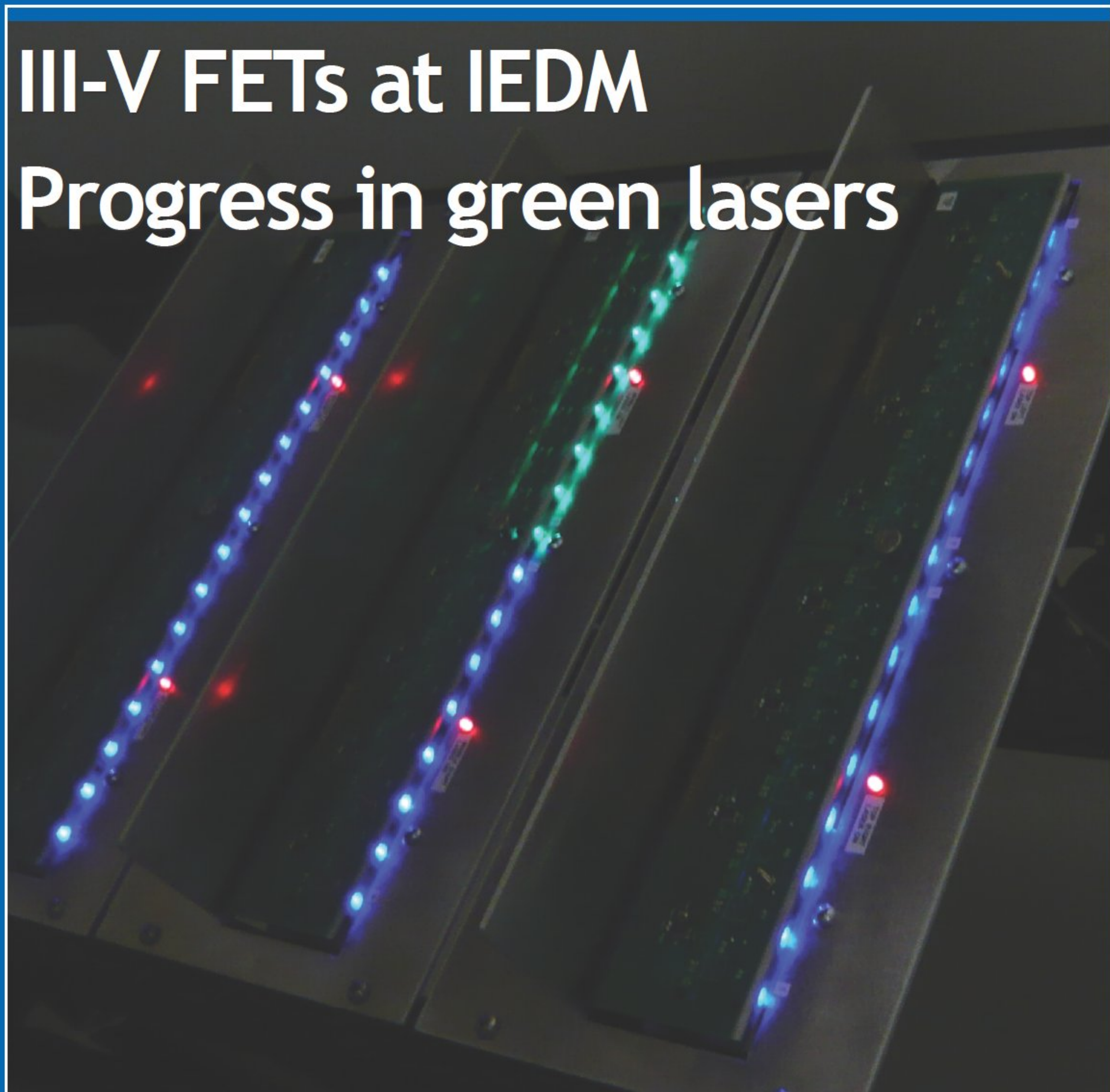


III-V FETs at IEDM

Progress in green lasers



Cree hits 200lm/W for power LED • Ferrotec buys Temescal
Aixtron to build R&D campus • Emcore forms Fiber Optics JV

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Editorial **2**

News

Markets **4**

Backlighting driving LED market and MOCVD reactor demand • Sapphire shortage looms in H2/2010 • Handset growth returns

Micro **10**

RFIC makers' Q4/09 results show continued recovery

Wide-bandgap electronics **22**

Cree launches HEMT MMIC PA • News from IEDM 2009

Materials and processing equipment **28**

Aixtron to build €40m R&D campus • Veeco launches K465i GaN MOCVD reactor • Wafer Technology extends GaSb to 4"

LEDs **44**

Cree hits 200lm/W for white power LED • Toyoda Gosei and Sharp agree patent cross-licensing • Luminus settles lawsuit with lender

Optoelectronics **61**

Kaai extends cw green lasers to 525nm • CST acquires Intense UK • News from Photonics West 2010

Optical communications **72**

Emcore forms Fiber Optics JV • Oclaro buys Xtellus • IPG buys PII

Photovoltaics **87**

Amonix buys Sunworks • First Solar settles on site for French plant

Technology focus: Green lasers **104**

SEI explains polarization clues to optimal GaN green laser stripes

Semi-polar $[\bar{1}014]$ direction preferred over $[\bar{1}2\bar{1}0]$ for lower threshold current and longer wavelength.

Technology focus: Optoelectronics **106**

Producing more light than heat from quantum cascade lasers

QCL wall-plug efficiencies have been boosted from 35% to 40–50%.

Technology focus: III-V FETs **108**

Direct wafer bond route to III-V field-effect transistors

Transferring III-V-on-insulator channel materials onto silicon.

Conference report: IEDM 2009 **110**

Dielectrics at the III-V logic starting gate

Focus shifts from demonstrating the benefits of high mobility and integration with silicon substrates to developing the gate stack.

InGaAs modeling contracts

Characterizing InGaAs at small geometries for high-speed logic.

Suppliers' Directory **118**

Event Calendar **124**

Advertisers' Index **124**

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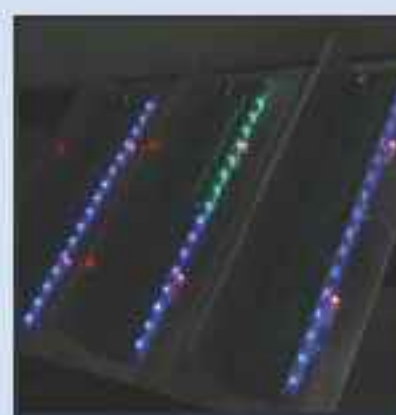
p20 Northrop Grumman has supplied MMICs for the European Space Agency's Herschel and Planck space telescopes.



p32 Veeco's new TurboDisc K465i GaN MOCVD reactor has Uniform FlowFlange technology for HB-LED production.



p55 LED light sources in the low-beam lights of the new Audi A8, which uses all-LED Osram headlamps.



Cover: UCSB spin-off Kaai has demonstrated what is claimed to be the longest-wavelength green laser diode operating in cw mode, extending its recent record of 523nm to 525nm. Optical output power of the 525nm laser is more than 5mW, up on the 523nm laser's 2–3mW. **p63**

Energy saving driving green quest

This issue we focus on developments in III-V field-effect transistors (FETs), including work presented at the International Electron Devices Meeting (IEDM) in December, in which the likes of Intel — in concert with epiwafer foundry IQE — has developed a high-k dielectric composite gate stack (rather than a Schottky gate contact) for InGaAs quantum-well channel FETs on silicon wafers that reduces gate leakage by a factor of more than 1000 (see page 110). Meanwhile, MIT reported modeling the performance of InGaAs inverted HEMT devices as their size is contracted to CMOS-scale dimensions, again aiming to reduce the gate leakage (see page 116). IEDM also saw reports of research on gallium nitride devices, some of which we cover on news pages 24–25 (to be featured in more depth next issue).

Nitride materials are also providing great progress in optoelectronics, specifically green lasers (targeted for RGB displays). On page 104, Japan's Sumitomo Electric explains the preferred crystal orientation for laser stripes to obtain lower threshold current and longer wavelength, while on page 62 we cover UCSB's progress with extending the wavelength of AlGaIn-cladding-free lasers on semipolar GaN, as well as how its spin-off firm Kaai has extended continuous-wave green lasing further, from its recent record of 523nm to 525nm.

Nitrides are also fueling the rapid adoption of LEDs in backlighting of LCD displays and, most recently, 'LED' TVs, as well as ultimately solid-state lighting (see market data on pages 4–7).

However, such rapid increases in demand — forecast to grow 61% in 2010 for HB-LEDs (see page 6) — is outstripping the pace at which capacity can be installed for the supply of equipment and materials.

Sapphire substrates, for example, are forecast to risk falling into short supply in second-half 2010 (page 8) before capacity expansions by the likes of Rubicon ramp up in 2011 (page 40). Meanwhile, demand for LEDs is driving a boom in sales of MOCVD reactors, particularly for LED makers in Asia. In Q4/2009, MOCVD system supplier Aixtron's revenue grew a more-than-expected 42% sequentially, while Veeco's MOCVD revenue more than doubled (to be reported in detail next issue). For 2010, IMS Research forecasts reactor sales of 348 units but a demand of 588, giving a shortfall of up to 240 reactors and a consequent shortage of LED die well into 2013.

In response, Veeco has launched a new K465i model of its TurboDisc GaN MOCVD reactor that incorporates Uniform FlowFlange technology to boost yields and productivity (see page 32). Meanwhile, as we went to press, Aixtron launched its new-generation AIX G5 HT MOCVD platform, which boosts capacity to 56x2-inch wafers (to be detailed next issue). The firm has also announced it is investing €40m over the next 2–3 years to build a new R&D campus that will accommodate 350 engineers developing next-generation systems, for which its accelerated timing "reflects the recent increase in volume and momentum we have seen in the markets" (see page 34).

Never before has the MOCVD sector seen such expansion, or such demands.

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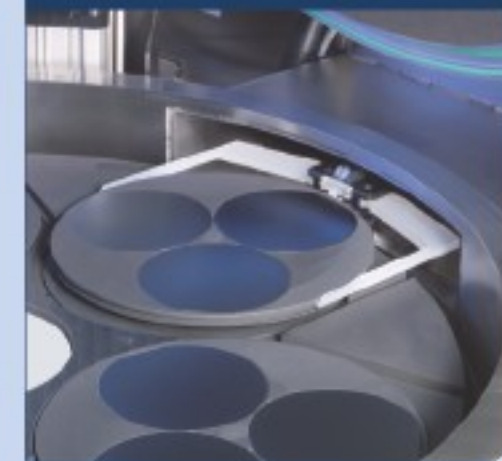
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PERFORMANCE

LED backlights drive rebound in LCD-TV panel market

After three consecutive quarters of losses, the global market for LCD-TV panels returned to profitability in second-half 2009, paving the way for a resumption of revenue growth in 2010, according to market research firm iSuppli Corp.

Following a 5.2% decline from 2008 to \$35.2bn in 2009, revenue from shipments of large-sized LCD panels used in TVs is set to rise 40% to \$49.2bn in 2010, spurring a resumption of profitability for the LCD-TV panel market.

Overall, the industry bounced back to a profit margin of 10% in third-quarter 2009 after successive quarters of negative performance. Suppliers had their first setback in third-quarter 2008 when sales of 32-inch panels (the most popular LCD-TV size) yielded zero profitability. This was followed by a loss of 23% in Q4/2008, and then negative margins of 31% and 12%, respectively, in Q1 and Q2/2009. That tide of decline has now reversed, and profitability for 32-inch LCD-TV panels is expected to

continue to rise throughout 2010, reaching 25% in Q4/2010.

"Revenue growth and profitability in the global LCD-TV panel market in 2010 will be driven by rising demand, the shift to larger-sized displays, the accelerating sales of higher-value panels, and increased manufacturing efficiency," says Sweta Dash, iSuppli's senior director, LCD Research. "These higher-value panels sport features including LED backlighting, full high-definition resolution and faster refresh rates of 120Hz and 240Hz." Furthermore, TV brands in 2010 are planning to focus on 3D solutions that will lead to faster adoption of higher-frequency panels such as 240Hz, Dash continues. "On the supply side, increased production efficiency from 8.5 and higher-generation fabs are also going to make larger-size TVs more affordable for the consumers. Furthermore, suppliers are set to cut costs by reducing the number of components used in TV panels, further bolstering profit margins."

After a rocky start, sales of panels using LED backlights are now rising and helping to drive improved profitability for the large-sized LCD panel business. In the early phase of adoption of LED-backlit LCDs in first-quarter 2009, suppliers sold these panels at prices below their manufacturing costs because of the general oversupply in the market, says iSuppli. While this helped drive adoption of LED-backlighting technology, it also exacerbated losses among suppliers. However, higher demand combined with supply constraints will lead to panel price increases and improved revenue growth opportunities for panel suppliers, forecasts the firm.

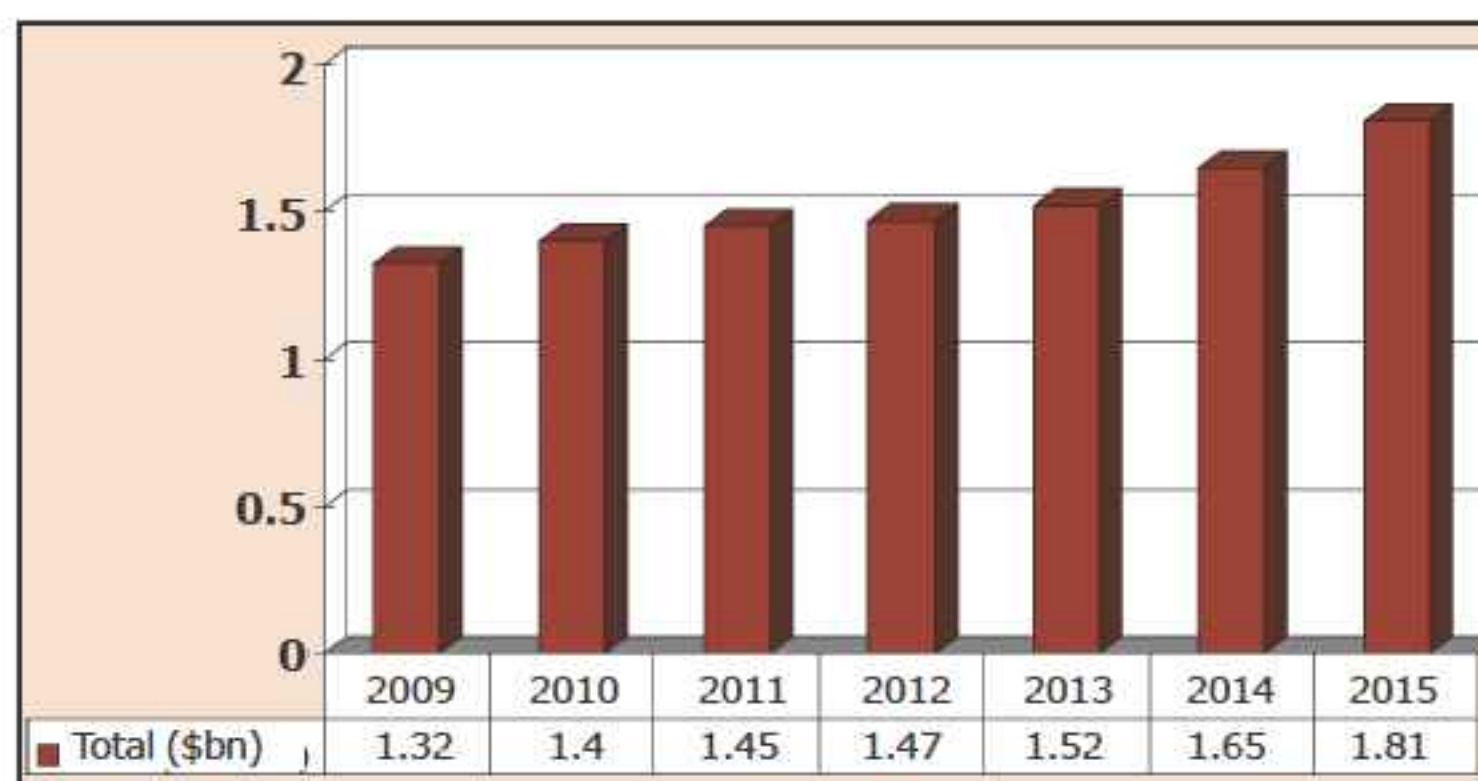
Global shipments of LCD-TV panels using LED backlights are set to rise to 25.4 million units in 2010, up by more than a factor of five from 4.8 million in 2009. By fourth-quarter 2010, 25% of shipped LCD-TV panels are expected to have LED backlights, iSuppli forecasts.

www.isuppli.com

LEDs in signage & professional displays \$1.8bn in 2015

Global consumption of packaged LEDs used in signage & professional displays was more than \$1.32bn in 2009 and will grow to \$1.4bn in 2010 and \$1.81bn in 2015, according to a new report from ElectroniCast Consultants.

"In terms of value, the consumption of HB-LEDs in signals and professional display devices will maintain the majority of the relative market share (2009–2015)," says Stephen Montgomery, president of International Business at ElectroniCast. "However, since there is a huge difference in average selling prices (ASPs) between high-brightness LEDs [with efficiency of 30lm/W or more] and standard LEDs [with efficiency of less than 30lm/W],



Consumption of LEDs in signage & professional displays, 2009–2015 (\$bn).

the market share leader, in terms of volume are the standard-type LEDs." The consumption value will increase due to the growth in unit volume, despite the effect of

declining ASPs. "Everyday we are noticing major signage replacement projects incorporating LEDs; we are not only seeing LED exit signs and message boards, we are seeing major corporate re-branding efforts, which

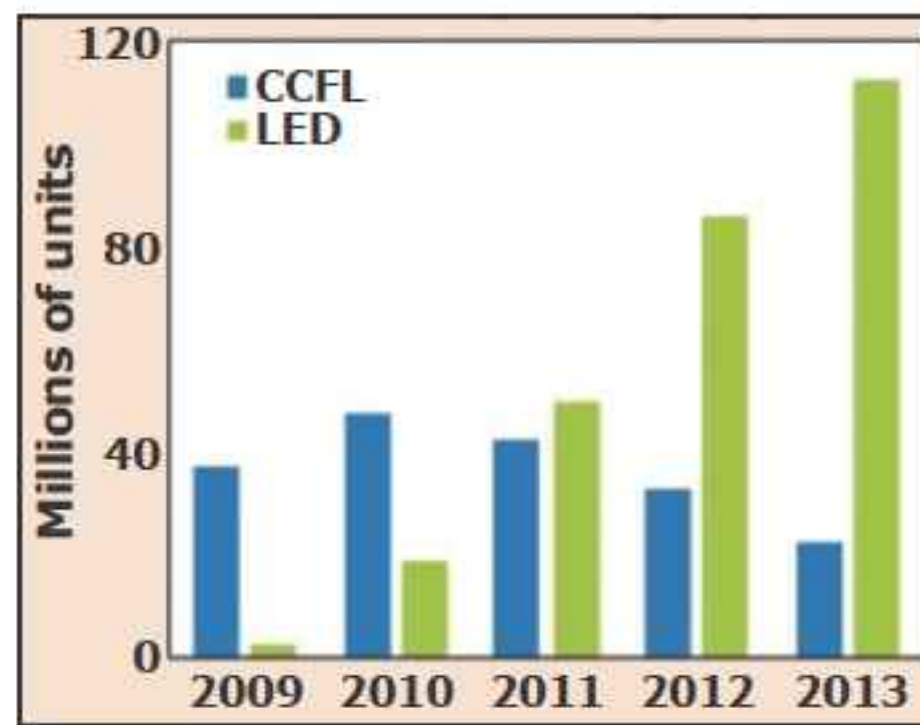
promote a corporate image of lower carbon footprints and sending a clear message that they are going green," Montgomery concludes.

LED-backlit LCD-TV shipments to rise eight-fold in 2010

LED-backlit liquid crystal display televisions (LCD-TVs) will gain considerable momentum in 2010 and beyond because of the increasing commitments from various parts of the TV supply chain, consumer demand and a higher focus on green technologies, according to the report 'LED-backlit LCD-TVs Pave the Way for a Green Future' from market research firm iSuppli Corp. Global shipments of LED-backlit LCD-TV 40-inches and larger in size will rise at a compound annual growth rate (CAGR) of 405% from a mere 34,000 units in 2008 to 112.1 million by 2013, forecasts iSuppli. In 2010 alone, shipments will rise by a factor of nearly eight, from 2.5 million in 2009 to 18.8 million units.

By 2013, 83.2% of 40-inch and larger LCD TVs shipped will use LED backlights, up from just 0.1% in 2008 and 6% in 2009, iSuppli says.

"Panel makers have been investing heavily in LED chipset makers or have been developing their own internal technologies in order to take advantage of what they believe LED-backlit LCD-TVs bring to the table: differentiation, innova-



Shipments of 40-inch and larger LCD-TVs for CCFL and LED backlights (2009-2013).

tion, low power consumption and, of course, the potential to reap the benefits of higher revenue," says Riddhi Patel, principal analyst for TV systems at iSuppli.

"For brands, LED backlighting represents a huge opportunity in a market segment already brimming with potential," Patel adds. "LEDs also help to differentiate products from others on store shelves. This will be even more important as the LCD-TV market begins to saturate and the replacement cycle occurring in the USA and elsewhere nears its conclusion."

Beyond differentiation and envi-

ronmental considerations, perhaps the greatest driving force for LED-backlit LCD-TVs is coming from the consumer. Consumers are attracted to LED-backlit LCD-TVs by attributes such as thinner form factors, improved picture quality (including better color saturation), and power savings and other green attributes, says iSuppli.

While the benefits of LED-backlit LCD-TVs are apparent, the challenges are as well, the firm cautions. The cost of LED backlights remains too high for mass-consumer adoption at this point: TV sets that use LEDs now are priced far higher than standard LCD-TVs based on cold-cathode fluorescent lamps (CCFLs). Other challenges include an inadequate component supply, a fragmented supply chain, short LED lifetimes, and thermal issues.

However, increasingly stringent government policies are forcing TV makers to shift their backlighting to environmentally friendly technologies that consume less electricity, especially at the larger TV sizes where power is a major concern.

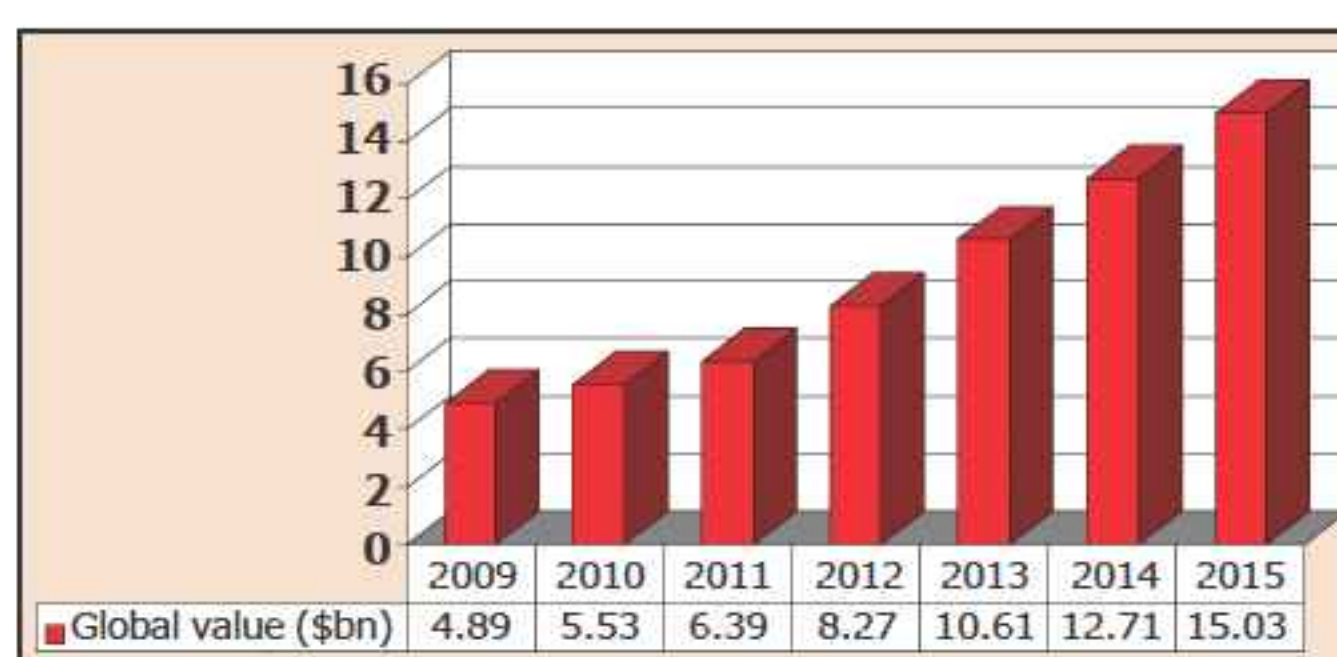
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HB-LED consumption to triple to \$15bn in 2015

Global consumption of high-brightness LEDs (HB-LEDs) in 2009 was worth nearly \$4.9bn and is forecasted to triple to \$15.03bn in 2015, according to market research firm ElectriCast Consultants in a new report that provides an examination and analysis of the changing market dynamics for various types of HB-LEDs used in selected applications.

As competing lighting solutions are readily available and accepted, HB-LEDs face the challenge of creating definitive positions in the illumination market, comments the firm. While this does not limit the potential success of HB-LEDs, it does create some challenges.

"Consumption of HB-LEDs in automotive/vehicle applications was



HB-LED consumption market forecast (in \$bn).

\$329m in 2009 (down slightly from 2007 and 2008)," says Stephen Montgomery, president of International Business at ElectriCast. "However, we view this sector as a strong opportunity with increased usage of white LEDs, especially in headlamps in automobiles and

accessory lighting in aircraft, trains, automobiles and even military applications," he adds.

"The use of solid-state lighting (SSL) is increasing, accelerated by government-based research,

initiatives, regulations and incentives from one

region to the next," Montgomery continues. "The use of LED-based general lighting is initiated from local, state/provincial-based retrofitting projects — then to commercial/business — and eventually to the consumer-level."

www.electronicast.com

HB LED demand to grow 61% in 2010, outstripping supply: Shortage of 195–240 MOCVD reactors in 2010; LED shortage into 2013

By the end of 2009, there were 1413 reactors at 75 manufacturers with a capacity of 188 billion die/year, according to market analyst IMS Research in what it claims is the first market research report characterizing the supply side of white and RGB LED production used for high-brightness (HB) LEDs.

Due to its technical and intellectual-property leadership in white LEDs, Japan's Nichia has a dominant 42.2% share of the \$5.2bn market for in-spec (binned) die, with more than \$2bn in revenue, says IMS Research (see Table 1). However, due to its strong focus on the rapidly growing solid-state lighting market, Cree Inc of Durham, NC, USA has surged to 10.6% market share (second biggest), followed by Japan's Showa Denko (7.7%) and Taiwan's Epistar (6.9%).

By unit volume, of the 33.8 billion in-spec (binned) die produced, Nichia again led, with a 16.5% share (see Table 2), followed by Epistar (12.1%) then Korea's Samsung LED Company (8.8%, vaulting to third biggest due to strong demand from Samsung's TV business), Cree (8.3%) and Showa Denko (6%).

By region, Taiwan leads with a 37% share of the 33.8 billion in-spec (binned) die produced, followed by Japan (24.2%), then Korea (21.3%), USA (10.8%) and Europe (4.4%) — see Table 3.

Due to its strong focus on the rapidly growing solid-state lighting market, Cree Inc of Durham, NC, USA has surged to 10.6% market share (second biggest), followed by Japan's Showa Denko (7.7%) and Taiwan's Epistar (6.9%)

Table 1: Top 5 LED makers by in-spec die revenue and share in 2009.

Supplier	Sales (\$m)	Share
Nichia	\$2,200.0	42.2%
Cree	\$550.0	10.6%
Showa Denko	\$402.1	7.7%
Epistar	\$359.8	6.9%
Epivalley	\$119.5	2.3%
Others	\$1,576.1	30.3%
Total	\$5207.5	100%

Table 2: Top 5 LED makers by in-spec die and market share in 2009.

Supplier	Die (m)	Share
Nichia	5582	16.5%
Epistar	4088	12.1%
Samsung LED	2974	8.8%
Cree	2821	8.3%
Showa Denko	2031	6.0%
Others	16,346	48.3%
Total	33,843	100%

Table 3: Regional LED production (in-spec die) and market share in 2009.

Region	Die (m)	Share
Taiwan	12,625	37.3%
Japan	8191	24.2%
Korea	7224	21.3%
USA	3660	10.8%
Europe	1493	4.4%
China	650	1.9%
Total	33,843	100%

IMS Research says that HB LEDs — including those based on gallium nitride (GaN) and indium gallium nitride (InGaN) — have been experiencing record breaking growth from early 2009 as a result of the rapid shift to LEDs in notebook displays. While this growth continues to accelerate, other markets increasingly migrating to LEDs include signaling, very large outdoor displays, digital billboards, personal lighting, automotive and

industrial. In addition, LEDs are enabling solid-state lighting to penetrate the general lighting market. Furthermore, the LCD TV market is now rapidly shifting to LEDs due to their improved performance, superior form factor and lower power. As a result, TVs should become the biggest market for HB LEDs in 2010 creating a supply shortage.

"Demand for HB LEDs is forecast to grow by 61% in 2010, and supply is unlikely to keep up, creating an opportunity for new manufacturers and new tool makers," says report author Barry Young, IMS Research senior consultant and managing director of the OLED Association.

The report forecasts MOCVD reactor sales of 348 units in 2010. However, an additional 195–240 are

Demand for HB LEDs is forecast to grow by 61% in 2010, and supply is unlikely to keep up, creating an opportunity for new manufacturers and new tool makers... An additional 195–240 are needed to meet demand (giving a total potential market of 588 reactors), says IMS. The report hence forecasts a shortage of 12–14 billion in-spec (binned) die in 2010, and that the shortage will continue well into 2013. This potential shortfall in supply is putting pressure on both the tool suppliers and LED makers to improve yields (or reduce the binning specs), increase capacity and speed up tool production, concludes the market research firm.

www.imsresearch.com

LEDs to surpass CCFL in large-area TFT LCD backlights in 2011

With the market for LED backlight units (BLUs) having emerged rapidly in the TFT LCD industry and momentum expected to continue over the next five years, LED BLUs will surpass CCFL/EEFL backlights in large-area TFT LCD panels in 2011, and achieve 74% penetration in 2013, according to DisplaySearch's latest 'Quarterly LED Backlight Report'. Large-area LED backlight demand for all applications will grow from 114 million units in 2009 to 770 million units in 2015.

"Without a doubt, LED backlights will be the dominant light source in all applications in 2011—representing a significant business and technology evolution for the entire backlight and panel supply chain," notes Kevin Kwak, director of LED Backlight Unit Research.

Shipments of LED backlight units for LCD TVs in particular will grow from 36.5 million units (a 20% penetration rate) in 2010 to 184.9 million units (72%) in 2015, forecasts DisplaySearch. "In order for LCD TVs with LED backlight units to gain market share, they must provide attractive performance and cost competitiveness simultaneously," Kwak adds. "Three main components will play a role in reducing costs: LED chips, light guide plates and dual-brightness enhancement films."

Cost and performance remain bottlenecks for panel makers for LED

backlight units in monitor panels. Despite this, the Energy Star 5.0 specification will drive growth for this segment. In particular, LCD makers are mass producing 18.5" x 24" LCD monitor panels with LED backlight units. DisplaySearch predicts that <26" LCD TVs with LED backlights, mainly using monitor panels, will also grow rapidly, as the cost premium is acceptable.

The notebook PC segment has the highest LED backlight unit penetration rate, as the power-saving benefit justifies the cost premium compared to CCFL BLUs. Mean-

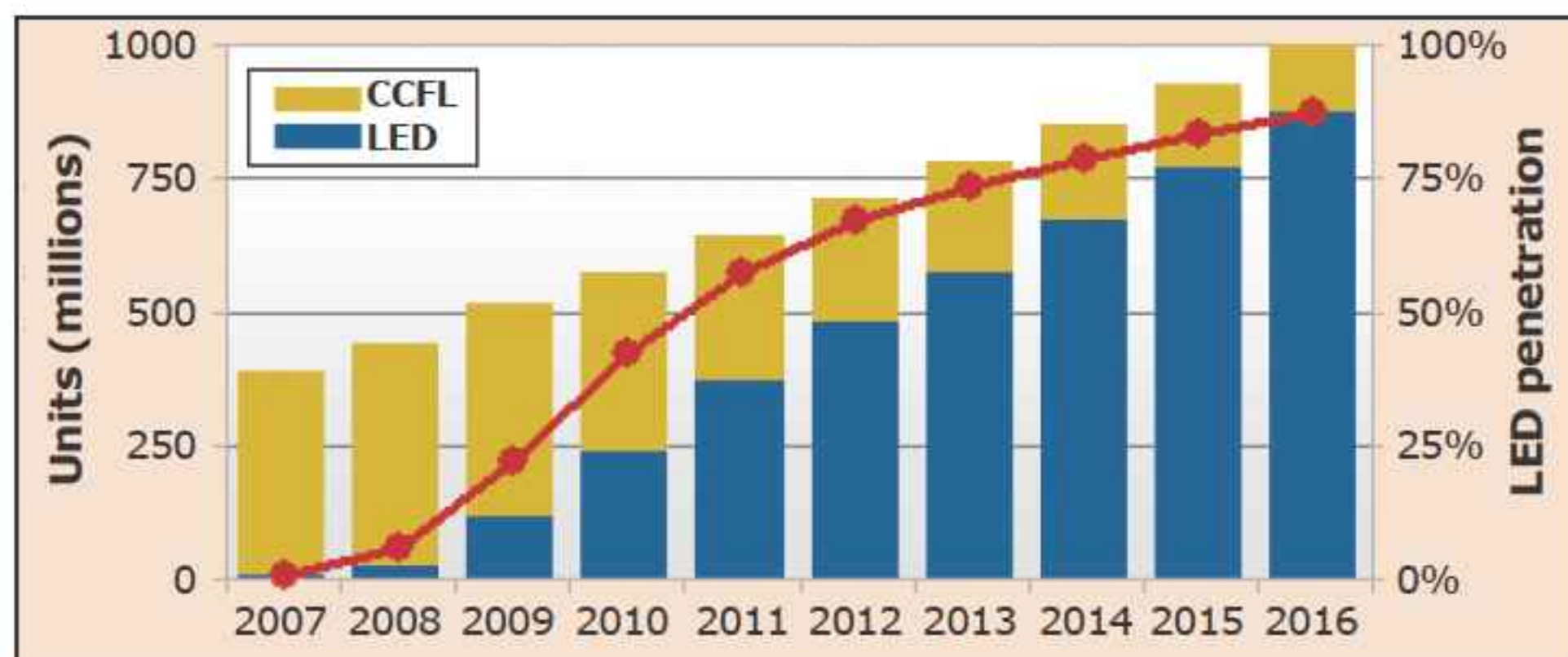
LED backlights will have an 84% share of notebook PC shipments in 2010 and will be close to 95% in 2011

while, the prices for side-view, high-intensity (1900–2200mcd) white LEDs continues to fall. As a result, LED backlights will have an 84% share of notebook PC shipments in 2010 and will be close to 95% in 2011,

reckons DisplaySearch.

● DisplaySearch's 12th annual USFPD Conference 'Laying the Foundations for the Next Wave of Growth: Energy Efficient & Low Cost Alternatives Lead the Way' is taking place on 2–3 March in San Diego, CA, USA.

www.displaysearch.com/usfpd



LED backlight unit penetration rate in 10"+ TFT LCDs (including notebook PCs, LCD monitors and LCD TV applications).

IN BRIEF

SiC and GaN power devices market to reach \$160m by 2013

In 2009 the only commercially available silicon carbide (SiC) power devices were SiC Schottky diodes and SiC JFETs (junction gate field-effect transistors), but in 2010 the market will change with the introduction of Cree's SiC MOSFET and International Rectifier's GaN-based power device platform, reports Market analyst firm IMS Research in 'The World Market for SiC & GaN Power Semiconductors — 2010'. Furthermore, several firms are aiming to release GaN Schottky diodes.

The SiC and GaN power device market could hence grow to

The market will change with the introduction of Cree's SiC MOSFET and International Rectifier's GaN-based power device platform

more than \$160m by 2013 and \$2.8bn by 2019, projects the report. SiC Schottky diodes in particular are forecast to account for almost one third of the total

market, with the bulk of revenues attributed to PFC power supplies.

"The next three years will be an important stage in the development of the SiC and GaN power device market," says research analyst Josh Flood. "Applications other than PFC power supplies are forecast to begin to adopt these new power devices, and other established power semiconductor suppliers have indicated they will be introducing new SiC and GaN power devices to the market in the near future," he adds.

www.imsresearch.com

Handset semiconductor sales rebound in Q4/09

In 2009, connectivity chips showed the greatest growth within the mobile phone semiconductor market, according to the report 'Mobile Device Semiconductors Market Data' from ABI Research. Total revenue for handset Bluetooth, GPS, and WLAN (wireless local-area networks) is forecasted to grow 16% in 2009 to more than \$1.9bn, and then to increase at a compound annual growth rate (CAGR) of 11% between 2009 and 2014.

"There has been a shift in balance within the mobile handset semiconductor market since 2008," says industry analyst Celia Bo. "Suppliers are feeling the impact of the uncertain macroeconomic environment, design win shifts, acquisitions and collaborations."

Major semiconductor components such as baseband processors (which account for over 50% of revenue in this segment) fell 9.6% from 2008; declines in mobile phone shipments as well as average selling prices (ASP) have both contributed in the drop in revenue due to the uncertain economic conditions. Application processors managed a moderate gain, while radio-frequency products fell in line with the overall market.

Signs showing a rebound in handset shipments in fourth-quarter 2009 indicate that the handset semiconductor market started to recover in the third quarter, and that revenue is expected to increase 3–8% over the next three year. The key driving force for connectivity chip penetration in mobile

handsets is rising consumer demand for advanced functions, which comprised the biggest growth segment in the mobile phone semiconductors sector.

According to ABI Research, Bluetooth has the highest attach rate compared to other connectivity types: the average penetration rate is expected to be 60% in 2014. GPS devices have secured a solid position in the automotive segment and are gaining traction in mobile phones too; the penetration rate is expected to be 21% this year, and 47% in 2011. The revenue increase for Wi-Fi chips is shown to be the highest among the three connectivity chips over the next five years, with a CAGR of 23.7%.

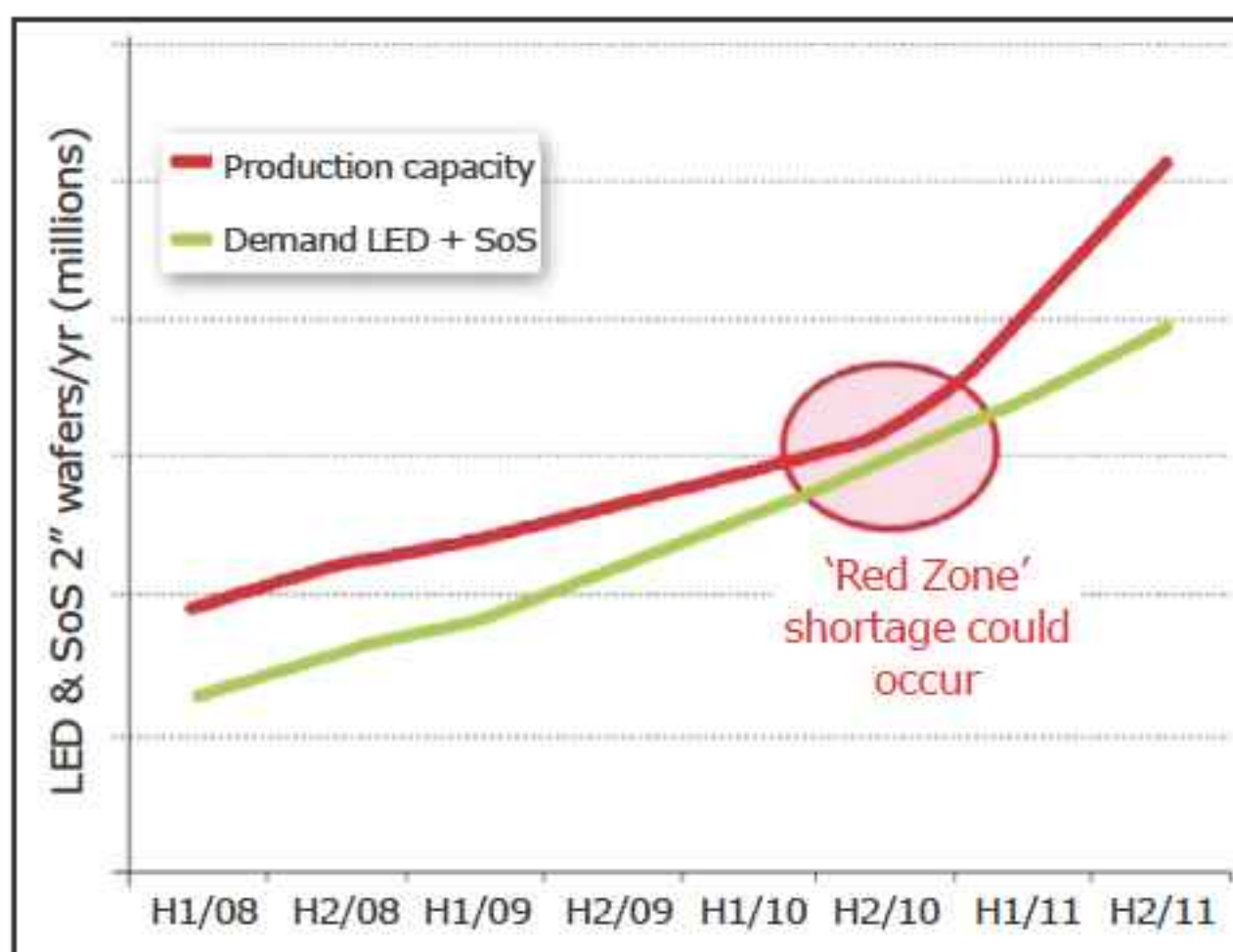
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Sapphire shortage in H2/2010 to ease in early 2011

The market for sapphire materials for electronic applications will exceed \$200m in 2010 despite the economic downturn, according to market research firm Yole Développement in its updated study 'Sapphire 2010 report' (which gives a forecast through to 2013).

Sapphire products serve two main applications in the electronics field: gallium nitride-based LEDs and RF devices ('SoS' silicon-on-sapphire technology), both for mobile phones. In 2009, the sapphire substrate market for electronic applications reached about 9 million wafers (2" equivalent) for LEDs, augmented by tens of thousands of 6" and 8" wafers for SoS RF applications.

In particular, in the LED segment, despite 2009's economic circumstances, the market for c-plane sapphire wafers grew 4% in 2009, thanks mostly to LED-backlight applications for liquid-crystal displays (LCDs). On the other hand, r-plane sapphire business for SoS markets has been strongly affected by the recession, as the main application markets are related to consumer appliances (mainly mobile phones).



Sapphire material demand versus capacity.

A 55% drop in revenue has hence been seen for r-plane sapphire.

The price of 2" sapphire is as low as ever. However, the risk of a shortage could generate turbulence. Price pressure on 2" sapphire remains critical, and Yole's models show that most suppliers have tiny margins on the material, with some even losing money on 2" business. The price level, especially in Taiwan, was extremely low in 2009, and the psychological \$10 threshold has probably been reached.

Yole hence forecasts a price increase of about 5% across the board in 2010. However, it will be unevenly distributed through the different diameters. Yole expects the 2" price to rise by up to 40%, whereas the price for 3" and 4" sapphire should remain stable compared to their low of 2009 and actually decrease by 20% compared to their average selling price (ASP)

through 2009, explains project manager Dr Philippe Roussel.

Indeed, Yole's demand-capacity analysis shows a shortage 'risk-zone' that should occur during second-half 2010, where not all the planned capacity will be fully installed, in the face of demand for LEDs that can create some turbulence.

However, Yole says that it now feels comfortable saying that this stress period should end in early 2011 with the full production ramp-up of sapphire producers.

www.yole.fr

Handset growth returns in Q4/09

Shipments rise 10.4% year-on-year to 324 million

Global mobile handset shipments were 324 million units in fourth-quarter 2009, up 10% on 294 million a year ago, according to market research firm Strategy Analytics latest report 'Q4 2009 Global Handset Market Share Update'. This was the cell-phone market's first quarter of positive growth since Q3/2008, signaling an end to the industry's year-long recession (which began during Q4/2008). Overall, full-year 2009 shipments were 1131.9 million, down 3.9% on 2008's 1177.3 million.

"We expect the global handset market to continue its recovery, with shipments growing a forecast 8% annually during the first quarter of 2010," says Strategy Analytics director Neil Mawston. "Consumers, operators and handset vendors are steadily regaining confidence. However, some major regions, such as South America, are still a little fragile, so it will not always be a smooth recovery and some regions will fare better than others," he adds.

Nokia shipped a more-than-expected 126.9 million handsets in Q4/2009, up a slightly above-average 12% on 113.1 million a year ago (and Nokia's best results since first-half 2008), growing market share from 38.5% to 39.1%. However, full-year shipments fell from 468.4 million in 2008 to 431.8 million in 2009, as market share fell from 39.8% to 38.1%.

In contrast, Samsung shipped a record 69 million handsets in Q4/2009, up a well above-average 31% from 52.8 million a year ago, boosting its market share from 18% to 21.3%. For the full year, despite the recession, shipments actually rose 16%, from 196.6 million in 2008 to 227 million in 2009 (exceeding 200 million for the first time), boosting market share from 16.7% to 20.1%.

LG also grew a well above-average 32% in Q4/2009, from 25.7 million a year ago to a record 33.9 million, gaining market share from 8.7% to 10.5%. Full-year shipments also rose by 17%, from 100.8 million to 117.9 million, boosting market share from 8.6% to 10.4%.

The handset recession's highest-profile casualties have been Motorola and Sony Ericsson, with each shedding several points of market share over the past 18 months. Motorola's shipments have fallen 37% from 19.2 million in Q4/2008 to 12 million in Q4/2009 (dropping from 6.5% market share to 3.7%),

This was the cell-phone market's first quarter of positive growth since Q3/2008. We expect the global handset market to continue its recovery, with shipments growing a forecast 8% annually during the first quarter of 2010.

its lowest quarterly volume since Q1/2001. So, full-year shipments fell from 100.1 million in 2008 to just 55.1 million in 2009. This took market share from 8.5% to 4.9%, behind Sony Ericsson's 5%, which has itself fallen from 8.2% (after its shipments dropped from 96.6 million to 57 million). Sony Ericsson's Q4/2009 shipments were 14.6 million, down a massive 40% on 24.2 million a year ago (dropping market share from 8.2% to 4.5%, which is nevertheless still better than Motorola's Q4/09 market share).

Both Motorola and Sony Ericsson developed inadequate 3G handset portfolios, says Strategy Analytics, enabling rivals like LG and Apple to lure operators with more attractive offerings during 2009.

Apple shipped a record 8.7 million iPhones in Q4/2009 (a healthy 2.7% market share, near its recent high of 3%). Apple recently unveiled the iPad multimedia tablet, which will complement the iPhone but may struggle to match the iPhone's sizeable volumes, reckons the market research firm.

www.strategyanalytics.com

Shipments (millions) and market share (top five vendors).

Shipments	Q4/08	2008	Q4/09	2009
Nokia	113.1	468.4	126.9	431.8
Samsung	52.8	196.6	69.0	227.3
LG Electronics	25.7	100.8	33.9	117.9
Sony Ericsson	24.2	96.6	14.6	57.0
Motorola	19.2	100.1	12.0	55.1
Others	58.8	214.8	68.0	242.8
Total	293.8	1177.3	324.4	113.9
Share	Q4/08	2008	Q4/09	2009
Nokia	38.5%	39.8%	39.1%	38.1%
Samsung	18.0%	16.7%	21.3%	20.1%
LG Electronics	8.7%	8.6%	10.5%	10.4%
Sony Ericsson	8.2%	8.2%	4.5%	5.0%
Motorola	6.5%	8.5%	3.7%	4.9%
Others	20.0%	18.2%	21.0%	21.5%
Total	-10.7%	4.9%	10.4%	-3.9%

CATV joins recovery as GaN and CMOS switches ramp up

For its fiscal third-quarter 2010 (ended 2 January), RF Micro Devices Inc of Greensboro, NC, USA has reported revenue of \$250.3m (down 1.8% on \$254.8m last quarter but up 24% on \$202m a year ago). About 80% of revenue came from the Cellular Products Group (CPG) and 20% from the Multi-Market Products Group (MPG).

CPG experienced robust order and design-win activity, driven by secular growth trends and new product cycles. Sales of WCDMA front ends, including the fast-growing TD-SCDMA segment, rose 80% year-on-year. Sales into smart phones and 3G devices approached 50% of cellular front-end revenue, and transceiver business 10–15%. Sales to reference design customers in China more than doubled year-on-year.

In MPG, Defense and Power end-market applications grew 17% sequentially, driven by military high-reliability and commercial point-to-point radio applications. After declining the most through last year's downturn, cable TV is now recovering, with sales to MPG's largest CATV customers more than doubling sequentially. Shipments of WiMAX components rose 22%. Shipments of automatic meter reading (AMR)/smart-grid components grew by 60% and are on track to double year-on-year.

On a non-GAAP basis, fueled by customer and product diversification, gross margin has risen from 22.6% a year ago and 38.1% last quarter to 38.4%. Also, compared to an operating loss of \$8.3m a year ago, operating income is up from \$41.7m last quarter to a record \$44.6m, with operating margin rising from 16.4% to 17.8%. Net income has risen from \$36.9m last quarter to a record \$38.8m, compared to a loss of \$12.4m a year ago.

Free cash flow (cash flow from operations of \$44.5m minus \$2.6m property and equipment expenditure) was \$41.9m. After retiring \$197m of convertible notes due in July, cash and cash equivalents are \$121.5m.

"RFMD's strategic focus on RF components and compound semiconductors is driving sustainable improvements in gross margin, operating margin and free cash flow," says chief financial officer Dean Priddy. Fiscal Q3 was RFMD's second consecutive quarter of record operating profitability and the third of sequential and annual increases in gross margin, operating margin and earnings per share.

During the quarter, CPG launched 14 new products (including its first fully qualified CMOS-based switches for cellular handsets) and is on track to release more than 40 products in fiscal 2010, driving customer diversification and margin expansion. MPG launched 86 new and derivative products (including its first fully qualified GaN power product) and has released 255 products so far in fiscal 2010 (on track for more than a product per day). The firm plans to launch multiple GaN-based power products in the March quarter.

"RFMD is capitalizing on major global secular growth trends, such as mobile broadband [including the proliferation of data-enabled wireless devices and increased RF dollar content per device], smart-grid/AMR and green technologies, while entering lucrative new product segments, like switch-based products for smart phones and GaN-based amplifiers for communications and defense systems, which expand our serviceable market, diversify revenue and expand margins," says president & CEO Bob Bruggeworth.

"As the global demand for data mobility accelerates, the adoption of smart phones, netbooks, data cards and other connected devices is significantly increasing the available RF dollar content for RFMD," he adds. "Similarly, the increasing demand for AMR/smart-grid applications and green technologies is creating new, incremental opportunities to diversify revenue and expand margins by leveraging RFMD's leadership in RF components and compound semiconductor technologies."

RFMD is enjoying strength in CPG, supported by strong calendar 2010 handset unit forecasts, expanded participation across customer programs and increasing adoption of connected devices, including smart phones and 3G devices. "As customers expand the smart-phone experience from the upper tier to the mid tier, we continue to forecast being in production in support of all the major smart-phone manufacturers over the next 15 months," says Bruggeworth.

In the diversified markets served by MPG, RFMD continues to see positive demand trends, supported by increasing customer ordering. In fiscal Q3, RFMD completed its first GaN foundry shuttle run, and a major North American CATV customer continues to move forward with broad-based adoption of RFMD's GaN technology.

Given demand in the March quarter RFMD expects CPG revenue to show better than the handset industry seasonality of 12% down, and MPG revenue to be flat to up sequentially (aided by strong CATV backlog).

For full fiscal 2010, non-GAAP operating margin is expected to near RFMD's annual target of 15% (about a year ahead of expected). It also expects strong free cash flow (in-line with recent quarters).

Smaller die sizes allow more units per wafer (boosting fab capacity) and CMOS switches will ramp in fiscal 2011 (giving the flexibility to outsource or insource). "We can significantly grow our front-end business without additional CapEx for at least the next couple of years [with fab utilization now just 70%]," says Priddy. "2–4% of sales for CapEx is appropriate going into fiscal 2011, and 4–5% longer term."

"For fiscal 2011, we expect a contribution margin of approximately 60% on each incremental dollar of revenue," says Priddy. "We're on track to deliver continued revenue and earnings growth." RFMD aims to exceed 15% operating margin.

www.rfmd.com

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Anadigics grows revenue 13.9% and halves loss in Q4/09

GaAs-based wireless and broadband communications component maker Anadigics Inc of Warren, NJ, USA has reported revenue of \$140.5m for 2009, down 45.6% on 2008's \$258m. On a non-GAAP basis, net loss more than doubled from \$15.8m in 2008 to \$33.7m.

However, although down 7.6% on \$45.2m a year ago, fourth-quarter revenue was \$41.8m, up 13.9% on Q3's \$36.7m (compared to late October's forecast of just 5–8% growth). Non-GAAP net loss has been cut from \$4.9m a year ago and halved from Q3's \$6.4m to \$3.2m.

During the quarter, cash, cash equivalents and short and long-term marketable securities fell from \$123.4m to \$92.5m, but this was after repaying \$38m upon the maturity of convertible notes.

"2009 was a pivotal year for Anadigics," says president & CEO Mario Rivas. "In late 2008 we laid

out specific key initiatives for 2009 that centered specifically on rebuilding customer relationships, achieving operational excellence, and preserving cash — we accomplished all of those goals... we ended 2009 a stronger company."

In Q4/2009, Anadigics delivered new high-performance 1GHz hybrid line amplifiers for CATV and launched the first family of gateway splitters featuring up to eight RF outputs, while its power amplifiers were adopted by Samsung for its new 3G TD-SCDMA handset for China.

So far, in first-quarter 2010, Anadigics has launched a new 5GHz WLAN power amplifier that increases range and throughput for WiFi and WHDI applications, delivered 3.5GHz full-band power amplifier for the growing mobile WiMAX market, and unveiled the smallest dual-band CDMA power amplifier for the latest generation of mobile handsets, as

well as teaming up with Altair Semiconductor to drive LTE technology development. In addition, Anadigics' power amplifiers were selected by Novatel Wireless for its HSPA+ mobile broadband USB modems.

"In 2010 we have begun to generate strong momentum with our new product pipeline and are now able to fully leverage our operational excellence, which together set the stage for the achievement of our growth and profitability goals," believes Rivas.

"In contrast to normal seasonality, we are seeing very strong growth in our Wireless bookings in the first quarter of 2010," says chief financial officer Tom Shields. Anadigics expects Wireless sales to grow about 20% sequentially, offsetting the previously anticipated weakness in sales for WLAN. Overall, for first-quarter 2010, Anadigics expects revenue to be level at \$41.8m.

PAs integrated on Altair's ExpressCard for power-efficient LTE uplink

Anadigics and Altair Semiconductor of Hod Hasharon, Israel, which develops low-power, small-footprint semiconductors for 4G handheld devices, have announced a cooperation focused on driving adoption of LTE technology.

The two firms have already collectively delivered solutions to the marketplace. In their latest cooperation, Altair is integrating Anadigics power amplifiers (PAs) into the recently announced FourGee LTE USB ExpressCard UE (User Equipment), which — with an ExpressCard34 form factor and a USB2.0 HS host interface — provides low-power-consumption data upload (within the USB specification power budget of less than 2.5W). The card has undergone extensive interoperability testing (IOT) and is now being used in field activities worldwide. As the natural evolution to existing, widespread 3G networks around the world, LTE is gaining strong momentum worldwide, with

42 LTE network operators in 21 countries already announcing a commitment to the 4G technology.

"Altair's LTE work with Anadigics is a powerful extension of our existing and fruitful cooperation in the mobile WiMAX space," says Eran Eshed, Altair co-founder and VP of marketing & business development. "Our strategic relationship with Anadigics will continue to be valuable for both organizations as Altair develops new reference design products in support of additional RF bands," he adds.

"By working with leaders like Altair, not just to enable but to drive 4G and LTE adoption, we make it possible for operators to migrate their networks to new technologies that support the next generation of wireless applications," says Greg White, Anadigics' senior VP of RF products.

The FourGee LTE USB ExpressCard UE is one of the first Category-3 datacard solutions (with speeds of 100Mb/s on download and 50Mb/s

on upload). Based on the FourGee-3100/6200 baseband/RFIC LTE chipset, ExpressCard is a test and IOT UE platform for system vendors and carriers involved in the development, trialing and deployment of LTE systems. It is also a reference design for terminal manufacturers working to develop commercial products based on the FourGee family of LTE chips. Altair says that Anadigics' power amplifiers are recognized for their high linearity and efficiency in what are claimed to be the industry's smallest packages.

