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p29 Osram's OSLOM MX ECE LED for frontal daytime running lights in mid-range vehicles.



p42 CIP's reflective SOA coaxially packaged in a pigtailed TO-56 can.



p59 California's Governor Arnold Schwarzenegger and US Energy Secretary Steve Chu break ground with Solyndra executives on Fab 2.



Cover: First Solar panels installed in Alhama de Granada, Spain. Such CdTe PV panels also comprise what is now the world's second biggest solar power plant (juwi's Lieberose solar farm near Cottbus, Brandenburg, Germany), while First Solar has just teamed with China on a 2GW plant in Inner Mongolia. **p54**

Emerging sectors augment recovery

After handset makers 'turned off the taps' in fourth-quarter 2008, the GaAs market will shrink 5% to \$3.5bn in 2009, reckons Strategy Analytics. However, the market has bottomed, it adds (as evidenced by the likes of RFMD and Skyworks raising their forecasts, as well as epiwafer maker IQE's orders rebounding: see pages 6-7 and 20, respectively). Also, demand from other wireless markets as well as defense, automotive, consumer and fiber-optic sectors should aid a return to growth in 2010 (hence TriQuint's acquisition of CATV and FTTP component firm TriAccess). However, the GaAs market's compound annual average growth rate will be just 4% through 2013 to \$4.5bn (short of the previously forecast \$5bn).

Mature markets such as mobile phones, outdoor video screens and automotive lighting are also driving a 3.7% drop in the high-brightness LED market this year, forecasts Strategies Unlimited. But, in contrast, emerging segments such as backlights for LCD displays in notebook PCs and TVs are growing strongly (see page 4), as evidenced by the launch of LED-backlit TVs from LG, Philips and Sharp at the IFA consumer electronics show in Berlin. Samsung expects to sell 2 million 'LED TVs' this year.

Another sector that has been hit by the financial crisis is the terrestrial solar market. However, while rejigging its concentrated photovoltaic (CPV) business strategy as the economics remain uncertain, Emcore has continued to win PV contracts for satellites (most recently with Northrop Grumman — see page 46).

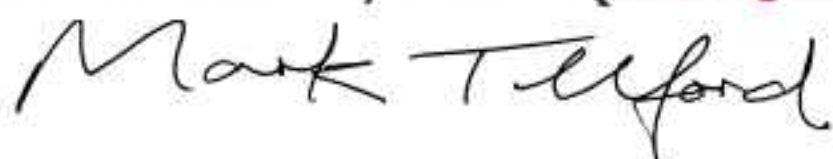
In contrast to CPV, the incumbent cadmium telluride PV panel maker First Solar is continuing to win utility-scale contracts for solar farms. Just as the in-progress juwi plant near Cottbus became the largest solar farm in Germany (and the world's second largest), First Solar won a contract to supply 27MW of modules for two utility-scale juwi projects in the US. It has also agreed a deal with the Chinese government to build a 2GW plant in Inner Mongolia (including maybe building module manufacturing sites there). Meanwhile, Cd-on-silicon PV developer Sunovia and partner EPIR are expanding their facilities prior to starting pilot production (see pages 54-56).

Also, amid continuing speculation about the economic viability of copper indium gallium diselenide (CIGS) PVs to compete with silicon, Nanosolar announced that, after entering serial production at its roll-to-roll printing facility in San Jose, CA, USA earlier this year, on 9 September it inaugurated its 640MW panel-assembly plant in Luckenwalde near Berlin, Germany, claiming contractual commitments worth \$4.1bn (page 58).

Meanwhile, the same week but further down the road (and attended by California's Governor Arnold Schwarzenegger and US Energy Secretary Steven Chu), CIGS PV maker Solyndra of Fremont, CA broke ground on its 500MW Fab 2, claiming more than \$2bn in contractual orders (page 59).

So, it would appear that CIGS PVs stand at the threshold of large-scale commercialization. However, it remains to be seen whether the sizeable support from both investors and government incentives will be rewarded by sustainable, long-term technical and economic viability.

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



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Editor

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

Commercial Director/Assistant Editor

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

Advertisement Manager

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

Original design Paul Johnson
www.higgs-boson.com

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Industry giants add to momentum for LED TVs

High-brightness LEDs are making further inroads into the LCD television market, with top manufacturers LG, Philips and Sharp all launching new sets that feature the technology.

At the high-profile Internationale Funkausstellung (IFA) consumer electronics show in Berlin, Germany (3–8 September), Philips revealed the latest in its high-end 'Aurea' line of LCD TVs.

The Aurea 2009 features 250 LEDs in its backlight and, according to the Dutch company, this yields a 40% energy saving when compared with a conventional LCD set based on a fluorescent lamp.

Joining Philips at IFA with more LED-backlit TVs was Korean rival LG, which showed off its new range of 'borderless' sets. When switched off, these TVs resemble a single, uninterrupted sheet of black glass — hence the product name. The

SL9000 model in the new range uses an LED backlight.

Not to be outdone, Japanese displays giant Sharp announced that LEDs will appear across the range of its latest Aquos TVs, including 32-inch models.

The new launches back up a recent forecast from Gerson Lehrman Group (GLG), which predicted that approximately 2 million LED-based TVs will be manufactured in 2009.

GLG analyst Jerald Kolansky believes that this figure will increase rapidly — to somewhere between 60 million and 75 million by 2013.

With up to 1000 LEDs required to backlight a 50-inch TV, the market opportunity for makers of high-brightness white emitters based on GaN is expected to be huge. Anticipation of that ramp-up in demand has already boosted orders for pro-

duction MOCVD reactors supplied by Aixtron and Veeco Instruments (see related stories below).

LG's Korean neighbor Samsung has spearheaded the industry's adoption of LED backlights in LCD TVs, and it has reportedly sold more than one million such units already.

Media reports quoting Yoon Bookeun, president of the firm's visual display business, suggest that Samsung expects to sell 2 million LED-based TVs this year.

Meanwhile, the analyst company DisplaySearch said in July that it expected LED backlights to feature in 40% of LCD TVs by 2013, before overtaking cold-cathode fluorescent lamps as the dominant backlight technology the following year.

By that time, all notebook PCs are also expected to feature LED backlights.

www.ifa-berlin.com

After 3.7% dip to \$4.9bn in 2009, high-brightness LED market to grow at 24% to \$14.9bn in 2013

Despite a shaky fourth quarter, the trend of recent years continued in 2008 as the high-brightness LED market grew 11% to \$5.1bn. However, a decline of 3.7% to \$4.9bn is expected in 2009, according to market research firm Strategies Unlimited in its report 'High-Brightness LED Market Review and Forecast — 2009'.

Despite the market decline, in all market segments the penetration rates for the use of HB-LEDs continue to grow. The fundamental drivers for HB-LED adoption have not changed, says the firm. It is the impact of the worldwide economic

recession on end-product demand, rather than any slowdown in the rate of HB-LED adoption, that is causing the HB-LED market to dip in 2009.

Also, the decline will not affect all HB-LED segments equally, says Strategies Unlimited. For example, although some of the more mature markets such as automotive lighting, mobile phones, and outdoor video screens are experiencing substantial downturns, other emerging segments such as backlights for LCD displays in notebook computers and TVs are showing strong growth. Moreover,

the LED lighting market is also continuing to grow, although at a somewhat slower pace than in recent years.

As well as providing strong counterweights to the decline in other segments and moderating the overall HB-LED market contraction in 2009, lighting and LCD backlighting are the applications that will drive recovery in 2010, and the market will grow at a compound annual growth rate (CAGR) of 24% to \$14.9bn in 2013, forecasts Strategies Unlimited.

www.strategies-u.com

GaAs growth to slow to 5% in 2009

Due to the global economic meltdown, year-on-year growth in the gallium arsenide market slowed from its previous forecast of 9% to 6% in 2008 and is projected to shrink 5% in 2009, wiping out the gains made last year, according to the annual GaAs industry forecast and outlook from market research firm Strategy Analytics. The GaAs market should generate revenues of \$3.5bn in 2009, it adds.

"The GaAs industry effectively shut down as handset manufacturers turned off the taps in the final quarter of 2008," notes the firm's Asif Anwar. "However, Strategy Analytics believes that the market has bottomed out and multiple GaAs device insertions in cellular handsets will be augmented by demand from other wireless mar-

kets as well as requirements from defense, consumer, fiber-optic and automotive sectors," he adds.

Demand from wireless markets, including cellular handsets, will continue to be the primary growth engine for the GaAs industry. While Strategy Analytics expects growth to return in 2010, with all major end-demand sectors growing through 2013, industry revenues will fall short of previous expectations of \$5bn. The overall growth will be tempered as a result of the economic downturn, and growth will show signs of flattening out in 2013. Overall, the GaAs, RF and microelectronic device market will grow at a CAAGR (compound annual average growth rate) of 4% through 2013, to \$4.5bn.

www.StrategyAnalytics.com

Multi-stream MIMO to drive doubling of Wi-Fi PA market to \$1bn in 2013

Vendors will ship \$4bn in Wi-Fi radio chips in 2013, mostly for cell phones, notebooks, netbooks, infrastructure, home entertainment systems and wireless gaming consoles, forecasts Strategy Analytics. Meanwhile, the adoption of 802.11n MIMO with multiple transmit streams will help to boost the market for Wi-Fi power amplifier modules to twice its 2008 size, despite continued pricing pressure, according to the report 'Wi-Fi Radio Component Forecast 2009-2013: New Applications & MIMO Drive Growth'.

"By the end of 2010, 802.11n will ship in more than half of all Wi-Fi systems," says Christopher Taylor, director of the firm's RF and Wireless Components research service. "Prices for single-stream 802.11n (1 x 1) chipsets and PAs have already dropped to match 802.11g, prompting OEMs to quickly begin to switch from 802.11g to 802.11n 1 x 1 chipsets in new products," he adds.

"As Wi-Fi continues to proliferate in new devices and applications,

multi-stream MIMO configurations of 802.11n (i.e. 2 x 2, 3 x 3 and 4 x 4, transmit x receive) will rapidly grow in support of demand for greater range, faster file transfers and streaming multimedia in many of these applications," says Taylor. This will push the Wi-Fi PA market to almost \$1bn over the next five years according to the Strategy Analytics Wi-Fi component forecast model, which considers MIMO stream adoption rates by application.

According to another report 'Wi-Fi Radio Component Vendor Share and Outlook: Broadcom & SiGe Semi Positioned to Maintain Leads', Broadcom will face increasing competition from cellular chip vendors bundling connectivity with their platforms, and from chip specialists targeting emerging applications such as Wi-Fi for home entertainment. In PAs, SiGe Semiconductor will face increasing competition from GaAs PA module specialists Skyworks, RFMD, TriQuint and Anadigics.

www.StrategyAnalytics.com

IN BRIEF

Military spending & GaN adoption offset wireless infrastructure slump in RF power semiconductor market

Although spending on RF power semiconductors in wireless infrastructure markets has continued to stagnate, other markets — notably the military — are seeing increased activity, so the total available market for RF power semiconductors in 2009 should approach \$1bn, according to a study by analyst firm ABI Research.

Also, gallium nitride — long seen as a promising new 'material of choice' for RF power semiconductors — is finally starting to gain some market traction. "Gallium nitride has markedly increased its market share in 2009 and is forecast to be a significant force by 2014," notes director Lance Wilson. "It bridges the gap between two older technologies, exhibiting the high-frequency performance of gallium arsenide combined with the power handling capabilities of silicon LDMOS," he adds. "It is now a mainstream technology which has achieved measurable market share and in future will capture a significant part of the market."

The vertical market that is showing the strongest uptick in the RF power semiconductor business has been military, which Wilson describes as being "now a very significant market". While the manufacturers of these devices are located in the major industrialized countries, the military market is now so global that end-equipment buyers can be from anywhere, Wilson concludes.

www.abiresearch.com

RFMD's free cash flow to beat forecast \$80–120m

At the Kaufman Brothers 12th Annual Investor Conference in New York, Bob Bruggeworth, president & CEO of RF Micro Devices Inc of Greensboro, NC, USA, gave a financial update for the firm's fiscal second-quarter 2010 (ending 3 October 2009), saying that demand for its products is tracking ahead of plan (with further growth expected on top of the June quarter's 23% revenue growth).

Bruggeworth attributes the increased demand to two major growth drivers:

- end demand in the cellular handset market is strong, and current customer forecasts and backlog support expectations for continued handset market strength into the December quarter;
- RFMD reckons that it is a primary beneficiary of the increasing demand for 3G smartphones, which require 3–5 times the RF dollar content of 2G handsets.

The firm believes that it is gaining share in the cellular market and expects sequential quarterly revenue

growth at each of its major cellular handset customers as RFMD outstrips growth in the handset market. Also, Bruggeworth said that visibility for the December quarter continues to improve in both its Cellular Products Group (CPG) and Multi-Market Products Group (MPG), reflecting increased customer forecasts and backlog and leading to RFMD expecting further revenue growth over its September quarter.

Accordingly, Bruggeworth reiterated RFMD's non-GAAP operating income target of 15% of total revenue and said that the firm is making progress converging on this target operating model in the near-term. In the June quarter, non-GAAP operating income was 11% of revenue, while operating expenditure was an on-target 25% of revenue and gross margin was 37% (compared to the target model of 40%).

June-quarter gross margin for MPG in particular was more than 40%. Given that MPG's markets comprise new segments such as

automated meter reading for which RFMD is launching a lot of new products and locking down new design wins, margins are expected to be boosted further. Also, later this quarter RFMD should complete the consolidation of its assembly operation from Shanghai into the Beijing plant (producing a noticeable effect on margins in the December quarter).

Meanwhile, in CPG, after RFMD in November 2008 first released products with their die size reduced by 30%, the firm expects 25% of its portfolio to be reduced-die-size products by the end of fiscal 2010. Furthermore, said Bruggeworth, RFMD will introduce another die-size shrink of 30% by the end of fiscal 2010.

Finally, for fiscal 2010, RFMD expects to exceed the high end of its previously stated forecast of free cash flow of \$80–120m (i.e. net cash provided by operating activities of \$90–140m minus property and equipment expenditures of \$10–20m).

PAs shipped to support early field deployment of 4G LTE handsets

RFMD is supplying its RF6276 and RF3280 power amplifiers (PAs) — which are designed to meet or exceed the data-centric performance requirements of the fourth-generation (4G) long-term evolution (LTE) mobile broadband standard — to two handset makers and two baseband manufacturers for 4G LTE mobile broadband handsets. The firm expects production revenue related to 4G LTE PAs to begin in fiscal second-half 2010 (ending 3 April).

"With these customer engagements, we are pleased to support the early field deployment of next-generation 4G LTE handsets," says Eric Creviston, president of RFMD's Cellular Products Group (CPG).

The compact, low-profile (3mm x 3mm x 1mm) RF6276 linear LTE PA is tuned for operation in LTE

bands 12 (698–716MHz) and 13 (777–792MHz) and delivers a blend of high power efficiency and lower current consumption as output power levels decrease. Also, two power-mode states with digital control interfaces adjust the bias current and optimize the PA for the desired output power range, while maintaining the stringent linearity requirements of LTE modulation, says the firm.

The compact (4mm x 4mm x 1.14mm) RF3280 linear LTE PA is tuned for operation in LTE band 7 (2500–2570MHz) and is optimized for use in linear multimode WCDMA/LTE mobile devices. Use of quadrature PA technology improves end-product immunity to VSWR (antenna mismatch) and eases end-product implementation, the firm says. The PA is designed

for RF front-end architectures utilizing analog bias control in combination with a mated DC–DC converter. This architecture enables dynamic PA loadline adjustments which optimize performance whether the handset is operating in WCDMA or LTE. The combination of analog bias control and a DC–DC converter also optimizes efficiency, at all power levels, and minimizes overall thermal impact, the firm claims. The RF3280 also includes an integrated output power detector that supplies a voltage signal relative to the output power level of the PA, reducing board area and simplifying implementation.

Both integrated modules require no external blocking or decoupling capacitors.

www.rfmd.com

Skyworks raises September-quarter revenue outlook by 6%

After a broad-based improvement in order demand, Skyworks Solutions Inc of Woburn, MA, USA, which manufactures linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has raised its revenue outlook for its fiscal fourth-quarter 2009 (to end September) by about 6%, from \$210m to \$220-225m (up 15-18% on fiscal Q3's \$191.2m).

It has also raised its outlook for non-GAAP diluted earnings per share from \$0.19 to \$0.21-0.22 (up from fiscal Q3's \$0.16). "Multiple new program ramps

New program ramps coupled with strong operational execution are contributing to better-than-planned top- and bottom-line growth

coupled with strong operational execution are contributing to better-than-planned top- and bottom-line growth," says president & CEO David J. Aldrich. "Our diversification into a broader set of analog semiconductor sectors, share consolidation in our core markets, and our scale advantages are increasingly enabling us to outperform our addressable markets."

www.skyworksinc.com

Skyworks secures multiple EDGE and next-generation WCDMA smart-phone design wins at Samsung

Skyworks Solutions Inc of Woburn, MA, USA says that Samsung is using both quad-band GSM/EDGE and next-generation WCDMA front-end solutions to power new 3G smart phones, including the Pixon12 (the world's first 12 megapixel touch-screen camera phone).

Skyworks has also secured EDGE and WCDMA power amplifier design wins for more than 15 further Samsung smart phones currently in production. These new models include:

- the GT-I8000 Omnia2 (featuring a vast AMOLED touch-screen);
- the GT-S8000 (Samsung's first Android phone);
- the GT-M6710, or new Beat Disc Edition handset;
- the GT-M7600 Beat DJ (the only mobile phone with music playback software); and
- the GT-S5600 touch-screen phone.

The SKY77186 (1920-1980MHz), the SKY77187 (1850-1910MHz), the SKY77188 (824-849MHz), and the SKY77189 (880-915MHz) power amplifier modules (PAMs) are fully matched 10-pad surface-mount 3mm x 3mm devices



Samsung's Pixon12 3G smart phone with SKY77186, SKY77189 and SKY77336.

developed for next-generation WCDMA applications in a single compact package. The firm claims that the small and efficient modules deliver talk-time advantages due to the high efficiencies attained throughout the entire power range. They also meet the stringent spectral linearity requirements of high-speed downlink packet access (HSDPA) data transmission with high power-added efficiency (PAE), the firm adds. In addition, a directional coupler is integrated into the modules, eliminating the need for any external coupler.

The SKY77336 PAM is designed in a compact form factor for quad-band cellular handsets including GSM850/900, DCS1800 and PCS1900, supporting gaussian minimum shift keying (GSMK) and polar enhanced data for GSM evolution (EDGE) modulation. Class 12 general packet radio service (GPRS) multi-slot operation is also supported, with lead (Pb)-free, restriction of hazardous substances (RoHS) compliant packaging.

"Skyworks is pleased to be further expanding its relationship with Samsung, particularly as they develop innovative platforms to support growing consumer demand for high-end smart phones with touch-screen and camera capability," says Liam K. Griffin, senior VP of sales & marketing. "The Samsung design wins, among others, not only demonstrate Skyworks' ability to capitalize on the three-fold increase in content in today's multimode phones, but also highlights Skyworks' ability to deliver high-performance, cost-effective solutions to the industry's top-tier handset OEMs."

Anadigics shrinks power amplifiers for 3G phones

GaAs-based component maker Anadigics Inc of Warren, NJ, USA has made available samples of the AWE6159 quad-band polar EGDE power amplifier (PA) module, which is far smaller than previous generations of PAs used in 3G phones.

Said to be 49% smaller than its own previous polar EDGE PAs for high-end handsets, the chip is designed to meet the stringent performance requirements of GMSK (Gaussian minimum shift-keying) and EDGE modes in mobile devices using open-loop polar modulation schemes required by top-tier 3G chipset providers.

The firm says that, despite measuring just 5mm x 5mm, and only 1mm thick, the AWE6159 delivers the higher saturated output power levels required by multi-mode 3G devices. "The new, much smaller AWE6159 includes an integrated power control for GMSK and EDGE modes to allow easy conversion between these two modes," says marketing director Bruce Webber.

"It's this key feature that successfully drove the adoption of our AWT6280 EDGE PA into millions of handsets, smartphones and data devices," adds the firm. "Many GSM operators have upgraded their networks, and EDGE capability is being designed into forthcoming WCDMA/HSPA mobile devices to provide the necessary compatibility."

The AWE6159 module also includes separate amplifier chains to support both GSM850/900 and DCS/PCS bands, each optimized to deliver GMSK and 8-PSK modulated RF with high efficiency and low harmonics.

"The 49% size reduction significantly decreases board area, while the lower battery current meets the growing efficiency requirements of 3G devices to preserve battery life and extend talk/data time," adds EDGE product line director Joe DeMoura.

www.anadigics.com

By Michael Hatcher.

TriQuint acquires TriAccess to boost cable TV and FTTP RFIC amplifier range

RF front-end product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has acquired TriAccess Technologies of Santa Rosa, CA, a provider of cable TV (CATV) and fiber-to-the-premise (FTTP) RFIC components for the amplification of high-quality multimedia content. TriQuint has been a foundry supplier to TriAccess for the last four years.

"The TriAccess team is a great fit for TriQuint," said Brian Balut, VP of TriQuint's Network Products.

"TriAccess brings a portfolio of products for the CATV and FTTP markets, with strong design and market understanding, which accelerates TriQuint's strategy of serving these applications," he adds.

Cable and telecom operators are competing to provide consumers with triple-play services (Internet, video and voice) and are upgrading their networks to provide the bandwidth needed for high-speed Internet, multiple HDTV streams, and applications such as video-on-demand (VOD). TriQuint says that these services require RF components that provide higher performance — i.e. higher bandwidth, better linearity, lower noise, reduced power consumption, and higher integration — all at reduced cost. Also, it is not just a US focus; Europe and the Asia-Pacific region are deploying similar systems. TriQuint's CATV products, combined with TriAccess' product lines, address these global needs, the firm adds.

"Together we can accelerate our success in multiple CATV and fiber-optic video markets worldwide. We are anxious to further utilize TriQuint's process technology and assembly & test resources," says TriAccess' president, chief technology officer & founder

Chris Day. "TriQuint is well known and highly respected by our customers, providing additional confidence that we are a dependable and stable source of supply," he adds. Day will manage what is now the TriQuint Santa Rosa Design Center, focused on the growing CATV and fiber-optic video markets.

TriAccess' results are not expected to materially impact TriQuint's net income.

In conjunction with the transaction, TriQuint's board of directors has

TriAccess brings a portfolio of products for the CATV and FTTP markets, with strong design and market understanding, which accelerates TriQuint's strategy of serving these applications

approved the issue of 170,300 stock options to ten former TriAccess employees under TriQuint's 2008 Inducement Award Program. A majority of TriQuint's independent directors approved the grant of the stock options in accordance with NASDAQ

Listing Standard 5635(c)(4).

The stock options granted as part of the award program have a 10-year life, with 25% vesting 12 months from the date of grant and the remaining 75% in equal quarterly installments of 6.25% over the next 12 quarters. The exercise price is \$7.54 (the closing price of TriQuint's common stock on 3 September). The options expire on 3 September 2019.

<http://triaccesstech.com>

www.triquint.com/rf

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Avago launches 0.25W analog variable-gain amplifiers

Avago Technologies has added two miniature 0.25 Watt analog variable-gain amplifiers to its portfolio for cellular infrastructure applications.

Housed in a compact 5mm x 5mm x 1.1mm, 10-lead module package, the ALM-80110/80210 devices have a common footprint for easy integration into most base-stations. High linearity and dynamic range performance across 400–2700MHz supports all major cellular bands in North America, Europe and Asia.

The ALM-80110 operates at 0.4–1.6GHz and the ALM-80210 at 1.6–2.7GHz, suiting use in wireless local loop (WLL), wireless local-area network (WLAN), transmitter receiver gain control, and temperature compensation circuitry applications. Both provide a high output 3rd order intercept point (OIP3) level of 40dBm over a wide attenuation range. They also have a wide gain control range and low power consumption, and what is claimed to be excellent input and output return loss.

The devices integrate Avago's high-linearity 0.25W amplifiers and silicon PIN diode-based pie attenuator into a multiple-chips-on-board (MCOB) module package. Both amplifiers have fully matched input and pre-matched output for ease of use and require minimal external RF matching components. High linearity and dynamic range is achieved via a proprietary 0.25 μ m GaAs enhancement-mode pHEMT process and low-distortion silicon pin diode technologies.

In a typical operating environment of 5V and 120mA, the ALM-80110 delivers 40dBm OIP3, 40dB attenuation range, 23.3dBm output power at 1dB compress point (P1dB), 13.5dB gain, 17dB input return loss (IRL), and 12dB output return loss (ORL) at 900MHz. The ALM-80210 offers 40dBm OIP3, 35.7dB attenuation range, 23.5 dBm output power at P1dB, 9.8dB gain, 13.6dB IRL and 12.1dB ORL at 1900MHz.

www.avagotech.com

Multi-project wafer foundry for DoD

HRL Laboratories LLC of Malibu, CA, USA (a corporate R&D lab owned by The Boeing Company and General Motors) has partnered with the National Secure Manufacturing Center at the National Nuclear Security Administration's Kansas City Plant (KCP) to provide multiple-project wafer services to the Department of Defense (DoD) Trusted Foundry Program. The National Secure Manufacturing Center provides the national security community secure manufacturing and engineering solutions.

KCP's Trusted Foundry Access Team will offer first-line technical support, implementation and design verification assistance for HRL's indium phosphide technologies. In addition, the center will offer application engineering support, design rule checking and multiple-project wafer aggregation services to improve design quality and reduce the variability of designs submitted to foundries that are part of the program.

"By combining our unique expertise and capabilities to provide multi-project wafer services, HRL and KCP can offer national security customers greater access to leading-edge technologies and low-volume production parts at lower costs," says Dr Charles Fields, senior scientist in HRL's Microelectronics Laboratory.

HRL fabricates InP HBTs for low power high-speed mixed-signal circuits, as well as HEMT millimeter-wave low-noise amplifiers with what is claimed to be the best noise figure and gain performance at 70–110GHz.

HRL manufactures space- and flight-qualified components for government programs and commercial markets. It has served the DoD, US government agencies and major contractors in providing microelectronics services for military and aerospace applications since 1960. The firm received accreditation as a DoD Trusted Foundry in 2007 and is one of only 13 accredited Trusted Foundries in the USA.

www.hrl.com

M/A-COM hires ex-WIN exec as CSO

M/A-COM Technology Solutions Inc of Lowell, MA, USA, which provides semiconductors, active and passive components and subassemblies for RF, microwave and millimeter-wave applications, has recruited Robert (Bob) Donahue as chief strategy officer, responsible for leading efforts in targeting faster-growth markets where its technology can provide a competitive advantage. He will also work with product line managers on new product and technology roadmaps, as well as overseeing the firm's channel and strategic account plans.

Lately, Donahue was executive VP of sales & marketing, business development and chief strategy officer at Taiwan's WIN Semiconductor Corp, where he developed the strategic plan and drove business segments of the firm from a very early-stage start-up to become the world's

largest pure-play GaAs foundry.

Previously, he was director of marketing at Hittite Microwave Corp of Chelmsford, MA, USA, which designs and supplies analog and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems for communication and military markets. Donahue also spent about nine years in engineering and product line management roles with M/A-COM Tech's IC business, and 10 years in engineering leadership positions at Raytheon.

"M/A-COM Tech has a multi-prong initiative to accelerate growth and enhance our competitiveness," says CEO Joe Thomas. "Having a well-articulated strategy that can be effectively implemented is essential to the achievement of these objectives," he adds.

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SiGe launches WLAN/Bluetooth FEM for direct-to-battery operation

SiGe Semiconductor has expanded its wireless LAN and Bluetooth product range by introducing the SE2579U front-end module (FEM), targeted at the embedded and module applications markets, including WLAN-enabled cellular handsets, digital cameras and personal media players (PMPs).

"We designed the SE2579U to address the specific challenges faced by OEMs needing to operate 'direct-to-battery', and to facilitate Bluetooth/WLAN concurrent mode operation solutions," says Sanjiv Shah, director, product marketing WiMAX, & embedded WLAN.

"Direct-to-battery operation does not require additional voltage regulation circuitry," he adds. "The high output power of the module improves link budgets and the quality of data transfer and the design specifically resolves the issues of simultaneous BT/WLAN operation."

The SE2579U is a complete 802.11 b/g/n 2.4 GHz WLAN RF FEM with a Bluetooth port in an ultra-compact form factor (3mm x 3mm x 0.5mm). It can operate simultaneously in both WLAN and Bluetooth receive mode without signal degradation found in current solutions. The device provides all the functionality of the power amplifier, power detector, filter, switch, low-noise amplifier, 2170MHz notch filtering and associated matching.

The SE2579U provides a complete WLAN/BT RF single package solution from the output of the transceiver to the antenna, and from the antenna to the input of the transceiver. It is easy to deploy, with all the critical matching and harmonic filtering integrated, while offering a simple 50 I(C) interface to the antenna. It also includes a power detector with 20dB of dynamic range and a digital enable control for transmitter power ramp on/off control.

www.sige.com

Jazz targets SiGe at replacing GaAs in mm-wave and cell-phone markets

Analog-intensive mixed-signal foundry Jazz Semiconductor Inc of Newport Beach, CA, USA, a subsidiary of specialty foundry Tower Semiconductor Ltd of Migdal Haemek, Israel, says that it is targeting its enhanced silicon germanium (SiGe) BiCMOS process, intellectual property and design enablement tools at replacing gallium arsenide components in high-growth markets such as millimeter-wave and front-end components for cellular phones.

Jazz claims that SiGe provides significant integration and cost advantage over GaAs, enabling products in the emerging markets of automotive collision avoidance, phased-array radar, and HDTV wireless distribution as well as established markets such as optical network and cell-phone front-end components. The firm says that it is working on SiGe solutions with more than half of the top 10 IC providers in several of these market segments. The combined millimeter-wave and front-end module (FEM) market is estimated to grow at a compound annual growth rate (CAGR) of over 23% from \$400m in 2009 to over \$750m in 2012, outpacing most other sectors in the semiconductor industry, according to data from the market research company Strategy Analytics.

Jazz's process technology includes a SiGe transistor with demonstrated performance of up to 200GHz as well as noise and power performance that is competitive with GaAs while offering as much as 40% lower die cost, the firm claims. Also included are CMOS options to enable mixed-signal and digital functions on the same chip, further reducing the cost of the complete system.

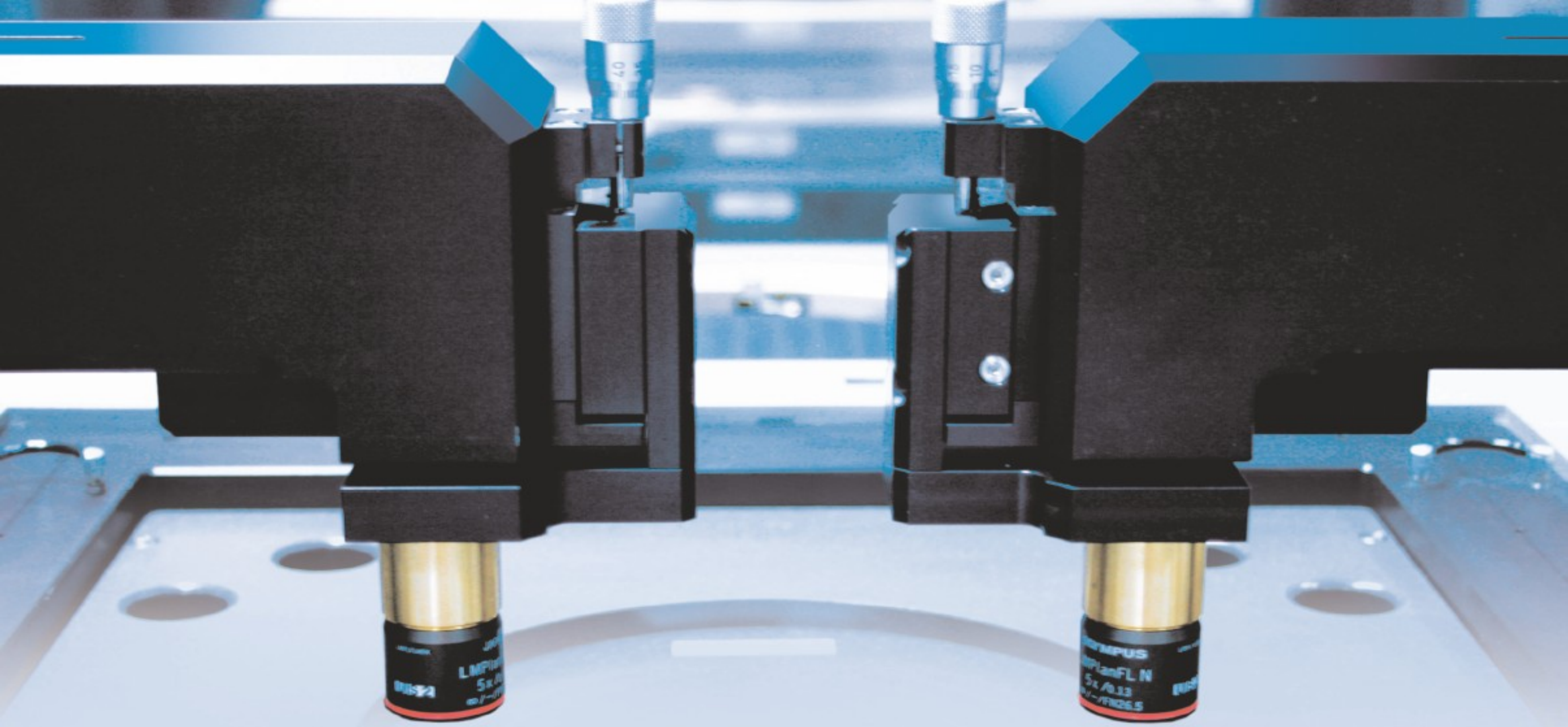
To facilitate the transition from GaAs- to SiGe-based designs, in June Jazz partnered with Agilent to provide a SiGe process design kit (PDK) in ADS 2009 (Advanced Design System), a design platform for GaAs-based products, aiming to

speed time-to-market for users targeting applications up to and beyond 60-77GHz. "Our collaboration with Jazz is in response to the strong market demand from our mutual customers for a fast and efficient RFIC design flow," said Avery Chung, foundry program manager of Agilent's EEs of EDA division, at the time. "With these new SiGe PDKs in ADS 2009, customers will be able to design high-performance ICs operating up to 60GHz and higher. They can use the breadth of capability ADS provides, including design-for-manufacturing toolsets and Momentum, the industry-leading 3D planar EM simulator."

As an example of a successful transition from GaAs to SiGe, Jazz cites its collaboration with University of California San Diego (UCSD) — announced in July — to develop a two-antenna quad-beam 11-15GHz phased-array receiver. This enables high-performance phased arrays for satellite communications by integrating many functions on the same silicon chip and replacing eight GaAs ICs, drastically lowering the cost of phased-array assembly, claims Jazz. First-time success was achieved using the firm's 0.18µm SiGe BiCMOS process and its own proprietary models, kit and the DIRECT MPW (multi-project wafer) program.

"We continue to see migration of GaAs products into SiGe as an exciting growth opportunity for our technology," says Dr Marco Racanelli, senior VP & general manager of the RF/HPA and Aerospace & Defense business groups. "This transition is largely complete in optical front-end components but just beginning in cellular phone front-ends and millimeter-wave applications," he adds. "We will continue to invest in high-performance processes as well as design enablement infrastructure to speed time-to-market for customers in these emerging applications."

www.jazzsemi.com



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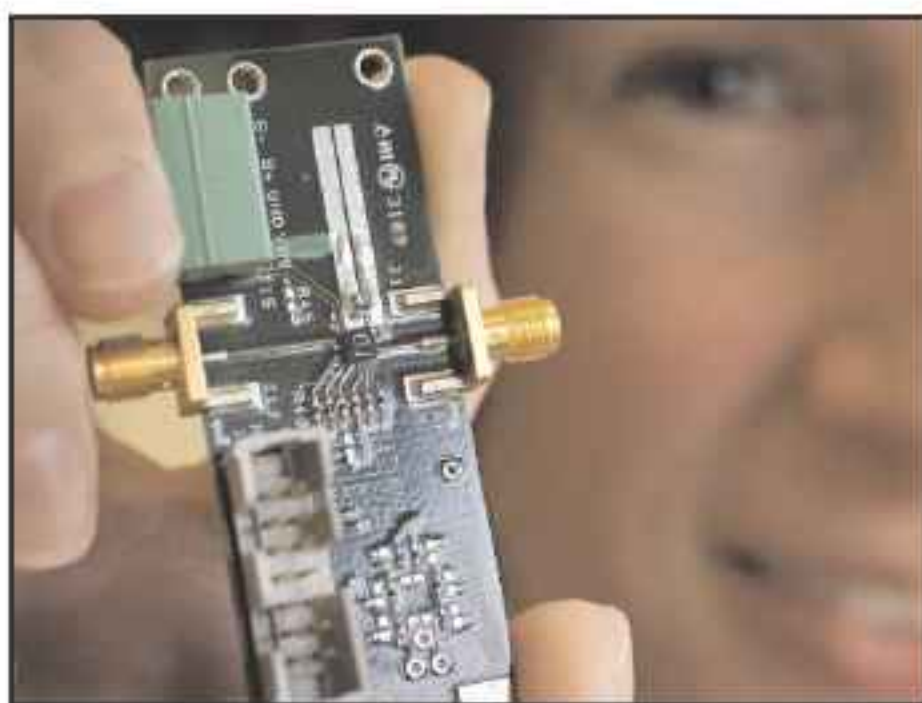
The key to your success

Black Sand raises \$10m in Series B funding as it claims first 3G CMOS RF power amplifier

After completing functioning engineering prototypes, fabless semiconductor firm Black Sand Technologies Inc of Austin, TX, USA, which was founded in 2005, has produced what it claims is the world's first RF power amplifier (PA) for 3G cellular communications made with conventional CMOS silicon manufacturing technology. The firm expects to ship its first product samples by the end of 2009.

