consortium

Another group that is using HVPE as a route to non-polar GaN substrates is a consortium of German/Swiss universities that aims to close the 'green gap' with light emitters, including lasers, under a project funded by Deutsche Forschungsgemeinschaft (DFG, German research foundation) and Switzerland's National Science Foundation (SNF). The title of the collaboration is 'Polarization Field Control in Nitride Light Emitters' (PolarCoN), which was established in 2008. The research is due to complete its €2m first phase in 2011. The universities that are involved are Ulm, Regensburg, Otto-von-Guericke Universität Magdeburg, Technische Universität Braunschweig, Stuttgart, Technische Universität Berlin, and the Swiss Federal Institute of Technology Zurich (ETH).

The research ranges from the growth of non-polar GaN quasi substrates by HVPE, through to the physics and technology of nitride-based non-polar green laser diode structures. The consortium says that various MOCVD, simulation and characterization activities will be carried out, with the main emphasis being on creating structures on HVPE substrates with surfaces in either non-polar or semi-polar directions, and overcoming the resulting material and structural problems. Another possible approach being considered is the minimization of polarization-induced fields on c-plane surfaces by carefully matching material combinations such as AlInN-GaInN.

The University of Ulm is leading the work on HVPE, with a view to growing non-polar full 2" wafers. The substrates that are being worked on include: r-plane sapphire, giving a-plane GaN; m-plane SiC, leading to m-plane GaN; and m-plane sapphire, resulting in m-plane/semi-polar GaN non-polar GaN bulk substrates. GaN grown with a c-plane is used as a reference. Ulm has also recently explored alternative structuring techniques to provide non-polar surfaces on c-plane GaN in inverted pyramid structures or stripes in a silicon dioxide mask.

Edging towards the green

Not all groups have abandoned the c-plane; for example, Nichia researchers have used a free-standing c-plane GaN substrate to grow their devices, managing to coax continuous 515nm 'green' laser light out of an InGaN structure [7]. The active layer consists of InGaN multi-quantum wells (MQWs). As with most commercial laser diodes, lower-refractive-index separate-confinement hetero-structures (SCHs) are used to confine the emitted light in the lasing cavity.

The dimensions of the resulting laser diode ridge were 2x600µm. CW characterization of the devices was carried out at 25°C (Figure 5). Below 500nm, the devices had a threshold current density of 1–2kA/cm²; this begins to increase as the amount of indium increases to the level needed to achieve a wavelength of 515nm (4.4kA/cm², corresponding to 53mA for the particular device). The 515nm device had an output power of 5mW at 88mA (and voltage 5.5V).

The paper also shows improved uniformity of photo-luminescence compared with previous laser diodes produced by the team that operated at wavelengths longer than 470nm. The Nichia group explains this as being due to their improved growth of the layers, particularly of the active MQW structure. The previous structures suffered from non-radiating regions with poor crystal quality. These non-radiating regions were not found in the newer structures.

Temperature variation and lifetime characteristics were also determined. Devices rated at 510–513nm wavelength were operated at 25°C, with automatic power control for 500 hours giving an estimate of the lifetime at more than 5000 hours — the point when the operating current has increased 30% over the initial current.

Nichia's team describes their achievement as being 'green' LDs, presumably on the basis that in terms of spectral colors (violet, blue, green, yellow, orange red) 'green' is allotted the 495–570nm space. However, green is better perceived when in the range 520–570nm, while blue comes from 440–490nm. The range 490–520nm is better described as 'blue-green'.

Defect reductions

Also working on the c-plane is optoelectronics device manufacturer Osram Opto Semiconductors, which has created a 515nm laser with an output power of 50mW with greater temperature stability, easier control and higher modulation capability at several 100MHz [8]. It defines 'true green' by the spectral range 515–535nm.

In pulsed mode at room temperature the laboratory prototype achieved an optical output of 50mW and a wavelength of 515.9nm; the threshold current density was about 9kA/cm² and the voltage was 7.1V.