The FourGee LTE USB ExpressCard UE is available in select FDD/TDD bands in the range 700–2700MHz. Altair's portfolio for LTE also includes the FourGee-3100 LTE CAT-3 baseband processor, the FourGee-6150 MIMO LTE RF transceiver (which supports LTE-TDD), and the FourGee-6200 multi-band LTE MIMO transceiver (which covers all global FDD/TDD bands).

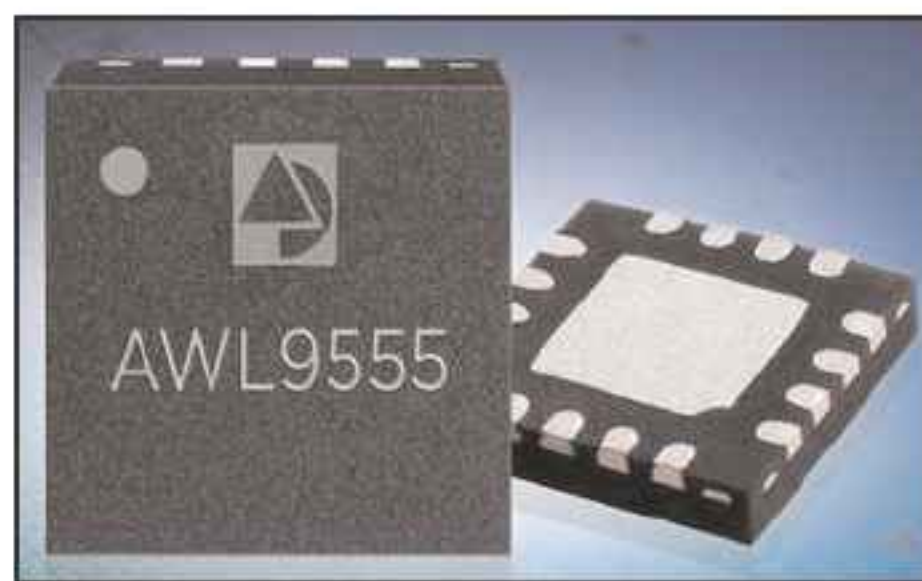
www.altair-semi.com

Anadigics launches 5GHz WLAN power amplifier to boost range and throughput for WiFi and WHDI

GaAs-based wireless and broadband communications component maker Anadigics Inc of Warren, NJ, USA has launched a new 5GHz wireless local-area network (WLAN) power amplifier (PA), developed to increase both range and data throughput for demanding, high-data-rate applications. The AWL9555 is suited to applications including the wireless transmission of HD video between residential gateway devices and TVs, routers offering 802.11a/n WiFi connectivity, and portable devices such as notebook PCs, netbooks and handsets that offer dual-band WLAN connectivity.

Enhanced multimedia applications such as streaming HD video require high data rates and robust signals, a combination that increases the demand for spectral bandwidth. Operating at 4.9–5.85GHz, the AWL9555 enables original equipment manufacturers (OEMs) to take advantage of the broad bandwidth available in the 5GHz unlicensed spectrum around the world, says Anadigics. The power amplifier provides high linearity and high output power over the full 5GHz band, enabling OEMs to deliver high-quality video and high-speed data wirelessly over a greater distance, the firm adds.

"Consumer demand for wireless connectivity everywhere is increasing, and now the trend is turning toward high-data-rate connectivity throughout the home for high-performance video gaming, access to high-definition video, and even high-speed Internet access in the yard," says Glenn Eswein, director of product marketing. "Groups such as the WHDI consortium are a driving force behind the integration of wireless connectivity into home entertainment systems, and Anadigics has leveraged its RF power amplifier expertise to develop



Anadigics' new AWL9555 5GHz WLAN power amplifier.

a device that enables OEMs to meet the high expectations of today's multimedia-savvy consumer."

WHDI (Wireless Home Digital Interface) is an emerging application that has strong support from leading OEMs including Samsung, LG Electronics, Hitachi and Sharp. With the proliferation of WHDI, manufacturers of cable boxes and home gateway devices can use the AWL9555 to provide the range and signal quality needed to deliver wireless HD video to TVs throughout the home, says Anadigics, so consumers can enjoy crystal-clear streaming video without the need for unsightly cables.

The AWL9555 is a highly integrated device with 50Ω internally matched RF ports and an integrated power detector with 20dB dynamic range that reduces overall component count and is easy to design into new equipment platforms, claims the firm. Its low-profile 3.0mm x 3.0mm x 0.55mm leadless package suits size-constrained mobile applications such as handsets which, according to ABI Research, are forecasted to drive strong growth in the WiFi market. With a 3.3V supply and a current of 175mA at +19dBm output power, the PA has 2.5% dynamic error vector magnitude (EVM) and 29dB of linear power gain.

The AWL9555 is available at \$1.57 each in quantities of 10,000.

www.anadigics.com

IN BRIEF

Anadigics makes Tong Hsing its 2009 Supplier of the Year

Anadigics has given its Supplier of the Year award to foundry services provider Tong Hsing Electronic Industries Ltd of Taipei, Taiwan (which manufactures micro-modules and custom semiconductor packages) during an inauguration ceremony for the latter's newest facility in the Philippines last month.

Anadigics' Supplier of the Year Award program was launched in 2009 to recognize suppliers that go "above and beyond" to deliver on its commitments.

Tong Hsing won the award based on its exemplary performance in several key areas, including technology, quality, responsiveness, delivery and total cost management. The award was also made in recognition of the strong strategic relationship with Anadigics.

"The team from both Tong Hsing and Anadigics have worked side by side for over ten years," says Tong Hsing's CEO Jay Yang. "We look forward to this partnership growing for many years to come," he adds.

"The importance of outstanding quality and operational excellence throughout the entire manufacturing value chain is key to our company's success," says Russ Wagner, Anadigics' VP operations. "In Tong Hsing, we have a supplier that understands our strategy and business needs and delivers without fail on a regular basis."

www.theil.com



Tong Hsing's CEO Jay Yang receiving award.

Novatel selects Anadigics' power amplifiers for HSPA+ mobile broadband USB modems

Anadigics says that wireless broadband solutions provider Novatel Wireless Inc of San Diego, CA has selected its WCDMA/HSPA and EDGE power amplifiers (PAs) for two new wireless HSPA+ mobile broadband USB modems.

HSPA+ is the next evolution of high-speed packet access (HSPA) wireless broadband technology, offering data rates of 14.4–28Mb/s (with the potential to achieve 42Mb/s on a 5MHz carrier) versus early 3G networks delivering 384kb/s data.

Novatel's Ovation MC996D and MC998D wireless broadband USB modems give laptop PC and notebook users upload speeds as high as 5.76Mb/s and download speeds of 21.6Mb/s or higher on HSPA+ networks, enabling high-quality video, multimedia, gaming and other data-intensive mobile applications. Anadigics says that its PAs deliver the power and linearity required for high-speed uplinks in EDGE, WCDMA, HSPA, and HSPA+ modes.

Both Novatel Wireless modems have received industry compliance from the Global Certification Forum (GCF), involving several hundred product lab test cases and extensive field trials that measured their performance on different 3G networks in Europe. The testing ensures that the MC996D and MC998D will have the highest reliability and functionality on HSPA+ mobile networks worldwide, says Anadigics.

The MC996D operates in 3G modes in the 2100MHz and 900MHz UMTS bands widely used in Europe and includes quad-band EDGE for connectivity on GSM/EDGE networks globally. The MC998D operates in 3G modes in the 2100MHz, 1900MHz and 850MHz UMTS bands used in North America and Japan, and also includes quad-band EDGE connectivity. Novatel selected Anadigics' AWT6222 and AWT6224 dual-band PAs for WCDMA, HSPA and HSPA+ operation, and its AWE6159 quad-band PA for EDGE mode operation.



Anadigics' AWT6222 and AWT6224 are dual-band HELP3 WCDMA/HSPA power amplifiers that incorporate the firm's proprietary technology for high efficiency at low power, while delivering the high output power and linearity required for high-rate, low-BER uplink transmissions in HSPA and HSPA+ modes. The products incorporate separate amplifier chains for two UMTS bands in a single 3mm x 5mm package, with common power and logic connections to reduce RF board area and simplify layout.

Anadigics' AWE6159 quad-band EDGE PA is designed to meet per-

formance requirements for GSMK and EDGE mode chipsets using open-loop polar modulation, such as the Qualcomm MDM8200. It has an internal reference voltage and integrated power control for both GSMK and 8PSK operation to reduce the number of external components and to simplify production calibration. The AWE6159's power control function includes battery detection circuitry for robust ORFS transient spectrum performance at low battery voltages. Its 5mm x 5mm package is 49% smaller than Anadigics' previous generation of polar-EDGE devices.

A recent survey by the Global mobile Suppliers Association (GSA) confirmed 315 WCDMA networks in operation at the end of 2009, of which 303 networks also offered HSPA service in operation (delivering subscribers data rates of 3.6Mb/s or higher). The GSA also confirmed 37 commercial HSPA+ networks in service, including systems in Australia, Europe and Asia. Another 29 operators around the world have committed to deploy HSPA+ in 2010 or 2011.

www.novatelwireless.com

Anadigics makes changes to board

Anadigics says that Dennis Strigl has rejoined its board as a Class I director. He fills the vacancy created by the resignation on 31 December of Gilles Delfassy due to his responsibilities as CEO of ST Ericsson. However, Delfassy will serve on Anadigics' Technical Advisory Board along with current board member David Fellows.

The firm has also amended its employment agreement with CEO Mario Rivas, dated 15 January 2009, to extend the stated term of employment from the end of 2010 to the end of 2013.

Strigl was previously a director of Anadigics from January 2000 to May 2008. He was also president



& chief operating officer of Verizon Communications from January 2007 until his retirement at the end of 2009. He was formerly

president & CEO of Verizon Wireless, one of the USA's largest wireless communications providers, since its formation in April 2000.

"Both Dennis and Gilles have tremendous managerial and technical experience from the wireless industry," comments Rivas. "Our board and management team look forward to benefiting from their perspectives and expertise."

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IN BRIEF

TriQuint's entire RF portfolio made available globally through Mouser

Electronic component distributor Mouser Electronics Inc of Mansfield, TX, USA is now the sole catalog distributor for RF product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA.

TriQuint's entire RF product line is available from Mouser, including amplifiers, control products, discrete transistors (FETs), filters and duplexers, frequency converters, integrated products, passives, RFID modules and semiconductors, as well as standard RF products. TriQuint also acquired WJ Communications Inc of San Jose, CA (in May 2008) and TriAccess Technologies of Santa Rosa, CA (in September 2009), whose products continue to be offered by Mouser.

"As their only global catalog distributor, Mouser can provide design engineers quick and easy access to these high-quality components through our print catalog, new enhanced online catalog, and customer service centers worldwide," says Mike Scott, Mouser's VP, Active Products.

"Choosing Mouser Electronics as our global catalog distributor opens doors for the rapid introduction of our newest products and technologies," says Jim DeBord, TriQuint's director of Global Distribution. "Their time-to-market advantage and ability to ship prototype quantities serve us both well in offering the latest products to design engineers the world over," he adds.

www.mouser.com
www.triquint.com



TriQuint grows a more-than-expected 12% in Q4/2009

Full year up 14% despite slump

RF front-end product and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported revenue of \$654.3m for 2009, up 14% on 2008's \$573.4m despite the global economic challenges. However, on a non-GAAP basis, gross margin fell from 34% to 33% and net income from \$40.3m to \$38.8m.

Nevertheless, following sequential growth of just 2% in Q3/2009, fourth-quarter 2009 revenue was \$193.3m, up 12% on Q3/2009's \$173m and up 30% on \$149m a year ago (and exceeding guidance of \$175–185m). All markets grew sequentially (including Mobile Devices by 15%), while year-on-year growth was 55% for Mobile Devices and 15% for Defense & Aerospace.

On a non-GAAP basis, gross margin has risen from 31.7% a year ago and 35% in Q3 to 38.4% (exceeding the expected 35–37%). This was due to an improved product mix and efficiency improvements achieved in manufacturing processes.

Due partly to increases in product development and selling expenses associated with revenue and design wins, operating expenses rose from Q3's \$44.8m (25.9% of revenue) to a more-than-expected \$51m (26.4% of revenue). The late third-quarter acquisition of TriAccess Technologies of Santa Rosa, CA, a provider of cable TV (CATV) and fiber-to-the-home (FTTH) devices, also increased expenses.

Despite this, non-GAAP net income has risen from \$6.8m a year ago and \$15.7m in Q3 to \$22.6m. During the quarter,

cash, cash equivalents, and investments rose \$19.3m (exceeding the expected \$15m) to \$153.9m.

"TriQuint found opportunity in the economic challenges of 2009,

Following sequential growth of just 2% in Q3/2009, fourth-quarter 2009 revenue was \$193.3m, up 12% on Q3/2009's \$173m and up 30% on \$149m a year ago (and exceeding guidance of \$175–185m)

generating great results in Q4 and a solid year of strategic and financial progress," says president & CEO Ralph Quinsey. "TriQuint continues to penetrate the high-volume and expanding mobile devices market and is building on our leadership position in networks, defense and aerospace," he adds. "Our strategy leverages our broad

technology portfolio, providing customers with complete RF solutions that simplify their design efforts, yielding faster time to market, improved performance and reduced board-space requirements."

For first-quarter 2010, TriQuint expects revenue to be down seasonally to \$170–175m, non-GAAP gross margin to be 36–38%, and operating expenses to be cut slightly to \$50m. Cash reserves should rise by \$15m.

For full-year 2010, TriQuint expects revenue to grow by about 20%.

www.triquint.com

Plextek's RF design services for TriQuint foundry clients

Electronics and communications design consultancy Plextek of Cambridge, UK says that it is cooperating with RF products maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA on a co-marketing agreement.

The agreement adds Plextek to TriQuint's third-party RF design resources website, which refers foundry customers to proven, specialist RF design services, enabling Plextek's support to augment their own development teams.

Plextek says that, for more than 20 years, its multidisciplinary engineering skill has been used to tackle customers' design projects and deliver within competitive time and cost constraints. The firm has a long history of full custom GaAs MMIC design for a wide range of applications, including millimeter-wave

ICs for broadband wireless access, wide-band low-noise amplifiers (LNAs), limiters and frequency converters for ESM (electronic support measures) systems, and precision attenuators for instrumentation. It has designed over 40 full-custom ICs on a wide range of foundries and processes, including TriQuint's fabs in both Oregon and Texas.

"Through our RFIC and MMIC design services, we can help TriQuint customers to get the most from TriQuint's foundry manufacturing processes whilst plugging any internal knowledge gaps or resource limitations," says Liam Devlin, Plextek's director – RF Integration. "Our chip designers come from commercial backgrounds, with experience of taking IC designs from conception through to high-volume manufacture, and

are aware of the issues associated with packaging, verification, validation, production test, yield and cost, thus ensuring customers achieve the optimum result," he adds.

"As the world's leading provider of innovative GaAs and GaN foundry technologies, we believe third-party design expertise, such as that provided by Plextek, will be invaluable to customers with limited design resources," says Mike Peters, TriQuint's director of marketing for Commercial Foundry. "Many of these customers are driving pilot programs to prove the viability of emerging markets critical to the growth of the RF industry," he adds. "We believe cooperative agreements such as this benefit the entire RF ecosystem."

www.plextek.com

www.triquint.com/prodserv/foundry

Copper flip-chip interconnects surpass 100 million units shipped

TriQuint has now shipped 100 million units of products incorporating its patented CuFlip copper flip-chip interconnect technology.

TriQuint claims that CuFlip enables superior RF performance and design flexibility, and speeds manufacturing and assembly. It adds that its highest-volume CuFlip-based product — the TQM7M5012 (a HADRON II power amplifier module) — powers some of the most popular consumer devices. More than 30 customers have chosen it for applications ranging from data cards, netbooks and e-readers, to machine-to-machine devices and many of the most popular 3G smartphones, including four of the top five cell-phone OEMs, three of the world's top data-card suppliers, three of the top five smart-phone makers, and the world's most popular wireless reading device.

The TQM7M5012 is a 5mm x 5mm HADRON II Polar EDGE power amplifier module (PAM), which is 50% smaller than previous generations.

The highly integrated module includes a power amplifier (PA) designed for GSM/EDGE wireless handsets and data devices in GSM 850/900/1800/1900 bands. It supports both class 12 GPRS mode and E2 open-loop polar EDGE mode, while delivering what is claimed to be best-in-class current consumption and noise performance in the critical GMSK mode, improving handset battery life and thermal efficiencies.

The TQM7M5012's design flexibility is enabled in part by CuFlip, which employs uniform copper bumps to enhance product performance, reliability, and manufacturing scalability. Unlike wire bonds, copper bumps enhance the thermal and electrical conductivity, allowing a more direct signal and better thermal path to the device without traveling through the epoxy and back-side gold-plated vias. Also, CuFlip can enable very low z height, offering a smaller overall footprint and lower height than competing offerings, the firm

claims, to support ultra-slim device designs.

CuFlip's ability to mimic the streamlined assembly process of a standard SMT component also helps cut cycle time and boost assembly-line throughput. Copper pillar uniformity ensures the precise manufacturing tolerance essential for higher parametric yields and optimal capacity utilization.

"CuFlip technology is a strategic differentiator for TriQuint," says product marketing manager Stuart Laval. CuFlip's ability to speed manufacturing and assembly enables cost savings that can be passed on to customers, he adds.

TriQuint is using CuFlip in several upcoming product lines, including the QUANTUM Tx module family for dual- and quad-band GSM/GPRS (2G) and GSM/GPRS/EDGE (2.5G) applications and the TRITON PA module family for WCDMA/HSUPA applications. Both are aligned with industry-leading transceiver chipset vendors, the firm adds.

Skyworks reports revenue up 17% year-on-year to record \$245m

For its fiscal first-quarter 2010 (to end-December 2009), Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has reported revenue of \$245.1m (exceeding guidance of \$238–242m). This is up 7% on last quarter's \$228.1m (continuing the recovery from the March quarter's \$173m) and up 17% on \$210.2m a year ago.

"Skyworks' strong performance is being driven by several key trends including the exploding demand for mobile Internet applications, increasingly diversified linear products and the rapid adoption of smart grid technologies," says president & CEO David J. Aldrich.

On a non-GAAP basis, gross margin has risen from 40.9% last quarter to 42.2%, driven by a diversified product mix, volume ramp of margin-accretive new products, factory process and productivity enhancements, product and end-yield improvements, and double-digit year-on-year material cost cutting.

Net income has risen from \$27.6m a year ago and \$41.8m last quarter to \$47.7m. During the quarter, cash flow from operations was \$53m. So, despite \$11m of depreciation, \$15m in capital

expenditure and retiring \$5m of convertible debt, cash and equivalents rose from \$370m to \$402m.

"As our improving gross and operating margins demonstrate, our innovative solutions are allowing us to further differentiate Skyworks, positioning us to create even greater competitive advantages," says Aldrich. Strong top- and bottom-line growth both sequentially and year-on-year demonstrate Skyworks' ongoing transformation to a high-margin and a highly diversified analog company, he adds.

During the quarter, Skyworks supported the launch of Google's Nexus One Android-based smart phone; launched what is claimed to be the industry's broadest-frequency-range voltage control oscillator (VCO) for 3G and 4G base-station infrastructure; ramped up analog control devices for Intel's wireless local-area networking (WLAN) applications; introduced a family of highly integrated CMOS switches with high isolation capability for the direct broadcast satellite TV market; started volume production of custom solutions supporting Itron's OpenWay energy management module; and extended ISO/TS 16949 automotive certification to its manufacturing plant in Mexicali, Mexico, allowing further penetration into new markets.

Based on broad-based business strength and new applications, for fiscal second-quarter 2010 (to end March) Skyworks expects revenue of \$225m, down 8% but significantly better than the seasonally normal 10–15% (and up 30% year-on-year). This is attributed to a high mix of less seasonal linear products business, as well as the continuous rise in smart grid business. Non-GAAP gross margin should drop slightly to 41–41.5% (due to the lower sales volume).

"Given our top-line growth plans, scale, product gross margin improvements and operating expense leverage, we now have a path to operating margins in the mid-20% on revenues of \$280–300m," says Donald W. Palette, VP & chief financial officer. Margins should start tracking towards 45%, driven by volume. "We've got the new products, higher dollar content, some of these new linear product markets that we're serving, and the 6" ramp [with full conversion from 4" wafers due to complete at the end of this quarter]." Skyworks is also continually focusing on design for cost and operational efficiencies in the factories, Palette adds. "All those things are going to contribute to expanding the margins."

www.skyworksinc.com

Skyworks supports Google's Nexus One mobile phone

Skyworks says several of its highly integrated 3G power amplifier modules are being incorporated in Google's Nexus One cell phone as part of HTC Corp's reference design.

HTC is behind many of the most popular operator-branded devices on the market, having established unique partnerships with the five leading operators in Europe, the top four in the USA, and many of Asia's fast-growing operators.

Google's newest Android-based handset is thin, light and fast, delivering speeds up to 1GHz. Features include a 5 megapixel camera with auto-focus, flash and geotagging, as well as onboard and expandable memory, noise suppression, and a stereo headphone jack with four contacts for inline voice and remote control.

"Participation in this platform demonstrates Skyworks' ability to

work with leading handset manufacturers, smart phone providers as well as reference design partners," says Liam K. Griffin, senior VP of sales & marketing. "We are pleased to broaden our support within the high-growth smart phone segment. These platforms have forged the way to 3G and 4G adoption, while being endorsed by consumers as the preferred path for mobile Internet access."

Hittite revenue grows more-than-expected 5.3% in Q4/09

For 2009, Hittite Microwave Corp of Chelmsford, MA, USA, which designs and supplies analog and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems, has reported revenue of \$163m, down 9.6% on \$180.3m in 2008. Net income fell from \$53.8m to \$46.2m.

However, although down 5.9% on \$46.4m a year ago, fourth-quarter 2009 revenue of \$43.7m is up 5.3% on Q3's \$41.5m (and slightly above the forecast \$42.5–43.5m), continuing the sequential revenue growth since the nadir of Q1/09.

Of total revenue, 78% came from three of Hittite's eight target markets (less narrow than 82% a year ago), with cellular infrastructure and military revenue flat year-on-year and microwave & millimeter-wave communications revenue falling. Of the other markets, automotive, broadband, and test & measurement also fell. In contrast, strong growth was seen for both the space market (driven by demand from international commercial satellite makers) and the fiber-optics market (driven by market share gains in the expanding electro-optic product line as well as demand from network operators for 40–100Gb/s systems).

"The fourth quarter was a strong finish to a challenging year," notes chairman & CEO Stephen Daly. "In 2009 we stayed focused on developing novel products for our core markets, and these products

will generate our future growth," he adds. The number of new products launched in 2009 was swelled by 30 in Q4 to 83, bringing the standard product portfolio to 803. In particular, the launch of four new product lines in 2009 (DROs, PLLs with integrated VCOs, comparators, and power conditioning) raised the total to 24 product lines (including 11 in the last three years, which are just now ramping up in revenue, Daly points out). As well as broadening Hittite's overall addressable market, this has also expanded the customer base to more than 3000 customers in 2009.

Though down slightly on \$13.6m a year ago, net income rose from \$12m in Q3/2009 to a more-than-expected \$13.4m in Q4.

This was due to gross margin rising strongly from 72% in Q3 to an exceptionally high 74.8% in Q4 (driven by improved product mix).

This contributed to full-year gross margin rising from 71.4% in 2008 to 72.2% in 2009.

Growth was seen for both the space market (driven by demand from international commercial satellite makers) and the fiber-optics market (driven by demand from network operators for 40–100Gb/s

Free cash flow was \$14.6m in Q4. So, even after repurchasing \$8.7m of its common stock plus \$600,000 in other equity-related activities, Hittite's cash reserves rose by \$5.3m to \$220.5m.

This was after capital expenditure of \$1.1m, boosting full-year CapEx from 2008's \$5.2m to \$7.3m in 2009 (focused on test & assembly equipment for production, as well as test equipment for engineering). After in February 2009 winning a \$35m long-term contract, a production line (including automated assembly equipment and a test facility) has been built and is now online, on track for shipping \$8m-worth of the contract in 2010 (starting in Q1/2010). Correspondingly, headcount rose 5% year-on-year (mostly in second-half 2009).

Net bookings for full-year 2009 were \$187.3m, up 2.2% on 2008's \$183.4m, boosting order backlog from \$39.6m to \$63.9m.

For Q1/2010, Hittite hence expects revenue to grow 19% sequentially and 36% year-on-year to \$50–52m (up 12% on Q4/08's record \$46.4m). However, this is mainly due to customers recovering from the recession, so double-digit growth is not expected to continue throughout 2010. Net income should grow to \$13.7–14.5m, assuming a more normal gross margin of 70–71%. This is despite operating expenses rising 10% due to the return of benefits put on hold in 2009, as well as additional expansion activities.

In addition to completing its 310,000-share stock repurchase program (on 26 January 2010), at the end of February Hittite also completed its \$3.5m purchase of a 105,000ft² building less than a mile from its headquarters in Chelmsford.

Hittite concludes by saying that, in 2010, it aims to continue the expansions currently underway in all four of its design centers, as well as investing in new design tools and equipment as it aims to broaden its engineering disciplines.

www.hittite.com

Hittite announces management promotions

Hittite has promoted three employees to newly formed senior management positions.

Everett N. Cole III (previously director of quality) is promoted to VP of hybrid manufacturing.

William D. Hannabach (previously director of operations) is promoted to VP of global operations.

Dong Hyun (Thomas) Hwang (previously director of sales) is promoted to VP of sales.

"This strategic expansion of our management team broadens our leadership to achieve further business growth and market penetration," says chairman & CEO Stephen Daly.

Norman Hildreth and Michael Olson will remain vice presidents and manage the firm's product engineering design and development centers. Brian Jablonski will remain VP operations.

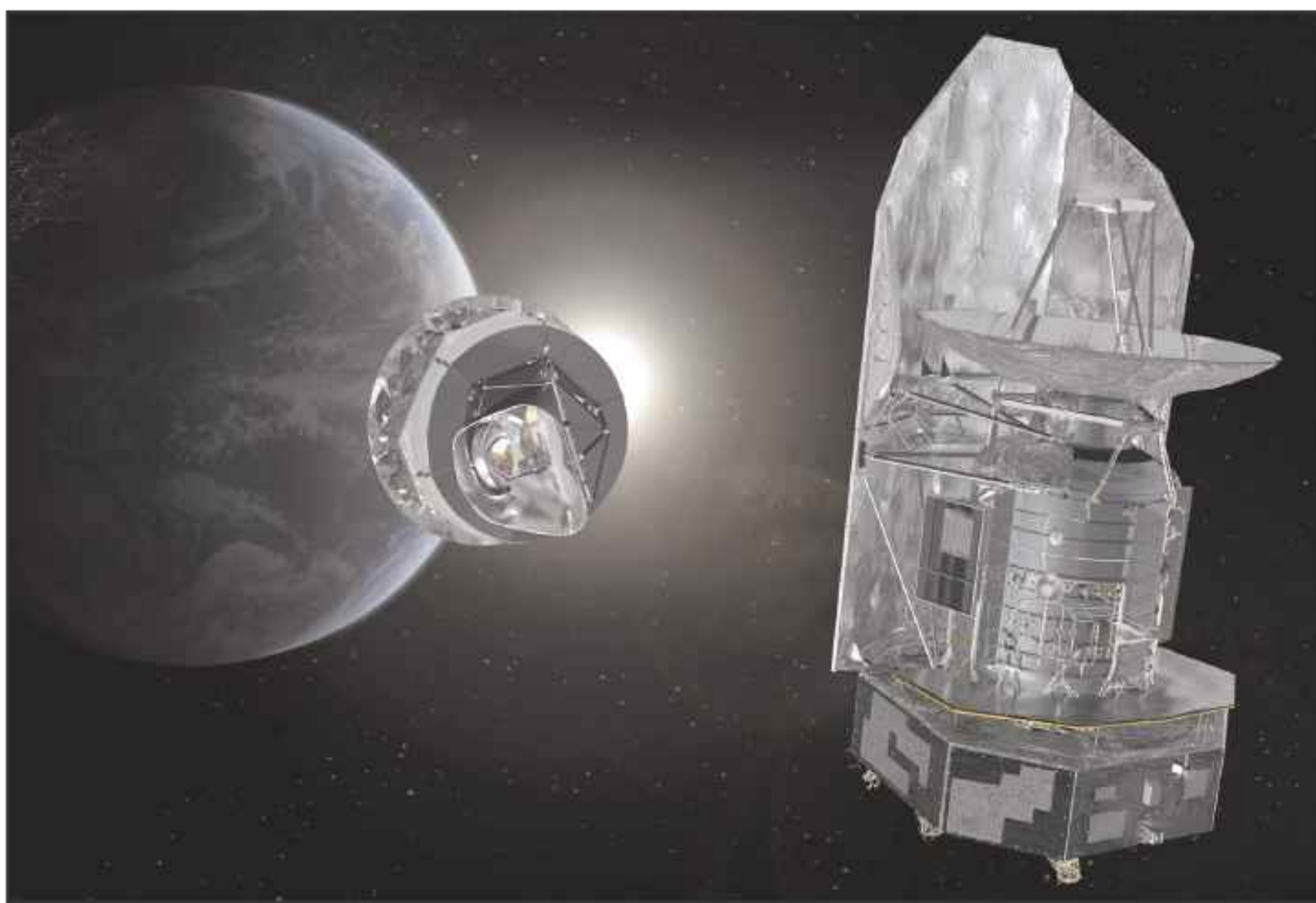
Northrop Grumman supplies MMICs for ESA spacecraft

Northrop Grumman Corp of Los Angeles, CA, USA says that its monolithic microwave integrated circuits (MMICs) are flying aboard two European Space Agency (ESA) space telescopes — the Herschel and Planck spacecraft — which are studying the formation of stars and galaxies, as well as relic radiation from the Big Bang. Using Herschel data, scientists earlier this year produced the most detailed images of deep space from 12 million years ago (when the Universe teemed with newly formed stars).

Both Herschel (which has instruments provided by a consortium of European-led institutes) and Planck involve significant participation from NASA. NASA's Herschel and Planck project offices are both based at the Jet Propulsion Laboratory (JPL) in Pasadena, which contributed mission-enabling technology for two of Herschel's three science instruments and for both of Planck's science instruments, respectively. European, US and NASA Planck scientists will work together to analyze the Planck data.

"Our high-performance MMICs enable key components for Herschel and Planck," says Dwight Streit, VP of Emerging Technologies for Northrop Grumman Aerospace Systems. Herschel and Planck use transistors and MMICs developed in Northrop Grumman's microelectronics facility in Manhattan Beach, CA. The circuits — designed at NASA, JPL, ESA and Northrop Grumman — form the foundation of Herschel's and Planck's low-noise amplifiers and switches, as well as Herschel's terahertz (THz) local oscillator sources. The systems include the lowest-noise MMIC-based millimeter-wave radiometers and THz multiplier sources ever built, it is claimed. "We have a long history of designing and flying MMIC-based radiometers and amplifiers that demonstrate state-of-the-art performance," Streit says.

Herschel — which is the largest space telescope ever launched,



The Herschel and Planck mission, led by ESA with participation from NASA, will use infrared light to explore our cosmic roots, addressing questions of how stars and galaxies are born. (Image: ESA/NASA - SOHO/LASCO).

with a 3.5m (11.5 foot) mirror — observes in the far-infrared and sub-millimeter wavelengths, allowing astronomers to see deep into star-forming regions, galactic centers, and planetary systems. Planck — which is Europe's first mission to study relic radiation from the Big Bang — observes the cosmic background radiation: the radiation released into the universe by the Big Bang about 14 billion years ago. Planck should help to answer how the universe came to be and how it evolved soon after.

Northrop Grumman has previously supplied microelectronics technology for spacecraft applications including radiometers for Jason 1, Odin, Cloudsat and the Microwave Limb Sounder program. "Our devices are also used in many ground-based applications around the world, including several ground-based telescopes that use them because of their state-of-the-art low-noise capability and their uniformity," says Richard Lai, director of Technology Programs for Northrop Grumman Microelectronics Processes and Products.

Jason 1 was launched to monitor

global ocean circulation, study the ties between the ocean and the atmosphere, improve global climate forecasts and predictions, and monitor events such as El Niño and ocean eddies. Odin was the first indium phosphide MMIC cryogenic amplifier to fly in space. It was designed to perform detailed studies of the physics and chemistry of the interstellar medium by observing emissions from key objects such as giant molecular clouds and nearby galaxies.

Northrop Grumman also supplied microwave amplifiers for the Cloudsat space-based radar, which is used to study cloud formation to measure how much ice and water are in the air at various altitudes. The Microwave Limb Sounder in use on NASA's Aura spacecraft was created to help better understand the processes and parameters vital to global climate change research and environmental policy by observing the chemistry of the Earth's lower stratosphere and upper troposphere.

www.northropgrumman.com
www.esa.int/planck
<http://herschel.jpl.nasa.gov>

Siklu launches first SiGe-based E-band transceiver for wireless backhaul

Siklu of Petach-Tikva, Israel has announced the availability of a 70GHz silicon germanium (SiGe) low-cost transceiver for high-speed applications that use the licensed 71–76GHz spectrum, claimed to be the industry's first SiGe-based E-band transceiver for wireless backhaul.

Designed with a high level of integration, the transceiver is the main building block in a series of technologies and concepts that aims to enable improvements in cost and power for wireless backhaul. "Until now, 70GHz products have been severely constrained by the high

cost of the radios, based on GaAs or InP modules," says co-founder & CEO Izik Kirshenbaum. The integrated transceiver has a novel RF and system design that offers a full suite of high-speed radio links at a fraction of the price of any currently available radio, he claims. "Mobile operators can capitalize on the massive bandwidth available in the millimeter-wave spectrum in the most cost-efficient way."

Siklu announced the first application of the transceiver at February's Mobile World Congress in Barcelona. www.siklu.com

Black Sand buys CMOS PA patents

Fabless firm Black Sand Technologies Inc of Austin, TX, USA, which was founded in 2005 and specializes in power amplifier technology for wireless applications, has acquired a patent portfolio related to CMOS power amplifiers (PAs) from Silicon Laboratories. The US and international patents include claims and methods related to PA architectures and implementations that can be used in a CMOS process.

Last September, Black Sand unveiled what it claimed was the first 3G CMOS RF power amplifier. "The acquired IP represents important technology for Black Sand," says CEO John Diehl. "When combined with our internally developed IP, these foundational patents give us a unique combination of outstanding technology and substantial IP."

Black Sand's RF PA products are targeted at mobile phones and other 3G wireless devices such as data-cards and netbooks. Mobile phones and wireless products currently use PAs based on gallium arsenide but the firm reckons that replacing GaAs with CMOS can improve manufacturing yield, performance, cost, battery life, and call quality.

www.blacksand.com

Low-power CMOS 1.6GHz LNA for GPS

Torex Semiconductor Ltd of Tokyo, Japan claims that it is first to develop a 1.6GHz low-noise amplifier (LNA) for GPS using a CMOS silicon process.

Many existing LNA products use either a GaAs or SiGe process. But, with rising demand for wireless devices in recent years, attention is focusing on CMOS for LNAs, says the firm.

Its XC2404A816UR-G LNA uses CMOS to achieve a low voltage drive (1.14–1.26V at fixed bias), low power consumption (12mW at fixed bias), and a low noise figure (NF=0.94dB, typical). Also, by adding one resistor for self bias, 1.8V and 2.85V power supply voltages can also be supported. In both the input and the output, 50 Ohm matching is possible with few external components required. A small USP-8A01 package (1.5mm x 1.5mm x 0.6mm) helps to save space.

Torex says that it also plans to develop CMOS-based products for applications outside the GPS market.

www.torex.co.jp/english

IN BRIEF

TELEFUNKEN's SiGe power HBT run rate reaches 100 million per year

TELEFUNKEN Semiconductors of Heilbronn, Germany, which offers analog & mixed-signal foundry services for RF, power management, and high-voltage high-temperature automotive applications, says that it has achieved a run rate of more than 100 million units per year in supplying silicon germanium (SiGe) power ICs using heterojunction bipolar transistor (HBT) technology. The firm claims that this validates the features of its low-cost SiGe power HBT technology compared to higher-cost III-V-based (GaAs, InP, GaN) high-electron-mobility transistor (HEMT) technology as well as market acceptance and market share gains of the technology.

TELEFUNKEN has been using the SiGe HBT process in manufacturing since 1998. In particular, its Foundry Group offers production with design rules from 0.8µm to 0.35µm on 6 inch wafers (8 inch should be available by third-quarter 2010).

With SiGe process design kits (PDKs), foundry customers can design integrated circuits with analog frequencies up to 80GHz as well as sufficient power capability, the firm says. TELEFUNKEN Semiconductors offers models using HICUM (HIGH-CURRENT Model) for HBTs with Monte Carlo simulations based on production statistics.

The firm says that its cost-efficient SiGe power technology is suited to applications in telecoms and high-speed data transfer such as DECT, CDMA, 5.8GHz WLAN and power amplifiers (WCDMA, 802.11, Bluetooth range extension, etc).

www.telefunkensemi.com

Cree launches GaN HEMT MMIC power amplifier

Cree Inc of Durham, NC, USA has launched a new gallium nitride high-electron-mobility transistor (GaN HEMT) MMIC power amplifier that offers 25W output power over an instantaneous bandwidth of 20MHz to 6GHz, and typically has 12dB of power gain and operates with supply voltages up to 50V.

The firm says the CMPA0060025F suits military and ISM (industrial, scientific and medical) applications that require high power and broadband amplification up to 6GHz. It is also packaged within a footprint of 0.25 square inches, making it one of the smallest high-power amplifiers covering this bandwidth on the market, it is claimed.

"The CMPA0060025F is a direct result of customer requests for a small, high-power, high-efficiency amplifier with performance through 6GHz," says Tom Dekker, director of sales & marketing for RF Products. "It is designed to satisfy these requirements using Cree's proven GaN MMIC foundry process and the

convenient package format found in our other GaN MMIC products," he adds. "We have received excellent customer feedback for our existing GaN MMIC products and are excited to be expanding this product line while continuing to offer custom MMIC foundry services."

Cree has also announced the sample release of two new GaN HEMT transistors that expand the power range and addressable applications of the product family.

The CGH40006P is a 6W GaN HEMT covering a frequency range of DC through 6GHz, and is suitable for driver and medium power stages within broadband amplifier topologies. In addition, it can be used in low-noise amplifier applications where the superior ruggedness of GaN HEMTs can lessen the need for the protection components that are typically required in GaAs MESFET low-noise amplifiers.

A demonstration amplifier using the new transistor, operating at 28V, provided a 2–6GHz instantane-

ous bandwidth achieving 12dB average small-signal gain and 8W typical saturated output power at greater than 50% drain efficiency over the entire band.

Cree has also introduced the CGH31240F, a high-power, class A/B S-Band GaN HEMT that is an internally matched 240W packaged device for the 2.7–3.1GHz band. Designed for civil radar applications such as weather and air traffic control as well as for marine radar, the CGH31240F, operating at 28V, offers over 10dB power gain while providing over 240W saturated power with greater than 50% power added efficiency using a 300µs, 10% duty-cycle pulsed signal.

"The CGH40006P and CGH31240F are important new products which reflect our roadmap of GaN HEMT transistors and MMICs that offer higher power, bandwidth and ruggedness than conventional technologies such as GaAs and Si," says Dekker.

www.cree.com

Arrow to distribute Cree's SiC-based power electronic devices

Cree has announced a distribution agreement with Arrow Electronics Inc for its silicon carbide (SiC) power semiconductor components.

The agreement gives Arrow's customers access to Cree's latest commercially available SiC junction barrier Schottky (JBS) products. Among the products available through Arrow will be the

recently released Z-REC Series of 600V Schottky diodes and the 1200V Schottky diode line.

"Expanding our Cree product offerings from [their] high-brightness and high-power LEDs to now include power products provides our customers even broader access to the products and support they need," says Robert Behn, VP

of supplier marketing for Arrow Electronics.

"Together, Cree and Arrow intend to accelerate the adoption of SiC power semiconductors to create more efficient switching power supplies, alternative energy converters and motor drives," says Bob Pollock, Cree senior VP, sales.

www.arrow.com/cree

Nitronex ships 200,000 devices to CATV amplifier firm

Nitronex Corp of Durham, NC, USA, which manufactures gallium nitride on silicon (GaN-on-Si) RF power transistors for the defense, communications, and industrial & scientific markets, says it has shipped over 200,000 custom devices to a major US-based cable television (CATV) amplifier supplier.

"Looking forward, we will build on

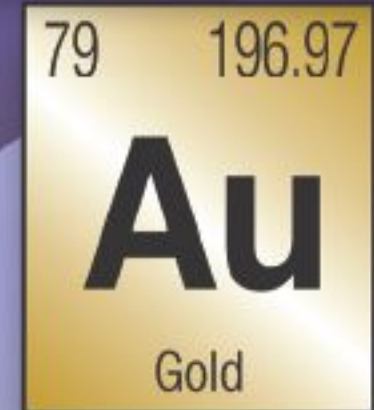
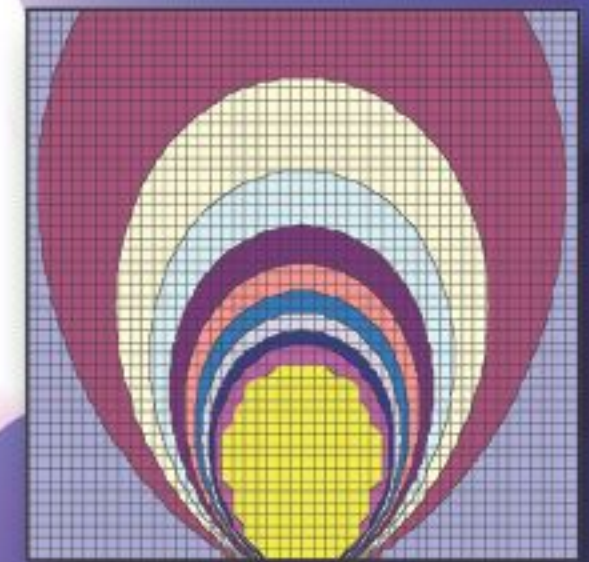
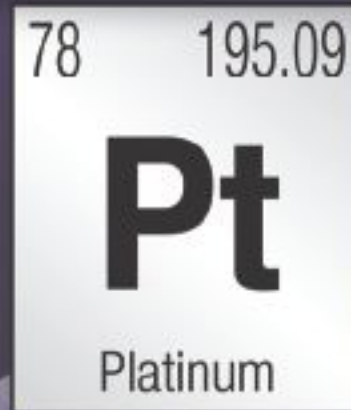
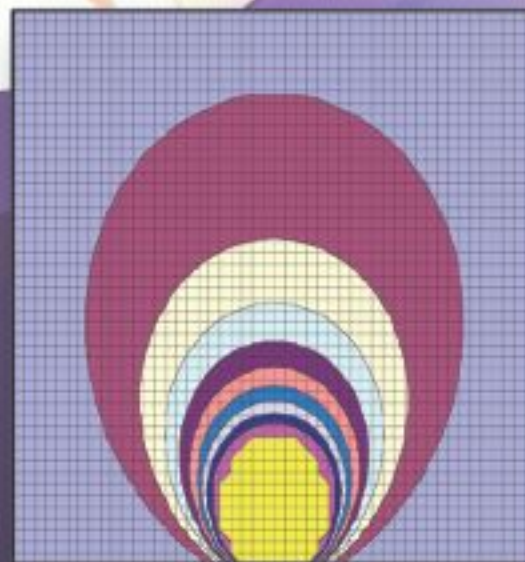
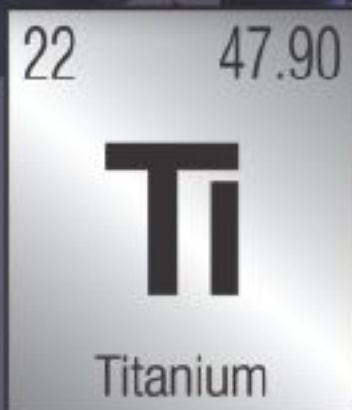
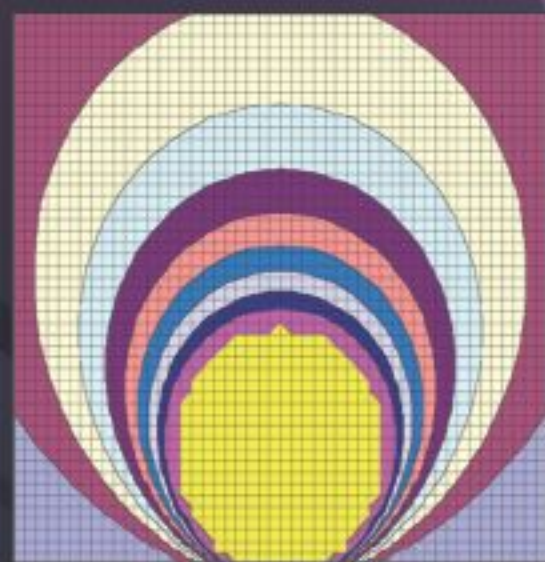
our success in 2009 via the development of new products and the expansion of our organization in 2010 to enable additional applications in the CATV market that utilize the benefits of our GaN technology," says president & CEO Charlie Shalvoy.

Nitronex claims that its custom device, inside the CATV amplifier, is

better able to withstand voltage surges in CATV networks than competing GaAs devices due to the inherent robustness of its GaN technology. This device also enables higher output power than competing GaAs-based technologies, reducing network cost by requiring fewer amplifiers, the firm adds.

www.nitronex.com

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First single-chip GaN inverter IC for motor drives

At December's IEEE International Electron Devices Meeting (IEDM 2009) in Baltimore, MD, USA, Panasonic of Osaka, Japan unveiled what it claims is the first demonstration of a single-chip GaN-based inverter IC for motor drives.

The six GaN-based transistors can be driven independently, yielding a high-efficiency motor drive. The new GaN inverter IC is applicable to motor drives in a variety of consumer electronics applications, says the firm.

Panasonic's integration of its proprietary gate injection transistors into a single chip takes advantage of the lateral device configuration. The gate injection transistor serves normally-off operation with low on-state resistance and a high breakdown voltage. Independent operation of each gate injection transistor is possible through planar

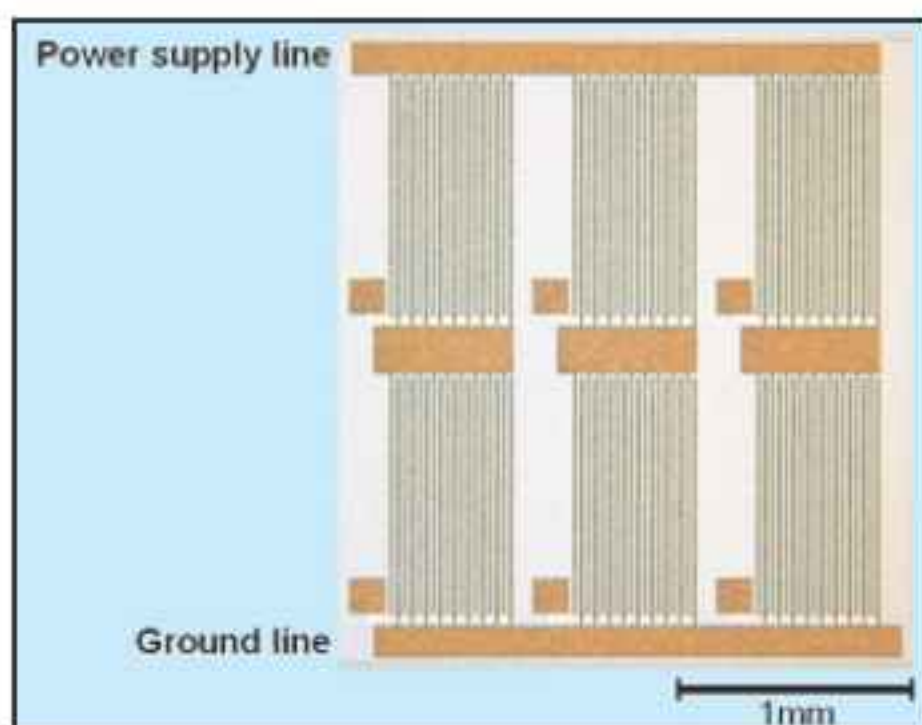


Photo of GaN inverter IC, which integrates six gate injection transistors.

isolation by using iron (Fe) ion implantation, maintaining a high breakdown voltage of about 900V between each transistor, which is stable even after high-temperature fabrication processing at more than 800°C.

Also, the GaN IC is fabricated on a cost-effective large-diameter silicon substrate. Using MOCVD, the epi-

taxial structure is grown with a novel buffer structure that fully relaxes the strain in the film caused by the lattice and thermal mismatches between GaN and silicon.

Panasonic says that using the new GaN-based monolithic inverter IC in a motor drive has confirmed that conversion loss is effectively reduced by 42% from that of a conventional silicon-based insulated-gate bipolar transistor (IGBT) at an output power of 20W. On-state loss is reduced, free from the off-set voltage in forward bias that is seen in a conventional IGBT. Integration of the GaN-based transistors also reduces parasitic inductance, so that switching loss is effectively reduced.

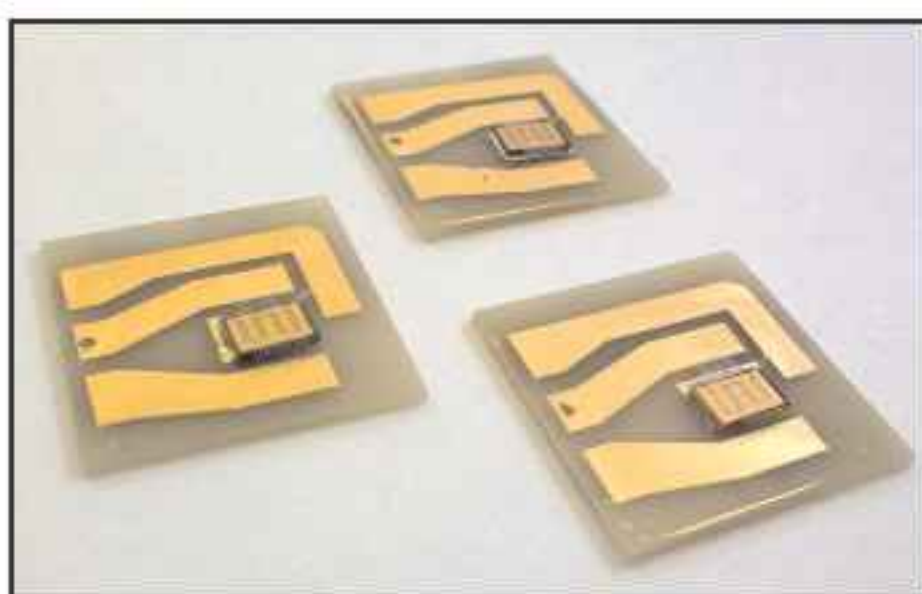
Panasonic has filed applications for 141 domestic and 90 overseas patents on the technology.

<http://panasonic.co.jp>

IMEC presents GaN-on-Si FET for E-mode power switching

At the IEEE International Electron Devices Meeting in December, the research center IMEC of Leuven, Belgium presented what it claims is a simple and robust gallium nitride on silicon (GaN-on-Si) double-heterostructure field-effect transistor (FET) architecture that meets the normally-off requirements of power switching circuits and is characterized by low leakage and high breakdown voltage (essential parameters for reducing the power loss of high-power switching applications).

High-voltage power devices are traditionally based on silicon MOS-FET structures. But, for a number of applications, silicon power devices have reached the intrinsic material limits, says IMEC. GaN compounds are the best candidates to replace silicon power devices due to their high bandgap energy (giving excellent transport properties) and their high electrical breakdown field. However, the cost of GaN power devices is high. Nevertheless, GaN epilayers grown on large-diameter



IMEC's SiN/AlGaIn/GaN FETs.

silicon wafers (potentially up to 200mm) offer a lower-cost technology compared to other substrates.

By growing SiN/AlGaIn/GaN/AlGaIn double-heterostructure FETs on a silicon substrate and combining it with in-situ SiN grown in the same epitaxial sequence as the III-nitride layers, IMEC has obtained enhancement-mode (E-mode) device operation (which is typically required in applications for safety reasons).

Device fabrication is based on an optimized process for the selective removal of in-situ SiN. The resulting SiN/AlGaIn/GaN/AlGaIn double-heterostructure FET is

characterized by a high breakdown voltage of almost 1000V (980V), excellent uniformity, and a low dynamic specific on-resistance of 3.5mW.cm² that is well within the present state-of-the-art, says IMEC. The results hold the promise of a large market opportunity for GaN-on-Si power devices, the research institute reckons.

Within its industrial affiliation program (IIAP) on GaN-on-Si technology (launched in July), IMEC and its partners are focusing on the development of GaN technology for both power conversion and solid-state lighting applications. A key goal is to lower GaN technology cost by using large-diameter GaN-on-Si and hence by leveraging economies of scale. IMEC invites both integrated device manufacturers and the compound semiconductor industry to join the program, adding that partners can build on its expertise in GaN as well as benefiting from sharing costs, risk and talent.

www.imec.be

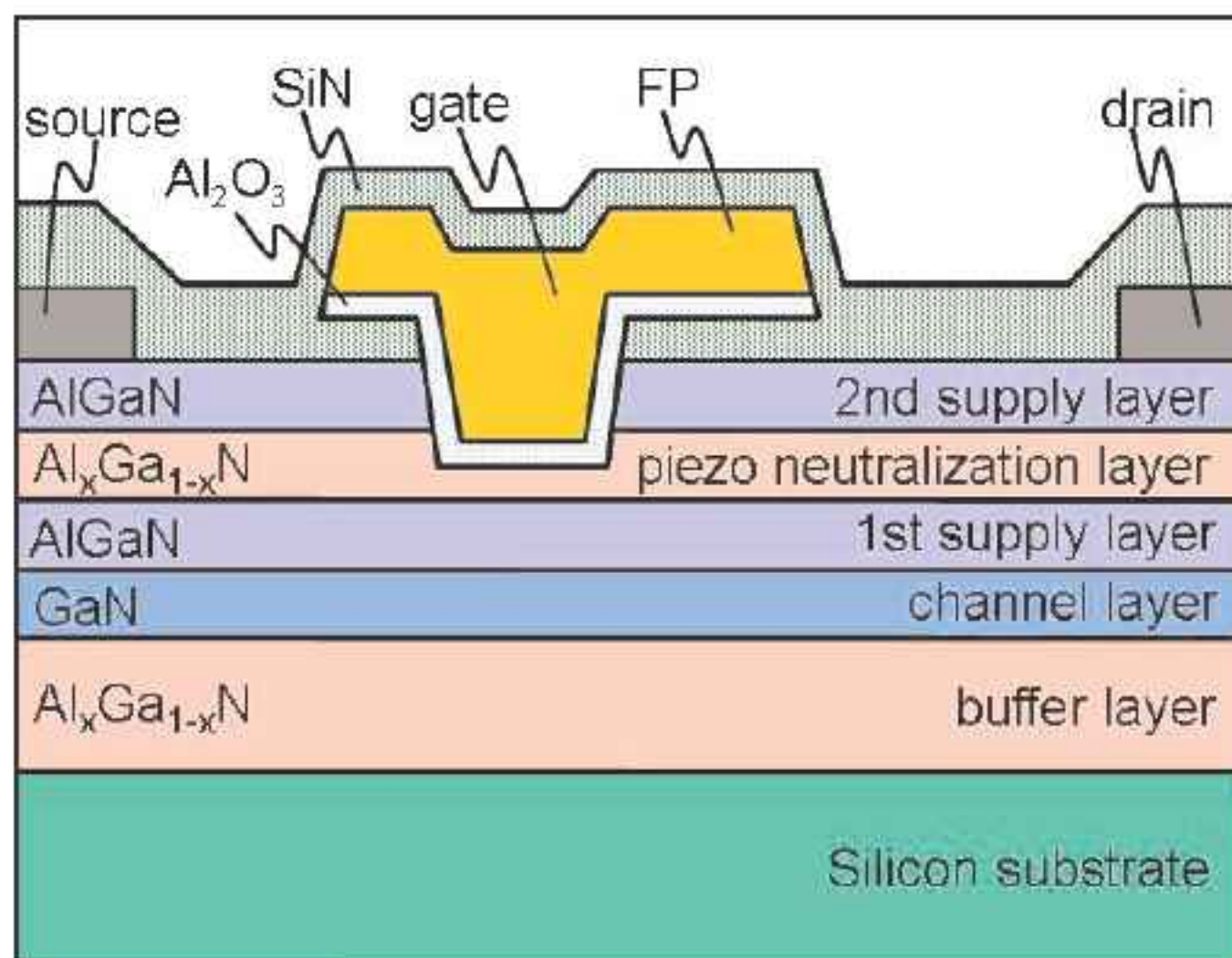
GaN-on-Si power transistor with high threshold voltage control

At December's IEDM, Tokyo-based NEC Corp and NEC Electronics Corp presented the development of a nitride power transistor on a silicon substrate that has improved normally-off characteristics (the control and suppression of electrical currents when voltage is not applied — a necessary feature for the safe operation of consumer electronics and IT devices).