The firm has also raised \$10m in second-round funding, led by Northbridge Venture Partners and joined by Austin Ventures (which participated in the \$8.2m first round two years ago). Black Sand will use the new funding to get its prototype power amplifier into mass production and accelerate development of additional products. The firm aims to have its first chip incorporated into 3G cell phones available for sale in second-half 2010.

Black Sand's RF PAs are targeted at mobile phones and other 3G wireless devices such as datacards and netbooks. The firm says that replacing incumbent gallium arsenide with CMOS silicon in



Black Sand's power amplifier chip.

power amplifiers should improve manufacturing yield, performance, cost, battery life, and call quality.

Over time CMOS has replaced GaAs technology in applications including audio chips and DVD decoders. However, CMOS does not lend itself easily to use in power amplifiers, so a new proprietary PA architecture was developed using patented mixed-signal technology that combines sensitive analog, digital and power circuits in silicon. "Black Sand, as the first company to deliver 3G PAs in CMOS, is ready to capitalize on the historic shift from GaAs to CMOS, and benefit from the explosion in demand for

new 3G devices appearing on the market," says the firm's CEO John Diehl.

"The RF front end of mobile phones is continuing to grow in complexity and with the development of linear 3G CMOS PA technology, enabling advances such as integrated digital control circuits, Black Sand is in a unique position to profit from this technological shift as the market moves from 2G to 3G," adds Brian Modoff, senior wireless equipment analyst at Deutsche Bank.

"Black Sand delivered working samples of their new PA architecture much sooner than expected," says Basil Horangic of Northbridge Venture Partners. "Their unique offering will provide the basis for a broad portfolio of products from 2G to 4G." Krishna Srinivasan, Partner at Austin Ventures adds, "Since inception, this team has executed in hitting milestones and developing new, world-class IP, and we are delighted to continue our support for the company as they enter a new phase of growth."

www.blacksand.com

RFaxis recruits director of strategic marketing & product planning

Fabless semiconductor firm RFaxis Inc of Irvine, CA, USA, which was founded in January 2008 to design RF semiconductors and embedded antenna solutions for the wireless and connectivity markets, has recruited Dr Yongxi Qian as director of strategic marketing, product planning & application engineering for what is claimed to be the first RF front-end integrated circuits (RFeICs), based on BiCMOS silicon.

Qian has over 15 years of extensive research, teaching and product development experience in RF, microwave and millimeter-wave engineering, and the wireless communications industry. He was most recently director of RF Engineering

at Microsemi Corp's AMSC Group, where he played a key role in establishing GaAs MMIC design groups serving the wireless local-area network (WLAN) industry. A senior member of the IEEE and author/co-author of over a half dozen books/book chapters and more than 200 publications, Qian has won technical awards including IEEE IMS and European EuMC Paper Awards, a NASA Class I Award and a Japan Microwave Prize. He received his Ph.D. from the University of Electro-Communications in Tokyo, Japan.

"Qian's wealth of industry knowledge directly applies to what we are doing at RFaxis, and we will

leverage his expertise as we move forward in our mission to become a one-stop shop for complete RF front-end solutions," says president & CEO Mike Neshat.

RFaxis' patent-pending RFeICs integrate the power amplifier (PA), low-noise amplifier (LNA), transmit and receive switching circuitry, the associated matching network, and harmonic filter, all in a single-chip, single-die device. RFaxis claims that the RFeICs combine superior performance, high sensitivity and efficiency, low noise, small form factor, and low cost for applications requiring low power, extended range and bandwidth, and small form factor.

www.rfaxis.com

Amalfi claims smallest, highest-performing CMOS transmit module for cellular handsets

Fabless design firm Amalfi Semiconductor of Los Gatos, CA, USA, a developer of CMOS-based RF and mixed-signal semiconductors for cellular mobile handsets, has made available samples of what it claims is the world's smallest, highest-performing CMOS-based transmit module for cellular handsets.

The AM7802 is part of the Amalfi Stratos power amplifier family, which uses a standard complementary metal oxide semiconductor (CMOS) process and proprietary architecture that has proven to outperform competing technology in performance, integration and cost, the firm claims. Integrating this CMOS architecture into a transmit module offers handset makers a much smaller (5mm x 6mm), simpler, lower-cost cellular handset front-end solution with up to 40% more battery life or talk time than existing modules from leading suppliers, it adds.

The AM7802 is a dual-band GSM/GPRS transmit module that is targeted primarily at the entry-level and ultra-low-cost (ULC) market segments in emerging markets. The ULC segment is targeted by all OEMs, including the traditional tier-one handset makers, and is one of the few segments that sustained market growth during the recent world economic downturn, says Amalfi.

"The emerging market handset (EMH) market segment is expected to grow at a compound annual growth rate of 9% between 2008 and 2012," says Brian Modoff, senior wireless equipment analyst at Deutsche Bank. "The availability of a proven CMOS technology that enables handset manufacturers to deliver superior performance and lower-cost handset solutions with more efficient battery usage could drive CMOS to become the dominant technology in this market," he adds.

Mobile phone power amplifiers typically use between one-third and 3.5W of power during cellular transmission, which represents 30–70% of the current used by the phone when the user is talking. The lower current consumption resulting from the Stratos AM7802 transmit module enables the cell phone to support up to 40% more talk time compared to existing solutions and allows cellular manufacturers to use smaller, less expensive batteries, reducing the size and bill-of-material (BOM) cost of the phone, the firm claims. A 40% longer battery life also could have a significant impact on energy savings.

"Cellular handset manufacturers worldwide want CMOS to win because of its historic cost, integration and performance advantages, and they have shown us that it is an easy design transition from GaAs to CMOS," claims co-founder & CEO Jim Finch. "Our CMOS transmit module has proven to significantly outperform all competitive solutions in power efficiency, size, and cost, which gives manufacturers the confidence they need to transition from GaAs to CMOS."

The AM7802 integrates the power amplifier, controller, transmit/receive switch, filtering and all matching components into a 30mm² package, yielding the industry's smallest, most integrated transmit module, it is claimed. The small size saves PCB space and cost and provides for more flexible design layout, allowing smaller phones or phones with additional features.

The transmit module uses Amalfi's proprietary AdaptiveRF CMOS architecture, which was designed for the development of CMOS power amplifiers (PAs) and has proven to achieve competitive peak performance and much better power added efficiency (PAE) of 48% in the typical operation ranges relative to leading GaAs power amplifiers, the firm claims.

A typical GaAs transmit module would need an improvement of more than 10% in PAE at maximum output power compared to current performance to match Amalfi's performance in the most common mid-range operating power levels applicable to GSM and EDGE cellular mobile handsets, it adds.

The AM7802 is capable of 1.5kV ESD on all pins, including RF pins,

The transmit module is capable of operation down to 2.7V, enabling handsets to operate longer

making the device less susceptible to electrostatic discharge damage during manufacturing, resulting in better yields and overall lower cost. It is

also capable of withstanding 8kV ESD on the antenna port, further lowering BOM cost as no additional ESD protection is required on the phone to meet industry standards.

The transmit module is capable of operation down to 2.7V, enabling handsets to operate longer and extract up to 10% additional talk time from existing lithium ion battery technology, it is claimed. This will also enable the use of next-generation, lower-voltage batteries when they are available, further reducing BOM costs.

In conjunction with the AM7802, from mid-September Amalfi will also be sampling the 4mm x 5mm Stratos AM8802 and AM8802D quad-band CMOS power amplifier modules, which use the same core PA with AdaptiveRF architecture and are capable of withstanding 2kV ESD as well as PAE of 58% and 59%, respectively. Using a standard bulk CMOS technology, they are manufactured by foundry partners and supported by leading packaging, assembly & test firms, it is claimed.

All of the products will be available in production quantity in Q4/2009.

www.amalfi.com

IN BRIEF

Designs featuring Cree GaN HEMT sweep prizes in IMS power amplifier competition

Cree Inc of Durham, NC, USA says that the IEEE Microwave Theory and Techniques Society (MTT-S) International Microwave Symposium (IMS 2009) in June represented the third consecutive year that an amplifier using its CGH40010 gallium nitride high-electron-mobility transistor (HEMT) has won the event's best power amplifier competition. David Yu-Ting Wu, representing the University of Waterloo, received the award for best-performance amplifier designed and demonstrated as judged on efficiency, power and frequency of operation.

Wu's Inverse Class-F amplifier was designed using Cree's proprietary non-linear GaN HEMT model. The model's accuracy in precisely predicting the required impedance conditions for high-efficiency operation was key to achieving first-pass design success, says Cree. The winning 3.27GHz amplifier produced 7.1W of RF output power at a power added efficiency (PAE) of 71%.

The CGH40010 was also used in Inverse Class-F circuit architectures by the second- and third-place student teams: Paul Saad, Hossein Mashad Nemati and Mattias Thorsell from Chalmers University of Technology, Sweden, and Junghwan Moon and Jungjoon Kim from Pohang University of Science and Technology (POSTECH), Korea.

"This is a hat trick, of sorts, for Cree," says Jim Milligan, Cree's director of RF and Microwave products. "Cree congratulates the students for their efforts and wishes them continued success."

www.cree.com

Raytheon awarded \$7m Phase 2 COSMOS contract by ONR

The US Office of Naval Research has awarded defense contractor Raytheon Company of Waltham, MA, USA a \$7m follow-on Phase 2 contract for work on the Compound Semiconductor Materials on Silicon (COSMOS) program, which is funded by the US Defense Advanced Research Projects Agency (DARPA). Previously, in June, HRL Laboratories received an 18-month Phase 2 contract from DARPA and the Air Force Research Laboratory to continue its separate work on COSMOS.

"The COSMOS program focuses on integrating high-performance compound semiconductors, such as InP or GaAs, with low-cost silicon transistors to achieve superior cost benefits and performance," says Michael Del Checcolo, VP of engineering for Raytheon Integrated Defense Systems (IDS). "These technological advances allow us to provide more complex and highly sophisticated solutions."

During its \$6.5m phase 1 COSMOS contract (awarded in September 2007), the Raytheon-led team demonstrated that high-performance compound semiconductor devices (InP HBTs) can be directly grown and fabricated on silicon substrates and monolithically integrated with CMOS transistors on the same substrate.

Like phase 1, for phase 2 Raytheon IDS is again partnering

with Raytheon Systems Ltd in Glenrothes, Scotland, UK; Soitec in Bernin, France; Teledyne Scientific Imaging Company in Thousand Oaks, CA; MIT in Cambridge, MA; Paradigm Research LLC in Windham, NH; epiwafer foundry IQE's North America manufacturing plant in Bethlehem, PA; and Silicon Valley Technology Center in San Jose, CA (using Raytheon's OpenAIR business model for assembling talent and capabilities).

The phase 2 contract will focus on improving the yield and integration density of compound semiconductor and silicon CMOS transistors fabricated on the same silicon wafer. Specifically, the team will use phase 1's findings to design and fabricate high-speed, low-power-consumption digital-to-analog converters (DACs) whose performance cannot be realized with existing technology.

COSMOS' stated goal for phase 2 is to demonstrate a heterogeneously integrated 13-bit DAC achieving 78dBc of SFDR (spurious-free dynamic range) at 1GHz output frequency. Phase 3 will be scaled to a much larger circuit, resulting in a heterogeneously integrated 16-bit analog-to-digital converter (ADC) supporting 98dBc of SFDR across a 500MHz bandwidth.

www.darpa.mil/MTO/Programs/cosmos

Raytheon's GaN MMIC power amplifiers achieve 1000 hours of reliable operation

Raytheon's GaN MMIC power amplifiers have achieved 1000 hours of reliable operation with no measurable performance degradation.

The increased reliability and efficiency of GaN can result in lower prime power consumption and relaxed cooling requirements, says Raytheon. GaN T/R (transmit/receive) modules can hence provide much higher long-pulse RF power than that of standard

GaAs T/R modules, the firm adds.

"This milestone enables us to insert GaN next-generation capability into a multitude of air and missile defense programs," says Pete Franklin, VP for National & Theater Security Programs at Raytheon IDS. "GaN will also give the warfighter significantly more mobility, capability and reliability on the battlefield," he adds.

www.raytheon.com

Accel-RF launches high-power RF automated accelerated reliability test system for GaN devices

Accel-RF Corp of San Diego, CA, USA, which produces accelerated life-test/burn-in test systems for RF devices, has launched the High Power RF (HiPR-AARTS) Automated Accelerated Reliability Test System to help manufacturers prove reliability for application-specific devices.

Accel-RF says that manufacturers are using its equipment to prove intrinsic reliability and performance degradation characteristics of gallium nitride (GaN) technology on discrete devices and lower-power monolithic microwave integrated circuits (MMICs). The next stage in the development of the technology is to build and test high-power devices for use in radar and military and communication electronics.

"As reliability is proven on lower-powered devices, the technology evolution is moving toward high-



Accel-RF's High Power RF Automated Accelerated Reliability Test System.

power GaN, MMICs, HEMT and HFET devices that require significant advancements in reliability testing equipment," says president & founder Roland Shaw. The new system is either liquid or air cooled,

has RF and DC pulsing capability, and can handle device power dissipation of up to 200W each. "This new system can manage over seven times more power than our current-generation product. This capability allows our customers to lifetest their products at channel temperatures in excess of 300°C, with performance characterization at normal operating temperature levels," Shaw adds.

"In addition to our customers, compound semiconductor manufacturers, specifically Wide Band-Gap initiative partners and Tri-Services component teams, are currently pushing the capabilities of our existing products," says Shaw. "Our new High Power RF Reliability Test System will give our customers plenty of capability to prove reliability of new technology in real-life conditions," he concludes.

www.accelrf.com

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Dow Corning ships low-defect 4-inch SiC substrates; work underway on wafers up to 6 inches in diameter

Materials giant Dow Corning says that it is now shipping its low-defect silicon carbide (SiC) substrates in volume quantities.

Last year at the European Conference on Silicon Carbide and Related Materials (ECSCRM), the US-headquartered firm reported that it had significantly improved micropipe densities, to about 10 such defects per square centimeter of material.

Jim Helwick, the director of Dow Corning's Compound Semiconductor Solutions division, said that the progress detailed then had now been applied to commercial products: "The new technology has been incorporated into wafer sizes up to 4 inches in diameter thus far, with work underway to exploit [it] in even larger diameter wafers up to 6 inches... In fact, we are seeing an improvement in defect densities as the diameter is increased," he added.

Reducing the level of defects in SiC semiconductor material is seen as a significant step in the wide-bandgap semiconductor community's efforts to stimulate the broad adoption of SiC-based devices.

Those devices have the potential to be used in high-power electronic applications such as communications, solar and wind energy systems, electrical distribution, and hybrid and electric vehicles — provided that production yields are sufficiently high to allow cost-effective manufacturing.

"We now have the wafer and epitaxy technology and high-volume production capabilities to supply our customers' growing needs for affordable, leading-edge SiC products," Helwick said.

Dow's 4H-SiC material — the polytype most widely demanded for SiC electronics — has been available in 3-inch format for some time.

The new technology has been incorporated into wafer sizes up to 4 inches in diameter thus far, with work underway to exploit [it] in even larger diameter wafers up to 6 inches

On its website, the firm quotes a typical bow of 6 μ m for those wafers, and a typical warp of 17 μ m.

The US firm is just one of a host of SiC wafer suppliers hoping to cash in on the anticipated market for wide-bandgap electronics as the technology becomes more widespread.

Rivals in Europe include France-based NovaSiC and Germany's SiCrystal. In the US Dow Corning competes with Cree and SemiSouth. Over the past couple of years, the first Chinese competitor has also emerged, in the form of TankeBlue.

At October's International Conference on Silicon Carbide and Related Materials (ICSCRM) in Nuremberg, Germany, SiCrystal will give an invited talk on its own development of high-quality 4-inch SiC substrates.

Meanwhile, Japanese giant Nippon Steel will detail its progress towards large-diameter 4H-SiC crystals. In the past, Japanese car companies Honda and Nissan have been at the forefront of SiC device development for applications in electric vehicles.

www.dowcorning.com/compoundsemiconductor

By Michael Hatcher.

SemiSouth awarded new SiC power JFET patents

SemiSouth of Starkville, MS, USA has been awarded its third US patent of 2009, and its 18th overall in SiC power electronics technology. The patents cover methods of making normally-off SiC JFETs, self-aligned SiC fabrication methods, and the integration of SiC JFET, diodes, and circuits.

Dr Jeff Casady, chief technology officer & VP of business development, says that the recent patents were the result of focused efforts, led by SemiSouth engineers, in pushing the technology forward for both near-term and long-term products. "Our normally-off SiC JFET, the most energy efficient and cost-effective SiC power transistor

switch, is an extremely important product to SemiSouth. After sampling the product globally for over one year, we are seeing very positive signs of adoption by our customer base in solar inverters, telecom power supplies, and other applications," he adds.

"These specific patents allow us to further strengthen the intellectual property we have around the normally-off SiC JFET, including different process designs and methods to integrate for added chip functionality in the future," comments Dr David Sheridan, director of engineering.

SiC can enable energy-efficient operation of power conversion and

power management in telecom power supplies, inverters in solar and high-frequency welding, future automotive electric vehicle platforms, and many other products, says SemiSouth.

The promise of SiC is its ability to make power supplies and power inverters up to 50–75% more energy efficient, operate at up to between four and eight times higher frequency, and as a result run cooler and be physically much smaller in size (e.g. SiC power JFETs are expected to increase the 'fuel' efficiency of hybrid electric vehicles and help make them more affordable).

www.semisouth.com



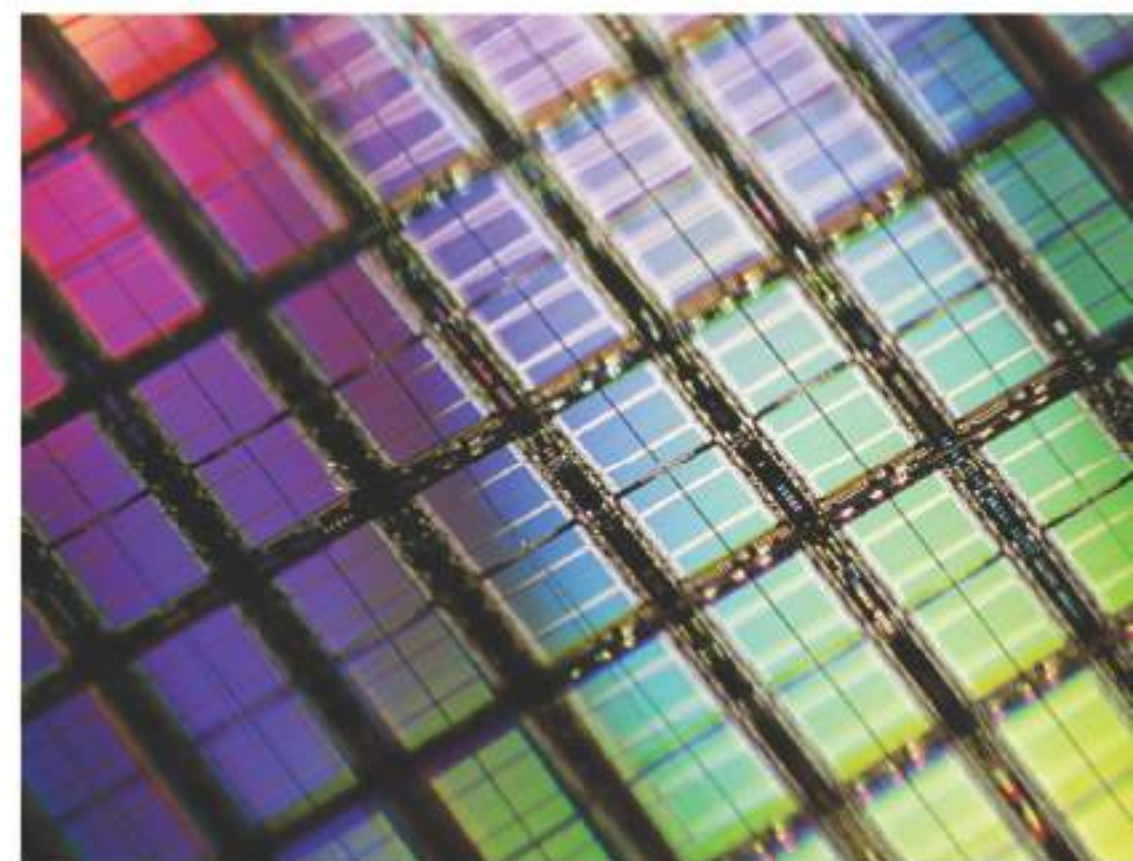
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IN BRIEF

IQE recruits directors of Wireless Product Sales and New Technologies in USA

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has appointed Kent Wardley as director of Wireless Product Sales (US) and Dr Walter Wohlmuth as director of New Technologies (US).

Wardley has over 20 years business development, sales and marketing experience within technology firms including Hewlett Packard, Epitaxx and Wireless Telecom Group. Most recently, he was VP sales for wireless module maker Ezuiro (acquired by Laird Technologies). Wardley will be based in New Jersey and responsible for expanding IQE's wireless business in the USA and Canada to boost the firm's market share.

Wohlmuth has wide experience of advanced semiconductor material design across a range of market sectors including digital, wireless technology and solar cells at firms such as RFIC makers TriQuint Semiconductor and RF Micro Devices as well as CdTe PV maker First Solar. He will be responsible for expanding business in the USA and Canada, mainly in the area of concentrated photovoltaic epitaxial materials.

IQE's wireless portfolio includes III-V PHEMT, HBT, and BiFET epi-wafers grown by MBE and MOCVD at manufacturing/epi-reactor sites in the USA, UK and Singapore.

The two appointments follow July's announcement of the appointment of Brian VanOrsdel as director of North American sales & strategic accounts for IQE's optoelectronic product portfolio.

www.iqep.com



Orders return to pre-recession levels at IQE

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has reported a sharp recent increase in orders, with senior managers now expecting a strong financial performance in the second half of 2009.

According to the UK-headquartered firm's latest trading outlook, orders have returned to pre-recession levels in the past couple of months, following the so-called 'de-stocking' period during which III-V device makers sought to protect themselves from the unfolding economic crisis. With that period now seemingly over, IQE's orders have been ticking up strongly since May.

In first-half 2009, IQE's sales showed the impact of the de-stocking exercise — with revenues diving to £21.4m (\$34.6m) from the figure of £30.2m registered in first-half 2008.

That translated to an operating loss of £0.8m, although the impact of the global slump on IQE's bottom line was mitigated after some significant cost-cutting measures.

In particular, IQE has kept a very tight rein on capital expenditure, which fell from £3.4m in the first six months of 2008 to only £0.7m in the opening half of 2009. It also reduced staff numbers significantly at the onset of the recession in late 2008.

CEO Drew Nelson highlighted the impact that the smartphone market, which has so far proved resilient to the recession, has had on the renewed demand for GaAs-based epiwafers. "Our core smartphone market has recovered quickly and is now growing rapidly as phones become more connected and multi-functional."

More smartphones means more GaAs-based semiconductor content and, according to a recent forecast from the market analyst company

Parks Associates, there will continue to be strong demand. The firm's Harry Wang predicts that annual shipments of smartphones like the Blackberry, Apple's iPhone, and Palm's new 'Pre' handset will grow at a compound annual rate close to 20%, reaching 310m units by 2013. That is more than double the current figure of 130m, suggesting that a lot more GaAs epiwafers will be needed to meet market demand over the next few years.

IQE's targeting of device makers focused on the smartphone market should be helped by its latest recruit. Walter Wohlmuth, who has just been hired as IQE's director of new technologies in the USA, was previously at TriQuint Semiconductor and RF Micro Devices, two of the world's biggest manufacturers of cellphone power amplifiers.

At TriQuint, Wohlmuth helped to pioneer the development of GaAs

Our core smartphone market has recovered quickly and is now growing rapidly as phones become more connected and multi-functional

BiFET devices, one of the technologies that is benefiting strongly from the growing demand for high-end mobile handsets. With

more recent experience in the photovoltaics sector at First Solar, Wohlmuth will also be responsible for expanding IQE's solar cell business in the USA and Canada.

IQE has reported 'excellent' progress in the development of III-V solar cells, claiming that its customers are now achieving record photovoltaic efficiencies with its epitaxial materials.

By Michael Hatcher.

Neo Material buys Recapture Metals

Toronto-based Neo Material Technologies Inc, which produces neodymium-iron-boron magnetic powders, rare earths and zirconium-based engineered materials for applications including cell phones and micro-chips, has agreed to buy privately held Recapture Metals Ltd of Peterborough, Ontario, Canada.

Recapture produces, reclaims and refines high-value niche metals and their compounds used mainly in the wireless, LED, flat-panel, solar and catalyst industries, including gallium and indium. As well as high-purity gallium, Recapture manufactures gallium trichloride for producing organometallic Ga compounds.

Primary gallium production takes place in Stade, Germany and secondary gallium production in both Peterborough and Blanding, UT, USA. The firm has about 65 staff in total. Revenues in 2007 and 2008 were CDN\$24.1m and CDN\$22.5m.

Neo is issuing 4.5m new common shares and paying CDN\$6.5m

(US\$6m) in cash to Recapture's shareholders. Neo is also making additional payments in cash or new common shares, at Neo's option, conditional upon certain EBITDA targets for three calendar years (starting in 2010) being met.

"This acquisition provides Neo with a solid platform and is a first step in our stated strategy to diversify into other complementary rare elements and specialty materials," says CEO Constantine Karayannopoulos.

"Strong hydrometallurgical skills in both primary production and recycling coupled with Neo's global sales organization, technical skills and presence in Asia make a powerful combination." Neo has 1300 staff in 15 sites across 10 countries, including processing units in China.

"Neo will provide experience, resources and diversification to further facilitate growth and implementation of our long-term vision," says Recapture's president Larry Seeley.

www.neomaterials.com

IN BRIEF

MCP forms Chinese gallium JV with Golden Harvest

UK-based Mining & Chemical Products (MCP Group), which manufactures gallium chemicals including gallium trichloride, gallium oxide and gallium nitrate, and China's Golden Harvest Ltd have formed the joint venture MCP Crystal Ltd to expand production of gallium in China.

The new venture consists of four operations in China: three 99.99% (4N) plants owned by Golden Harvest and MCP Shenzhen (with estimated output of 70-80 tonnes per year), and a high-purity plant that produces 99.9999% (6N) gallium and 99.99999% (7N) gallium.

"We see continuous growth in all of Asia," says MCP Group's commercial director Sean Fuller.

www.mcp-group.com

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LayTec moving to expanded HQ before 10th anniversary

In September, LayTec GmbH of Berlin, Germany, which provides in-situ thin-film monitoring systems, is moving to a new office that is twice as large as its existing facility. The firm says that it will now have more labs for R&D, as well as more room for production and quality control, customer seminars and hands-on training.

Also, on 9 October, LayTec will hold an 'Oktoberfest' party at the new office to celebrate the 10th anniversary of the firm's formation. In the late 1990s, CEO Dr Thomas Zettler and his team at the Technical University of Berlin developed and patented the first real-time epitaxy monitoring tool based on reflectance anisotropy spectroscopy (the Epi-RAS). LayTec was subsequently spun off in October 1999.

The firm currently provides solutions for monitoring MOVCD,



LayTec's new building in Berlin.

MBE and other thin-film growth processes (two thirds of the firm's installed equipment is in production

line applications for LEDs). However, since 2006 the application range of its in-situ monitoring systems has been expanded to amorphous and organic thin-film growth processes, e.g. sputter deposition, vapor thermal evaporation (VTE), and organic vapor phase deposition (OVPD).

LayTec says that in 2008 it recognized the strong demand from manufacturers of solar cells based on copper indium gallium diselenide (CIGS) and cadmium telluride (CdTe). Within a year, it received its first orders for SolR — its first in-line monitoring system for photovoltaic thin-film application (launched this February). LayTec is now cooperating with partners to further develop metrology solutions for the entire range of photovoltaic thin-film processes.

www.laytec.de

Mitsubishi orders MOCVD system for white HB-LEDs

Deposition equipment maker Aixtron AG of Herzogenrath, Germany says that Tokyo-based Mitsubishi Chemical has ordered an AIX 2800G4 HT Planetary Reactor MOCVD system, for delivery in 42x2-inch wafer configuration for the production of InGaN-based white ultra-high-brightness (UHB) LEDs.

Having already made considerable progress in the mass-production of phosphors for high-brightness white LEDs, Mitsubishi Chemical is

about to complete the next stage in its strategic plan. With the aid of the AIX 2800G4 HT Planetary Reactor, the firm aims to rapidly transition from UHB LED development to volume production. Combining this with its phosphor capabilities, Mitsubishi Chemical says that it should soon be manufacturing white LEDs for applications including display backlighting and solid-state lighting.

The ongoing strategic plan also involves Mitsubishi Chemical Corp's

absorption in April of Kasei Optonix Ltd of Naruta, Japan (a subsidiary of Mitsubishi Chemical Holdings Corp that produces phosphor products, as well as x-ray field products and piezo-electric devices) by acquiring the remaining 2.6% stake belonging to Dai Nippon Toryo Co Ltd. Mitsubishi Chemical reckons that the merger should further strengthen its phosphor business for white LEDs and flat-panel displays.

www.aixtron.com

Nanjing's Institute of Optoelectronics orders MOCVD system

Aixtron says that in first-half 2009 it delivered an AIX 2400G3 HT MOCVD system to Nanjing University's Institute of Optoelectronics (IOE) at Yangzhou City. The system will be used to develop ultra-high-brightness (UHB) InGaN/GaN-based LEDs.

The Institute of Optoelectronics was established in December 2007

on the basis of a collaborative agreement between Nanjing University and the Yangzhou local government. Located in Yangzhou High-tech Venture Services Center, IOE has work space of over 1500m² and researches the epitaxial growth, processing and development of novel optoelectronic devices.

"After a complete investigation and in consultation with local experts, the Aixtron MOCVD system was confirmed as the first choice for our GaN LED research projects," says Institute of Optoelectronics director Dr Chen Peng. "We are building new capacity and exploring leading LED science and technology," he adds.

Johnson Matthey ships hydrogen & nitrogen purifiers for PV making

Johnson Matthey of West Chester, PA, USA, which designs and manufactures bulk and point-of-use hydrogen and nitrogen purifiers, has recently shipped several palladium and getter purifiers that should enable further advances in photovoltaic (PV) manufacturing.

"These latest shipments reaffirm our commitment to support the ongoing growth of the global electronics industry, particularly the rapidly expanding demand for PV applications," says Stuart Bestrom, sales manager for the firm's Gas Purification Technology (GPT) group.

A major North American semiconductor company is using JM HP Series V-purge purifiers to support its diversification into indium nitride (InN) high-efficiency solar cells. A purifier is installed on each MOCVD reactor to provide high-purity hydrogen during the growth process. The purifiers use palladium membrane technology to allow selective diffusion of hydrogen in a compact system with continuous monitoring of operating status.

Incorporating Johnson Matthey's palladium membrane technology (as well as patented V-purge technology to ensure quick start-up and rapid removal of hydrogen during power failure and other alarm conditions), the PSH Series hydrogen purifiers offer a single-system solution for hydrogen flow rates of 10–60Nm³/hr. They accept inlet gases with a purity of 99.9% or better and employ a catalytic pre-purifier to protect against oxygen impurity spikes. Designed for installation in Class I, Division II environments, they are PLC-controlled with a color touch-screen HMI interface and provide continuous monitoring of purged electrical bays to ensure safety compliance.

Bestrom also says that a major US-based manufacturer of thin-film solar cells and modules (suited to large-scale utility applications, including solar farms) has installed

several PSH-40 JM hydrogen purifiers at its fab in Shenzhen, China for purifying hydrogen used in amorphous silicon thin-film manufacturing. "The China PV market is projected to grow 30% annually for the next several years, so JM expects to see ongoing orders for PV applications," says Sean Peng, Asian sales manager of Gas Purification for GPT, which handles JM's GPT sales, training and service in China.

Palladium membrane technology is preferred by PV and semiconductor fabs for use with the compressed hydrogen supply common in Asia and particularly China, says Bestrom.

"Purification of compressed hydrogen is challenging because it has ppm (parts per million) levels of oxygen, hydrocarbon and nitrogen impurities that are difficult to remove using catalytic or getter purifiers," he adds. "Customers have reported premature breakthrough and shortened lifetimes with regenerable and heated getter purifiers and this unanticipated maintenance means increased cost-of-ownership," he explains.

"Palladium purifiers remove these ppm-level impurities (O₂, H₂O, CO, CO₂, N₂ and THC) without affecting lifetime, yet still provide outlet purity less than 1 part per billion."

Another application for GPT's hydrogen and nitrogen purifiers is in the production of silicon powder used to manufacture solar wafers. A large Europe-based renewable energy company is using multiple HP Series V-Purge hydrogen purifiers and PureGuard heated getter nitrogen purifiers to eliminate oxygen and nitrogen contamination during powder production. "The company requires ppt (parts per trillion) purity to prevent even the smallest contamination that can compromise wafer quality," says Bestrom. "This process was developed in R&D and then transferred to a higher-volume production line."

www.pureguard.net

IN BRIEF

Veeco wins multi-system MOCVD order for Lumileds' LUXEON LED production ramp

Epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview, NY, USA has received a multi-system order for TurboDisc K465 gallium nitride (GaN) metal-organic chemical vapor deposition (MOCVD) systems to be shipped to high-power LED maker Philips Lumileds Lighting Company of San Jose, CA, USA over the next two to three quarters in order to support its production ramp of LUXEON LEDs.

"Veeco's K465 ultimately provides a high level of automation, helps us reduce manufacturing costs, and provides a flexible platform as we look to the future," says Lumileds' chief procurement officer Mike Pugh. "Additionally, our confidence level in working with Veeco's systems and services is very high," he adds.

"The TurboDisc K465 has been designed to help customers seamlessly transition to larger wafer sizes, which we believe will be increasingly important to ensure a long capital life, lower customers' cost of ownership and increase their productivity," comments Veeco's CEO John Peeler.

Veeco says that its TurboDisc K465 GaN MOCVD system is the only production-proven, fully automated MOCVD platform that is available on the market. The K-Series MOCVD platform includes the K300 and K465 models, offering a modular, upgradeable path to a higher-throughput, larger-diameter reactor chamber and reduced cost of ownership, the firm adds.

www.veeco.com

IN BRIEF

Evatec and CORIAL to cooperate

Thin-film deposition and etch system maker Evatec Ltd of Flums, Switzerland (home of the Balzers BAK evaporator) and CORIAL SAS of Meylan, France, which designs and manufactures RIE, ICP, HDP and PECVD plasma etching and deposition equipment, have signed an agreement to deliver processes and platforms for the optics, optoelectronics and semiconductor markets.

Among the first benefits will be the availability of CORIAL's unique plasma technology capability on Evatec's new Radiance cluster tool. The first Radiance, launched at Semicon Europa 2008, has already been delivered to MiPlaza (Microsystems Plaza, part of the Philips Research organization at Eindhoven) and is suited to precision optics, optoelectronic, and semiconductor applications.

CEOs Andreas Waelti (of Evatec) and Marc Derbey (of CORIAL) comment that the agreement makes significant steps for both firms in meeting the demands of their many shared customers. "Our cooperation will extend far beyond addition of CORIAL's plasma technology to Evatec's existing process platforms and we will build on the strengths of both companies to create a 'Thin Film Powerhouse' for high-performance processes," says Waelti. "The new agreement means we can offer our customers seamless transition in process and production platform whatever their volumes in typical applications including sensors, displays and MEMS."