The slope efficiency was about 130mW/A. A previous Osram Opto laser diode grown on c-plane GaN crossed the 500nm boundary [9] and had a threshold current of 8.2kA/cm² and a slope efficiency of 650mW/A.

The device was based on improved epitaxy and design of the active region, giving a 10-fold reduction in defect levels. An 11µm broad-area gain-guided laser structure was used in a pulsed mode (500ns pulse length, 1% duty cycle) to minimize thermal effects and for accurate measurement of thermal characteristics.

Osram Opto is also involved in the project MOLAS, which is funded by the German government's Ministry for Education and Research until March 2011 (FKZ 13N9373). Targeted at technologies for ultra-compact and mobile laser projection systems, among its aims is the projection of consistently sharp, true-color, high-contrast images — irrespective of the projection distance or surface — even in cell phone or camera formats. ■

The author Mike Cooke is a freelance technology journalist.

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Table 1. Comparison of some achievements towards green laser diodes in 2009.

	Date online	Reference	Wavelength nm	Threshold			Slope W/A	Operation mode
				mA	kA/cm ²	V		
Sumitomo	21/8/09	[1]	520	95	7.9	9.4	0.10	cw
Osram Opto	17/7/09	[8]	515.9		9	7.1	0.13	pulsed
Sumitomo	17/7/09	[2]	531	924	15.4			pulsed
Sumitomo	17/7/09	[2]	520	491	8.2	17.7	0.04	pulsed
UCSB	24/6/09	[3]	481	380	18		0.05*	pulsed
Nichia	22/5/09	[7]	515	53	4.4	5.2	0.14**	cw
Osram Opto	27/2/09	[9]	500		8.2		0.65	
Rohm	18/2/09	[6]	499.8	46	3.1	5.9	0.05	cw
Rohm	18/2/09	[6]	492.8	42	2.8	5.9	0.40	cw

* Slope estimated from graph in paper. ** Slope calculated from data in paper.

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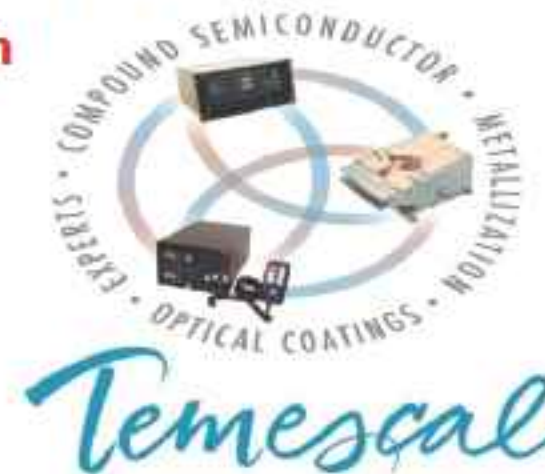
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7 Wafer processing materials

Air Products and Chemicals Inc

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www.airproducts.com/compound

MicroChem Corp

1254 Chestnut St. Newton,
MA 02464, USA

Tel: +1 617 965 5511

Fax: +1 617 965 5818

E-mail: sales@microchem.com

www.microchem.com

Power + Energy Inc

(see section 8 for full contact details)

Praxair Electronics

(see section 5 for full contact details)

8 Wafer processing equipment

EV Group

DI Erich Thallner Strasse 1,
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Oxford Instruments Plasma Technology

(see section 6 for full contact details)

Power + Energy Inc

(see section 8 for full contact details)

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532 Weddell Drive, Sunnyvale, CA,
USA

Tel: +1 408 734 0459

Fax: +1 408 734 0961

www.samcointl.com

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www.synova.ch

TECDIA Inc

(see section 16 for full contact details)

Tegal Corp

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Petaluma,
CA 94954,
USA

Tel: +1 707 763 5600

www.tegal.com

Veeco Instruments Inc

(see section 6 for full contact details)

9 Materials & metals

Goodfellow Cambridge Ltd

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TECDIA Inc

(see section 16 for full contact details)

10 Gas and liquid handling equipment

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Cambridge Fluid Systems

12 Trafalgar Way, Bar Hill,
Cambridge

CB3 8SQ,
UK

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

EMF Semiconductor Systems Ltd

(see section 6 for full contact details)

IEM Technologies Ltd

Fothergill House, Colley Lane,
Bridgwater, Somerset TA6 5JJ,
UK

Tel: +44 (0)1278 420555

Fax: +44 (0)1278 420666

www.iemtec.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

EMF Semiconductor Systems Ltd
(see section 6 for full contact details)

k-Space Associates Inc

3626 W. Liberty Rd.,
Ann Arbor, MI 48103,
USA

Tel: +1 734 668 4644
Fax: +1 734 668 4663

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.