The transistor features a new structure for the layer beneath the gate electrode, which improves the controllability of threshold voltage that intercepts electrical currents, enabling the realization of low power losses, high-speed switching and high-temperature operations, says the firm.

NEC says that, although power transistors using silicon have a key role in advancing energy conserving as they convert electrical power and serve as a controlling element for applications ranging from consumer electronics to industrial machinery, expectations are high for the implementation of nitride transistors, which demonstrate lower-level losses, higher speeds and higher-temperature operations compared with existing silicon transistors. However, it is important to suppress variations in threshold voltage and to improve the reproducibility of their normally-off characteristics, the firm stresses.

In existing transistors composed of a two-layer structure consisting of an aluminum nitride gallium (AlGaN) electron supply layer and a gallium nitride (GaN) channel layer, a great deal of variation in threshold voltage occurs due to differences in the thickness of the AlGaN electron



Schematic diagram of NEC's five-layer structure, which improves normally-off characteristics.

supply layer under the gate, which is etched down from 20–30nm to just a few nanometers in order to achieve normally-off characteristics. A high-precision etching process is particularly needed to reduce the variation in threshold voltage and to stabilize the normally-off characteristics.

A five-layer structure enables NEC's new transistors to control the threshold voltage with a high degree of precision by reducing its dependence on the thickness of the electron supply layer. This is accomplished by introducing an electric charge neutralization layer (the 'piezo' neutralization layer) within the electron supply layer, while also introducing a buffer layer — beneath the channel layer — with the same composition as the piezo neutralization layer. This structure enables uniform manufacturing of nitride semiconductor power transistors that realize normally-off characteristics at a low cost. The transistors also exhibit low power loss and high breakdown voltage, the firm adds.

NEC says that it aims to accelerate its R&D towards the design, evaluation and implementation of nitride power transistors.

www.nec.co.jp

IN BRIEF

Accel-RF ships reliability test systems for European GaN device development

Accel-RF Corp of San Diego, CA, USA, which produces turn-key accelerated life-test/burn-in test systems for compound semiconductor devices, says that in fourth-quarter 2009 it installed five high-power reliability test systems at customers in Europe. Shipped to both government research and commercial entities, the systems will be instrumental in developing gallium nitride devices.

Accel-RF's founder & president Roland Shaw says that the shipments represent the acceptance of the company's high-power reliability test systems by the compound semiconductor community to test the reliability of GaN technology in the European Union.

Accel-RF has been selling RF reliability systems in the USA since 2004, but five systems delivered and installed in Europe in Q4/2009 further demonstrates expansion outside the USA, Shaw adds.

Service and first-line support for the systems will be performed by Peritest Eurl, based near Paris, France. "Accel-RF's technical staff will always be working with our customers," Shaw says. "Peritest Eurl for sales, service, and first-line support in Europe has worked well for Accel-RF," he adds.

"Global expansion for complex equipment like ours has to be done carefully... even with this major expansion effort we have maintained a very close relationship with all of our customers," Shaw asserts.

www.accelrf.com

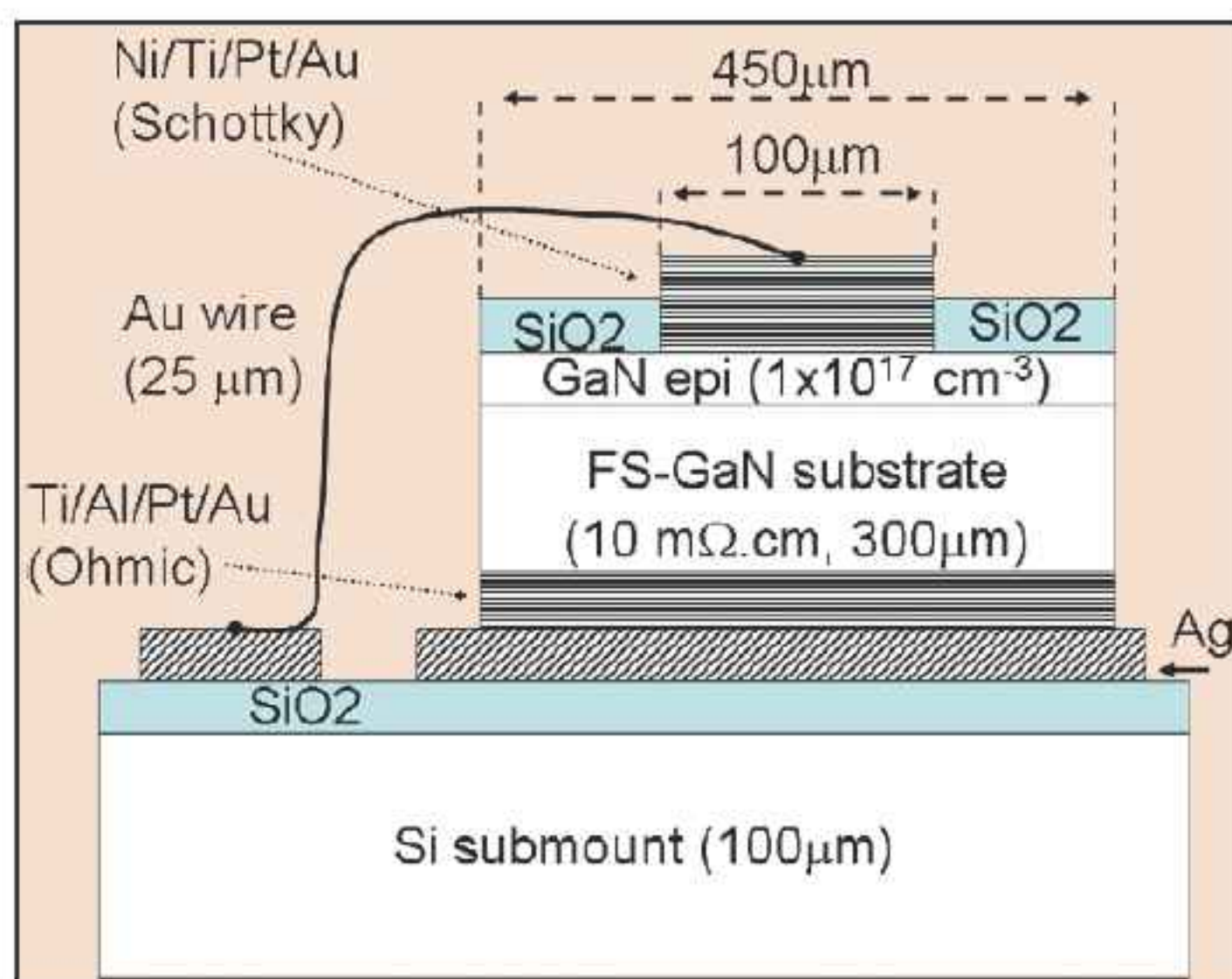
Long-term thermal probe into GaN-Schottky performance

European researchers have built Schottky diodes on free-standing gallium nitride (FS-GaN) substrates that can withstand storage temperatures up to 400°C [O'Mahony et al, *Semicond. Sci. Technol.*, vol24, p125008, 2009]. Such devices have been of interest lately with a view to application in hybrid electric vehicles and other high-temperature environments (e.g. aerospace equipment). This would add a further capability for the commercial deployment of GaN in addition to visible-ultraviolet light emission and use in radio/microwave power amplification.

GaN has a wide bandgap ($\sim 3.5\text{eV}$) that leads to a high breakdown field ($\sim 2\text{--}3 \times 10^6\text{V/cm}$) and high thermal conductivity (1W/cm-K). In theory, GaN-based Schottky devices should exhibit lower values for intrinsic leakage and specific on-resistance. Further, the ability to operate at higher temperatures than present-day silicon-based devices ($\sim 150^\circ\text{C}$) would reduce/simplify or even remove the need for associated cooling equipment.

As usual in such work, there are barriers to achieving optimum performance. In nitride-based devices, substrate material quality is a particular concern, since GaN is difficult to grow with low threading dislocation defect levels. For the high-temperature Schottky diode application, it is also important to find a thermally stable metal combination for the Schottky contact with the GaN material.

Free-standing GaN substrates are often used to reduce defect levels in subsequent epitaxial layers, compared with GaN grown epitaxially on sapphire or silicon. In addition, the substrate can be made electrically conductive with n-type silicon doping, allowing a vertical rather than planar structure to be realized for better power and thermal characteristics (less current crowding, better heat dissipation and better reverse breakdown).



Schematic of packaged GaN-Schottky diode.

Nickel is a popular Schottky metal for GaN. However, at high temperature (greater than 500°C) problems arise, such as Ga and N out-diffusion, and intermixing to form Ni-Ga or metal nitrides.

The researchers — based in Ireland (Tyndall National Institute), Germany (AZUR Space GmbH), Netherlands (European Space Agency) and UK (Imperial College) — used 50mm-diameter FS-GaN substrates from Lumilog. The FS-GaN substrates are grown using hydride vapor phase epitaxy (HVPE) to create a 300µm-thick layer of GaN on sapphire that is then separated from the sapphire. The researchers grew a lightly doped n-GaN epitaxial layer on the FS-GaN using MOCVD. The ohmic contact (Ti/Al/Pt/Au; 3/50/50/200nm) was deposited on the unpolished back-side of the substrate.

The Schottky top contact was designed using a nitride over gallide (NOG) technique developed at the University of Florida. In NOG, nickel is thought to form a stable gallide interface with the GaN and titanium forms a nitride to prevent nitrogen out-diffusion. The contact used in the European work consisted of (Ni/Ti/Pt/Au; 50/10/50/200nm) evaporated into a 100µm-diameter hole formed in a 200nm silicon dioxide layer.

The resulting diodes had a low forward voltage (less than 1.5V) and low on-resistance ($0.3\text{m}\Omega\text{cm}^2$) at high current density (1300A/cm^2).

The diodes were subjected to long-term testing to determine their stability. Tests included forward current (1.3A/cm^2) and reverse voltage (-3.5V) biased storage at 300°C in

N_2 for 466 hours. Non-biased storage testing for up to 1000 hours at 350°C and 400°C in N_2 or at 300°C for 1500 hours in air was also carried out. For the 400°C test, there was a significant increase in both barrier height and ideality after storage for only 48 hours, whereas the other tests showed under 10% drift in ideality and barrier height during the long-term storage tests.

Although the diodes had a high reverse leakage initially, this was reduced by storage at high temperature. The diode resistance was increased by such storage, an effect attributed to degradation of the diode-submount interconnect.

The researchers claim that their work is the first reported study on the long-term stability of Schottky diodes on free-standing GaN. Although catastrophic degradation such as thermal runaway was not observed, the researchers propose that optimized thermal annealing of the Ni-based Schottky contact metallization in the temperature range 350–400°C is necessary for stable long-term operation of such devices at high temperature. Also, further work is needed to understand the changes in ideality with thermal treatment.

www.iop.org/EJ/abstract/0268-1242/24/12/125008/
Author: Mike Cooke.

Fluorine-enhanced AlGa_{0.3}N HEMTs

Researchers at Xidian University in China have compared the effectiveness of various fluorine plasma treatments in achieving enhancement-mode (normally off) nitride semiconductor high electron mobility transistors (HEMTs) using a fluorine plasma treatment [Quan Si et al, J. Semicond., vol30, p124002, 2009].

Normally, HEMTs produced using combinations of aluminum gallium nitride (AlGa_{0.3}N) tend to operate in depletion-mode (normally on). Although depletion mode devices can be used to produce useful circuits, electronics based on enhancement mode devices tend to waste much less power. The ubiquity of silicon-based complementary metal-oxide-semiconductor (CMOS) electronics is based in part on the ease with which enhancement mode devices can be built using that technology.

Enhancement-mode AlGa_{0.3}N HEMTs could make for energy efficient circuit options that operate at high power, frequency and/or temperature. Applications for which AlGa_{0.3}N HEMT technology (even in depletion-mode) is being developed include power amplifiers for wireless communications network base-stations (up to ~40GHz) and inverters for conversion between DC and AC power in electric and hybrid vehicles. The development of enhancement-mode devices in the technology could extend its reach into more complex devices that include logic.

Fluorine plasma treatment has been one of the methods used in recent times to shift the threshold voltage of AlGa_{0.3}N into the enhancement-mode region (Figure 1). The Xidian researchers used step-and-repeat lithography and reactive ion etch to separately expose regions of the same AlGa_{0.3}N/GaN wafer to four different 150 second plasma treatments with carbon tetrafluoride (CF₄) in the reactive ion etch chamber (Figure 2). This avoids the performance differences that can arise from devices built of different wafers.

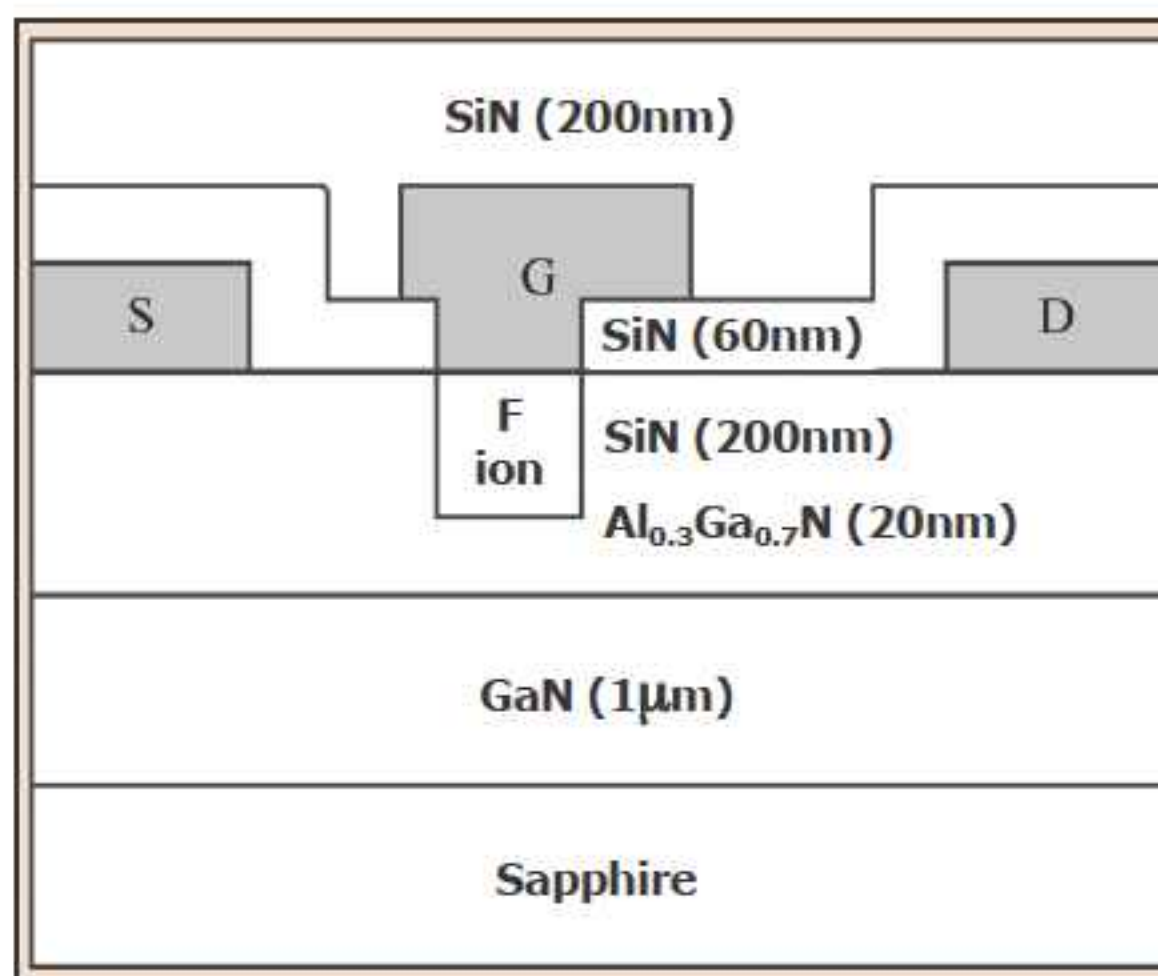


Figure 1. Schematic cross section of enhancement-mode AlGa_{0.3}N/GaN HEMT.

The AlGa_{0.3}N/GaN layers were grown on sapphire using MOCVD. The AlGa_{0.3}N layer contained 30% AlN. The final HEMTs had source/drain regions with ohmic contacts and a Schottky gate.

The effect of the plasma treatment was to shift the threshold voltage upwards from the negative value achieved without plasma treatment (region 1). As the plasma power increases, the fluorine ion (F⁻) density and kinetic energy increases. This means that the fluorine penetrates to greater depth in the AlGa_{0.3}N

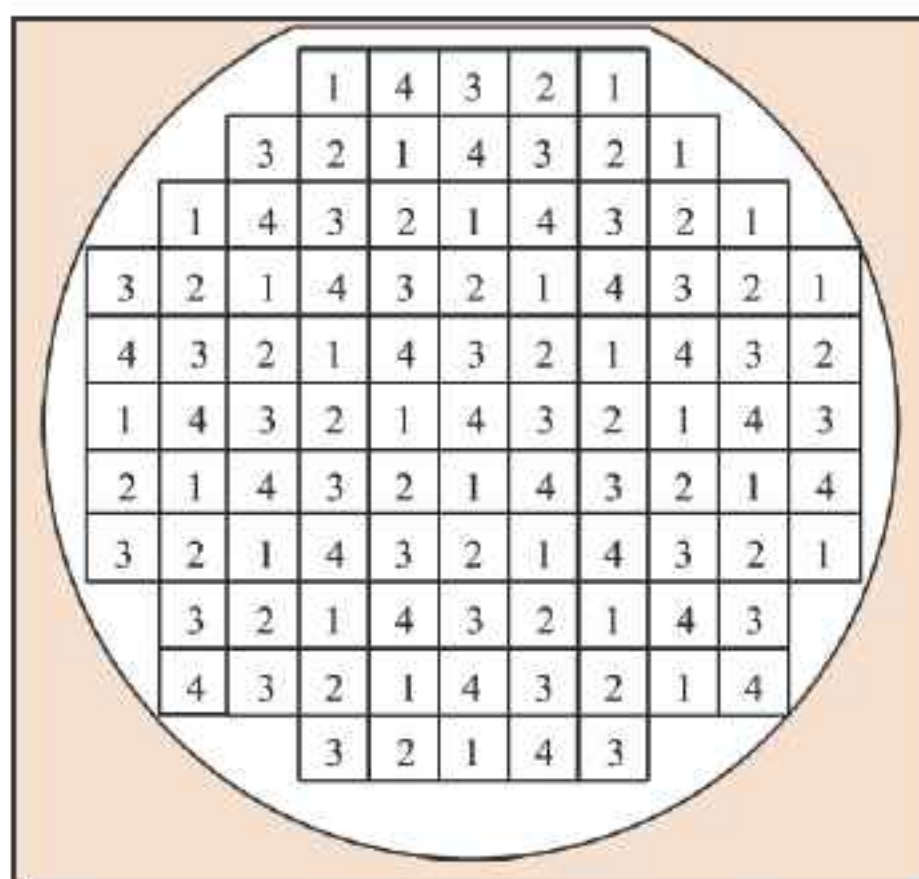


Figure 2. The arrangement of plasma treatments on the AlGa_{0.3}N/GaN wafer. Region 1 corresponds to conventional HEMT devices with no plasma treatment. Regions 2-4 were subjected to plasma treatments of 150 seconds with powers of 55W, 150W and 250W, respectively.

barrier below the gate region, coming closer to the GaN channel. However, higher power (150W) plasma treatment also damages the performance of the device in terms of reduced electron mobility in the channel. At the highest plasma power tested (250W), the fluorine ions reach the channel, killing electron mobility.

The threshold shift with a plasma power of 150W is sufficient to result in enhancement-mode operation with some impact on electron mobility, compared with

normal depletion-mode HEMTs. The peak current density was 501mA/mm and the peak transconductance was 210mS/mm. The threshold voltage was +0.57V. The etch damage resulted in a peak transconductance smaller than that of traditional GaN HEMTs.

It was found that gate leakage under forward bias was comparable to that of conventional devices, while the reverse bias leakage was reduced in plasma treated devices, indicating an increased tunneling width. A final effect of the 150W plasma treatment was reduced extrinsic cut-off and maximum oscillation frequencies in small-signal RF measurements (see Table).

<http://dx.doi.org/10.1088/1674-4926/30/12/124002>

Author: Mike Cooke.

Table. Measured extrinsic cut-off (f_T) and maximum oscillation (f_{max}) frequencies for three different plasma treated devices. A plasma power of '0W' represents 'no plasma treatment'.

Plasma power (W)	f_T (GHz)	f_{max} (GHz)
0	20.9	31.6
55	21.3	32.4
150	19.4	26

IN BRIEF

Wafer Technology extends GaSb wafer range to 4-inch

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK says that its substrate subsidiary Wafer Technology Ltd of Milton Keynes, UK is to extend its gallium antimonide (GaSb) product range to include 4-inch diameter wafers.

Gallium antimonide materials are used in the manufacture of a wide range of products including infrared laser diodes, detectors and thermophotovoltaic (TPV) cells that can convert infrared (heat) energy into electrical power.

The firm says that 4-inch GaSb-Te wafers are now available and can be specified in the same way as for existing 2-inch and 3-inch GaSb products. High-accuracy orientations ($\pm 0.1^\circ$) and proprietary epitaxy-ready finishes are offered to ensure consistent performance in epitaxial growth. Whole 4-inch wafer etch pit density (EPD) maps (69 points) are supplied to support yield maximization in the manufacture of large-area detector arrays.

"Delivering 4-inch gallium antimonide product is an important milestone for Wafer Technology, especially at a time when the industry is looking to produce larger-area epitaxially grown arrays," comments Wafer Technology's general manager Dr Mark J. Furlong.

"Our 4-inch gallium antimonide wafers have been very well received by our first customers qualifying this product, so we are looking forward to satisfying new demands for large-area GaSb wafers in 2010," Furlong adds.

www.wafertech.co.uk/galliumantimonide.htm
www.iqep.com

IQE second-half 2009 revenue up 45% on first half

In a trading update for 2009, epi-wafer foundry and substrate maker IQE plc of Cardiff, Wales, UK says that, following the industry-wide destocking that adversely impacted the first-half 2009, it experienced a strong second-half recovery. The firm therefore expects to report full-year 2009 results in line with market expectations, despite the adverse currency impact of sterling strengthening against the US dollar in second-half 2009.

Second-half revenue is expected to be 45% higher than first-half revenue (which was £21.4m). With the benefit of high operational gearing and stringent cost controls, IQE also expects earnings before interest, tax, depreciation and amortization (EBITDA) to rise more than threefold from £1.9m in first-half 2009, boosting full-year EBITDA to about £8m (down only slightly on 2008's £8.4m).

Continued tight control of working capital and capex also delivered substantial free cash generation in second-half 2009. Net debt is therefore expected to be significantly better than market expectations at about £15m — a reduction of about £4m since June (compared to first-half 2009's net debt of £18.9m).

IQE says that its strong second-half performance reflects increasing demand for gallium arsenide wafers in the wireless communications market, as well as a diverse range of high-growth optoelectronics markets.

The growth in wireless is being driven by a structural shift as GaAs-rich smartphones enjoy a rapid increase in popularity, and emerging economies such as the BRIC (Brazil, Russia, India and China)

nations roll out 3G networks to satisfy increasing demand for high-speed mobile internet and data services.

The growth in optoelectronics is being driven by a diverse range of factors, says IQE. Demand for solar cells and solid-state lighting is growing in response to regulatory and environmental pressures. In contrast, consumer and industrial demand is driving growth in a number of applications including 'hands free' gaming, laser projection, high-speed data communications (broadband), and advanced optical storage.

"We have demonstrated a high degree of resilience through a challenging year," says chief executive Dr Drew Nelson. "Proactive management protected the business through the downturn, without jeopardizing our ability to respond when sales volumes recovered strongly in the second half," he adds. "Despite the economic turmoil, IQE has continued to strengthen its market position by attracting new talent and gaining new product qualifications to increase market share."

"We are making good progress in developing and commercializing key intellectual property that will provide a competitive advantage and secure leading positions in a number of emerging high-growth markets, including solar power, laser projection systems and solid-state lighting," continues Nelson. "The board remains confident that IQE is well positioned to achieve continued growth in sales, profits and cash flow in 2010."

IQE expects to report preliminary results for second-half 2009 on 24 March.

www.iqep.com

II-VI completes Photop acquisition

II-VI Inc of Saxonburg, PA, USA has completed its acquisition of Photop Technologies Inc of Fuzhou, China (announced on 28 December). The initial consideration consisted of \$45.6m in cash and 1,146,000 shares of II-VI common stock. The purchase agreement also provides up to \$12m of additional cash earn-out opportunities based on Photop achieving certain agreed financial targets in 2010 and 2011. The final purchase price will be subject to customary closing adjustments, including working capital adjustments.

Founded in 2003 through a merger of four firms (involved in optic, laser, fiber-optic, and photonic crystal material products), Photop has more than 3000 staff (including over 350 engineers in Fuzhou, Shanghai and Guangzhou) and is a vertically integrated manufacturer of engineered materials, optical components, microchip lasers for visible display applications, and optical modules for fiber-optic communication networks as well as diverse consumer and commercial applications. Photop generated about \$43m in revenues for the first nine months of 2009.

Photop is being combined with II-VI's subsidiary VLOC Inc and Near-Infrared Optics business for financial reporting purposes. This combined group, along with the Compound Semiconductor Group, will be directed by II-VI Inc vice president Dr Vincent D. (Chuck) Mattera Jr, who has been promoted to executive VP.

II-VI Inc produces crystalline compounds including zinc selenide for infrared laser optics, silicon carbide for high-power electronic and microwave applications, and bismuth telluride for thermoelectric coolers. Business groups include:

- **Compound Semiconductor Group:** II-VI's Wide Bandgap Materials (WBG) group manufactures and markets single-crystal silicon carbide substrates for use in solid-state lighting, wireless infrastructure, RF

electronics and power switching; the Marlow Industries Inc subsidiary designs and makes thermoelectric cooling and power generation solutions; and the Worldwide Materials Group (WMG) provides expertise in materials development, process development, and manufacturing scale up.

- **Near-Infrared Optics Group:** VLOC makes near-infrared and visible light products for industrial, scientific, military and medical instruments and laser gain materials and products for solid-state YAG and YLF lasers.

- **Infrared Optics Group:** II-VI Infrared makes optical and opto-electronic components for industrial laser and thermal imaging systems; HIGHYAG Lasertechnologie GmbH makes fiber-delivered beam transmission systems and processing tools for industrial lasers.

- **Military & Materials Group:** Exotic Electro-Optics (EEO) makes infrared products for military applications; Pacific Rare Specialty Metals & Chemicals (PRM) produces and refines selenium and tellurium materials.

The Photop acquisition is expected to be neutral to II-VI's net earnings in fiscal 2010 (ending 30 June). Photop's positive operational results for the six months ending 30 June are expected to offset (i) acquisition-related expenses and (ii) the dilutive effect of the II-VI shares used for the acquisition. The transaction is expected to be accretive in fiscal 2011.

During its fiscal second-quarter 2010 (ended 31 December 2009), II-VI incurred about \$1m of transaction-related expenses, after-tax. After the acquisition, for fiscal 2010 II-VI updated its revenue guidance from \$264-274m to \$293-305m (while maintaining its guidance for earnings per share from continuing operations of \$0.85-0.95). But, since reporting fiscal Q2 results on 19 January, it updated this further to \$306-311m (and \$0.97-1.03)

www.ii-vi.com

IN BRIEF

EpiWorks completes Phase II of capacity expansion

EpiWorks Inc of Champaign-Urbana, IL, USA, which manufactures 4-inch and 6-inch epiwafers for the wireless and solar cell industries, as well as 2-, 3-, 4- and 6-inch wafers for the laser and detector industries, has completed Phase II of its capacity expansion (unveiled last April), providing enough cleanroom space to produce more than 200,000 6-inch epiwafers per year at the facility.

The firm's Phase I expansion (completed in April 2007) boosted 6-inch capacity to more than 50,000 wafers per year.

"We have carefully planned the additional cleanroom space and production capacity with customers to ensure that EpiWorks continues to stay ahead of demand," says executive vice president Dr David Ahmari. "With the new cleanroom on-line, the additional wall-to-wall capacity also enhances our ability to quickly add more production tools and provides greater flexibility for new product development," he adds.

EpiWorks made progress with customers in 2009, despite the unusual economic conditions, says CEO Quesnell Hartmann. "In addition to maintaining profitability, EpiWorks qualified several new wireless, laser and detector products and established a new solar cell wafer product line. The new production floor will allow us to increase output in each of these areas," he notes. "Our contractors and employees have done a fantastic job meeting our timing and budgetary goals, thus providing a smooth runway for increasing production in 2010 and beyond," Hartmann concludes.

www.epiworks.com

AXT's opto-related revenues to grow at 15–20% annually

In December, Richard Shannon, senior analyst at securities brokerage firm Northland Securities Inc, issued an analysis of the optoelectronics business prospects of AXT Inc of Fremont, CA, USA (which manufactures gallium arsenide, indium phosphide and germanium substrates and raw materials) that suggests a good growth market combined with attractive margins in certain product segments. He believes that AXT's total addressable market (TAM) can grow in excess of 20% annually over the next few years, with optoelectronics markets forming another growth driver in addition to the wireless and solar/concentrated photovoltaic (CPV) markets.

While GaAs is about 75% of AXT's total revenue, Northland Securities' research on AXT has focused on its semi-insulating (SI) GaAs substrates (43% of total revenue so far in 2009) for power amplifiers and switches in wireless handset (RF) applications, selling directly or indirectly to customers like Triquint Semiconductor, Anadigics, Avago Technologies. However, about 33% of the firm's GaAs revenue comes from semiconducting (SC) GaAs, mainly for optoelectronics applications (most prominently LEDs, although Northland Securities sees solid growth also coming from laser diodes and sensors). The firm believes that the TAM addressed by AXT's SC GaAs products is growing by 15–20% annually over the next few years (from at least \$4.9bn currently).

Recent research and conversations with management suggest that gross margins for certain optoelectronics applications are now at or above corporate average. Specifically, high-brightness LEDs (HB LEDs) and laser diodes bring attractive margins, and AXT is expected to pursue higher market share.

Many investors have focused on the opportunities for backlighting for TVs and notebook screens,

which should exhibit strong growth in the next couple of years. There are two types of LED backlighting: direct lighting (with red, green and blue LEDs behind and across the entire span of the LCD panel to create a white light, with AXT supplying the red LEDs); and edge lighting (with white LEDs — which do not use GaAs — on the edge of the panel, and mirrors directing light to each pixel). Edge-lit LCD TVs are becoming increasingly popular because of their lower cost and very thin profile. Overall, Northland Securities views backlighting as a good opportunity for AXT, albeit one that may be moving away from it if more edge lighting is used.

In the automotive market (which uses LEDs in dashboards, tail-lights — which are red, using GaAs — and headlights), Osram Opto Semiconductor GmbH of Regensburg, Germany is a consistent top 10 customer, making the application a focus market for AXT.

AXT also serves the low-brightness LED market, but gross margins are among the lowest that AXT addresses. The firm has sold more into this market at times to fill up capacity, but Northland Securities sees AXT focusing more on other markets in the future.

Overall, AXT is addressing high-growth optoelectronics markets, with the LED market projected to grow 25% annually over the next couple of years, and corresponding growth of 15–20% for AXT achievable, it is reckoned.

While there are product areas such as the low-brightness LED market where gross margins are challenging, these can be offset by much more attractive margins such as for HB-LEDs, laser diodes and

sensors. Northland Securities says its conversations with AXT management suggest that a good portion of the recent improvement in gross margins, particularly in third-quarter 2009, come from favorable product mix within the SC GaAs product line (and not just from 6-inch SI GaAs substrates). Hence, AXT's gross margins can still perform well even with strong growth from the SC GaAs product line, believes Northland Securities.

However, the firm concludes that the main risks for AXT are the following:

- Since AXT makes a non-proprietary product, it can be subject to commodity pricing environments from time to time.
 - AXT is potentially exposed to difficult pricing for its commodity raw material inputs. Although it appears to be in an advantageous supply agreement, pricing is based on a discount to the market price.
 - AXT derives most of its raw material inputs from its joint ventures in China. The risks inherent in China are highlighted by the potential issue regarding changing tax policies that surfaced in late 2006. While there was ultimately no negative affect to AXT, Northland Securities believes that its operations would have been materially affected.
 - Much of AXT's growth plan depends on the handset market (through the sale of SI GaAs 6-inch wafers), so if this market falters or its primary customers lose share then AXT would be materially affected. GaAs substrates are also at risk of technology substitution for antenna switches.
 - The LED market is focusing on prospects in general illumination, which requires costs to be much lower than they are currently. Northland Securities therefore expects to see strong pricing declines in this market, which impact AXT's gross margins.
- www.northlandsecurities.com
www.axt.com

The TAM addressed by AXT's SC GaAs products is growing by 15–20% annually over the next few years (from at least \$4.9bn currently)

AXT wins Ge contract from Azur

AXT has won a five-year contract to supply germanium (Ge) substrates to AZUR SPACE Solar Power GmbH of Heilbronn, Germany, a provider of solar cells for space and terrestrial applications.

AXT says that the contract is the result of a collaboration between the two firms that has enabled AZUR SPACE to obtain what is claimed to be an industry-leading average conversion efficiency of 40% for triple-junction concentrator photovoltaics (CPV) solar cells and 30% for triple-junction GaAs space solar cells.

"Since 1964, AZUR SPACE has been at the forefront of the development of solar technology and we are excited that our collaboration over the past months has resulted in one of the highest conversion efficiency rates in the industry, further advancing the potential of this important triple-junction CPV technology," says CEO Morris Young. "We look forward to a long and prosperous relationship," he adds.

"AXT has been a great partner to work with throughout the qualification process," says Patrick Kilper, AZUR SPACE's manager for supply management. "Its germanium substrates consistently met our stringent requirements and we are pleased that the company has its own source of germanium raw materials [through its China joint venture] to ensure adequate supply as customer demand for our solar cells continues to rise."

AXT says that Ge is becoming more widely used for space and terrestrial solar cell applications as the worldwide focus on satellite technology and alternative energy development increases. Europe continues to lead the world in investment into solar energy development, but government subsidies in the USA, Asia and Australia are promoting the development of the technology around the world.

www.azurspace.com

www.axt.com

IN BRIEF

OEpic leases space

Optoelectronic foundry OEpic Semiconductors Inc of Sunnyvale, CA, USA is to make available H6 cleanroom space (ranging from 300ft² to 2000ft²) to customers interested in installing and operating their own growth, processing or test equipment (subject to availability of space, allocated on a first come first served basis). The lease period is 1-3 years, with renewal provision.

The offer is open to clients with monthly foundry contracts, and has the restriction that their volume of foundry business should exceed the monthly rent. Electricity, water, gases (nitrogen and hydrogen), dry air, house vacuum, wastewater treatment, and storage for chemicals, parts, gas cylinders etc can provided if needed. Access to H2 rooms for gas cabinet installation is also available.

www.oepic.com

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Veeco launches TurboDisc K465i GaN MOCVD system

Epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview NY, USA has launched the TurboDisc K465i gallium nitride MOCVD system for the production of high-brightness LEDs (HB-LEDs). The firm says that beta-site customers have rapidly qualified the K465i for volume production, and that it has received orders from multiple LED makers throughout the Asia-Pacific region.

Based on the production-proven K-Series platform, at the heart of the K465i is Veeco's patent-pending Uniform FlowFlange technology. Designed to create a uniform alkyl and hydride flow pattern across all wafers, the K465i delivers what is said to be superior uniformity and repeatability with the industry's lowest particle generation, driving what is reckoned to be best-in-class LED yields nearing 90% in a 5nm bin.

Also, FlowFlange's simplified design provides ease-of-tuning for fast process optimization on wafer sizes up to 8" in diameter as well as fast tool recovery time after maintenance, allowing what is reckoned to be the LED industry's highest productivity. Fully automated, the K465i enables reduced cost of ownership compared to competing tools, the firm adds.



Veeco's TurboDisc K465i GaN MOCVD system.

"With superior wavelength uniformity and excellent run-to-run repeatability, the K465i extends Veeco's lead in capital efficiency — the number of good wafers per day for each capital dollar — for high-volume LED manufacturers," says Bill Miller, senior VP & general manager of Veeco's MOCVD business. "Our beta-site customers achieved world-class results in a very short period of time," he adds.

"The K-Series is a robust, reliable, multi-generational MOCVD platform that is in production at more than 80% of the world's key LED manufacturers," comments CEO John R. Peeler. "Veeco is committed to advancing its leadership position by increasing R&D investment, introducing innovative new technologies, ramping MOCVD production

capacity, and partnering with customers to maximize their LED manufacturing," he adds. "The K465i MOCVD system is the latest example of Veeco driving down the cost of LEDs to enable applications such as display backlighting and general illumination."

Demand for HB-LEDs is high and expected to increase in

the coming years. In an

August 2009 report 'High-

Brightness LED Market Review and Forecast 2009', market research firm Strategies Unlimited forecasted that the HB-LED market will grow at a compound annual growth rate (CAGR) of 24% from \$5.1bn in 2008 to \$14.9bn in 2013.

"Research indicates the fundamental drivers for the HB-LED market have become even stronger in recent years as new applications for LEDs in lighting and backlights continue to emerge," says Robert V. Steele, director of Strategies Unlimited's LED practice. "To meet the overwhelming demand that we expect this will create over the next few years, LED makers will need to quickly ramp up their manufacturing capabilities, including the addition of substantial MOCVD capacity."

www.veeco.com/mocvd

Veeco appoints new chief financial officer

David D. Glass has joined Veeco as executive VP, finance & CFO, replacing John F. Rein Jr (who announced his retirement last June).

Glass joins Veeco after 25 years with Rohm and Haas Company, a \$10bn global specialty materials firm bought in 2009 by The Dow Chemical Company. He recently returned from Shanghai after serving as CFO of both Rohm and Haas' \$2bn Electronic Materials division and the Rohm and Haas Asia-Pacific region.

From 2003–2007, Glass was Rohm and Haas' corporate controller in Philadelphia, leading 350 staff and responsible for company-

wide accounting, financial controls and SEC reporting. Previously, in China, he was finance director of APAC and then general manager of Rohm and Haas' Coatings business for Greater China, overseeing manufacturing, technical support, sales and marketing teams.

Prior to that, in Montgomeryville, PA, Glass was president of Toso-Haas Biotech, a stand-alone joint venture between Rohm and Haas and Tosoh of Japan. Prior roles include five years in the UK, first as finance director for Europe then as director, European Emerging Markets Business Development. He has

been involved in over a dozen M&A transactions for Rohm and Haas.

"Dave possesses the right combination of operational and financial skills to help me lead Veeco during this period of rapid business expansion," says CEO John Peeler. "His over 20 years at a world-class corporation such as Rohm and Haas, in a diverse set of managerial, financial and operational roles, make him uniquely suited to be our next CFO," he adds.

"The company is poised to achieve new levels of growth, with significant opportunities around the world," comments Glass.

Riber returned to profit in '09, despite revenue drop; expects growth in 2010

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported sales of €7.8m in fourth-quarter 2009, boosting full-year sales to €17.3m (down 10% on 2008's €19.2m). First-half sales had been just €5.9m. Of full-year 2009's sales, 45% came from Europe, 41% from Asia, and 14% from North America.

Offsetting the lack of production system sales in the context of the economic crisis (compared to €5.2m for production systems in 2008), sales of research machines reached a record €10.1m (up 26% on 2008's €8.1m). In particular, 14 MBE tools were dedicated to research centers (up from 13 in 2008), including 10 sold in second-half 2009.

The components and services division also continued to expand, yielding record sales of €4.8m (up 30% on 2008's €3.7m), driven by

the integration of VG Semicon's business (acquired from Oxford Instruments Plasma Technology in late September 2008).

Sales of cells and evaporation sources rose 6% from 2008's €2.3m to €2.4m, proving resilient to the economic crisis due to new markets. These included cells for organic LEDs (OLEDs), which achieved sales of €1m in 2009.

Despite the drop in overall revenue, Riber has also confirmed its guidance for a return to net profitability for 2009, combined with an improved cash position.

Due to the progress made in the last year (product diversification, the development of after-sales activities, higher productivity and product quality, and better cost control), Riber says it has a sound base that should enable growth in 2010.

Full 2009 results will be released on 25 March.

www.riber.com

IN BRIEF

MBE facility opened

In January, the new Molecular Beam Epitaxy (MBE) facility at University College London (UCL) was officially opened by HRH The Princess Royal.

UCL reckons that the new MBE systems will enhance expertise in nanotechnology and photonics at UCL and the London Centre for Nanotechnology, as well as boosting global competitiveness in optoelectronic and semiconductor science.

UCL uses MBE to grow structures for both electronic and photonic devices, including high-speed transistors, LEDs, high-efficiency solar cells, and solid-state lasers.

In particular, the new facility has special source arrangements, with the combination of arsenic, antimony and phosphorus crackers with gallium, aluminium and indium solid sources claimed to be unique in Europe.

www.ee.ucl.ac.uk/research/MBEOpening

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Aixtron investing €40m to expand to new R&D facilities

Emerging LED lighting market driving accelerated strategy

Deposition equipment maker Aixtron AG of Aachen-Herzogenrath, Germany has announced what it describes as an important step in the implementation of its accelerated R&D strategy by building a new R&D campus at its premises in Herzogenrath-Kohlscheid.

The new facility will be able to host up to 350 engineers at the end of phase 1, significantly increasing the laboratory resources and prototype capabilities used to develop next-generation material deposition manufacturing systems. To fully develop the new modular facilities (which will use a renewable energy design to minimize carbon footprint), Aixtron plans to invest up to €40m over the next 2–3 years.

Aixtron says that it will continue to focus the principal manufacturing

of standard deposition equipment at its nearby main facilities in Herzogenrath, Kaiserstraße, supported by the engineering and assembly locations in Cambridge, UK and Sunnyvale, CA, USA.

"This is a vitally important next step in the implementation of our product development strategy, and the accelerated timing reflects the recent increase in volume and momentum we have seen

The new facility will be able to host up to 350 engineers at the end of phase 1, significantly increasing the laboratory resources and prototype capabilities

in the markets we serve," says CEO Paul Hyland. "It also underlines our commitment to deliver continuous improvement to the productivity of our products."

Regarding near-term objectives, the requirement to meet the improved performance and reduced cost of ownership objectives necessary to support the needs of the emerging LED general lighting market will require significant focus and commitment, believes the firm. "The new facility will further increase our ability to be able to deliver both of these requirements," says Hyland. "As we go into a very exciting period of innovation and growth, it is our firm intention to step up a gear to maintain our position," he adds.

www.aixtron.com

FOREPI orders ten more MOCVD tools

Aixtron says that, in Q3/2009, Formosa Epitaxy Inc (FOREPI) of Lung-Tan, Taoyuan, Taiwan placed an order for multiple MOCVD reactors — comprising CRIUS Close Coupled Showerhead systems and AIX 2800G4 HT Planetary Reactor systems — for use in the production of ultra-high brightness (UHB) InGaN-based blue LEDs. The order will be shipped during 2010 and will be installed alongside FOREPI's existing high-throughput Aixtron MOCVD systems.

"The reasons for our latest purchase come down to the simple need to add more capacity with high-yield equipment as FOREPI ramps up again to meet booming market demand," says FOREPI's president Frank Chien. Special features of the systems on order include 4" capability for all new systems, he adds. "All purchased

tools are 4" production capable and will give us a rapid, straightforward route to begin offering 4" wafer preparation."

FOREPI says that, in its second decade of commercial operation, it remains focussed on the pure-play manufacturing of high-brightness InGaN-based LED wafers and chips. Products include high-power blue, green and near-UV LEDs.

The reasons for our latest purchase come down to the simple need to add more capacity with high-yield equipment as FOREPI ramps up again to meet booming market demand

www.forepi.com.tw

Record '09 revenue and profit to far exceed guidance

Aixtron's preliminary revenue for fourth-quarter 2009 is €117m (up 42% on €82m both in Q3/2009 and a year ago). This takes full-year 2009 revenue to a record €302m, up 10% on 2008's €274.4m. This is also well above guidance of €280m (raised in late October from initial guidance of €200–220m).

Earnings before interest and taxes (EBIT) in Q4/2009 was €33m (28% of revenue), almost doubling from €16.7m (20% margin) in Q3 and more than quadrupling from €7.4m (9%) a year ago. Full-year EBIT was €62m (20% margin), almost doubling from €32.5m (12%) in 2008.

Aixtron will issue final 2009 results on 11 March.

Record demand for ion beam tools

Oxford Instruments Plasma Technology (OIPT) of Yatton, Bristol, UK says that it has seen a significant boost in demand for its Ionfab ion beam etch and deposition tools, with 2009 being the best year ever for sales of the systems. Orders for systems have been received both for R&D and production applications, from a range of customers worldwide.

These include sales to Saudi Arabia's King Abdullah University of Science and Technology (KAUST) for R&D; Sweden's Chalmers University of Technology for ultra-low-temperature R&D etch; CEA LETI in Grenoble, France for R&D; and a major manufacturer in China for an Ionfab500 System to undertake medium batch optical coating production.

OIPT says that Ionfab allows the versatility and flexibility to perform etch and/or deposition, maximizing system utilization. Specifications

can be closely tuned to applications, enabling faster and repeatable process results, says the firm, and offering functionality in multiple modes: ion beam etching (IBE), reactive ion beam etching (RIBE), chemically assisted ion beam etching (CAIBE), ion beam sputter deposition (IBSD) and ion-assisted sputter deposition (IASD).

"OIPT is one of the few companies in our technology sector that has not only weathered the recession but also grown significantly," claims the firm's sales & customer service director Mark Vosloo. "Each of these Ionfab ion beam systems has been custom built for individual customer applications, from R&D to production, etch and deposition," he adds. "Versatility, coupled with excellent uniformity and process results, mean that OIPT is increasingly becoming the supplier of choice for ion beam systems," he claims.

www.oxford-instruments.com

HB-LED tool sales boosted by LCD TVs

In the last 12 months sales of OIPT systems for producing HB-LEDs have more than doubled, supplying nearly all major Asian HB-LED makers and greatly increasing OIPT's market share.

"Use of LED backlighting units in LCD TVs is currently driving substantial growth in the HB-LED market, and this growth is predicted to continue over the next few years", says sales & customer service director Mark Vosloo.

"Backlighting in notebook PCs and increased penetration of LEDs in automotive and architectural lighting is also driving the market."






Recent orders include the batch System133 PECVD load-locked tool and Plasmalab 800Plus PECVD open-load tool as well as the batch System133 ICP380 etch tool for GaN, AlGaInP and sapphire etching.

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IN BRIEF

Matheson Tri-Gas to distribute RASIRC's products in USA

RASIRC of San Diego, CA, USA, which designs and manufactures products for controlled humidification and ultra-pure steam generation for critical manufacturing processes, says that Matheson Tri-Gas Inc of Basking Ridge, NJ (the largest subsidiary of the Taiyo Nippon Sanso Corp Group) has become the exclusive

US-wide distributor for its purification and delivery systems, including the RainMaker humidification



RASIRC's Steamer.

system (RHS) and the RASIRC Steamer, in semiconductor and micro-electronics markets.

"This new relationship has significant benefits for our present and future customers, including the ability to support their long-term growth in dynamic market environments," says RASIRC's founder & president Jeffrey Spiegelman. "The agreement is expected to significantly raise the profile of RASIRC's capabilities within the electronics and solar marketplace," he adds.

"This is a strong alliance, coupling the sales presence of industry leader Matheson Tri-Gas and RASIRC's innovative technology and product portfolio," says Volker Heilmann, Matheson Tri-Gas' senior VP, Strategic Products & Equipment. "We look forward to a long-term relationship developing out of this agreement."

www.mathesontrigas.com

www.rasirc.com

Ferrotec acquires Temescal Division of Edwards Vacuum

Ferrotec (USA) Corp of Bedford, NH and San Jose, CA, USA, a supplier of materials, components, and precision system solutions, has acquired Edwards Vacuum Inc's Temescal Division in Livermore, CA.

Originally founded in 1952, Temescal makes electron-beam-based evaporative coating systems, claiming the largest installed base of metallization tools addressing a broad range of materials used in the compound semiconductor industry (for applications including cellular, satellite/cable TV, specialized optoelectronics, and full-spectrum LED and solid-state lighting).

With more than 100 staff before the acquisition, Ferrotec (USA) Corp (formerly Ferrofluidics Corp) is a

subsidiary of Japan's Ferrotec Corp (which has more than 3000 staff).

"As Ferrotec continues to expand support for evaporative coating markets, we expect this acquisition to have strategic and synergistic importance," says Ferrotec (USA) Corp's president Eiji Miyanaga. "By combining Temescal's deposition process and system engineering expertise with our complementary technology portfolio and our strong global position in the semiconductor industry, we intend to bring an enhanced product offering and play an increased role in the rapidly growing compound semiconductor market," he adds.

www.temescal.net

www.ferrotec.com

RASIRC launches Steamer '02

Steam purification firm RASIRC of San Diego, CA, USA has introduced the RASIRC Steamer '02, the next generation of its ultrapure steam generation and control technology.

The firm claims its existing Steamer — which can be used in the semiconductor, MEMS, solar, and optical device industries (where thermal oxide films are essential) — is the only technology to generate ultra-high-purity (UHP) steam from de-ionized (DI) water.

"The Steamer '02 was developed to meet the move from R&D to production for our solar and semiconductor customers," says president Jeffrey Spiegelman. "This unit allows customers to run the new generation of five stack furnaces and get the same result every time, both run-to-run and tube-to-tube."

The new Steamer introduces several features:

- an additional control loop for the heated steam process line between the steamer and the tool;
- an integrated flow meter for improved repeatability, flow accuracy,

and response time;

- a reduced footprint and simplified installation through addition of an internal three-way valve; and
- improved tracking of flow rate and energy use through an updated user interface.

The Steamer technology allows the use of DI water for critical processes by removing volatiles, ionic contaminants, and other impurities from steam. Yield is boosted since metals, hydrocarbons, and particles are rejected by the non-porous membrane to deliver pure steam. Throughput is increased with continuous unattended 24/7 operation and up to 20% improvement in growth rate, the firm claims. Compared to pyrolytic torches, there is no thermal build up with increased flow rate, it's safer (as hydrogen and oxygen are eliminated from the oxidation process), it operates at significantly lower temperature, and it handles a wide range of pressures and flow rates, says RASIRC.

www.rasirc.com

LayTec develops AbsoluT for precise on-site temperature calibration

LayTec GmbH of Berlin, Germany, which provides in-situ optical metrology equipment for thin-film processes, has developed the AbsoluT temperature calibration tool for its EpiTT, EpiTwinTT and EpiCurveTT systems. The new instrument is designed for on-site temperature calibration inside the MOCVD chambers of Aixtron's Planetary and CRIUS MOCVD reactors via their original viewport, without the need for any sophisticated alignment and with what is claimed to be unrivaled accuracy.

The firm says all reactor-to-reactor and ring-to-ring temperature variations caused by manufacturing tolerances of the equipment (viewport and window variations) can now be easily corrected, replacing the less accurate and more time consuming method of eutectic calibration that is used currently.

A calibration with AbsoluT takes just 30 minutes, shortening maintenance cycles. The user only needs to put the tool's head into the chamber and press its heat-resistant surface against the reactor lid under the optical view-port. The calibration data is automatically tracked and processed for further temperature measurements.

The new method was recently approved at industrial customer sites. "After calibration, the temperature measurement in MQW showed identical results in each system," reports one customer that tested the AbsoluT.

In a typical calibration result (see Figure) AbsoluT was used in five identical CRIUS reactors running the same LED recipe. The initial values (black) were obtained with reference to the black-body pre-calibration before shipment. They are clearly higher than the real temperature, and head-to-head or reactor-to-reactor variations are in the range $\pm 7.5\text{K}$.



Head, with reference light emitter.

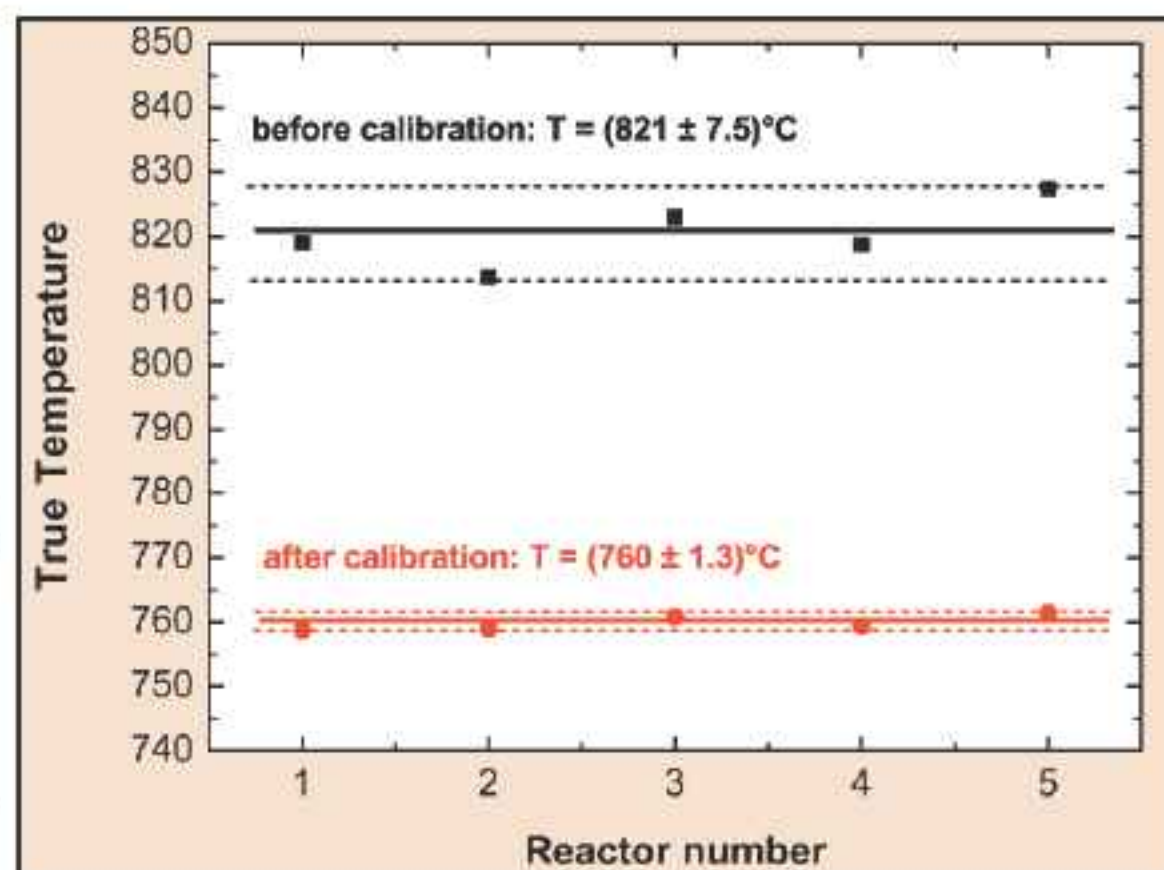
As the original viewport of the MOCVD system is not available at LayTec for pre-calibration, on-site variations of the viewport diameter (typically about 10%)

cannot be corrected. The viewport aperture, however, affects temperature sensing in CRIUS-type reactors because the intensity of the infrared radiation detected by the pyrometer changes if the viewport diameter differs. The new AbsoluT calibration eliminates these effects: after temperature calibration (red), the correct temperature of 760°C was measured and the variation of $\pm 1.3\text{K}$ was validated by the identical photoluminescence (PL) emission wavelengths of wafers from all five reactors.

LayTec says it will make AbsoluT available to customers in April.

● LayTec has recruited Mirja Schwarz as a new manager for marketing services, responsible for marketing activities in photovoltaics. Schwarz already has experience in marketing from working at LayTec as a student in 2008.

www.laytec.de



Temperatures in five identical reactors, before (black) and after (red) calibration.

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Jordan Valley launches high-resolution XRD system for LED and compound semiconductor quality control

X-ray metrology tool maker Jordan Valley Semiconductors Ltd (JVS) of Migdal Haemek, Israel has launched the QC3, a high-resolution x-ray diffractometry (HR-XRD) system for controlling production quality at LED and compound semiconductor fabs.

Adding to the HR-XRD product line that JVS acquired in 2008 with Bede Scientific Instruments Ltd of Durham, UK (which became Jordan Valley Semiconductors UK Ltd), the QC3 was developed on the basis of Bede's industry-proven QC200 and D1 systems. JVS says that optimizing both the hardware and software has improved the new system's performance for higher productivity and system reliability, and reduces both cost of ownership and system price by tailoring the functionality to the user's specific needs.