The cooperation will also extend beyond technology, with the two firms strengthening their links through sharing a common sales and service organization in many markets around the globe.

www.evatecnet.com
www.corial.net

Lam cuts losses as revenue grows 25%

For its fiscal fourth-quarter 2009 (ended 28 June), etch and wafer-cleaning equipment maker Lam Research Corp of Fremont, CA, USA has reported revenue of \$217.8m. Though still down 62% on \$566m a year ago, this is up 25% on last quarter's \$174.4m.

"Business conditions improved in the June quarter, contributing to Lam's ability to show improved financial results for the quarter," says president & CEO Steve Newberry. "Revenues increased as a result of customer investments to add wafer starts at the leading edge in both foundry and memory, as well as higher fab utilization contributing to improvement in the customer service business," he adds. Ongoing gross margin has risen from 26.8% to 31.1%, due mainly to improved factory and field utilization.

Operating expenses have been cut from \$128.9m to \$114.3m, driven

by a full quarter savings in employee-related expenses and other cost-reduction measures that were part of the March quarter's restructuring. On 20 November, Lam announced restructuring activities and other cost-reduction actions targeted at reducing expenses by \$15-20m per quarter.

Ongoing net loss has been cut from \$89.8m last quarter to \$57m. During the quarter, cash and cash equivalents, short-term investments and restricted cash and investments balances fell from \$806.4m to \$757.8m.

"While we are encouraged that our customers have increased spending on equipment, we plan to maintain our focus on cash management while continuing our strategic investments in leading-edge solutions for our customers' current and next-generation wafer fabrication needs," says Newberry.

www.lamresearch.com

Veeco launches dicing system for solar, LED and optics applications

Veeco Instruments Inc of Plainview, NY, USA has introduced the Optium ADS-800 Series Advanced Dicing System to provide high-productivity dicing for a broad range of demanding applications, including high-brightness LEDs, solar cells, optics, and microelectronics, in R&D environments, pilot-line production and high-volume production. The ADS-800 offers repeatable cut quality of devices at what is claimed to be unprecedented throughput compared to other dicing systems.

"Our new ADS-800 Series Advanced Dicing System incorporates over 30 years of dicing expertise, offering high throughput and precise cutting of premium devices, critical for emerging markets such as LED and solar," says executive VP Robert P. Oates. "We are able to reduce manufacturers' dicing saw capital costs by over



Veeco's Optium ADS-800 Series.

40% due to our tool's highly rigid cast-iron structure, high-performance air-bearing spindle and multi-blade cutting technology," he adds.

www.veeco.com

OIPT launches Nanofab800Agile deposition system for controllable nanostructure growth

Etch and deposition equipment maker Oxford Instruments Plasma Technology (OIPT) has extended its Nanofab range of flexible tools and processes, which deliver catalyst treatment and controllable growth of nanotubes and nanowires, as well as delivering standard and high-temperature plasma-enhanced chemical vapor deposition (PECVD).

The firm says that the new Nanofab800Agile system provides development opportunities to influence the growth of nanostructures. With a temperature of up to 800°C and agile heating and cooling for rapid turnaround, the system also delivers control of nanostructure alignment and dimensions.

Additional benefits include variable sample sizes (up to 200mm wafers, maximum), excellent temperature uniformity, and agile temperature control, the firm claims. The system



Oxford Instrument's new Nanofab800Agile system.

is also configured with a vacuum load-lock to ensure process repeatability and chamber cleanliness.

Featuring an optional liquid source delivery system, and with custom-developed setup for aligned growth

and control of film stress, the Nanofab800Agile has the ability to process in high-pressure and high-flow regimes.

"This latest addition to our range means our customers will benefit

Oxford Instruments says that the new Nanofab800 Agile system provides development opportunities to influence the growth of nano-structures

www.oxford-instruments.com

from advanced features, such as rapid heating and cooling cycles, excellent temperature uniformity and process control," says senior product manager Ian McKinlay.

"This is backed up by OIPT's extensive process library and applications expertise."

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www.oxford-instruments.com/semi



The Business of Science®

Kulicke & Soffa launches ConnX-LED automatic ball bonder to increase efficiency and productivity

At the 11th China International Optoelectronics Expo at Shenzhen Convention and Exhibition Center (6–9 September), chip assembly equipment and packaging materials supplier Kulicke & Soffa Industries Inc (K&S) of Fort Washington, PA, USA is extending its ConnX bonding platform by launching the ConnX-LED automatic ball bonder.

With new features and enhancements specifically designed for LED applications, K&S says that ConnX-LED can help to increase efficiency and productivity, and meet the challenges of the fast-paced, high-growth LED market.

The firm says that the ConnX-LED has all the features required for bonding LED packages, including

accuracy to $\pm 3.5\mu\text{m}$, automatic recovery paths for common production stoppages, and programmable back-up power, reducing cost of ownership in a highly competitive market space.

ConnX-LED joins the iStack, ICONN ConnX and ConnX-VLED in Kulicke & Soffa's Power Series platform for next-generation assembly equipment in challenging applications. Driven by what is claimed to be the most powerful X-Y-Z motion control system available on the market, the firm says that its Power Series products deliver high levels of speed, accuracy and throughput for reduced cost of ownership for the segment that the respective model serves.

"Recent industry research projects a 20% annual growth rate in total LED demand through 2012, as LED backlight displays and energy-saving lighting solutions continue to penetrate their market niches," says chairman & CEO Scott Kulicke. "The launch of ConnX-LED is just one of the steps we've taken recently to optimize our product portfolio and distribution approach to address this market, one we have not traditionally served," he adds. "We are now well positioned with the right products and sales infrastructure to gain meaningful share in this important and growing segment," Kulicke believes.

www.kns.com

Nano-imprint lithography system maker Obducat wins its first order from Russia

Obducat AB of Malmö, Sweden, which supplies systems based on nano-imprint lithography (NIL) and electron-beam lithography, has won its first order from Russia.

Due for delivery in third-quarter 2009 to the Russian Academy of Sciences' Institute of Semiconductor Physics in Novosibirsk, Siberia, the NIL Eitre 6 system (worth slightly more than SEK3m) will be used primarily in the R&D of nano-electronics and photonics. The institute has more than 200 staff performing research in micro- and nanoelectronics, photonics and information technology.

The institute's research will in future hence be conducted using

Obducat's patented IPS-STU (Intermediate Polymer Stamp — Simultaneous Thermal and UV) process technology, the firm says.

"Getting an early foothold in the Russian market is of vital importance, seeing that it will allow us to create connections with this customer's partners, i.e. institutions and companies that may be future customers," says Obducat's CEO Patrik Lundström. "In the light of the investments that RUSNANO, the Russian Corporation of Nanotechnologies, is planning in areas such as LED and solar cells, there is a clear possibility of strong growth potential in this market in the years to come," he adds.

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

The aim is to support the development of the Russian nanotechnology-based industry towards the global market, and the establishment of partnerships with nanotechnology centres around the world.

www.obducat.com

Toshiba selects Obducat nano-imprint lithography technology

Early in August, Obducat received an order from its distributor Canon Marketing Japan for an NIL system to be delivered to electronic and electrical product maker Toshiba

for R&D in several key application areas including optoelectronics.

Obducat says that its technology was selected from among a range of suppliers after several evalua-

tions of imprint trials (using its IPS and STU processes), claiming that its NIL technology demonstrated the best imprint quality with minimum defects.

Nanometrics' founder & vice-chairman Coates resigns from board

Nanometrics Inc of Milpitas, CA, USA, a supplier of process control metrology systems primarily for manufacturing semiconductors, solar photovoltaics and high-brightness LEDs, says that founder & vice-chairman Vincent J. Coates has resigned from its board of directors.

Coates founded Nanometrics in 1975 and was chairman until July 2007. He developed the first NanoSpec tool as a general-purpose instrument targeted at bio-technology and industrial applications but, after some early applications wins in thin-film metrology for semiconductor devices, he quickly changed the target and focus of the business. Since the launch of the first NanoSpec 10, the firm developed multiple product lines addressing many aspects of process control and metrology for the semiconductor

industry, while still supporting the original NanoSpec line for broader industry use.

In 1995, SEMI recognized Coates with a lifetime achievement award for his work in scanning electron microscopy. He currently holds more than 20 US patents.

"His contributions to the company culture and technology have been key factors that have contributed to Nanometrics' success," says chairman Bruce Rhine. "We look forward to his continuing contribution as a member of our Scientific Advisory Committee [which he has chaired since July 2007]."

Nanometrics adds that, effective immediately, Norman Coates has re-joined its board of directors (which is his third tenure on the board).

www.nanometrics.com

Honeywell thermal management material to boost LED performance

Honeywell of Morris Township, NJ, USA has developed the LTM6300-SP thermal interface material, which it claims can improve the energy efficiency of LEDs through effective transfer of heat generated by LED lamps.

As LEDs become smaller, faster and more powerful, more heat is being generated in a confined space, which can damage the LEDs' performance. If LEDs overheat, they become dim, their color is muted and their lifespans are shortened.

As semiconductor devices, LEDs require more precise heat management than traditional light sources, the firm adds. Honeywell says that its thermal management materials are designed to meet this specific challenge, helping to effectively transfer heat in semiconductor applications.

LTM6300-SP is a high-thermal-performance phase-change mater-

ial that is claimed to be superior to silicone-based products, which typically pump out and degrade at high temperatures. Based on the firm's packaging expertise in thermal management, LTM6300-SP is designed to be used mainly as a screen-printable paste and complements Honeywell's other thermal interface products.

"LTM6300-SP is the first in a series of HEM [Honeywell Electronic Materials] phase-change materials being developed for the growing LED segment," says Brian Daniels, chief technology officer of HEM (part of Honeywell Specialty Materials). LTM6300-SP was designed for LED backlights for flat-panel displays, but the packaging technology can be also implemented in LEDs used in a wide range of applications, from automobiles to computers.

www.honeywell.com/em

IN BRIEF

JPSA recruits Tekcore co-founder as director of LED business development

JPSA of Manchester, NH, USA, which makes UV laser-based materials processing workstations for wafer processing and micromachining, says that Nithi M. Nithipalan has joined as director of International Business Development for the LED industry. He will lead JPSA's efforts in marketing, sales and product development, targeted at the high-growth global LED industry.

"His extensive experience in international business and his intimate knowledge of the LED industry is precisely what JPSA needs to guide us as we continue to expand our LED business internationally," says president Charles Cuneo.

Nithipalan has more than 31 years of experience working at international technology companies, including several of the leading manufacturers of LEDs. Most recently, he was CEO & president of Seoul Optodevice Company Ltd in South Korea, a subsidiary of LED maker Seoul Semiconductor Co Ltd. Previously, he was president & CEO of Tekcore Co Ltd in Taiwan, which manufactures high-brightness GaN-based LEDs. Nithipalan co-founded Tekcore and, while there, completed an IPO of the company's stock.

Nithipalan also has a BSc in Civil Engineering degree from the UK's University of Surrey and a post-graduate diploma in Mechanical Systems from University of Alberta, Canada.

www.jpsalaser.com



international business and his intimate knowledge of the LED industry is precisely what JPSA needs to guide us as we continue to

Korea completes its longest LED street-lamp installation

In line with the South Korean government's call to implement more energy efficient solutions, Wonju City in Gwang Won province has completed the country's longest LED street-light installation to date.

Incorporating a total of 37,440 cool-white Golden DRAGON Plus LEDs from Osram Opto Semiconductors GmbH of Regensburg, Germany, 520 PRAUS 150W LED-based street lamps from Korean firm GALED Co Ltd have replaced traditional MH 250W and 400W street lamps along the road from Wonju interchange to South Wonju interchange. GALED expects the LED-based street lamps to save 48% on power consumption, while the total cost of ownership can be further reduced due to the LEDs' 50,000 hour lifetime (minimizing maintenance and replacement costs).



Korea's longest LED street-light installation: 520 lamps use 37,440 Golden DRAGON Plus LEDs.

"We continue to work with local Korea governments to provide them with high-quality and energy- and cost-efficient lighting solutions to meet their needs," says GALED CEO Gi-Seon Jeon. "In conjunction with our partner Osram Opto Semiconductors, we are able to provide energy-efficient, high-brightness, customizable lighting solutions."

"Osram is committed to providing lighting solutions that maximize the return-on-investment for not only our customers like GALED, but for the governments and municipalities that are depending on cost-effective, high-quality lighting products," says Dr Alfred Felder, president & CEO of Hong Kong-based subsidiary Osram Opto Semiconductors Asia Ltd.

The Korea government plans to replace all incandescent light bulbs at public facilities with more energy-efficient LED bulbs by 2012. Stressing the importance of energy conservation in the current economic environment, President Lee Myung-bak has instructed local Korea government chiefs to focus on ways to reduce energy consumption in their regions.

www.galed.co.kr

All-LED lighting installed in Osram Opto's reception building

Osram Opto Semiconductors claims its recently completed reception building in Regensburg is one of the first buildings in Germany to be lit inside and out exclusively by LEDs.

Over 4500 white and colored LEDs provide the accent, effects and room lighting, enabled by new LED systems that have a wide array of colors and a very high light yield. Due to their small size, they save space and can be fitted inconspicuously, increasing options in general lighting applications, the firm says.

Osram Opto says the new building acts effectively as a showroom, displaying applications that can be implemented today. Using lights from various suppliers, it demonstrates how white and colored LEDs can not only create an atmosphere via accent and effects lighting but also illuminate rooms and workspaces in an energy-efficient way, the firm adds.

Many of the LEDs in the reception area are dimmable; brightness can be adjusted between 5% and 100%. Presence and daylight sensors in

the washrooms ensure that light is only used when needed. Along with general energy efficiency, this enables savings of 35% with white LED lighting versus conventional light sources, the firm reckons. Also, with a life-span of more than 50,000 hours, they are very durable and almost maintenance-free.

A 17m² wall of light, consisting of a highly elastic, translucent foil only 0.4mm thick, provides variable lighting conditions. In the panel's frame there are LED strips (LI-EX profiles) that emit light sideways (parallel to the wall). The profiles of luminaire maker LI-EX on the upper and lower screen frames are fitted with Osram's warm-white and cold-white Golden Dragon Plus LEDs, the profiles on the right and left with colored Golden Dragon RGB LEDs. So, the wall can dynamically display all the chromaticity coordinates between warm and cold white as well as colors and moving color transitions.

LED strips in red, green and blue were also installed behind the 4m²

glass area of the visitor counter, enabling varied lighting set-ups. Behind the counter, LEDs backlight the monitors and provide lighting for an ergonomic and fatigue-free working environment, says the firm.

LEDs also set the tone in other areas of the building. White Power TOPLEDs were used for the mirror and ceiling lighting in the lavatories as well as for accent lighting on door frames. Outside LEDs light the pathway and handrail. Also, there are almost no visible lamps and light switches in the building (the wall of light is controlled via a Traxon touch-wheel, for example).

"Illuminating the building with LEDs all-round proves that the LED technology has left its niche," claims project manager Artur Grösbrink. "It can be used in any area of professional lighting and is also eminently suited for showcasing rooms and buildings. Decorative effects are just as feasible as stimulating workspace or atmospheric room lighting," he adds.

www.osram-os.com

Osram claims smallest 1W LEDs for backlighting LCDs

Osram Opto Semiconductors GmbH of Regensburg, Germany has introduced what it claims is the smallest 1W LEDs for backlighting LCD panels.

Measuring just 3mm x 3mm x 1.6mm and integrating an polynomial lens (with a beam angle of 125°) with optimized beam characteristics for maximum light extraction, the two white versions of the new OSOLON LX LED allow efficient side injection of almost 80% of the emitted light into light guides with a thickness of just 2–4mm. This enables the manufacture of ultra-thin-profile displays.

The OSOLON LX is manufactured using the firm's latest ThinGaN chip technology with chip-level conversion, and provides high optical efficiency and extremely uniform distribution of light, the firm claims. The substrate and lens materials are optimized for very long lifetimes, exceeding those of CCFLs



An optimized lens can inject almost 80% of the OSOLON LX's light into a light guide.

(cold-cathode fluorescent lamps).

The compact LED format and high light output (typically 75lm or 90lm at an operating current of 350mA) is sufficient to inject the light from two sides or even from only one side to provide uniform backlighting for computer monitors and TVs of up to 65-inches in diagonal size.

The OSOLON LX is available for two color spaces. The multi-white

version (high color gamut white) covers 100% of the sRGB color space and has a typical light output of 75lm. The ultra-white version covers 80% of the sRGB color space and has a typical light output of 90lm.

"Manufacturers who require only 80% of the sRGB standard, such as in data processing or industrial applications, can opt for the more efficient ultra-white version, enabling them to achieve the required brightness level with fewer LEDs and with up to 30% savings in costs," says Winifred Schwedler, marketing manager for LCD Backlighting. "So, every customer can have precisely the LEDs that they need for their particular application."

TVs equipped with OSOLON LX LEDs were premiered at the 2009 IFA show in Berlin (4–9 September).

www.osram-os.com

Compact LEDs for daytime running lights in mid-range vehicles

Osram Opto Semiconductors GmbH of Regensburg, Germany has launched the OSOLON MX ECE and OSOLON SX ECE LEDs — low-cost, high-power ceramic components designed for use in daytime running lights in the front light clusters of mid-range vehicles. The firm says that the new LEDs are a key new addition to its automotive lighting portfolio, which consists of millions of LEDs currently in use in the rear light clusters, the brake lights and the daytime running lights of vehicles on the road.

The MX ECE and its lower-power sister component, the SX ECE, are positioned between Osram's Advanced Power TopLED and Golden DRAGON, supplementing the range in terms of both performance and price. Both LEDs address the increasing acceptance of daytime running lights outside the luxury and top-of-the-line automotive markets.



Osram's OSOLON MX ECE LED.

Both LEDs are compact (just 3mm x 3mm) and use Osram's latest ThinGaN chip technology. The MX ECE is manufactured as a 1W component, providing light output of 70–95lm, and can be operated at temperatures up to 150°C. The 0.5W SX ECE has the same dimensions and thermal stability as the MX, but with light output of 40–60lm. The small dimensions enable both LEDs to be integrated into compact, low-profile designs.

"The OSOLON MX ECE and the OSOLON SX ECE are tailor-made to meet the demands of the automotive industry," says Mike Godwin, director of Visible LEDs at Osram Opto's North America subsidiary Osram Opto Semiconductors Inc in Santa Clara, CA, USA. "Both these ceramic components are ideal for daytime running light (DRL) applications," he adds. "They can be installed in headlight systems or incorporated in fenders as individual lights."

In addition to the two new models in the OSOLON series, Osram currently offers a portfolio of LEDs for the automotive sector that includes light sources in various versions and performance classes to meet different requirements — from the Advanced Power TopLED for daytime running lights to the OSTAR Headlamp for low- and high-beam headlights. The range fully covers the brightness range from 25lm to 1000lm.

Epistar develops 80lm/W warm-white LED; expects 100lm/W in fourth-quarter 2009

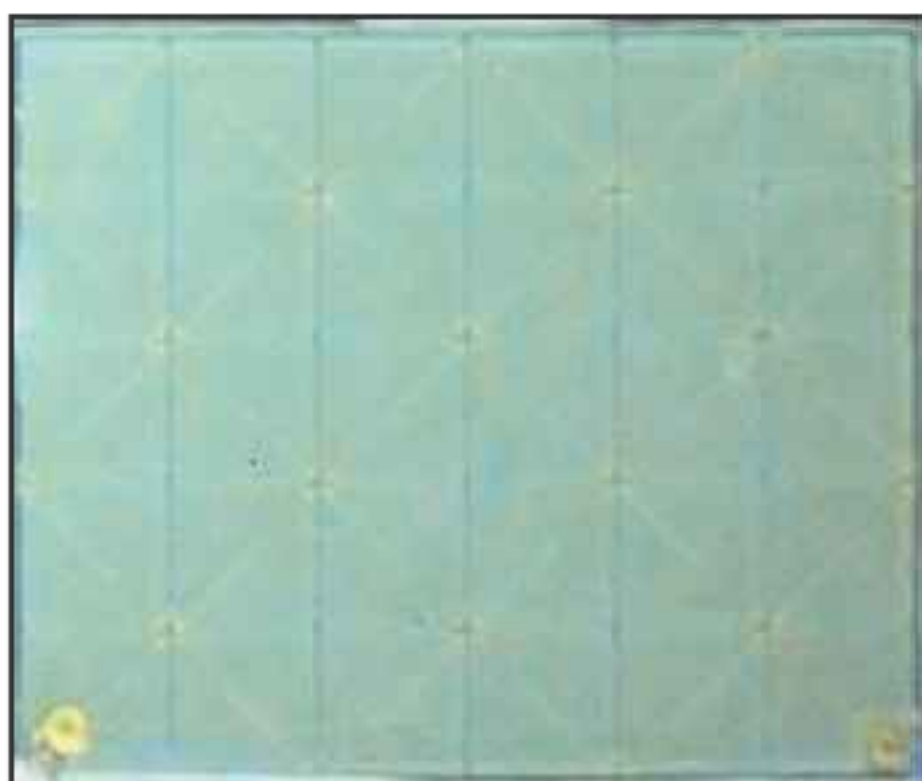
Epistar Corp of Hsinchu Science-based Industrial Park, Taiwan says that it has developed a warm-white LED with a correlated color temperature (CCT) of 3000K, a color rendering index (CRI) of 80, and a luminous efficacy of 80lm/W.

The firm says that it has been developing technology that can simultaneously achieve high CRI and high efficacy (the two main performance metrics in the lighting industry using white LEDs).

Usually, these two metrics work against each other and their combination becomes a trade-off, especially for warm-white LEDs.

To achieve better CRI, red phosphor is needed to compensate for the shortage in the red spectrum. However, the efficacy of existing red phosphor is low (about 40lm/W), resulting in low overall efficacy.

Epistar's new LED includes one or several high-voltage monolithically



Layout of the blue monolithically integrated multi-chip array.

integrated DC multiple-chip arrays combined with a bridge structure for an AC drive. Several red LED chips are also incorporated into the design. With the help of the high-brightness red and blue LEDs, the overall efficacy is increased while high CRI is achieved at the same time.

The firm adds that it expects to demonstrate a new product in



Sample packaged with Epistar's newly developed chips.

fourth-quarter 2009 with a CRI of more than 80 and efficacy of 100lm/W at a CCT of 3000K.

Epistar's announcement follows South Korean LED maker Seoul Semiconductor Inc saying in late August that it had launched the Acriche A4 AC-LED, which has a CCT of 3000K, a CRI of 85, and luminous efficiency of 75lm/W.

www.epistar.com.tw

Seoul's Acriche A4 LED provides 75lm/W and CRI of 85

South Korean LED maker Seoul Semiconductor Inc has launched the Acriche A4 LED, which it claims has not only a luminous efficiency of 75lm/W but also an output that appears close to a natural white light (unlike other high-efficiency white LEDs, which have a cold bluish-white output unsuitable for many forms of illumination).

Two-third's of the world's lighting consists of warm-white lights (with a color temperature of 2700–3000K); Seoul Semiconductor says that its new A4 is capable of replacing such warm-white incandescent and compact fluorescent lamp (CFL) light sources in many applications.

Currently, white LEDs are divided into two major markets:

- products with a normal color rendering index (CRI) of 70–80 (e.g. of high-efficiency bluish-white LEDs), which focus more on bright-



Seoul Semiconductor's Acriche A4.

ness than on color and have the disadvantage of being different from natural light;

- products with a high CRI greater than 85 (closer to the ideal CRI of 100 of natural light), which suit high-quality light applications but are often much less bright than their lower-CRI counterparts.

Consequently, normally a trade-off is required between brightness and CRI (the naturalness of the

white-light output).

However, Seoul Semiconductor says that the Acriche A4 can satisfy both CRI and brightness, overcoming the previous requirement to lower luminous efficiency by several tens of percent in order to achieve high CRI. In contrast, the A4 has a color temperature of 3000K and includes new technologies that provide a high CRI of 85 with a high luminous efficiency of 75lm/W.

This is also the first time that an alternating current (AC) LED has achieved better luminous efficiency than LEDs that run on direct current (DC), claims Seoul Semiconductor. "With the mass production of the Acriche A4 series, we will be able to provide both high-quality and normal-use markets with light sources that have exceptional performance and lower prices," says the firm.

www.acriche.com

Danville joins LED City program

Danville has become the first city in Virginia 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. Danville joins existing program members Raleigh, NC, Ann Arbor, MI, Austin, TX, Anchorage, AK, Indian Wells, CA and Fairview, TX in the USA; Toronto and Welland in Canada; Tianjin in China; Gwangju in South Korea; and Torraca in Italy.

In response to the Go Green Virginia initiative sponsored by the Virginia Municipal League (VML), the city has installed Cree LED lights in the Danville Water Treatment Plant and in the Adult Detention Center.

The Virginia Municipal League started the Go Green Virginia program to encourage local governments to reduce energy usage and promote sustainability. As part of the initiative, the Green Government Challenge is a friendly competition designed to promote the implementation of specific environmental policies and practical actions that reduce the carbon emissions generated by both the local government and the broader community. The two LED lighting installations, with their longevity and savings in maintenance and energy costs, should aid Danville's green efforts. Additionally, the installations are supported by the American Public Power Association as part of a Demonstrating Energy Efficiency Developments (DEED) program grant.

"Danville, and the rest of the country, can no longer afford to rely on the less efficient technologies of the past," says the city's mayor Sherman Saunders.

The city installed Cree LR24 luminaires in the filter room of the Water Treatment Plant, replacing fluorescent fixtures. The original fluorescent T12 lighting fixtures will be left in place for an unspecified period for side-by-side lighting quality comparisons. Due to the better quality of lighting, plant operators have reported improved productivity and increased task efficiency. LED lighting has also reduced potential labor costs by about \$75 per hour for fluorescent bulb changes.

The installation in the Adult Detention Center, part of a room renovation, involved retrofitting a conference room with Cree LR6 and LR24 luminaires to replace incandescent bulbs. The LR6 luminaires are outfitted with a rotating lens that allows for direct and indirect lighting options, which is necessary for hosting video conferences, as the room is often used for distance learning as well as staff training.

The two interior LED lighting installations will not only serve as a green demonstration for the city, but will also serve as guidelines for the lighting design of Danville's new SEnTeC energy research facility for the Institute for Advanced Learning & Research. The city is also exploring the possibility of an LED streetlight demonstration in the downtown area and is currently installing smart meters across its utility service area.

"These projects demonstrate the light quality and cost savings that can be realized with LED lighting and represent the city's commitment to becoming an energy-efficient and green government," says Cree's LED programs manager Deb Lovig.

www.ledcity.org

www.danville-va.gov

IN BRIEF

Cree stock offering raises \$434m, targeting \$150m CapEx in fiscal 2010

On 16 September, Cree Inc of Durham, NC, USA, which manufactures LED chips, lamps and lighting fixtures as well as gallium nitride and silicon carbide power-switching and RF/wireless devices and SiC substrates, closed an underwritten public offering of 11 million shares of its common stock at a price of \$35.50 per share.

The offering included a 30-day option for the underwriters to purchase up to 1.65 million additional shares to cover over-allotments. Cree subsequently said on 17 September that this option had been exercised in full.

The exercise of the over-allotment option brings the expected total net proceeds to \$434.1m (after deducting offering expenses and underwriting discounts and commissions payable by Cree).

The firm says that it intends to use the proceeds from the offering for anticipated capital expenditures (CapEx) of about \$150m in its fiscal 2010 (from 1 July 2009 to end-June 2010) and additional future capital expenditure needs. By comparison, CapEx was about \$55m in fiscal 2009, including \$14.7m in fiscal Q4/2009. In contrast, on reporting its fiscal Q3 results on 11 August, Cree said that CapEx in fiscal Q1/2010 would rise to \$25-30m (mainly for LED component capacity increases in China and LED chip capacity in the USA). The firm aims to double LED component capacity over the next year.

The remaining proceeds will be used for general corporate purposes (e.g. working capital and potential strategic investments).

www.cree.com

IN BRIEF

Lumileds LUXEON Rebel hot/cold factor improves SSL efficiency and simplifies thermal design

LED maker Philips Lumileds of San Jose, CA, USA says that continued advances in its core LED chip and packaging technology have led to recent breakthroughs, implemented in its latest LUXEON Rebel LEDs for illumination applications, that improve luminous efficacy and light output performance at luminaire operating temperatures.

Hot/cold factor compares the light output of the LED at junction temperatures (T_j) of 100°C and 25°C (which is how LEDs are specified on a datasheet). LEDs in a luminaire are operated at very high junction temperatures, often between 80°C and 110°C. As the temperature increases, light output and efficacy decrease. With a hot/cold factor of 0.93, the just-released LUXEON Rebel LEDs deliver more light and better efficacy than virtually any other power LED, the firm claims. Typical hot/cold factors range from 0.80 to 0.85 at junction temperatures of 100°C. Maximizing this factor is critical as companies design solid-state lighting solutions that are intended to meet ENERGY STAR requirements, Lumileds adds.

"Hot/cold factor is one of the clear differentiators between LEDs," says Rudi Hechfellner, director of Technical Solutions. "A high HC factor can simplify the thermal system design and lower the cost per lumen in the final application."

Hot/cold factor charts for all LUXEON Rebel LEDs are available from the datasheets.

www.philipslumileds.com

Portuguese cities expand LUXEON-based LED street-light installation

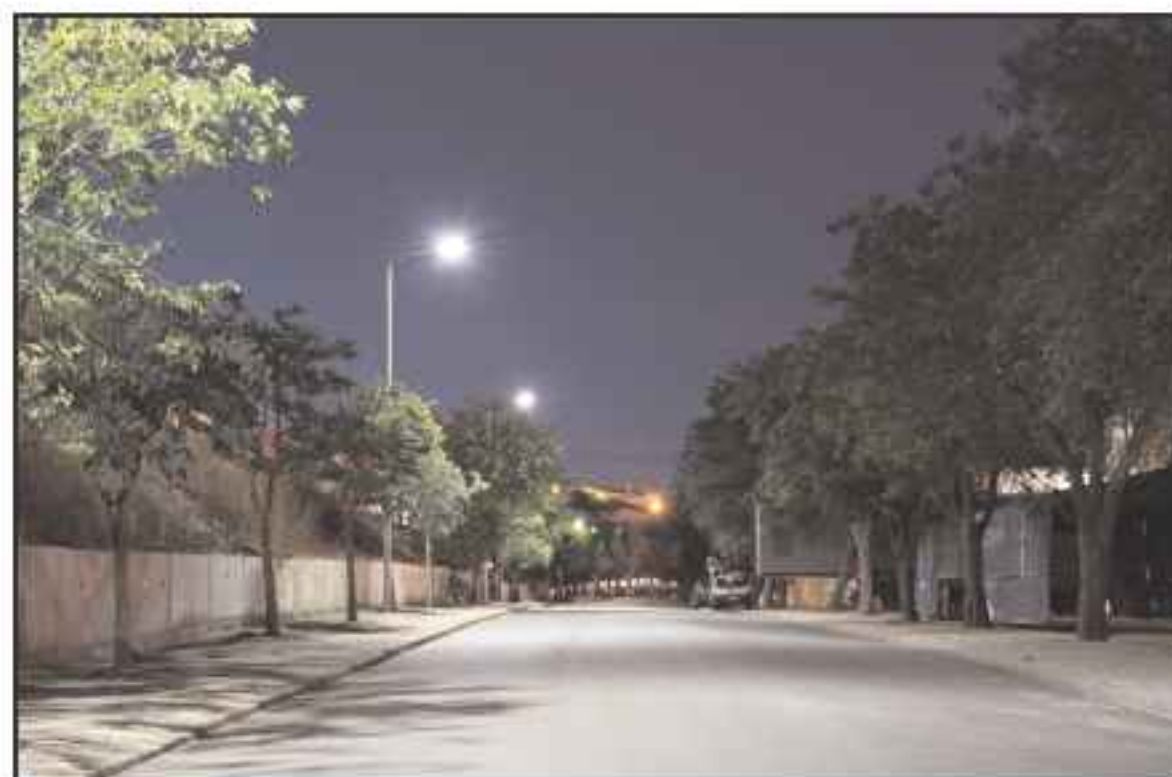
After first being introduced in April on a street in the town of Pombal, the implementation of LED street lighting in Portugal has gathered pace over the summer as EnergiaViva has completed installing the new UrbanLED street light in ten towns and cities, namely Alcochete, Moita, Barreiro, Arraiolos, Pombal, Santa Maria de Feira Vale de Cambra, Estarreja, Coimbra and Torres Vedras.

Using LUXEON Rebel power LEDs from Philips Lumileds of San Jose, CA, USA, the luminaires provide a combination of power efficiency, color rendering index (CRI), uniform light distribution, and low maintenance and repair costs. The white light from the UrbanLED transforms areas that were previously a dark yellowish color from the high-pressure sodium lamps that they replace.

These qualities have seen it quickly gain favor in Portugal, says Lumileds. Installation work in a further 20 Portuguese municipalities is expected to be completed this autumn.

The forecast implementation of UrbanLED around Portugal is proof of the financial case that the high-efficiency, low-maintenance street lighting offers, states Lumileds.

The accelerating roll-out of LED street lighting means that high-pressure sodium lamps could begin to be eliminated from Portuguese streets. "In the ten towns that have UrbanLED street lights, the municipal authorities are already seeing the benefits—a hugely improved urban environment at night time, lower electricity costs, and a reduced requirement for the time of maintenance crews," says



Street light using LUXEON LEDs lights a neighborhood in Portugal.

EnergiaViva director Luis Mota. "It's encouraging to see how many more local authorities in Portugal are also taking a long-term view and investing in state-of-the-art lighting," he adds. "We see a complete national conversion to solid-state technology as a realistic goal over the next several years."

The installation progress in Portugal is the result of a consortium of companies in the energy, lighting and construction industries. Exporlux and its development division BlueSpan (which is responsible for the luminaire design) plus Rosas Construtores SA have joined forces and, as EnergiaViva, deliver a complete solid-state street-lighting solution to municipalities.

It's encouraging to see how many more local authorities in Portugal are also taking a long-term view. We see a complete national conversion to solid-state technology as a realistic goal over the next several years

Philips and Lighting Science Group settle litigation with commercial relationship, license and investment

LED lighting designer and manufacturer Lighting Science Group Corp (LSG) of Satellite Beach, FL, USA and Netherlands-based Royal Philips Electronics have settled all their commercial and intellectual property disputes through an agreement that revives their former commercial alliance.

The firms filed lawsuits against each other in spring 2008 based on a dispute over patents and IP owned by LED lighting manufacturer LED Effects of Sacramento, CA (acquired by LSG in October 2007) and by LED lighting system maker Color Kinetics of Burlington, MA (acquired by Philips in June 2007, becoming Philips Solid-State Lighting Solutions).

The new agreement provides that trade in LED lighting products

between the companies will be intensified, that LSG takes out a royalty-bearing license to the Philips LED-based Luminaires and Retrofit Bulbs licensing program, and that Philips will make a \$5m limited equity investment in publicly traded LSG (in the form of a convertible note that will convert to preferred shares upon LSG's planned rights offering).

The commercial relationship involves mutual sourcing and supplying of LED components and products. The agreement also provides for mutual releases for all claims relative to the past, including all intellectual property and commercial claims, and all the pending cases between the companies will be dismissed.

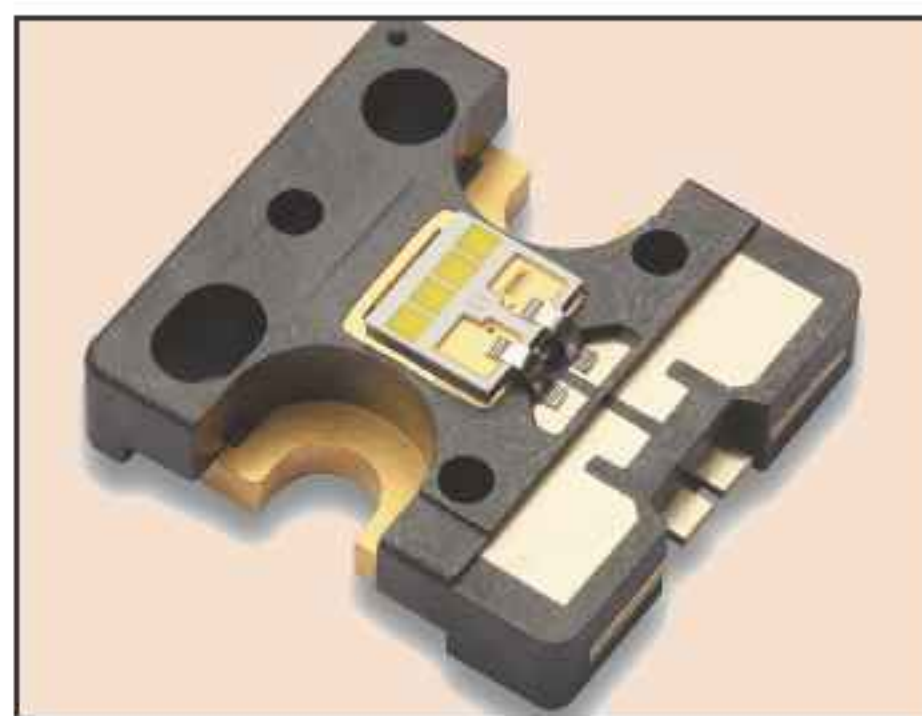
www.lsgc.com

Lumileds launches Altalon power LEDs for automotive forward lighting

LED maker Philips Lumileds of San Jose, CA, USA has launched its LUXEON Altalon power LEDs for the next generation of advanced automotive forward lighting. The firm says the LEDs' small size, high brightness, and lower energy consumption also suit high- and low-beam applications, daytime running lamps, static bending lamps and position lamps.