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Seesener Str. 10-13, 10709 Berlin,
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Fax: +49 30 3180 8237

www.laytec.de

Optical Reference Systems Ltd

OpTIC Technium, St Asaph
Business Park, St Asaph, LL17 0JD,
UK

Tel: +44 (0)1745 535 188
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www.ors-ltd.com

WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)

Bregstrasse 90, D-78120
Furtwangen im Schwarzwald,
Germany

Tel: +49 7723 9197 0
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www.wepcontrol.com

12 Inspection equipment

Bruker AXS GmbH

Oestliche Rheinbrueckenstrasse 49,
Karlsruhe, 76187,
Germany

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Fax: +49 (0)721 595 4587

www.bruker-axs.de

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USA

Tel: +1 408 875 3000
Fax: +1 510 456 2498

www.kla-tencor.com

13 Characterization equipment

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www.jawoollam.com

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Fax: +1 614 818 1600

www.lakeshore.com

14 Chip test equipment

Keithley Instruments Inc

28775 Aurora Road,
Cleveland, OH 44139,
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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

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

J P Sercel Associates Inc

220 Hackett Hill Road,
Manchester, NH 03102,
USA

Tel: +1 603 518 3200
Fax: +1 603 518 3298

www.jpsalaser.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

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Tel: +1 408 748 0100
Fax: +1 408 748 0111

www.tecdia.com

Tecdia is a **TECDIA** manufacturer of single-layer chip capacitors, chip resistors, DC boards, bias-Ts, diamond scribing tools and dispensing nozzles.

17 Assembly/packaging foundry

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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
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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

23 Services

Henry Butcher International

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London WC1V 6EG,
UK
Tel: +44 (0)20 7405 8411
Fax: +44 (0)20 7405 9772
www.henrybutcher.com

M+W Zander Holding AG

Lotterbergstrasse 30, Stuttgart,
Germany
Tel: +49 711 8804 1141
Fax: +49 711 8804 1950
www.mw-zander.com

TECDIA Inc

(see section 16 for full contact details)

24 Consulting

WSR Optical Device Solutions

P.O. Box 248, Flemington,
NJ 08822,
USA
Tel: +1 908 428 4986
www.wsr-ods.com

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

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9–11 November 2009

SOLARCON India

Hyderabad, India

E-mail: solarconindia@semi.org

www.pvgroup.org

30 November – 4 December 2009

MRS Fall Meeting 2009

Boston, MA, USA

E-mail: info@mrs.org

www.mrs.org

1–2 December 2009

2nd Thin Film Solar Summit US

San Francisco, CA, USA

E-mail: cora.ng@thinfilmtoday.com

www.thinfilmtoday.com/us

1–5 December 2009

White LEDs (Second International Conference on White LEDs and Solid State Lighting)

Taipei, Taiwan

E-mail: ccy@cc.ee.ntu.edu.tw

<http://conference.ipo.ntu.edu.tw/icwledssl2009>

2 December 2009

OIDA's 18th Annual Forum – Photonics in Communications

Santa Clara, CA, USA

E-mail: iams@oida.org

www.oida.org/events/forum09

2–3 December 2009

Photovoltaics USA 2009

San Jose, CA, USA

E-mail: info@IDTechEx.com

www.idtechex.com/photovoltaicsusa09

2–3 December 2009

2nd European Solar Investment and Finance Summit

Berlin, Germany

E-mail: info@newsolartoday.com

www.newsolartoday.com/eufinance

2–4 December 2009

SEMICON Japan 2009

Makuhari Messe, Chiba, Japan

E-mail: jshowsinfo@semi.org

www.semiconjapan.org

5–6 December 2009

24th DGKK Workshop

Berlin, Germany

E-mail: submission@dgkk2009.de

www.dgkk2009.de

7–9 December 2009

IEEE International Electron Devices Meeting

Hilton Baltimore, MD, USA

E-mail: iedm@his.com

www.ieee.org/conference/iedm

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10–14 January 2010

IEEE Radio & Wireless Symposium (RWS 2010)