"The new QC3 HR-XRD production tool demonstrates JVS' commitment to LED manufacturing metrology solutions that meet and exceed our

customers' technical and cost of ownership expectations," says president & CEO Isaac Mazor. "Customers are looking for accuracy, repeatability, low cost of operations, ease of service and excellent price/performance — and our QC3 system delivers all of these requirements," he claims.

"By optimizing the configuration to the specific market-segment needs, the QC3 meets our customers' process technology needs at outstanding price/performance ratio," says corporate VP & UK site manager Dr Paul Ryan. "With our field-proven and popular control and analysis software tools, such as RADS, our customers enjoy the ease of operation with outstanding accuracy and repeatability that are key for today's demanding compound semiconductor process control tasks," he adds.

The QC3 has been configured to provide symmetric and asymmetric measurements for all common

semiconductor wafers, such as GaAs, InP, silicon, and GaN (thick buffers). Additionally, skew symmetric measurements are possible on the same hardware, to allow additional capability for GaN wafers in particular. These reflections allow the thickness, composition, relaxation and strain of multi-layer structures to be determined. Custom sample plates can be defined with locations for multiple wafers, along with large translation ranges, in order to maximize productivity by loading batches of wafers at once into the tool. Using JVS' knowledge of in-line metrology, the full measurement cycle can be automated for multiple wafers within a batch, with results reported to the factory. Analysis is performed through RADS, which is claimed to be the oldest HR-XRD analysis package (proven in industry and academic institutions alike).

www.jvsemi.com

Camtek launches inspection tool for LED manufacturing

Camtek Ltd of Migdal Haemek, Israel, which makes automatic optical inspection (AOI) systems for printed circuit boards, high-density interconnect substrates, and semiconductor manufacturing and packaging, has launched the Condor 5LED, a new AOI system focused on the variety of specific requirements that are unique to LED makers.

The LED market's inspection needs are characterized by 3–6" wafers, each of which may contain from 100 to over 200,000 LEDs per wafer. The defect specifications and unique inspection process of customers raise a significant challenge for AOI suppliers to solve, says Camtek.

Camtek has already been addressing the needs of this market for more than two years and has designed solutions on a per-customer basis, built into existing platforms. Up to now, the firm has

installed six such systems in three countries. "Throughout the past year, we have been benchmarked a number of times against competitors, and we have been chosen as the 'tool of choice' several times," claims general manager Roy Porat. The Condor 5LED incorporates this experience into a single solution

targeted at the LED market.

"We are optimistic with regard to this segment in 2010," says Porat. "Given indications for significant growth from our customers in the LED market, we aim to grow our business with the Condor 5LED in the coming quarters and years."

www.camtek.co.il

Camtek has appointed Nir Dery as VP marketing and Gilad Golan as VP of its R&D division.

Dery joined Camtek in January 2001 and has held various positions including project manager and marketing manager (PCB division). Previously, he was a department manager at PCB technologies Ltd.

Golan has been R&D manager for the Micro Electronics Division since November 2006, and R&D Division

Manager since February 2009. From 2005 to November 2006, he was CEO of equipment maker Ellumina Vision Ltd, and from 2000 to 2005 general manager of Accretech Israel, the R&D site of Accretech (TSK) for wafer inspection. Prior to that, he held various managerial positions with Accretech Israel and Opal Technologies (both semiconductor inspection and metrology equipment makers).

Cascade Microtech acquires SUSS MicroTec Test Systems

Cascade Microtech Inc of Beaverton, OR, USA, which provides production test products including unique probe cards and test sockets for wafers, ICs, packages, circuit boards and modules, as well as MEMS and LED devices, has acquired SUSS MicroTec Test Systems GmbH, the semiconductor test systems subsidiary of SUSS MicroTec AG of Garching near Munich, Germany. The test systems business specializes in wafer-level test solutions for devices under test (DUT), and strengthens Cascade's position in the design, development and manufacture of wafer probing solutions for the electrical measurement and test of ICs and chips.

The purchase price (subject to a post-closing purchase price adjustment) consists of a fixed amount of €4.5m (\$6.3m) — €2m (\$2.8m) in cash and €2.5m (\$3.5m) in shares — plus €2.5m (\$3.5m) in escrow (for release to the seller upon meeting certain post-sale conditions). SUSS MicroTec Test Systems GmbH revenue was €25m (\$35m) for 2008 and €10.6m (\$14.8m) for the nine months to end-September 2009. Cascade expects the acquisition to be accretive by the end of 2010.

Cascade says that chip makers are now creating complex devices of unprecedented performance, features and functionality, straining traditional test methodologies. The industry continues to drive down geometries used in applications

following Moore's Law. The firm reckons that its test technology should now provide a market opportunity to engage and satisfy the test demands created by this continual drive to smaller devices.

These expanded core competences should enable Cascade to further support complex probing and measurement requirements. Additional benefits include an expanded global service network.

"This is a key strategic move for Cascade Microtech which strengthens our product portfolio and leverages our combined resources and competences," says chairman & CEO F. Paul Carlson. "We now have the critical mass to focus on the technical challenges our customers have in developing semiconductor processes and designing devices into the next decade. This acquisition should enable us to aggressively address emerging applications such as 3D TSV, LED, and MEMS that are on an accelerated growth curve," he adds.

"SUSS Test Systems' experience in 3D, LED and MEMS test applications is a natural complement to Cascade Microtech's legacy of innovations in semiconductor probe technology," comments SUSS MicroTec's president & CEO Frank P. Averdung. "We anticipate future collaboration with Cascade Microtech in order to address the complex issues in developing and testing 3D TSVs."

www.cascademicrotech.com

www.suss.com

Q4 revenue rebounds to 2008 level

For Q4/2009, Cascade Microtech has reported revenue of \$15.5m (not including revenue from the acquisition of Suss MicroTech Test Systems division, announced on 27 January). This is up 11% on \$14m in Q3/2009 and 1% on \$15.4m a year ago (and at the high end of guidance of \$14–16m).

"We saw an increase in bookings and revenues to levels last seen in 2008," comments chairman & CEO Dr F. Paul Carlson.

Net loss has been cut from \$31.4m a year ago (which included a non-cash impairment charge of \$27.7m) and \$1.4m in Q3/2009 to \$0.5m (although that includes a \$2.7m tax benefit reflecting tax law changes). Cash and investment balances fell by \$1.5m to \$33.6m.

"Our focus in 2010 is on achieving continued revenue growth and leveraging our earnings model," says Carlson. "Our previously announced acquisition of the Suss MicroTech Test Systems division in January is a key strategic move for Cascade Microtech which strengthens our product portfolio and should enable us to leverage the combined resources and competencies in 2010 and beyond."

For Q1/2010, Cascade forecasts revenue of \$19–23m (including revenue from Suss MicroTech Test Systems).

Cascade appoints interim executive vice president

Cascade Microtech's VP of engineering Steve Harris has been given an additional appointment as interim executive VP for the transition period until a new CEO is appointed. "This is an important appointment ensuring continuity and growth while the company is searching for a new president & CEO," says chairman, interim pres-

ident & CEO Dr F. Paul Carlson.

"Harris will ensure that management processes and goals are followed to support and lead the activities of the solid executive management team already in place," says Carlson.

Harris joined Cascade last January after nearly five years as VP of research, development & engineering

at Electro Scientific Industries Inc. When Harris joined ESI in 1997, he first led the Central Engineering group and was later general manager of the Semiconductor Link Processing business unit. Previously, he began his career at Tektronix, where he spent 13 years in product development and engineering management positions.

Sapphire substrate maker Rubicon details \$60–65m capacity expansion, to start operation in 2011

Rubicon Technology Inc of Franklin Park, IL, USA, which makes monocrystalline sapphire substrates and products for the LED, RFIC, semiconductor and optical industries, has released additional details about its two-year capacity expansion plan outlined in early November.

The firm says that its existing facilities are nearing maximum capacity, and demand for sapphire substrates — particularly for LED applications — is expected to be strong in the coming years. "We are at the beginning of a long-term growth cycle in the LED industry," believes president & CEO Raja Parvez. "Demand for LED backlighting for applications such as LED TVs and notebook computers continues to experience considerable growth. In addition, the other current LED applications, such as automotive and signage, should continue to strengthen as the global economy

improves, and progress continues to be made in the area of general illumination," he adds.

Rubicon plans to add a new second-generation crystal growth facility near its existing facilities in Illinois that will nearly double its current crystal growth capacity and will house larger furnaces, providing greater ability to serve the growing demand for large-diameter substrates. Concurrently, the firm will build a facility in Asia to expand post-crystal-growth processing operations, which should reduce manufacturing costs while enhancing revenue-generating capacity through the expansion of large-diameter post-crystal-growth processing capability.

"These expansion initiatives are designed to ensure Rubicon maintains its global leadership in high-quality, large-diameter sapphire substrates and to ensure our pricing remains competitive while max-

imizing our revenue and margins generated from our existing and new manufacturing facilities," says Parvez.

Both new facilities are expected to open by the end of 2010, when additional capacity will begin to come on-line. Rubicon estimates that it will take about a further 12 months for all machinery and equipment to be installed and operational. It expects to spend \$60–65m over the next two years on the two new facilities.

"We expect both facilities to be fully operational by the end of 2011, and that this new capacity will increase our annual revenue-generating capacity to at least \$130m once the facilities are fully operational," says chief financial officer William Weissman. "This estimate is based on today's pricing and certain assumptions related to our product mix."

www.rubicon-es2.com

Rubicon recovers as LED backlighting drives pricing up 7% in Q4

Rubicon Technology has reported full-year 2009 revenue of \$19.8m, almost halving from 2008's \$37.8m. However, fourth-quarter 2009 revenue was \$8.5m, up 49% on Q3/2009's \$5.7m and more than double the \$4m a year ago, driven by strong demand from the LED market as Rubicon continues to recover from its low of \$2.3m in Q1/2009.

"Demand from the LED market continues to strengthen, particularly the demand for LED backlighting," says president & CEO Raja Parvez. "With LED backlighting becoming more cost competitive and with the enhanced performance, thin profile and energy efficiency they provide, we expect LED backlighting to continue to rapidly gain market share over traditional backlighting solutions," he adds.

"With the increasing demand from the LED market, the pricing environment is rapidly improving," comments chief financial officer William Weissman. Pricing rose about 7% sequentially in the fourth quarter, and Rubicon expects a rise of at least 15% in first-quarter 2010. "While pricing is not yet back to pre-recession levels, we are seeing considerable improvement."

Revenue also rose for large-diameter substrates. "Certain LED chip manufacturers have been adding significant capacity using 4-inch wafers," continues Parvez.

With the increasing demand from the LED market, the pricing environment is rapidly improving

"In addition, orders for 6-inch wafers from major LED chip manufacturers for use in R&D have nearly doubled in the quarter".

Due to improved factory utilization, increased pricing and a shift in product mix, gross margin rose to 12% in Q4/2009. Compared with full-year 2008's net profit of \$4.4m, full-year 2009 yielded a net loss of \$9.6m. However, quarterly loss has been cut from \$1.79m a year ago and \$2.1m last quarter to \$755,000 in Q4/2009. Also, although cash balance has fallen from \$7.6m at the end of 2008 to \$3.9m at the end of 2009, there was no further decline during Q4/2009.

For first-quarter 2010, Rubicon expects revenue of \$10.5m (up 24% sequentially), as well as gross margin in the mid-20s and a return to profitability.

Nitride substrate firm Kyma recruits crystal growth engineers and adds director of business development

Kyma Technologies Inc of Raleigh, NC, USA, which supplies crystalline gallium nitride (GaN) and aluminum nitride (AlN) materials, has announced several new hires and staffing changes.

Dr Heather Splawn has joined Kyma in the newly created position of director of business development, responsible for helping the firm capitalize on new business growth opportunities. Splawn recently completed her PhD in Electrical Engineering at Duke University and has a track record of leadership, with experience including president of Duke University's Engineering Graduate Student Council (EGSC) and president of Upsilon Phi Epsilon (an international honor society for the computing and information disciplines).

In addition, Dr Troy Baker and Dr Ziad Herro have been hired as crystal growth engineers, responsible for helping to advance the firm's

GaN and AlN crystal growth manufacturing capabilities. Both have strong backgrounds in the physics and engineering of wide-bandgap semiconductor crystal growth, says Kyma. Baker received his PhD in Materials Science and Engineering from University of California Santa Barbara (UCSB) under the direction of professor Shuji Nakamura.

Herro received his PhD in Condensed Matter Physics jointly between Germany's University of Erlangen-Nürnberg and the University of Montpellier 2, Groupe d'Etude des Semiconducteurs, France.

Also, Greg Mulholland has been promoted to director of operations, while VP of business development has been added to Dr Edward

Troy and Ziad are already accelerating progress in our substrate development and production activities

Preble's existing role of chief operating officer (becoming COO & VP business development).

"The leadership shown by Ed and Greg is making a great impact throughout our organization," says Kyma's president & CEO Dr Keith Evans. "The technical contributions by Troy and Ziad are already accelerating progress in our substrate development and production activities. And with the addition of Heather, we can now apply proper bandwidth to a number of opportunities," he adds. "Going forward, I am bullish on our ability to continue to stimulate and penetrate the market for advanced nitride semiconductor materials — through great customer focus, a relentless pursuit of continuous product improvement and new product development, and a keen eye towards new business development opportunities."

www.kymatech.com

Kyma wins \$2.8m DoD funding for low-defect GaN development

Kyma is to receive \$2.8m from the US Department of Defense (DoD) for the continued development of low-defect-density GaN materials for high-performance electronic device applications.

This funding (included in the Fiscal Year 2010 Department of Defense Appropriations Bill) will support Kyma's ongoing efforts to make bigger and more cost-effective bulk GaN substrates, which are needed for multiple next-generation defense systems as well as several major commercial applications.

Kyma says that the funding will help to support the development of a viable domestic supply of GaN materials. Historically, the DoD has led the way in advancing semiconductor materials, creating domestic high-tech jobs and supporting the development of

entire new industries, while supporting key advances in US defense capabilities. The USA led the way in developing silicon, gallium arsenide, and indium phosphide, which have enabled over \$250bn in commercial device applications. However, the USA has fallen behind in producing GaN materials, which are already more important than GaAs and InP, says the firm. Japan has a major effort in GaN, while recently South Korea and China have begun aggressively pursuing GaN materials capabilities. With more than \$100bn in eventual commercial device applications and a likely impact on essentially all future defense systems, there is a pressing need for the USA to develop and maintain a strong domestic GaN manufacturing capability, Kyma asserts.

Kyma says that it is working with US Air Force Research Laboratory (AFRL) to get an associated contract in place. The firm's Dr Heather Splawn will serve as principal investigator.

"Kyma is sincerely grateful for the support and the vision of our congressional delegation, led by Congressman David Price, for making this funding possible," says president & CEO Dr Keith Evans. "We also thank AFRL for their continuing interest and support for domestic bulk GaN development," he adds.

"Our primary goals include creation of new sustainable high-tech jobs, enhancement of our ability to serve our existing customers, and further penetration of our end markets," adds Dr Edward Preble, Kyma's chief operating officer & VP business development.

HexaTech raises \$300,000 in debt financing

Privately held firm HexaTech Inc of Morrisville in the Research Triangle Park (RTP) area of North Carolina has raised \$300,000 in debt financing, according to a filing with the US Securities and Exchange Commission (SEC), reports the Triangle Business Journal.

HexaTech was spun off from the Department of Materials Science of North Carolina State University in 2001 with a transfer of technology — developed by the firm's co-founders Dr Zlatko Sitar (president & chief technology officer) and Dr Raoul Schlessler (VP development) — to produce single-crystalline aluminum nitride (AlN) substrates for both electronic and optoelectronic devices. Subsequently, in November 2005, the firm raised \$8.9m in a Series A round of financing led by Intersouth Partners of Durham, NC

and joined by H.I.G. Ventures, Sevin Rosen Funds and NC IDEA.

HexaTech says that its proprietary technology combines the benefits of physical vapor transport (PVT) growth and of seeded growth for the reproducible production of single-crystal AlN boules. Seeded growth enables the fabrication of AlN boules of pre-defined crystallographic orientation. AlN wafers fabricated from the crystals are of well-defined orientation and of high, reproducible crystal quality, the firm says.

HexaTech also subsequently demonstrated a polarity-controlled device layer deposition process that is compatible with industry-standard MOCVD growth equipment. Control over the polarity opens up processing routes that allow the production of efficient deep-UV LEDs by growing aluminum gallium nitride (AlGaIn)

layers on AlN substrates (targeting an emission wavelength of 254nm, which is known to interact with DNA in a way that stops water-borne organisms from reproducing).

Consequently, in 2007, HexaTech won a \$2m Advanced Technology Program (ATP) grant from the US Commerce Department's National Institute of Science and Technology (NIST) as part of a \$3.28m, three-year project (starting in November) to develop high-efficiency deep ultraviolet LEDs for use as a high-energy UV light source to kill micro-organisms in drinking and waste water (as a longer-lasting and more environmentally friendly replacement for existing mercury-based UV tubes).

www.hexatechinc.com

www.bizjournals.com/triangle/stories/2010/01/04/daily45.html

SETI wins \$0.5m SBIR award to advance deep UV LEDs

Sensor Electronic Technology Inc (SETI) of Columbia, SC, USA has been awarded a \$500,000 Phase II SBIR award from the US National Science Foundation (NSF) to further advance its deep ultraviolet (DUV) LEDs, which involve a proprietary and patent-pending approach to fabricate high-quality p-type cladding layers for enhanced output power and light extraction.

The aim of NSF's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs is to increase the incentive and opportunity for small firms to undertake cutting-edge, high-risk, high-quality scientific, engineering, or science & engineering education research that would have the potential of high economic pay-off if the projects are successful.

The new Phase II project aims to develop and commercialize next-generation high-power DUV LEDs in the UV-B spectral range (280–315nm). It targets boosting LED efficiency and lifetime through improvements in the material qual-

ity, doping and device design, leading to low-cost, high-power semiconductor DUV radiation sources with wall-plug efficiency exceeding 5% and operation lifetimes greater than 5000 hours.

Deep UV LEDs are currently available from SETI at wavelengths of 240–400nm and are primarily used in medical, bio-analytical, sensing, and homeland security markets. The firm says that the targeted

enhancements should lay the groundwork for large-scale penetration of high-volume markets, such as global sanitation and disinfection.

SETI says that, once operating at this level of performance, deep UV LEDs offer an environmentally friendly UV light source without the scrap and toxicity issues surrounding conventional mercury-based lamps.

www.s-et.com

SETI attains ISO9001:2008 certification

SETI says that it has gained and (as of 13 December) is operating in full compliance with the international quality system standard ISO9001:2008.

"ISO9001:2008 certification validates our commitment to quality and the exceptional customer service that we have built over the past five years of commercially supplying our deep UV LED products," says president & CEO Dr Remis Gaska.

SETI claims to be the only commercial supplier of deep UV LEDs and LED products, and offers wavelengths from 240nm to 400nm at output powers of 0.3–50mW. The firm also offers a full portfolio of standard LED and LED Lamps as well as custom-designed devices and systems for markets including analytical instrumentation, optical sensors, process control, medical systems, and water and air purification.

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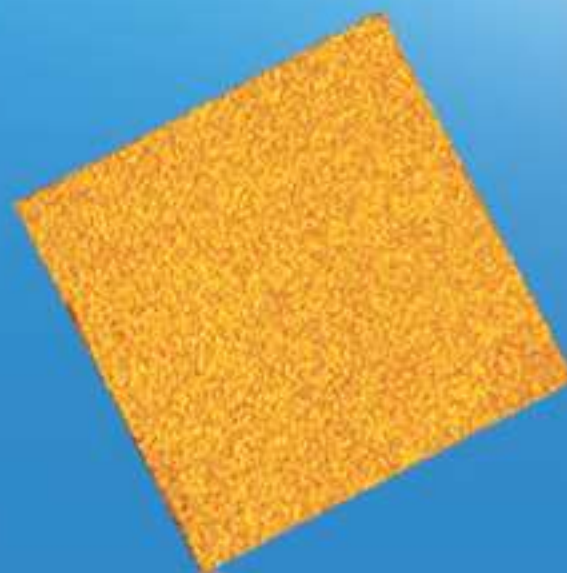
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DOE selects SSL Core Technology, Product Development, and Manufacturing projects for \$37.8m funding: Veeco and Applied Materials funded to develop GaN epi growth tools

On behalf of the Department of Energy's National Energy Technology Laboratory, US energy secretary Steven Chu has announced the competitive selection of 17 projects as part of the DOE's solid-state lighting (SSL) R&D program, which covers both LEDs and organic LEDs (OLEDs). Funded under the American Recovery and Reinvestment Act, awards totaling about \$37.8m will be supplemented by nearly \$28.5m in private industry cost share, making \$66.3m in total.

The awards are in response to solid-state lighting (SSL) funding opportunity announcements (FOAs) — announced last June — for Core Technology, Product Development, and US Manufacturing.

This is the sixth round of DOE SSL funding for both Core Technology and Product Development — covered under the Exceptional Circumstances Determination issued by DOE in June 2004 — and the first time that DOE has funded US solid-state lighting Manufacturing projects. This expanded focus is part of a new DOE initiative to accelerate the adoption of SSL technology through manufacturing improvements that reduce costs and improve quality. These efforts are also intended to play a key role in developing, establishing and/or maintaining the SSL technology and manufacturing base within the USA.

"These solid-state lighting projects will help us significantly cut our energy use, reduce our carbon footprint, and save money," says Chu. "This funding will also support the US as a global leader in this rapidly evolving industry, creating high-tech, value-added jobs," he adds. The DOE's goal is, by 2025, to develop solid-state lighting technologies that, compared with conventional lighting (e.g. incandescent bulbs), are much more energy efficient, longer lasting, and cost-competitive by tar-

getting a product system efficiency of 50% with lighting that accurately reproduces the sunlight spectrum.

Funding for the three program areas, as well as project titles and awardees (for LEDs, in addition to OLEDs) include the following:

Core Technology Research (\$4m): three projects focus on advancing the technical knowledge base of SSL for general lighting purposes, targeting improved efficiency and performance with reduced costs (all critical to the widespread deployment of solid-state lighting). Performers of cooperative agreements will provide an average cost-share of 23% of the total project value of \$5.2m.

Product Development (\$10.3m): six projects support the development or improvement of commercially viable SSL source, component, or integrated luminaire products (materials, devices, or systems), promoting the market introduction of viable SSL products. Technical activities are focused on a targeted market application with fully defined price, efficacy, and other performance parameters necessary for success of the proposed product. Performers will provide an average cost-share of 23% of the total project value of \$13.4m.

Awardees and projects include:

- Cree Inc of Durham, NC — 'Ultra-Compact High-Efficiency Luminaire for General Illumination' will involve synergetic LED component, optic, thermal management, and driver developments to create an 80lm/W luminaire that emits at a color temperature of 3000K with a color rendering index (CRI) of 90. This integrated approach aims to establish a technology platform capable of providing high-efficiency LED components that can be adopted across a variety of SSL applications.
- Philips Lumileds Lighting Company LLC of San Jose, CA — '130lm/W, 1000lm Warm-White LED for Illumination' targets a CCT of

2700–3500K and a CRI of more than 80 from a 2mm x2mm InGaN die with a warm-white phosphor Lumiramic plate in a solder-free lead-frame package.

US SSL Manufacturing (\$23.5m): eight projects focus on achieving significant cost reductions and enhanced quality by improving manufacturing equipment, processes, or monitoring technique (addressing the technical challenges that must be overcome before prices fall to a level where solid-state lighting will be competitive with existing lighting on a first-cost basis). Performers will provide an average cost-share of 51% of the total project value of \$47.7m. Awardees and projects include:

- Applied Materials Inc of Santa Clara, CA — (\$4m) 'Advanced Epi Tools for Gallium Nitride LED Devices' aims to develop a multi-chamber system for metalorganic chemical vapor deposition (MOCVD) and hydride vapor phase epitaxy (HVPE), which has the potential to decrease operating costs, increase efficiency of LEDs, and improve binning yields. The approach builds upon the firm's Centura platform (which is used for growing low-cost, high-quality epitaxial wafers for silicon-based integrated circuits).
- Veeco Instruments of Somerset, NJ (with team members Sandia National Laboratories and Philips Lumileds) — (\$4m) 'Implementation of Process-Simulation Tools and Temperature-Control Methods for High-Yield MOCVD Growth' aims to develop a complementary set of high-resolution short-wavelength and infrared in-situ monitoring tools for accurate substrate temperature measurement and growth rate monitoring (to be tested in LED processing by Lumileds, expecting a 100% improvement in wavelength yield and a 75% cost reduction for LED epitaxy).

● Philips Lumileds — (\$1.9m) 'Low-Cost Illumination-Grade LEDs' aims to realize a 30% yield improvement and 60% reduction in epitaxy manufacturing costs for high-power LEDs through implementing GaN-on-Si epitaxial processes on 150mm substrates (rather than industry-standard sapphire), using the firm's proven thin-film flip-chip capabilities with its LUXEON Rebel lamp.

● KLA-Tencor Corp of Milpitas, CA, with team member Philips Lumileds — (\$3.5m) 'Automated Yield Management and Defect Source Analysis Inspection Tooling and Software for LED Manufacturing' aims to improve product yield for high-brightness LEDs by developing an automated

optical defect detection and classification system that identifies and distinguishes harmful defects from benign defects (allowing for traceability in defect origin, and including hardware and correlated software package development).

● GE Lumination of Valley View, OH — (\$772,000) 'Development of Advanced Manufacturing Methods for Warm-White LEDs for General Lighting' aims to develop precise and efficient manufacturing techniques for the firm's 'remote phosphor' platform of Vio warm-white LED products (driving materials, labor and capital productivity to achieve about 53% reduction in overall cost, while minimizing color variation).

● Ultratech Inc of San Jose, CA (with team member SemiLEDs) — (\$1.3m) 'A Low-Cost Lithography Tool for High-Brightness LED Manufacturing' aims to modify and optimize a projection stepper process for LED manufacturing to allow higher throughput, greater yields, lower initial capital cost, and lower cost of ownership (able to accommodate various wafer sizes and thicknesses and to handle the typical wafer warpage of larger-diameter substrates).

Full details of the award contracts are to be finalized in negotiations between the DOE and each grantee. www1.eere.energy.gov/buildings/ssl/fundopps_011510.html

Cree demonstrates 6-inch LED downlight for residential market

At the 2010 International Builder's Show in Las Vegas in January, Cree demonstrated its new CR6 LED, a 6-inch LED downlight designed for the residential market.

"By delivering the beautiful, warm light created by Cree True-White technology in an affordable, energy-efficient LED residential fixture, we're providing consumers with an alternative to energy-

wasting incandescents and the poor color-rendering of compact fluorescent bulbs," says Cree LED Lighting's president Neal Hunter.

"There is no residential LED downlight on the market today that can come close to matching the value and performance of the CR6," he claims. "This product builds on the success of the award-winning LR6, which has shipped

more than 350,000 units to date."

The CR6 takes the technology at the heart of the LR6 family of recessed LED downlights and redesigns it to deliver maximum value for residential lighting, the firm claims. The CR6 downlight, planned for availability in mid-2010, is being designed to meet ENERGY STAR criteria, and for an end-user price of about \$60.

Energy Focus wins \$1.6m in DARPA and NASA awards

Energy Focus Inc of Solon, OH, USA says its R&D team has received three LED lighting awards totaling \$1.6m.

Two awards ('Explosion-Proof Solid State Lighting for Extreme Environments' and 'A Spectrally Dynamic Berth Light for Active Circadian Cycle Management') are phase 2 Small Business Innovation Research (SBIR) grants from the US Defense Research Projects Agency (DARPA). The third award — 'Innovative Solid State Lighting Replacements for Industrial and Test Facility Locations' — is a phase 1 Small Business Technology Transfer (STTR) program grant from the National Aeronautics and Space Administration (NASA). The two additional awards from DARPA continue a long-standing

relationship, but the STTR award is the firm's first grant from NASA.

The first DARPA award, for the development of explosion-proof lights for shipboard use, also covers advanced driver development. These lights will be able to qualify for Class 1 Division 1 explosion-proof standards for civilian use, opening up a significant new market, says chief technology officer Roger Buelow.

The second DARPA award is for development of circadian rhythm enhanced lights for the Navy. These lights adjust their spectrum throughout the day to improve sleep patterns and productivity. For the military, this is especially important for warfighters whose duties include 24-hour operational readiness.

The third award, from NASA, is to replace test stand and parking lot fixtures with high-performance LED lighting, including high-performance explosion-proof lights.

"While significant, this new funding is only a fraction of the government-sponsored R&D we've already received for work in 2010," says CEO Joseph Kaveski. "We're especially pleased to begin the development of a new generation of lighting products that enhance health and wellness as well as provide energy efficiency," he adds. "We expect the results of these projects to lead to both increased product sales as well as increased specification opportunities for our lighting retrofit business."

www.energyfocusinc.com

LED demand drives Cree's sales up 18% to a record \$199.5m

For its fiscal second-quarter 2010 (ended 27 December 2009), Cree Inc of Durham, NC, USA has reported record revenue of \$199.5m, up 18% on \$169.1m last quarter and 35% on \$147.6m a year ago (and above the targeted \$180–190m).

In particular, LED product revenue grew 17% sequentially from \$156m to \$182m, driven by a strong increase in LED sales for lighting applications and incremental growth in LED lighting products and LED chips. Revenue for power and RF devices grew 34% from \$13.1m to \$17.5m (including \$3.7m of government contract revenue), with RF demand driven mainly by military applications and power demand driven by both high-efficiency power supplies and, increasingly, solar applications.

Operating expenses have grown only slightly from \$47.1m last quarter to an under-target \$48m. R&D expense was under-target by about \$1m, after earlier-than-expected transition of some new products from R&D to production. SG&A (selling, general & administrative) expense was also under-target by about \$1m, after slower-than-expected head-count additions. "We continue to hire in both areas, but there is a lag in how quickly we are able to hire new people as compared to our expense targets," notes chief financial officer John Kurtzweil.

Gross margin has risen from 38.3% a year ago and 43.6% last quarter to 47.2%. This was also above the targeted 44%, due to better-than-expected execution on the LED factory ramp-up (which enabled higher production volumes and better factory overhead spreading), better-than-planned yield improvement across LED product lines, and a more stable pricing environment for LED chips

and components, as well as the continued progress in power and RF product lines.

Net income has risen from \$10.7m a year ago and \$21m last quarter to a record \$33.8m. Revenue and profits exceeded targets due to a combination of strong LED demand and solid factory execution, comments chairman & CEO Charles Swoboda.

Cash flow from operations was \$21.5m. Minus capital expenditure of \$41.4m, free cash flow was -\$19.9m. Nevertheless, due to the higher revenue and increased profitability, cash and investments rose \$65.6m to \$954.1m.

Fiscal third-quarter 2010 (ending 28 March) is normally considered to be a seasonally weaker quarter due to slower consumer market and the Chinese New Year holiday, says Swoboda.

However, order backlog is higher than at this point last quarter due to increased demand for LED components (for lighting applications) and

LED lighting products, as well as for power and RF devices. In particular, during fiscal Q2, Cree's LRP38 LED lamps were selected for initial deployment in about 650 Walmart stores, validating that LED lighting is ready for mainstream commercial applications, it is claimed.

For fiscal Q3/2010, Cree therefore targets revenue of \$215–225m (up 8–13%, limited by the rate of new capacity ramp-up and factory execution). Gross margin should be roughly level, at 46.5%. R&D

expenses should rise by \$1m (to support new LED product development) and SG&A expenses by \$2.5–3m (due mainly to growth in marketing expenses and sales commissions, along with staffing new design centers in the USA, Europe and Asia as Cree expands global customer support). Net income should rise to \$37–40m.

"LED lighting adoption continues to gain momentum, and our near-term focus is on factory execution and capacity expansion at both our US and Asia manufacturing facilities to meet the higher demand," says Swoboda. Cree was recently awarded \$39m as part of the American Recovery and Reinvestment Act's Advanced Energy Manufacturing tax credit program to support investment in new manufacturing capacity and jobs in North Carolina related to energy-efficient LED lighting.

Kurtzweil says that, to position Cree to meet revenue growth targets for fiscal 2010 and first-half 2011, the firm is raising its targeted fiscal 2010 CapEx to \$240–260m (enabling it to triple power LED component production capacity during fiscal 2010). This will cover: expanding LED factories to support increased demand (including bringing online its new LED chip plant in Huizhou, China in fiscal first-half 2011, after buying a facility there in fiscal Q2/2010); manufacturing equipment to support the growth in business; and new product development. In particular, expenditure will support additional LED chip and component packaging capacity, as well as development of the firm's initial production capability on 150mm-diameter substrates (which should start to come on line over the next two years, says Swoboda).

www.cree.com

Cree breaks 200lm/W barrier in R&D for white power LEDs

After reporting efficacy of 186 lumens per watt (and 197 lumens output) only in early December, LED maker Cree Inc of Durham, NC, USA has claimed another luminous efficacy record of 208 lumens per watt for a white power LED.

While this level of performance is not yet available in Cree's production LEDs, the firm says that the R&D result passes a significant milestone within the solid-state lighting industry.

Cree's tests — conducted under standard LED test conditions at a drive current of 350mA at room

temperature — confirmed that the LED produced 208 lumens of light output and achieved 208 lumens per watt efficacy at a correlated color temperature of 4579K.

We have now broken the elusive 200lm/W efficacy barrier for a single white power LED. This is a result of improvements in blue optical output power, lower operating voltage and higher conversion efficiency

"We have now broken the elusive 200lm/W efficacy barrier for a single white power LED," says John Edmond, Cree's co-founder & director of advanced optoelectronics.

"This is a result of improvements in blue optical output power, lower operating voltage and higher conversion efficiency," Edmond adds.

"We continue to push the envelope in white LED technology to enable the highest efficiency white lighting products in the marketplace," he claims.

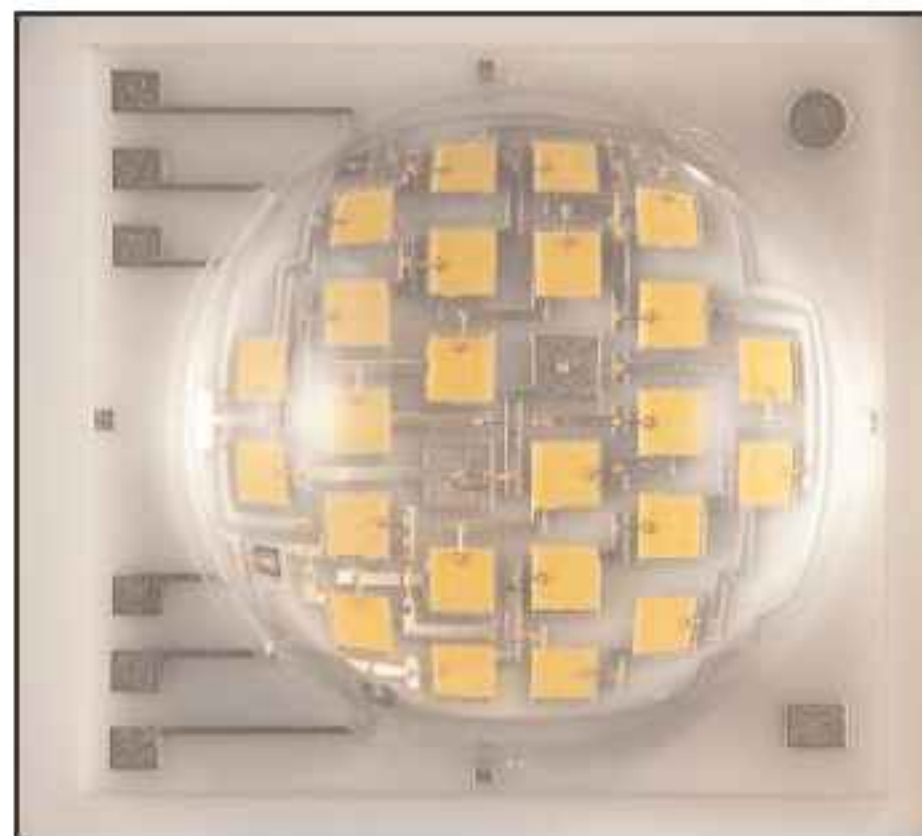
www.cree.com

XLamp MPL EasyWhite LED delivers up to 1500lm at 75lm/W in 12mm x 13mm footprint

Cree has launched the XLamp MPL EasyWhite lighting-class LED which, it claims, has the performance, color consistency and lumen density to displace conventional energy-inefficient light sources, all in the industry's smallest package.

Featuring Cree's unique EasyWhite color binning, the LEDs are specified like traditional light sources (by simply indicating the desired color temperature and brightness). "Cree has virtually eliminated the need to learn and understand LED bins thanks to EasyWhite color temperatures," says Fred Dorrani, president of T³ Mark Inc, an LED integrator specializing in light engines. "Combined with the single-light-source design of the LED, it can simplify design and manufacturing, speeding overall time-to-market and improving product consistency."

The multi-chip MPL EasyWhite LED can provide up to 1500 lumens at a drive current of 250mA by packaging 24 chips in a compact 12mm x 13mm footprint (72%



Cree's XLamp MPL EasyWhite LED.

smaller than the nearest-competing LED component, Cree believes). The LED is optimized for directional lighting applications, including PAR- or BR-style light bulbs. With appropriate system design, it can deliver the required light output for a 3000K, 75W-equivalent BR-30 light bulb, but would consume 78% less energy than traditional incandescent technology, says Cree, meeting the efficacy and lumen-output requirements for integral LED lamps as defined by ENERGY STAR.

MPL EasyWhite LEDs are offered in 2700K, 3000K, 3500K and 4000K color temperatures (in the center of the respective ANSI C78.377-2008 color bins). Due to their consistency, the color space occupied by each is 75% smaller than the total area of the corresponding ANSI C78.377 color bins, Cree reckons, reducing component count and eliminating complex mixing recipes and the pixilation often associated with other LED designs.

"We are providing the MPL LEDs the way the lighting industry has wanted to buy LEDs," claims Paul Thielen, Cree's director of marketing, LED components. "Customers using EasyWhite color temperatures can shorten the design and manufacturing cycle for new products, while improving color consistency and reducing pixelation in their product," he adds. "The MPL EasyWhite LED further broadens Cree's portfolio of application-optimized LEDs, specifically designed to meet the needs of the lighting industry."

Alaska's Valdez joins LED City program as it prepares to convert all street lights to LED technology

The city of Valdez in south-central Alaska has joined the LED City initiative, an international community of government and industry parties initiated by LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA in December 2006 to evaluate, deploy and promote LED lighting for municipal infrastructure.

Valdez joins existing program members Raleigh and Chapel Hill, NC; Ann Arbor, MI; Austin and Fairview, TX; Anchorage, AK; Indian Wells, CA; Danville, VI; and Boston, MA in the USA; Toronto and Welland in Canada; Tianjin and Huizhou in China; Gwangju in South Korea; and Torraca and Apecchio in Italy.

Valdez, which has a population just 4353, is now in the process of converting all of its 343 street lights to LED technology. As part of the project, city officials have negotiated a new, reduced billing rate with Copper Valley Electric Association for the LED street lights, and will renegotiate its maintenance contract when it expires in 2011.

"We project we can achieve 45% or higher energy savings with the new BetaLED fixtures we are installing, compared with the high-pressure sodium lights we are



LED street lights in Valdez.

replacing," says mayor Bert Cottle. "As we look ahead and anticipate rising energy costs, investing in LED technology becomes even more attractive," he adds.

"Community feedback on the initial lights has been overwhelmingly positive," Cottle notes. Valdez initially installed two trial street lights outside City Hall in January 2009 and solicited feedback from the community. "Valdez citizens like the

quality and color of the new LED lights and they are happy about the projected energy and maintenance cost savings." The city began replacing the first one-third of its streetlights in December and expects to complete the full conversion by 2011. The new LED lights are expected to last ten times longer than the high-pressure sodium lights currently in use.

"Copper Valley is taking a leadership role in the utilities industry by setting a reduced rate on LED street lights," comments Greg Merritt, Cree's VP of government relations. "Other utilities are grappling with how to handle LED street-lights tariffs, and Copper Valley's proactive stance can serve as a model for promoting energy-efficient LED lighting."

The BetaLED fixtures can be operated at three light levels. Initially, the fixtures will be operated at a higher setting for maximum light output during the winter months, when snow removal activities require high light levels. In future, city officials can choose to switch the lights to a lower operating level, depending on actual light-level requirements, potentially increasing energy savings to 60%.

www.ci.valdez.ak.us

City of Ann Arbor converting more streetlights to LEDs

The City of Ann Arbor in Michigan, USA is converting more city streetlights to LEDs over the next year after seeing at least \$10,000 in energy savings in 2009 from using the lights, according to www.annarbor.com. The city's Energy Programs Manager Andrew Brix estimates that the city also saved a further \$40,000 in maintenance costs from having LED lights instead of incandescent streetlights.

The city owns about 2000 streetlights and expects to switch over a further 800 of them to LED lights

by the end of 2011. The changeover is being funded by a \$1.2m Energy Efficiency and Conservation Block Grant (EECBG), a program authorized by the Energy Independence and Security Act of 2007 (EISA) and administered by the US Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) but funded for the first time under the American Recovery and Reinvestment Act of 2009.

There are about 7000 streetlights throughout the city, including about 5000 lights owned by

Detroit-based utility firm DTE Energy but with energy costs paid by the city. The city energy office is evaluating whether it would save money in energy costs by purchasing those streetlights and converting them to LEDs.

In 2009, the energy office said it was able to save the city \$153,000 in energy costs from streetlight and traffic light energy savings, as well as savings in natural gas costs from locking in prices earlier in the year.

www.ledcity.org
www.eecbg.energy.gov
www.annarbor.com

LED University program gains Arizona State University and Milwaukee Area Technical College

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA says that Milwaukee Area Technical College (MATC) and Arizona State University (ASU) have both joined its LED University program.

Launched in April 2008, the LED University initiative is an international community of universities working to evaluate, deploy and promote the adoption of energy-efficient LEDs across their campuses (in areas such as offices, student housing, parking garages, walkways and streets). The aim is to save energy, protect the environment, reduce maintenance costs, and provide better light quality for improved visibility and safety.

Milwaukee Area Technical College officials recently retrofitted a six-storey, 900-vehicle parking garage, replacing high-pressure sodium lights with LED lighting products from BetaLED. Founded in 1912, MATC is one of the Midwest's largest community-based technical colleges, with about 57,000 students.

More than 500 BetaLED fixtures are now illuminating the garage on MATC's campus, cutting energy use for lighting by 55%. The college expects to recoup \$25,000 annually in maintenance costs savings over the 12-year life of the fixtures.

"MATC is committed to implementing new technologies that help us reduce energy use today as well as providing a clear path to help us stave off the effects of the electricity rate hikes we all anticipate," says MATC's interim president Vicki J. Martin Ph.D. "With help from Johnson Controls, this project serves as a demonstration of MATC's commitment to ongoing sustainability initiatives and an example to our students and community of the significant steps we are taking to reduce energy consumption and our carbon footprint," she adds.



Parking deck in six-storey garage retrofitted with LED lighting.

"Switching to LED lighting is a high-impact step MATC can take to reduce its impact on the environment," says Cree's LED programs manager Deb Lovig. "Starting with a parking garage is an ideal way to evaluate the technology and to gather energy and maintenance cost-savings information," she adds. "MATC is a living laboratory for LED lighting, and the experience gained from this installation can be shared with the larger community so that others in the Milwaukee metro area might gain the confidence to begin switching to energy-efficient LED lighting."

Working with APS Energy Services of Tempe, AZ (a full-services energy services subsidiary of Pinnacle West Capital Corp), Arizona State University has replaced more than 2000 existing 150W metal-halide fixtures with Lighting Science Group's 78W LED low-bay luminaires in six parking structures. ASU has also replaced 6-inch incandescent downlights in the Sandra Day O'Connor School of Law rotunda with Cree LR6 recessed LED downlights, which consume 85% less energy.

ASU hence expects to reduce its energy consumption by 1.5 million kilowatt hours per year (equivalent to annual greenhouse gas emission from 208 passenger vehicles). The move to LEDs could deliver annual savings of up to \$127,000 in energy and maintenance costs, and the new fixtures are projected to

last 50,000 hours (about three times longer than a typical metal-halide bulb, and compared to about 1000 hours for an incandescent bulb).

With about 80,000 students, faculty and staff, ASU is focusing on energy conservation and sustainability programs, including the installation of LED lighting solutions across its campus. For the second year in a row, ASU was named one of the nation's 'greenest' universities by The Princeton Review in its Green Rating Honor Roll (an annual rating of environmentally friendly institutions).

"LED lighting is another proof point for our ongoing green efforts," says Bonny Bentzin, ASU's director of sustainable business practices. "Installing LED fixtures on campus provides an energy-efficient means to achieve higher quality of light, as well as offering financial benefits due to the associated energy and maintenance savings."

"Not only are they promoting environmentally conscious projects, but they are also helping to instill these principles in their students and lead other universities by example," comments Deb Lovig, Cree's LED programs manager.

Milwaukee Area Technical College and Arizona State University join inaugural participant North Carolina State University as well as University of California at Santa Barbara, the University of Arkansas, Marquette University, the University of Notre Dame, University of California Davis, the University of Miami, the University of Alaska at Anchorage, Madison Area Technical College, Joliet Junior College and Alfred University in the USA, as well as Tianjin Polytechnic University in China.

www.matc.edu

www.asu.edu

www.apses.com

www.leduniversity.org

www.CreeLEDRevolution.com

'Auger largely responsible for limited LED efficiency'

Many researchers blame Auger recombination for the observed drops in efficiency of InGaN LEDs at high drive currents (above current densities in the range 10–50A/cm²). This limits the prospects for replacing traditional lighting with more efficient LEDs at low cost.

University of Michigan researchers have used large signal modulation measurements on InGaN lasers to derive the Auger coefficient for InGaN material at room temperature [Zhang et al, Appl. Phys. Lett., vol95, p201108, 2009]. The value that is obtained compares well with that obtained from considering the 'efficiency droop' in LEDs with a similar wavelength as deriving from the Auger mechanism, leading the researchers to write: "It is apparent that Auger recombination is largely responsible for limiting device efficiencies at high injection currents."

LEDs and laser diodes depend on bringing together negatively and positively charged carriers ('electrons' and 'holes', respectively) in semiconductor materials to recombine, releasing energy in the form of photons/light. Auger recombination refers to a competing process where electrons and holes recombine, but the energy released is transferred to another electron or hole. This competing mechanism is expected to increase with charge carrier densities, and hence at high drive currents.

The Michigan group used a multi-quantum well (MQW) laser (Figure 1) with InGaN wells and GaN barriers that emitted at a wavelength around 407nm (near ultraviolet). The Auger coefficient was derived by measuring the turn-on delay for stimulated emission and comparing the behavior with injected current with what is expected from an analysis using the carrier rate equation below threshold. The recombination was modeled up to terms cubic in the charge carrier density. The linear and quadratic terms were taken as representing the Shockley–Read–Hall recombination

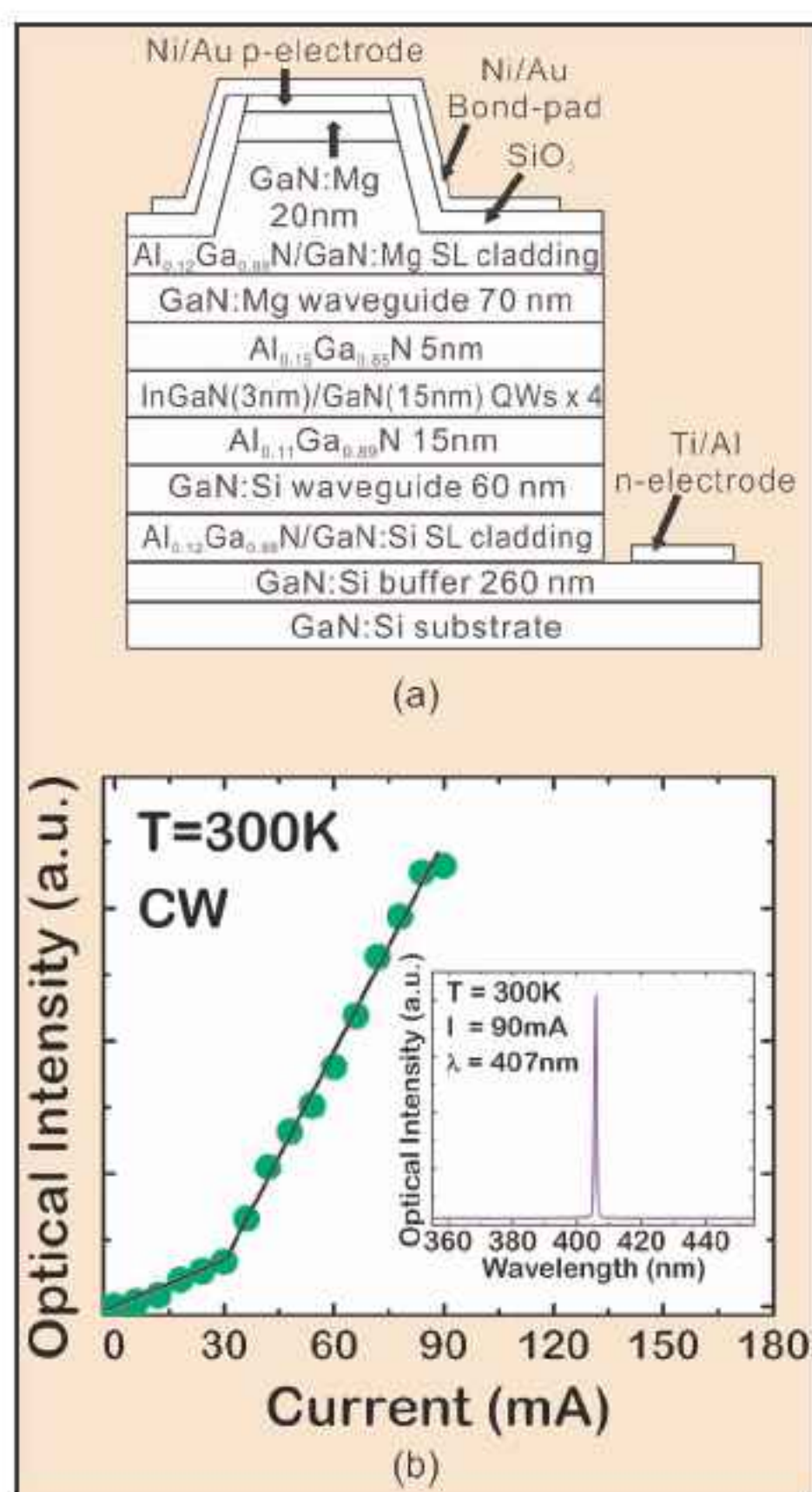


Figure 1. Schematic of InGaN/GaN MQW laser heterostructure (a) and measured light-current characteristics (b).

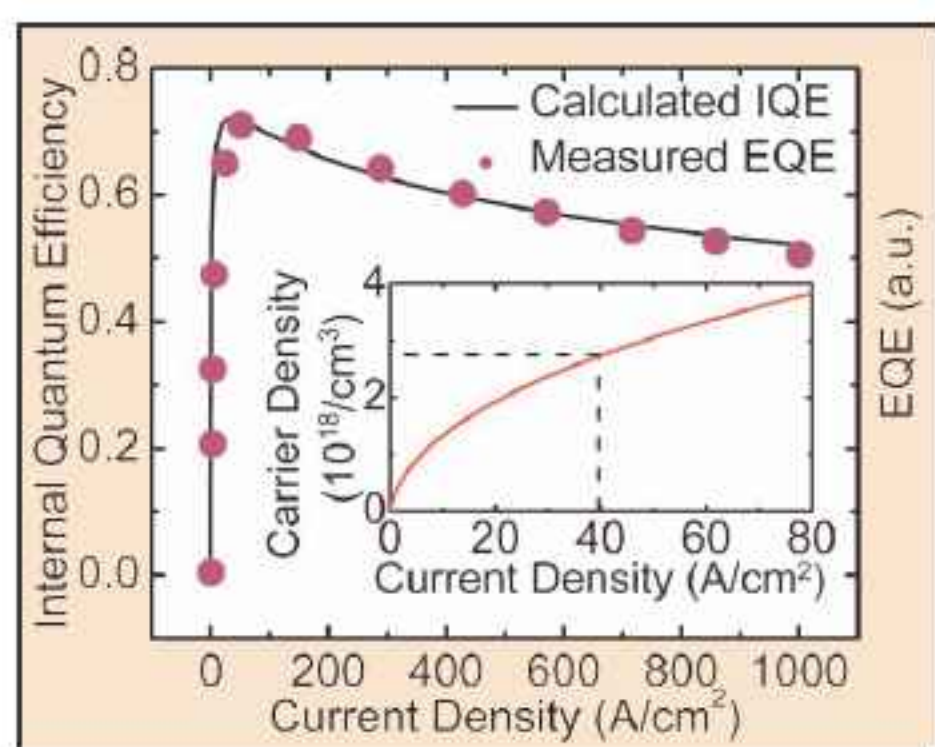


Figure 2. Michigan's calculated internal quantum efficiency (solid line) as a function of injection current of near-UV InGaN/GaN QW LED, based on measured Auger recombination coefficient. Solid circles show reported data [Yang et al, IEEE Trans. Electron Devices, vol55, p1771, 2008] for an LED emitting at nearly the same wavelength. Inset: calculated relation between carrier density in QWs and current density. Dashed lines signify the point of maximum efficiency.

rate (i.e. non-radiative recombination through intermediate levels in the energy bandgap) and the radiative recombination rate. The values of these other coefficients were derived from spectroscopy of the bandgap levels and a nitride device simulator, respectively. The turn-on delay was measured using 120 nanosecond pulses (15% duty cycle) from zero to a current above threshold. The rise time was 100ps (20%–80%). The Auger coefficient is given by the Michigan group as being $C_a = 1.5 \times 10^{30} \text{cm}^6/\text{s}$ at 300K.

This Auger coefficient was used to predict the internal quantum efficiency as a function of injected current density for 410nm (near-UV) InGaN LEDs. It was assumed that the diffusion length of the holes was long enough for a simple assumption of uniform hole density over the 12nm MQW structure (this is often not the case with InGaN MQWs). It was further assumed that all recombination occurs in the MQW region. A 70% internal quantum efficiency peak is predicted at $\sim 40 \text{A}/\text{cm}^2$. The predictions were compared with experimental results (Figure 2) given by West Virginia University [Yang et al, IEEE Trans. Electron Devices, vol55, p1771, 2008].

The Michigan group comments on the apparent inconsistency where the Auger coefficient is an order of magnitude lower than that in longer-wavelength indium gallium arsenide on indium phosphide (InGaAs/InP) MQWs, but where no efficiency droop is seen at comparable current levels. Michigan makes the point that carrier densities — the important factor in Auger recombination — are also affected by the thickness of the MQW region and the carrier lifetimes. For nitride devices the MQW is thinner and carrier lifetimes are longer, both factors increasing carrier densities for a given current density.

www.eecs.umich.edu

<http://link.aip.org/link/?APPLAB/95/201108/1>

Author: Mike Cooke.

US National Air and Space Museum exhibit lit by Cree LED fixtures

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA says that its LR24 recessed LED luminaires have been installed in the Smithsonian Institution's National Air and Space Museum in Washington DC.

Designed for the museum's new 'Moving Beyond Earth' exhibit

(which includes a

12-foot tall space shuttle model, parts of the Hubble Space Telescope, and a model of the Ares launch vehicle), the LED lights replace high intensity discharge work lights, offering the high lumen output and efficacy required for people to work in the gallery.

Work lights, on for about eight hours per day, allow museum staff to clean the gallery and perform other maintenance during non-exhibit hours. Replacing the mercury vapor work lights with LR24s can reduce maintenance costs and save energy, says Cree.

The LED lights deliver uniform and bright light and weigh less than other fixtures, helping to reduce strain on the 20-foot high ceilings of the exhibit (which covers 5000 square feet of space). The LR24s are also designed to produce little heat (aiding stable temperature and humidity levels, and saving on air-conditioning needs and related costs) and emit virtually no ultraviolet rays (which can help protect the many historical artifacts featured in the exhibit).

Cree says that the LR24 luminaires underwent an extensive life-cycle-cost business-case analysis that demonstrated estimated energy savings of 80% over the incumbent



The LED-illuminated 'Moving Beyond Earth' exhibit at the Smithsonian Institution's National Air and Space Museum in Washington DC.

mercury vapor fixtures. Other evaluation criteria included maintenance costs, thermal/HVAC impact and ultraviolet emissions (which can degrade artifacts).

"The Air and Space Museum installation shows the versatility of our lighting products as well as the cost and environmental benefits associated with LEDs," says Gary Trott, Cree's VP of market development.