"Altalon enables our automotive customers to provide forward lighting solutions that deliver never-before-possible performance and features while at the same time provide unique visual identities for their vehicle brands," says Steve Barlow, executive VP of sales & marketing. By using Lumileds' thin-film flip-chip die, the Altalon is the brightest automotive LED available, the firm claims.

Already implemented in the Audi R8



LUXEON Altalon power LED in 1x4 chip configuration.

for low- and high-beam functions, the Altalon can deliver more than 850 lumens and 60MNits at a drive current of 1000mA. It is also AEC-Q101C qualified. The color temperature is 5600K and it conforms to both ECE and SAE specifications.

www.philipslumileds.com/solutions/automotivelighting

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US Recovery Act funding goes to green LED research

The US Department of Energy (DOE) has awarded up to \$6.4m in funding to four research projects focused on improving green LEDs and organic blue emitters.

Of the total, \$4.6m has been provided via the American Recovery and Reinvestment Act, designed to help pull the US out of recession, in part through investing in new, energy-efficient technologies.

Much of the new funding is being channeled into work on improving green semiconductor emitters, in a bid to close the so-called 'green gap' — the region of the visible spectrum in which it is most difficult to fabricate efficient emitters from semiconductor materials.

Researchers at the National Renewable Energy Laboratory (NREL) in Colorado, Sandia National Laboratories in New Mexico, and the US Army Laboratory in

Maryland will all receive funding to tackle the green problem, using three very different approaches.

The NREL team will attempt to reach the green through manipulating gallium indium phosphide (GaInP) alloys, traditionally used to fabricate red, orange and yellow emitters. They will seek to demonstrate the viability of a high-bandgap version of this semiconductor to push to the shorter wavelengths required for green emission.

Sandia's team will focus on a different semiconductor entirely, using gallium nitride (GaN) substrates to improve the efficiency of green emitters, while the Army team will aim to exploit negative polarization charge in the active region of green LEDs.

Each of those projects is receiving \$1.8m in DOE funding, while the

remaining \$1m has been awarded to the Pacific Northwest National Laboratory in Washington.

Researchers at PNNL are working on organic devices, and will use the money to develop new, stable materials suitable for emitters working in the blue part of the visible spectrum.

Unlike inorganic light emitters, where the problem region has traditionally been the green spectrum, with organic devices the long-term stability of blue devices has always been the major stumbling block.

All of the projects fall under the DOE's solid-state lighting core technology research program, and are aimed at improving the efficiency and quality of solid-state white-light sources.

www1.eere.energy.gov/buildings/ssl
By Michael Hatcher

Taiwan High Court affirms district court's order for Everlight to pay Nichia NT\$80m in damages

On 29 July the Taiwan High Court rejected an appeal filed by Everlight Electronic Co Ltd (one of the largest LED packaging firms in Taiwan) and upheld in its entirety a ruling made in October 2007 by the Taiwan Banchiao District Court.

That court found that certain LED products (models 99-215UWC/TR8, 99-115UWC/XXX/TR8 and 99-115UTC/710/TR8) supplied by Everlight infringed the Taiwanese Design Patent number 089036 owned by Japan-based LED maker Nichia Corp (concerning an SMD-type LED used in backlighting LCDs in cell phones etc). The Taiwan Banchiao District Court also ordered Everlight and its statutory representative to pay damages of NT\$80m (about US\$2.4m).

Nichia originally filed the lawsuit (Taiwan Banchiao District Court case no. 2006-Chongchi-3) in April 2006, based on a design patent infringement assessment report (for part numbers 99-215UWC/TR8 and 99-115UWC/XXX/TR8) by a Taiwanese expert.

Nichia says that the Taiwan High Court decision has evidenced the justifiability of the firm's action for patent enforcement.

Everlight says that, since it has discontinued manufacturing the relevant LED products, the Taiwan High Court's judgment does not affect its business

The firm holds counterpart design patents for the LED in other countries as well as in Taiwan, and says that it will continue taking appropriate measures around the world to protect and ensure its intellectual property rights.

Despite the Taiwan High Court judgement, Everlight maintains that it is certain that the design patent is invalid and that it did not infringe the patent, adding that it aimed to file an appeal with the Supreme Court.

In addition, Everlight says that, since it has discontinued manufacturing the relevant LED products, the Taiwan High Court's judgment does not affect its business.

www.everlight.com
www.nichia.com

LED maker Luminus joins National Electrical Manufacturers Association

Luminus Devices Inc of Billerica, MA, which makes solid-state light sources for illumination applications (including high-definition TVs, video projectors, avionics displays, and lighting systems), has joined the National Electrical Manufacturers Association (NEMA), the US association of electrical and medical imaging equipment manufacturers (which was founded in 1926).

The 430 member companies manufacture products used in nine industry divisions, including the generation, transmission and distribution, control, and end use of electricity. Worldwide sales of NEMA-scope products exceed \$120bn. Companies manufacturing electrical products in the USA are eligible to join NEMA.

Luminus says that its PhlatLight (Photonic Lattice) LEDs are used in lighting applications that require high bright-

ness and efficiency, wide white color palette, high color rendering, and very long life. Indoor and outdoor general lighting applications include street lighting, entertainment, architecture,

Luminus is looking forward to becoming active in leading standards establishment, influencing energy-related legislation and legislation that impacts emerging technologies

automotive, medical and dental, avionics, manufacturing and machine vision, as well as display and digital signage markets.

"NEMA members are among the most significant electro-industry manufacturers in the world and Luminus is looking forward to becoming active in leading standards establishment, influencing energy-related legislation and legislation that impacts emerging technologies," says president & CEO Keith T. S. Ward. "We also look forward to participating in NEMA's enLIGHTen America initiative, which is aggressively promoting sustainability and energy savings through the application of the latest technologies in lighting," he adds.

www.nema.org

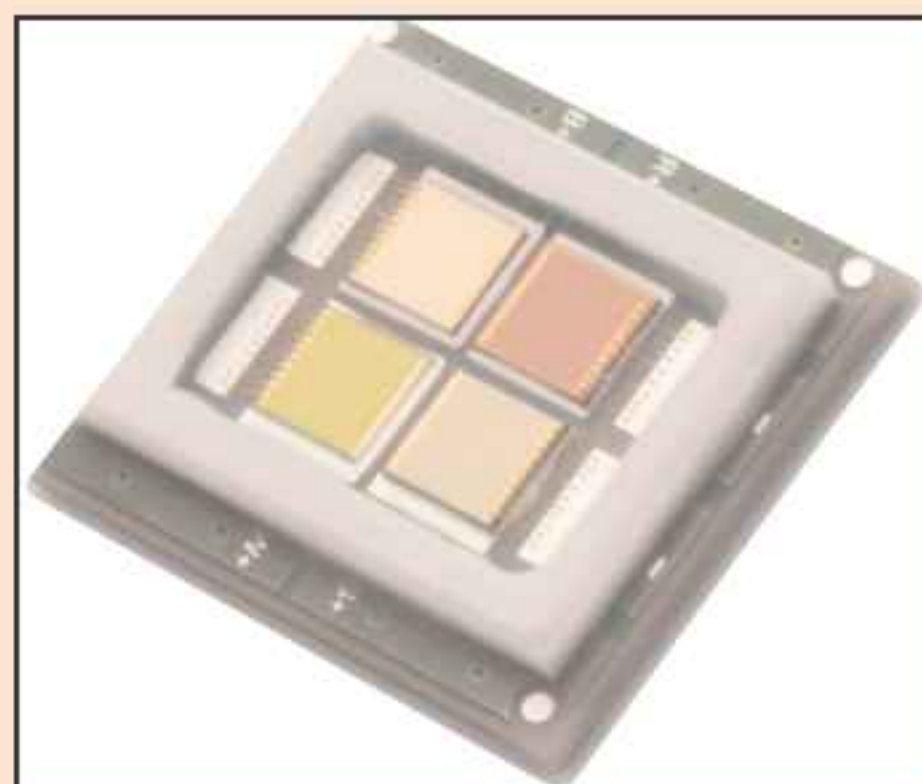
Multi-color LED launched for entertainment & architectural lighting

Luminus Devices Inc of Billerica, MA, which makes solid-state light sources for illumination applications (including high-definition TVs, video projectors, avionics displays, and lighting systems), has made available samples of the SBM-160 PhlatLight LED (for volume shipments starting in November).

The firm claims that the new device is the brightest multi-color LED available in a surface-mount (SMT) package, suiting entertainment and architectural applications where high optical output and high efficiency are required.

The SBM-160 is a four-chip package consisting of individually addressable red, green, blue and white LEDs that generate more than 1500 lumens of combined white light: 250+lm in red, 570+lm in green, 100+lm in blue and 700+lm in daylight white (6500K).

The large, multi-chip design has a total emitting surface area of 16mm². The optical source window



Luminus' SBM-160 PhlatLight LED.

of just 4mm x 4mm helps to eliminate the color shadowing and color mixing challenges that lighting designers typically face, says Luminus. The total footprint is only 10mm x 11mm.

The high-thermal-conductivity package uses a high-performance ceramic substrate, resulting in thermal resistance of less than 1.5C/W per die. A protective window covers the chips, which emit directly into air, allowing for proximity optics that optimize collection efficiency and eliminate

unwanted color fringing.

With separate, isolated four-channel control, a single SBM-160 module can replace multiple 1W emitters and multi-color LED arrays, says Peter Weller, general manager for Luminus' lighting business. "We have reduced design complexity and cost, enabling new dimensions of design freedom," he adds.

Luminus says that the SBM-160 integrates seamlessly with

The firm claims that the new device is the brightest multi-color LED available in a surface-mount package

free and provide a lifetime of 60,000 hours with lumen maintenance of greater than 70%.

www.luminus.com

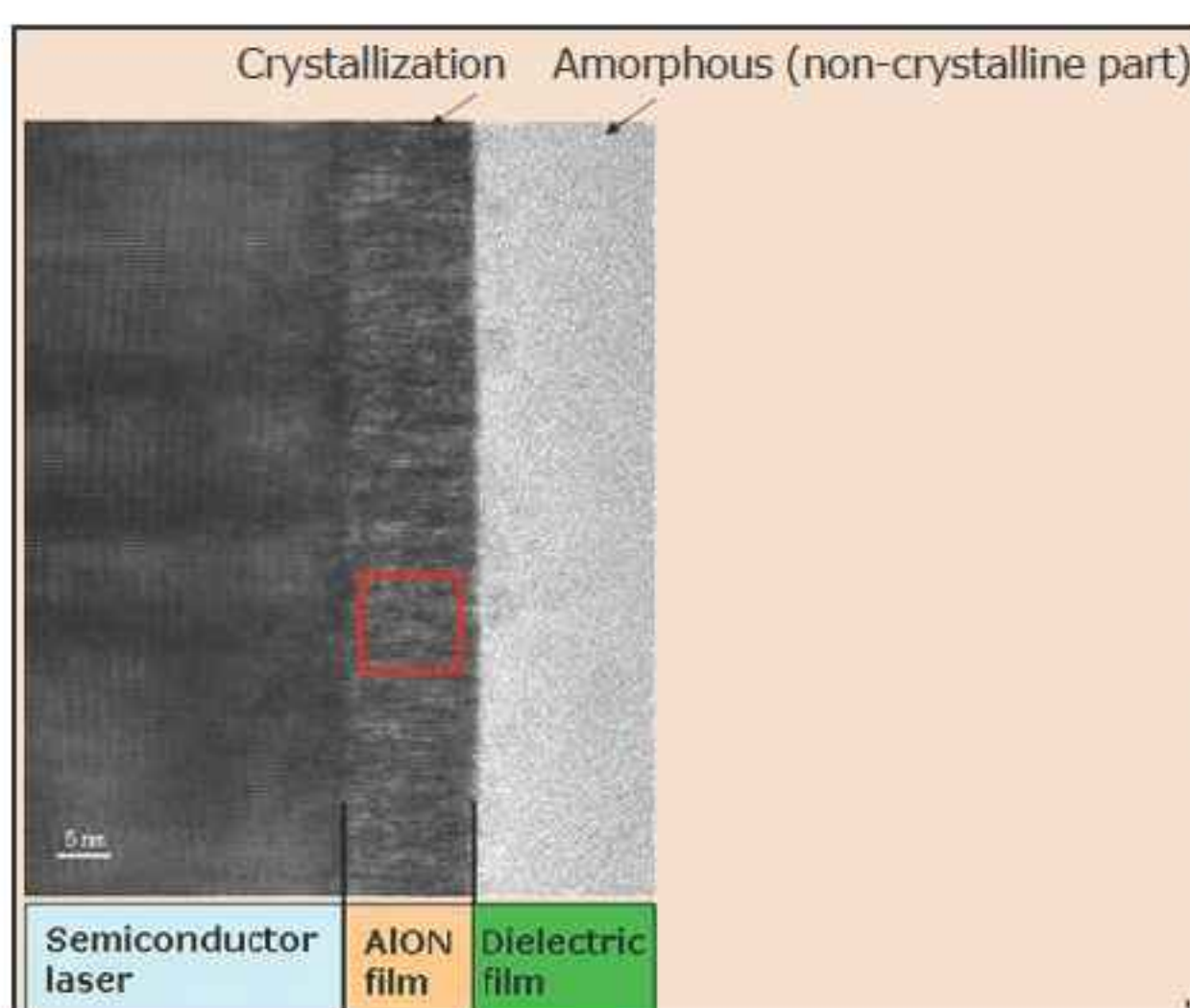
standard SMT manufacturing processes and equipment. The firm adds that its PhlatLight (Photonic Lattice) LEDs are mercury-

Sharp develops 500mW Blu-ray laser for 8x recording on quadruple-layer 100GB discs

At the 70th Autumn Meeting of the Japan Society of Applied Physics (8–11 September), Sharp Corp reported the development of a blue-violet laser (emitting at a wavelength of 405nm for use in Blu-ray Disc recorders) with optical output as high as 500mW under pulsed operation.

Just in June, Sharp started volume production of a Blu-ray laser with 320mW pulsed output that can burn single- and dual-layer discs at 8x speed. Previously, in April 2008, Sharp started production of Blu-ray lasers with pulsed output power of 250mW for recording on dual-layer discs at 4–6x. At that time, Sharp had projected only shipping 350mW lasers by the end of 2009, and 400mW lasers (for multi-layer recording at 8–12x speeds) in 2010.

Sharp enhanced the output power to 500mW by using a new method of processing the edge face of the laser resonator. Normally, the edge face of the laser crystal is protected



Cross section of laser incorporating AION film.

by a dielectric film. In this case, an aluminum oxynitride (AION) film was sputtered between the edge face of the laser and the dielectric film, followed by epitaxial growth where the growth axis of the laser epilayers corresponds to that of the AION crystal. In the past, the crystalline material of the laser was covered just by a non-crystalline dielectric film, so the edge face had

a surface state that absorbed laser light, and consequently the crystal was degraded by the heat that was generated. In contrast, the new laser allows more output than was previously possible with just the dielectric alone.

For the new laser structure, Sharp has already verified reliable operation for more than 1000 hours at 80°C with a pulse width of 30ns and an output of 500mW.

The new 500mW laser has the capability of writing at 8x speed on triple- and even quadruple-layer Blu-ray discs. Using current technology (25GB per layer), this would allow 75GB or 100GB recordable discs.

However, Sharp has not decided when to mass produce the new laser because the specifications of triple or more layer Blu-ray disc have not yet been determined. Nevertheless, the firm says that it is ready to commercialize the laser.

<http://sharp-world.com>

Sumitomo boosts 520nm green InGaN laser to continuous-wave operation at room temperature

Researchers at Sumitomo Electric Industries Ltd's Semiconductor Technologies R&D Laboratories in Itami, Japan have demonstrated room-temperature continuous-wave operation of InGaN-based laser diodes on semi-polar {2021} gallium nitride substrates emitting at a wavelength of 520nm in the green region of the spectrum (Yoshizumi et al, Appl. Phys. Express 2 (2009) 092101, 21 August).

The latest advance follows the team reporting in mid-July what it claimed was the first semiconductor laser diode emitting in the pure-green region of the spectrum, but under pulsed operation at room temperature. For the average

pulsed laser emission wavelength of 520nm, the typical threshold current was 491mA (corresponding to a threshold current density of 8.2kA/cm²) and the threshold voltage was about 18V. For the longest lasing wavelength achieved (531nm), the threshold current was 924mA (Enya et al. Appl. Phys. Express 2 (2009) 082101, 17 July).

Previously, in late February Osram Opto Semiconductors GmbH of Regensburg, Germany demonstrated the first gallium nitride (GaN)-based laser with an emission wavelength of 500nm (blue-green), and at the end of May Japan's Nichia Corp reported blue-green lasing at 510–515nm (both using

InGaN quantum wells grown on a c-plane GaN substrate).

In the latest development by Sumitomo Electric Industries, through improving the quality of epitaxial layers on {2021} GaN substrates using lattice-matched quaternary InAlGaIn cladding layers and also through adopting a ridge-waveguide laser structure, continuous-wave operation at 520nm was achieved with a threshold current of 95mA (corresponding to a threshold current density of 7.9kA/cm²) and a threshold voltage of 9.4V.

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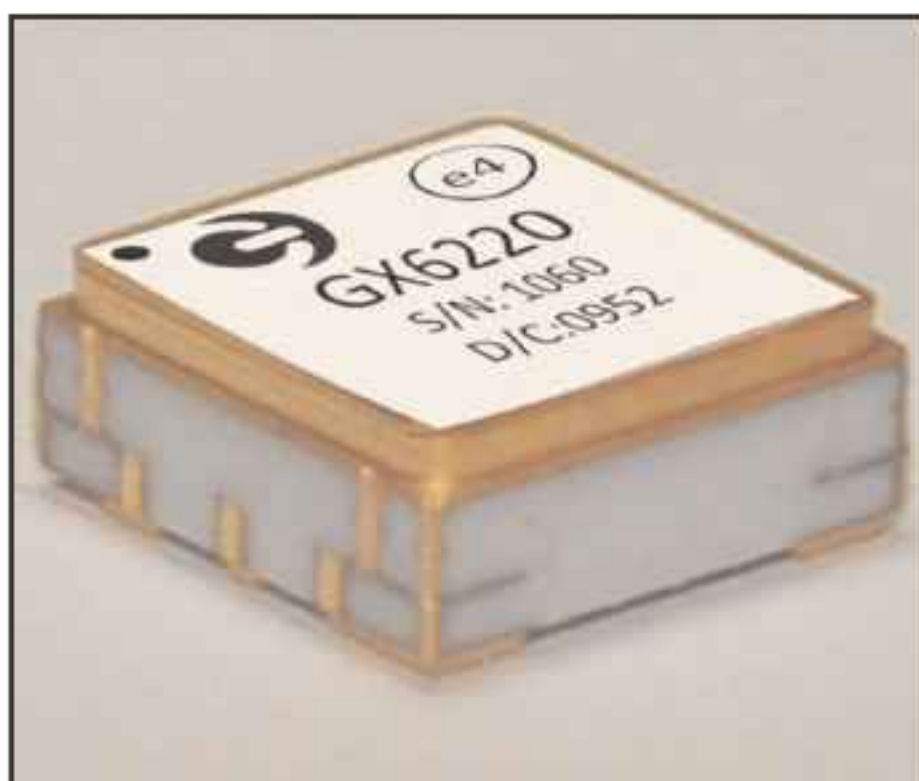
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GigOptix launches SMT 40Gb/s DQPSK modulator driver for metro and long-haul transponders

GigOptix Inc of Palo Alto, CA, USA, which designs optical modulators, drivers and transimpedance amplifier (TIA) ICs based on III-V materials, has made available samples of the GX6261, a 40Gb/s differential quadrature phase shift keying (DQPSK) modulator driver in surface-mounted technology (SMT) for metro and long-haul optical transponders. Because of its spectral efficiency and tolerance to various dispersion mechanisms over long reaches, GigOptix says that DQPSK modulation is slated to become the dominant format as 40G line cards become common in long-haul and metro networks.

"The GX6261 represents a significant addition to GigOptix's growing high-speed driver portfolio," says Padraig O'Mathuna, director of product marketing. "Our early-engagement customers have indicated that competitor parts consume 50% more power than the GX6261 and require 40% more real estate on the circuit board," he claims. "Both savings are significant, since each 40G transponder requires two of these drivers and this enables our customers to design much lower-power transponders, and the smaller form



GigOptix's new SMT-based GX6261, 40Gb/s DQPSK modulator driver.

factor is more convenient for compact transponder design."

O'Mathuna also added that the GX6261 is important in GigOptix's strategy of providing the lowest-power solutions for optical links, as the firm covers both ends of the link with power-efficient products. A 40G DQPSK transponder not only requires two drivers such as the GX6261 on the transmit side but also a linear TIA such as GigOptix's GX3220 (launched at the end of July) on the receive side. GigOptix claims that the GX6261/GX3220 combination is the lowest-power and smallest chipset solution for a 40G DPQSK transponder implementation.

"Higher-bandwidth links are needed to satisfy the explosive growth in demand for network capacity," comments Daryl Inniss, VP & practice leader of Communications Component at market research firm Ovum. "40G is a reality today, with systems being deployed by many operators. We predict it will grow quickly over the next few years as technology innovation enables it to be as cost effective as 10G," he adds.

"The introduction of lower-cost, lower-power and smaller-size SMT devices all contribute to enabling 40G transponders to begin to effectively compete with 10G designs and thereby facilitate mass adoption."

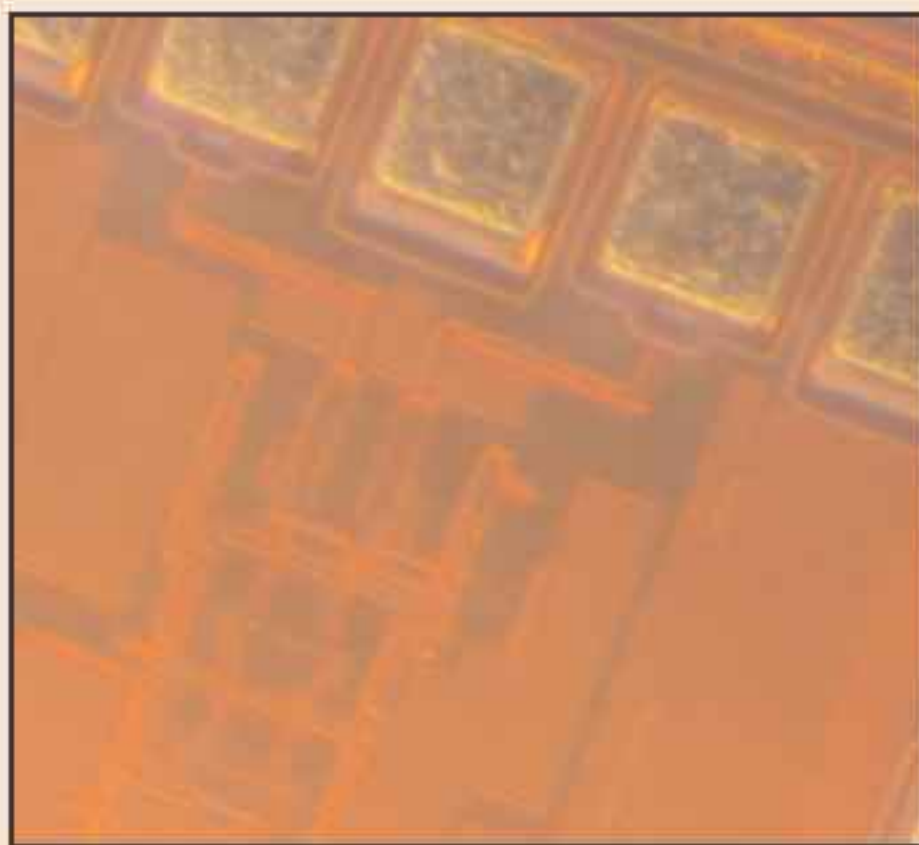
Ovum's most recent wide-area network (WAN) optical components market forecast projects that the volume of 40G optical transmitters will grow a compound annual growth rate (CAGR) of 71% from 20,000 units in 2009 to 183,000 in 2013, with DQPSK being the fastest-growing segment of the 40G telecom market. In addition, the 100G WAN optical component market will show similar growth rates starting from 2010.

www.GigOptix.com

GigOptix launches 28Gb/s TIA for 40G and 100G

GigOptix has made available samples (in die form) of the GX3220, a 28Gb/s linear TIA with integrated automatic gain control for 100G DP-QPSK and 40G DQPSK applications.

"The GX3220 is a very low-power, small-form-factor solution that more than addresses customers' functionality requirements," says Padraig O'Mathuna, director of product marketing. "The 100G transponder standardization is still under way and power dissipation is a major concern amongst the defining group... We have not only met the current low-power dissi-



The GX3220 28Gb/s linear TIA with integrated automatic gain control for 100G DP-QPSK and 40G DQPSK.

pation requirement but have successfully surpassed it," he adds.

As well as low power consumption and a frequency range up to 28Gb/s, key features include: high linearity

100G transponder standardization is still under way and power dissipation is a major concern and low harmonic distortion compliant with the draft 100G OIF recommendations, and support for a variety of photodiodes from vendors.

Infinera expands R&D with new Ottawa design center

Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has added to its optical networking R&D team by opening a new design center in Ottawa, Ontario, Canada. The firm says that its new center of excellence will tap into the pool of expertise available in Ottawa (a longtime hub of optical networking development).

Infinera's 400Gb/s photonic integrated circuit (PIC) is in development at the firm's development centers and fabrication plant in Sunnyvale. Future generations of its optical systems will be designed to take increasing advantage of signal processing technologies to process the large amounts of data transmitted and received by both these and higher-capacity PICs.

"The advantages of photonic integration are even more compelling at 400Gb/s than they have been at 100Gb/s," comments CEO Jagdeep Singh. "Putting the best people together is key to finding the best solutions to the challenges facing the world's networks, and establishing ourselves in Ottawa

increases our ability to recruit the best," he adds.

Dr Kuang-Tsan Wu, who has been recruited to lead the Ottawa team, is an expert in designing optical systems using high-speed electronics and advanced modulation formats.

The advantages of photonic integration are even more compelling at 400Gb/s than they have been at 100Gb/s, comments CEO Jagdeep Singh

"The combination of the PIC and advanced signal processing technologies provides an opportunity to create a significant disruption in future optical systems," Wu says.

● Infinera spoke at three events at the 35th European Conference and Exhibition on Optical Communication (ECOC 2009) in Vienna, Austria (20–24 September), highlighting

Prior to joining Infinera, Wu led the team that designed Nortel's 40Gb/s coherent receivers with advanced signal processing technologies. Infinera is currently recruiting a small number of additional engineers to join the Ottawa team.

advances in its photonic integration technology and the impact photonic integration is exerting on optical networks.

Chief marketing & strategy officer Dr Dave Welch participated in two workshops on 20 September: 'Energy Efficiency in Next Generation Core Networks and Switches' and 'Monolithic and Hybrid Photonic Integrated Transceivers for Advanced Modulation Formats — PIC Technologies for Advanced Modulation Formats'.

Also, in the ECOC conference, Infinera PIC team member Mehrdad Ziari discussed 'Large Scale Integration of Photonic Integrated Circuits on Indium Phosphide and High-Index-Contrast Si Platforms'.

Infinera says that the common theme running through the presentations is the benefits that photonic integration bring in cost, space consumption, power consumption, scalability, and reliability of optical systems. With a fourfold increase in the capacity of PICs expected, the firm says that its next-generation systems will be designed to deliver further benefits in all these areas.

www.ecocexhibition.com
www.infinera.com

Pangaea HK and GigOptix to form joint venture for China consumer electronics market

GigOptix Inc of Palo Alto, CA, USA, which designs optical modulators, drivers and transimpedance amplifier (TIA) ICs based on III-V materials, and distribution firm Pangaea (HK) Ltd of Hong Kong have signed a memorandum of understanding to extend their partnership through the formation of a joint venture company in China.

The new organization will be headquartered in Hong Kong and is intended to support customers in the region with the development of low-cost and customized reference

With this joint venture we plan to accelerate the creation of cost-effective optical interconnect designs

products," says Pangaea's CEO & president Richard Fung. "With this joint venture we plan to accelerate the creation of cost-effective optical

designs for GigOptix products.

"We have a vision that optical interconnects will become essential to the next generation of consumer electronics

interconnect designs to support our customers in making the switch from copper and to realize the power and performance advantages optical can offer," he adds.

"Through this joint venture we will provide a greater support for customers in China, which is paramount to the adoption of our devices in the optical interconnect market," says GigOptix's chairman & CEO Dr Avi Katz. "Our goal is to enable our customers to bring attractive products to the market quickly."

www.GigOptix.com

Infinera adds SOAs to PICs in new submarine system: Global Crossing boosts capacity and speed over its 26,000 route-km mid-Atlantic & South America network

Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own InP-based photonic integrated circuits (PICs), is launching a new submarine solution to bring the benefits of photonic integration (including enhanced capacity, new services, and rapid deployment) to undersea networks.

Designed to be deployed at land-based terminals, the system is already shipping to customers and is currently carrying live traffic for Global Crossing.

Carriers worldwide are seeing increasing bandwidth demand on submarine networks, driven by the growing pervasiveness of the Internet and network usage, says the firm. Many of those networks are reaching the limits of their current capacity. Infinera says that its new submarine solution offers network operators a cost-effective way to protect their investment in subsea infrastructure while adding new capacity to the network and taking advantage of other features of the firm's Digital Optical Networks architecture. The system enables carriers to deliver additional capacity, typically including a doubling of the number of wavelengths on their subsea networks, while providing rapid deployment, ease of operation, and flexibility of the Infinera platform. With the ability to use one optical platform for their subsea networks and their terrestrial networks, operators can deploy an end-to-end solution with significant savings in capital and operating cost and simplified operation, reckons Infinera.

For the new submarine system, Infinera's large-scale photonic integrated circuits (PICs) have been enhanced with the addition of semiconductor optical amplifiers (SOAs) to provide trans-oceanic optical reach. The enhanced PICs are implemented in Infinera's new

Submarine Line Module (SLM), which provides 100Gb/s of PIC-based dense wavelength division multiplexing (DWDM) capacity on each line card. Up to 16 SLM modules multiplexed onto a single fiber can provide up to 160 wavelengths on existing submarine optical networks. In addition, new technology is incorporated to provide what is claimed to be significant cost and space savings compared to traditional DWDM submarine networks.

The submarine system has already been deployed by global carriers over a total of almost 50,000 subsea route-kilometers, including by Global Crossing on its Mid-Atlantic Crossing (MAC) and its South American Crossing (SAC) networks (a total of 26,000 route-km) without the need to deploy a completely new subsea network. Software automation makes provisioning quicker and easier: augmentations can be provided in days or weeks instead of up to 6–12 months on traditional submarine networks.

Global Crossing first deployed an Infinera terrestrial network in 2006. The new subsea network extends the reach of the firm's existing terrestrial digital optical architecture over its subsea facilities, enabling single-key-stroke optical network provisioning end-to-end to on-net cities between continents, says Jim Watts, Global Crossing's VP of transport engineering.

The submarine networking market has grown strongly in recent years, as growing trans-continental Internet traffic has risen sharply, propelled by increasing adoption of

Internet-capable mobile phones, high-speed Internet connections to homes and businesses, and growing prosperity in underdeveloped markets, where hundreds of millions of people have begun using Internet technology. According to data from analyst firm Ovum, the submarine networking market rose 56% to \$858m in 2008, and will grow a further 23% this year to \$1.06bn, followed by 20% in 2010 to \$1.27bn. In contrast, the total optical networking market is expected to fall 5.5% this year to \$15.4bn then rebound by 5% in 2010.

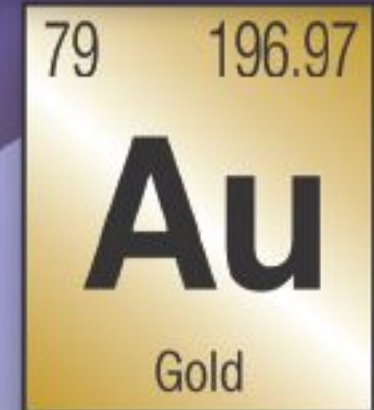
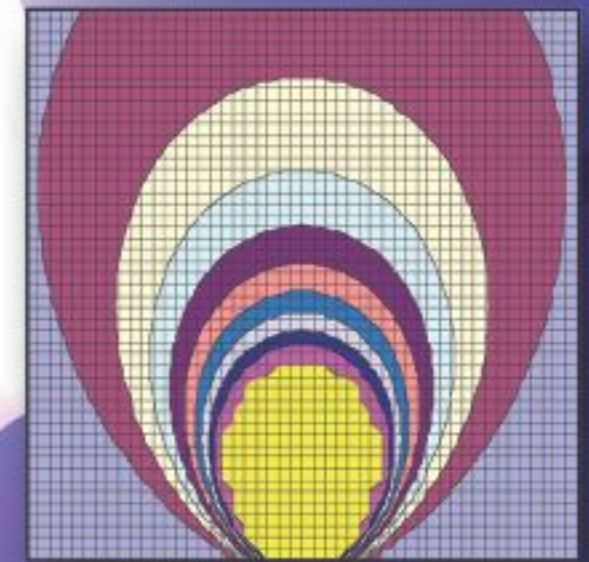
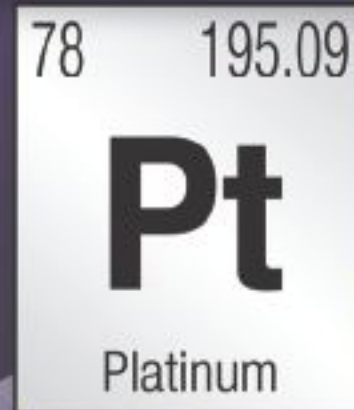
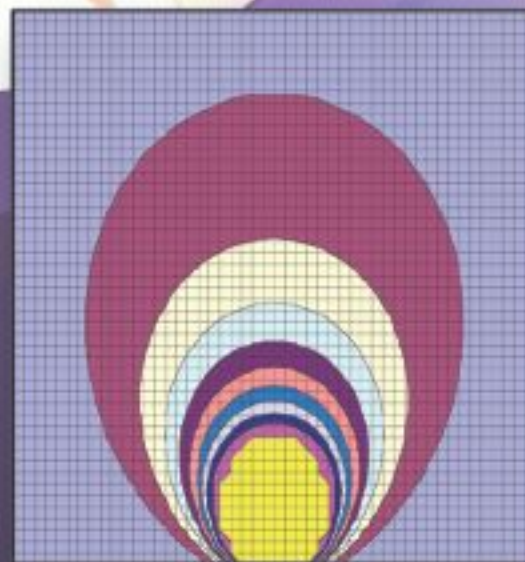
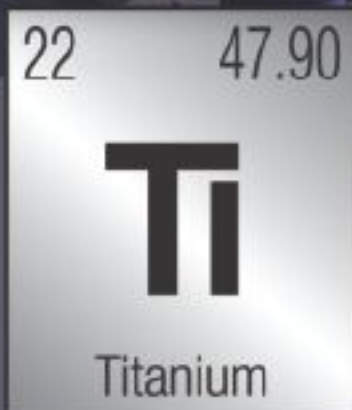
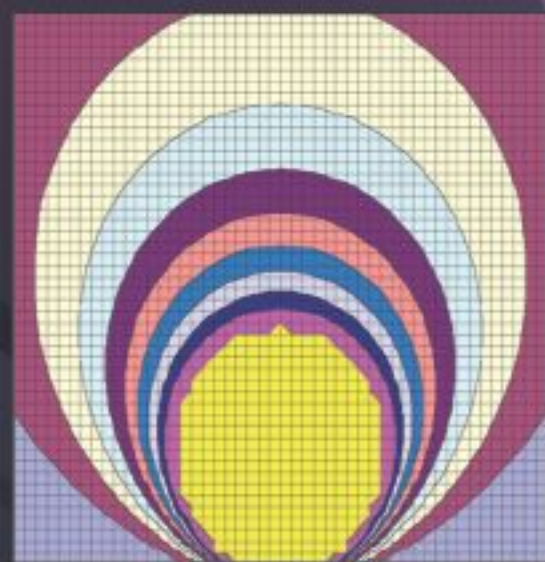
"Subsea cable operators are struggling to increase capacity... Installing a new cable plant is both time consuming and expensive, therefore terminal upgrades are becoming very attractive," says Ron Kline, Ovum's research director, Optical Networks. "Operators are looking for more channels and higher rates per channel (40G and ultimately 100G) through terminal-only upgrades so they can postpone the time and expense of putting in new subsea systems... Integrating SLTE [submarine line terminal equipment] and terrestrial systems provide an attractive solution for operators looking to simplify operations and reduce costs," he adds.