New Orleans, LA, USA

<http://rawcon.org>

20–22 January 2010

10th Fiber Optics Expo (FOE 2010)

Tokyo Big Sight, Japan

E-mail: foe@reedexpo.co.jp

www.foe.jp/en

23–28 January 2010

**SPIE Photonics West 2010, including:
LASE 2010, OPTO 2010, MOEMS-MEMS 2010**

Moscone Center, San Francisco, CA, USA

E-mail: CustomerService@SPIE.org

<http://spie.org/photronics-west.xml>

2–3 February 2010

**2nd annual Concentrated Photovoltaics
Conference**

San Diego, CA, USA

E-mail: heidi@newsolartoday.com

www.cpvtoday.com/usa

2–4 February 2010

**PHOTON's 5th Photovoltaic Technology
Show 2010 USA**

San Francisco, CA, USA

E-mail: info@photon-expo.com

www.photon-expo.com/en/pts_2010_usa/pts_2010_showinfo.htm

3–5 February 2010

SOLARCON Korea

COEX, Seoul, Korea

E-mail: julee@semi.org

www.solarconkorea.org/SOLARKOREA-EN

7–9 February 2010

Industry Strategy Symposium Europe 2010

Dublin, Ireland

E-mail: clee@semi.org

www.semi.org/isseurope

10–12 February 2010

Strategies in Light 2010

Santa Clara Convention Center, CA, USA

E-mail: tcarli@strategies-u.com

<http://sil09.events.pennnet.com>

2–5 March 2010

LED China 2010

Gungzhou, China

E-mail: LED@TrustExhibition.com

www.ledchina-gz.com/english/syly.asp

3–5 March 2010

**3rd International Solar Cell/Module
Technology Expo (PV Expo 2010)**

Tokyo Big Sight, Japan

E-mail: pv@reedexpo.co.jp

www.pvexpo.jp

7–9 March 2010

Photovoltaic Fab Manager's Forum

Berlin, Germany

E-mail: semieurope@semi.org

www.semi.org/pvfmf

16–18 March 2010

**SEMICON China 2010, including
SOLARCON China 2010**

Shanghai New International Expo Centre (SNIEC), China

E-mail: semichina@semi.org

<http://semiconchina.semi.org/scchina-en>

16–18 March 2010

LASER World of PHOTONICS China 2010

Shanghai New International Expo Centre (SNIEC), China

E-mail: laser@mmi-shanghai.com

www.world-of-photonics.net/en/laser-china/start

21–25 March 2010

**Optical Fiber Communication Conference
and Exposition and National Fiber Optic
Engineers Conference (OFC/NFOEC 2010)**

San Diego Convention Center, CA, USA

E-mail: info@ofcconference.org

www.ofcnfoec.org

22–24 March 2010

**SEMATECH Surface Preparation and
Cleaning Conference (SPCC 2010)**

Austin, TX, USA

E-mail: erica.mcgill@sematech.org

www.sematech.org/meetings/spcc

24–26 March 2010

**6th Photovoltaic Science Application and
Technology (PVSAT-6) Conference and
Exhibition**

University of Southampton, UK

E-mail: info@uk-ises.org

www.pvsat.org.uk

29–31 March 2010

**Semiconductor and Integrated
Opto-Electronics Conference (SIOE'10)**

Cardiff University, Wales, UK

E-mail: K.A.Shore@bangor.ac.uk

www.astro.cardiff.ac.uk/research/pm/events/?page=sioe



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