The 'Moving Beyond Earth' exhibition explores the achievements and challenges of human space-flight in the USA during the space-shuttle and space-station era through artifacts, immersive

The installation shows the versatility of our lighting products as well as the cost and environmental benefits associated with LEDs

experiences and interactive computer stations. "It's a natural fit for American innovation to be behind the scenes of an exhibit that proudly displays American history," says Trott.

www.nasm.si.edu/exhibitions/gal113/mbe

Cree Cup in China selects 50 designs in LED lighting contest

Jointly organized by Cree and the Beijing-based China Association of Lighting Industry (CALI), the first Cree Cup — Creative LED Lighting Design Contest for China university students has completed its preliminary round which, lasting three months, produced more than 100 designs from nearly 1000 students representing about 100 universities.

The contest review committee (consisting of LED industry experts, academic scholars and industrial design/lighting application experts) examined the submitted designs based on creativity, practicality and marketability. After this evaluation, 50 designs were selected to continue to compete in the contest's final stage: physical production.

"Registration for the contest shows the great enthusiasm of our university students for LED lighting," says professor Zhan Qingxuan of Tsinghua University's School of Architecture and chairman of the contest review committee.

However, LED lighting courses have yet to be widely adopted in universities, explaining why some designs lack practicality despite featuring novel designs, says the committee. "As the government increases requirements for energy-saving and environmental protection, we believe that LED lighting will achieve greater popularity," says Zhan. "As university students at large have an opportunity to take part in such high-level contests, it will further promote knowledge of LED lighting and help to train a new generation of innovative talents."

A core aim of the contest is to discover and motivate high-caliber LED design talent to support China as an LED manufacturing and innovation center. "We look forward to seeing fine physical implementations during the final round," says Tang Guoqing, general manager for Cree China Sales & secretary-general of the contest's organizing committee.

www.fleishman.cn/cree-creating

Bridgelux boosts Series D funding by extra \$50m to \$80m

Bridgelux Inc of Sunnyvale, CA, USA, which claims to be the only vertically integrated maker of LED solid-state light sources specifically for the lighting industry, has appointed William D. Watkins as CEO and a member of its board of directors. Mark Swoboda (CEO since June 2007) becomes president, leading product development, R&D initiatives and sales & marketing.

The firm has also raised an extra \$50m in its Series D round of financing, led by VantagePoint Venture Partners and joined by all other existing investors (DCM, El Dorado Ventures, VentureTech Alliance, Chrysalix Energy Venture Capital and Harris & Harris Group) as well as new investors (including an undisclosed strategic investor).

Bridgelux closed the first tranche of Series D equity in April 2008 at \$30m (making \$80m in total), along with a \$10m line of credit from investors. That \$40m was used to develop new products, some of which were rolled out in 2009. In total, the firm has now raised \$113.5m in venture capital, including \$23m in August 2007, \$8.55m in May 2005, and \$2.5m in angel funding in 2002.

"We view solid-state lighting as an advanced technology capable of rapidly transforming the \$100bn lighting industry by offering a more cost-effective, efficient and environmentally sensitive lighting solution, and Bridgelux is uniquely positioned to drive its adoption," says Alan E. Salzman, CEO of largest investor VantagePoint Venture Partners.



CEO Bill Watkins.

While continuing to drive R&D activities (including adding staff), Bridgelux aims to use the latest funds to meet market demand by developing its manufacturing technologies and expanding its global manufacturing infrastructure (potentially through international partnerships). While using foundry partners in Taiwan, this quarter Bridgelux is consolidating production from two locations in Sunnyvale into one plant in Livermore, CA.

Watkins joins Bridgelux after a 13-year career at Seagate Technology (the world's largest hard disc drive and storage solutions company), having been CEO for the last five years (leading growth strategies and improvements, including increasing revenue from \$6.5bn to over \$13bn) and president & chief operating officer from 2000 to 2004 (responsible for hard disc drive operations and transforming manufacturing processes to yield significant increases in capacity and efficiency).

Watkins joined Seagate in 1996 as part of its merger with Conner Peripherals, where he established the Conner Disk Division and was senior VP of Worldwide Operations as well as president of Disk Operations. His more than 30-year career in technology manufacturing includes Domain Technology, where he led the team that developed the MINT

(Magnetic Information Technology) disc media manufacturing process. Previously, on three separate occasions, he was part of management teams that took companies public. He currently serves on the board of Maxim Integrated Products, Flextronics and Vertical Circuits Inc. "Bringing on a leader of Bill's caliber and adding to the company's financial resources mark the beginning of what we believe will be a remarkable growth phase as the company continues driving down the cost of its solutions, which in turn opens successive new markets for them," comments Salzman.

Board member & DCM general partner Peter Moran describes Watkins' operational experience running technology manufacturing businesses on a global scale while they served together on the board of another private firm. "We will also use the new capital to support our ongoing core technology development and market penetration efforts, as we look to grow substantially in the years ahead," he adds.

"Bridgelux experienced substantial growth over the past two years and has achieved scale and a perfect market position given the opportunity we have in the near term," says Watkins. "We intend to seize this opportunity and dramatically grow the company. In the coming weeks we will be announcing several initiatives that will further underpin our growth strategy as we pursue this huge market opportunity."

www.bridgelux.com

Bridgelux to open new manufacturing & HQ complex in April–May

Bridgelux is to transfer its two San Francisco Bay Area manufacturing operations in Sunnyvale (where it has 100 staff) to one two-building manufacturing and headquarters complex in Livermore. The new facility is subleased from Fremont-based etch and wafer-cleaning equipment maker Lam Research, reports the San Jose Mercury News.

"They were actually looking offshore to expand when this space became available," says Rob White, Livermore city's economic development director. "Bridgelux has room to grow at the site [each building is about 120,000ft² in size]. Many of their employees will relocate here from Sunnyvale," he adds. "The company's plan calls

for an increase to as many as 400–500 jobs over the next five years," comments assistant city manager Troy Brown.

Bridgelux intends to install manufacturing equipment at the new complex over the next couple of months, White says. The facility should open in April or May.

www.mercurynews.com

Bridgelux expands portfolio of LED arrays for general lighting market

After launching its first LED array products early last year, lighting firm and LED maker Bridgelux Inc of Sunnyvale, CA, USA has unveiled three LED array product families that deliver high-quality, energy-efficient light sources cost-optimized for the solid-state lighting market. The new products are designed to replace incandescent, halogen, high-intensity discharge (HID) and compact fluorescent lighting.

Bridgelux says that the low power consumption, long lifetime, and high-quality light of the LED arrays offer options suitable for indoor and outdoor applications ranging from retrofit light bulbs to street and wide-area lighting. The firm believes that the new products will help to drive transformation of the \$40bn global lighting industry into a \$100bn market opportunity.

"With a broad range of solid-state light sources delivering performance and value to virtually all industry market segments, Bridgelux is well-positioned to help our customers meet all of their design application needs within the context of increasingly stringent global regulatory requirements," claims Jason Posselt, VP of marketing.

The new products reflect Bridgelux's core strength of reducing design complexity and simplifying lighting system development and integration, while driving down the cost of solid-state lighting to enable widespread adoption, he adds.

Bridgelux's LED array product portfolio now features light output that ranges from 240 to 4500 operational or 'hot' lumens (lumens under normal operating conditions), providing a full breadth of LED solutions to replace a broad range of high-volume conventional light sources:

- The ES Array Series enables lamp and luminaire makers to meet rapidly increasing global regulatory standards for general lighting such as Energy Star and Title 24 in the USA and Part L in the UK. The series



delivers 400–2000 'hot' lumens in a compact high-flux-density light source, enabling the replacement of incandescent, halogen and fluorescent conventional light sources. The new arrays are 30–60% more energy-efficient than previous product generations while reducing the price per lumen.

- The RS Array Series delivers high light output for applications including retail, street, wide-area, high-bay, and commercial lighting, replacing conventional light sources such as 50–70W metal halide (HID) and high-wattage compact fluorescent (CFL) lamps. The arrays produce 3100–4500 'hot' lumens, enabling clean and uniform lighting effects without pixilation and excellent beam control for precision lighting. In retail lighting installations, the arrays have delivered a return on investment in less than two years, claims Bridgelux, while delivering the high quality of light proven to positively influence product turnover and customer experience in this environment.

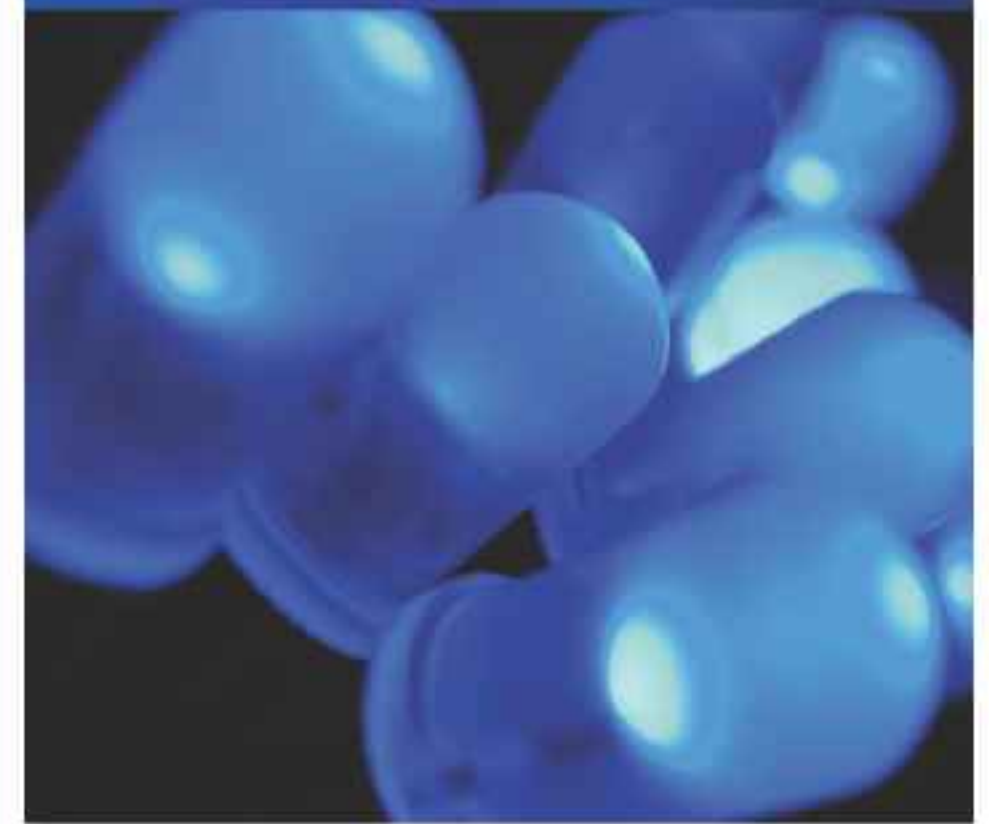
- The LS Array Series is a new set of miniaturized LED arrays that enable both diffuse and directional light sources for applications including landscape lighting, home luminaires, white goods and retrofit light bulbs. Delivering 240–360lm, they can replace low-wattage halogen, incandescent and CFL lamps.

As well as being RoHS compliant, Bridgelux says that it is in the process of securing UL recognition for its entire range of LED arrays to further simplify the design and customer acceptance process.

www.bridgelux.com

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Seoul Semiconductor launching 100lm/W LED

South Korean LED maker Seoul Semiconductor Co Ltd says that in first-quarter 2010 it is starting mass production of what it claims is the first 100lm/W AC LED light source (available for sampling by March), offering 25% greater efficiency than existing LED light products.

"Acriche now has up to ten times the efficiency of incandescent bulbs and greater system-level performance as compared to generic DC LEDs," claims Seoul Semiconductor vice president S.M. Lee.

Like other products in the firm's main Acriche product range of AC-driven semiconductor light sources (which operate directly from an AC power supply), the new 100lm/W LED needs no AC-DC converter, and is hence more energy- and cost-efficient than DC LEDs. Additionally, it generates less than a tenth of the carbon emissions of



Seoul Semiconductor's 100lm/W AC LED light source.

an incandescent bulb (key to meeting new regulatory standards in markets worldwide).

Seoul Semiconductor says that it is in the process of carrying out investment activities, active R&D, and marketing promotions to boost the supply of Acriche in the USA and to raise consumer awareness of the benefits of LED technology, and has so far invested nearly \$20m (with plans to expand

investment further in the future). The firm adds that it is making a particular effort to apply Acriche's patented technology in multiple lighting applications through continual R&D for dynamic product evolution.

The annual global market for LEDs exceeds \$5bn, and is expected to grow at more than 24% per year. Seoul Semiconductor expects Acriche to appeal to the US market, where the race to instill 'green' lifestyle practices has intensified, the firm says, resulting in increased numbers of lighting systems being replaced or upgraded with LED solutions.

Anticipating continued robust demand for Acriche in the USA, Seoul Semiconductor says that it is dedicating foundry resources to ensure that supplies of the product are readily available.

www.acriche.com

IN BRIEF

Toyoda Gosei and Sharp agree patent cross-licensing

Japan's Toyoda Gosei Co Ltd and Sharp Corp have entered into a cross-licensing agreement granting each other the right to use inventions related to nitride-based LEDs and laser diodes covered by patents owned by the respective firms in Japan and other countries.

The two firms say they will continue to develop high-brightness LEDs and pursue expansion of the LED market through fair competition.

Toyoda Gosei and Sharp own wide-ranging optoelectronics patents. The two firms say that, as a result of the cross-license agreement, they will be able to step up their R&D efforts and meet the rapidly growing demand for LEDs.

www.toyoda-gosei.com

www.sharp.co.jp

SemiLEDs' customers confirm new I-core LED achieves over 120lm/W

LED chip maker SemiLEDs Corp of Boise, ID, USA (which has fabrication facilities in Hsinchu Science Park, Taiwan) says that its new I-core LED chip (launched in early November) has achieved luminous efficacy of more than 120lm/W in mass production in optimized white light packages of both Nationstar Optoelectronics and SENGLED (LED packaging firms based in mainland China).

The tests performed by Nationstar Optoelectronics and SENGLED were performed with a SemiLEDs 45mil I-core LED chip (available in mass production, along with the 40mil I-core LED) operated at a drive current of 350mA in a 1W package. Both firms now plan to ramp capacity for street-light applications, says SemiLEDs.

SemiLEDs claims that the tests' results for the I-core prove the advantages delivered through its

chip technology. The firm's patented and proprietary 'metal vertical photon' MvpLED chip technology features a vertical structure with a copper alloy base that provides greater thermal conduction as well as electrical conduction, it is claimed.

In particular, the I-core is designed with new electrodes that are convenient for wire bonding. SemiLEDs says that advantages include improved reliability, delivered through the optimization of stress management for the chip at high-current operation. The firm claims that the IC LED is also significantly brighter, as its robust design results in much improved light extraction.

The I-core LED is available in SemiLEDs' ultra-high-brightness chip portfolio in blue (white) color, in both 40mil and 45mil chip sizes.

www.semileds.com

Nakamura awarded Harvey Prize by Israel's Technion

Shuji Nakamura, professor of materials in the University of California Santa Barbara's College of Engineering and co-director of its Solid State Lighting and Energy Center, has been named one of the two winners of the 2010 Harvey Prize for advancements in science and technology (along with Sir David Baulcombe, a botanist and research professor at the UK's University of Cambridge). Awarded annually by the Technion - Israel Institute of Technology, the prize was presented on 17 February at a ceremony on the university's campus in Haifa, Israel.

Nakamura is known for his pioneering work on blue, green, and white LEDs and the blue laser diode. He was also part of a UCSB team that developed the world's first nonpolar blue-violet laser diodes.

Chosen for the prize for "seminal

contributions to light sources based on nitride-containing III-V semiconductors", Nakamura "pioneered the research that led to the first semiconductor laser producing blue emission, which increases significantly the density of optical storage devices," the citation states. "His work on nitride-containing light emitting diodes led eventually to the white light LED, which totally revolutionized lighting concepts. These white light LEDs will dominate light-producing systems, as they are significantly more efficient than conventional incandescent light bulbs, ensuring huge reductions in energy consumption."

First awarded in 1972, the Harvey Prize includes a \$75,000 cash stipend to each winner. Supported by a fund established by the late Leo M. Harvey of Los Angeles, the prize recognizes individuals who have made great contributions to

science and technology and human health, and individuals who have helped advance the cause of peace in the Middle East. Of past winners, 13 have gone on to win Nobel Prizes. They include David Gross, director of the Kavli Institute for Theoretical Physics at UC Santa Barbara, who won the Harvey Prize in 2000 and the Nobel Prize in Physics in 2004.

Previous international awards for Nakamura in recognition of his research include Finland's Millennium Technology Prize (in 2006) and Spain's Prince of Asturias Award for Technical and Scientific Research (in 2008). Earlier he was a recipient of Japan's Takeda Award, as well as an Innovation Award from UK magazine The Economist.

www.admin.technion.ac.il/harvey
www.materials.ucsb.edu/LINKS/PROFnakamura

New Audi A8 uses all-LED Osram headlamps

Osram Opto Semiconductors GmbH of Regensburg, Germany says that its LEDs are responsible for both the low and high beams (as well as other specific lighting functions) in the all-LED headlamps of the new top-of-the-line Audi A8 luxury sedan.

Audi's current range of vehicles already has LED daytime running lights installed in the headlamps. But Osram says that now, in the new A8, its OSTAR LEDs have advanced headlamp lighting beyond simple low and high beams: special lighting functions such as motorway beams, cornering lights and all-weather lights are now handled by LEDs (with individual light sources visible in the headlamps, distinguishing the Audi from other automobiles at night).

Osram's OSTAR headlamp is available as a new product platform with up to five LED chips, each with typical light values of 160lm at 700mA. Together, depending on the



LED light sources in the Audi A8's low-beam lights.

variant and operating current, 125–1100lm is achievable. With its scalable brightness, the OSTAR headlamp suits all headlamp functions such as low and high beams, cornering lights, fog-lamps and even daytime running lights, says Osram.

"LEDs have left the niche market of limited-edition and luxury vehicles and have arrived successfully in volume production," says Peter Knittl, LED automotive director

at Osram Opto Semiconductors. "As they already meet all the requirements of modern automobile lighting and are setting new standards in many respects, LEDs are perfectly suited to mass-market use," he claims.

Due to LED technology, headlamps are evolving from a mechanical component to an electronic module, the operation of which is linked to the vehicle's electronic system, says Osram. For example, for a glare-free full beam, data from the navigation system and information from a light-based driver assistance system are combined, so the lighting system can intelligently illuminate only the required parts of the road when cornering or in oncoming traffic. LED arrays play an important role — depending on the lighting function, individual LED pixels can be switched on or off, enabling light to adjust to various conditions.

www.osram-os.com

IN BRIEF

Jetronic to distribute Luminus' LEDs in China and Asia

Luminus Devices has expanded in China, Hong Kong and Taiwan through a commercial partnership in which Hong Kong-based Jetronic Technology Ltd will distribute its PhlatLight LEDs to electronics firms selling projection and display systems in the home and commercial market.

"Demand in Greater China has been steadily increasing and Jetronic will help Luminus expand our products in one of the fastest-growing regions of the world," says president & CEO Keith T.S. Ward.

PhlatLight LEDs are now used as the solid-state light source in projection systems from firms including Acer, BenQ, Chi Lin, Delta Electronics, LG, Samsung and Toshiba. They are also used in lighting applications that require high brightness and efficiency, wide color gamut, high color rendering and long lifetimes.

"Projection systems and the display industry in general are migrating at a very fast pace towards solid-state light sources, which will ultimately displace conventional light sources in mainstream products," says Jetronic's president Thomas Wong.

Luminus has also hired Robin Hung as regional sales manager in Asia, based in Taiwan and responsible for identifying and developing strategic accounts in the region. Hung was previously sales director at LedEngin and general manager at Telegent Technology. He also has experience with Conexant Systems, Future Electronics, Hewlett Packard and Siemens. "Asia's rapid growth presents us with a great opportunity and Robin will give us a major presence in the region," says Ward.

www.jetronic.com
www.luminus.com

Luminus settles lawsuit with lender Hercules, but lays off 30 staff

Luminus Devices Inc of Billerica, MA, which makes LED solid-state light sources for illumination applications (including high-definition TVs, video projectors, avionics displays, and lighting systems), has settled a lawsuit filed on 18 December against its lender Hercules Technology Growth Capital Inc of Palo Alto, CA (which provides financing to technology and life sciences firms).

Luminus claimed that Hercules had blocked it from accessing \$12m in bank accounts after improperly declaring it to be in default on a \$15.1m loan. Since being founded in 2002, Luminus has raised \$140m in funds, and was close to raising another \$15m from investors when the accounts were frozen.

According to a Boston Globe report, Luminus said that Hercules' actions were a "blatant attempt to seize the upper hand in ongoing negotiations with Luminus and its sponsors". However, Hercules claimed that it had no choice but to exercise its rights under the loan agreement, after Luminus in November almost doubled May's forecast for 2009 losses to more than \$29m and lowered its 2010 revenue forecast by 60% to \$24.8m, raising doubts about its cash flow being adequate to repay the loan. Starting this year, Luminus was supposed to pay Hercules \$800,000 per month over the next two years.

Before freezing the accounts, Hercules said it talked to Luminus about the possibility of existing investors injecting another \$15m, but investors demanded "unreasonable modifications to the loan agreement", including deferring some of the payments and converting some of the debt to stock. Without the additional investment, Hercules said Luminus' cash collateral would have quickly dissipated, putting the loan at risk.

Luminus was hence forced to lay off most of its 130 staff in Billerica and at its factory in Woburn, MA.

Now, Luminus has withdrawn its legal action after Hercules agreed to release the bank accounts after renegotiation of the \$15.1m loan, including reducing the amount borrowed. Luminus has also been able to line up some bridge funding from its board of directors and existing investors to help fund it until it can finish raising the \$15m from investors (allowing it to recall most staff). However, to improve efficiency, Luminus has decided to cut 30 jobs (mainly in manufacturing).

"From the outset, Luminus was confident of a full and cooperative outcome to the recent legal action we took against Hercules," says president & CEO Keith T.S. Ward.

"Luminus has complete and unwavering support from its investors, a committed board of directors, and a strong internal leadership team," he stresses. The firm says investors and shareholders are committed to supporting its growth-oriented 2010/2011 business plan (approved in late 2009), and that it is committed to the customers, applications and markets for its PhlatLight LEDs.

The firm's products are used by some of the world's largest electronics companies, including Acer, LG, Sony, Samsung and Toshiba. "We are committed to our 2010/2011 vision of continued growth in projection display, general illumination lighting and UV industries," says Ward, adding that, in general illumination lighting markets such as architectural, retail, residential, roadways, digital signage, industrial high-bay and in entertainment lighting applications, companies such as Vari-Lite have validated use of the firm's large-chip PhlatLight LEDs in many new lighting applications.

The firm still expects revenue this year to double from nearly \$10m last year. "We had our best month ever in December," Ward notes.

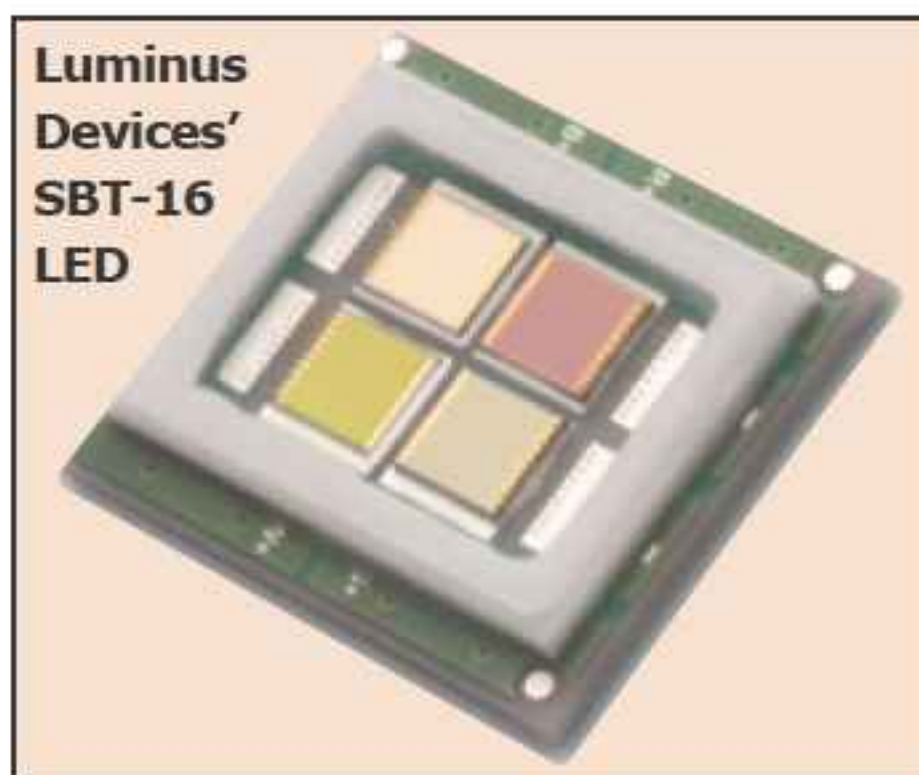
www.boston.com/business/ticker/2010/01/luminus_settles.html

RGB chipset for ultra-mobile projectors

Luminus Devices has launched a new PhlatLight (Photonic Lattice) LED available in a surface mount package (SMT). The SBT-16 is designed to bring new levels of efficiency and performance for personal and ultra-mobile projectors (an emerging class of miniature projection devices with sizes of typically 150–400cm³). These accessories may include digital media players and can connect to portable devices such as PDAs and notebook and netbook computers to provide a large display experience.

The SBT-16 chipset includes separately packaged red, green and blue LEDs that are each 1.6mm² with a 16:10 format, suiting illumination of 0.2–0.4" imagers with wide formats such as WVGA, 720p or 1080p resolutions. As with all PhlatLight LEDs, the SBT-16 is matched to the system architecture to deliver optimum system efficiency in a compact form factor (essential for personal projectors).

"We expect the pico and ultra-mobile projector market to grow to 3.4 million units by 2012," says Mike Fisher, convergence and new technologies consultant at market research firm FutureSource. "The introduction of higher-brightness projectors enables new usage models and brings further versatility to



this category, both of which are critical requirements for this market to materialize," he adds. "By taking the pico hand-held accessory category to new performance levels, PhlatLight LEDs are an essential technology enabler for the category, and Luminus is poised to expand its current leadership in projection displays to this consumer-driven category."

"Pico projectors can now display larger screen sizes and can be used in higher ambient lighting conditions, which make them more practical and valuable both in consumer and business applications," says Stephane Bellosguardo, director of product marketing for Luminus' display business group.

The SBT-16 integrates with standard SMT manufacturing processes and equipment, and is now sampling to lead customers.

Luminus in full production with warm-white PhlatLight LEDs for lighting applications

At the Strategies in Light event in Santa Clara, CA, USA (10–12 February), Luminus Devices announced general availability of its PhlatLight LEDs in warm-white colors (critical for indoor commercial and residential lighting applications).

Warm-white PhlatLight LEDs are part of the firm's SST-50 and SST-90 product lines. With a minimum CRI (color rendering index) of 80 and a typical CRI value greater than 85, the new LED will ensure that the color quality standards set by Energy Star can be achieved,

says Luminus.

"Our rapidly expanding product line now includes high-quality warm-white PhlatLight LEDs well suited for commercial and residential lighting applications, including retrofit bulbs and indoor lighting fixtures," says president & CEO Keith T.S. Ward. "Luminus is committed to providing market-leading performance and the ability to use fewer warm white PhlatLight LEDs in the new lighting applications of the future," he adds.

www.luminus.com

IN BRIEF

Sales managers for US, Europe and Asia

Luminus has appointed John Rimbo as national account manager, responsible for developing and managing distributor accounts, as well as allied sales administration activities. "We have been successful to date partnering directly with many of the world's largest purchasers of LEDs," says president & CEO Keith TS Ward. "We now have an opportunity to achieve growth through established distribution channels. John's experience is a fine addition to our current capabilities."

Prior to joining Luminus, Rimbo was district manager for billion-dollar distributor Crescent Electric Supply, where he developed and implemented sales and marketing strategies. He also has extensive experience with General Electric.

Luminus has also appointed Robert de Jonge as sales manager for Europe, based in The Netherlands and responsible for identifying and developing strategic accounts throughout the region. "Luminus is experiencing rapid growth in Europe and our customer base is broadening every day," says Ward. "Having Robert on-site will improve our responsiveness to new opportunities."

Prior to joining Luminus, de Jonge was marketing director for NXP Semiconductors in Eindhoven. He also has experience with Philips in lighting and medical products.

Luminus has also hired Robin Hung as Asia regional sales manager, based in Taiwan and responsible for identifying and developing strategic accounts. "Luminus LEDs are well suited to the display lighting market, as well as other emerging applications," comments Ward.

Samsung partners with Luminus Devices on first LED-based data front projector

Luminus Devices says that its PhlatLight PT-120 is being used as the light source in Samsung's new XGA (1024 x 768 pixel) LED data projector (the first LED-powered data projector). Its PhlatLight LEDs are already used as the solid-state light source for all projection technologies, including 3LCD, DLP and LCOS.

Demonstrated by Luminus at the Consumer Electronics Show (CES) in Las Vegas (7-10 January), Samsung's new XGA LED-based data projector validates that LEDs can start replacing conventional arc lamps in mainstream front projectors used in business, education and commercial applications, says Luminus. This market is forecasted by market research firm Pacific Media Associates Inc to grow to

more than 6 million units in 2010. For front projectors, the high reliability of LED light sources eliminates the need for expensive lamp replacement (typically \$250-400, including parts and labor), driving down the total cost of ownership and reducing the administrative burden to manage stocks of replacement lamps and disposal of used lamps.

"Samsung's new LED data projector is a great illustration of how Luminus works in close partnership with its customers to create a new multi-million unit market for PhlatLight LEDs and demonstrates that our unique large chip technology is a great fit for mainstream data projectors," says Luminus' CEO Keith T.S. Ward. "In today's challenging economic landscape, the market-

place is asking for affordable, long-lasting, lower total-cost-of-ownership projectors in the business and education markets. Luminus and Samsung are fulfilling this demand while also creating new value for our customers with next-generation technology advancements such as amazing color depth and instant start and restart functionality," he claims.

"Samsung's new front data projector expands our line of LED projectors for business and education markets," says Jeong-Ho Nho, VP of Samsung's visual display division. "PhlatLight LEDs enable new features and innovation that customers recognize and value while delivering environmentally friendly products," he adds.

www.samsung.com

Luminus' LEDs power LG's HX300G XGA ultra-compact projectors

Luminus Devices' PhlatLight LEDs are powering LG Electronics' latest sub-1kg high-brightness LED projectors.

The HX300G combines XGA (1024 x 768) resolution with 300 ANSI lm brightness in a compact form factor suitable for mobility applications, small-to-medium size meeting rooms and casual home entertainment.

Similarly to the recently announced LG HS200, the HX300G incorporates versatile input/output connectivity options, including HDMI, USB, and an FM transmitter for audio broadcast to an external stereo system, and displays digital pictures or movies directly from solid-state memory drives. Leveraging the 'instant start' capability of its LED light source, the HX300G can be set up to display professional or entertainment content in seconds and can also display a variety of content without any external source device.



LG Electronics' HX300G projectors.

"The HX300G brings XGA resolution and higher brightness to our line of LED projectors, addressing requests from our business customers as well as most consumers," says LG's marketing team leader Brian Park. "PhlatLight LEDs deliver the performance needed to project larger screen sizes in normal ambient lighting conditions, while maintaining a very compact form factor," he adds. "This directly translates into new opportunities to grow our LED projector sales in small and medium meeting rooms

for business as well as in homes, where they are a viable second large display that, unlike flat-panel TVs, can easily be moved around the house."

The HX300G is LG's third-generation projector illuminated by PhlatLight LEDs. "It brings both market-leading performance and distinctly innovative features, illustrating LG's technological leadership and marketing sophistication in this emerging category," comments Stephane Bellosguardo, director of product marketing for Luminus' display business group. "This projector's ease-of-use and ability to read content from USB mass-storage devices makes it perfect for personal projection and will equally please mobile business users and consumers."

Luminus demonstrated the new LG HX300G and the HS200 at the Consumer Electronics Show (CES 2010) in Las Vegas (7-10 January).

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Hitachi Cable develops 1mm x 1mm 55lm red LED chips

Japan's Hitachi Cable Ltd says that it has developed a high-power red LED chip offering a maximum luminous flux of 55 lumens (at a current of 500mA). The firm says that this luminous flux was enabled by increasing the size of the LED chip and the use of a fine-line electrode structure.

In response to demand for LEDs with higher luminous efficiency, Hitachi Cable has already developed high-brightness red 'MR-LED' chips (measuring 0.33mm x 0.33mm) that form a metal reflector (MR)

under the light-emitting layer (yielding 2.6lm at a current of 20mA). This product is currently being supplied to LED package manufacturers and other customers.

However, recognizing the growing demand for higher output LED chips, the firm has also now incorporated fine electrode structures and enlarged the chip dimensions to 1mm x 1mm in order to develop high-power red LED chips offering outputs as high as 55lm.

Increasing the chip's dimensions is one of the methods of improving per-chip light output. However, larger chips increase the difficulty of distributing a uniform current across the entire light-emitting layer. On the other hand, if large electrodes are positioned in the upper layer of the chip for more uniform current dispersion, light from the light-emitting layer will be blocked, reducing the light extraction efficiency.

To resolve these problems in developing a new LED chip, instead of using larger electrodes Hitachi Cable has used two pad electrodes for receiving power, a backbone

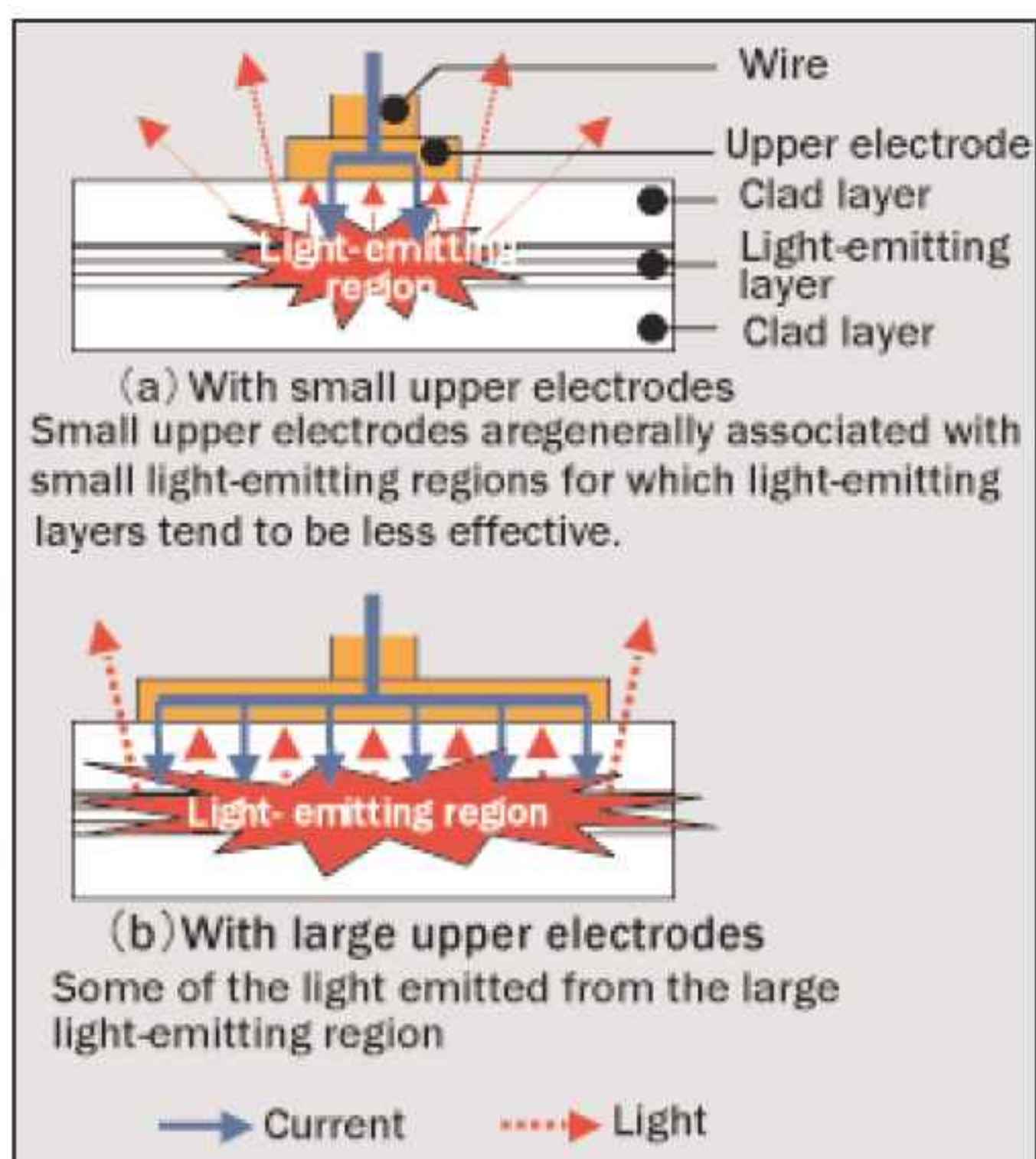


Figure 1. Problems caused by enlarged chip size.

electrode connecting the two electrodes, and multiple fine-line electrodes that extend from the backbone electrode on the upper chip layer.

By employing fine-line electrodes, Hitachi Cable says that it has succeeded in achieving uniform dispersion of current across the entire chip surface without blocking light from the light-emitting layer,

The firm has incorporated fine electrode structures and enlarged the chip dimensions to 1mm x 1mm

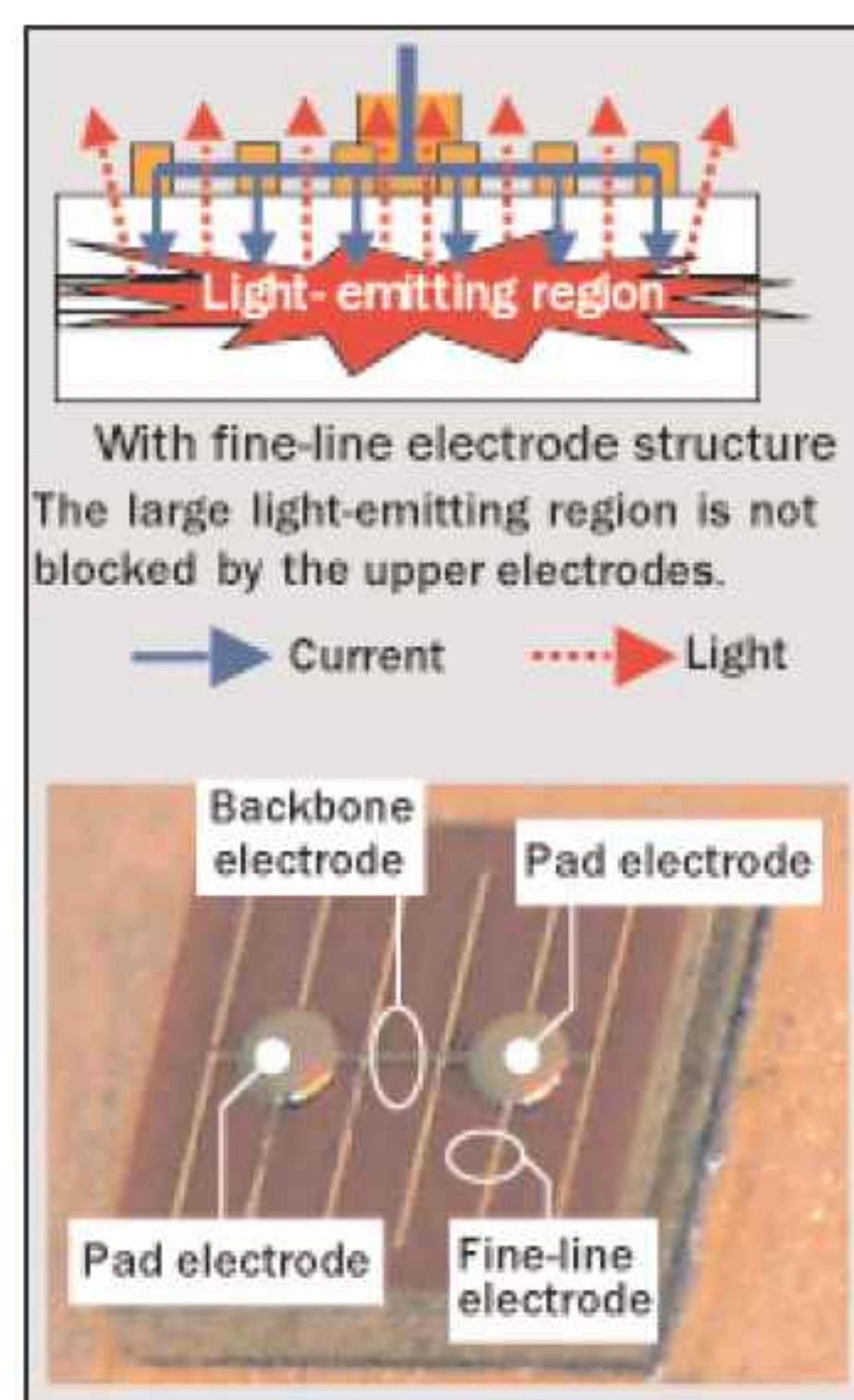


Figure 2. Structure of new LED.

attaining a maximum luminous flux of 55 lumens in a large LED chip of 1mm x 1mm—equivalent to the combined output of 21 MR-LED chips (of 0.33mm x 0.33mm). With its higher output, the new LED chip is expected to find applications not only in display applications but also as a light source for devices such as projectors.

Hitachi Cable says that it will continue to pursue active development of higher-power LED chips while expanding its lineup, including yellow and infrared LED chips. www.hitachi-cable.co.jp/en

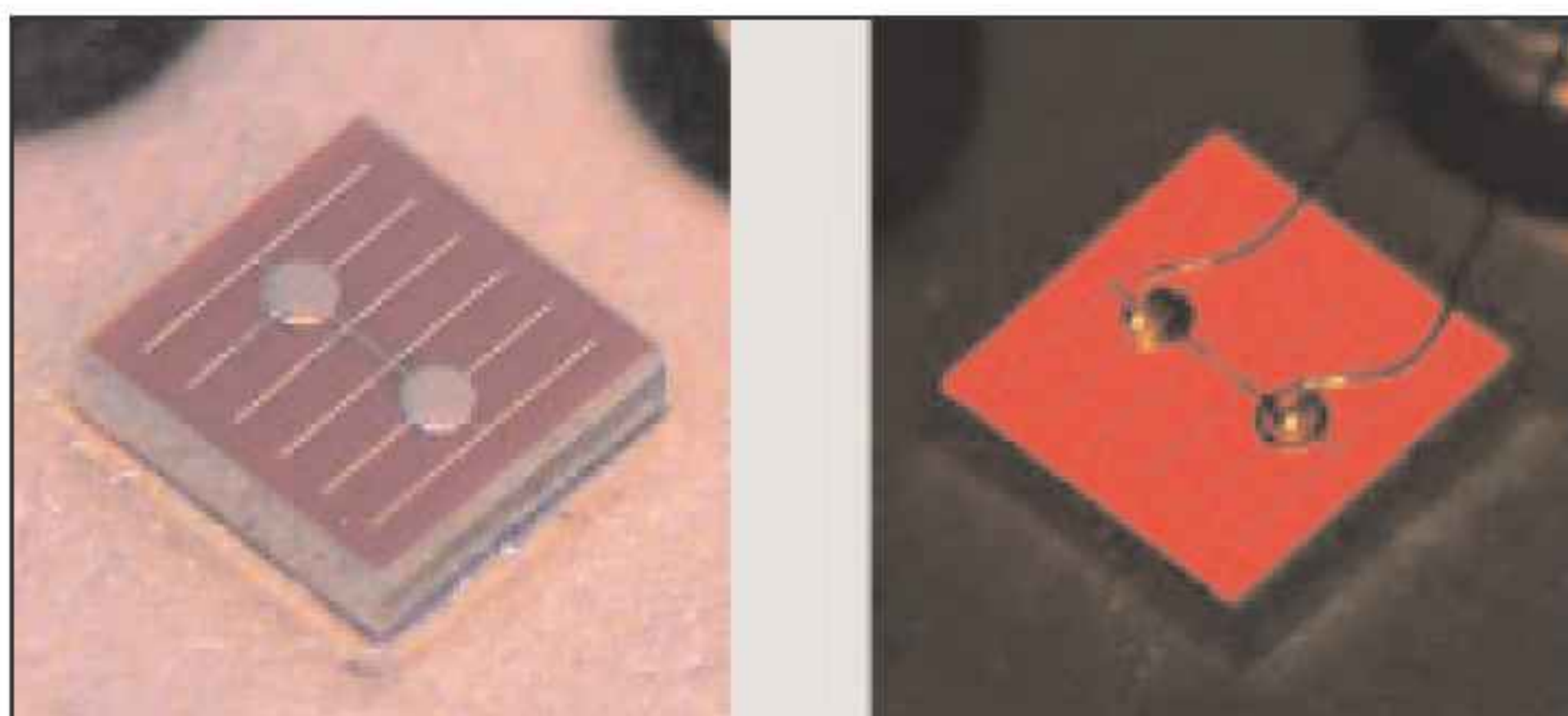


Figure 3. LED when no light is emitted (left) and while emitting light (right).

Opnext launches shorter-wavelength, higher-power red lasers for miniature projector and show laser markets

At January's Photonics West 2010 exhibition in San Francisco, optical component, module and subsystem maker Opnext Inc of Fremont, CA, USA introduced an upgrade to its red laser diode product portfolio with higher-temperature-operation red laser diodes developed for the rapidly growing miniature projector and show laser markets.

Opnext says that, due to its optimized manufacturing processes, the HL63603TG and HL63133DG achieve shorter wavelength and higher power. The human-eye sensitivity in both diodes has been improved by 25% from previous diodes, and the wall-plug efficiency of the HL63603TG has been increased by 18–28%.

Opnext claims that its HL63603TG offers the world's highest-temperature operation of 60°C and 120mW in the 637nm wavelength band in a 3.8mm diameter package. The HL63133DG offers high-temperature operation of 40°C and 170mW in the 637nm band with a 5.6mm diameter package. Both operate in a single transverse mode. The firm says that the performance was accomplished through a new development process including an innovative waveguide structure and optimized structure parameters. The active layer thickness and facet reflectivity results in lower power consumption, providing extended battery operating time.

Production of the HL63133DG series began in January. Sample shipment of the HL63603TG were scheduled to begin in February.

"Opnext is one of the key red laser diode suppliers for our Light Touch reference product, an interactive projector that instantly transforms any flat surface into a touch screen," says Chris Harris, CEO of Light Blue Optics of Cambridge, UK, which develops and supplies miniature holographic laser projection systems for applications including

automotive, digital signage and consumer electronics markets.

Founded in 2004, LBO's projection technology uses laser light sources and patented holographic techniques to deliver large, full-colour, high-quality video images that remain in focus at all distances (without needing a projection lens), whilst maintaining the Class 1 laser safety classification essential to consumer electronics applications. Uniquely, the projection system can be touch-enabled, meaning any flat surface such as a table can instantly be transformed into a touch-sensitive display, eliminating the need for a screen and allowing users to interact with multi-media content.

Light Touch — an interactive projector that transforms any flat surface into a 10-inch touch screen — is Light Blue Optics' first product, and was unveiled at January's Consumer Electronics Show (CES 2010) in Las Vegas. Firms working with Light Blue Optics to bring its projection technology to market also include Adobe, CSR, Foxconn, Interbrand, Microsoft, Micron, Nichia, Photop and Toshiba.

"Light Touch has multiple opportunities in high-volume markets, and our relationship with Opnext is helping enable our company to realize these opportunities in full," Harris says.

"The miniature projector and show laser markets are expecting rapid growth due to mobile applications," says Tadayuki Kanno, Opnext's senior VP Device Business unit.

"Customers require a red laser diode with high brightness and a thin package for their smaller RGB-laser-based consumer projection products. Our new devices meet and exceed this demand of laser diodes with shorter red wavelengths, higher power, all while being housed in a thin package."

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AlGaN-cladding-free semipolar laser nears green

Researchers from University of California Santa Barbara (UCSB) and Japan's Mitsubishi Chemical have been extending the wavelength of AlGaN-cladding-free laser diodes grown on semipolar (20 $\bar{2}$ 1) GaN substrates [Anurag Tyagi et al, Appl. Phys. Express, vol3, p011002, 2010]. The pulsed (1kHz repetition, 0.01% duty cycle) wavelength of 506.4nm is the longest reported so far for such devices. Although AlInGaN-cladded semipolar GaN laser diodes have achieved green laser light, the growth of AlInGaN is problematic and UCSB is exploring better ways to achieve the optical confinement delivered by the AlInGaN cladding with a view to the needs of production.

Green laser diodes have been the aim of much development in the past couple of years. The leading desire is to replace the complicated arrangement in the color projector equipment that presently uses second harmonic generation (SHG) to convert non-green laser light into green. A direct green laser diode would enable such equipment to be produced with increased energy efficiency, compactness and reliability, hopefully at reduced cost. Other opportunities could arise from replacement of the bulky solid-state and gas lasers used in other applications.

Although green laser light (520–570nm) has been obtained from the nitride material system on easier-to-produce polar c-plane GaN (0001) substrates, problems can arise from such laser diodes as a result of the spontaneous and strain-induced (piezoelectric) polarization charges, leading to electric fields of up to ~1MV/cm. These fields lead to separation effects between the positive (electron) and negative (hole) charge carriers that one wants to

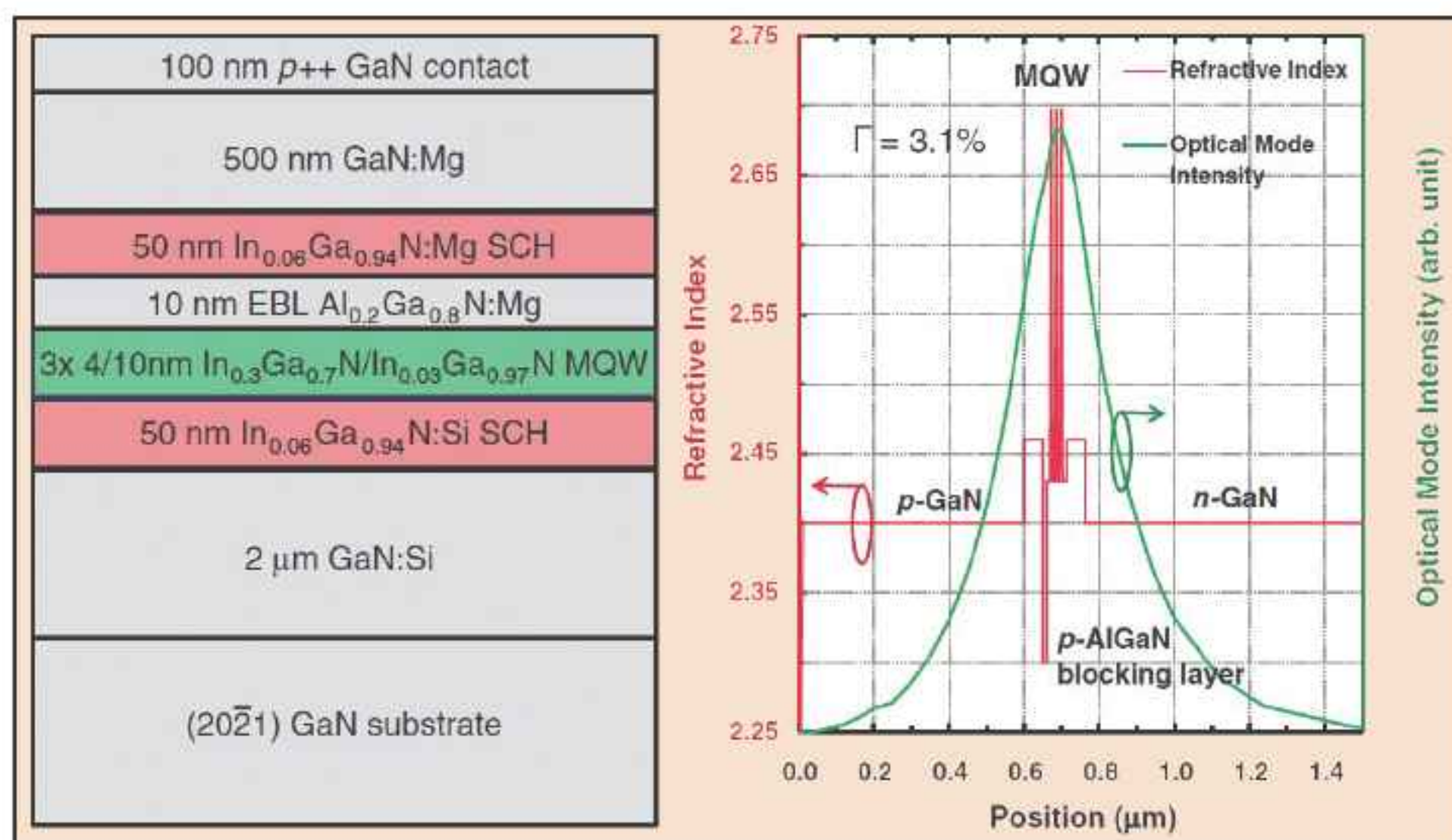


Figure 1. Cross-sectional schematic (a) of UCSB laser diode's layer structure on (20 $\bar{2}$ 1) freestanding GaN. The structure includes a three-period multi-quantum well (MQW), electron blocking layer (EBL), and separate-confinement heterostructures (SCHs). This leads to an index profile and calculated optical mode intensity (b) with a transverse confinement factor (Γ) of 3.1%.

recombine to produce light, reducing the radiation levels. In addition, a blue-shifting of the laser wavelength occurs with increased current levels — this is not desirable in applications where maintaining color consistency is important, such as for color projectors.

Non-polar m-plane oriented GaN (1 $\bar{1}$ 01) would seem a solution to such problems, but laser diodes produced on such materials have been limited to wavelengths smaller than 500nm. From quantum wells (QWs) designed to emit under photoluminescence in the 560nm region, one finds that the material quality suffers from a high level of stacking faults that would make electroluminescence difficult to achieve. In fact, UCSB has previously produced laser diodes on m-plane freestanding GaN from Mitsubishi Chemical [You-Da Lin et al, App. Phys. Express, vol2, p082102, 2009].

More luck has recently attended the semipolar (20 $\bar{2}$ 1) orientation,

with Japan's Sumitomo Electric Industries (SEI) managing to develop pulsed and continuous-wave LDs emitting at 520nm [Yoshizumi et al, Appl. Phys. Express vol2, p092101, 2009] and 531nm [Enya et al. Appl. Phys. Express, vol2, p082101, 2009], respectively.

As mentioned above, this achievement used a lattice-matched quaternary AlInGaN cladding to confine the optical mode for lasing. The growth of such quaternary layers is difficult to control, since the ideal conditions (temperature, pressure, growth rate, etc) of each of the components (AlN, GaN, InN) are widely different.

The UCSB/Mitsubishi group has previously avoided this problem with shorter-wavelength (violet, blue) laser diodes by dispensing with the cladding layer. Instead, a larger active volume and/or high-indium-content waveguiding layers can be used to create sufficient optical confinement. ➤

In the latest work, the cladding was provided by GaN rather than AlInGaN (Figure 1). The LD layers were grown using atmospheric-pressure metal-organic chemical vapor deposition on (20 $\bar{2}1$)-oriented freestanding GaN substrates provided by Mitsubishi Chemical. By using GaN rather than AlGaIn, the tendency for cracking is reduced, enabling significantly faster growth rates. The lateral dimensions of the laser diode were 3 μm x 1500 μm .

The resulting laser diodes had measured threshold current densities of 23kA/cm² before the application of a high reflective (HR) coating and 19kA/cm² after. The corresponding threshold voltages were 17.5V and 16V, respectively. These are relatively high values, which the researchers suggest are due to a non-optimized structure and doping profile. The lasing peak in this room temperature (RT) characterization was 504.2nm.