"The submarine market represents the latest segment to adopt Infinera as its vendor of choice, continuing Infinera's momentum in penetrating new applications within the optical transport market," says Infinera's CEO Jagdeep Singh. "Submarine network operators are facing the challenge of bandwidth demand expanding much faster than revenue, and the Infinera submarine solution will help them address technical and economic challenges, while getting the most out of their infrastructure," he adds.

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The submarine networking market rose 56% to \$858m in 2008, and will grow a further 23% this year to \$1.06bn

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OneChip launches low-cost PIC-based EPON transceivers

At the 11th China International Optoelectronic Expo (CIOE 2009) in Shenzhen, China (4–9 September), OneChip Photonics Inc of Ottawa, Canada launched what it claims are the first optical transceivers for fiber-access networks to be based on photonic integrated circuits (PICs).

OneChip says the transceivers will allow optical network system builders to deploy fiber-to-the-premises (FTTP) services more cost-effectively to meet demand for high-bandwidth voice, data and video services.

“OneChip’s new Ethernet passive optical network (EPON) transceivers are the first fully integrated optical access transceivers on the market,” says OneChip’s CEO Jim Hjartarson. “They will give system providers and carriers the ability to significantly lower the cost and boost the performance of their FTTP networks, while meeting business and consumer demand for high-bandwidth voice, data and video services.”

The transceivers that feature the indium phosphide-based PICs are designed to be implemented in both optical line terminals, which sit inside the central offices of service providers, and in optical network units, which are deployed at each customer’s premises.

This means that OneChip’s PICs could be made in very large volumes, if they can be fabricated for a sufficiently low cost.

Although PICs are already a feature in long-haul and regional fiber-optic systems — particularly those produced by Infinera of Sunnyvale, CA, USA — until now they have been regarded as too expensive for high-volume applications like FTTP.

But it is possible to vertically integrate all of the active and passive transceiver components into a multi-guide InP-based structure in a single epitaxial growth step, says OneChip.

Those components, which are usually manufactured separately and assembled to form the transceiver, include a distributed feedback (DFB) laser, an optically pre-amplified detector (OPAD), a wavelength splitter (WS), a spot-size converter (SSC), and various elements of passive waveguide circuitry.

Crucially, no expensive re-growth or post-growth modification of the epitaxial material is required, says OneChip, adding that the approach is inherently high-yielding. Previous attempts to manufacture PICs have fallen foul of low production yields, making the components too expensive for volume use.

OneChip seems to have overcome these problems, and says that it plans to ship its first production EPON transceivers before the end of this year. It is sampling the devices to prospective customers, while similar OLT and ONU transceivers for Gigabit PON (GPON) networks are in development.

If the PIC-based components find favor with those customers, OneChip stands to claim a significant chunk of the growing FTTx fiber-access optical transceiver market — estimated by analyst firm Ovum to grow from \$419m in 2009 to \$456m by the end of 2013.

OneChip appears to have caught the imagination of venture capitalists, closing a \$19.5m investment round earlier this year despite the global financial crisis.

OneChip says that it plans to ship its first production EPON transceivers in fourth-quarter 2009. The device will be made for it by electronic manufacturing services (EMS) provider Sanmina-SCI Corp of San-Jose, CA, which earlier this year acquired JDS Uniphase Corp’s optoelectronics plant in Shenzhen, China.

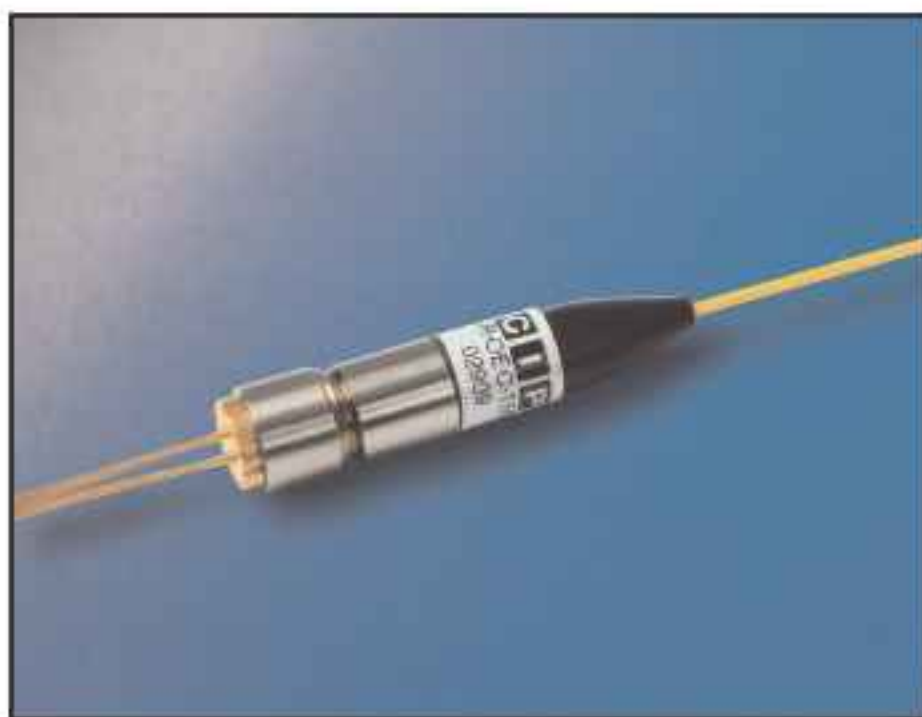
www.onechipphotonics.com

By Michael Hatcher

CIP develops uncooled coaxially packaged reflective SOA

CIP Technologies of Martlesham Heath, Ipswich, UK (which makes photonic hybrid integrated circuits and InP-based optoelectronic chips, devices, arrays and modules) has announced a new addition to its range of semiconductor optical amplifiers (SOAs).

The firm claims that, for the first time, a high-signal-gain reflective SOA coaxially packaged in a pigtailed TO-56 can is capable of uncooled operation over an extended temperature range, making it suitable for a broad range of applications including sensor networks and WDM-PONs (wavelength division multiplexing passive optical



CIP’s reflective SOA coaxially packaged in a pigtailed TO-56 can.

networks).

The SOA-R-OEC-1550-CO uses CIP’s proprietary buried InP heterostructure design and offers

over 20dB of signal gain across the C-band at temperatures up to 70°C. The device is a pigtailed coaxial design, and incorporates a monitor photodiode.

“CIP already offers uncooled reflective SOAs in TO-can packages for use in Bi-Di modules, but our customers have also been asking for a convenient pigtailed package suitable for early evaluation of WDM-PON architectures,” says SOA product manager Dr Ian Lealman. “In this configuration, the product is also proving to be an ideal source in a range of fiber-optic sensor networks,” he adds.

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IN BRIEF

Oclaro expands AMS distribution deal to all telecom products

Oclaro Inc of San Jose, CA, USA is to expand its distribution partnership with AMS Technologies of Martinsried, Germany to cover all products from its telecom divisions.

The combined product ranges cover components, modules and subsystems including amplifiers, tunable and high-speed transmitters, receivers and dispersion compensation technologies.

"AMS Technologies has been our strategic partner for several years," says Oclaro's European sales manager Ralph Dean. "The expansion of the distribution agreement serves to augment our sales and marketing strategy for the European region." AMS has offices in France, Germany, Italy, Spain and the UK.

www.oclaro.com

www.ams.de

nLIGHT named one of America's 5000 fastest-growing private firms

nLIGHT of Vancouver, WA, USA, which manufactures high-power semiconductor lasers and specialty optical fibers for material processing, medical, defense, solar and consumer applications, has been named to Inc's annual ranking of the 5000 fastest-growing private companies in America.

INC 5000 consists of the 5000 fastest-growing private companies in America based on percentage revenue growth from 2005–2008.

"We continue to grow despite the recession and achieved record revenue in the second quarter," says president & CEO Scott Keeney.

www.inc.com/inc5000/2009

www.nlight.net

Finisar grows 20% and returns profit, driven by 10–40Gb/s applications

For its fiscal first-quarter 2010 (ended 2 August 2009), fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has reported revenue of \$135.5m (above the \$134m expected as recently as 4 August, and above the prior guidance of \$120–130m).

However, excluding \$6.7m from the Network Tools division (sold to JDS Uniphase Corp on 15 July), revenue from continuing operations was \$128.7m, up 19.8% on \$107.5m last quarter and 11.2% on \$115.8m a year ago (including the impact of the Optium merger, completed on 29 August 2008).

Excluding the contribution from Optium, optics revenue of \$99.9m is up 21.3% on \$82.3m last quarter but down 13.7% from what was a record (prior to the merger) of \$115.7m a year ago.

Revenues for 10–40Gb/s products was \$51.9m, up 27.8% on \$40.6m last quarter and 61.1% on \$32.2m a year ago (due mainly to Optium).

"Order trends continue to underscore healthy customer demand for ROADMs [reconfigurable optical add-drop multiplexers] and products capable of transmitting at 10Gb/s for use in datacom and telecom applications," says executive chairman Jerry Rawls. Finisar also saw the first orders and revenue for its QuadWire product for 40Gb/s parallel optics applications.

On a non-GAAP basis, gross margin was 28.8%, up on 27.2% last quarter (reflecting greater product shipments) but down from 36.6% a year ago (reflecting lower revenues and yields from higher-speed components as well as the impact of the Optium merger ahead of manufacturing cost synergies expected

over the next three quarters).

"While gross margins for optics were up from last quarter and a little better than we expected, we can look for additional improvement in the near term as our top line continues to improve, product mix turns favorable and additional synergies are realized with respect to manufacturing costs," says CEO Eitan Gertel.

Although down from \$9m a year ago, income was \$1.8m compared to a loss of \$3.4m last quarter.

During the first quarter, cash and short-term investments (plus other long-term investments that can be readily converted into cash) rose from \$37.2m to \$60.4m, mainly reflecting the sale of the Network Tools business for \$40.6m in cash.

Following the completion of an exchange offer on 6 August where it retired \$47.5m in principal amount of its convertible subordinated notes due 15 October 2010 (in exchange for 28.3 million shares of common stock and \$24.9m in cash), Finisar has retired a further \$15.2m principal value of its notes in an all-cash, privately negotiated transaction.

● Also, following stockholder authorization, Finisar's board of directors has approved a 1-for-8 reverse split of its common stock (from 515 million to 64 million shares), which began trading on NASDAQ on a split-adjusted basis on 28 September under the temporary trading symbol FNSRD. The trading symbol is due to revert to FNSR after about 20 trading days.

The reverse split is intended to encourage investor interest in Finisar's stock by giving more visibility to earnings per share as a measure of company performance. The firm also believes that a higher share price could broaden Finisar's appeal to investors, in addition to reducing per-share transaction fees and certain administrative costs.

www.finisar.com

Finisar saw the first orders and revenue for its QuadWire product for 40Gb/s parallel optics



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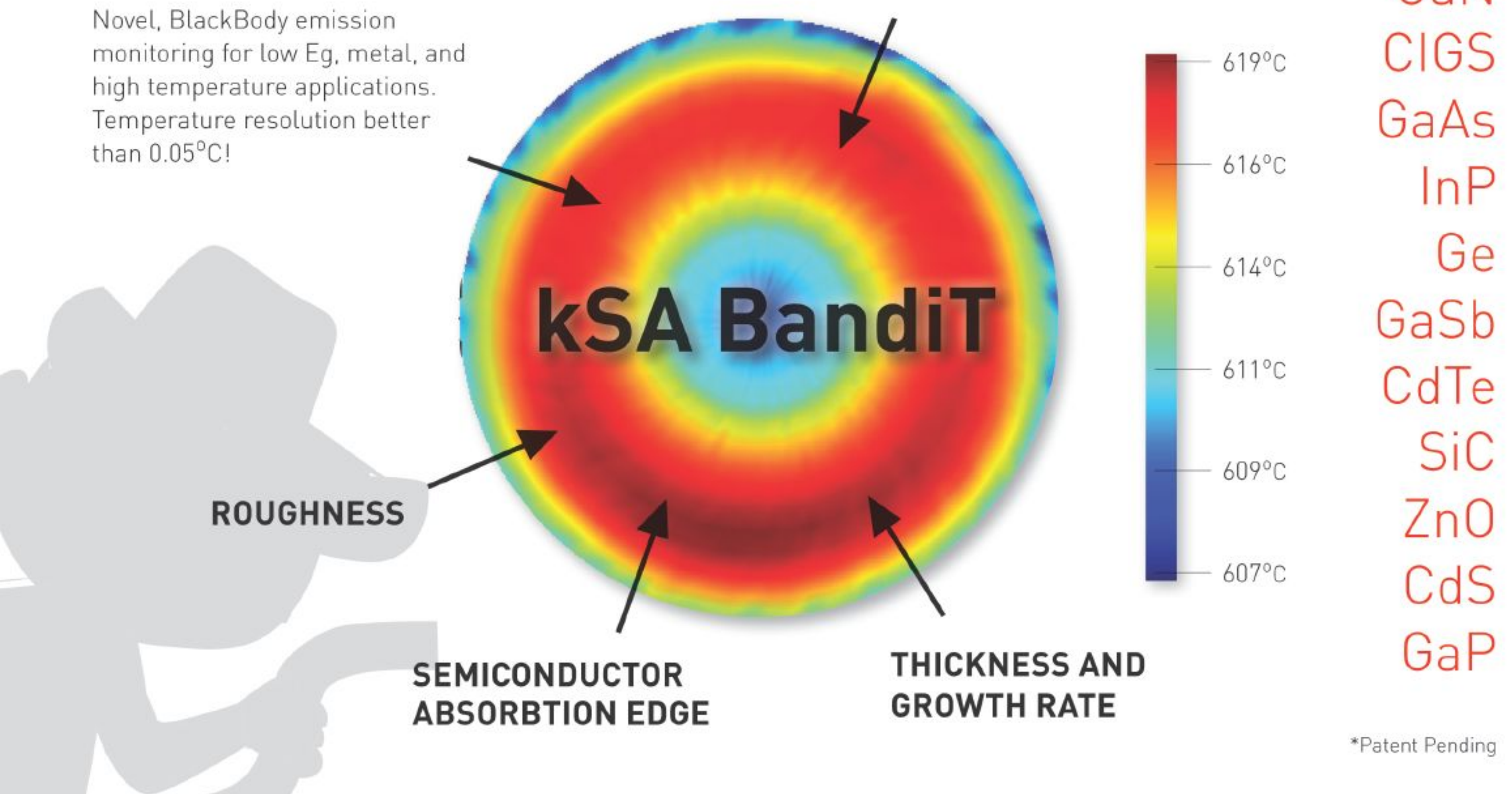
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Emcore lands \$17m satellite PV deal with Northrop Grumman

US defense contractor Northrop Grumman has signed a long-term deal with Emcore to secure volume supplies of high-efficiency solar cells.

Northrop Grumman will deploy the multi-junction cells, which are based on III-V materials and manufactured using MOCVD at Emcore's facility in Albuquerque, in a variety of satellite missions.

The deal runs through 2012 and will yield Emcore up to \$17m in sales over the full period.

Emcore's radiation-hard cells, designed specifically for satellite power applications, are now said to have a conversion efficiency of 30% on initial deployment in space.

Although expensive, the superior performance of these types of device over silicon-based cells has made them the dominant technology in satellite power.



Artist's impression of NPOESS satellite.

Northrop Grumman's aerospace systems division is currently working on a number of satellite missions, for applications including space-based climate monitoring.

For example, the division is the prime contractor for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program. When launched, the low-Earth-orbiting NPOESS spacecraft is

expected to deliver much-improved data on weather and climate.

It is hoped that the data gathered by the NPOESS will aid in reducing the potential loss of human life and property by allowing more efficient disaster planning and response to severe weather conditions such as tornadoes and floods.

"Our proven manufacturing capabilities and unsurpassed reliability heritage make Emcore the supplier of choice for demanding spacecraft power systems," says Emcore's chief operating officer Christopher Larocca of the latest deal. "We look forward to working with Northrop Grumman Aerospace Systems to power their satellite missions for many years to come."

www.emcore.com

www.as.northropgrumman.com

By Michael Hatcher

RUSNANO invests in solar batteries for spacecraft

The Supervisory Council of RUSNANO has approved a joint venture project with Research-Production Enterprise NPP Kvant for the manufacture of solar batteries for spacecraft.

The project will yield GaAs-based batteries for satellites and space stations, with efficiency boosted by 15–32% compared to silicon-based batteries. The new batteries comprise three-junction solar cells consisting of up to 30 interleaved layers, each 10–15nm thick.

RUSNANO says that the batteries will fully comply with the requirements of global spacecraft manufacturers for solar power systems. Their energy conversion efficiency in space environment is estimated at 30% with an operational life of 15 years, making them competitive with the best designs on the market.

Subordinate to the RF Federal Space Agency (Roskosmos),

NPP Kvant is Russia's leading organization developing and making solar cells (mainly for space applications), as well as designing, manufacturing, testing and providing solar batteries for spacecraft.

Yet so far Russia has not made its own GaAs-based multi-junction solar cells. However, state policy for development of the space industry stipulates that solar batteries for Russian spacecraft should be made in Russia. Both enterprises specializing in solar battery assembly (NPP Kvant and SATURN) currently import GaAs solar cells. So, project implementation will help to achieve a goal for the national space industry: the establishment of its own solar battery supply chain for spacecraft, cutting its dependence on imports.

RUSNANO's managing director Aleksandr Kondrashov says that the project aims to protect Russia's

interests in space exploration. It also provides economic value, as solar cells make up 70% of the cost of space solar batteries.

RUSNANO will provide NPP Kvant with a long-term loan of 550m rubles spanning five years. JSC Information Satellite Systems — Reshetnev Company (the main consumer of the project's products) will contribute a loan of 50m rubles to the project.

Production is being set up in Moscow as an extension of NPP Kvant. The first products should be launched this year. Target capacity (the production of 240m² of solar cells) is expected to be reached in 2012. NPP Kvant already has contracts with several buyers to supply GaAs solar batteries during 2009–2016 (covering 60% of manufacturing output). Foreign spacecraft manufacturers are also considered as potential clients.

www.rosnano.ru

City of Mesa to showcase SolFocus CPV technology from NREL PV Incubator Program

Concentrator photovoltaic (CPV) system maker SolFocus Inc of Mountain View, CA, USA has completed its grant administered by the US Department of Energy's National Renewable Energy Laboratory (NREL), under the PV Incubator Program.

The 18-month, \$2.2m subcontract was awarded in November 2007 by the Department of Energy to develop reflective-optic-based CPV panels that would enable the reliable generation of solar energy at a large scale capable of being cost competitive with fossil fuels. After a final review at NREL's campus in Golden, CO, it was determined that the SolFocus technology met or exceeded the program's requirements.

The optics developed under the program have been incorporated into SolFocus' second product, the 1100S CPV system, which was launched last November and recently transitioned into full-scale commercialization (with 11MW of product being shipped this year and an estimated 100MW of manufacturing capacity in place by the end of 2011). "They developed a highly innovative 650x concentrating PV module emphasizing high reliability and high efficiency," says NREL senior scientist Martha Symko-Davies.

As the first showcase for the technology developed through the PV incubator program, eleven SF-1100S CPV arrays will be installed at the 92kW Central Arizona Project Water Treatment Plant of the City of Mesa, Arizona (a pilot and initial endeavor for a long-term, private/public strategic collaboration that aims to demonstrate the technical and commercial viability and value of a larger-scale approach to distributed generation). The arrays will interconnect with the Salt River Project's electric distribution system meter, providing power to



Close up of reflectors in SolFocus' CPV system.

Red Mountain Park (across the street from the treatment facility). "The city of Mesa is committed to developing renewable energy sources as part of its environmental sustainability program," says the city's director of economic development, Bill Jabjiniak. "SolFocus has become an important partner to the City of Mesa in its economic development efforts as well as in its sustainable energy initiatives." In April, SolFocus completed a 15-fold capacity expansion of its Mesa glass reflector manufacturing factory (to 2 million concentrating reflectors annually, sufficient for 30MW of solar power generation), with full production expected in second-half 2009 and an annual payroll of more than \$7.5m.

The funds awarded for city of Mesa showcase build on a series of commercial milestones for SolFocus: the close of Series C Funding earlier this summer; an agreement in July with GreenWing Energy Management Ltd of Vancouver, Canada to supply CPV systems for its large-scale solar power projects in the western USA; the largest CPV installation in Europe currently underway in Greece; and the first certification of a CPV system to IEC 62108 standards in May.

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IN BRIEF

Second tranche of funds for Circadian

Circadian Solar of Coventry, UK, which is developing concentrated photovoltaic (CPV) systems incorporating GaAs multi-junction solar cells, has received approval for a £2m investment by Seven Spires Investments Ltd (SSIL). This is the release of the second tranche of an £8m investment planned to be rolled out over three years by SSIL.

The first tranche was received in early 2008 by AdvanceSis (founded in 2004 as a spin-off from the University of Warwick to commercialize strained silicon structures), before it changed its name to Circadian Solar in mid-July to reflect its focus on commercializing CPV technology.

"Circadian Solar is well on target to become a major player in the supply of CPV energy systems," says SSIL's Edward McCabe. "They have achieved all technical and commercial milestones to date," he adds.

"This funding will permit Circadian Solar to complete its commercial-scale demonstration and test system," says the CPV firm's CEO Dr Robin Godfrey. After sending a 1kW tracker unit in August to its Mediterranean test site for field testing, Circadian will follow up with a commercial-size system later this year. "It [the funding] will also allow an important investment into a joint venture aimed at significantly reducing the cost of high-performance solar cell devices over the next few years, as part of our drive to lower the costs of CPV systems to grid parity," he adds.

"Benefits aren't just applicable to the countries where these units will be established... the associated advantages of manufacturing and job opportunities will be felt much closer to home," asserts Godfrey.

www.circadiansolar.com

Tokai University completes solar car equipped with Sharp III-V solar cells for Global Green Challenge

Japan's Tokai University has completed construction of its 'Tokai Challenger' solar car, which will be used from 24–31 October in the Global Green Challenge (one of the world's largest solar car races, formerly the World Solar Challenge).

The race's solar car category has vehicles powered only by the sun's energy crossing the Australian continent from Darwin to Adelaide (about 3000km). Tokai University drivers include Kenjiro Shinozuka (who in 1997 became the first Japanese to win the Paris to Dakar Rally overall) as well as university students and alumni.

The Tokai University Challenge Center Team consists of 19 members (mostly students) led by professor Hideki Kimura, who researches high-efficiency solar cars at the School of Engineering's Department of Electrical and Electronic Engineering. The team has previously crossed the Australian desert three times—in 1993, 1996, and 2001—for the World Solar Challenge. In 2008, with Shinozuka as driver, the team won the 4200km South African Solar Challenge.

To maximize performance under the harsh conditions of the race, the Tokai Challenger is covered not with silicon solar cells but with triple-junction compound semiconductor solar cells — using indium gallium phosphide (InGaP), indium gallium arsenide (InGaAs) and germanium (Ge) for the top, middle and bottom layers, respectively. They are made by Tokyo-based electronics firm Sharp Corp, the only manufacturer whose solar cells are approved for use by the Japan Aerospace Exploration Agency (JAXA). Originally developed for space applications (sealed with glass to make a module), they are instead sealed with a film to enable mounting on curved surfaces and to minimize weight.

With a conversion efficiency of 30%, the 2176 cells (measuring 77mm x 39mm each) cover 6m² and provide power output of 1.8kW.

Sharp says that, despite crystalline and thin-film silicon solar cells currently being its main solar power products, it aims to continue its progress in R&D on compound semiconductor photovoltaics.

www.globalgreenchallenge.com.au



Tokai University Challenge Center Team with the Tokai Challenger solar car.



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Concentrator combination sets efficiency record of 43%

Researchers at Australia's University of New South Wales (UNSW) have set a world record for photovoltaic conversion efficiency, thanks largely to a new, high-efficiency silicon cell operating in the near-infrared range of the spectrum.

Anita Ho-Baillie and professor Martin Green, research director of the Australian Research Council's Photovoltaics Centre of Excellence at UNSW, used five different cells and spectrum-splitting optics to reach an experimental efficiency of 43% — measured under the global ASTM G173-03 spectrum, a terrestrial standard. Earlier this year, a US team put together a similar system operating at 42.7% efficiency.

Instead of using multi-junction cells that typically feature in today's state-of-the-art concentrator photovoltaic (CPV) systems, Green and Ho-Baillie have returned to an earlier method, in which the solar spectrum is split and steered towards individual, unstacked cells.

Although this can make a CPV system more optically complex than those featuring multi-junction cells, it does mean that more of the solar spectrum can be converted into electricity, without the need for a



Ho-Baillie and Green with last year's record-breaking solar cells.

single, but highly complex, semiconductor stack. As a result, the Australian team was able to use five different cells for solar conversion.

"The greater flexibility in cell choice made possible with the spectrum-splitting approach, combined with the low losses associated with dichroic reflectors, makes it likely that higher efficiency will always be possible than with the monolithic approach," suggests the team. Their paper describing the latest work was published in September in the journal *Progress in Photovoltaics*.

The five cells used in the new system include four based on compound semiconductor alloys — component maker Emcore and the US National Renewable Energy Laboratory (NREL) supplied the four

GaInP/GaAs and GaInAsP/GaInAs cells used in the experimental setup (which were part of the multi-cell combination that set the previous record of 42.7%, in combination with a fifth cell from the University of Delaware). But the main improvement on the previous record results from a silicon cell designed at UNSW and operating in the 890–1100nm region.

Although the 43% conversion figure is higher than what any such cell arrangement would be able to deliver in a terrestrial CPV system, Green believes that any optical losses would be similar in magnitude to those seen with the more conventional stacked-cell approach.

Stuart Wenham, director of ARC's PV Center of Excellence, believes that the work indicates the future potential of solar photovoltaic power. "This latest record involves an expensive combination of cells and the sunlight was focused to produce a much higher intensity than standard sunlight for these measurements," he said. "[But] it does show what may eventually be practical."

www.pv.unsw.edu.au

By Michael Hatcher

Magnolia appoints Kopin technology director as CTO

Magnolia Solar Inc of Woburn, MA, USA, which is developing nano-based solar cell technologies for terrestrial applications, has appointed Dr Roger E. Welser as its chief technology officer. He will be responsible for leading the development of next-generation solar cells employing nanostructured materials to cover the UV, visible and infrared parts of the spectrum, targeted at increasing the efficiency and lowering the cost of thin-film photovoltaics.

Magnolia says that, over the next decade and beyond, the use of photovoltaics for energy production is expected to grow from less than 1% currently to more than 10%. The emphasis for next-generation

solar cell technology is to develop nano-based processes that can be grown on low-cost materials such as glass or polymers, and to bring the cost of solar electricity energy generation to less than \$1 per watt.

Most recently, Welser was director of technology & new product development in III-V materials at Woburn-based epiwafer foundry Kopin Corp. His R&D group at Kopin focused on bandgap engineering of material structures to improve the performance and cost of GaAs-based transistor devices. But Welser was also actively involved in the field of photovoltaics. In July 2008, Magnolia said that it was collaborating with him on developing indium nitride

(InN)-based quantum dot solar cells for both the US National Aeronautics and Space Administration (NASA) and defense applications. Magnolia and Kopin have also collaborated previously on programs using gallium nitride (GaN)-based materials.

Welser's graduate studies were supported by the NASA Graduate Student Researcher's Program, with a focus on materials for high-efficiency, multi-junction III-V solar cells. More recently, he won funding from NASA, the US Defense Advanced Research Projects Agency (DARPA) and the National Science Foundation (NSF) to pioneer the development of quantum solar cell structures.

www.magnoliasolar.com

OPEL continues growth as Spanish grid field installation nears

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 reported that its revenues for second-quarter 2009 were up slightly year-on-year.

In addition, OPEL has now shipped about \$1m (363kW) of its Mk-I HCPV panels to its 440kW grid field installation in the Tarragona region of northern Spain, up from \$400,000 (138kW) at the end of Q1/2009.

OPEL and its Spanish partner BETASOL, which builds utility-grade solar farm installations for subsequent sale to investor groups, announced in mid-August that they had completed the second, 110kW phase of the four-phase, 440kW utility-grade solar power plant. The first phase was completed between December and early July. One of the world's first commercial HCPV installations, to date 220kW is installed and providing power to the grid. This will be recognized as revenue once the field is sold to a third party.

The balance of the installation was scheduled to take place during third-quarter 2009. When fully completed, the plant will supply electricity to over 350 households.

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 (acre/hectare) than silicon or thin-film flat panels, with the potential to boost photovoltaic 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.

"OPEL continued to execute on its growth path during the second quarter and maintain a solid cash position, particularly during these unprecedented economic conditions," says chief financial officer Michael McCoy. "OPEL continues to focus on completing the multiple phases of our first Spanish installation [which is intended to act as a showcase], growing our sales force to take advantage of a variety of new opportunities, and driving down the cost of our products."

www.opelinc.com

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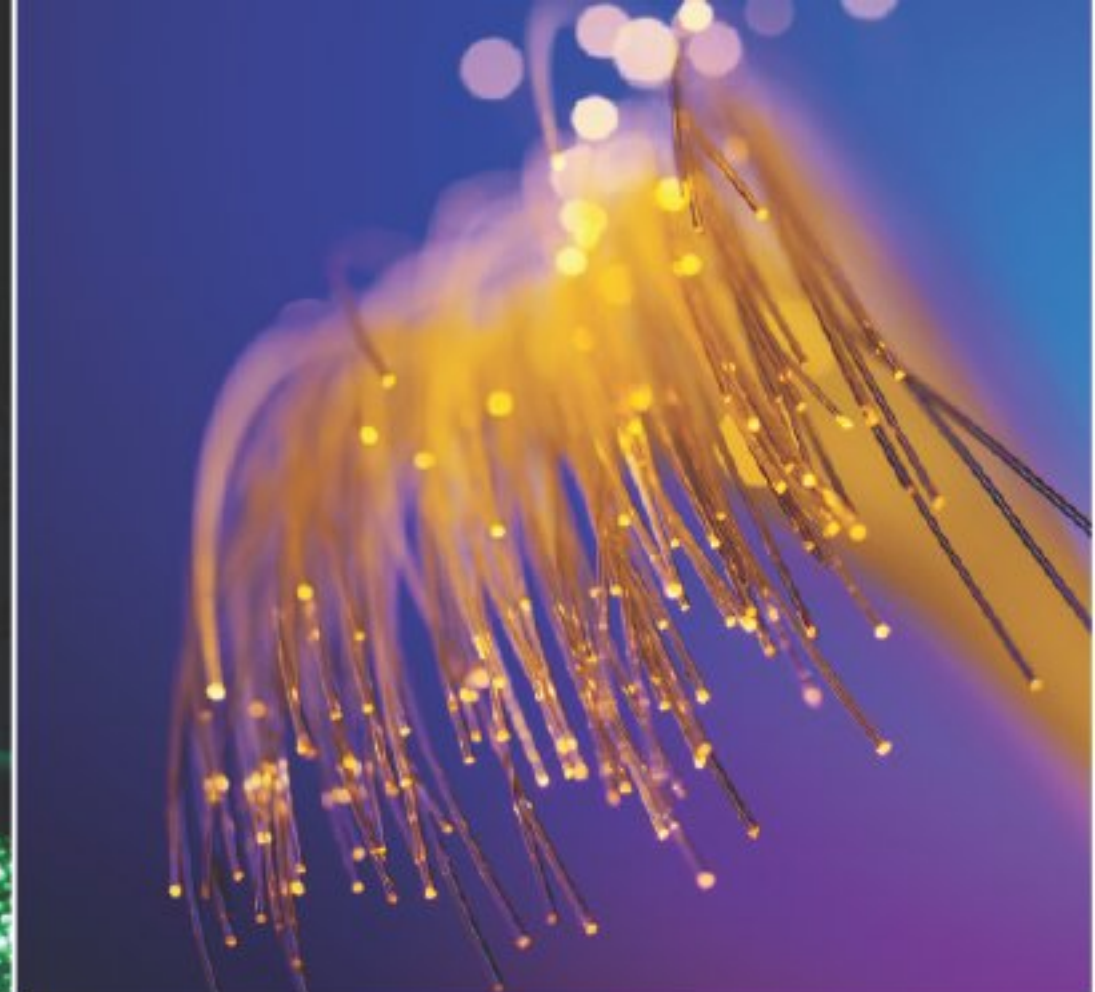
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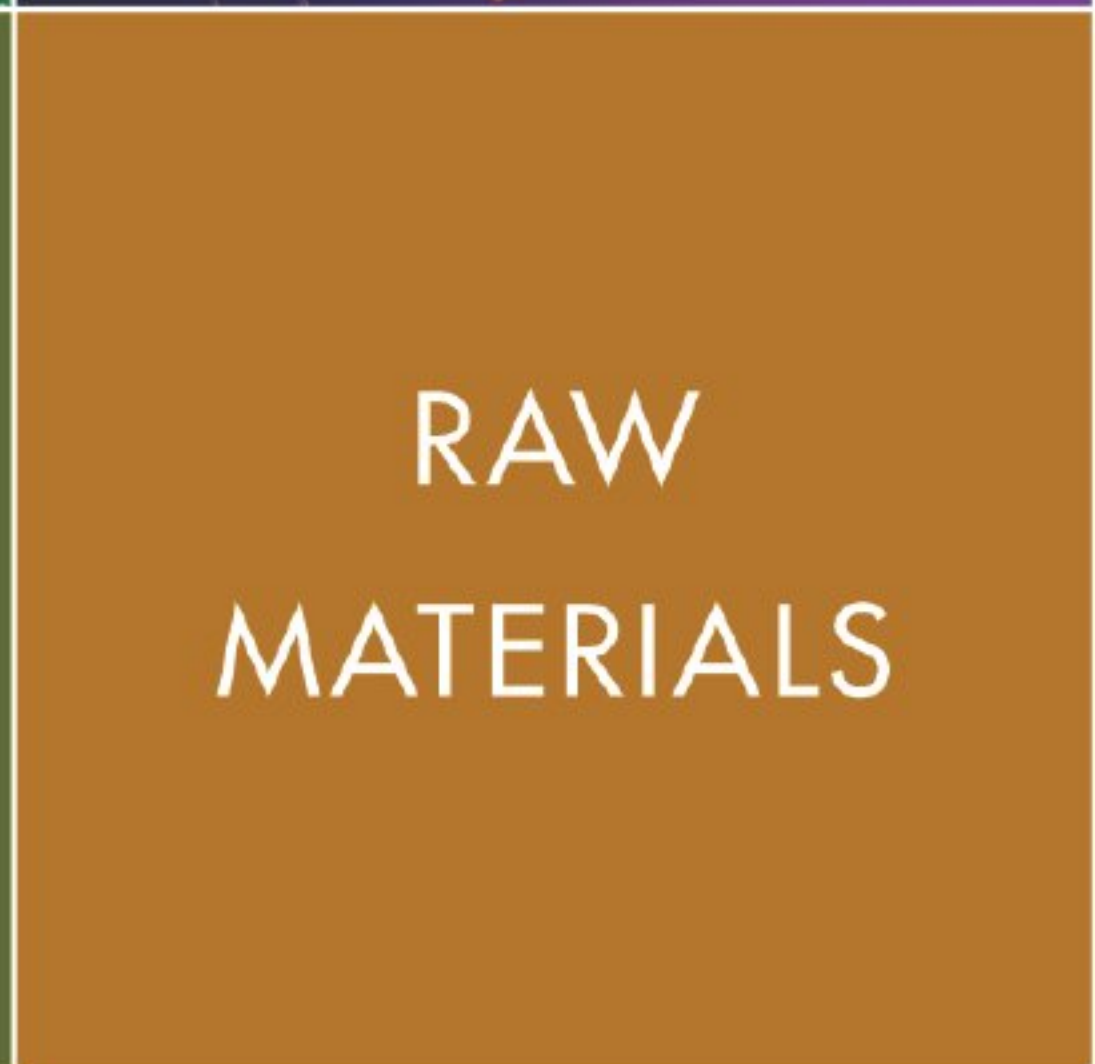
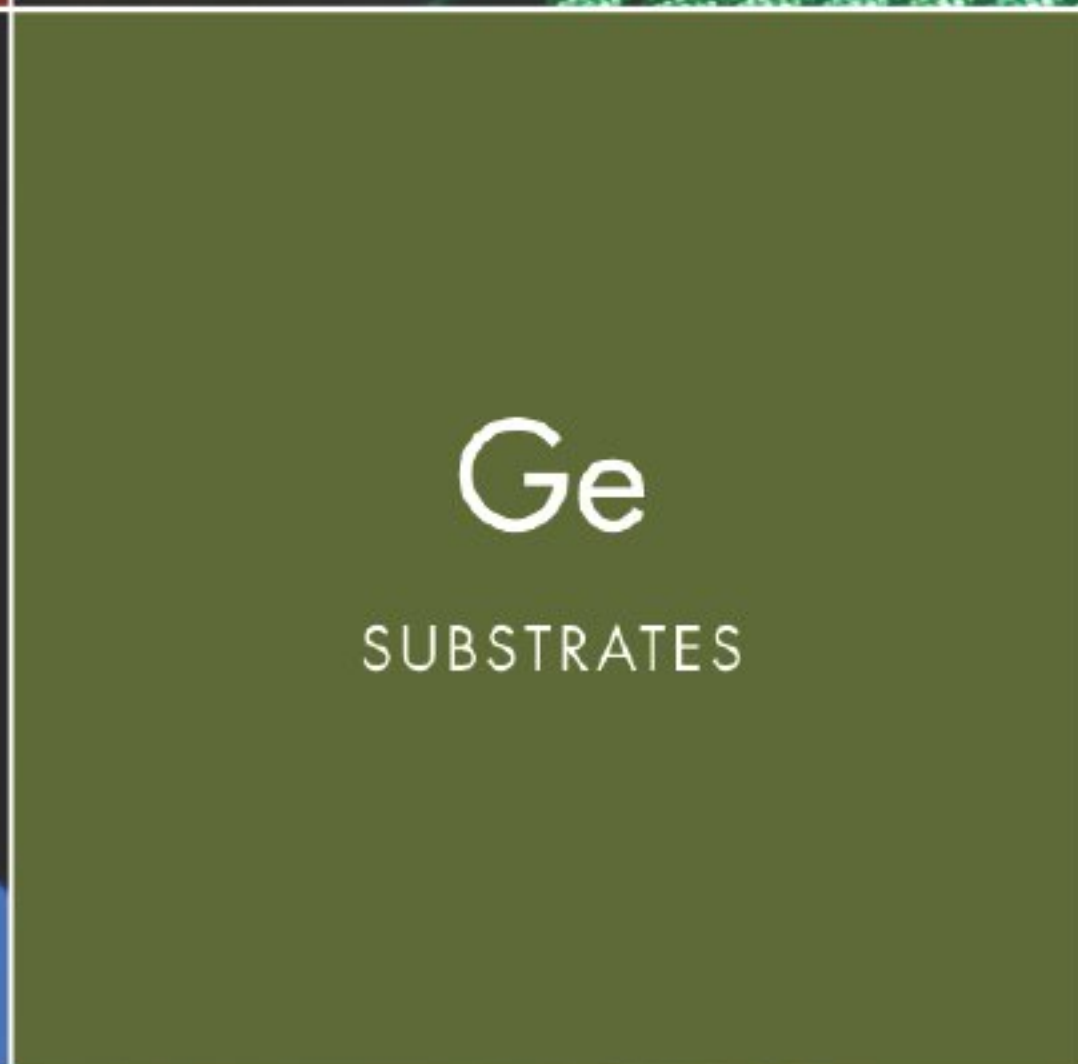
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First Solar to team with Chinese government on 2GW Inner Mongolia power plant

In the presence of chairman Wu Bangguo of the Standing Committee of the National People's Congress of China, First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic modules based on cadmium telluride (CdTe), has signed a memorandum of understanding (MOU) with the Chinese government to build a 2GW solar power plant in Ordos City, Inner Mongolia, China.

The plant will be built over a multi-year period. Phase 1 will be a 30MW demonstration project that will begin construction by June 2010. Phases 2, 3 and 4 will be 100MW, 870MW and 1000MW, respectively. Phases 2 and 3 will be completed in 2014 and Phase 4 will be completed by 2019.

"This major commitment to solar power is a direct result of the progressive energy policies being adopted in China to create a sustainable, long-term market for solar and a low-carbon future for China," said CEO Mike Ahearn at the signing ceremony. "It repre-



CEO Mike Ahearn greets Wu Bangguo.

sents an encouraging step forward toward the mass-scale deployment of solar power worldwide to help mitigate climate change concerns," he added.

The project will operate under a feed-in-tariff that will guarantee the pricing of electricity produced by the power plant over a long-term period. "The Chinese feed-in tariff will be critical to this project," Ahearn said. "This type of forward-looking government policy is necessary to create a strong solar market and facilitate the construction of a project of this size, which

in turn continues to drive the cost of solar electricity closer to 'grid parity' – where it is competitive with traditional energy sources."

The MOU contemplates that, during the implementation of the initial phases of the project, First Solar will actively review the possibility of module and supplier manufacturing sites in Ordos, and other considerations required to support a First Solar investment. The firm also intends to facilitate expansion of the supply chains in China for thin-film photovoltaic module production and for the recycling of photovoltaic modules after use.

"Discussions with First Solar about building a factory in China demonstrate to investors in China that they can confidently invest in the most advanced technologies available," said Cao Zhichen, vice mayor of Ordos Municipal Government.

Final agreement between the parties is subject to the negotiation and execution of definitive agreements among the parties.

www.firstsolar.com

The announcement of the MOU follows a visit by a delegation of senior Chinese government leaders to First Solar's headquarters in order to learn how its CdTe thin-film photovoltaic module technology can help contribute to China's goal of achieving a low-carbon economic future as well as meeting China's increasing demand for sustainable renewable energy.

Hosted by Ahearn, the delegation — led by Wu Bangguo — met with First Solar executives to examine the firm's solar panels. The officials also discussed the potential for the US and China to address global climate change through the creation of solar markets that take advantage of the solar resources in both countries.

"If the US and China work together and strongly support solar growth, we believe we can reduce the cost of solar electricity to grid parity and create the blueprint for accelerated mass-scale deployment of solar power worldwide to mitigate climate change," Ahearn said.

The Chinese delegation's visit was part of an itinerary that takes them to Washington DC to meet with congressional leaders and the Obama administration on a variety of energy, trade and business initiatives. Ahearn said he is encouraged that both China and the US are becoming increasingly aware of the importance of promoting policies supportive of solar energy.

"As a nation, we need strong policy support to create a vibrant

solar industry and the green jobs that come with it," Ahearn said. "Solar represents one of our best opportunities to help address global climate change and energy security, and we should ensure that it becomes a permanent, sustainable source of renewable electricity."

First Solar recently announced deals to build two large-scale projects in Southern California. The installations (among the largest of their kind) will have a capacity of 550MW, enough to provide power to about 170,000 homes.

"We are interested in teaming with progressive government and community leaders to help them achieve their goals for mass-scale deployment of affordable solar power," Ahearn comments.

First Solar to supply 27MW of modules for juwi's US utility installations

First Solar has been selected by Colorado-based engineering, procurement and construction (EPC) contractor juwi solar Inc (a subsidiary of juwi Holding AG of Wörrstadt, Germany) to supply CdTe solar modules for two US projects. These represent new orders, extra to the existing long-term framework agreement (of May 2005) between First Solar and juwi solar GmbH.

The projects include a 15MW (DC) installation for JEA, the eighth largest community-owned electric utility in the USA. First Solar will also supply another 12MW (DC) for

juwi solar Inc's project with American Electric Power in Ohio. Construction is expected to begin in fourth-quarter 2009 and be completed by the end of 2010.

"First Solar's modules are a cost-effective solution for utility-scale installations, making them an ideal fit for these projects," reckons the firm's president Bruce Sohn.

"We expect that our strong relationship with First Solar will be an important element toward the expansion of solar power in the US," says juwi solar Inc's managing director Michael Martin.

juwi project becomes Germany's biggest solar farm, and world's second biggest

The Lieberose solar farm (under construction in Turnow-Preilack, near Cottbus, Brandenburg) has become the world's second biggest solar power plant (and Germany's biggest), covering 162 hectares.

This follows placement of the 560,000th solar panel by German Infrastructure Minister Wolfgang Tiefensee and Brandenburg Minister President Matthias

Platzek. Renewable energy firm juwi Group of Wörrstadt, Germany — using First Solar modules — has now developed the three largest PV power plants in Germany.

Despite the current economic and financial crisis, since January the two firms have been building a utility-scale project with a total investment of more than €160m. First Solar also partly financed the project. Upon completion, about 700,000 CdTe modules (covering about 500,000m²), mainly from First Solar's nearby Frankfurt/Oder factory, will produce about 53MW annually (enough for 15,000



German Infrastructure Minister Wolfgang Tiefensee and Brandenburg Minister President Matthias Platzek, with juwi Holding AG head Matthias Willenbacher front-left.

homes). The solar farm should be fully operational by the end of 2009.

As general contractor, juwi Solar GmbH is responsible for planning, logistics, supervising construction and delivering the finished solar farm, which is expected to be sold to an investor upon completion. "By their size and the efficiency with which the solar panels are produced, they contribute to significantly lower prices and to accelerating the advent of competitive solar electricity," said Willenbacher and Hansen.

www.firstsolar.com
www.juwi.de

Former Honeywell Aerospace president appointed as CEO

After initiating an external search in late April (led by a committee of its board of directors), First Solar has appointed Robert J. Gillette as chief executive officer (as well as board member). He succeeds Mike Ahearn, who will continue to serve in the full-time position of executive chairman.

Ahearn says that Gillette has a unique combination of skills and experience that suits leading First Solar in its next wave of growth.

For the last four and a half years, Gillette was CEO & president of Honeywell Aerospace, Honeywell International's most profitable



business group (with current annual sales of more than \$12bn). In this role, he led more than 40,000 associ-

ates at nearly 100 manufacturing and service sites worldwide.

Gillette joined Honeywell in 1996 and has served in senior management positions including president & CEO of Honeywell Transportation Systems and president of Honeywell Turbo Technologies. Previously, he spent over 10 years at General Electric.

"Rob has a track record of fostering innovation and bringing new technologies and products to market," says Ahearn. "He has built organizational capability to enable businesses to scale in complex and geographically diverse markets and he has worked extensively in global markets, including Europe, Asia and South America," he adds. "He has demonstrated a leadership style that meshes well with our core values and will enable him to form strong working relationships with our management team."

IN BRIEF

Sublimation system completed

Sunovia and EPIR have completed the design and construction of a closed space sublimation (CSS) system for fabricating polycrystalline cadmium telluride (CdTe) solar cells. Deposition rates using CSS are high compared to other thin-film deposition techniques, suiting high-volume production.

"Two-junction CdTe-on-silicon (CdTe/Si) devices can reach efficiencies comparable to those of three-junction III-V solar cells on the market today, so the fabrication of three-junction and inverted three-junction CdTe-based devices have the potential to achieve efficiencies greater than 50%," says EPIR's founder & CEO Dr Siva Sivananthan. "Multi-junction CdTe-on-silicon photovoltaic devices can be manufactured at a fraction of the cost of the existing III-V solar cells," he adds.

"Our technology combines high-quality, single-crystal CdTe with silicon substrates for high-efficiency, two- and three-junction solar cells," Sivananthan says. "We already have a baseline silicon solar cell fabrication process in-house that results in over 15% efficiency. Setting up the CSS now gives us the baseline CdTe process, which furthers our extensive understanding of II-VI materials and solar cells, and allows us to accelerate the commercialization of our CdTe/Si products," he reckons.

"EPIR is well known in the field of infrared detectors and they are now using this expertise to develop a novel photovoltaic technology," says former NREL fellow Dr Timothy Coutts. "This tool gives EPIR state-of-the-art research ability in polycrystalline CdTe in addition to its already industry-leading single-crystal CdTe-on-silicon epitaxial layer growth and device fabrication."

Sunovia and EPIR expanding R&D and pilot manufacturing facility

Sunovia Energy Technologies Inc of Sarasota, FL, which is commercializing cadmium telluride (CdTe) solar cells, and its partner EPIR Technologies Inc of Bolingbrook, IL (in which Sunovia has a stake) are to expand their R&D and pilot production facilities in Bolingbrook to allow them to begin optimizing their high-efficiency, low-cost CdTe-on-silicon (CdTe/Si) concentrated photovoltaic devices (prior to starting pilot-scale production there).

The firms have also expanded their materials synthesis and device fabrication facility to 26,000ft², including 4000ft² of cleanroom laboratory space. The expanded facility also houses R&D and engineering staff, which has doubled over the past year.

EPIR is currently servicing more than 20 governmental contracts (worth more than \$20m), including contracts with the Department of Energy, Department of Defense, and the Missile Defense Agency.

Sunovia and EPIR (a developer of II-VI materials and devices for infrared sensor and imaging in applications including night-vision, missile tracking and space exploration) partnered in January 2008 to commercialize a novel

approach to photovoltaics that takes advantage of EPIR's expertise in growing high-quality, single-crystal layers of CdTe on silicon.

EPIR was founded in 1998 by chairman & CEO Dr Siva Sivananthan, who pioneered mercury cadmium telluride (HgCdTe) on silicon infrared technology for night vision. It uses molecular beam epitaxy to produce single- and multiple-element focal plane array IR detectors,

which are supplied with packaged detector/cooler assemblies. For solar applications, by producing a very high-efficiency CdTe/Si photovoltaic cell and concentrating the sunlight that strikes it by up to 500 times its normal intensity, a much greater amount of electricity can be produced in a given area and at a lower cost than traditional photovoltaics, the firms say.

"This expanded laboratory and pilot production space will accelerate our already fast-paced R&D efforts. Both our facility expansion and R&D progress are at least 12 months ahead of schedule," says Sivananthan. "In preparation for our first CdTe/Si product, we have designed this facility in a manner that will allow us to transition into pilot production using the same space and equipment," he adds.

"By basing our concentrator solar cells on silicon instead of germanium, as is the norm for the high-efficiency III-V concentrator cells produced today, we can use production equipment that the integrated circuit industry has spent years and hundreds of millions, if not billions, of dollars optimizing."

"By leveraging the infrared materials and sensor expertise within EPIR Technologies, we have not only expedited the commercialization process for the high-efficiency solar wafers, but have done it at a drastically reduced development cost," comments Sunovia's chairman & CEO Carl Smith. "The solar modules that we are commercializing are among the most efficient in the world, and can be manufactured at a fraction of the cost of other solar cells," he claims. "In addition to the solar wafers, EPIR has completed the expansion of its infrared manufacturing capabilities, which has allowed us to aggressively pursue additional customers on the night vision side of the business."

www.sunoviaenergy.com

www.epir.com

EPIR is servicing more than 20 governmental contracts (worth more than \$20m) including with the DOE, DOD, and MSA

Veeco receives multi-system web coater order from Hong Kong CIGS PV maker

Epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview NY, USA has received a multi-million dollar order for its suite of FastFlex web coating systems, for shipment in early 2010 to the plant in Suzhou, China of GroupSat (Hong Kong) Ltd. The order consists of one Mo (molybdenum) deposition system, one TCO (transparent conductive oxide) deposition system and two copper indium gallium diselenide deposition systems.

"We have an aggressive plan to become the first true CIGS thin-film solar manufacturer in China," says GroupSat's CEO Nasir M. Ameriar. "As a provider of flexible solar products, we will cater to markets in China, the Middle East, North Africa

and Asia, and have chosen Veeco's FastFlex web coating systems because we are convinced that their technology and process support will help us achieve our goals," he adds.

The FastFlex platform has a flexible architecture with high uptime that can be configured to specific needs, with a choice of rotary or planar magnetrons for high-throughput, high-temperature effusion sources, and substrate sizes up to 1m wide. "Our FastFlex systems feature the industry's only fully integrated thermal evaporation sources, which we believe provides our customers a high-throughput, low-cost manufacturing solution," says David Bruns, senior VP & general manager, Veeco Solar Equipment. "Ultimately, the

success of CIGS technology is tied to increasing cell efficiency and driving down manufacturing cost per watt."

CIGS offers the combined benefits of higher efficiencies and lower costs compared with silicon, says Veeco. Market research firm Greentech Media estimates that CIGS production capacity will grow at a compound annual growth rate (CAGR) of 86% from 264MW in 2009 to 1.7GW in 2012. Veeco adds that CIGS solar cells offer the broadest range of applications of any thin-film solar technology, including solar farms, in building integrated photovoltaics (BIPVs), flat and pitched roofs, rooftop shingles, and portable devices.

www.groupsat.com

www.veeco.com

DuPont launches metallization paste for thin-film PV

US-based DuPont has launched Solamet PV412 photovoltaic (PV) metallization paste, the latest in a line of silver conductor materials developed for thin-film PV technologies.

"Solar cell manufacturers can significantly reduce their cost per watt of solar energy by using high-performing materials that allow them to achieve higher cell efficiencies, higher production yields, and more efficient use of materials," says Robert Cockerill, Thin Film Photovoltaic marketing manager — DuPont Microcircuit Materials. "We worked closely with leading thin-film PV manufacturers as we developed Solamet PV412, because we share a common goal of enabling more cost-effective manufacturing of solar cells with improved efficiency and yield to help solar energy become more competitive with other forms of energy generation."

In particular, as it developed Solamet PV412, DuPont collaborated with Ascent Solar Technologies Inc (ASTI) of Thornton, CO, USA, a

developer of flexible thin-film photovoltaic modules based on copper indium gallium diselenide (CIGS).

"Innovative materials are critical to advancing our technology for thin-film photovoltaics," says Dr Prem Nath, ASTI's senior VP production-operations. "ASTI is building a position as a leader in the production of lightweight flexible photovoltaics used for portable power and building-integrated photovoltaic (BIPV) products," he adds. "As our technology has evolved, the ability to work closely with our supplier DuPont in early-stage testing as it adapted Solamet photovoltaic metallizations to other materials and manufacturing processes has been a big advantage."

Solamet PV412 photovoltaic metallization paste is designed for use on devices where a transparent conductive oxide is used. It suits

use with CIGS, amorphous silicon (a-Si) on flexible substrates, and heterojunction with intrinsic thin layers (HIT) PV cells, as well as any PV application where a low-temperature curing conductor is required. Key features include fine line printing down to 80µm resolution, long screen residence time for robust printer operation, low contact resistance, low gridline resistance, high adhesion to indium tin oxide, and strong compatibility with most transparent conductive oxides.

Solamet is part of a growing portfolio of products represented by DuPont Photovoltaic Solutions. DuPont expects to nearly triple its annual PV sales across all product platforms to more than \$1bn by 2012 based on strong fundamentals for long-term revenue growth in the solar energy market. Thin-film PV is projected to be the fastest-growing segment of the solar module industry, mainly because of its potential to reduce the cost of producing solar energy.

<http://photovoltaics.dupont.com>

DuPont expects to nearly triple its annual PV sales by 2012

Nanosolar opens 640MW CIGS PV panel assembly plant in Berlin

Nanosolar, which started making copper indium gallium diselenide (CIGS) thin-film photovoltaic cells at its roll-to-roll printing facility in San Jose, CA, USA in late 2007 (entering serial production earlier this year), inaugurated its panel-assembly serial-production factory in Luckenwalde near Berlin, Germany on 9 September in an event attended by Germany's Minister of the Environment, the Governor of the State of Brandenburg, and other leading public officials.

The fully automated assembly plant processes Nanosolar's cells into finished panels using high-throughput manufacturing techniques and tooling developed by Nanosolar and its partners, allowing a production throughput of one panel every 10s (an annual capacity of 640MW when fully utilized and operating around-the-clock).

However, initial utilization rates will be much lower, with start-up production at just 1MW per month (less than 2% of maximum capacity). But as customers attain project financing from commercial banks for the new panel, Nanosolar will increase monthly production to deliver on its contractual commitments, which total \$4.1bn to date, from "highly bankable customers, including the world's largest utility power producers" (many are European utilities, including Beck Energy/Belectric, EDF's renewable energy subsidiary EDF EN, AES Solar, juwi, and NextLight). "With almost all large solar installations credit financed, broad-based product bankability is our key next commercial goal," says CEO Martin Roscheisen. "We have long prepared for this, including through the technology choices we have made, the strong balance sheet we have maintained, the quality of customers we have secured, and the local production we have built."



One roll of CIGS foil from Nanosolar's San Jose plant can deliver total power of 100kW.

In May 2006, Nanosolar achieved power-conversion efficiencies (for a cell sample on glass) of 14.5%. Now, Roscheisen has revealed that, in tests performed in April at the US National Renewable Energy Laboratory (NREL), Nanosolar's best CIGS-on-aluminum-foil cells were independently verified to deliver a conversion efficiency of 16.4%, which is claimed to be the most efficient printed solar cell and the most efficient cell on a low-cost metal foil (with a material cost of only a cent or two per square foot and mil thickness). The tests also showed that a best-in-class CdS/Cu(In,Ga)Se₂ cell with an area of 0.5cm² yielded a conversion efficiency of 15.3%. The higher figure quoted by Nanosolar refers only to the active area of the cell. The firm's lab and production teams have made more progress on efficiency than on any of Nanosolar's business plans, says Roscheisen.

The results were revealed in a white paper on Nanosolar's web site and also showed that the median efficiency of its best in-production rolls is 11.75%.

In the white paper, Nanosolar also revealed more about its production technology than has been released to date. Having tried out a wide range of different techniques to deposit CIGS onto a conducting substrate, the firm settled on a foil-

lamination process. Instead of using a glass substrate (typical for other CIGS cell makers), Nanosolar uses an aluminum foil. The other main difference is the thickness of some of the key layers of the cell: e.g. Nanosolar's molybdenum layer, used as the bottom electrode in the material stack, is only 50nm thick. Its CIGS layer is (as is typical) about 1µm thick.

"This new approach is particularly cost efficient," claims the firm.

"Roll-to-roll lamination is a widely employed, simple, and very-high-throughput processing technique," it adds. "It works specifically (and only) for thin-film solar cells based on high-conductivity foil."

Crucially, the production of stoichiometric ratios of copper, indium, gallium and selenium has been addressed in a reproducible way.

Conventionally, high-vacuum processes common to semiconductor manufacturing, such as sputtering or evaporation techniques, have been used to deposit the active elements of the cell reliably. Nanosolar is now able to do this using a wet printing process, without the need for cleanroom conditions.

"Our team has developed proprietary types of nanoparticles, [and] proprietary organic dispersion chemistry by which these nanoparticles can be dispersed into a readily printable ink," claims the firm, adding that a proprietary rapid thermal processing technology is able to convert the precursor layer into a high-quality, dense semiconductor film.

Nanosolar clearly believes that there is plenty of room to improve the technology further: "We are only at the very beginning of the potential of our technology platform and see more opportunities than ever based on the manufacturing processing we have established."

www.nanosolar.com

CIGS PV maker Solyndra breaks ground on 500MW Fab 2

Solyndra Inc, which was founded in 2005, has begun construction of its second copper indium gallium diselenide (CIGS) photovoltaic (PV) panel manufacturing plant less than a mile from its current 300,000ft² plant and headquarters in Fremont, CA, USA.

The ground-breaking ceremony was attended by California's Governor Arnold Schwarzenegger and US Energy Secretary Steven Chu (joined by US Vice President Joe Biden via satellite from Washington).

Covering 1 million square feet and designed for an annual production capacity of 500MW, Fab 2 will enable Solyndra to fulfill a backlog of announced contractual orders (from customers in the USA and Europe, including GeckoLogic, Phoenix Solar and Carlisle Energy Services) now worth more than \$2bn, despite the firm only coming out of stealth mode in autumn 2008.

Solyndra has developed a proprietary thin-film cylindrical solar panel built from tubes that capture sunlight across a 360° photovoltaic surface capable of converting direct, diffuse and reflected sunlight (from below) into electricity. The firm says that this 'self-tracking' design allows the capture of significantly more sunlight from low-slope commercial rooftops than conventional flat-surfaced solar panels, which require costly tilted mounting devices to improve the capture of direct light from the sun, offer poor collection of diffuse light, and fail to collect reflected light from rooftops or other installation surfaces. Also, gaps between the tubes and their frame let wind pass through, reducing the need for heavy, roof-penetrating fastenings or anchoring; their lighter weight also allows installation on scantier roofs. Simple horizontal mounting hardware also allows fast and economical installation, claims the firm.



Energy Secretary Steve Chu and California Governor Arnold Schwarzenegger break ground, flanked by Solyndra executives.

Solyndra says that its two fabs will produce enough solar panels over their lifetime to cut over 350 million metric tons of CO₂ emissions or 850 million barrels of oil.

"Fab 2 will allow us to meet customer demand while making a positive impact on the world's energy and environmental needs," says CEO & founder Dr Chris Gronet. "We are grateful for the vision and support of President Barack Obama, the US Department of Energy (DOE), the US Congress, and our investors."

The first phase of Fab 2 is being financed by public and private capital. Solyndra is the first recipient of a DOE loan guaranteed under the American Recovery and Reinvestment Act and Title XVII of the

Construction of Fab 2 will employ over 3000 people... The plant should open by late 2010 and begin shipments in 2011

Energy Policy Act of 2005 (also the first loan guarantee issued by the DOE since the 1980s). Announced in March but only finalized recently after Solyndra secured its portion of Fab 2's financing, the \$535m loan from the US Treasury's Federal Financing Bank is providing 73% of the \$733m project cost, supplementing \$198m from a recent financing round led by Argonaut Private Equity. Solyndra has now raised about \$820m in venture capital in total.

Solyndra estimates that the construction of Fab 2 will employ over 3000 people, and ongoing operation will create over 1000 jobs. The plant should open by late 2010 and begin shipments in 2011 (with the installation of Solyndra PV systems generating hundreds of additional jobs, the firm reckons). A second phase of Fab 2 should employ 1000 more, says Ben Bierman, Solyndra's VP of operations. The firm currently employs 600.

www.solyndra.com

IN BRIEF

Odersun joins Global Cleantech 100

A jury of experts has selected Odersun AG of Frankfurt (Oder), Germany, which manufactures flexible thin-film solar cells and modules using proprietary CISCuT (copper indium disulfide on copper tape) reel-to-reel technology, out of more than 3500 candidates as one of the 100 most promising cleantech companies worldwide.

The Global Cleantech 100 is compiled by the UK newspaper The Guardian in cooperation with Cleantech Group. For the first time a ranking list has gathered an international collection of "companies offering technological breakthroughs that will make a large dent in the carbon problem". The central criteria for inclusion in the listing were that the technology has a wide application and has previously attracted capital investment to fund its development. Odersun's investors include Doughty Hanson Technology Ventures (UK), Virgin Green Fund (USA/UK), Advanced Technology & Materials (China), PCG Clean Energy & Technology Fund (USA), Allianz Group's AGF Private Equity (France) and Valor KG (Austria). Odersun was also ranked 'Europe's hottest Cleantech Company' in The Guardian/Library House 'CleanTech 100' in September 2008.

"The integration capability of our modules makes solar energy generation suitable for more and manifold applications worldwide such as solar integrated roofs and facades," says CEO Dr Hein van der Zeeuw.

The firm's CIS-based flexible solar reels can be assembled into modules of various sizes using a range of materials to package the cells. The jury concluded that Odersun modules' "ability to be integrated en masse into the fabric of the building is a huge asset".

www.odersun.com

Global Solar hits 15.45% efficiency

Global Solar Energy Inc of Tucson, AZ, USA, which makes CIGS (copper indium gallium diselenide) thin-film photovoltaic cells for both glass modules and flexible substrates, says the US National Renewable Energy Laboratory (NREL) has confirmed 15.45% total area efficiency for its production-level CIGS material.

The firm has also reached a peak efficiency of 11.7% for production CIGS solar cell strings made at its 40MW plant in Tucson (opened in March 2008) and its 35MW plant in Berlin Adlershof Technology Park, Germany (opened last November). Global Solar claims to be the only full-scale producer of CIGS solar cells on a flexible substrate.

"The 15.45% total-area conversion efficiency, independently verified by NREL for a thin-film CIGS solar cell fabricated by Global Solar Energy, is a significant achievement for such rapid deposition on a metal

foil substrate in a manufacturing environment," says Dr Harin S. Ullal of the National Center for Photovoltaics at NREL. The research was supported in part by NREL's Thin Film PV Partnership Program.

Global Solar has been producing its CIGS solar cells on flexible materials for more than five years, for applications from portable solar chargers to traditional glass modules and building-integrated photovoltaic (BIPV) products.

"In less than two years, Global Solar increased production capacity from 4.2MW to 75MW worldwide and continues to increase the efficiency," says CEO Michael Gering. "These achievements not only help advance the solar solutions developed by our existing customers and partners, but also open the door of opportunity for new usages and BIPV applications in the market."

www.globalsolar.com

Saint-Gobain buys out Shell JV

In mid-August France-based materials maker Saint-Gobain SA acquired Netherlands-based energy company Royal Dutch Shell plc's 50% stake in the two firms' joint venture Avancis GmbH & Co KG of Torgau, Saxony, Germany.

Avancis was formed in November 2006 to combine the know-how of Shell research, development and production in CIS (copper indium diselenide) thin-film technologies and Saint-Gobain's expertise in manufacturing glass and building materials. Its R&D division in Munich has since developed processes for making thin-film CIS-based PV modules.

Avancis is already operating its first plant (with an annual production capacity of 20MWp). Two more production lines are being started up to reach full production capacity as fast as possible, says chief operating officer Hans-Peter Hoheisel.

The technology requires expertise in glass coating and in glass thermal treatment, two processes belonging

to the core portfolio of Saint-Gobain (which provides flat glass for the building and automotive industries).

The firm says that the acquisition strengthens its position in the renewable energy market, adding that it intends to accelerate the industrial development of Avancis.

Saint-Gobain provides products and services in solar energy via Saint-Gobain Solar, its new entity which groups all of the firm's solar businesses. Saint-Gobain Solar says that its strategy hinges on three independent activities:

- making components for PV modules (special glass, performance plastics etc) and high-performance mirrors for solar thermal plant operators;
- production by Avancis of thin-film CIS-based PV modules for distributors and integrators; and
- designing and marketing PV solutions for residential homes, offices, industrial installations and farm buildings.

www.avancis.de/en

Lightweight flexible CIGS PV array supplied to SkySentry for airship test

Ascent Solar Technologies Inc of Thornton, CO, USA, a developer of flexible thin-film photovoltaic modules based on copper indium gallium diselenide (CIGS), says that SkySentry, a high-altitude vehicle developer in Colorado Springs, CO, has received its first flexible CIGS PV array for an aerostat test in Sandusky, OH, scheduled for mid-September. The aerostat is part of the US Army Space and Missile Defense Command's High Altitude, Long-Endurance (HALE) testbed.

"Power production and storage are the most difficult challenges of operating stationary vehicles for lengthy periods in the stratosphere," says SkySentry's president & CEO Charles Lambert. "This test will use an aerostat — a tethered blimp — to characterize performance of a solar array on a dynamic platform, understand the performance of thin-film arrays on a buoyant vehicle in terms of temperature and impact on an inflated substrate, determine the consistency of solar output for high-altitude applications and quantify the effect of clouds and variable weather on performance of an aerostat-mounted array," he adds.

Corollary benefits include comparing high-efficiency solar array deployments on aerostats as pri-



CIGS PV arrays attached to aerostat.

mary or supplementary power generation with other technologies such as off-shore power generation with wind turbines.

"This shipment represents our first delivery of flexible monolithically integrated CIGS PV specifically for airship experimentation," says Ascent Solar's president & CEO Farhad Moghadam. "SkySentry's testing of our photovoltaics on the aerostat, along with advanced power management, will demonstrate their approach towards an important application for national security and surveillance."

www.SkySentry.net

Ascent internally certifies module encapsulation for flexible CIGS PV laminate

Ascent Solar has announced the internal qualification of a packaging solution for its flexible monolithically integrated CIGS thin-film photovoltaic modules.

In internal qualification testing, its flexible packaging solution passed the rigorous standard of 1000 hours of damp heat testing (85% relative humidity and 85°C temperature) guideline set forth by IEC 61646 standards for performance and long-term reliability of thin-film solar modules.

"This is a breakthrough development not just for Ascent Solar but also for the advancement of flexible CIGS technology and the differentiating capabilities it brings," claims CEO Dr Farhad Moghadam. This sets the stage for certification of the firm's products by external agencies, he adds. "This is also well timed to meet the requirements of our initial production from the 30MW high-volume manufacturing plant scheduled to commence at the beginning of 2010."

Ascent Solar hires senior VP of sales & marketing

Ascent Solar has recruited Rafael Gutierrez as senior VP of sales & marketing.

Gutierrez has more than 20 years of experience in strategic marketing, business development, product development, general management, and corporate strategy, including a proven track record of developing strong customer relationships, says president & CEO Farhad Moghadam. "As we prepare to begin high-volume production at the beginning of next



year, the customers that Rafael establishes today will help shape the company for tomorrow and beyond," he adds.

"Rafael's past experience in the highly competitive consumer electronics market will be an invaluable asset to Ascent Solar as we pursue our strategy to earn new business and fuel growth."

Prior to joining Ascent, Gutierrez was general manager of Consumer Electronics in Seagate Technology's Consumer Solutions division. Previously, he was responsible for Seagate's business development and strategy for Consumer Electronics and Storage Services. During more than 18 years at Seagate, he held executive roles in corporate strategy, strategic marketing, advanced concepts, and product development.

Before joining Seagate, Gutierrez held engineering development positions with Digital Equipment Corp. He also has an M.S. in operations research & applied statistics from the University of Northern Colorado and a B.A. in Mathematics from Bellevue University.

"With the advantages of its lightweight flexible thin-film modules and technology scalability, Ascent Solar is uniquely positioned to truly open new market opportunities and at the same time establish new standards for existing ones," comments Gutierrez.

www.ascentsolar.com

Buffer boost for InGaN-on-Si solar cell

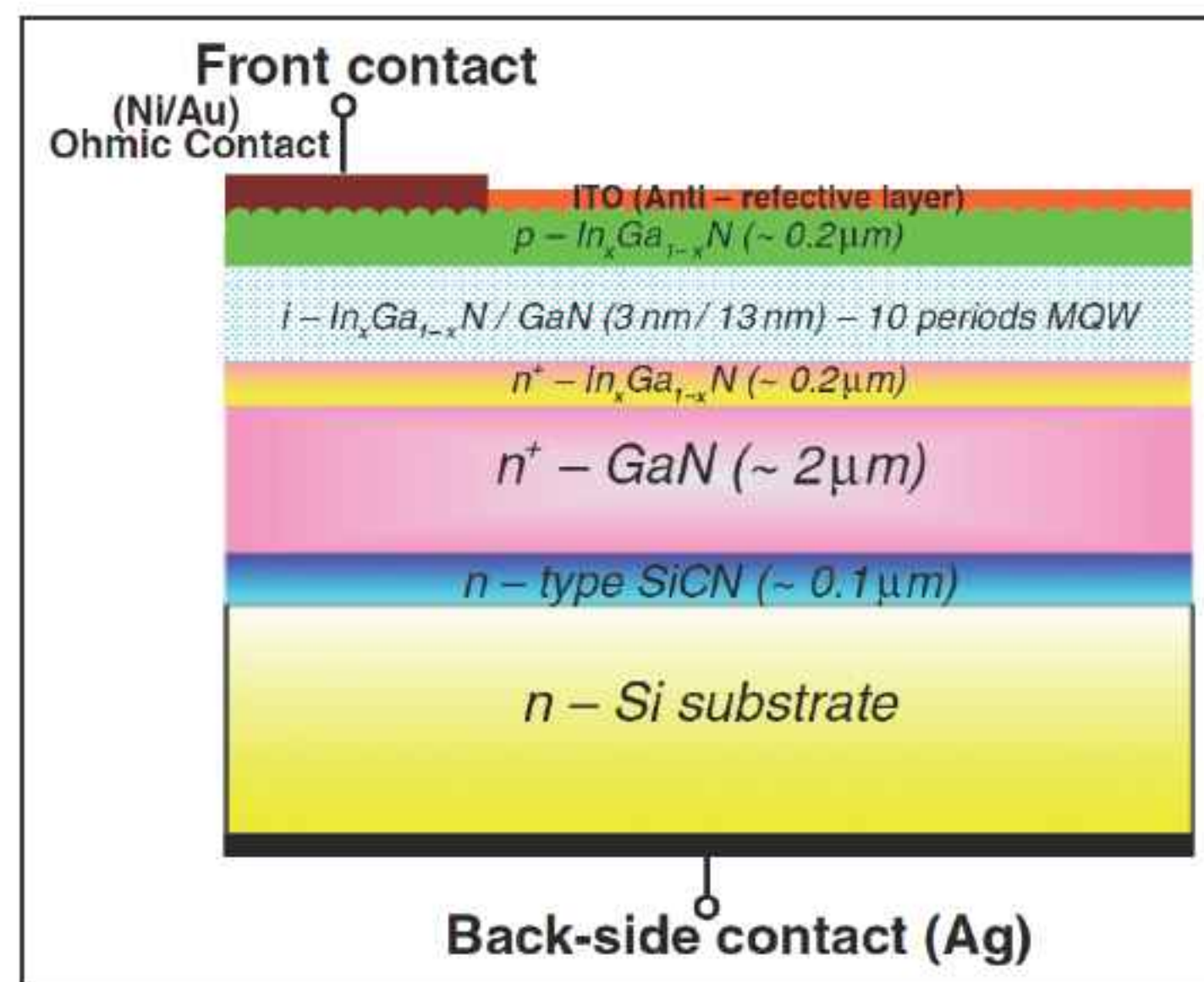
Bor Wen Liou of Taiwan's Wufeng Institute of Technology has been developing indium gallium nitride (InGaN) multi-quantum well (MQW) based solar cells grown on a silicon (Si(111)) substrate [Bor Wen Liou, Japanese Journal of Applied Physics, vol.48 p. 072201, 2009].