The blue-shift of the device's spontaneous electroluminescence (EL) with increased current density (Figure 2) was found to be much reduced when compared with published results from Osram for a 515nm c-plane device [Querren

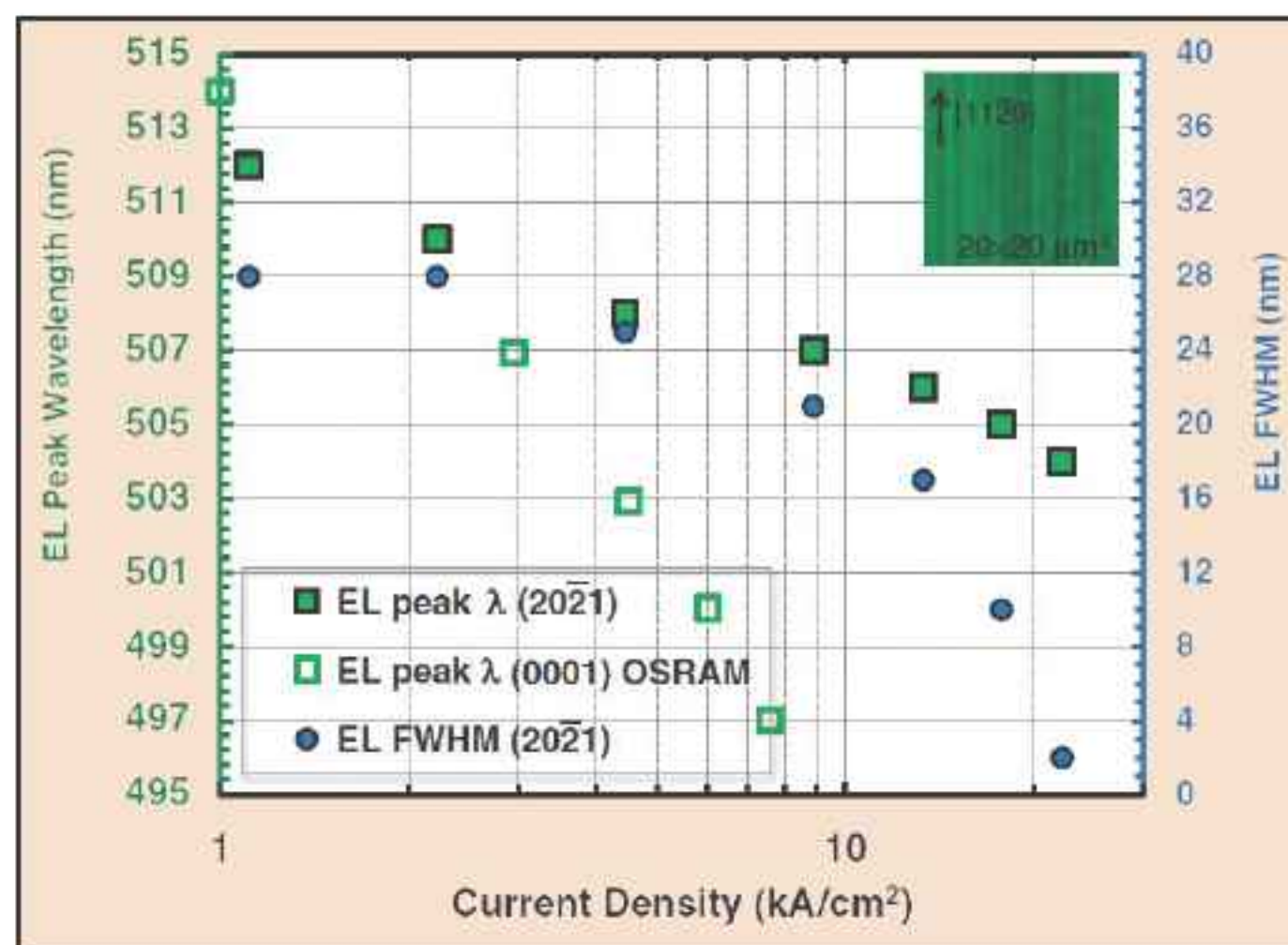


Figure 2. Dependence of spontaneous emission electro-luminescence (EL) peak wavelength and full-width at half maximum (FWHM) on current density. Peak EL wavelength data for 500nm c-plane LD developed by Osram are shown for comparison. Inset: fluorescence microscope image of the as-grown LD epitaxial wafer.

et al: Appl. Phys. Lett., vol94, p081119, 2009]. The researchers note that their thresholds were a factor of two larger than that for the longer-wavelength c-plane device. By reducing the threshold, it is hoped that longer-wavelength behavior will be available from UCSB's (20 $\bar{2}1$) GaN structure.

The characteristic temperature was found from the variation of the

threshold current to be about 130K. This compares favorably with the low value of 90K obtained for m-plane LDs. The value also falls within the range of values achieved for c-plane LDs of 120–200K. Higher characteristic temperatures indicate less increase in threshold with a rise in temperature.

The lasing wavelength also increases (red-shifts) with temperature and reaches 506nm at 60°C.

Among the paper's authors is Shuji Nakamura, who pioneered much of the development of nitride semiconductors for light and laser emission while at Japan's Nichia Corp in the 1990s before becoming a UCSB professor in 1999. <http://apex.ipap.jp/link?APEX/3/011002>
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<http://apex.ipap.jp/link?APEX/2/082102>
 Author: Mike Cooke.

Kaai extends cw green laser diode record to 525nm

Kaai Inc of Goleta, CA, USA, which aims to commercialize green and blue laser diodes based on indium gallium nitride for consumer applications, has demonstrated what is claimed to be the longest-wavelength green laser diode operating in cw (continuous-wave) mode, extending its recent record of 523nm to 525nm. Kaai had previously demonstrated 520–522nm lasers last September.

Direct-diode green semiconductor lasers offer dramatic improvements in size, weight, and cost over conventional gas or solid-state lasers and enable new applications in consumer projection displays, defense pointers and illuminators, biomedical instrumentation and therapeutics, and industrial imaging applications. In particular, for

red-green-blue displays, lasers emitting in cw mode at the green wavelength of 532nm are targeted.

Longer-wavelength lasers have been reported previously, but only operating in pulsed mode, e.g. 531nm lasers fabricated by Japan's Sumitomo Electric Industries Ltd (SEI) on semipolar GaN substrates and reported in July (Yoshizumi et al, Appl. Phys. Express vol2, p092101, 2009). Before now, the longest-wavelength laser operating in cw mode emitted at 520nm, also made by SEI and reported last August (Enya et al, Appl. Phys. Express, vol2, p082101, 2009). Kaai's lasers are fabricated on both nonpolar and semipolar GaN substrates.

Optical output power of Kaai's 525nm laser is more than 5mW, up

on the 523nm laser's 2–3mW. The firm is now aiming to improve the laser's efficiency, so that output power can be increased.

Kaai was founded in 2008 by GaN-based laser pioneers professors Shuji Nakamura, Steven Denbaars and James Speck of University of California, Santa Barbara (UCSB). Management is led by Dr Richard Craig and includes commercial laser industry veterans. The vertically integrated firm operates a fabrication plant in Santa Barbara. Kaai displayed its green and blue lasers at January's Consumer Electronics Show (CES) in Las Vegas. The firm targets samples of its 525nm green laser in first-half 2010, for production in second-half 2010.

<http://engineering.ucsb.edu>

IN BRIEF

Mitsubishi launches 500mW red laser

Mitsubishi Electric is sampling the ML520G72, which it claims is the highest-output-power 638nm red laser diode, suitable for pico projectors and portable display systems that need a high-brightness red light source.

Pico projectors have attracted increasing attention, embedded in or connected to mobile systems such as cell phones and laptops to create a large-area display capability in a small battery-powered terminal. LEDs and laser diodes are mainly used as the light source because they can project a wider range of colors compared to lamp-based projectors. Compared with LEDs however, laser diodes deliver higher output power with less power consumption, enabling batteries to last longer. They also enable focus-free operation, because optical systems with great depth of field can be used with laser beams.

After in January 2009 launching a 638nm laser with record output of 110mW (operating CW), in July the firm launched a 638nm laser with 300mW output, high brightness and pure red tone. The new laser now offers 500mW, boosting high-luminous projectors to 60lm. LED-based projectors typically offer only about 10lm. Also, the new laser has what is claimed to be industry-leading electrical conversion of 32% at 500mW and at a case temperature of 25°C, helping to cut pico-projector power consumption.

Supplied in a 5.6mm CAN package, the ML520G72 can be operated at -5°C to 40°C when emitting 500mW CW, and up to 50°C pulsed at a duty ratio of 25% or less and a frequency of 50Hz or higher. At 500mW CW, operating current is 680mA and operating voltage is 2.3V.

<http://global.mitsubishielectric.com>

Leeds wins €2.5m European grant to research terahertz optoelectronics

University of Leeds researcher professor Edmund Linfield has won a €2.5m Advanced Investigator Grant from the European Research Council for 'Terahertz Optoelectronics — from the Science of Cascades to Applications'. Quantum cascade lasers (QCLs) are constructed from thousands of layers of compound semiconductor material. QCL THz sources are small devices that, it is hoped, can be developed into portable equipment accessing the previously difficult 'THz gap' in the electromagnetic spectrum.

Linfield's is one of only 105 projects selected across Europe out of 736 applications in physical sciences and engineering. Linfield plans to use the funding to study both the fundamental science and potential applications of THz QCLs. "The potential uses for terahertz technology are wide-ranging, but are currently limited to niche applications in fields such as pharmaceutical analysis and astronomy, as most systems on the market are both expensive and physically large," Linfield comments. "The availability of cheap, compact systems would open up a wide range of opportunities in fields including industrial process monitoring, security screening, atmospheric science, and medicine."

The Advanced Investigator Grant aims to support established research

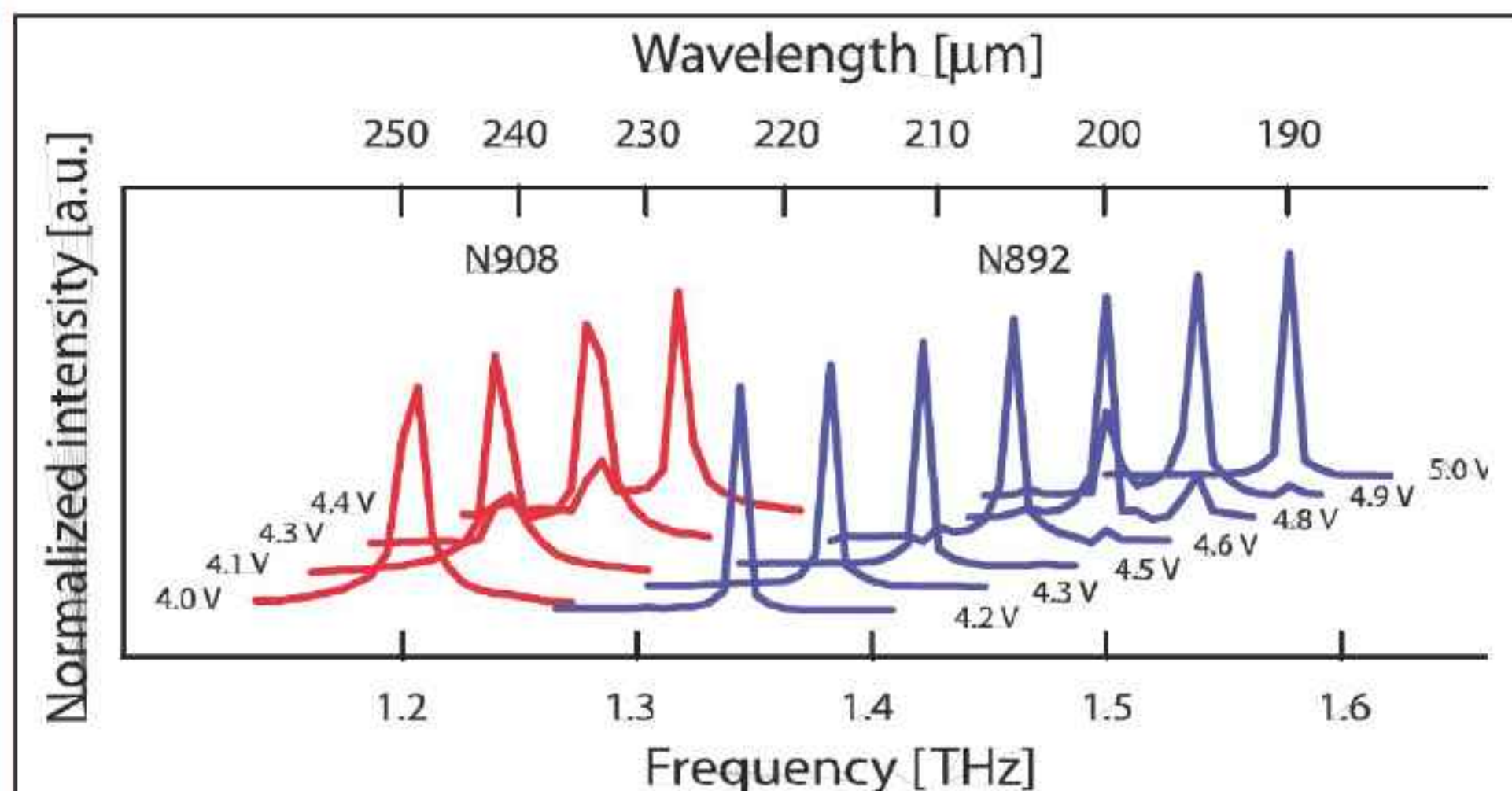
leaders in carrying out pioneering work in their field. The scheme is in its second year. The latest grant to Linfield follows an award in 2009 to professor Giles Davies — also from the University of Leeds' School of Electronic & Electrical Engineering — for 'New Opportunities in Terahertz Engineering and Science'. Candidates for the grant can be of any nationality, but must be "scientifically independent and have a recent research track-record and profile which identifies them as leaders in their respective field(s) of research".

Davies was coordinator of the €5m 'TeraNova' program, funded under the European Union's 6th Framework (FP6), which completed its work in February 2009 and was reviewed in May. Among the achievements of the TeraNova collaborators was QCLs emitting in pulses or continuous waves at frequencies down to 0.8THz at 200K.

Leeds has one of only a very small number of labs in the world able to grow terahertz quantum cascade lasers, using molecular beam epitaxy. The 160m² facility was funded in part by a Royal Society Wolfson Foundation Laboratory Refurbishment award and in part by SRIF II funding from Leeds University.

www.engineering.leeds.ac.uk/imp/tpae.shtml

Author: Mike Cooke.



Spectra for some QCLs developed in the TeraNova project.



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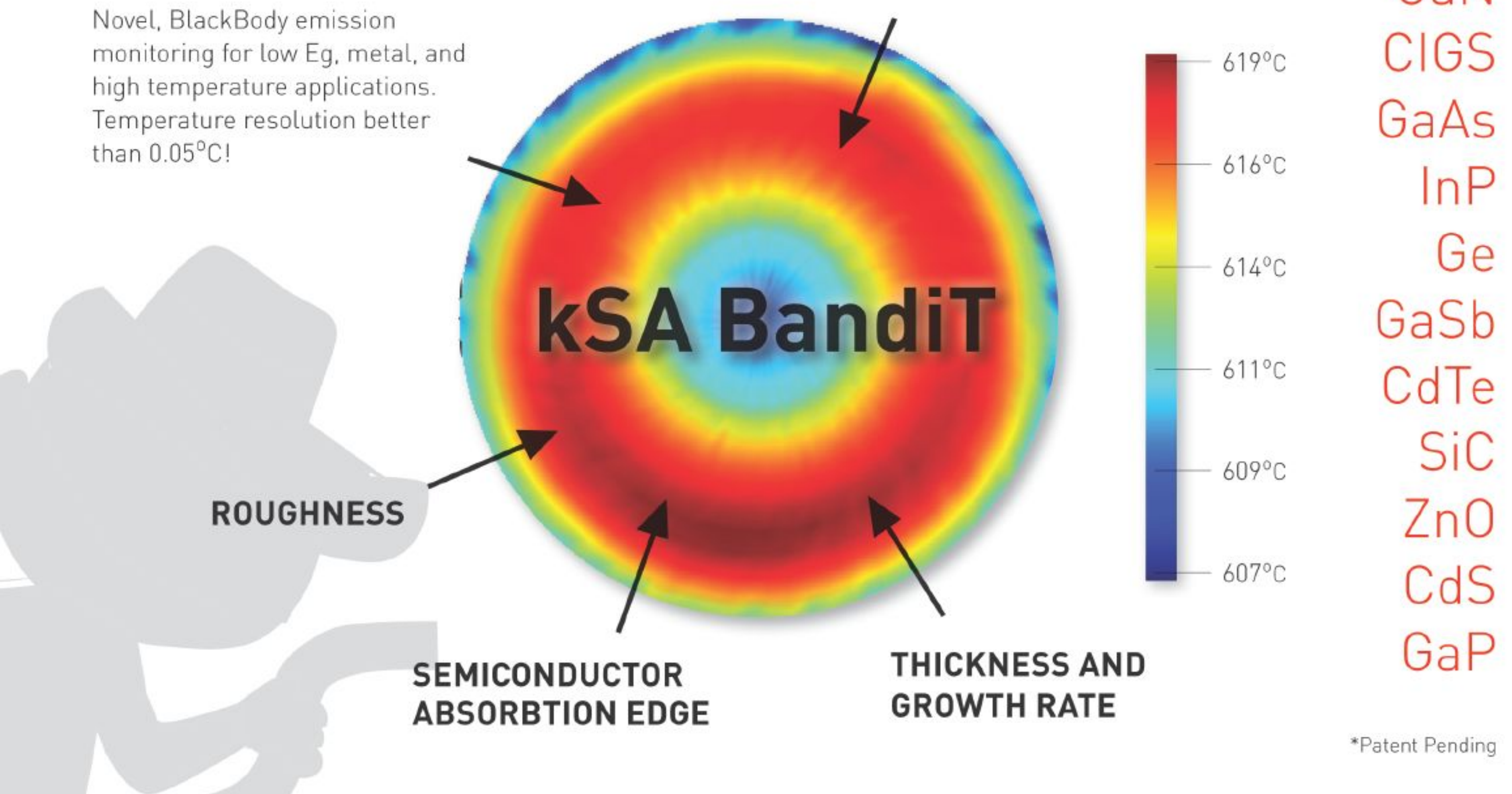
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API minimizes drop in margin despite sales slump

For its fiscal third-quarter 2010 (ended 25 December 2009), Advanced Photonix Inc (API) of Ann Arbor, MI, USA (which designs and makes silicon, InP- and GaAs-based photodetectors, high-speed optical receivers, and terahertz instrumentation) has reported sales of \$4.6, down 15% on \$5.4m the prior quarter and down 40% on \$7.6m a year ago. The decrease was broad based across four of the firm's five markets (telecom, homeland security, military, medical and industrial).

For the first nine months of the fiscal year, despite revenue dropping 32% from the record \$23.6m the prior-year period to \$16m, gross margin has only fallen from 45% to 42%. The firm says that such relatively robust gross margin reflects the results of company-wide cost-reduction initiatives as well as prior years' facilities consolidation activities. Advanced Photonix consolidated its wafer fabs in Camarillo, CA and Dodgeville, WI into Ann Arbor in mid-2007 and closed the silicon photodiode

assembly facility in Dodgeville in late 2007.

"The first nine months of the year have been negatively impacted by the recessionary environment and this quarter was hit exceptionally hard," says chairman & CEO Richard Kurtz. "Our proactive actions in making the necessary cost-reduction steps and consolidating our facilities have paid off and helped minimize the financial impact," he adds.

Nevertheless, on a non-GAAP basis, net loss has more than doubled from \$452,000 last quarter to \$921,000 for fiscal Q3, compared to income of \$261,000 a year ago. Earnings before interest, taxes, depreciation, and amortization (EBITDA) has also worsened from -\$220,000 to -\$646,000, compared to +\$591,000 a year ago.

Proactive actions in making the necessary cost-reduction steps and consolidating our facilities have paid off

"We continue to expect the balance of the year to be challenging... We do not anticipate top-line revenue to meet our 2009 guidance, predominantly due to the continued softness in capital expenditures resulting from the recession," says Kurtz.

However, he believes that the firm has hit the bottom of the revenue decline and expects to slowly return to growth, driven mainly by the HSOR [high-speed optical receiver] and Terahertz product platforms. "Our new Terahertz contract for the F-35 announced last month will strengthen our application product development in the aerospace and industrial markets, and we will continue to develop the next-generation 100G HSOR products that will be shipping in the coming quarters," says Kurtz. "While the recession's impact on our revenues has been severe this year, we expect to resume our organic growth in fiscal-year 2011, when capital expenditures begin to return to normal levels."

www.advancedphotonix.com

Picomatrix amends Michigan facility lease, saving \$1.6m

Advanced Photonix Inc (API) says that its subsidiary Picomatrix LLC has entered into a 'Fourth Addendum & Extension Agreement' for the lease of its facility in Ann Arbor, MI, USA.

The 50,000ft² plant houses research, development and manufacturing for its terahertz and high-speed optical receiver (HSOR) product platforms, API's corporate headquarters, and the semiconductor microfabrication facility for all three of Advanced Photonix's product platforms (optoelectronic solutions, HSORs and terahertz instrumentation). The facility was completed in 2001 and was designed to meet the unique requirements of its ultra-fast optoelectronic product platforms, including indium phosphide

and gallium arsenide material growth, semiconductor micro-fabrication, and precision hybrid assembly and high-speed test. In addition, the plant includes an HSOR laboratory and three secure user laboratories for collaborative terahertz application development.

In 2001, the firm entered into a 10-year lease with two 5-year options to renew at a lease rate tied to the CPI (consumer price index), with a minimum increase for each 5-year option. The original lease included the first right of refusal to purchase the facility and was scheduled to expire on 31 May 2011. The firm has now amended the lease terms and extended the expiry to 31 May 2021. The new arrangement represents a 19% reduction in lease payments over

the new term (about \$1.6m in savings). It has also retained the right of first refusal to purchase the property during the new lease term. In addition, it has negotiated an option to purchase the facility on 31 May 2016 for no less than \$7.1m.

"This represents a significant cost saving for the company in these challenging economic times, preserves our substantial investments in this unique facility, and ensures our ability to make future investments to support our long-term growth objectives without the expense and disruption of relocating to another facility," says API's chief financial officer Rob Risser. "We expect the savings to begin to be reflected in our results in the first quarter of 2010."

III-V opto foundry CST acquires laser maker Intense's UK assets

Expansion driven by sensing, energy and medical markets

Compound Semiconductor Technologies Global Ltd (CST) of West of Scotland Science Park, Glasgow, UK has acquired the UK fabrication assets (in Hamilton, near Glasgow) of Intense Ltd, which makes single- and multi-mode monolithic laser array products and high-power laser diodes.

As part of the transaction, Intense will retain a minority stake in CST, which was formed in 1998 by the universities of Strathclyde and Glasgow together with Scottish Enterprise and which claims to be the only 'pure play' foundry supplier of III-V optoelectronics wafers and chips.

CST says that the acquisition is in line with its expansion strategy, underpinned in May 2009 by finance worth £4m (£2.15m of new investment and the restructuring of £1.85m of long-term debt) from the private equity fund

European Digital Partners (EDP), Scottish Enterprise's co-investment fund, and the Scottish Government's Regional Selective Assistance (RSA) scheme. The acquisition also further strengthens CST's optoelectronics foundry business model with new technical capability, engineering resources and production capacity. The deal will allow CST to consolidate all production activities in Hamilton and extend its existing contract laser manufacturing relationship with Intense.

The acquisition further strengthens CST's optoelectronics foundry business model with new technical capability, engineering resources and production capacity

"This is a natural progression of the acceptance of the favourable economics of the foundry business model in the optoelectronics sector," says CEO Neil Martin. "It also affirms our long-held belief in the 'pure-play' foundry," he adds.

"We are seeing solid growth in established markets such as FTTH [fiber-to-the-home] and defense, which has supported our expansion in the current recessionary period," Martin continues. "Increased capacity is required to support further growth in these markets and to allow us to develop new foundry offerings for emerging technologies driven by 'cleantech' applications in sensing, energy and medical markets," he adds. "We are investing now in order to be ready to take advantage of new opportunities that will certainly emerge through the global economic recovery."

www.compoundsemi.co.uk

Intense announces new executive appointments

Intense has appointed Berthold Schmidt as CEO. He replaces Scott Christie, who has become executive chairman of the board of directors.

In his new role as CEO, Schmidt has promoted Kevin Laughlin to chief commercial officer, widening Laughlin's current remit to take global responsibility for all business development, sales, and marketing activity.

"Berthold joined Intense in 2008 and has made a significant contribution to the development of the company since," says Christie. "I am delighted that someone with his reputation in the market and strong blend of technical and commercial skills is in place to



CEO Berthold Schmidt (top left), executive chairman Scott Christie (top right) and chief commercial officer Kevin Laughlin.

drive the business forward globally. I am also pleased to see that he

has moved quickly to shape his management team," he adds.

"Intense is at an interesting point in its development, having recently sold its UK front-end fabrication unit [to Glasgow-based III-V optoelectronics foundry Compound Semiconductor Technologies Global Ltd] and started the process of consolidating all product line development and manufacturing into its New Jersey, USA site [in North Brunswick]," says Schmidt. "The business operates across the defense, medical, industrial, and print markets with increasingly high-performance laser modules and systems," he adds.

www.intenseco.com

QPC lasers claim record power and brightness at 1410–1550nm eye-safe wavelengths

At the SPIE Photonics West 2010 exhibition in San Francisco (26–28 January), Laser Operations LLC of Sylmar, CA, USA, which makes the QPC product line, launched lasers with what are claimed to be record power and brightness operating at 'eye-safe' wavelengths of 1410–1550nm.

The firm has shipped the first fully collimated 10kW CW wavelength-stabilized Brightlock stack array. It also announced brightness and efficiency improvements across the Ultra laser module product line, including fiber-coupled modules

producing 125W CW at 1470nm. Laser Operations says that the new performance levels allow the needs of many medical, military, and material processing applications (which previously required solid-state lasers) to be met with low-cost, efficient and compact diode sources.

Laser Operations has leveraged its unique vertically integrated design and manufacturing capabilities to advance long-wavelength semiconductor lasers, says VP sales & marketing Laurent Vaissie. "With our indium phosphide laser chips now achieving 45% wall-plug efficiency,

OEM customers enjoy even higher brightness and lower power consumption from our modules at critical wavelengths such as 1470nm and 1550nm," he adds.

"The underlying technologies that power these achievements have momentum behind them, and we expect considerable continued improvements in the months to come," says founder & chief technology officer Jeff Ungar, adding that the advance points the way to 10–100kW-class eye-safe lasers for military and industrial applications.

www.qpclasers.com

Ultra-G green laser wins Prism Award for Photonics Innovation

As part of the 2nd annual Prism Awards ceremony and banquet at Photonics West (this year marking the 50th anniversary of the invention of the laser), the BrightLock Ultra-G green laser received a Prism Award for Photonics Innovation for 'most innovative laser product of the year'.

Launched by Laser Operations last September, the Ultra-G green laser platform is a visible laser product family based on the firm's proprietary BrightLock monolithic chip

wavelength stabilization technology.

Designed for medical applications, the Ultra-G MEDICA package includes a compact and cost-effective fiber-coupled source delivering more than 3W CW at 532nm in a narrow-core detachable delivery fiber combined with smart medical features such as a low-power aiming beam, fiber detector and removable blast shield for applications in dermatology and ophthalmology.

The Ultra-G is also available as an energy-efficient, compact and

ruggedized package delivering a collimated beam of up to 6W CW of visible green light at 532nm, suited for applications including long-range non-lethal visual disruption applications in defense and law enforcement. Laser display manufacturers developing digital cinema and front projectors can also use the Ultra-G's BrightLock monolithic stabilization technology for stable and passively cooled operation over a wide temperature range.

www.photonicsprismaward.com

Alfalight extends 808nm laser to 3.5W, and launches 879nm and 793nm lasers with wavelength stabilization

Alfalight Inc of Madison, WI, USA, which makes high-power diode lasers for industrial, defense and telecoms markets, has announced the availability of the 808C laser diode series of 3.5W, 808nm devices in a 6-pin package with a 105µm/0.15 NA output fiber (product number XM6-808C-10-353).

The new devices extend the firm's 808nm-wavelength product range with a 40% increase in output power while maintaining a lifetime of 20,000 hours. "Alfalight offers a

significant increase in output power at 808nm with no compromise on our proven reliability standards," says VP sales & marketing Ron Bechtold.

The 808nm series includes a 3W version (XM6-808C-10-301) integrating Alfalight's proven Wavelength Stabilization Technology (WST), which offers 0.07nm/°C wavelength stability (a factor of five times more stable over temperature than standard semiconductor lasers, it is claimed). WST eliminates the need for precise temperature control

for solid-state laser pumping and other spectrum-sensitive applications.

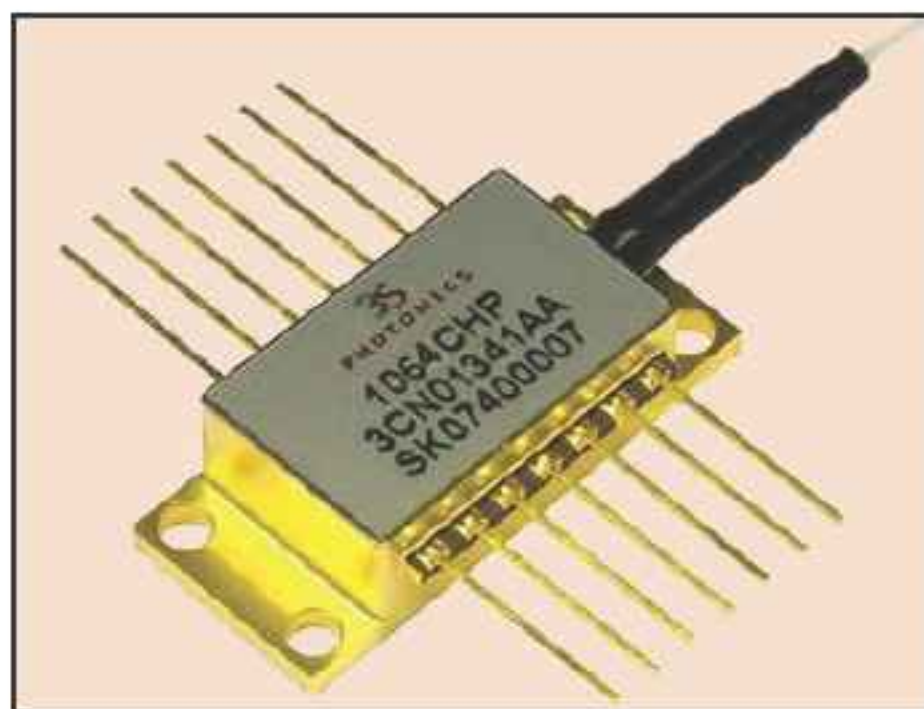
The firm has also announced the addition of new WST products at other increasingly important wavelengths, including a 30W, 879nm combined power module (CPM III) with a 685µm/0.22NA output fiber connector (XC3-879CW-38-301); and a 5W, 793nm 6-pin laser with 200µm/0.15NA fiber connector (XM6-793CW-60-501).

www.alfalight.com

3S demonstrates reliable high-power pulsed operation of 1064nm wavelength-stabilized diode lasers

During a technical presentation at the SPIE Photonics West 2010 event in San Francisco, 3S Photonics of Nozay, France demonstrated reliable high-power pulsed operation of its 1064nm wavelength-stabilized diode lasers.

Most pulsed fiber lasers are built on a master oscillator—power amplifier (MOPA) architecture, says 3S. This configuration has the advantage, among others, of exploiting direct modulation of the diode laser seed (the MO) to reach high repetition rates and high peak-power pulsed operation. To enhance the fiber laser's global performance and reliability, high-power single-lateral-mode 1064nm diodes with outstanding long-term behavior are needed. However, the



3S Photonics' 1064 CHP laser.

reliability of these devices at high power has been a challenge for years, due to the high built-in strain in the quantum well, says the firm.

"The 1064nm single-lateral-mode laser diodes developed by 3S Photonics have demonstrated state-of-the-art reliability results, in

both continuous-wave and pulsed conditions exceeding 1W peak-power at 2.35A," claims Yannick Bailly, VP of marketing & product lines management. "Aging tests in continuous-wave conditions prove the intrinsic robustness of our 1064 CHP seed laser modules even at very high junction temperatures, while specific tests in pulsed operation at 45°C and high repetition rates of several hundred kHz confirm the stability of the devices in accelerated conditions representative of operating applications," he adds.

Both free-running and wavelength-stabilized — using a fiber Bragg grating (FBG) — packaged devices show very stable performance under pulsed conditions, the firm adds.

www.3Sphotonics.com

3S Photonics closes acquisition of Avensys

3S Photonics of Nozay, France, which makes laser chips, optical discrete modules and passive components for telecom networks, has closed its acquisition (announced on 17 December) of optical telecom component firm Avensys Inc (the sole operating subsidiary of Avensys Corp of Montreal, Quebec, Canada), including its two divisions Avensys Technologies and Avensys Environmental Solutions.

3S' acquisition of Avensys Inc — and its 49% stake in ITF Laboratories Inc — is expected to result in a business, operating in both North America and Europe, with product synergies and a much greater ability to expand product lines and services beyond current capabilities.

With staffing of 200, Avensys realized turnover of \$23m in the fiscal year to end June. Avensys Technologies designs and makes optical components, modules and fiber Bragg gratings for the telecom market as well as high-power devices, sub-assemblies

and packaged fiber-based sensors for the industrial market. Avensys Environmental Solutions provides the Canadian market with environmental monitoring solutions and services for air, water, soil and geo-structures. ITF Labs develops integrated photonics solutions as well as components and fiber-based systems for fiber lasers and optical sensing applications.

The staff of Avensys Inc and ITF Laboratories will be retained, and the operations of Avensys Inc will remain at its location in Montreal. 3S' president & CEO Alexandre Krivine is now also president & CEO of Avensys Inc. Hassan Kassi remains president & CEO of ITF, and will also remain chief operating officer of Avensys Inc.

The acquisition accords with the implementation of 3S' external growth strategy that it planned last July after raising €13m from three investment funds: €2.5m from Alto Invest, €450,000 from Midi Capital, and €10m from the French government's Strategic Invest-

ment Fund (Fonds Stratégique d'Investissement, or FSI, formed in November 2008 to help key firms amid the financial crisis).

"Avensys is recognized as a world leader of fiber Bragg gratings and fiber laser technology in a broad range of markets," claims Krivine. "This acquisition will also enable 3S Photonics to address the environmental market through the Avensys Solutions division."

3S and Avensys aim to combine their global sales and marketing channels to leverage each firm's strength in their respective key accounts, enabling them to provide expanded customer service and products.

"We stand to benefit greatly from the synergies with 3S Photonics to step into the market of integrated optics, particularly in telecom and fiber laser markets," reckons Kassi. "The transaction will place Avensys Inc in a better financial position and will enable increased investments in R&D."

www.avensys.com

Oclaro launches 60W 8xx nm fiber-coupled diode laser

At Photonics West 2010, Oclaro Inc of San Jose, CA, USA launched its next-generation Prosario fiber-coupled diode platform, which delivers up to 60W at wavelengths of 8xx nm (40–60W at 808nm; 50W at 880nm) from 400–800µm-diameter fiber in an industry-standard footprint.

A detachable fiber and optional aiming beam make it suitable as a quick and easy drop-in solution for system upgrades (without the cost of changing system architectures). An electrically isolated package allows ease of integration into different system designs.

Similar to the Orion, the Prosario is a highly integrated product family resulting from Oclaro's acquisition last July of Newport Spectra-Physics' high-power laser diodes business.

By combining technologies in device design and proprietary E2 facet passivation from Oclaro's facility in Zurich, Switzerland with packaging technologies from the Spectra Physics wafer fabrication plant in Tucson, AZ, USA, Prosario fiber-coupled diodes deliver what is claimed to be unmatched performance and reliability at a lower price.

Prosario was designed specifically to meet the cost, reliability and performance requirements of the DPSS (diode-pumped solid-state) laser and direct-diode medical and materials processing markets.

Brightness is 0.56mW/cm²*sr from fiber core diameters of 400µm with

a 0.22NA and 600/800µm with a 0.11 NA. Also, next-generation precision micro-optics technology and optimized thermal management at the package output enable operation at higher powers with increased reliability, the firm says.

"Oclaro is now able to serve the entire mid-power fiber-coupled market segment with the Prosario platform addressing the 40W+ market and our recently announced Orion platform [also launched at Photonics West] meeting the needs of the sub-40W space," says executive VP & division manager Yves Le Maitre. "By providing the most comprehensive family of high-brightness fiber-coupled diodes in the industry today, our customers will be able to better serve their markets with the right level of performance, reliability and cost needed for the target application."

Oclaro also unveiled its latest Orion fiber-coupled laser diode, which it claims is the industry's lowest-price/highest-performance 8xxnm fiber-coupled laser diode. The firm reckons that the Orion is half the size and 1.5x the brightness of competing fiber-coupled diode lasers in its category, delivering output of 30W at 808nm and 35W at 880nm, with 95% of the light contained within a 0.15NA from a 200µm diameter fiber (twice the output power of the previous Orion family product).

"Until now, there has been no product to effectively serve the

mid-power fiber-coupled market with the right level of brightness, low cost, robustness and reliability," says Scott Dunbar, general manager of Oclaro's High Power Laser Diode portfolio. "The Orion platform is designed to meet all of these needs and allows DPSS laser systems to maintain their competitive edge against fiber laser systems."

The latest Orion is the first integrated product resulting from Oclaro's acquisition of the Spectra-Physics' high-power laser diode business.

Oclaro says that Orion suits DPSS laser, direct-diode medical and industrial materials processing applications that demand higher power and brightness, lower cost and smaller form factors.

In particular, the form-factor allows the design of smaller solid-state lasers at lower cost and with more functionality. Also, advanced hermetic packaging improves robustness and reliability, claims the firm. Orion's 'mini-bar' design produces brightness of >1.5mW/cm²*sr, enabling new architectures and easier system tolerances.

Oclaro says that it now offers two next-generation product platforms to serve the entire mid-power fiber-coupled market segment. Orion suits the sub-40W market, while Prosario addresses 40W+, resulting in what is claimed to be the most extensive product range of high-brightness, fiber-coupled diodes.

www.oclaro.com

Oclaro boosts 808nm single-emitter pump module to 7W

Oclaro unveiled a fully qualified, uncooled 808nm single-emitter pump module that delivers a minimum 7W from a 200µm core fibre (1W more than the prior version), designed to meet greater power and reliability demands of Nd:YAG solid-state lasers for material processing and medical markets.

Now in full volume production, the module includes the latest-generation multimode 808nm

pump laser chip that has undergone a 5000hrs accelerated life test and, operating at increased power conditions, reached lifetimes of more than 200,000hrs mean time to failure (MTTF).

"Our new single-emitter modules allow customers to upgrade their existing systems with increased power and reliability without the prohibitive cost of changing pump source footprints and internal

design configurations," says division manager Yves Le Maitre. "This will enable customers to quickly and cost-effectively get to market with higher-performing products."

The module uses the same hermetically sealed package platform as single-emitter fiber laser pumps, enabling high-volume, scalable and cost-effective manufacturing. Devices are also available as a chip-on-submount or chip-on-C-Mount.

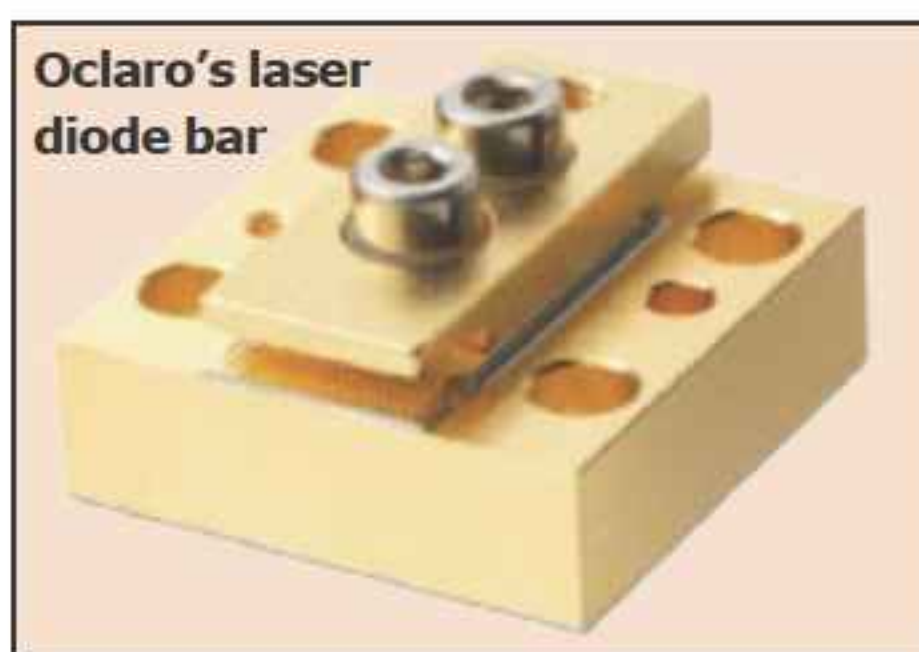
Oclaro claims brightest and most powerful conductively cooled laser diode bars, with fill factor reduced to 20%

Oclaro showcased two new conductively cooled laser diode bars: a 80W 20% fill-factor bar and a 50W 18% fill-factor 'half-bar'.

High brightness in the 9xx nm to 10xx nm wavelength range simplifies the design and reduces the overall costs for equipment in multi-kilowatt direct diode applications, fiber laser pumping, medical and industrial manufacturing applications, says the firm.

Oclaro says that it has used its expertise in epitaxial design and mounting technology to reduce the filling factor of the 80W bar from 30% to 20%, while maintaining the output power of 80W and increasing the brightness by 50%. The 50W 'half-bar' delivers even greater brightness and, due to the reduced bar width, can offer much smaller smile values well below 1 μ m. Both products are conductively cooled mounted with hard solder on an industry-standard CS type assembly that is fully compatible with previously released products.

Both new products reach conversion efficiencies greater than 60%



at their operation points of 50W and 80W, making them very power efficient and saving costs related to power and heat management, says Oclaro. The small slow-axis divergence and small emitter width suits fiber-coupling and beam-shaping application in single- and multi-bar configurations. The wide wavelength range from 910nm to 1070nm enables wavelength combining for power scaling to multi-kilowatt levels.

The firm says that the new laser diode bars allow coupling to smaller fibers, as well as less stringent tolerances for alignment of beam shaping optics. They also reduce fiber-coupling losses by enabling smaller spot sizes, which increases

overall efficiency and has a positive impact on cooling requirements for fiber couplers and system. Smaller and more compact systems can hence be created that leverage industry-standard components and automated processes, minimizing system complexity and decreasing cost.

"By offering an unparalleled combination of brightness, high power and cost savings in our laser diode bars, we believe our customers will deliver a new generation of advanced direct diode systems, fiber laser pumps and medical products," says Yves LeMaitre, executive VP & division manager.

Also, similar to all Oclaro high-power laser products, the front facet of the bar is protected against catastrophic optical damage by the firm's E2 mirror passivation process. In addition, telecom-grade AuSn (gold tin) hard solder makes the product suitable for demanding industrial and defense applications in both continuous-wave (CW) and hard-pulse operation modes.

www.oclaro.com

Oclaro reports 550W output for QCW-mode laser diode bars

Lead design engineer Jurgen Muller of Oclaro presented new results on high-power laser diode bars operating in quasi continuous wave (QCW) mode that demonstrate what are claimed to be significant performance improvements, delivering output power of more than 550W at 200 μ s pulse width and wall plug efficiency levels of more than 65%.

"The scalability of the high-power CW bar design to pulsed operation modes over a wide wavelength and temperature range will be a valuable feature in the solid-state laser pumping, laser illumination, direct-diode material processing, and medical markets," reckons R&D director Norbert Lichtenstein. The new dataset comprises



results for an extended wavelength range from 808nm to 1080nm at temperatures up to 70°C. For 808nm laser diodes on a conductively cooled standard CS-type assembly, up to 580W was measured at 500 microseconds and about 1% duty cycle. Similar results were achieved with 9xxnm laser diode bars. The latter were also assembled on a compact

sandwich assembly with a footprint of just 12mm x 10mm and a height of 4.7mm. This device was operated up to >400W at 6% duty cycle and 25°C.

Oclaro also presented five technical papers at the associated symposium LASE 2010:

- 'CW to QCW power scaling of high-power laser bars';
- 'Eye-safe high-power laser diode in the 1410–1550 nm range';
- 'Reliable operation of 8xx mini-bar-based hermetic modules';
- 'Extending the wavelength range in the Oclaro high-brightness broad area modules'; and
- 'Novel single-mode fiber-coupled broadband seed source for pulsed fiber laser systems'.

Oclaro grows 10%, driving cash generation and investment

For its fiscal second-quarter 2010 (ended 2 January), Oclaro Inc of San Jose, CA, USA, which makes optical components and modules for communications, industrial and consumer applications, has reported revenues of \$93.6m. Even allowing for \$300,000 after mid-December's acquisition of Xtellus Inc of Denville, NJ, which makes wavelength selective switching (WSS) products for reconfigurable optical add/drop multiplexers (ROADMs), this is above late October's guidance of \$87–92m and mid-December's raised guidance of \$91–93m.

Revenue is also up 10% on \$85.1m last quarter and more than double \$43.4m a year ago. However, the latter follows the formation of Oclaro on 27 April from the merger of San Jose-based Bookham Inc with Avanex Corp of Fremont, CA. It is also affected by July's acquisition of the high-power laser diode business of Newport Spectra Physics (in exchange for laser and photonics components supplier Newport Corp of Irvine, CA acquiring Oclaro's Advanced Photonics Solutions division's New Focus business).

Of fiscal Q2's revenue, the Advanced Photonics Solutions business contributed \$11.3m, up 4.5% on \$10.8m last quarter. Telecom revenue was \$82.3m, up 11% on \$74.2m last quarter (including growth in both the Transmission and the Regeneration & Optical Routing segments).

On a non-GAAP basis, gross margin has risen from 17.9% a year ago to 26.1% last quarter and now 26.8%. Adjusted EBITDA has improved to \$4.3m, from \$4.1m last quarter and minus \$3.3m a year ago.

Though still down on \$3.3m a year ago, non-GAAP net income was \$2.1m, up on break-even last quarter. During the quarter, after capital expenditure of \$1.6m and

using \$2.9m in cash for restructuring expenses, Oclaro's cash balance grew from \$52.5m to \$56m.

"Generating positive cash flow, on top of 10% sequential revenue growth, in our second full quarter since the creation of Oclaro is a significant accomplishment," says president & CEO Alain Couder, who thanks staff for their contribution during the downturn and the extra effort to execute on integration (leading to \$1.5m of bonuses being approved for non-executive staff in the March 2010 quarter). "From a strategic perspective, we took steps to acquire Xtellus Inc and secure the WSS technology critical to our product portfolio."

For its fiscal third-quarter 2010 (ending 3 April), Oclaro expects revenue to rise 3.5–9% to \$97–102m (including \$2–3m of Xtellus-related revenues). "We expect to grow our revenue and are driving to increase our gross margins in what is traditionally a seasonally weaker March quarter," says Couder. Non-GAAP gross margin should be 26–29%, tempered by half of the annualized price erosion of 15%

impacting the March quarter (as the industry shifts from renegotiating pricing twice a year, in December and June, to just once a year in December). "Improving our gross margins in the quarter when our industry experiences the bulk of its

Improving our gross margins in the quarter when our industry experiences the bulk of its annual pricing re-negotiations would demonstrate our ability to continually drive costs out of our products

annual pricing re-negotiations would demonstrate our ability to continually drive costs out of our products and leverage our global skill and infrastructure," notes Couder. In addition, adjusted EBITDA should be \$4–7.5m.

In fiscal Q3, capital expenditure should rise above \$3m as Oclaro invests in R&D (expecting to see revenue from VCSELs related to Intel's LightPeak technology in late 2010) as well as building inventories to enable the firm to respond to demand. Oclaro therefore expects to consume cash. Nevertheless, the cash balance should be maintained over \$50m, helped by cutting operating expenditure by \$0.5–1m.

In particular, integration of acquisitions is on track, with the Spectra Physics' high-power laser diode wafer fab in Tucson, AZ due to be closed by the end of March (via consolidation into Oclaro's fabs in Caswell, UK and Zurich, Switzerland). Also, closure of the former Avanex site in Bangkok, Thailand is underway, with most staff being relocated to the nearby site of Avanex's subcontract manufacturer Fabrinet. Couder estimates that the 'wrap-up' of synergies from such integration should add between two and three percentage points to gross margin, reaching the firm's target of 30% in the quarter to end-June. The next target is 35%.

Couder comments that Oclaro is targeting Xtellus-related revenue of \$17–23m for the coming year. However, to grow revenues further, he says that the firm could consider further acquisitions, including in non-telecom sectors (to extend its available market). Nevertheless, the focus remains first on making progress on manufacturing execution beyond the current phase of integration, he stresses.

www.oclaro.com

Oclaro acquires wavelength selective switch firm Xtellus

In response to demand for a total solution including wavelength selective switches (WSS) products to aid regeneration and routing needs, optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has acquired Xtellus Inc, which is based in Denville, NJ, USA (with manufacturing and development facilities in Israel and South Korea).

Xtellus provides a family of WSS products capable of powering reconfigurable optical add/drop multiplexer (ROADM) applications over the entire optical network, from the edge to the core. Combining this WSS portfolio with Oclaro's integrated subsystem design capability gives the firm a strong position in the high-growth ROADM market, Oclaro reckons.

As well as being one of the fastest-growing segments of the optical component market, the WSS acquisition completes Oclaro's portfolio of product areas required to support strategic positioning throughout the metro and long-haul areas of the telecom market.

Oclaro says that Xtellus uses a strategic mix of core technologies, both liquid crystal and MEMS, that will uniquely enable it to deliver a complete family of scalable WSS to power ROADM applications across edge and core optical networks. Smaller-port-count edge WSS applications, where managing product costs aggressively is a key to success, are based on liquid crystal technology. For core WSS applications, Xtellus uses a combination of high-reliability 1-Axis MEMS to switch across high port counts, while also maintaining liquid crystal for attenuation.

Xtellus stockholders will receive shares of common stock of Oclaro worth \$33m, part of which will be held in escrow for 18 months to support Xtellus' indemnification obligations to Oclaro. The agreement also provides for a value guarantee under which stockhold-

Xtellus provides WSS products capable of powering ROADM applications

ers could receive additional consideration of up to \$7m if Oclaro's common stock trades below certain levels at the end of 2010 and if Oclaro's revenue from Xtellus products is more than \$17m in 2010.

The agreement also calls for a retention program under which certain staff will receive up to \$5m in a combination of cash (a maximum of \$1m, to be paid upon close) and restricted stock awards which will generally be subject to time-based vesting and partially subject to the conditions of the value guarantee.

Oclaro expects that, in terms of non-GAAP operating income, Xtellus' operations will be close to breakeven in each of the first two quarters of calendar 2010, generating gross margins consistent with Oclaro's corporate targets, and moving into positive non-GAAP operating income in second-half 2010. Any Xtellus-related net cash burn in 2010 is expected to be largely limited to the working capital required to support their corresponding revenue ramp.

www.xtellus.com

Oclaro receives supplier awards from Fujitsu and Huawei

At the Fujitsu Suppliers' Reception 2010 on 26 January, Oclaro received the Distinguished Partner Award from Japanese optical and wireless networking solutions provider Fujitsu Ltd in recognition of its contribution to the development and production of optical gain blocks (incorporating Oclaro's pump lasers) for Fujitsu Network Communications Inc of Richardson, TX, USA.

"It was important to Fujitsu to partner with a supplier that could deliver the industry-leading optical solution that we require for our customers," says T. Touge, president of Fujitsu Ltd's Network Product business unit. "Oclaro was able to collaborate effectively with our team to deliver products that met those requirements in the

time frame we needed," he adds.

Oclaro's president & CEO Alain Couder attributes the firm's ability to meet Fujitsu's price performance and schedule requirements to its component portfolio and design capabilities.

Also, in December, Oclaro received the Excellent Core Partner Award from telecom equipment maker Huawei Technologies Co Ltd of Shenzhen, China at the Huawei 2009 Core Partner Convention. Oclaro was the only supplier in the Optical category to receive the award.

Oclaro says that the award represents its fifth significant vendor recognition from Huawei in recent years, reflecting its consistent delivery of high-performance, high-reliability products and the

quality of its customer service.

"As one of the industry's top vendors with global sales to the world's largest carriers, Huawei is a very important and strategic customer," said Couder.

"Customers need reliable suppliers who can consistently deliver quality products with short lead times and add real value with local sales support; we achieve this through the combination of our ownership of core technologies and manufacturing facilities," he claims. The firm says that it is also working to partner with customers on new product designs, technical support, quality assurance and development planning.

www.huawei.com
www.oclaro.com

EU CMOS photonics project achieves phase-one goals

Grenoble-based CEA-Leti (the French government's Laboratory for Electronics & Information Technology), which coordinates the pan-European consortium HELIOS (pHotonics ELectronics functional Integration on CMOS), says that the 19 partners have met or exceeded their phase-one goals for the large-scale CMOS photonics project.

Launched by the European Commission in May 2008 within the Information and Communication Technologies (ICT) theme of its 7th Framework Program (FP7), the €8.5m, four-year project is designed to drive European R&D in CMOS photonics and to pave the way for industrial development. Specifically, it aims to develop microelectronics fabrication processes for integrating compound semiconductor-based photonics with CMOS silicon circuits and to make the technology available to a wide variety of users.

Partners include CNRS, Alcatel Thales III-V lab, Thales, University of Paris-Sud, 3S Photonics and Photline Technologies in France, IMEC in Belgium, Phoenix BV in Holland, IHP and the University of Berlin in Germany, Austriamicrosystems and the University of Vienna in Austria, IMM and the University of Trento in Italy, the University of Valencia, the University of Barcelona and DAS Photonics in Spain, and the University of Surrey in UK. The overall project cost is €12m.

"Europe has a well-established photonics components industry and it is strategically important for us to maintain photonic chip design and chip-integrating functions that provide new opportunities for our microelectronics companies and enable us to compete with other countries," says Leti's CEO Laurent Malier.

"HELIOS combines the advanced, upstream research on CMOS photonics from leading research laboratories and universities with the commercialization expertise of some of Europe's leading technology companies that will make this

technology commercially viable," he adds.

First-phase achievements have concentrated on light photodetection and light coupling/routing.

Completed milestones include:

- the characterization of vertical and lateral PIN Ge and III-V MSM photodetectors (showing low dark current, high optical responsivity and high optical bandwidth compatible with 40Gb/s operation);
- demonstration of germanium photodiode bandwidth of 90GHz;
- demonstration of inverted taper coupling structure with 1dB loss;
- design and fabrication of a transition between rib/strip waveguides with less than 0.2dB measured loss;
- demonstration of a high-efficiency grating coupler showing a coupling efficiency of -1.6dB and a 3dB bandwidth of 80nm;
- more than 30 publications in international conferences or journals; and
- organization of a winter school and two international events.

The project's success in developing microelectronics fabrication processes for integrating photonics with CMOS circuits would cement Europe's role as a global leader in emerging CMOS photonics technology, says Malier. It should also have a major impact on industry, e.g. by leading to low-cost solutions for applications including optical communications, optical interconnections between chips and circuit boards, optical signal processing, optical sensing, and biological applications. By co-integrating optics and electronics on the same chip, high-functionality, high-performance and highly integrated devices can be fabricated, while using a proven microelectronics fabrication process. In addition, advances in CMOS photonics should move the emphasis from device component to architecture. Industrial and R&D efforts can then be focused on new products or new functionalities rather than on the technology level.

HELIOS includes the development of essential building blocks such as

efficient sources (silicon-based and heterogeneous integration of III-V on silicon), fast modulators and, more long term, the combination and packaging of these building blocks for the demonstration of complex functions to address various industrial needs. These include a 40Gb/s modulator on an electronic IC, a 16x10Gb/s transceiver for WDM-PON applications, a photonic QAM-10Gb/s wireless transmission system, and a mixed-analog and digital transceiver module for multi-function antennas.

Other priorities of the project are:

- the development of high-performance generic building blocks that can be used for a broad range of applications, ranging from WDM sources by heterogeneous III-V/silicon integration, fast modulators and detectors, passive circuits and packaging;
- building and optimizing the entire supply chain to fabricate complex functional devices (photonics/electronics convergence will be addressed at the process level and also at the design level as HELIOS helps to develop an adequate design environment);
- investigating promising approaches that offer advantages in terms of integration on CMOS for next-generation CMOS photonics devices; and
- roadmapping, dissemination and training to strengthen European activities in this field and to increase awareness of new users about the potential of CMOS photonics.

As the coordinator of HELIOS, which includes nearly 60 researchers from member organizations, Leti is responsible for the project's technical, administrative and financial management and for day-to-day technical monitoring, direction and progress. Leti is also a key contributor to the development of building blocks and integration processes that are part of HELIOS.

www.helios-project.eu

www.leti.fr

Luxtera and Siemon co-developing active optical cabling for data center infrastructure

Network cabling firm Siemon of Watertown, CT, USA has integrated 40Gb/s active optical cable (AOC) of Luxtera Inc of Carlsbad, CA into its product portfolio in order to expand and enhance its data center solutions and services.

Siemon says that it selected fabless firm Luxtera for its ability to combine silicon CMOS photonics technology and high-performance, low-cost single-mode fiber. The CMOS photonics use an integrated optoelectronic chip with a directly attached fiber and a micro-packaged laser. Siemon says that the 'fiber to the chip' technology enables its Moray active optical cabling to break the cost barriers and distance restrictions associated with existing vertical-cavity surface-emitting laser (VCSEL) and multi-mode fiber solutions. Unlike traditional optics that use VCSELs

and multi-mode fiber for short connections, Luxtera's silicon CMOS photonics-based single-chip transceivers support any distance from 1m to 4000m for inter- and intra-building connections while decreasing the number of components in the active optical cable and improving its reliability.

"By collaborating with Siemon, we can deliver to customers a complete data center infrastructure that includes our high-performance, low-cost transceiver technology," says Luxtera's VP of marketing Marek Tlalka. "Using silicon photonics transceiver technology along with single-mode fiber transmission media, Siemon is able to offer a cost-effective cable that delivers high-performance connectivity as well as increased reliability and extended distance," he adds.

"Luxtera has proven to be a for-

ward-thinking company, particularly with its utilization of silicon CMOS photonics technology and single-mode fiber," says Siemon's business development manager Ed Cady. "Luxtera's technology made it easy to seamlessly add value to our product portfolio of data center infrastructure solutions."

Siemon's first AOC offering is a four-lane QSFP (quad small-form-factor pluggable) 40G active optical cabling family that supports Ethernet switch, FibreChannel SAN storage, InfiniBand server systems and several other IO interface links between various blades, boxes, racks, containers and buildings.

Siemon showcased its product portfolio (including Moray AOC) at the DesignCon event in Santa Clara, CA (1-4 February).

www.siemon.com

www.luxtera.com

IPG acquires Photonics Innovations

High-power fiber laser and amplifier maker IPG Photonics Corp of Oxford, MA, USA has acquired Photonics Innovations Inc (PII) of Birmingham, AL, which makes active and passive laser materials and tunable lasers for scientific, biomedical, technological, and eye-safe range-finding applications.

The acquisition allows IPG to expand its product range to the mid-infrared (wavelengths of 2-5 μ m). PII's core capabilities include optical and laser materials fabrication, solid-state and tunable laser design, and optical and sensing systems development.

PII was established in 2007 by researchers at The University of Alabama at Birmingham (UAB) to apply proprietary and patented optical materials, lasers, and spectroscopic technologies to the development and commercialization of optical sensing instruments

in rapid sensing, identification, and quantification of agents and materials. In addition to active and passive laser materials and tunable lasers, PII develops mid-IR microchip and external-cavity broadly tunable light sources for scientific, sensing, medical and defense applications.

"With the acquisition of Photonics Innovations, we plan to enhance IPG's product portfolio in the middle-infrared spectral range — an exciting emerging market," says IPG's chairman &

With the acquisition of Photonics Innovations, we plan to enhance IPG's product portfolio in middle-infrared spectral range — an exciting emerging market

CEO Dr Valentin Gapontsev. Combining IPG's fiber laser technology with PII's proprietary transition-metal-doped zinc sulfide (ZnS) and zinc selenide (ZnSe)-based crystal laser materials has opened up opportunities to build new hybrid laser sources in the 2-5 μ m wavelength range, he adds. "Both companies have complementary expertise.... We look forward to integrating our similar entrepreneurial cultures," says Gapontsev.

"The combined company now has significantly more resources and the ability to target many new applications in biomedical, sensing, instrumentations, advanced systems, and material processing," says PII's president Dr Sergey Mirov. "IPG is a natural strategic fit for PII, and we believe this will benefit both companies' customers."

www.ipgphotonics.com

www.photonicsinnovations.com

IN BRIEF

GigOptix hires VP of optical comms sales

GigOptix has recruited Jay de la Barre as its new VP of optical communications sales.

Also, Elie Massabki, who was VP of sales & marketing and general manager for the CX product line, is now VP of RF & ASIC sales. Vivek Rajgarhia, VP of global sales of GigOptix Inc, has resigned.

"Addition of Jay to the GigOptix family and the reassignment of Elie solidifies our new sales approach internationally as part of our long-term growth strategy and improved operating efficiency," says CEO & chairman Dr Avi Katz.

"We grew our business to serve three major vertical markets including optical communications, instrumentation and defense that are all fed from the same product technology platform of high-speed RF, analog and mixed-signal devices. Our new sales approach will allow us to address all customers in each of the market segments more efficiently," he adds.

"This strategy will prove beneficial to our customers, the industry as a whole, and help garner additional new business," Katz believes.

"With Jay's recognition in the industry, he will make an immediate impact in our endeavor to grow the company and I look forward to the new business developments that he will bring."

de la Barre has over 20 years of experience in semiconductor sales. Prior to joining GigOptix, he was director of North American and European sales at Sierra Monolithics, which specializes in mixed-signal design. From 2002 to 2004, he was director of marketing signal source at Vari-L Company, which was acquired by Sirenza Micro Devices, where he was responsible for RF microwave module sales in Asia. de la Barre has a degree in Business Administration from Regis University.

GigOptix outlines 2010 strategy

GigOptix has provided an update on its strategic plan for 2010.

"2009 was another eventful year for GigOptix as we continued to emphasize and focus on executing both our organic and strategic growth initiatives," says chairman & CEO Dr Avi Katz. "Over the past several years it has been our strategy to identify and acquire businesses with synergistic qualities in markets vertical to our core business, with a strong product and customer base and advanced intellectual property, along with other valuable assets," he adds. These acquisitions include iTerra Communications LLC (a manufacturer of amplifiers and modulator driver ICs) in July 2007, Helix Semiconductors AG of Zurich, Switzerland (a manufacturer of transimpedance amplifiers, limiting amplifiers, and VCSEL drivers) in January 2008, and Lumera Corp of Bothell, WA, USA (a manufacturer of polymer electro-optic modulators) in December 2008.

This strategy culminated last November with the firm's largest acquisition so far, ChipX Inc of Santa Clara, CA, a privately held fabless supplier of analog and mixed-signal custom application-specific integrated circuits (ASICs) including standard cell, structured ASIC and hybrid ASIC technology.

"ChipX more than doubled 2009 revenue on a pro forma consolidated basis and brings an attractive set of valuable customer relationships, providing us the opportunity to cross-sell existing products,"

Katz says. GigOptix has begun restructuring and integrating ChipX to deliver cost reductions through physical consolidation of the firm's headquarters in the Bay Area, elimination of redundancies, cost reductions of service and tools, and sizing the organization appropriately.

"Although only a few months removed from the closing of this acquisition, integration has gone well and we have already begun to see the financial benefits during the first quarter of 2010," Katz reports.

GigOptix says that it has recently made progress expanding its existing product and customer base, which the company reckons should deliver opportunities for revenue growth in 2010. Highlights include:

- increasing traction with Government agencies (receiving an award of \$4.5m sponsored by the Air Force Research Laboratory to develop integrated driver and polymer modulator technology to support terabit networks — with most work expected to be performed in 2010);
- continuing to maintain strong ties with the US Government, military and other governmental agencies (expecting to receive more contracts in the future);

- launching a new family of TIAs for optical receivers (to complement the firm's optical drivers);

- winning key contracts with several major customers to supply GX6120 electro-absorption modulated laser drivers, GX6155 Mach-Zehnder modulator drivers, and the HX family of parallel drivers and receivers for use in active optical cables including optical HDMI (with particularly strong traction with customers in Asia); and

- progress in sales of 100G polymer modulators for research applications and extending the temperature stability of EO polymer with the introduction of the M3 material (with the product having passed Telcordia-level testing and now being used in the latest 40G and 100G modulators to be released this year).

"In conjunction with our integration of ChipX, our acquisition strategy, and continued organic growth plans, we have materially enhanced our management team," continues Katz. New chief financial officer Ron Shelton (appointed in December) and VP of optical communications sales Jay de la Barre both bring strong financial and industry experience that will play critical roles in GigOptix's growth, he adds.

GigOptix says that it will report its fiscal 2009 results in March.

www.GigOptix.com

GigOptix's 45G differential limiting amplifier enters mass production

GigOptix Inc of Palo Alto, CA, which designs modulator and laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials as well as polymer electro-optic modulators, says that its GX3440, a 45Gb/s differential limiting amplifier announced in April 2009, is now shipping in full production.

The GX3440 was designed to be used in 40G DPSK (differential phase-shift keying) and 40G DQPSK (differential quadrature phase-shift keying) telecom receivers and can also be used in instrumentation applications.

GigOptix says that it is the first of its family of differential and transimpedance amplifiers to be released to production this year that comprehensively addresses customers' requirements for telecom and datacom receiver amplifier solutions.

Key features of the GX3440

include: low power dissipation, high input sensitivity, broad bandwidth to accommodate up to 44.6Gb/s, and large differential output voltage.

"The design and development for this high-performance 40G DPSK balanced receiver was driven by a leading Japanese 40G ROSA [receive optical sub-assembly] manufacturer based on our proven history of producing high-speed designs," says chief technology officer Andrea Betti-Berutto. "The GX3440's high-performance design enables our customer to meet the exacting requirements of 40G telecom receivers."

In its latest transceiver and optical interconnects market morecast, market research firm Lightcounting predicts strong market growth at a compound annual growth rate (CAGR) of 70% for the 40G market segment through 2013.

www.GigOptix.com

PMDs launched for flip-chip assembly

GigOptix has announced volume availability of flip-chip versions of its HXT/R4 family of parallel physical media dependent (PMD) ICs.

Available in 4- and 12-channel variants, they have been validated for use at extended data rates, allowing support for multiple applications from 5 to 12.5Gbps/channel. Robustness of design and feature set allow optimum tradeoff between power dissipation for each optical link, as demonstrated by running a 100m link with under 100mW total power dissipation, says the firm.

"These devices support the request from the market for ever increasing performance and assembly yield while reducing the cost of the optical interconnects," says Joerg Wieland, VP & general manager of GigOptix-Helix. "Flip-chip technology is a further step in providing the best solutions in the market as data rates continue to rise."

Millionth PMD IC shipped for parallel optical interconnects

GigOptix has shipped its 1 millionth production chip for multichannel optical interconnects.

The firm says its HX product line — rooted in GigOptix-Helix AG in Zurich, Switzerland — has been a pioneer in parallel high-speed technology since the 1990s and has provided devices supporting the evolution of standards and multi-source agreement (MSA) form factors like SNAP12 and QSFP.

The 1 million physical media dependent (PMD) ICs shipped in the last few years address datacom applications and, with increasing volumes, industrial and consumer applications such as DVI/HDMI active optical cables (AOCs).

"I have been personally involved in the development and spreading of a new technology since I founded Helix Semiconductors in 1990," says GigOptix-Helix's VP & general manager Joerg Wieland.

"We expect the market to grow at an accelerated rate as optical interconnects are being used in many more applications, including desktop and even mobile devices," he adds. "Since we are able to continuously reduce the size, cost and power consumption with the latest design techniques and process technologies, we keep creating new high-growth opportunities. We are overwhelmed by the interest and adoption of key datacom and consumer electronics global customers."

GigOptix's vertical-cavity surface-emitting laser (VCSEL) driver and TIA arrays enable the implementation of optical interconnects for both datacom and consumer applications. 1x, 4x and 12x TX/RX solutions are available with transmission rates up to 150Gb/s aggregate and power dissipation of lower than 10mW for

a 10Gb/s channel.

The PMD IC market is predicted to see considerable growth in the coming years as multichannel optical interconnects increase penetration in datacenters, as they provide speed, reach, reduced power consumption and ease of installation beyond what can be achieved with copper cables. According to market forecast data from LightCounting LLC, the datacom active optical cable segment alone will increase at a compound annual growth rate (CAGR) of 38.5% to \$192m by 2013.

This trend is also expected to extend further to consumer electronics interconnects, including optical versions of HDMI, DisplayPort, USB and Intel's LightPeak, which are likely to achieve notable production volumes by 2012.

IN BRIEF

New CFO for Infinera

In June, Ita Brennan (Infinera's VP, finance & corporate controller) will succeed Duston M. Williams (chief financial officer since June 2006). "Since before our IPO, Duston has helped Infinera through a critical stage in its history as a company, building an outstanding finance group and overseeing the development of an outstanding balance sheet," says executive chairman Jagdeep Singh.

"I have accomplished much of what I set out to do at Infinera — prepared and helped take the company public, built a strong balance sheet and created a strong finance organization that is tightly integrated and highly respected company-wide and within the optical transport industry," says Williams. "A key part of that effort has been the development of Ita Brennan as the next leader of the finance team. Ita and I have worked together closely for the last five years at two public companies."

Brennan has had increasing responsibilities in the finance organization since joining four years ago from disk drive maker Maxtor, where she served in senior financial and operations roles in the USA and Europe. Previously, she was at Informix Software Ireland Corp. Brennan began her finance and accounting career at Deloitte & Touche.

"We have recruited a world-class team, built a company with a unique long-term business model, and I am looking forward to helping to manage our growth and development in the next several years," said Brennan.

"We are delighted to have an executive of Ita Brennan's caliber and experience to lead our finance organization during our next stages of development and growth," says president & CEO Tom Fallon.

Infinera reports 8% revenue growth to \$90m, plus record bookings

For full-year 2009, Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has reported revenue of \$309.1m (down 12.5% on 2008's \$353.4m). However, fourth-quarter 2009 revenue was \$90.2m, up 8% on \$83.4m last quarter (as the recovery continues from Q2/2009's low of \$68.9m) and up 5% on \$86.2m a year ago (on an adjusted GAAP basis).

On a non-GAAP basis (excluding restructuring costs of \$3.3m in Q3 and \$0.5m in Q4 related to consolidating the Maryland-based fab into the main fab in Sunnyvale), gross margin was 40%. This is up from 38% last quarter (and Q2/2009's low of 31%) and above 36% a year ago.

Non-GAAP net loss has more than doubled from \$3.1m last quarter to \$6.5m, although this is better than Q2's \$18.2m and \$9m a year ago. This contributed to full-year 2009 net loss of \$45.4m, compared to net income of \$14.3m in 2008. Cash and cash equivalents fell from \$167m to \$110m during 2009.

"We are pleased with the continuation of our sequential growth in revenues and gross margins in the fourth quarter as well as our record bookings for the quarter and year, reflecting our success in expanding our customer footprint throughout fiscal year 2009," says president & CEO Tom Fallon.

"In the fourth quarter, we invoiced our highest level of tributary adapter modules (TAMs) in six quarters and saw continued strength in our common equipment sales," he adds.

During the quarter, three new customers raised Infinera's customer count to 69. New customers include Tiscali (one of Italy's leading telecom firms), which selected both Infinera's DTN and ATN systems for its nationwide Italian backbone and metro networks. Also, Infinera

shipped equipment for a nationwide build-out for an unnamed leading Internet content provider that was Infinera's top customer in Q4/2009 (after receiving initial orders only in Q3/2009). The other large Q4 customer was Level 3, which con-

The market continues to embrace Infinera's disruptive PIC-based approach of providing the best, most cost-effective and most flexible optical networks to address their bandwidth needs

tributed 12% of revenues (up from slightly less than 10% in Q3). The top five customers included two of the world's largest Internet content providers and two established European customers, as well as Level 3. Also, in addition to previously announced submarine network wins in the Americas with Global Crossing and Telefonica,

Infinera recently won a 6000km trans-Atlantic submarine route with an existing customer.

"We are seeing good opportunities with both current and prospective customers across all served markets," notes Fallon. "The market continues to embrace Infinera's disruptive PIC-based approach of providing the best, most cost-effective and most flexible optical networks to address their bandwidth needs—both with our existing products and the new products on our roadmap," he continues. "To meet these needs, we are committed to continuing to invest in technologies and products that will advance Infinera's technology leadership position across our expanded addressable markets of submarine, ultra-long haul, long haul, metro core, and metro edge."

www.infinera.com

Inphi samples first OIF-compliant 100G coherent TIA

In conjunction with the Fibre Optics Expo (FOE 2010) in Tokyo, Japan (20–22 January), high-speed analog semiconductor firm Inphi Corp of West Lake Village, CA, USA announced the availability of engineering samples of two components unveiled to meet demand for extending 40G applications and emerging 100G applications.

“The pervasive use of the internet, and subsequent evolution of cloud computing, has led carriers and data centers to scale their core networks to the next level, rapidly ramping from 10G to 40G networks and embarking on 100G solutions,” says president & CEO Young K. Sohn. The new 2850TA and 2251TA components provide crucial technologies needed to enable the build-out of 40G and 100G networks, paving the way for the continued evolution of cloud computing and improvements in bandwidth, capacity and power, he adds.

The 2850TA dual-differential linear transimpedance/variable-gain amplifier (TIA/VGA) is claimed to be the first 100G coherent TIA to

be shipped that is compliant with Optical Internetworking Forum (OIF) standards, addressing the emerging demands for next-generation 100G. Coherent detection achieves 100G serial bit rate transmission over existing metro and backbone networks and has been adopted by the OIF. Receiver makers can now build 100G coherent receivers for long-haul and metro regional networks, says Inphi.

The demand for **Coherent detection achieves 100G serial bit rate transmission over existing metro and backbone networks and has been adopted by the OIF** 100G solutions — representing a 10x increase in data rates — puts severe demands on the underlying technologies in the transceivers and line cards of next-generation networks, says Inphi. The firm claims that the 2850TA offers unparalleled signal integrity, ensuring error-free data transport.

“We have worked closely with Inphi and have designed in their 100G coherent amplifier in our best-in-class optical receivers for 100G,” comments Andreas Umbach, CEO & co-founder of u2t Photonics AG of Berlin, Germany, which manufactures indium phosphide-based ultra-high-speed photodetectors and receivers. “Inphi’s commitment to develop the 2850TA helped us to develop a coherent receiver compliant to the rigorous OIF-standards,” he adds.

Inphi claims that the 2850TA has the following benefits:

- the highest bandwidth (greater than 25GHz) available, offering more margin in 100G system design;
- superior linearity for coherent receivers, at less than 5% THD (total harmonic distortion), exceeding OIF requirements; and
- low power dissipation (250mW/channel) to conserve energy.

www.inphi.com

www.foe.jp/foe/en

Inphi claims highest-sensitivity 40G linear TIA

Inphi is also extending its line of 40G solutions with the 2251TA, which it claims is the highest-sensitivity linear TIA/VGA for 40G DQPSK (differential quadrature phase-shift keying) applications.

“The 40G optical market grew rapidly in 2009, with port shipment roughly doubling when compared to 2008,” according to Andrew Schmitt, directing analyst (optical) at Infonetics Research. “Based on their strong technology and market position, Inphi should benefit from both 40G and 100G as each market evolves,” says Schmitt.

“Inphi’s ability to address the difficult technical challenges faced by carriers has secured Inphi’s position as the leading supplier of 40G TIAs and drivers,” claims Dr

Loi Nguyen, Inphi’s VP, networking & communications products.

“Drawing on our unique analog design skills, Inphi’s 2251TA tackles a major limitation on transmission distance — signal distortion.”

The 2251TA allows extended reach by addressing polarization mode dispersion (PMD), a common problem faced by carriers operating at 40Gb/s that causes signal distortion and limits the reach of 40G networks. The 2251TA addresses these challenges by delivering what is claimed to be:

- the highest sensitivity over a wide range of optical signal-to-noise ratio (OSNR), which improves link margins;
- greater linearity (< 5% total harmonic distortion), which

enables the use of electrical dispersion compensation (EDC) technology to combat distortion due to PMD; and

- the lowest power dissipation available.

Combination with Inphi’s recently introduced 2811DZ differential driver in surface-mount technology provides a cost-effective, complete transmit and receive solution for next-generation 40G DQPSK systems, says Inphi.

Inphi also demonstrated next-generation drivers and receivers for 40G DQPSK small-form-factor transponders at the Fibre Optics Expo’s 40G/100G Device Zone. In addition, Nguyen gave a technical presentation on ‘High Speed Analog Solutions for Next Generation 100G Coherent Systems’.

Opnext delivers first SMT multiplexer IC for 100G; 128Gb/s SiGe chip designed for DP-QPSK modulation

Optical component, module and subsystem maker Opnext Inc of Fremont, CA, USA claims that it has developed the world's first ultra-high-speed surface-mount technology (SMT) multiplexer integrated circuit (IC) for 100Gb/s applications.

The chip — fabricated using silicon germanium (SiGe) 0.13µm process technology — was designed in-house to be used inside Opnext's coherent 40Gb/s and 100Gb/s transponder modules and subsystems. The 128Gb/s multiplexer IC transmits the data in 32Gb/s lanes suitable for transmission using the DP-QPSK

(dual-polarization quadrature phase shift keying) modulation scheme, as documented in the Optical Internetworking Forum (OIF) 100G ultra-long-haul DWDM Framework, for 100 Gigabit Ethernet (100GbE) and OTU4 transmission in the wide-area network (WAN).

The multiplexer IC also employs ball grid array (BGA) technology to allow standard SMT manufacturing processes, enabling higher-density transponder designs with ICs mounted directly onto the PCBs.

"One of the major challenges of increasing 40G production was the

manufacturability, quality and performance consistency of the hardware," says Roberto Marcoccia, VP of R&D for Opnext's subsystems business unit. "This SMT IC eliminates the radio-frequency connectors and coaxial cabling, a major source of these volume manufacturing issues."

Opnext says that it continues to employ selective vertical integration on components such as this new SMT IC, with the goal of delivering to its OEM partners the lowest-cost and highest-performance solution compliant with the 100Gb/s OIF multi-source agreement (MSA).

EXFO & Opnext achieve full interoperability

In January, EXFO Electro-Optical Engineering Inc of Quebec City, Canada and Opnext completed joint interoperability trials for testing IEEE-compliant 100 Gigabit Ethernet (100GbE) optics.

Using the EXFO FTB-85100G Packet Blazer (40/100G) and the Opnext 100GBASE-LR4 CFP multi-source agreement (MSA)-compliant optical module, the trials included generating 100GbE IP traffic at 100% wire speed with pseudo-random bit sequence (PRBS) patterns and monitoring error-free transmission with full Ethernet statistics.

The result brings together two different innovations which are key in enabling the rapid development of next-generation carrier and data-center 100G networks. The FTB-85100G's signal conditioning feature includes pre-emphasis and receiver-equalization control-testing capabilities to provide Opnext and other transceiver manufacturers with a way to optimize the interface between the host ICs on the tester and gearboxes inside the CFP in order to get best interoperability of the interface.

"Opnext's 100G CFP optical module continues to gain momentum as the first-generation 100G trans-

ceiver, allowing network equipment makers, carriers and data-center owners to seamlessly establish 100G connectivity," says Tadayuki Kanno, president of Opnext's module and device business units.

"We were the first test and measurement manufacturer to release a portable 100G tester and the first and only one to support the signal conditioning testing capability," says Etienne Gagnon, EXFO's VP of product management & marketing. "This allowed us to work closely with Opnext at this critical stage of their 100G CFP product development by providing a robust product that meets both R&D and manufacturing test requirements."

Also, EXFO's Packet Blazer offers a full range of other unique 802.3ba compliance test functions to support the whole gamut of 40G/100G and OTU3/OTU4 OTN testing applications, as it is part of a growing set of 100G test solutions. EXFO's end-to-end 100G portfolio—covering early system development through to field deployment—helps users establish thorough testing methods beyond compliance to address complex issues such as optical transceiver testing.

www.EXFO.com

Opnext honored by Cisco for Productivity Excellence

Opnext has received Cisco's "Excellence in Productivity" award for 2009, recognizing Opnext for best-in-class supply chain management, resulting in the highest level of product value, technology and quality.

"This recognition from Cisco reinforces Opnext's solid commitment to developing key technologies to meet the needs of our partners and support their business initiatives," says CEO & president Gilles Bouchard.

"Opnext did an exceptional job this past year helping Cisco meet its value engineering targets and providing high-quality products that transform how people connect, communicate and collaborate," said John Oberstar, director of Global Supplier Management for Cisco.

The distinction was awarded during Cisco's 18th annual supplier appreciation event, which celebrated the exceptional ability of Cisco's suppliers to navigate change, anticipate the future needs of Cisco and Cisco customers and put in place the tools and plans to stay ahead of the curve.

www.opnext.com

Opnext's revenue falls by a further 6% quarter-to-quarter: 40G subsystem recovery driving March-quarter rebound

For its fiscal third-quarter 2010 (to end-December 2009), optical module and component maker Opnext Inc of Eatontown, NJ, USA has reported revenue of \$76.1m. This is up 7.9% on \$70.5m a year ago \$12.1m, but largely due to the former StrataLight Communications Inc (acquired on 9 January 2009). Compared with \$81m last quarter (which had itself been down 5% on the previous quarter), revenue is down a further 6% and at the low end of guidance of \$75–80m.

Sales for 10Gb/s and below products has risen 10.4% from \$49.9m last quarter to \$55.1m, as revenue from 10Gb/s products rose 12.6% (due mainly to increased sales of XFP and 10G data products). Despite rising by 70% from \$5.1m a year ago to \$16.8m (mainly as a result of the StrataLight acquisition), sales for 40Gb/s and above products are down 40.1% from \$28m last quarter, due mainly to a decline in sales of 40Gbps subsystems. Revenues from industrial & commercial products are down 22.2% from \$5.4m a year ago, but up 35.5% from \$3.1m last quarter to \$4.2m.

Cisco Systems Inc, Alcatel-Lucent (ALU), and Nokia Siemens Networks (NSN) each represented 10% or more of revenue (and 54% combined, down from 56% last quarter due to lower 40Gb/s subsystem sales to NSN and Cisco, partially offset by increased 10Gb/s and below sales to Cisco and ALU).

"Last quarter we indicated that we expected to see bifurcation in our markets, with continuing growth in 10G and below, while 40G and above would remain challenged, and that's what we experienced," says president & CEO Gilles Bouchard.

On a non-GAAP basis, gross margin has fallen from 24.2% last quarter to 18.5%, due mainly to the lower 40Gb/s subsystem sales. Operating loss was \$13.1m, up from \$8.2m last quarter due to the reduced gross margin, partially offset by expenses falling by \$0.6m.

Excluding \$6.5m of payments in connection with the StrataLight Employee Liquidity Bonus Plan, Opnext generated \$2.7m of cash from operations. However, after \$2.4m of capital expenditure,

\$2.6m of capital lease payments, and \$3.8m of cash used in operations, cash and cash equivalents fell during the quarter by \$8.7m, from \$155m to \$146.3m.

For its fiscal fourth-quarter 2010 (to end-March), Opnext anticipates continued recovery of industrial & commercial business revenues, 10G and below revenues to increase modestly (despite first-calendar-quarter price reductions), and moderate growth in 40G and above business (driven by further growth in 40G modules, new 40G subsystems deployments, and the emergence of 100G). Opnext hence expects revenue to rise by 2.5–9% to \$78–83m.

"We are achieving important milestones in our 100G development program, as evidenced by our recent multiplexer chip announcement [first ultra-high-speed SMT multiplexer IC for 100G, announced on 27 January]," highlights Bouchard. "Customers are responding positively to the program and we continue to enter into new 100G partnerships."

www.opnext.com

Oplink increases margin and profit despite revenue dip

For its fiscal second-quarter 2010 (to end-December 2009), optical networking component, module and subsystem maker Oplink Communications Inc of Fremont, CA, USA has reported revenue of \$32.7m, down 13% on \$37.6m a year ago and 3% on \$33.6m last quarter (though still up on the March 2009 quarter's low of \$30.8m).

Despite the decline, gross margin has risen from 22.7% a year ago and 29.3% last quarter to 33.6%. Operating expenses of \$7.9m were roughly level with last quarter, and down from \$19.9m a year ago.

"We reported solid gross margins while continuing to manage operating costs," says president & CEO Joe Liu.

Net income rose to \$3.1m, up from \$1.8m last quarter and a loss of \$10.5m a year ago. During the quarter, Oplink generated \$8.5m in cash from operations, helping to boost cash, cash equivalents and investments from \$168.7m to \$188.8m. "We are pleased with our second quarter performance and execution, especially considering ongoing macroeconomic conditions," comments Liu.

"In the coming quarter, we expect telecommunications spending to continue to be constrained and will experience some seasonality and the impact of a shorter manufacturing period, including the Chinese New Year," Liu says. "We remain committed to providing customers with the highest-quality design, integration and manufacturing of optical components and expect to achieve market share gains as carrier spending normalizes."

For its fiscal third-quarter 2010, Oplink expects revenue of \$30–34m.

www.oplink.com

IN BRIEF

New director appointed

Finisar Corp of Sunnyvale, CA, USA, which makes fiber-optic communications components and subsystems as well as network test & measurement systems, has appointed Thomas E. Pardun to fill a vacancy on its board of directors.

Morgan Jones of Battery Ventures, who had been a board member since completing the merger of optical subsystem maker Optium Corp of Horsham, PA, USA in August 2008, previously said he would not stand for re-election at Finisar's annual meeting of stockholders on 18 November. "I would also like to thank Morgan Jones for his service and his valuable contributions following the Optium merger," said executive chairman Jerry Rawls.

Finisar's board consists of nine directors who are elected to staggered three-year terms. Pardun will be a director until the annual stockholders meeting in 2012.

Pardun was chairman of Western Digital Corp (one of the world's largest hard-disk drive makers) from January 2000 until January 2002 and again since April 2007. He worked for eight years at MediaOne and its predecessor company US West, most recently as president of MediaOne International Asia-Pacific before retiring in July 2000. Prior to US West, he was president of the Central Group for Sprint. Previously, Pardun held various management positions during 19-year with IBM, concluding as director of Product Line Evaluation at IBM's New York marketing headquarters.

"His background in both high-volume manufacturing and the telecommunications industry gives him a valuable perspective from which to guide our company in the years ahead," says Rawls.

www.finisar.com

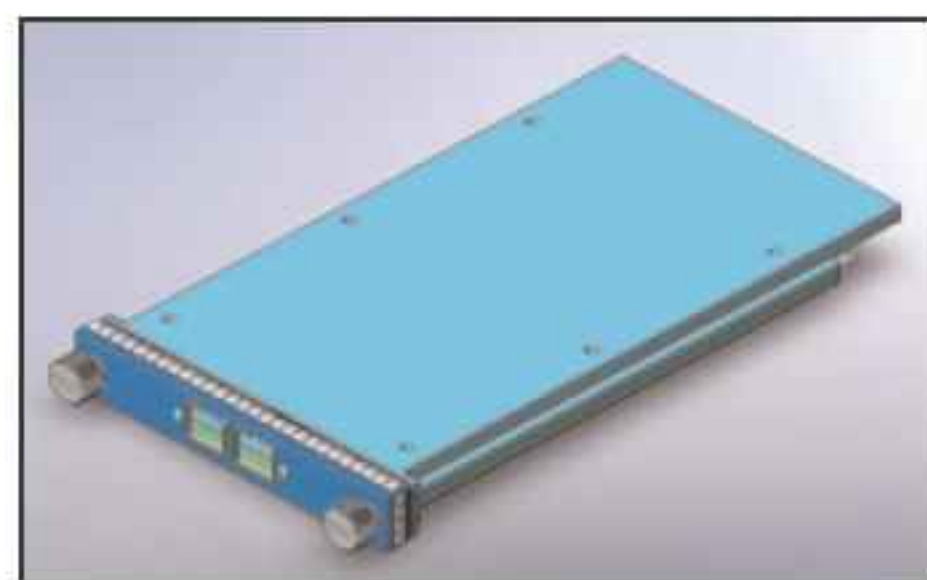
Ixia and Finisar demonstrate 100Gb/s Ethernet interoperability

Fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA and Ixia of Calabasas, CA, USA, which provides converged IP performance test systems and service verification platforms, have demonstrated interoperability between Ixia's K2 100Gb/s and 40Gb/s IP test interfaces with Finisar's 100G Ethernet (100GE) CFP optical transceiver modules.

The test setup included a Finisar 100GE LR4 CFP optical transceiver module operating in the Ixia K2 100Gb/s Ethernet/IP test module. Error-free operation was demonstrated by transmitting IP packets to a second Finisar 100GE LR4 CFP optical module over 25km of single-mode fiber, greatly exceeding the 10km distance being standardized for this application by the IEEE.

"Initial performance testing of the Finisar 100GE LR4 CFP transceiver in their facility was very promising," comments Glenn Wellbrock, director of Optical Transport, Network Architecture and Design for Verizon, who witnessed the event. "I look forward to testing the module in our laboratories together with system vendors soon."

Finisar's 100GE LR4 CFP optical transceivers are compliant with the CFP multi-source agreement (MSA) and support the 100GBASE-LR4 (4x25G) optical interface standardized in the IEEE P802.3ba Draft document. They are part of a family of CFP trans-



Finisar's CFP transceiver form factor.

ceiver modules that also includes 40G Ethernet and multimode fiber versions. Finisar's entire portfolio of transceiver modules uses internally developed integrated circuits and internally packaged optics.

"Demonstrating interoperability of 100GE CFP modules with leading 100GE test systems is a very positive milestone for the entire industry," claims Christian Urricariet, Finisar's director of product marketing for high-speed optics. "The LR4 versions of the pluggable CFP transceivers will enable successful 100G Ethernet deployments by our key customers," he reckons.

Ixia claims that its K2 higher-speed Ethernet (HSE) load module is the industry's only 100GE IP test solution capable of transmitting, receiving and analyzing full line-rate 100Gb/s Ethernet traffic. It is the latest load module in Ixia's test platform, which includes test chassis and load modules designed for different interface types and speeds. All load modules, including both the 40GE and 100GE models, test the full range of IP networking devices — from layer 2 through 7.

"Ixia's use of the Finisar CFP demonstrates the feasibility of pluggable optics for both 40/100GE," says Ixia's chief innovation officer Errol Ginsberg. "This extremely successful demonstration conducted by Ixia and Finisar for carriers such as Verizon shows that 100GE technology is quickly moving forward and will soon approach the deployment phase," he reckons.

www.ixiacom.com

This extremely successful demonstration conducted by Ixia and Finisar for carriers such as Verizon shows that 100GE technology is quickly moving forward and will soon approach the deployment phase

Finisar's better-than-expected December-quarter revenue up 14% to a record \$166–167m

Finisar Corp of Sunnyvale, CA, USA, which makes fiber-optic communications components and sub-systems as well as network test & measurement systems, says that, on the basis of preliminary financial results (subject to adjustment) for its fiscal third-quarter 2010 (ended 31 January) it expects to report revenue of \$166–167m. This far exceeds the company's revenue guidance of \$148–158m provided early in the quarter. Also, based on the mid-point of the new expected range, revenue is up 14.3% on the prior quarter's \$145.7m and up 32.1% on \$126.1m a year ago.

In the absence of a material adjustment, this will also surpass the previous record of about \$163m for the combined revenues of Finisar and optical subsystem maker Optium Corp of Horsham, PA, USA for the fiscal quarter to end-July 2008, just prior to the merger of the two companies on 29 August 2008.

Finisar says that quarter-to-quarter revenue growth was mainly a result of increased sales of products for 10Gb/s and reconfigurable optical add-drop multiplexer (ROADM) applications, although revenue in almost every product category increased sequentially.

Based on the higher preliminary revenue for fiscal third-quarter 2010, Finisar expects to be at the upper end of its original guidance for non-GAAP gross margin of 30–32% (up from 29.6% last quarter) and for operating margin of 6–8% (compared to 6.1% last quarter).

A complete assessment of cost of revenues and operating expenses is not yet available but, based on past experience, Finisar expects GAAP results to include \$8–10m in additional non-cash and infrequently occurring charges.

Finisar will issue final results for its fiscal third-quarter 2010 on 3 March.

www.finisar.com

IN BRIEF

Finisar files for \$100m public offering

Finisar has filed with the Securities and Exchange Commission to offer and sell from time to time, in one or more public offerings, up to \$100m of common stock, preferred stock and/or warrants to purchase any of these securities.

Proceeds may be used for general corporate purposes, including acquisitions, capital expenditure and repaying debt. The specifics of any potential future offering, along with the prices, terms and use of proceeds of any securities offered, will be determined at the time of the offering.

"Since we have recently completed several transactions designed to strengthen our balance sheet, we have no immediate plans to offer additional securities," says executive chairman Jerry Rawls. "Having a shelf registration statement in place will allow us the flexibility to act on an expedited basis to take advantage of strategic opportunities should they arise."

AOI appoints Fuji Electronics as Japan distributor

Applied Optoelectronics Inc (AOI) of Sugar Land, near Houston, TX, USA has announce a distribution agreement for the Japanese market in which Tokyo-based Fuji Electronics Company Ltd will provide distribution, sales and marketing support, as well as initial customer support for AOI's products in Japan.

AOI is a vertically integrated manufacturer with epitaxial growth, wafer processing, and optical module packaging as well as fiber-optic transceiver and component manufacturing facilities in Taipei, Taiwan (for FTTx and datacom applications), and component and module manufacturing facilities in Ningbo, China (focusing mainly on video transmission applications). The agreement

covers AOI's complete product line, including fiber-optic components (e.g. laser diodes and photodiodes), fiber-optic transceivers, cable TV products, and other fiber-optic modules and subassemblies.

"The market for AOI's fiber-optic products in Japan is robust and is expected to continue to grow for some time into the future as the global economy rebounds and new infrastructure projects around the world proliferate," says Dr Stefan Murry, AOI's VP of global sales & marketing. "We have been looking for a strong and diversified company to represent our products in Japan and we believe that Fuji Electronics represents exactly the type of partner we need," he adds.

"Fuji Electronics has always endeavored to provide the latest products made from the most advanced technology," says Kenji Otake, senior executive officer in Fuji Electronics' Strategic Marketing division. "AOI's history of innovation in optical device, module, and subsystem manufacture, especially its unique molecular beam epitaxy (MBE) process, fits this technology leadership role perfectly," he adds. "Our large network of sales offices across Japan, strong financial position, and nearly 40-year track record allow us to offer exceptional value to both our customers and our principals, including AOI."

www.fujiele.co.jp

www.ao-inc.com

JDSU's margin growth focused on new products:

but revenues constrained by component shortages

For its fiscal second-quarter 2010 (ended 2 January), JDSU Corp of Milpitas, CA, USA has reported non-GAAP net revenue of \$343.8m, down 2.9% on \$354m a year ago but up 15% on \$298.6m last quarter, and at the high end of the \$320–345m guidance (despite component supply constraints thwarting a further \$8–10m of shipments). The Americas represented 50% of revenue, Europe 28% and Asia-Pacific 22% (with growth in all three regions).

Advanced Optical Technologies revenue was \$54.6m (16% of total revenue), up just 0.9% on last quarter's \$54m and 2.8% on \$53m a year ago. Communications Test & Measurement revenue was \$177m (51% of total revenue), up 23% on last quarter's \$143.4m and 2.3% on \$173m a year ago.

Communications & Commercial Optical Products (CCOP) revenue was \$112m (33% of total revenue), down 12% on \$128m a year ago but up 11% on last quarter's \$101m. In particular, Commercial Lasers business revenue was \$16.7m, down 9% on a year ago but up 10.6% on last quarter. Optical Communications revenue was \$95.6m (60% from transport; 40% transmission). This is down 12.7% on \$109.5m a year ago but up 11.2% on last quarter's \$86m.

"We continue to gain market share as we see demand increasing not only for our ROADMs [reconfigurable optical add-drop multiplexer] and 300-pin tunable, but also for newer products such as the Super Transport Blade, the mini 50GHz ROADM [which started to ship during the quarter] and the tunable XFP," says president & CEO Tom Waechter about the Optical Communications segment. ROADM revenue is

recovering, growing by more than 50% on last quarter to back over 20% of optical revenue, as demand increased for the third consecutive quarter. Also, record revenue in China was driven primarily by Huawei.

Trends in transmission include the disruption of the 10G market with JDSU's tunable XFP, and more demand for 10G transceivers and VCSELs for wireless backhaul and data-center applications, says Waechter. For transport, JDSU continues to work closely with customers on 40 and 100G solutions (e.g. becoming the first vendor supplying both ROADMs [its next-generation 50GHz ROADM] and modulators carrying live 100G traffic in a deployed network).

The tunable XFP (the first tunable made available in an XFP form factor) is a new, disruptive technology to the fixed-wavelength XFPs and 300-pin 10G tunable transponder markets, continues Waechter. Since release to production in September, JDSU has engaged with 26 customers and shipped to 13.

The Super Transport Blade's unique architecture provides substantial footprint savings, claims Waechter. "We received significant

production orders to-date from two customers, with multiple designs at each customer, and we have been designed into a third customer... We are currently working with most other customers."

Revenue for new products less than two years old has hence risen from 30% last quarter to about 40%.

Optical Communications gross margin has consequently continued to recover, from last quarter's 19.7% to 22.5%, due to reduced manufacturing costs, higher fab utilization, and a more favorable product mix. In addition, Commercial Lasers gross margin improved by six percentage point to 32.4%.

Collectively, the improved margin in CCOP, together with favorable segment revenue mix, has contributed to JDSU's overall non-GAAP gross margin rising from 43.5% a year ago and 44% last quarter to 44.6%.

Although cut from \$134.9m a year ago, operating expenses of \$125.3m are up on last quarter's \$121.2m, due mainly to higher sales compensation (as a result of the higher revenues), selective strategic R&D investments, and a partial reinstatement of employee benefits. However, due to the higher revenue and gross margin, operating income was \$28.1m (an operating margin of 8.2% of revenue, above the guidance of 5–8%). This is up from \$10.2m (3.4% of revenue) last quarter and back above \$19.1m (5.4% of revenue) a year ago. In particular, operating income for CCOP was \$3.2m, compared to last quarter's operating loss of \$1.5m.

Overall, non-GAAP net income was \$26.6m, almost triple the \$9m last quarter and back above

We continue to gain market share as we see demand increasing not only for our ROADM and 300-pin tunable, but also for newer products such as the Super Transport Blade, the mini 50GHz ROADM, and the tunable XFP

\$25.6m a year ago. For the quarter, free cash flow was \$27.1m, raising total cash and investments from \$673.1m to \$698m.

"Results reflect revenue growth across all the business segments and a clear demonstration of the leverage in our operating model," says Waechter. "Our continued focus on innovation remains a key component in driving long-term top-line growth and profitability," he adds.

For its fiscal third-quarter 2010 (ending 3 April), as a result of rising lead times from component suppliers as well as an Optical Communications average selling price (ASP) decline above the quarterly range of 2–4% (due to just-completed pricing negotiations), JDSU expects revenue to be constrained to \$325–350m. With operating expenses expected to rise by \$4–5m, non-GAAP operating margin should fall to 5–7.5%.

For CCOP in particular, the business model supports operating margin of 10–15% at a quarterly revenue of \$150m or greater.

"With completion of the consolidation of our optical fabs, gross margin improvement initiatives are now focused on increasing factory utilization," says chief financial officer Dave Vellequette.

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The goal is to increase the percentage of revenue from products less than two years old to more than 50% over the next three years

JDSU's target for sustainable gross margin in its Communications & Commercial Optical Products business is 25–30%. "We believe we can operate in this range by the end of fiscal 2010," Vellequette adds.

JDSU says that it aims to continue to collaborate with its customers and invest in profitable market-based innovation to drive gains in market share as well as revenue growth. The goal is to increase the percentage of revenue from products less than two years old to more than 50% over the next three years.

Overall, Vellequette says that he believes JDSU's cost structure is such that the firm can sustainably realize an overall operating margin of 10% when its total quarterly revenue is in the range \$375–385m and its gross margin is at a level of 46%.

www.jdsu.com

JDSU launches Mini 50 wavelength selective switch module to provide highly cascadable and 40G/100G solution

Optoelectronic chip and module maker JDSU of Milpitas, CA, USA has announced the Mini 50 WSS, representing the next generation of its 50GHz wavelength selective switch modules, which have been deployed in networks worldwide since 2003 (with proven optical performance and reliability in routing and managing network traffic with 40G data rates, and ready for 100G network speeds). JDSU claims that its WSS modules are the only ones that are carrying live 100G network traffic today.

With consumer demand for bandwidth-intensive broadband applications such as video over the Internet increasing rapidly, many network equipment manufacturers and service providers are increasingly seeking for optical components that help to optimize traffic to get the most out of their networks, says JDSU. The new module, in 1x9-port configuration, hence comes in a more compact package



JDSU's new Mini 50 WSS module.

(with reduced height and a smaller form factor) with increased functionality to support more sophisticated mesh network architectures.

Also, optical performance is designed to better isolate and maintain signals. Testing in JDSU's lab has proven that it can support network traffic through more than 16 nodes (network entry and exit points) with minimal effect on the network signal. Furthermore, it is projected to be able to support (or 'cascade') a signal in traveling through up to 26 nodes without

compromising the signal (creating greater agility and faster speeds in networks than was previously possible, helping consumers access their applications without interruption).

Designed for lower-cost and high-volume production, says JDSU, the Mini 50 WSS became commercially available in December and is currently in various phases of implementation with several network equipment makers.

"JDSU's Ottawa-based R&D team continues to be at the cutting edge of WSS technology," claims Gurpreet Mand, director of reconfigurable add/drop optical multiplexers (ROADM) Products for JDSU's Communication & Commercial Optical Products (CCOP) business segment. "The Mini 50 WSS is yet another example of a next-generation solution from JDSU that has a platform that is highly scalable to support emerging applications."

Emcore to sell 60% stake in Fiber Optics business for \$27.8m

On 3 February, Emcore Corp of Albuquerque, NM, USA, which makes components and subsystems for the broadband, fiber-optic, and solar power markets, entered into a share purchase agreement to create a joint venture with Tangshan Caofeidian Investment Corp (TCIC), a Chinese investment firm administered by Tangshan City's Caofeidian Industry Zone in Hebei Province. The zone is a fast-developing area in the strategic Bohai Rim Economical Region with a total investment of \$26.4bn. Residents include China Capital Steel and Sinopec.

TCIC will purchase a 60% stake in Emcore's Fiber Optics business, including its telecom, enterprise, cable TV, fiber-to-the-premises (FTTP), and video transport product lines (but excluding its satellite communications and specialty photonics fiber-optics product lines). The new JV, Emcore Fiber Optics Ltd (EFO), will be registered in Hong Kong. TCIC will pay Emcore \$27.8m in cash and provide further funding of \$27m to EFO after closure of the deal.

Chairman of the board Reuben F. Richards Jr will resign as executive chairman of Emcore and assume the role of EFO's CEO. Also, other Emcore senior executives and staff currently working for the transferred product lines will be offered posts.

Emcore's president & CEO Dr Hong Q. Hou will also serve as a director of EFO, providing strategic and operational oversight. TCIC has nominated Dr Yi Li as chairman of EFO's board, and will name a chief financial officer after the deal closes.

The aim of the JV is, over the next several years, to focus on developing a high-volume, low-cost manufacturing infrastructure and a local customer support organization to better serve the expanding customer base in China and worldwide. TCIC has also committed to providing further funding for the JV's future strategic growth through acquisitions.

"This is one of the most transformational transactions in the history of Emcore," believes Hou. "This transaction creates two well capitalized, industry-leading companies within their respective industries and will enable Emcore to focus on growing its photovoltaic and defense/home-land security businesses," he adds. "This strategy was put into motion more than two years ago by our board of directors... We look forward to continuing to expand our Fiber Optics business."

"TCIC plans to provide a competitive fulfillment infrastructure and expand the JV's customer penetration in Asia by strengthening the China operation," says Wenhong

Tang, vice mayor of Tangshan City. "Emcore's Fiber Optics business is a great platform for future growth through accelerated new product development," he adds.

"This recapitalization allows the Fiber Optics business to aggressively expand its business penetration to major OEM customers worldwide, and accelerate new products to market," comments Richards. "In addition to the organic growth, we will also pursue other strategic growth opportunities in the form of acquisitions to expand our business."

The transaction was expected to close within 90 days, pending relevant government and regulatory approvals and approval by both firms' boards of directors.

In conjunction with establishing the joint venture, a supplemental agreement with TCIC will see Emcore establish its China terrestrial concentrator photovoltaics (CPV) manufacturing and operations base in Caofeidian Industry Zone. The agreement includes a commitment by TCIC to provide Emcore with the equivalent of \$3.3m in RMB-denominated loans, tax and rent incentives and assistance in developing Emcore's solar power business in China.

www.caofeidian.gov.cn

New Mexico business expert joins Emcore's board

Sherman McCorkle has been elected to fill a vacancy on Emcore's board as a Class B independent director.

McCorkle is a native New Mexican and has been involved in the New Mexico business community for most of his career. Since 1993 he has been president & CEO of Technology Ventures Corp (TVC), an Albuquerque-based organization that assists start-up firms in developing and commercializing

technologies from research universities and the national laboratories.

Previously, he was CEO & president of Sunwest Credit Services Corp from 1988. In 1977, he co-founded and was charter director of Plus Systems Inc (the original platform that enabled electronic banking and ATM systems). McCorkle is also a co-founder & charter director of New Mexico Bank and Trust and First Community Bank.

"As chairman of Sandia Science and Technology Park, Sherman was instrumental in persuading Emcore to locate and expand its operations in Albuquerque, and has been a great advocate of Emcore in reaching out to the local community, state government, and congressional offices," says chairman Reuben F. Richards.

As a Class B director, McCorkle will stand for re-election at the 2010 annual meeting of shareholders.

Emcore revenue recovers a further 5%, driven by space PVs and CATV

For its fiscal first-quarter 2010 (to end-December 2009), Emcore Corp of Albuquerque, NM, USA, which makes components and subsystems for the broadband, fiber-optic, and solar power markets, has reported revenue of \$42.4m. This is down 21% on \$54m a year ago, but up 5% on the September quarter's \$40.5m (following that quarter's 5.3% recovery from the June-quarter low of \$38.5m).

Photovoltaics revenue was \$16.8m (40% of overall revenue, up from 28% a year ago). This is up 12.7% on \$14.9m a year ago, and 3% on \$16.4m last quarter due to a 14% increase for satellite solar power products (which garnered \$120m in orders and purchase agreements in the last year), offset by a decrease for terrestrial concentrated photovoltaic (CPV) products.

Fiber Optics revenue was \$25.6m (60% of overall revenue, down

from 72% a year ago). This is down 35% on \$39.2m a year ago, but up 6% on \$24.1m last quarter due mainly to a 25% rise in revenue from the broadband division's cable TV (CATV) product lines (boosting broadband gross margin to 36%).

Overall Fiber Optics gross margin was 16.7%, up greatly from -1.1% a year ago and 13% last quarter (on a non-GAAP basis), due to improved margins across most product lines as well as lower inventory excess and obsolescence charges.

Photovoltaics gross margin was 22.1%, up on last quarter's 10.6% (non-GAAP), after reversing \$2.9m of inventory reserves sold last quarter relating to legacy CPV products.

Total gross margin was 18.9%, up from 12% last quarter (non-GAAP). Operating loss has been cut from \$52.5m a year ago and \$13.9m last quarter to \$11.9m (the firm's

best operating performance since the June 2008 quarter).

During the quarter, Emcore consumed \$1.2m in cash from operations, contributing to cash, cash equivalents, restricted cash, and available-for-sale securities falling from \$16.9m to \$16.5m.

During the quarter, order backlog fell 2% from \$62.6m to \$61.2m, with Photovoltaics down 11% from \$47.7m to \$42.3m (due to rescheduling part of a major customer's shipments beyond Emcore's 12 month backlog reporting horizon) and Fiber Optics up 26% from \$14.9m to \$18.9m (the third consecutive quarter-to-quarter increase).

For its fiscal second-quarter 2010 (to end-March), Emcore expects revenue to rise 6-11% to \$45-47m (with increases in both Photovoltaics and Fiber Optics).

www.emcore.com

ATK panel contract for NASA's Orion Crew Exploration Vehicle

Emcore has been awarded a contract by ATK Space Systems of Goleta, CA to manufacture, test and deliver solar panels for its UltraFlex solar arrays, which will be used to power the Orion spacecraft being developed by Lockheed Martin Space Systems Company for the US National Aeronautics and Space Administration (NASA). The period of performance for the first two vehicles runs through 2013 and is valued at \$9-11m. The flight solar array system is expendable for each Orion mission, and continuous production should run through 2020 and beyond.

The Orion crew exploration vehicle (CEV) program will serve as NASA's next-generation human space transportation system, replacing the current Space Shuttle and providing systems capable of

transferring astronauts to and from the International Space Station (ISS), the Moon and other destinations within the solar system. NASA expects to order multiple Orion Constellation vehicles over the next decade.

Emcore's latest-generation ZTJ triple-junction solar cells will be designed into the solar panels delivered to ATK. With a beginning-of-life (BOL) conversion efficiency of 30%, the ZTJ is the highest-performance space-qualified multi-junction solar cell available, claims the firm.

"The ATK UltraFlex solar array design will be providing 14kW of power per shipset with superior performance characteristics and mission-enabling features, including ultra-lightweight, high strength, high stiffness and compact stowage

volume," says Dave Messner, VP & general manager of ATK's Solar Array and Deployables site. "The Emcore solution will enable ATK to provide the UltraFlex solar array configured for Orion so that it will provide over 20 times the strength and 10 times the stiffness of our conventional rigid panel solar arrays, at less than one-third the weight," he adds.

"The solar panels for this program will provide the critical power needs required for the next phase of NASA's human exploration program," says Christopher Larocca, chief operating officer of Emcore (which claims to be the largest manufacturer of high-efficiency radiation-hard solar cells for space power applications). "We have enjoyed a long-term relationship with ATK Space Systems," he adds.

www.atk.com

IN BRIEF

OPEL and SOLYPAC sign dealer agreement for utility-scale markets

OPEL Solar Inc, a subsidiary of OPEL International Inc of Shelton, CT, USA and Toronto, Canada, which makes high-concentration photovoltaic (HCPV) panels, has entered into an international dealer agreement with SOLYPAC Technology Co Ltd of Seoul, South Korea.

The agreement makes available to SOLYPAC the complete OPEL Solar product line to supply utility-scale projects, especially its Mk-I HCPV panel and its array of single- and dual-axis trackers, which have the potential to increase photovoltaic yields of solar farms by up to 40%, the firm claims.

"It expands our international reach to supply utility-scale solar projects with OPEL's advanced solar technology and the increased efficiency that concentration photovoltaics and tracking provides," says OPEL Solar's chief operating officer Frank Middleton about the deal.

"Our international dealer agreement with OPEL Solar is a highlight for SOLYPAC because its full product line opens the door to bring HCPV and PV panels installed on its tracker products to South Korean and other international market places in which we have active business proposals, including the United States," says SOLYPAC's president and chief strategy & marketing officer JK Kim.

OPEL will also provide technical support for the installed projects. OPEL Solar provides PV panels to be used with OPEL's trackers to meet the needs of regions with low solar irradiance, generating more energy than fixed mounted installations, the firm claims.

OPEL boosts US sales force with director of Western Regional Sales

High-concentration photovoltaic panel maker OPEL International Inc of Shelton, CT, USA and Toronto, Canada has recruited Jay Johnson as director of Western Regional Sales, responsible for business development and the sales process. Based in Northern California, Johnson will handle project sales and dealer network expansion for the subsidiary OPEL Solar Inc.

"The expansion of our solar sales force in the US reinforces OPEL Solar's commitment to the creation of green jobs to the US economy, and it puts OPEL Solar closer to the hub of solar project activity arising in California and throughout the Southwest," says OPEL Solar's CEO Robert Pico. Johnson has extensive utility solar photovoltaic experience. "We expect he will play an important role in broadening OPEL's solar power grid installation business in the US market," adds Pico.

Johnson has 15 years of experience in business development, including years in solar power project and

energy project development sales. Prior to joining OPEL Solar, he worked for Akeena Solar in California as a commercial sales executive and for CETX Energy Agency in Texas as director of Energy Services (procuring generation services throughout the active deregulated electricity states of Texas, Illinois, and the New England market). Most recently, he was director of commercial sales for CentroSolar America, where he opened the California operations for the Germany-based solar manufacturer. Johnson also holds a BS Degree in Business Administration from California State University and a MBA in Technology Management from the University of Phoenix.

"By having Jay cover the western US, OPEL Solar can increase its responsiveness to customers and capitalize on growth of its solar business in that region," says OPEL Solar's chief operating officer Frank Middleton.

www.opelinc.com

First live HCPV installation in Spain

At the CPV Today 2nd Annual Concentrated Photovoltaic Summit USA in San Diego (2-3 February) — where OPEL Solar was one of several sponsors of the event — the firm's VP of Engineering Dr Javier Berrios gave a presentation, 'CPV Systems: The Road to Successful Installations', focusing on going live to the electric grid with one of the first commercial high-concentration photovoltaic (HCPV) installations in Spain, using its HCPV panels and dual-axis solar trackers.

In addition, at the PV Power Plants 2009 event in Las Vegas, chief operating officer Frank Middleton spoke on the firm's technologies as a viable source of solar electric power generation for utility-scale projects, addressing



OPEL's Mk-I HCPV panel.

'Solar Concentration and Tracker Systems' in a panel of industry experts.

OPEL Solar has also continued to host customer visits to its commercial solar farm in Spain, where customers, investors, and institutions can see the installation and electric production of OPEL's Mk-I HCPV panels mounted on dual-axis solar trackers.

Concentrix's CX-75 module wins IEC certification

Concentrated photovoltaic (CPV) system maker Concentrix Solar GmbH of Freiburg, Germany says that its latest CX-75 generation of FLATCON module has received IEC 62108 certification from the International Electrotechnical Commission (IEC) electrical and electronic standards organization. The firm's previous module generation passed the IEC tests in 2007.

Concentrix was spun off from the Fraunhofer Institute for Solar Energy Systems ISE in 2005, but in December 80% of its shares were acquired by Soitec of Bernin, France, which makes engineered substrates including silicon-on-insulator (SOI) wafers (as well as III-V epi-wafers through its Picogiga International division).