Liou reports that the best energy conversion efficiency achieved for his $\text{In}_{0.68}\text{Ga}_{0.32}\text{N}$ in a p-MQW-n structure so far was 38.5%. The tests used the air mass AM1.5G spectrum that is used to simulate solar radiation on Earth at common latitudes for application. The efficiency achieved compares with multi-junction gallium arsenide solar cells that come in at better than 40% efficiency. Traditional silicon solar cells have efficiencies of ~16%.

To improve performance, Liou uses a silicon-carbon nitride buffer layer to bridge the large 17% lattice mismatch between Si and GaN. SiCN has a smaller lattice constant (4.36Å) compared with that of Si (5.43Å). This represents a reduction of the mismatch with the thick GaN layer on which the device is grown to around 4%. A lesser lattice mismatch can lead to fewer problems such as defects, dislocations, cracking, etc.

Devices using InGaN are usually grown either on more expensive silicon carbide (SiC) or on sapphire which suffers from a very low thermal conductivity (0.35W/cmK). Silicon's thermal conductivity is 1.5W/cmK.

The SiCN buffer was grown on n-type Si(111) substrates using rapid thermal chemical vapor deposition (RTCVD). A Thomas Swann low-pressure metal-organic chemical vapor deposition (LP-MOCVD) was used for the InGaN layers. The main source gases were trimethylgallium (TMGa), trimethylindium (TMIn), and ammonia (NH_3). Doping was achieved using Bis(cyclopentadienyl) magnesium (Cp_2Mg) and



Schematic of $\text{In}_x\text{Ga}_{1-x}\text{N}/\text{GaN}$ -based solar cell with an MQW structure using SiCN/Si(111) substrate. The conducting indium tin oxide (ITO) has an anti-reflective coat to improve entry of light into the device.

silane (SiH_4) for p-type and n-type, respectively.

The constructed solar cells contain a 10-period InGaN/GaN MQW (not intentionally doped) sandwiched between p- and n-type InGaN layers (see Figure).

For Liou's devices, lower indium contents were found to give higher performance (Table) in terms of conversion efficiency (η), open-circuit voltage (V_{oc}), short-circuit current (J_{sc}), and fill factor ($FF = (\text{maximum power}) / (J_{sc} V_{oc})$). This is attributed to the wider energy band gap of InGaN with lower indium content.

Liou believes significant progress has been made towards application of the technology in a concentrator-solar cell module set-up. ■

<http://jjap.ipap.jp/link?JJAP/48/072201>

By Mike Cooke.

● Bob Forcier (CEO of RoseStreet Labs) has noted the following concerning the original article by Bor Wen Liou: "The highest-efficiency cell with the open-circuit voltage of 3.16V, short-circuit current of 56.5mA/cm² and fill factor 0.918 would produce a power of 0.164W from 1cm² when illuminated with AM 1.5G solar spectrum. Since the incident power of the solar spectrum is only 0.1W/cm², that would suggest an unrealistic power conversion efficiency of 164% rather than the 38.5% listed in the paper."

Parameters for $\text{In}_x\text{Ga}_{1-x}\text{N}$ devices with and without MQW region and various In contents (x).

Type	x	V_{oc} (V)	J_{sc} (mA/cm ²)	FF (%)	η , efficiency (%)@28°C
p-n	0.94	2.83	38.1	88.7	30.1
	0.83	2.88	38.5	85.2	32.4
	0.68	3.09	40.1	86.3	33.5
p-MQW-n	0.94	2.92	55.1	89.5	35.1
	0.83	2.96	55.8	90.4	36.4
	0.68	3.16	56.5	91.8	38.5

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Extending dot-dash advantages to InP

Mike Cooke reports on recent quantum dot/dash laser diode developments aiming at 1.55 μm wavelengths.

Fiber-optic communications depends on an interlocking series of advantages/disadvantages in various structures. For example, while C-band communications at about 1.55 μm has the least attenuation in the basic fiber, the E band at 1.3 μm has the least dispersion.

In the transmitter section also there are trade-offs between the uses of various systems — light-emitting diodes (LEDs), laser diodes (LDs) — and their material bases: gallium arsenide phosphide (GaAsP) on GaAs substrates and gallium indium arsenide phosphide (GaInAsP) on InP substrates. The GaAsP/GaAs option covers the 1.3 μm applications, while GaInAsP/InP is needed for 1.55 μm communications.

Qdots/dashes

For InP LDs, much of the present research is focused on using quantum dot (Qdot) or quantum dash (Qdash) structures. Qdot lasers are expected to enable high-speed modulation, low threshold current, and high characteristic temperature (allowing higher-temperature operation). Some success in these respects has been achieved in producing InAs dots on GaAs substrates that lase in the 0.9–1.4 μm range.

For 1.55 μm , the InAs/InP system is seen as being more suitable in terms of the resulting dot sizes due to the lower lattice mismatch between the materials (3.2%) compared with GaAs-based dots (7.2%). Unfortunately, rather than forming round dots of suitable size (~25nm diameter), a high density of wires/dashes extended in the $[1\bar{1}0]$ lattice direction or too large (50nm diameter) dots tend to result, depending on the growth conditions.

There are a number of approaches that are being researched for use of the InAs/InP system as a Qdot-like system. One is to find ways to reduce the dash-like character of the confinement structures by using special growth techniques or substrates. Another is to live with and grow to love the peculiar characteristics of dashes. A further approach is to abandon the self-assembly normally used to create dots/dashes and build controlled, specially shaped structures directly using photolithography techniques.

Reorientation

One technique that reduces dot sizes is to use InP substrates oriented in the high-index (113)B plane direction rather than the more usual low-index (001).

Researchers based in France at the Institut National des Sciences Appliquées (INSA) de Rennes have been investigating the optimal substrate orientation for creating InAs Qdots on InP substrates for 1.55 μm communication laser wavelengths [1]. With (113)B substrates, INSA achieved smaller dots (of about 25nm diameter) and low threshold currents in laser diodes produced using the dots. However, such substrates are difficult to incorporate into standard InP production technology.

Another approach being explored at INSA in France is to use substrates that are cut off the (001) InP crystal ingot with a somewhat misoriented surface that reduces the tendency to form wires, dashes or larger dots. The investigation involved comparing the structures produced with misorientations of about 2° in the (111)A or (111)B directions, and a nominal on-axis (001) sample.

A Riber 32 gas-source molecular-beam epitaxy (GSMBE) system was used to create the Qdot structures. It was found that the arsenic flux is also critical for producing suitable Qdots. The buffer layer on which the dots were grown was $\text{Ga}_{0.2}\text{In}_{0.8}\text{As}_{0.435}\text{P}_{0.565}$, which is lattice matched to the InP substrate. The emission wavelength of the buffer layer is 1.18 μm .

A high flow of 6 standard cubic centimeters (sccm) of the arsine (AsH_3) source gas (resulting in an As flux of about 30x the In flux) leads in all cases to large dots (60–65nm base diameter). However, 0.3sccm of AsH_3 results in smaller isotropic dots on the B-surface substrates (Figure 1). The 2nm-high dots measure 30–35nm in diameter and are produced with a density of 7×10^{10} Qdots/cm². The dot height varies by around 30%, irrespective of the arsine flow rate.

The 1nm-high structures grown on nominal and A-surface substrates are elongated in the $[1\bar{1}0]$ direction. The elongations are 200–500nm and 100–200nm for the nominal and A-surface substrates, respectively.

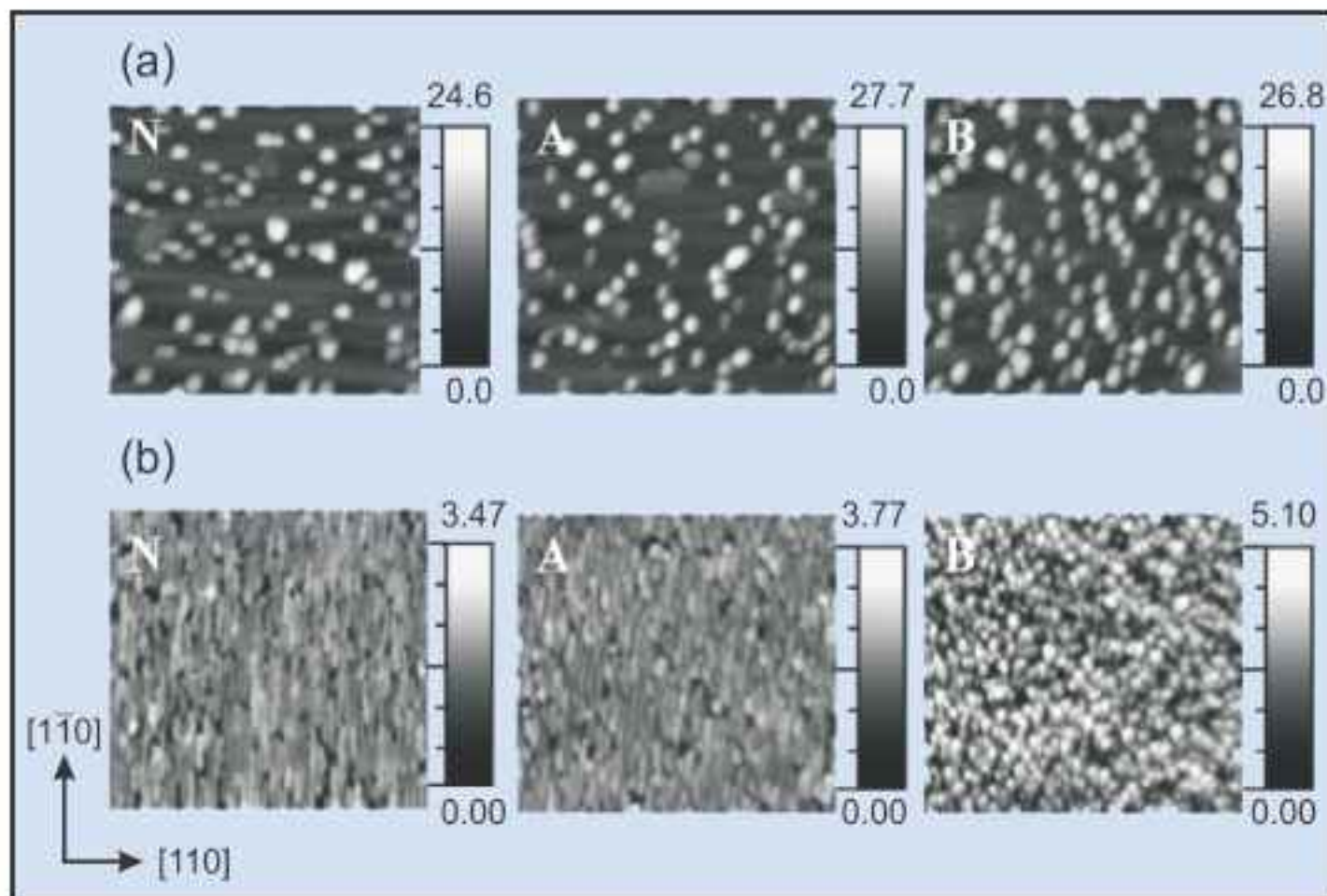


Figure 1. Atomic force microscopy of InAs Qdot/Qdash structures produced at Institut National des Sciences Appliquées (INSA) de Rennes, France, on miscut (001) InP substrates. The arsine flow rate is varied: (a) 6 sccm and (b) 0.3 sccm. The scan field is $1\mu\text{m} \times 1\mu\text{m}$. N = nominal on-axis (001) InP surface, A = (001) InP surface miscut in the (111)A direction, B = similar miscutting in the (111)B direction. High densities of smaller dots (rather than large dots or dashes) are only produced on the B-miscut substrate with a lower flow rate.

Focusing on B-surface substrates, a variation of temperature was then investigated, growing dots at 400°C and 450°C , in addition to the 480°C of the previous experiments with the range of substrates and flow rates. The lower arsine flow rate was naturally used as giving better results at 480°C . A modest increase in dot density to 9×10^{10} Qdots/ cm^2 , and a decrease in dimensions to 26 nm diameter and 1 nm height, was achieved with decreasing temperature.

A double capping process, using the same $\text{Ga}_{0.2}\text{In}_{0.8}\text{As}_{0.435}\text{P}_{0.565}$ material composition as in the buffer layer, allows tuning of the photoluminescence of the 480°C Qdots to emission wavelengths close to the $1.55\mu\text{m}$ target. Double capping consists of a growth interruption under an arsenic/phosphorous (As_2/P_2) flux. The aim is to reduce the tendency of As atoms in InAs regions to be replaced by P, which is believed to be the cause of inhomogeneous broadening of the emission spectrum in the InAs/InP Qdash system. The typical photoluminescence line-width for InAs/InP Qdashes is 100 meV, which is much larger than that for InAs/GaAs Qdots. This can be reduced to about 62 meV with double capping [2].

A 1 mm cavity laser structure consisting of five Qdot layers on the miscut (001) substrate, separated by $\text{Ga}_{0.2}\text{In}_{0.8}\text{As}_{0.435}\text{P}_{0.565}$ spacers, was grown that produced room-temperature electroluminescence at $1.62\mu\text{m}$. The lasing threshold current density was $1.06\text{kA}/\text{cm}^2$ ($206\text{A}/\text{cm}^2$ per layer). The device measured $1 \times 0.1\text{mm}$. The output power is not reported.

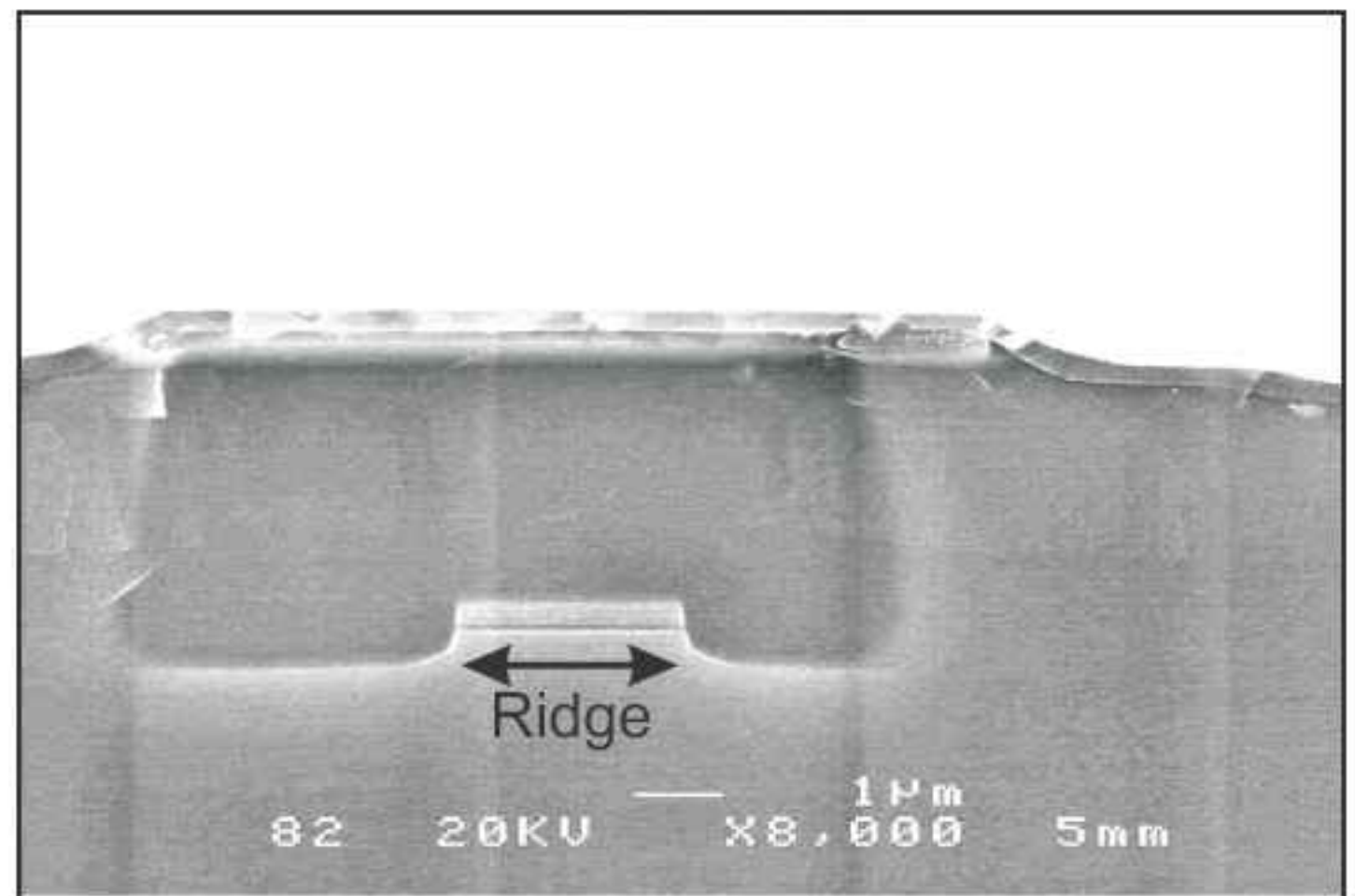


Figure 2. Scanning electron micrograph (SEM) of Alcatel-Thales III-V Labs' buried ridge stripe laser. The ridge measures $2.5\mu\text{m}$ and contains a stack of six active QDash layers.

Dashed hopes

The INSA group sees their results as being comparable to those of Alcatel-Thales researchers who achieved a $110\text{A}/\text{cm}^2$ per layer current density threshold for an InAs Qdash laser on nominal InP(001) substrates. The Alcatel-Thales III-V Lab in France has worked on InAs/InP quantum dash based lasers and optical amplifiers using a variety of dots and dashes.

To improve characteristic temperature values and dynamic performance, the Alcatel-Thales group has found p-doping of the barriers with beryllium in the active Qdash layer to be useful [3]. High characteristic temperatures indicate less degradation in performance as temperature increases. Less variation in performance with temperature offers the potential for simpler/less costly control circuitry.

Six Qdash layers were separated by 40 nm barriers ($\sim 4 \times 10^{18}/\text{cm}^2$ beryllium) within two 80 nm separate confinement heterostructures (SCHs). Broad area (BA) and buried ridge stripe (BRS) Fabry-Perot (FP) laser structures were produced (Figure 2). Characterization of a series of BA devices suggests an unacceptably large value for the threshold current density of $\sim 10\text{kA}/\text{cm}^2$ for an infinite length cavity (Figure 3). This is connected with the increase in non-radiative (Auger) recombination as p-doping increases.

However, the characteristic temperature (T_0) is higher than that for an undoped reference device — 135 K in the range $25\text{--}85^\circ\text{C}$ for a $425\mu\text{m}$ BA device, compared with $\sim 80\text{K}$ for undoped barriers. For the same range and continuous-wave operation with more than 6 mW output, T_0 is 103 K. These values are better than for AlGaInAs-based multi-quantum well structures that have been explored to increase the generally poor characteristic temperature of InP-based LDs.

The relaxation frequency, indicating better dynamic performance, is also improved from 7.5 GHz for the

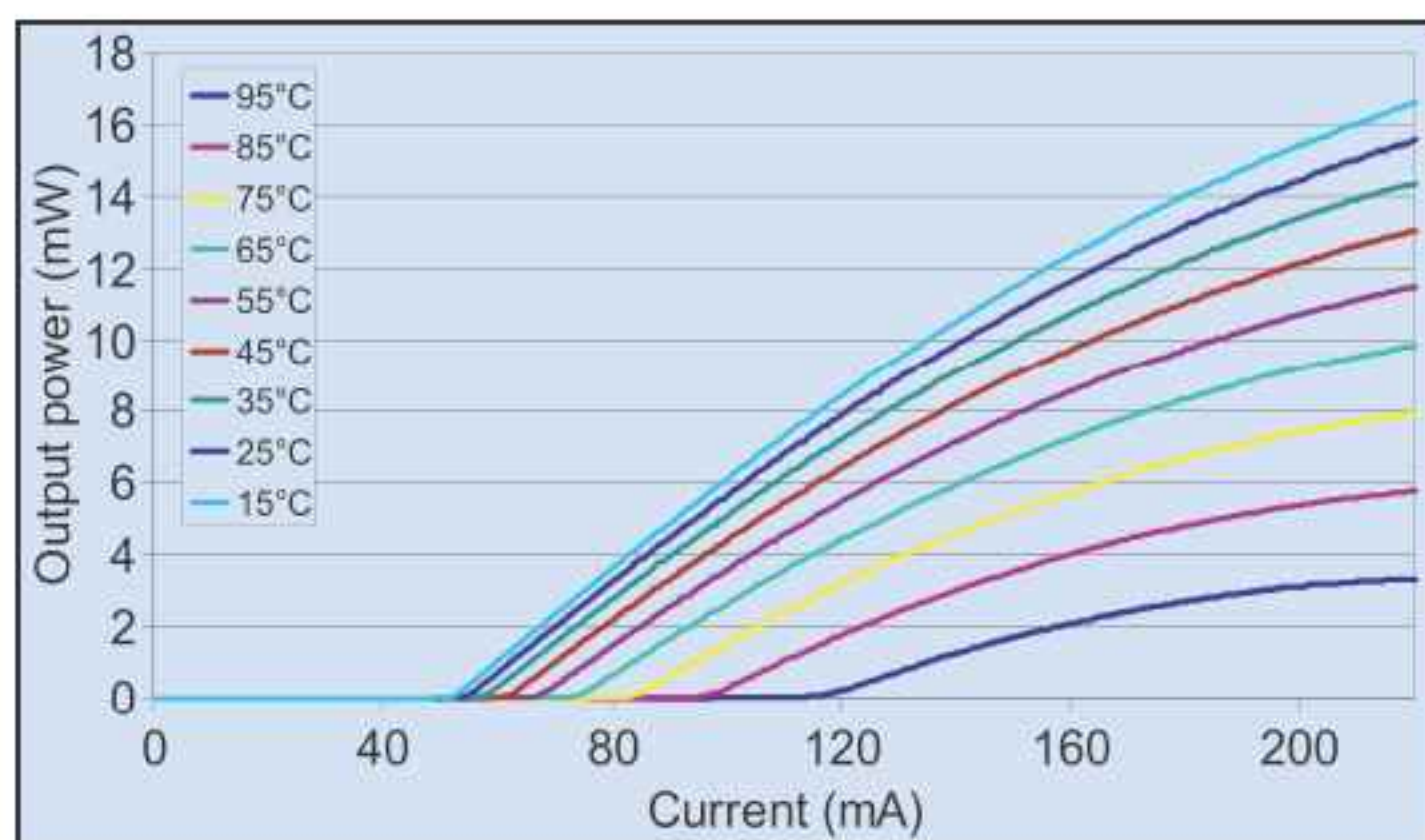


Figure 3. Temperature dependence of output power versus current (L-I) for Alcatel-Thales III-V Lab's 1.5x600µm high-reflectivity coated LDs using p-doped barriers at various temperatures (15–95°C in steps of 10°C). High temperature degrades output power, along with increasing threshold current.

undoped device to 13.5GHz at an injected current of 200mA on the BRS formation. "To our knowledge, this value is the highest relaxation frequency ever reported in CW operation for InP-based Qdot and Qdash lasers," say the researchers. Similar techniques have been used to develop semiconductor optical amplifiers at Alcatel-Thales [4].

Alcatel-Thales III-V Lab has also contributed to work by the French CNRS Laboratoire de Photonique et de Nanostructures (CNRS/LPN) on InAs/InP Qdash mode-locked lasers that have repetition rates greater than 300GHz with low timing jitter down to 400fs [5]. Such devices are seen as having potential for applications such as ultra-high bit rate (320Gb/s) clock recovery, terahertz generation based on photoconduction, and microwave photonics.

Further work at CNRS/LPN, with some contributions from Alcatel-Thales III-V Lab, has been on developing Qdash-based passive mode-locked lasers.

One device produced sub-picosecond $\sim 1.5\mu\text{m}$ light pulses with a 346GHz repetition rate (claimed to be a record [6]). Rather than using more complicated arrangements with special absorbers or multiple sections, as is often used to create mode-locking, a simple single-section laser diode was used. This avoids extra processing steps.

The Qdash structure was grown using GSMBE on sulfur-doped (001) InP (n-type). Six layers of InAs

InAs/InP Qdash mode-locked lasers that have repetition rates greater than 300GHz with low timing jitter down to 400fs are seen as having potential for applications such as ultra-high bit rate (320Gb/s) clock recovery, terahertz generation based on photoconduction and microwave photonics

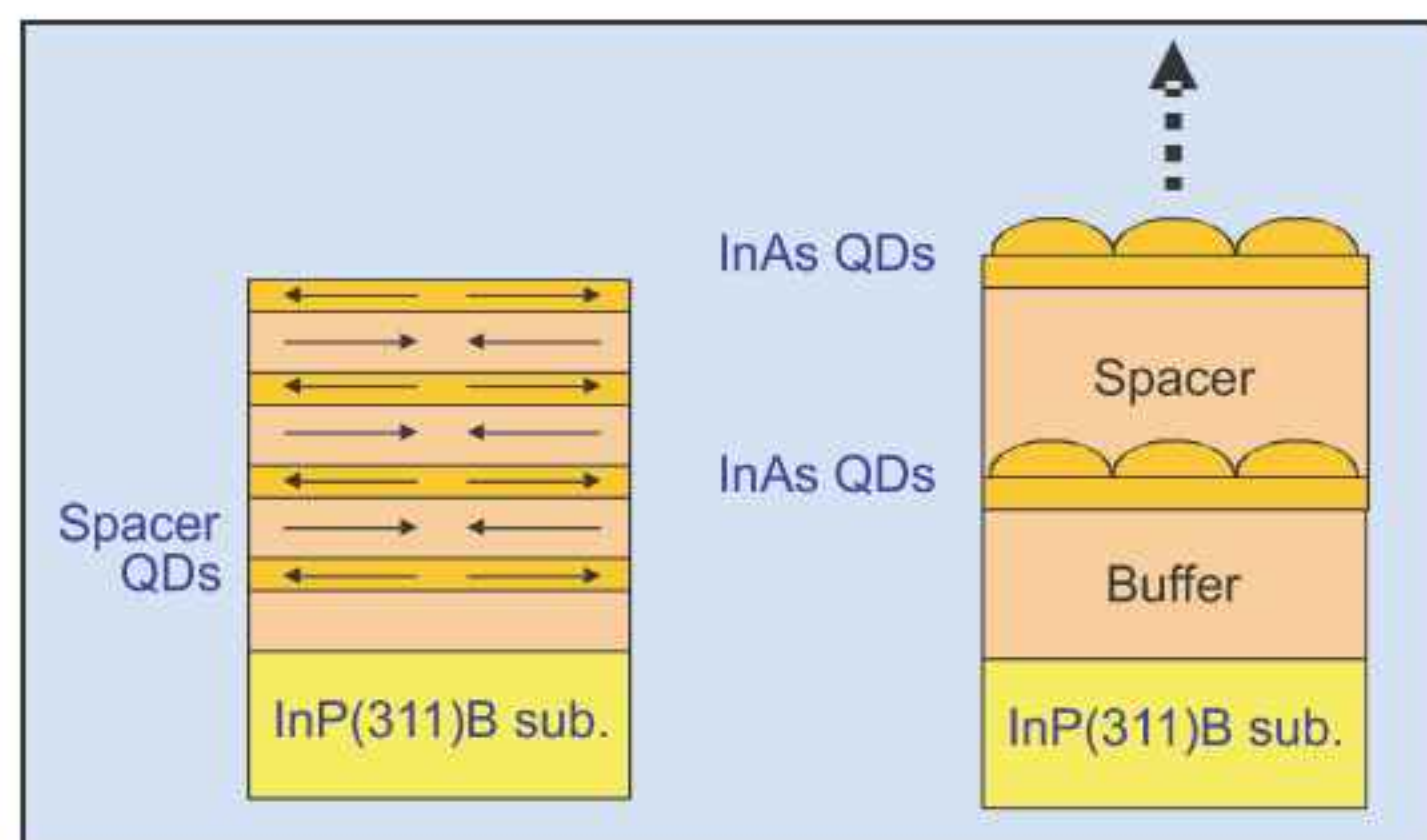


Figure 4. Compensating spacer layers are used by Japan's National Institute of Information and Communications Technology (NICT) to reduce the average strain in quantum dot structures. The buffer ($\text{In}_{0.52}\text{Al}_{0.48}\text{As}$) is lattice matched to the InP substrate. The spacer is a quaternary alloy (InGaAlAs).

dashes make up the active regions separated by 80nm barriers and with 40nm SCH layers. Undoped $\text{Ga}_{0.2}\text{In}_{0.8}\text{As}_{0.4}\text{P}_{0.6}$ layers ($E_g=1.17\mu\text{m}$) lattice matched to the substrate were used for these barriers and SCH layers. BA and BRS lasers were then created with InP cladding and GaInAs contact layers.

The laser threshold current density, from the extrapolation of measured data to infinite length, was $0.68\text{kA}/\text{cm}^2$ ($110\text{A}/\text{cm}^2/\text{layer}$). The characteristic temperature was 70K for the temperature range 20–80°C.

BRS lasers with cavity lengths of 120µm and 170µm were investigated for mode locking. The wavelengths were 1.53µm and 1.55µm, respectively. The threshold was 6mA in both cases. Stable mode-locking was observed for currents in the range 60–250mA. The repetition rates were 346GHz (pulse width 560fs at 217mA) and 245GHz (pulse width 870fs at 180mA) for the 120µm and 170µm cavities, respectively. The mode locking is attributed to enhanced four-wave mixing in the material system.

In addition to general mode-locked laser applications above, monolithic semiconductor mode-locked lasers (MLLs) could be of use in optical interconnects and low-noise electro-optic sampling.

Another group working on mode- (and injection-) locking with a view to applications is the University of New Mexico's Center for High Technology Materials, where Qdot and Qdash systems are both being developed on GaAs and InP substrates. Recent work has focused on accurately modeling such systems to enable system design optimization for features such as modal gain, low losses, line-width enhancement, elimination of pre-resonance dip, modulation bandwidth, etc. For injection locking, low temperature and high bias current is favored for the slave Qdash laser. Some of this research is financed by the US Air Force Research Laboratory (ARFL).

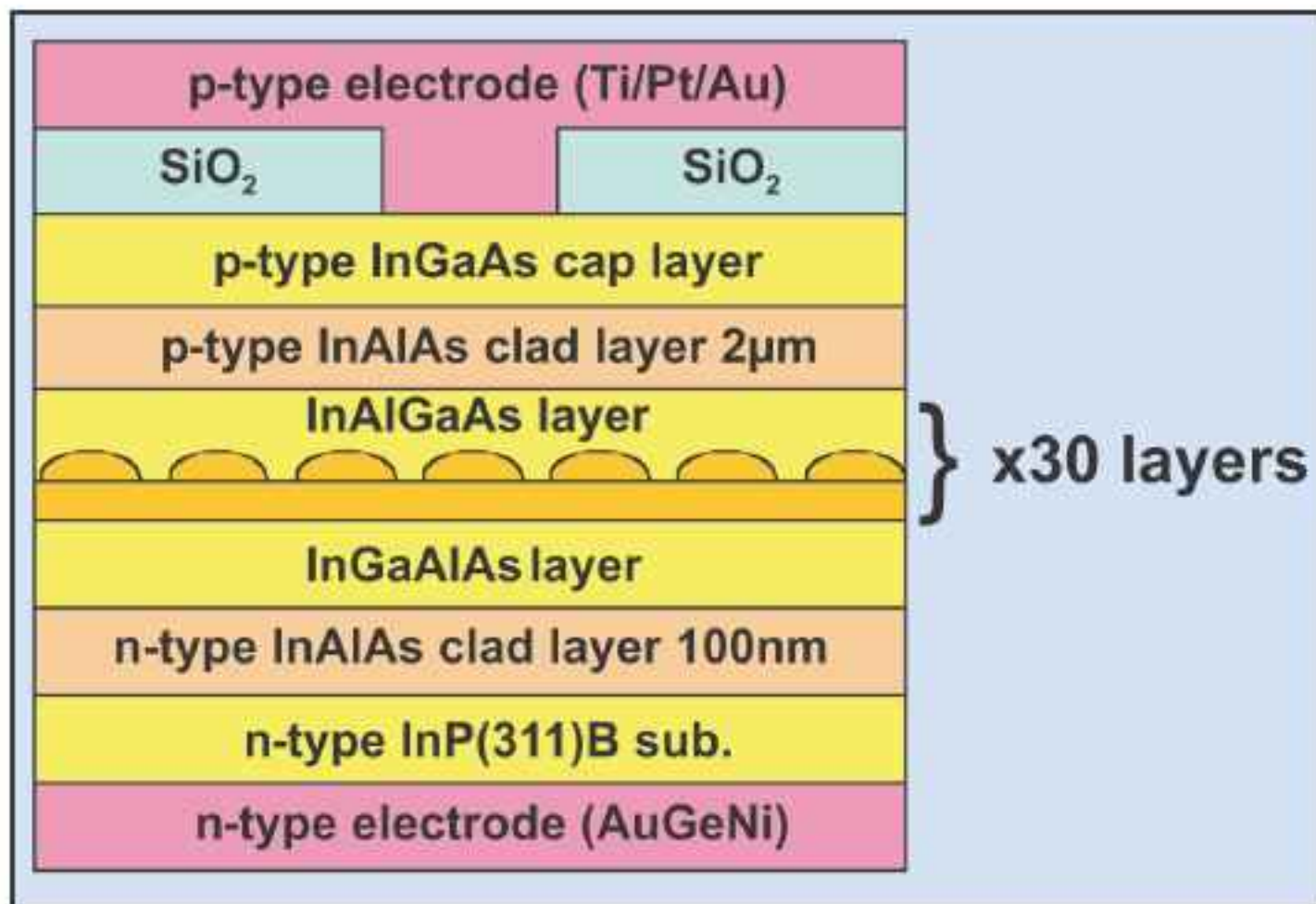


Figure 5. NICT laser diode structure, targeting devices with a line width of 50µm and cavity length of 600–1400µm.

Stacking

Japan's National Institute of Information and Communications Technology (NICT) has been looking at the possibilities of increasing Qdot densities through stacking on InP(311) substrates [7]. The problem that NICT has been focusing on is the accumulation of strain that often occurs when layers of InAs Qdots are built up on InP(311)B substrates.

The NICT approach has been to separate the Qdot layers with compensating spacer layers with the opposite strain so that the strain is reduced across the structure (Figure 4). The spacer layer that is used is a quaternary $\text{In}_x\text{Ga}_y\text{Al}_{1-x-y}\text{As}$ material with $y \sim 0.2$. LDs produced using 30 layers of Qdots (Figure 5) resulted in a current threshold of 517.5mA (57A/cm² per dot layer) and a slope efficiency of 0.052W/A at room temperature. The lasing wavelength was about 1530nm. The characteristic temperature (T_0) was a high 113K.

Beyond self-assembly

Researchers at the University of Wisconsin at Madison (UW-Madison) have taken a somewhat different approach to producing Qdot structures on InP. The usual techniques often depend on the 'self-assembly' of the dots on the growth surface. UW-Madison has instead developed patterning methods to produce useful nano-confinement structures.

One approach uses di-block co-polymer masks — i.e. organic materials that, under treatment, polymerize into regions with different etching properties. For example, polystyrene-b-poly(methyl methacrylate) (PS-b-PMMA) can be spun onto SiO₂ dielectric and, after ultraviolet radiation, the material polymerizes into PMMA cylinders in a PS matrix [8]. The cylinders can be removed by a reactive ion etch (RIE) to form a mask for wet etching into the dielectric. The mask is then removed and the holes in the dielectric filled with III-V material to produce Qdots (Figure 6).

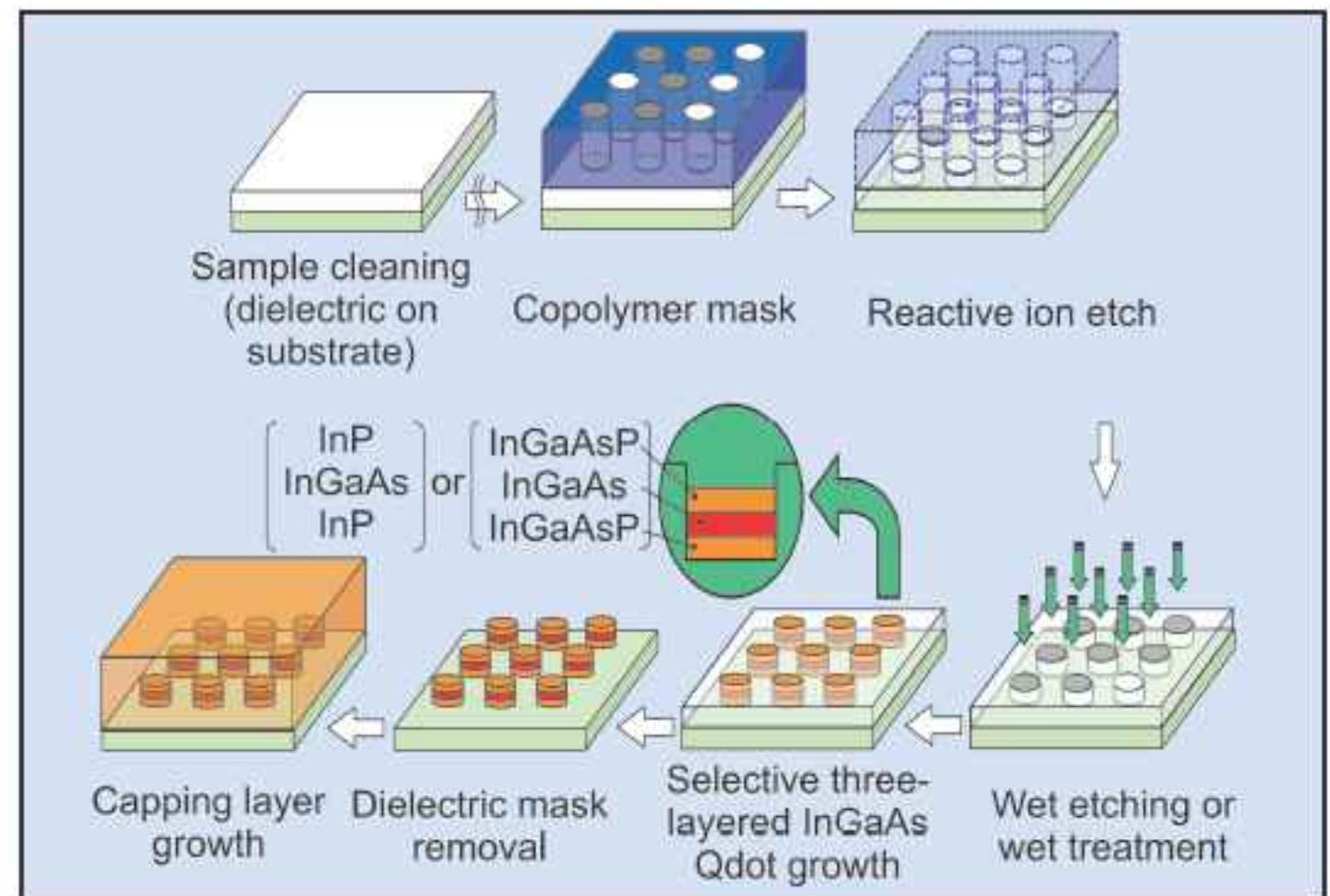


Figure 6. University of Wisconsin-Madison process flow for producing Qdots using oriented block co-polymers.

Unlike previous attempts to produce patterned Qdots on InP that resulted in 60nm diameter structures, some 99.5% of the dots produced by UW-Madison come in at less than 34nm. The density of the dots is only marginally less than those produced using self-assembly techniques.

Photoluminescence characterization has been carried out on InGaAsP/In_{0.53}Ga_{0.47}As/InGaAsP dots in an InGaAsP SCH (Figure 7). The dot emission peak could be varied between 1400nm and 1600nm by varying the InGaAs layer thickness from 1nm to 25nm. By changing the confining InGaAsP layer of the Qdot to

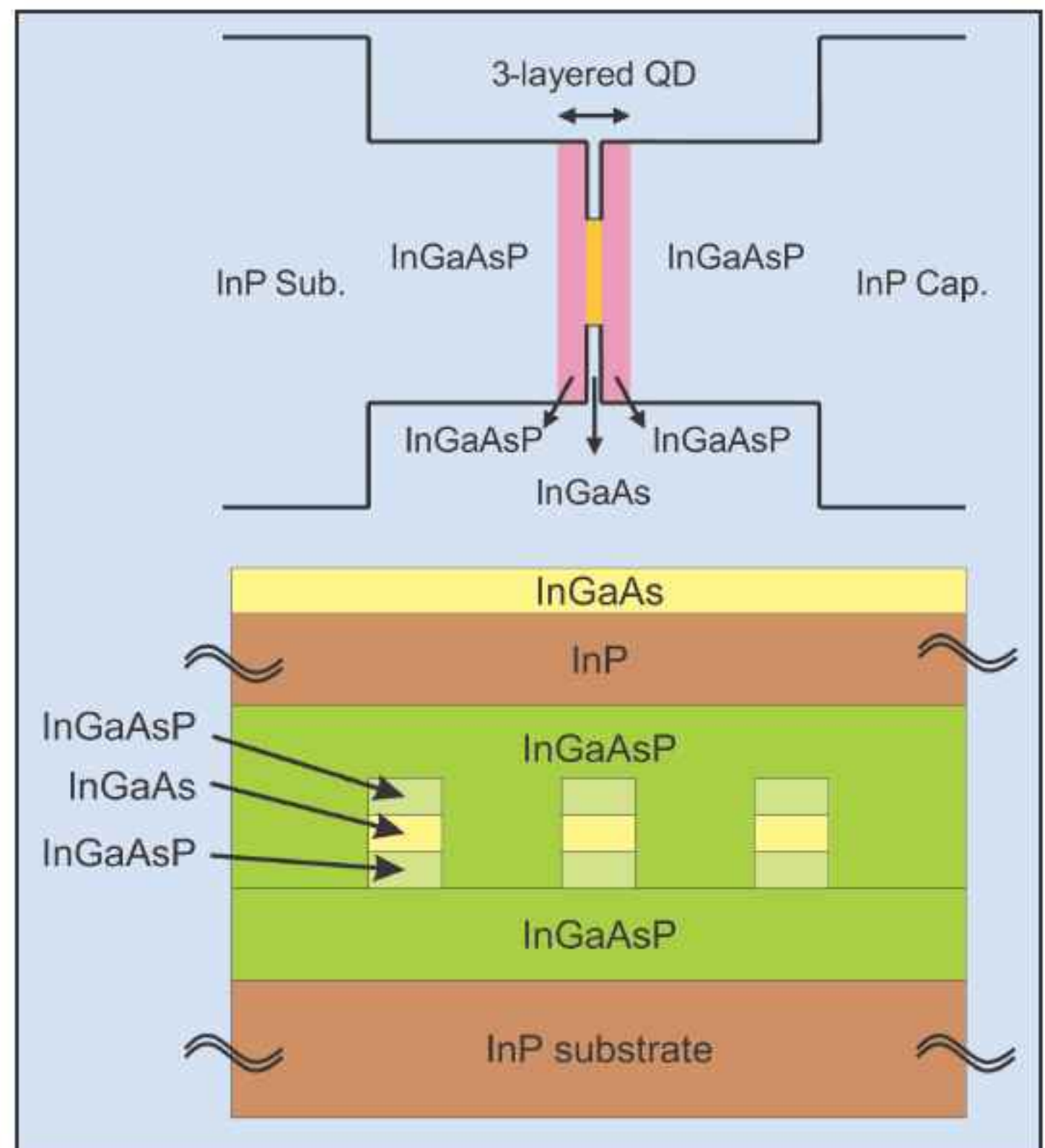


Figure 7. Madison's InGaAsP/InGaAs/InGaAsP Qdots incorporated into SCH as needed for LDs.

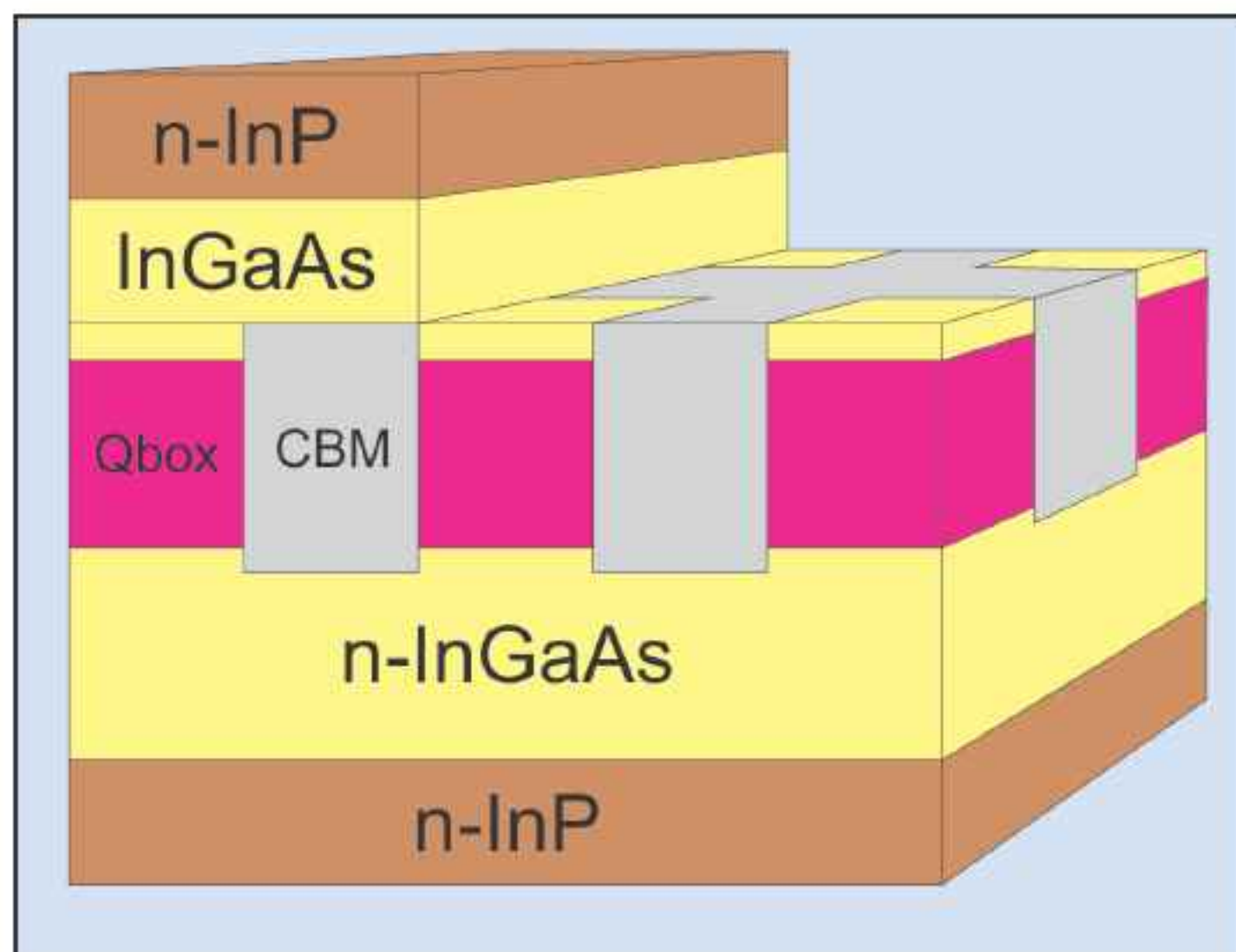


Figure 8. Madison Qbox structures.

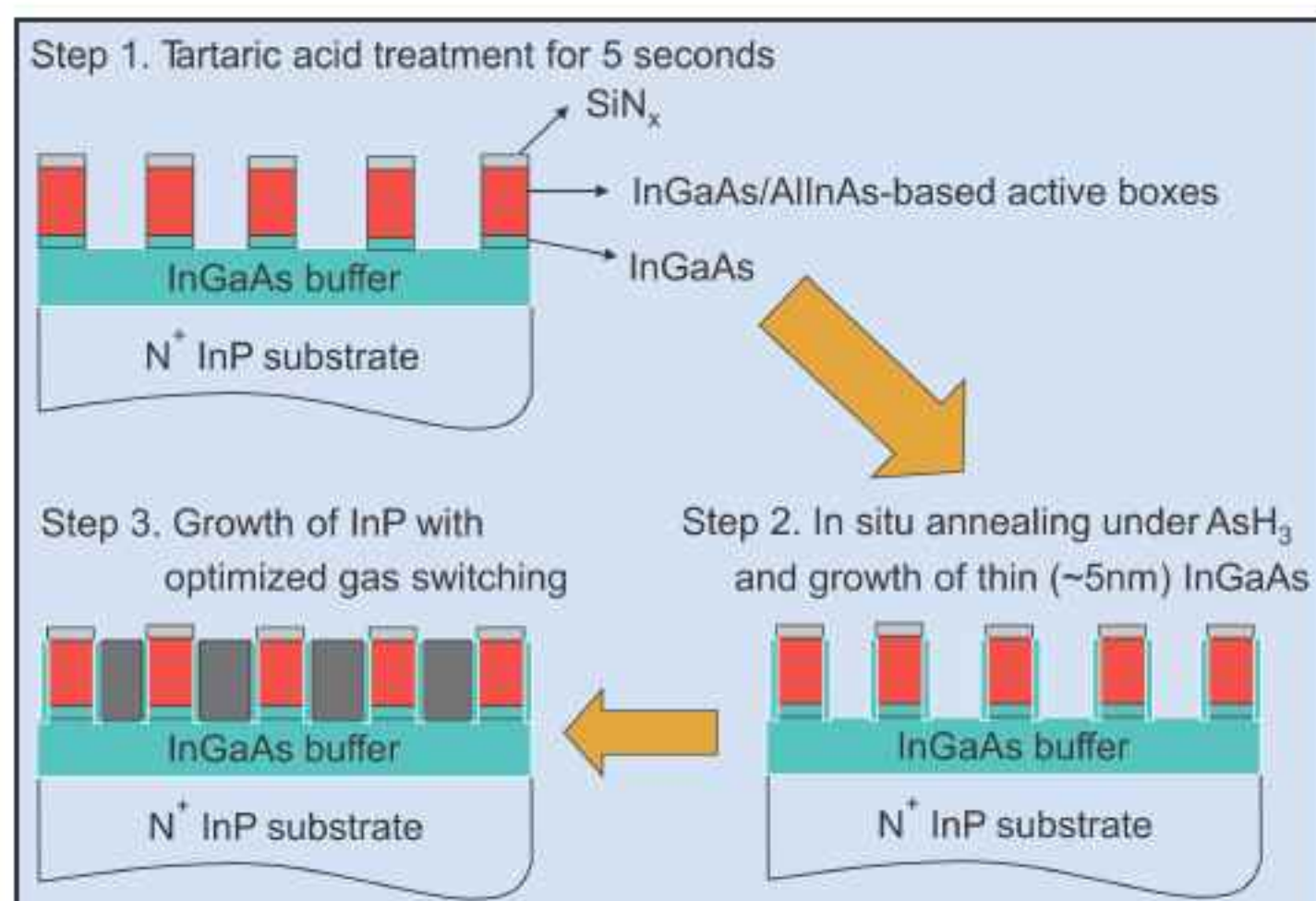


Figure 9. Madison technique for regrowth of current blocking material.

InP, a near 90x increase in brightness in PL was achieved, although the peak wavelength also reduced from 1556nm (full-width half maximum 63meV) to 1474nm (FWHM 34meV). Plans are afoot to produce lasers based on such Qdots.

Another structuring technique being explored by UW-Madison is to etch through an active layer to create quantum 'boxes' (Figure 8). The 30nm x30nm x56nm boxes are separated by an iron-doped semi-insulating InP current-blocking material that is regrown in the space left by the etch. The patterning for the reactive ion etch is achieved using a SiN_x mask. The active layer consists of boxes of InGaAs/AlInAs. It is important to develop suitable passivation techniques for the etch surfaces (Figure 9) before regrowing the CBM [9]. Capacitance-voltage measurements have been made to characterize the passivation effectiveness, and the first electroluminescence experiments on the mid-wave infrared intersubband transitions (between quantized states in the conduction band) have found peaks at about 3.5 and 3.8 μm , as expected from models.

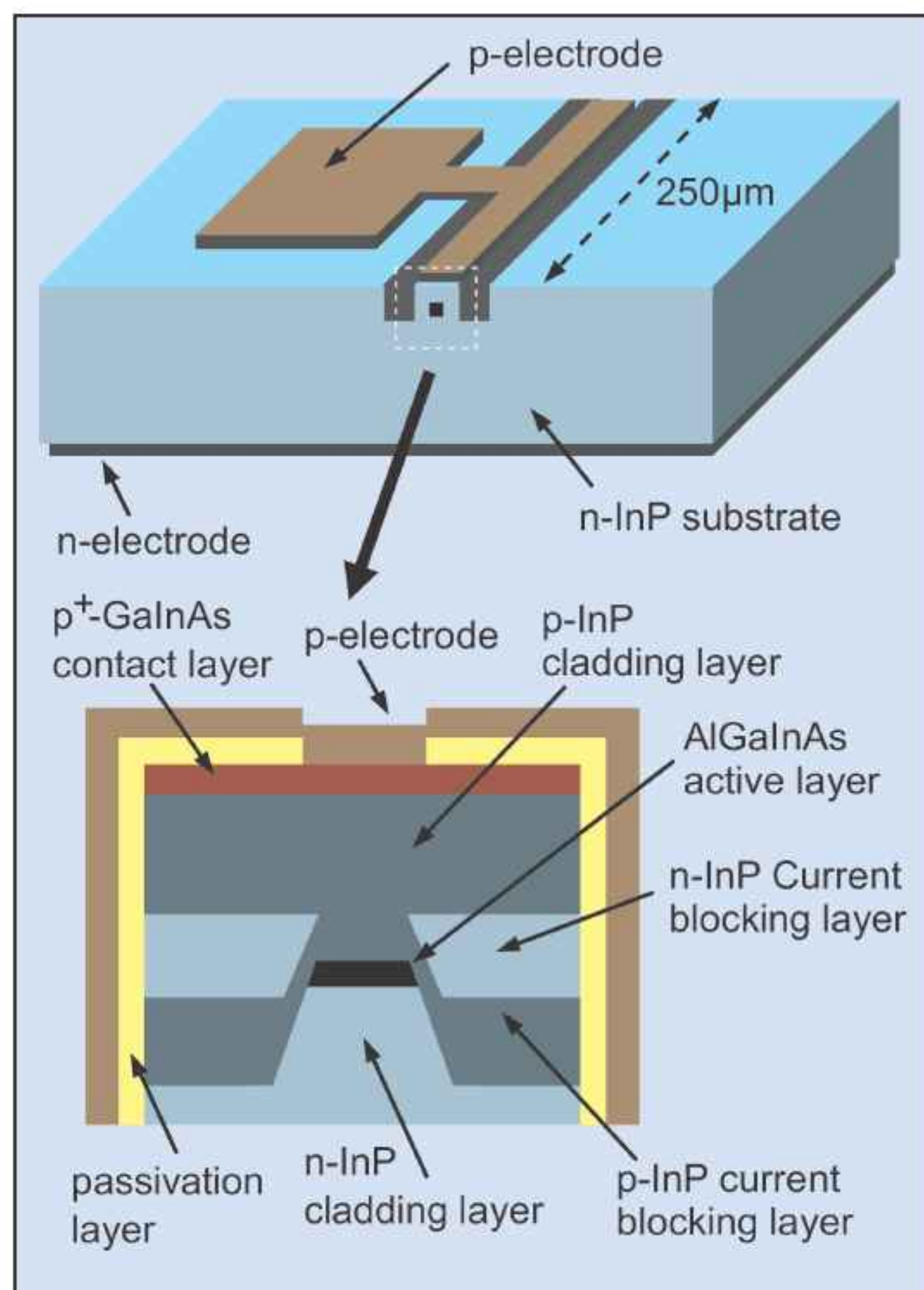


Figure 10. Schematic structure of an AlGaInAs/InP buried heterostructure DFB laser diode.

Other InP laser diode stories from IPRM

While much of the laser diode research reported at the recent Indium Phosphide and Related Materials conference (IPRM, 10–14 May 2009) centered on confined quantum dot/dash systems in indium phosphide (see above), there were a number of other developments presented. Two examples follow.

● ESD

Sumitomo Electric Industries (SEI) has been addressing electrostatic discharge (ESD) issues in aluminum gallium indium arsenide on InP substrate (AlGaInAs/InP) laser diodes (LDs) aimed at optical communications applications (Figure 10). Company researchers have managed to produce buried heterostructure (BH) Fabry-Perot LDs with estimated lifetimes of 240,000 hours. Protection circuits can be used in LD modules, but SEI is interested in applications that use isolated LD chips. Such work has been carried out before on GaInAsP/InP LDs, but not the 1.3 μm AlGaInAs/InP distributed feedback LDs that SEI is working on [10].

The 'human body model' (e.g. finger contact) with voltages from 0.5kV to 3.0kV was chosen as the most suitable for LD ESD tests. It was found in a test of

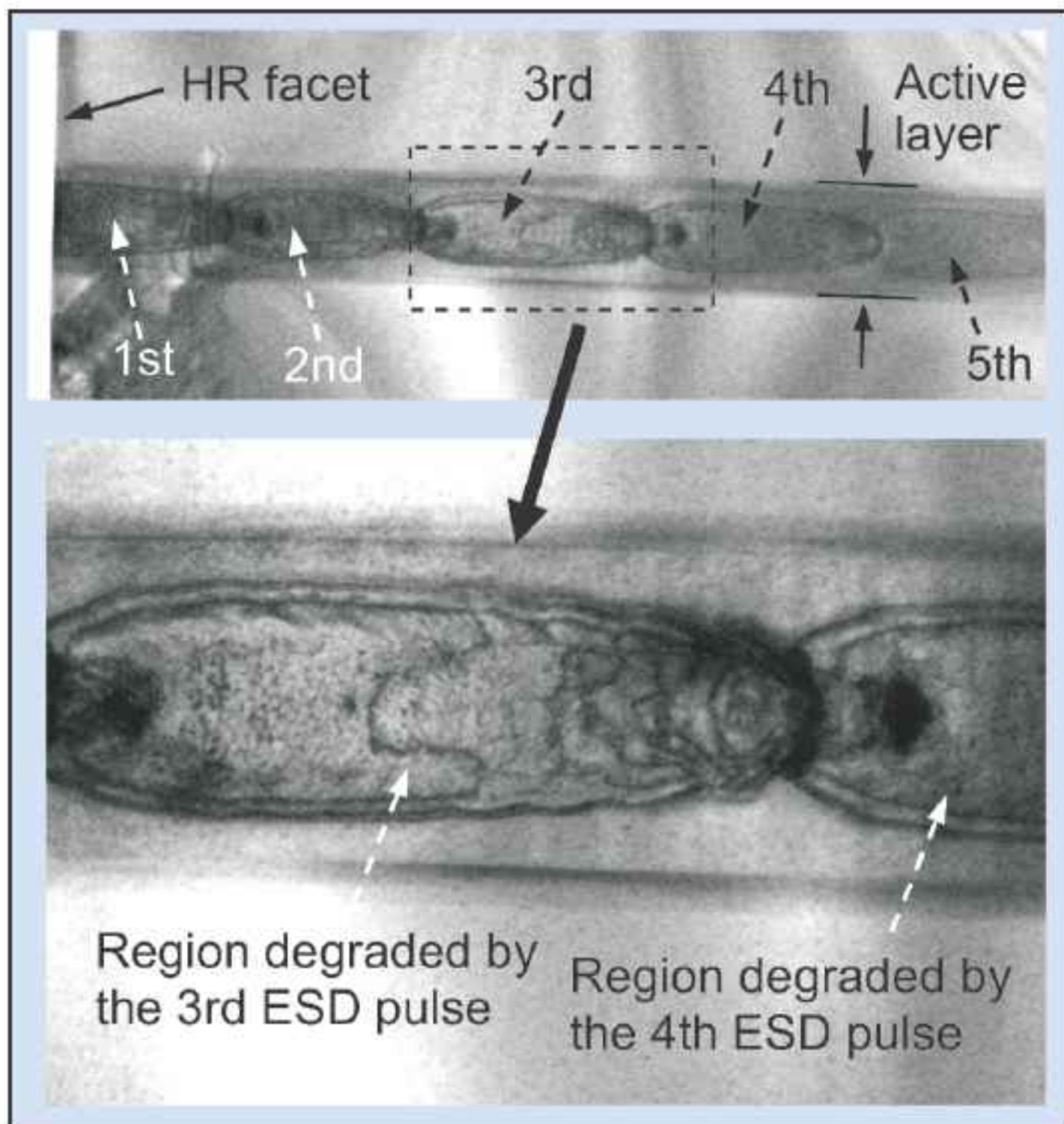


Figure 11. TEM plan image of an AlGaInAs/In PLD degraded by 0.5kV forward-biased ESD test at Sumitomo Electric Industries.

33 devices that a forward bias of 0.5kV degraded some devices, while for reverse bias a voltage above 2.5kV was needed. For normal use, 1kV ESD tolerance is considered sufficient, so only forward-bias ESD is a concern for these devices.

Further investigation of the electroluminescence of a degraded device revealed a dark region of $\sim 10\mu\text{m}$ in the active layer near the high-reflection facet (Figure 11). The investigations suggest that the active layer melted under absorption of the intense laser light. The researchers successfully applied a technique previously used for GaInAsP/InP LDs — a thin passivation layer of aluminum was applied to the facet to reduce recombination levels near the high-reflectivity coating, reducing the intensity of light and hence the tendency to produce melting in this surface region. This reduced the degradation rate at 1kV ESD from 40% for unpassivated devices to 0%.

● Hybrids

University of Tokyo researchers have been working on plasma-aided direct bonding of InP-based multi-quantum wells (MQWs) to silicon-based substructures to create self-aligned laser components [11]. Alignment is particularly important for optical systems to ensure that power losses and threshold currents are minimized, and that flexible tuning is achieved for single-mode and other modes of operation.

The QW system consists of InGaAsP material, along with separate confinement heterostructures (SCHs) and InP buffer. The silicon-on-insulator structures include

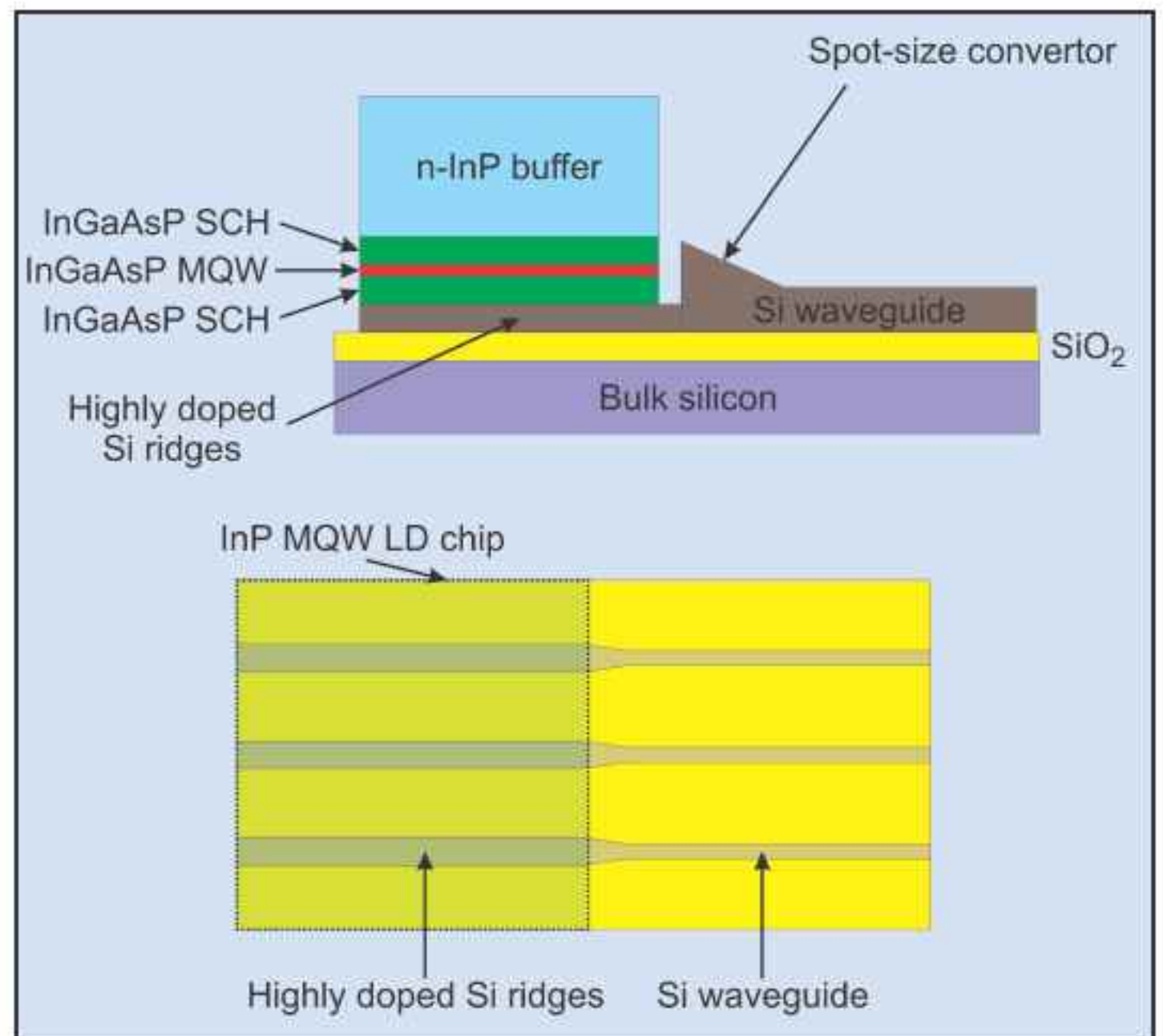


Figure 12. Side and top schematic views of hybrid of InP-based laser and silicon waveguide structure as developed by University of Tokyo.

waveguides, spot-size converters, and highly doped silicon ridges. The connection between the MQW system and waveguide is a parallel butt-end arrangement.

The ridge structures can be produced either during growth on the InP structure, or on the silicon structure. These structures provide one of the electrode contacts for providing current injection into the MQW. By adding distributed Bragg reflection (DBR) or distributed feedback (DFB) structuring to the ridge, single-mode or frequency tuning features can be achieved. The bonding is described as 'almost alignment free'.

The refractive index of the phosphorous-doped silicon ridge (3.1–3.4) is higher than that for normal InP cladding and hence provides extra confinement of light in the lateral MQW active region. ■

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

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Praxair Electronics
542 Route 303,
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Tel: +1 845 398 8242
Fax: +1 845 398 8304
www.praxair.com/electronics

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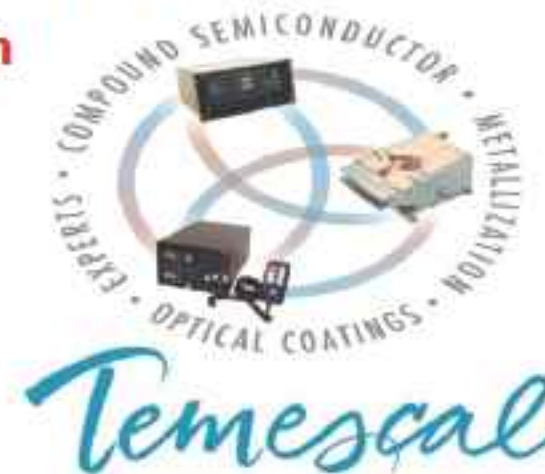
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www.microchem.com

Power + Energy Inc

(see section 8 for full contact details)

Praxair Electronics

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8 Wafer processing equipment

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(see section 16 for full contact details)

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www.tegal.com

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9 Materials & metals

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www.cambridge-fluid.com

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Tel: +1 215 942-4600

Fax: +1 215 942-9300

www.powerandenergy.com

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Fax: +1 805 541 9399

www.saesgetters.com

11 Process monitoring and control

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(see section 6 for full contact details)

k-Space Associates Inc

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12 Inspection equipment

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18 Chip foundry

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Fax: +33 169 33 02 92
www.ums-gaas.com

19 Facility equipment

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Fax: +1 541 917 3623
www.marlerenterprises.net

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Ansoft Corp

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Fax: +1 604 320 1734
www.crosslight.com

Semiconductor Technology Research Inc

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Fax: +1 804 740 3814
www.semitech.us

22 Used equipment

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www.ClassOneEquipment.com

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www.ledfuari.com

4-9 October 2009

216th Meeting of the Electrochemical Society (ECS 2009)

Vienna, Austria

E-mail: meetings@electrochem.org

www.electrochem.org/meetings/biannual/216/216.htm

5-9 October 2009

ITU Telecom World 2009

Palexpo, Geneva, Switzerland

E-mail: jean-claude.dufour@itu.int

www.itu.int/WORLD2009

6 October 2009

Photonic Integration Forum 2009

Santa Clara, CA, USA

E-mail: iams@oida.org

www.oida.org/events/integration09

6-8 October 2009

SEMICON Europa 2009

Messe Dresden (Dresden Exhibition Center), Germany

E-mail: ljaeth@semi.org

www.semiconeuropa.org

7-9 October 2009

PV Taiwan 2009 (Taiwan International Photovoltaic Forum & Exhibition)

Taipei World Trade Center Exhibition Hall, Taiwan

E-mail: pv@taitra.org.tw

www.pvtaiwan.com

11-14 October 2009

2009 IEEE Compound Semiconductor IC Symposium (CSIC 2009), including:

23rd annual Reliability of Compound Semiconductors (ROCS) Workshop

Sheraton Greensboro Hotel at Four Seasons, Greensboro, NC, USA

E-mail: csics09reg@ieee.org

www.csics.org

11-16 October 2009

International Conference on Silicon Carbide and Related Materials (ICSCRM) 2009

Nuremberg, Germany

E-mail: info@icscrm2009.org

www.icscrm2009.org

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18–23 October 2009

8th International Conference on Nitride Semiconductors (ICNS-8)

International Convention Center, Jeju Island, Korea

E-mail: secretary@icns8.org

<http://icns8.org>

20–21 October 2009

LEDs 2009 Conference

San Diego Convention Center, CA, USA

E-mail: olga.adamovich@pira-international.com

www.ledsconference.com

21–23 October 2009

ILOPE (14th International Lasers, Optics and Photonics Exhibition)

Beijing, China

E-mail: lishu@ciec.com.cn

www.ilope-expo.com/en

27–29 October 2009

Solar Power International 2009

Anaheim Convention Center, CA, USA

E-mail: sep081@experient-inc.com

www.solarpowerinternational.com

2–4 November 2009

HETECH-2009 (18th European Heterostructure Technology Workshop)

Günzburg/Ulm, Germany

E-mail: hetech2009@uni-ulm.de

www.uni-ulm.de/en/in/hetech2009.html

2–6 November 2009

ACP 2009 – Asia Communications and Photonics Conference and Exhibition

Shanghai, China

E-mail: spie@spie.org

www.acp-ce.org

3–5 November 2009

WiMAX World Emerging Markets

Prague Convention Center, Czech Republic

E-mail: info@trendsmidia.com

<http://europe.wimaxworld.com>

9–11 November 2009

SOLARCON India

Hyderabad, India

E-mail: solarconindia@semi.org

www.pvggroup.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

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5–6 December 2009

24th DGKK Workshop

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E-mail: submission@dgkk2009.de

www.dgkk2009.de

7–9 December 2009

IEEE International Electron Devices Meeting

Hilton Baltimore, MD, USA

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www.ieee.org/conference/iedm

20–22 January 2010

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