IEC 62108 is the CPV industry's standard, ensuring that modules and assemblies are suitable for long-term operation in a wide range of outdoor climates. Concentrix says that, by producing the CX-75 module in its fully automated production line (with an annual production capacity of 25MW), it can ensure consistent, high-precision manufacturing in high volume.

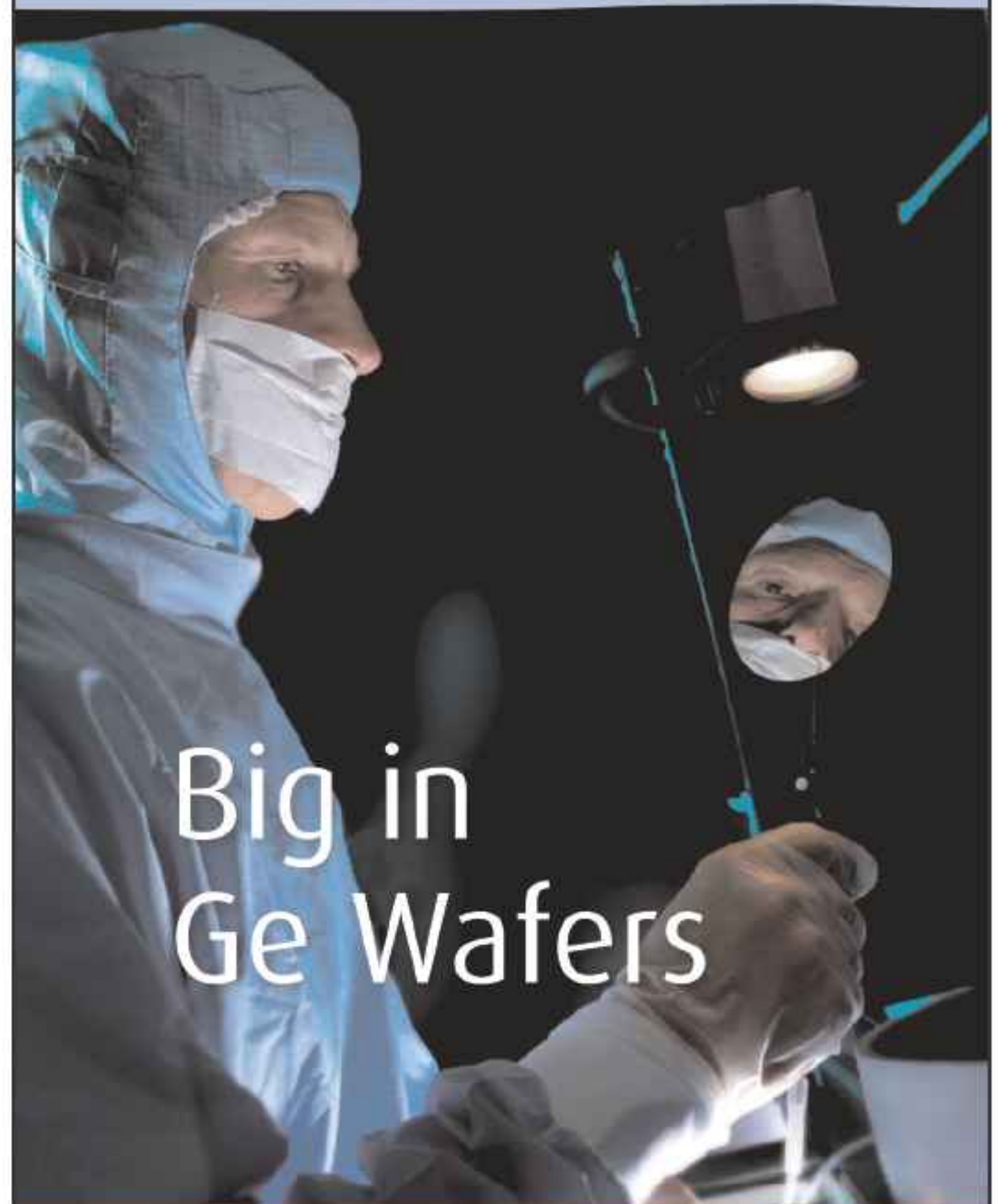
Concentrix claims that the high degree of automation ensures that all modules are of equal quality and deliver high efficiencies and reliable system operation over long time periods. In particular, the firm says that, with the CX-75, it has boosted the AC system efficiency of its concentrator systems from 23% (achieved in May 2008) to 25% (last August), while average module efficiency is now 27.2%, as confirmed at installations in San Diego, CA, USA, and Puertollano, Spain.

The IEC 62108 certificate confirms that the new CX-75 module is ready for full, commercial deployment in utility-scale electricity production, says Concentrix's CEO Hansjorg Lerchenmuller. "It attests that our systems are capable of withstanding prolonged exposure in harsh climates and are designed to withstand severe environmental conditions such as rain, hail and high winds."

Assessment was performed by the Spanish accredited testing institute CENER (Centro Nacional de Energias Renovables) and certified by the Spanish Association for Standardization and Certification (AENOR). The certificate confirms that the CX-75 has passed all the necessary IEC performance and accelerated aging tests and hence received design qualification and type approval.

Since 2009, the IEC 62108 standard specifies the requirements for the design qualification and type approval of CPV modules and assemblies suitable for long-term operation in demanding outdoor conditions. According to the testing standards for conventional PV modules, the IEC 62108 norm simulates environmental conditions and influences for CPV modules to verify the performance reliability and aging resistance. This includes testing of hail impact, mechanical load, insulation and wet insulation as well as outdoor exposure.

www.concentrix-solar.de



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Amonix acquires Sunworks

Silicon-to-GaAs convert buys solar panel maker

On 21 December, concentrating photovoltaic (CPV) system maker Amonix Inc of Seal Beach, CA, USA announced that, on 9 November, it completed its acquisition of Sunworks Solar LLC of San Francisco, CA, which was founded in 2008 to make US-made utility-scale amorphous-silicon thin-film photovoltaic panels.

Sunworks' co-founder Brian Robertson becomes CEO of Amonix; co-founder Guy Blanchard joins as senior VP of sales & corporate development; and managing director Matthew Meares (who previously worked on sales and project development at Sunworks) joins as director of project finance.

In July, Sunworks said that it was aiming to construct a 75MW solar panel manufacturing plant in New York, but Robertson says that Amonix does not plan to become an amorphous-silicon thin-film photovoltaic panel manufacturer.

Founded in 1989 and with 15 years' experience of field deployments in real-world conditions, Amonix is on its seventh-generation CPV system, after in March launching the Amonix 7700, which is designed for utility-scale deployment (applicable to both distributed generation and

centralized solar farms). The firm has switched from using 27.6%-efficient silicon cells (which it had made itself) in its previous-generation systems to using Spectrolab's 37%-efficient GaAs-based multi-junction cells, producing what was claimed to be the first CPV system with efficiency of 25% (AC, post-inverter).

"Amonix systems clearly work in utility-scale applications. With the addition to our management team of three of the most productive solar industry business executives in the country, we have what it takes to get large, complex projects completed," says founder, chief technology officer & chairman Vahan Garboushian (whom Robertson replaces as CEO). "We are ready to leverage our expertise and years in the field to take our growth to the next level."

Amonix says that Robertson, Blanchard, and Meares have been instrumental in securing financing for more than half of all photovoltaic projects deployed under power purchase agreements (PPA) in the USA.

Before co-founding Sunworks, Robertson co-founded and was president of North America's

largest solar energy services provider SunEdison (acquired by silicon wafer maker MEMC Electronic Materials in November for \$200m in cash and stock). Robertson also has a degree in Computer Science from MIT and an MBA from Harvard Business School.

Blanchard jointly led development of Sunworks' project pipeline. He has extensive asset and project finance experience, previously as managing director for Fortress Investment Group's Drawbridge family of funds, where he was a principal investor with a focus including renewable energy investments. Blanchard has a BS and an MBA from the University of California, Davis.

At Sunworks, Meares was responsible for utility-scale solar panel sales and project development. Previously at Germany-based HSH Nordbank, he was responsible for project finance, mezzanine, and equity transactions in the power sector, with an emphasis on renewable energy. Meares has a BS in Mechanical Engineering from North Carolina State University and an MBA from Duke University's Fuqua School of Business.

www.Amonix.com

Spire awarded \$2m from DOE tax credit program

Spire Corp of Bedford, MA, USA, which provides capital equipment and turnkey production lines for manufacturing photovoltaic (PV) cells and modules, says that its epiwafer foundry subsidiary Spire Semiconductor LLC of Hudson, NH has received confirmation from the US Department of Energy (DOE) that the firm's '48C' application under the Advanced Energy Manufacturing Tax Credit (MTC) program has been approved, leading to the allocation of more than \$2m for the expansion of its

III/V Compound Semiconductor Foundry facility.

"Spire Semiconductor being awarded over \$2m in tax credits for its path of commercialization of our concentrator photovoltaic (CPV) technology could not have come at a better time," says Spire Corp's chairman & CEO Roger G. Little. "We have just announced the approval of Phase II of our National Renewable Energy Laboratory (NREL) subcontract for developing technology to cost-effectively manufacture 42%-efficient,

500-sun, multi-junction concentrator solar cells for systems," he adds.

"With the PV industry continuously growing, the availability of this tax credit will allow us to grow along with it," Little continues. "This opportunity will allow us to establish a state-of-the-art commercial manufacturing line to produce our proprietary triple-junction high-efficiency cells and support our growing CPV customers."

www.spirecorp.com/spire-bandwidth-semiconductor
www.energy.gov/recovery/48C.htm

DOE provides \$12m for four early-stage PV firms

US energy secretary Steven Chu has announced that the Department of Energy's National Renewable Energy Laboratory (NREL) of Golden, CO, USA is to invest \$12m in funding (including \$10m from the American Recovery and Reinvestment Act) to support the development of early-stage solar energy technologies.

The Photovoltaic (PV) Incubator Program partners NREL with companies that have developed new solar cell technologies to help move them to commercial-scale manufacturing, aiming to potentially support new domestic high-tech manufacturing jobs over the long term.

The latest partnerships support the DOE's goal of making solar energy cost-competitive with conventional forms of electricity by 2015 as well as the Obama Administration's commitment to a clean energy economy.

The partnerships leverage the technical expertise of NREL, which will provide guidance and technical assistance to help the companies overcome common challenges for

small-scale or pilot manufacturing. Firms awarded under the incubator program will work closely with NREL to move prototype and pre-commercial PV technologies into pilot and full-scale manufacturing. The anticipated subcontracts, of up to \$3m each, will be awarded as 18-month phased subcontracts, with payment made on completion of project milestones.

The partnership projects (subject to negotiation) include:

- Alta Devices Inc of Santa Clara, CA will focus on developing an innovative high-efficiency (more than 20%), low-cost compound semiconductor photovoltaic module, with market entry expected in 2011;
- Solar Junction Corp of San Jose, CA will develop a manufacturing process to produce a very high-efficiency multi-junction cell, for use by concentrating PV (CPV) manufacturers to produce lower-cost CPV systems;
- TetraSun of Saratoga, CA will focus on a back-surface passivation

for high-efficiency, low-cost crystalline silicon solar cells; and

- Sempruis Inc of Durham, NC will focus efforts toward a massively parallel, microcell-based CPV receiver, combining the benefits of unique-to-solar manufacturing techniques with the performance and operational benefits of microcell concentrating photovoltaics.

"Working with NREL researchers reduces the implementation risk associated with new solar technologies and increases the likelihood that the performance and reliability objectives can be achieved in the near future," says NREL incubator manager Martha Symko-Davies.

The PV Technology Incubator project represents a novel DOE business approach. Technical benchmarks with firm due dates are identified in each proposal. Subcontractors will receive funding only after each deliverable has been tested and verified by NREL to have met the predetermined targets.

www.nrel.gov

Spire authorized for Phase II of NREL CPV contract

Spire Corp of Bedford, MA, USA, which provides capital equipment and turnkey production lines for manufacturing photovoltaic (PV) cells and modules, says that its epi-wafer foundry subsidiary Spire Semiconductor LLC of Hudson, NH has completed Phase I of its High Efficiency Concentrator Solar Cell program with the US Department of Energy's National Renewable Energy Laboratory (NREL), and has been notified that NREL will authorize Phase II.

Under the 18-month, \$3.7m subcontract awarded in April 2009 (consisting of \$2.96m in government funding and a \$745,000 cost share), Spire Semiconductor is developing

technology to cost-effectively manufacture 42%-efficient, 500-sun, III-V triple-junction tandem concentrator photovoltaic (CPV) cells.

Spire Semiconductor has now passed through the NREL Stage Gate Review, a go/no-go decision point to validate progression of the project and assure that progress meets contract objectives. These objectives include estimates of key performance parameters of competitive levelized cost of energy (LCOE); annual manufacturing capacity potential; direct manufacturing cost; and cell mean-time-between-failure (MTBF). During Phase I, PV cell performances of

greater than 39% efficiency were achieved.

"It validates our efforts toward developing a proprietary gallium arsenide concentrator solar cell that exceeds anything commercially available," says Spire's chairman & CEO Roger G. Little.

"The PV industry will continue to grow significantly this year and well into the future," reckons Little. "CPV systems offer many advantages. With Spire's strong position in the solar industry, the availability of our custom GaAs concentrator will put us in a good position to help our customers meet this market demand," he concludes.

www.spiresemi.com

Helios launches 31%-efficient SunCube CPV module

Founded in 2007 and backed by ten local entrepreneurs, Helios Solar LLC says that — in partnership with designer-integrator Vibrant Solar Inc (based in the same office space in Denver, CO, USA) — it has launched its SunCube Mark 9.2 concentrating photovoltaic (CPV) module.

Sales have begun, with installations due to begin in the Spring. Vibrant is performing all sales and installation in the initial phase, while Helios focuses on supply and building US plants to make SunCube domestically.

Developed by Australia's Green and Gold Energy Pty Ltd (GGE), SunCube is assembled at India licensee Square Engineering's plant (where four assembly lines can each produce 100MW of SunCubes per year) and imported by Helios under an exclusive license from GGE for southwestern USA and Hawaii (and throughout the USA, until there are other US licensees).

"I watched Green and Gold develop from one inventor, Greg Watson, and one working model nearly four years ago through his R&D facility opening in January 2008, licensing to India then Spain, until they were ready for us [in the US]," says Helios' CEO president & founder Scott VanKirk.

The 300W SunCube module is 31% efficient, compared with 10–18.5% for standard PV thin-film and flat panels. So, fewer modules are required, at lower cost, to produce enough electricity to power a home, commercial business, factory or large power user, city, or utility. "Other CPV modules have been announced, but none that we know of have near the efficiency of the SunCube," claims Helios' VP of marketing & sales Mark Simmons. As of December, Vibrant has the first five SunCubes installed in the USA up and running daily on the roof of their offices. "Internal testing showed what we expected, so we are beginning sales," says Simmons.

Emcore of Albuquerque, NM makes the triple-junction GaAs cells used in the SunCube, housed in a



SunCubes in a roof-mounted installation.

ground-mounted dual-axis tracking system, which optimizes the available sunlight (concentrating 750+ suns on the chips) and yields about double the electrical output compared to standard solar panels. Triple-junction cells have a high tolerance to heat and produce power when silicon cells fail in the heat, says Helios. SunCube arrays could be placed in desert areas throughout southwestern USA, where the temperature prohibits the use of standard PV panels.

"We recently quoted a project for military base housing which required \$14.6m in standard rooftop solar panels. Using SunCubes instead, the project only costs \$9.1m, for the same amount of electricity," says Simmons. He estimates that, together, he and Vibrant's director of sales Robert Quist have delivered proposals for over 3000MW of SunCubes so far. "A lot of RFPs from government and other non-profits are non-starters with the cost of standard solar modules, but work economically with SunCubes," claims Quist. Vibrant has both leasing and power purchase agreement partners that can offer the product on a 10–25 year basis at production rates as low as \$0.04/kWh when local or state incentives are available, making it competitive with new coal plants (a cost parity that is essential for renewables to eliminate coal).

Most RFPs stipulate an array size such as 1MW or, in the recent case of the Denver Public Schools RFP, 100kW of solar times 30–50 sites.

Helios says that the SunCube needs half the acreage of standard solar ground arrays per MW-hr of production, and can be repaired and retrofitted in the field. Also, Emcore is already working on chips with efficiency of 50% and more, and the SunCube's plug-and-play feature allows it to keep up with developing chip technology, the firm adds.

Helios aims to create jobs in the US by hiring for its assembly plant, sourcing all parts locally, and contracting installation through Vibrant and its array and civil engineering partners. "We are in the process of site selection while sales ramp up," says VanKirk. "We should start hiring in second-quarter 2010."

Helios is planning to build one or more module manufacturing plants in Colorado and possibly more across the southwestern USA. VanKirk and Simmons say that they have been meeting with Economic Development Corporations and Colorado state officials in the process of site selection for the first plant, with an RFP to all EDCs and cooperative groups along the Front Range (part of the Rocky Mountains in north-central Colorado) being sent out. Each line is expected to employ 180 staff directly and more than 1000 indirectly.

Also, an alliance between Helios and the only independent nuclear power plant company in the USA is in the planning stage. Colorado commercial real-estate broker Thorne Davis (of Davis Company), with ex-State Representative Dr Juan Trujillo consulting, is spearheading the effort to develop the Colorado Energy Park in southeast Pueblo County, intending 20MW or more of SunCubes along with other renewable energy producers plus a nuclear plant. The client has also requested and received a proposal for 2000MW of SunCubes per 3400MW nuclear plant, says Helios.

www.heliossolarcpv.com

www.vibrantsolar.com

Progress towards high-efficiency InGaN/Si tandem cells

The US Lawrence Berkeley National Laboratory (LBNL) and RoseStreet Labs Energy (RSLE) have jointly reported the development of a gallium nitride/silicon tandem solar cell [Reichertz et al, Appl. Phys. Express, vol2, p122202, 2009]. The aim of the 'proof-of-principle' device (Figure 1) is to enable use of the bandgap characteristics of two materials to pick up energy from different energy photons in solar radiation, boosting efficiency.

Pure GaN is not ideal for this, since very little solar radiation falls in the energy range of its bandgap, meaning that the efficiency of a GaN/Si tandem device is limited to around 1.5% under the standard 1x AM1.5G solar radiation testing conditions. This is worse than if one made a single-junction Si solar cell (for which over 20% is possible).

The problem with the pure-GaN structure is that carrier generation is low, given the low level of (ultraviolet) radiation in the solar spectrum with photon energies above the bandgap. The result is low generated current density. Since the GaN part of the device is connected in series with the Si part, its current performance as a whole is limited to that of the GaN portion.

The hope is to narrow the gap of the top semiconductor by adding indium to create InGaN with a suitable bandgap that matches the requirements of solar radiation, giving efficiencies nearing 30%. Such work by the researchers at RSLE and LBNL on incorporating indium is described as 'ongoing'.

The pure-GaN device structure was produced on n-type silicon (111) substrates using plasma-assisted molecular beam epitaxy (PA-MBE). A buffer layer of aluminum nitride was used to bridge the large lattice mismatch of about 17% between GaN and Si. An interesting by-product of the AlN layer is that some Al diffuses into the Si, producing a p-type Al-doped region in the silicon, forming the Si part of the solar cell. The grown GaN layer is n-type until

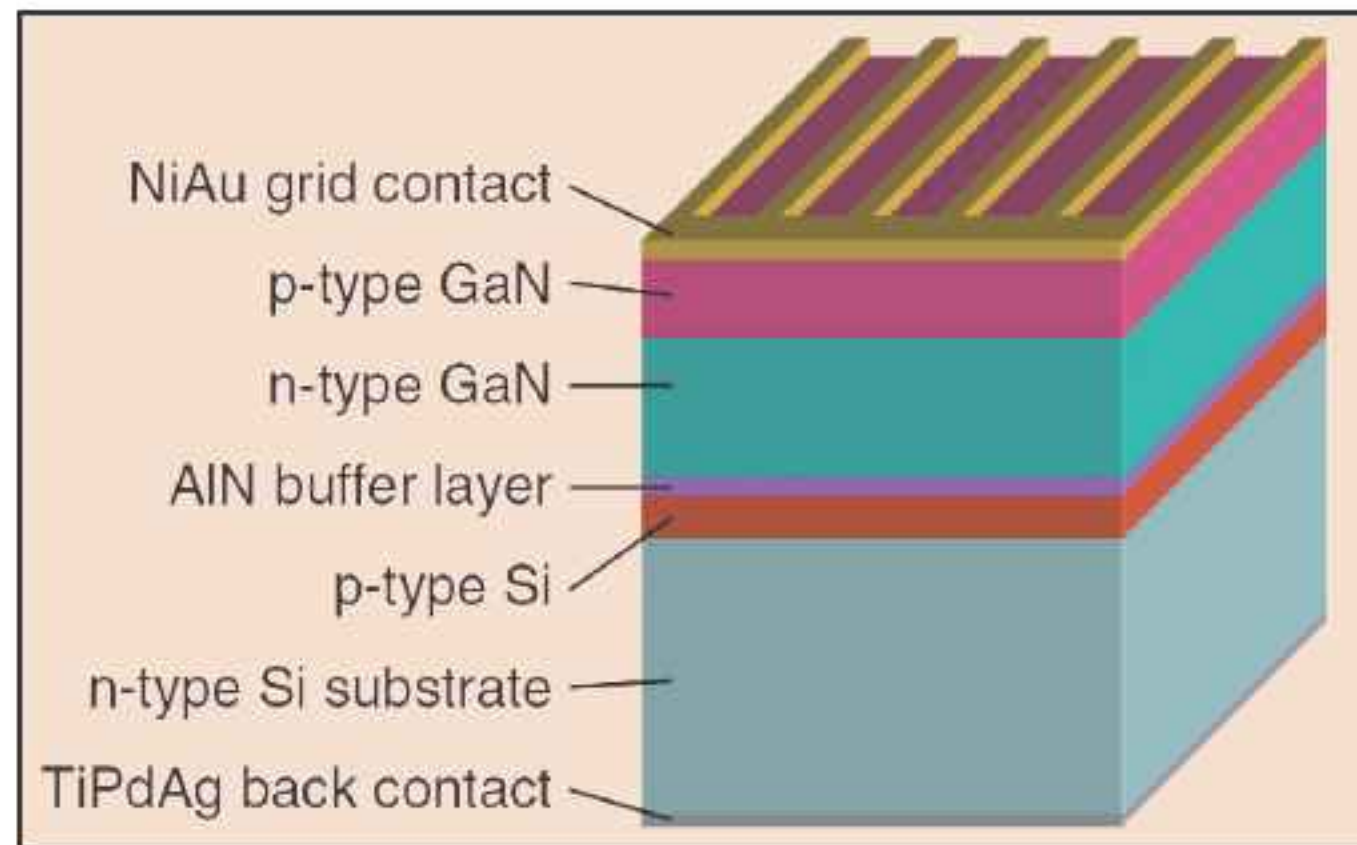


Figure 1. GaN/Si tandem solar cell prototype.

a magnesium source is turned on to produce p-type GaN material.

A low-resistance tunnel junction between the two cells is needed if such a structure is to be effective. The researchers confirmed a total series resistance of $0.5\Omega\text{-cm}^2$ by characterizing a device with no p-type GaN layer. The efficiency of this truncated device was $\sim 9\%$.

The full device had a measured efficiency below 1% at 1x AM1.5G. The open-circuit voltage (V_{oc}) was 1.44V (2.5x that of the Si bottom cell), but the short-circuit current density (J_{sc}) was only 0.16mA/cm^2 . The fill factor (maximum power/ $V_{oc} \times I_{sc}$) was 40%.

Increased V_{oc} (2.4V) is possible by adding a monochromatic light bias source above the bandgap of GaN to increase carrier generation in the top cell (Figure 2).

RSLE claims intellectual property rights over the technology.

<http://apex.ipap.jp/link?APEX/2/122202>

www.rosestreetlabs.com

Author: Mike Cooke.

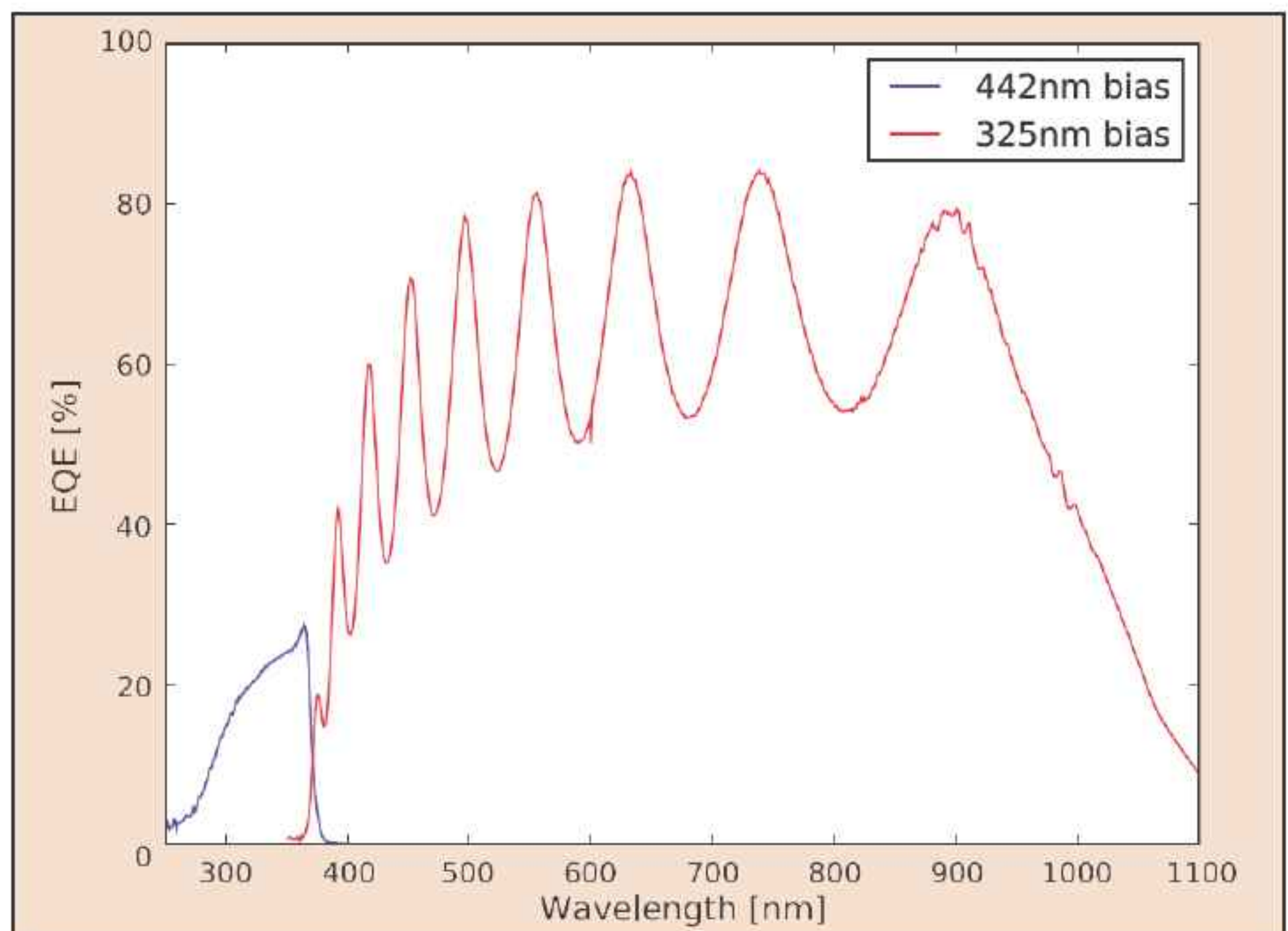
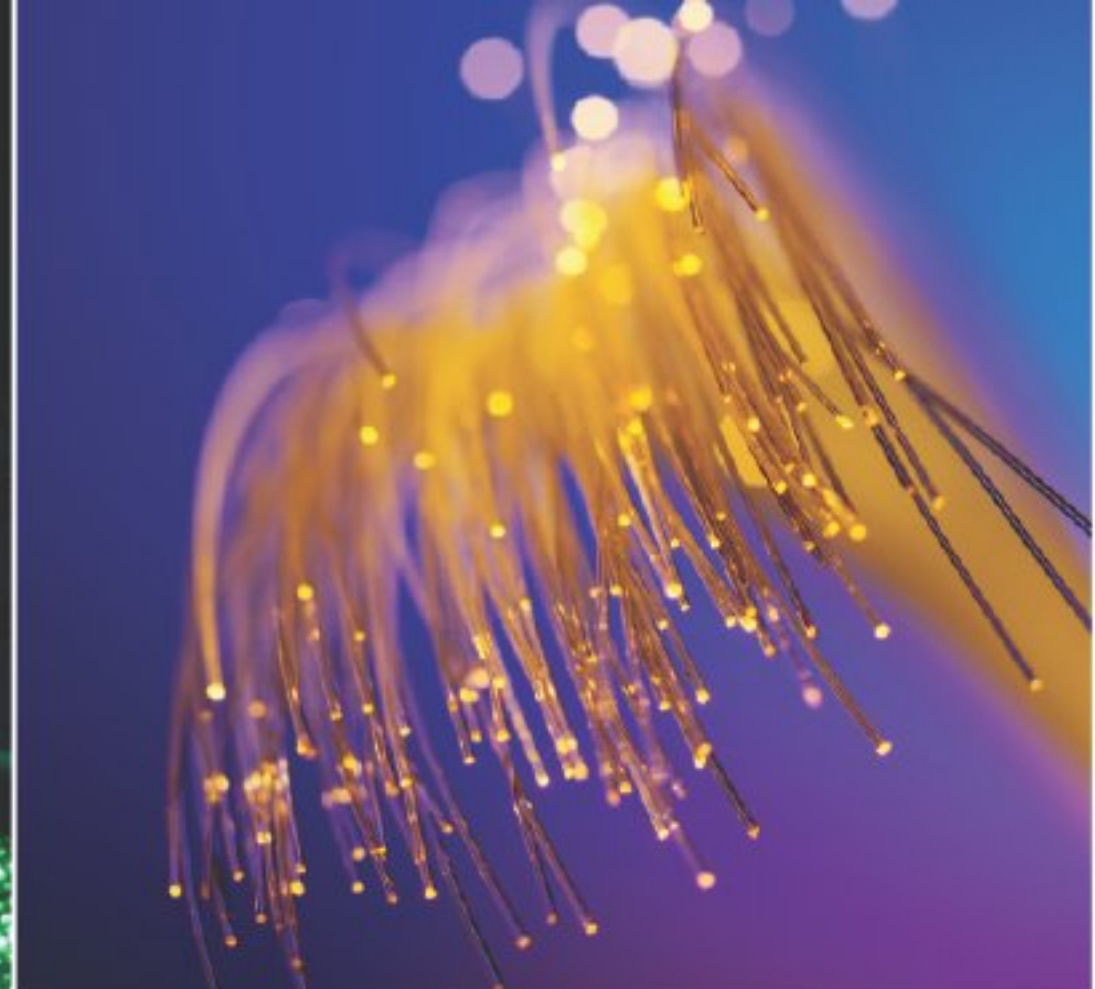
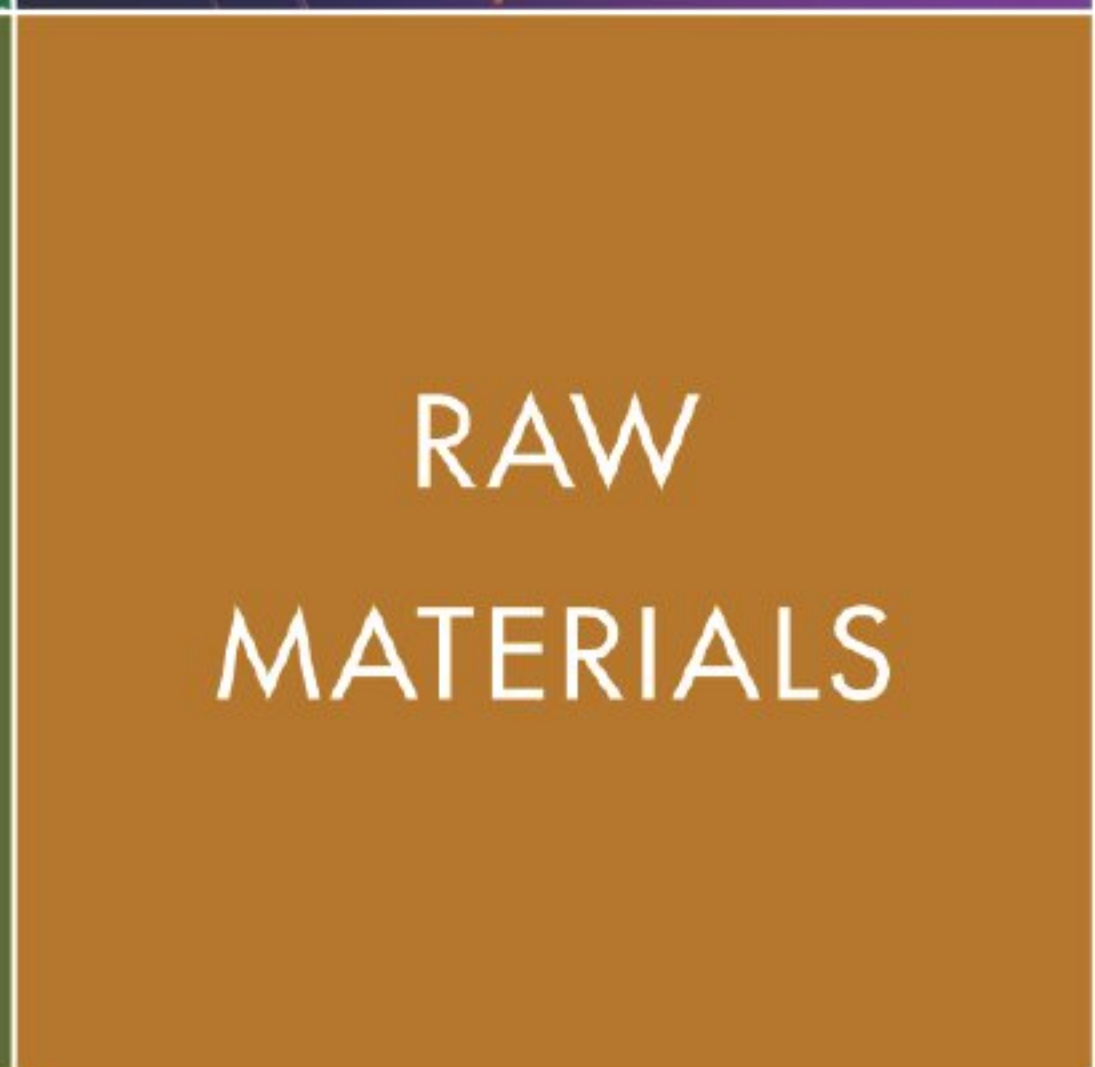
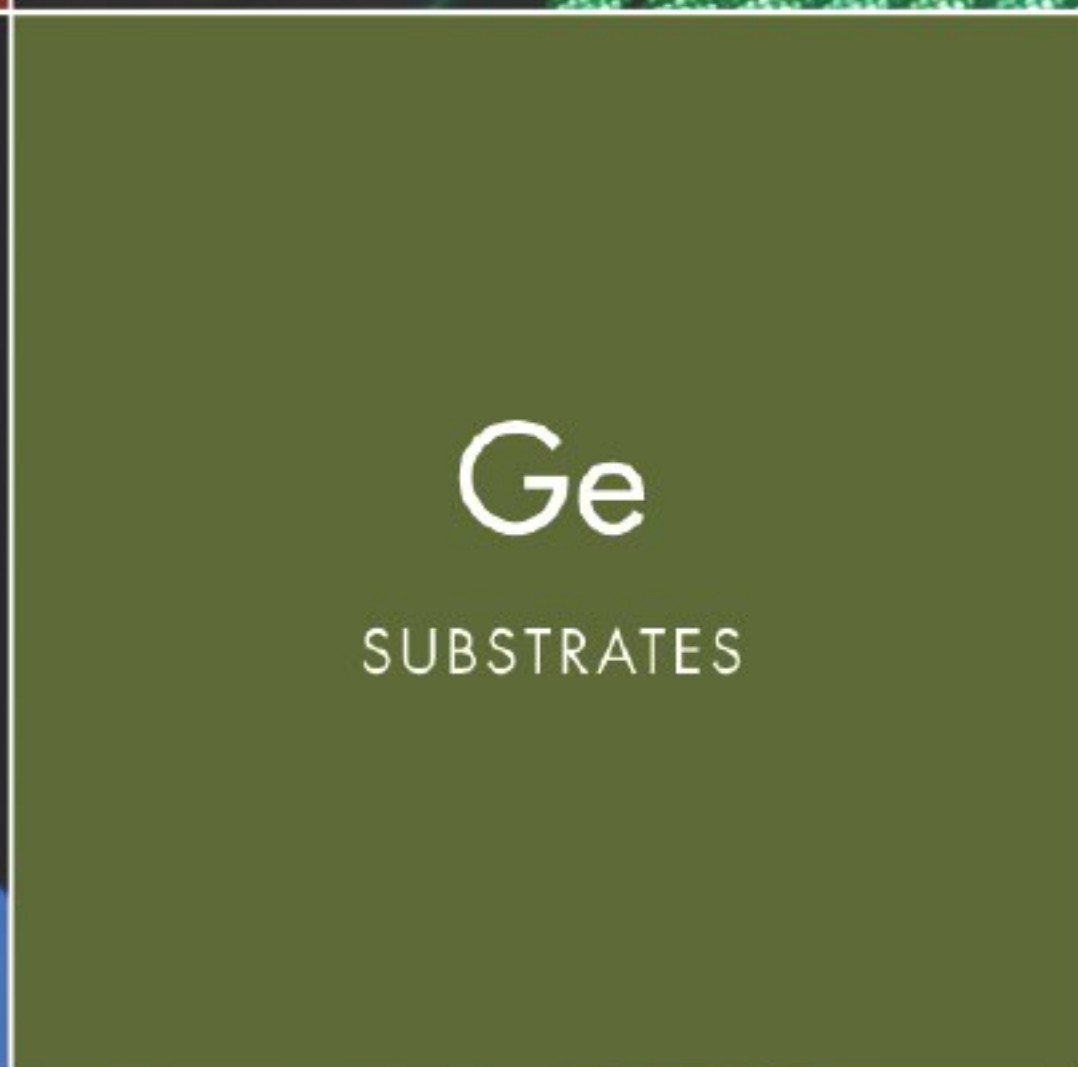


Figure 2. External quantum efficiency (EQE) spectra of pn-GaN/pn-Si tandem solar cell under different bias light conditions. Monochromatic bias light is used to separately measure each sub cell. Biasing the Si sub cell with 442nm wavelength allows scanning of the EQE spectrum of the GaN cell, while the shorter wavelength 325nm falls above the GaN band gap, biasing the top cell only, enabling measurement of the EQE of the silicon cell. Note the Fabry-Perot oscillations in the sub-cell spectrum from interference between various reflections from the interfaces by the light in the GaN layer, indicating the high optical quality of the GaN surface.

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NRG starts up California's largest PV plant

Commercial operation has started at the 21MW solar power project in Blythe, CA, which is the largest photovoltaic plant in California. Developed and built in three months by First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic modules based on cadmium telluride (CdTe), it was acquired in November by NRG Energy Inc of Princeton, NJ through its subsidiary NRG Solar. The plant's electricity output is being sold to Southern California Edison (SCE) under a 20-year power purchase agreement.

Located in Riverside County about 200 miles east of Los Angeles, the Blythe plant is the largest thin-film PV project in the US and is five times the size of the next largest PV project in California. The plant will generate over 45,000MW-hrs of electricity per year, avoiding 12,000 metric tons of carbon dioxide emissions annually (the equivalent of taking more than 2200 cars off the road). NRG estimates that, at peak



First Solar working on finishing the 21MW Blythe plant.

capacity, it can supply the power needs of almost 17,000 homes. First Solar will provide operations and maintenance services under a long-term contract with NRG.

"It is forward-thinking businesses such as First Solar that will help California reach its nation-leading greenhouse gas reduction and

Renewable Portfolio Standard goals, as well as create the new green jobs that will help spur our economic recovery," comments California Governor Arnold Schwarzenegger.

"Solar is the great untapped resource in California, and we are pleased to be part of this significant milestone for solar development in our state," says Marc Ulrich, SCE vice president, Renewables and Alternative Power. "Bringing this power to the grid helps SCE maintain its position as the nation's leading utility for renewable energy."

First Solar expanded its offerings in California in 2008. The Blythe plant is a model for First Solar's future large-scale solar developments. "The development, project finance and construction of this solar plant demonstrate First Solar's capabilities in utility-scale projects," says the firm's president Bruce Sohn. "We are pleased to be bringing it online ahead of schedule."

www.nrgenergy.com

First Solar to provide 22MW of cadmium telluride solar modules to New Mexico utility PNM

First Solar has signed a contract to construct 22MW AC of utility-scale cadmium telluride (CdTe) thin-film photovoltaic (PV) solar power plants at five separate sites within the service territory of New Mexico's largest electric utility PNM (a subsidiary of PNM Resources, an energy holding company based in Albuquerque, NM), which provides electric utility service to about 500,000 retail customers.

The 22MW of capacity will be sufficient to supply 7000 average-sized New Mexico homes, says PNM. If approved by state regulators, this capacity would be the first contracted under the terms of an agreement that PNM reached recently with state environmental, renewable energy and govern-

mental organizations. The plan's specifics — to be filed with the New Mexico Public Regulation Commission (PRC) on 25 January — call for a total of 45MW of utility-scale solar PV to be added to PNM's system in the 2010–2011 timeframe.

The sites will be chosen on the basis of cost, availability and suitability of land; the quality of a site's solar potential; environmental and permitting considerations; and the level of local support (the sites chosen will be announced as they are determined).

Construction on the first site is expected to start by 2011, or as soon as the PRC approves PNM's renewable plan. First Solar expects construction at all five sites to be

completed by late 2011. The build-outs should create about 100 construction jobs. Once completed, PNM will own the sites as part of its generation portfolio to serve New Mexico customers.

More than 1800MW of First Solar's PV panel technology has been deployed so far in multiple projects worldwide. "PNM's decision to use First Solar's panels demonstrates the value PV technology can bring to electric utilities seeking to adopt renewable energy generation," says First Solar's president Bruce Sohn. New Mexico has excellent solar resources and is well positioned to take advantage of affordable renewable energy, he adds.

www.pnm.com

First Solar and EDF settle on site for French CdTe PV panel plant

In late December, First Solar and renewable energy firm EDF Energies Nouvelles (EDF EN) of Paris, France (a 50%-owned subsidiary of energy supplier EDF Group) said that they were in the final stages of exclusive negotiations with the town of Blanquefort, near the city of Bordeaux, France, to locate a new plant there to manufacture its cadmium telluride solar panels.

Co-financed by First Solar and EDF EN, the French plant (announced last July) will be operated by First Solar and sell its entire production of thin-film photovoltaic panels to EDF EN for its first 10 years of operation. Construction is expected to begin in second-half 2010, and full annual production capacity of more than 100MW should be reached in early 2012 (making it France's largest solar panel manufacturing plant).

The plant is expected to create up to 400 jobs in the region of Aquitaine and represent a total investment of about €100m

(\$150m). First Solar says that the decision to focus on Blanquefort for the plant follows an extensive review of potential sites throughout the country.

"Blanquefort is the ideal location for our second manufacturing facility in Europe [after its first, in Frankfurt-an-der-Oder, Germany, inaugurated in July 2007], and producing there will bring us closer to the French solar market, which we believe has the potential to become one of Europe's brightest," said First Solar's CEO Rob Gillette. First Solar and EDF EN believe that France will become a major market for solar electricity in Europe

Construction is expected to begin in second-half 2010, and full annual production capacity of more than 100MW should be reached in early 2012

thanks largely to forward-looking French solar policies. "We look forward to deepening our relationship with France. Aquitaine has impressed us with its passion, excellent infrastructure and highly skilled workforce," he adds.

"Securing a competitive supply of modules will allow us to optimize and speed up the deployment of our ambitious French solar program," said EDF Energies Nouvelles' CEO David Corchia. "This will be a key catalyst in the development of a strong solar industry in France."

The manufacturing site will also include a facility for recycling solar panels (France's first such facility, and Europe's only solar panel recycling plant outside Germany). First Solar already operates what it claims is the solar industry's first comprehensive, pre-funded collection and recycling program in order to encourage the recovery of its panels and re-use of materials.

www.edf-energies-nouvelles.com

First Solar acquires project development pipeline of Edison Mission Group

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe), has completed the acquisition of a portion of Edison Mission Group's (EMG) solar project development pipeline.

First Solar and EMG have worked together on the projects since October 2008, with First Solar providing engineering, procurement and construction services while EMG was responsible for land acquisition and permitting. First Solar will now handle all development for the projects, including permitting. "First Solar is a good partner and the obvious

purchaser of our interest in these projects, which we have jointly developed," says Gerry Loughman, EMG's senior VP of development.

"It builds on our strategy to cultivate robust and predictable module demand in utility-scale applications," says Lisa Bodensteiner, First Solar's VP of business development for North America. The acquisition complements and diversifies First Solar's existing portfolio of utility-scale thin-film photovoltaic solar projects, which are largely sited on public land, range up to 550MW in size, and are mostly under contract with utilities. Located in California and

the Southwest, the EMG projects are sited largely on private land, range from 20 to 150MW, and are not yet contracted with utilities.

Anticipated module demand for EMG projects was included in advanced pipeline information provided last December by First Solar. In December, the firm completed development and construction of its first California utility-scale solar power plant, the 21MW AC Blythe project, which was sold to NRG Energy Inc of Princeton, NJ and supplies electricity to Southern California Edison (see page 96).

www.edison.com
www.firstsolar.com

IN BRIEF

MiaSolé awarded \$100m in US tax credits to ramp up CIGS PV production

MiaSolé of Santa Clara, CA, USA, which was founded in 2001 to make copper indium gallium diselenide (CIGS) thin-film photovoltaic modules, has received two Advanced Energy Manufacturing Tax Credits (MTC) totaling \$101.8m from the Obama administration for the manufacture of solar cells and modules that aim to lower the cost of renewable clean electricity generation. After doubling staffing from 150 to 300 in 2009 and starting commercial shipments last November, MiaSolé will be adding jobs to ramp up its plant.

The American Reinvestment and Recovery Act of 2009 (ARRA) authorized the Department of Treasury to award a total of \$2.3bn in tax credits for investments in 183 manufacturing facilities for clean energy products across 43 states. More than 500 applications were submitted. Winners were selected on the basis of their commercial viability, domestic job creation, technological innovation, potential for reducing air pollution and greenhouse-gas emissions, and the speed at which the projects would be completed.

"The award is a reflection of the Department of Energy's confidence in MiaSolé's technology and business model," believes CEO Dr Joseph Laia. "We look forward to ramping our manufacturing capacity and creating jobs aided by these funds," he adds. "We also view the commitment of the administration to create green manufacturing jobs as important in positioning the US towards the future."

www.miasole.com

www.energy.gov/recovery/48C.htm

USE completes 1.9MWp Solyndra project in Belgium

Solyndra Inc of Fremont, CA, USA, which was founded in 2005 to manufacture copper indium gallium diselenide (CIGS) photovoltaic (PV) systems consisting of panels and mounting hardware for commercial rooftops, says that its authorized re-seller and solar integrator Umwelt-Sonne-Energie GmbH (USE Projects) of Holzgerlingen, near Stuttgart, Germany has completed the largest collective Solyndra project to date, consisting of 1928kWp of generation capability installed on 10 rooftop sites in Belgium owned by a large international food retailer. This follows Solyndra signing a long-term sales contract with USE last July.

The power generated by the systems will be sold to local utilities under an agreement with the building owners. "This is a great example of how Solyndra's PV systems can take advantage of underutilized commercial rooftop space to generate significant power," says Solyndra's CEO & founder Chris Gronet. "The project also offers a good model for how distributed power generation can work in an urban setting," he adds. "USE Projects designed and delivered a PV system that we believe can enable the highest energy production per roof over the system lifetime while

taking advantage of Solyndra's low overall installation costs."

Solyndra's cylindrical, thin-film PV systems are designed to generate more electricity from typical low-slope commercial rooftops while providing significantly lower installation costs than conventional flat-plate PV technologies. The Belgian project involved installations on ten sites in ten cities, and was completed in just two months.

"Solyndra was the best solution for this challenging project given

Solyndra was the best solution for this challenging project given the number of sites, different roof orientations and desire for highest possible energy yield per roof,"

the number of sites, different roof orientations and desire for highest possible energy yield per roof," says USE's CEO Arnold Berens. "Our trained technical staff found the systems

easy to install," adding that the project helps the rooftop host to meet corporate citizenship goals while generating significant clean power.

www.use-energie.de

www.solyndra.com

Solyndra appoints senior VP, corporate development & general counsel

Solyndra says that John Gaffney is to join it as senior VP, corporate development & general counsel (leading its legal and corporate development activities, and reporting to CEO Chris Gronet).

Most recently, from January 2008 to December 2009, Gaffney was an executive VP at First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride, where he led the legal, corporate

development, sustainable development and environmental affairs departments. Previously, he practiced law for over 20 years at Cravath, Swaine & Moore LLP, where he became a partner in 1993 and advised numerous corporate and institutional clients on merger, acquisition and capital markets transactions. Gaffney holds a B.A. from The George Washington University and a J.D. and an M.B.A. from New York University.

CIGS PV maker Solyndra files for \$300m initial public offering

On 18 December, Solyndra Inc of Fremont, CA, USA, which makes copper indium gallium diselenide (CIGS) thin-film solar systems for commercial rooftops, filed a registration statement with the US Securities and Exchange Commission (SEC) for a proposed initial public offering of its common stock in early 2010, aiming to raise up to \$300m.

Argonaut Private Equity and its affiliates already have 35.74% of Solyndra's outstanding common stock on an as-converted basis, and have the right to purchase up to 15% of the shares offered at the initial price to the public (although it is under no obligation to buy any). Other existing shareholders include Madrone Partners (11%), US Venture Partners (10.19%), RockPort Capital Partners (7.5%), CMEA Ventures (6.81%) and Redpoint Ventures (5.94%), as well as founder & CEO Christian Gronet (8.06% — Solyndra was founded in May 2005 as Gronet Technologies Inc but renamed in January 2006).

Solyndra's proprietary 11–14%-efficient solar panels comprise a 1m-by-2m array of 40 cylindrical tubes. This 'self-tracking' design — with a 360° surface that can absorb direct, diffuse and reflected sunlight (from below) — allows the capture of more sunlight from low-slope commercial rooftops than conventional flat-surfaced panels, which need costly tilted mounting devices to improve the capture of direct sunlight, offer poor collection of diffuse light, and fail to collect reflected light. Also, gaps between the tubes and frame let wind pass through, reducing the need for heavy, roof-penetrating fastenings or anchoring; lighter weight also allows installation on scantier roofs. Simple horizontal mounting hardware also allows fast and economical installation, claims the firm.

By 3 October, Solyndra had raised nearly \$970m through equity financing, including a \$281m round F in Q3/2009.

Capital expenditure rose from \$5.1m in 2006 to \$94.8m in 2007, \$144.5m in 2008, and \$101.5m for the nine months of 2009 (plus an estimated \$87m in Q4/2009). CapEx is expected to be \$590m in 2010. Solyndra has also invested at least \$290m in R&D.

Consequently, net losses have risen from \$27.2m in 2006 to \$114.1m for 2007 and \$232.1m in 2008, when it generated \$6m in revenue (69% from Germany). In the first nine months of 2009, net loss was \$119.2m on revenue of \$58.8m. In total, since starting commercial shipments in July 2008, Solyndra has sold 18.8MW of panels (1.6 MW in 2008 and 17.2MW in the first nine months of 2009). More than 85% of shipments have been to Europe.

In total, Solyndra has announced more than \$2bn in sales deals in the USA and Europe. In particular, framework agreements with system integrators and roofing materials manufacturers outline general terms for delivering up to 865MW of solar energy systems (panels and racks) by the end of 2013. However, Solyndra's existing

300,000ft² factory is running at an annual production rate of just 45MW (though it should expand to 110MW by the end of 2010).

Hence, in September, the US vice president Joe Biden announced that the Department of Energy (DOE) had finalized a \$535m federal loan guarantee that is expected to provide debt financing of 73% for construction of the first phase of the firm's \$733m second panel manufacturing plant (Fab 2) covering about 1 million square feet in nearby Milpitas. The groundbreaking ceremony in September drew Energy Secretary Steve Chu and California governor Arnold Schwarzenegger. Annual production capacity should be 250MW by first-half 2012. The second and final phase should add another 250MW (raising capacity to 500MW) and cost another \$642m, funded partly by proceeds from the IPO.

Solyndra has also applied for a federal loan guarantee of \$469m to help finance phase 2. The new plant should initially create 3000 construction jobs, and lead to as many as 1000 jobs once the facility opens, reckons the firm (which currently employs 600). The second phase should employ 1000 more.

www.solyndra.com

Solyndra signs North America distributor

Solyndra has signed an agreement with Allied Building Products Corp of East Rutherford, NJ, a national distributor of roofing, solar and other building products and materials and now Solyndra's first distributor of its CIGS thin-film solar systems in North America.

"Allied Building Products has broad reach, extensive customer support and strong logistics

capabilities in the roofing channel," comments Solyndra's CEO & founder Chris Gronet.

"Solyndra's unique solar panel technology should be considered by all commercial building owners evaluating new low-slope roof installations or re-roofing applications," asserts Allied Building Products' CEO Bob Feury.

www.alliedbuilding.com

centrotherm produces first CIGS PV modules in Taiwan

centrotherm photovoltaics AG of Blaubeuren, Germany, which provides equipment for the production of solar silicon, crystalline solar cells and copper indium gallium diselenide (CIGS) thin-film solar modules, says its Thin Film division has produced its first CIGS modules on a turnkey production line, for a Taiwanese client entering the thin-film market with its first turnkey line.

Designed and installed for a capacity of about 30MW, the line consists of 60 machines extending over a total distance of 400m. A team of about 20 process engineers operates jointly with the customer on location. The target is for full productivity, with an average efficiency of 10%, to be achieved by the end of 2010. With a surface area of 1.5m², the modules being produced are currently the largest

in mass production, it is claimed.

centrotherm photovoltaics says that it is backing CIGS technology as it offers the best prospects of achieving the highest efficiencies in thin-film mass production. Compared with other thin-film technologies, the production process also dispenses with the use of toxic process gases. "Our strength, which consists of combining technology and process know-how, is also evident in our turnkey concept for CIGS modules," claims chief technology officer Dr Peter Fath. "It is distinguished by technically simple industrial process management, with which we enable our customers to achieve cost-efficient production along with competitive efficiencies."

Production costs significantly below €1 per Watt-peak are con-

ceivable in thin-film mass production in the future, reckons the firm. "We believe that it [CIGS] will be a medium-term winner, also compared with the business in the crystalline cell area, which is currently significantly stronger," Fath stresses. However, centrotherm photovoltaics does not yet anticipate a strong increase in demand this year. "Falling costs for crystalline cells are raising the benchmark higher," Fath cautions. "Thin-film technology still has a lot of catching up to do by comparison."

In addition to the Taiwanese client, in February 2009 Centrotherm said that Germany's Illies Renewables had ordered a 50MW product line worth more than €60m for its factory in Magdeburg-Rothensee, for delivery in first-half 2010.

www.centrotherm-pv.com

XsunX completes fully functional hybrid CIGS PV device

XsunX Inc of Aliso Viejo, CA, USA, which develops and commercializes thin-film photovoltaic (TFPV) solar cell technologies and manufacturing processes, has announced that it has completed a fully functional CIGS (copper indium gallium diselenide) thin-film solar device.

"With this completed sample we have reached a critical milestone in our development process," says CEO Tom Djokovich. The initial iteration of the device was executed according to the firm's business plan, which outlined a year-end deadline for this stage of development. "This initial achievement illustrates a realistic set of company goals and demonstrates the strength of our relationships with the business and technical expertise that kept us on track," he adds.

XsunX says it is pioneering a hybrid solar cell technology, developed in partnership with an established equipment supplier to the hard disk drive (HDD) industry. Last September, XsunX and deposition tool supplier Intevac Inc of

Santa Clara, CA announced a joint business agreement to co-develop techniques and equipment for the production of processes and equipment for making CIGS solar cells

Developed for high-rate HDD production, Intevac's technology focuses on a relatively small deposition area for silicon solar wafers. This has been adapted to produce CIGS solar cells deposited onto stainless-steel substrate with a 'pseudo square' configuration.

As well as being sized to match existing HDD manufacturing processes, XsunX says that, by maintaining a small deposition area (initially about 5" squares), its new breed of TFPV manufacturing techniques will produce an appropriately proportioned cell that can be used on existing solar module production lines by manufacturers looking for a direct 'drop-in' replacement for traditional silicon cells. Featuring a less brittle and hence less fragile substrate, the CIGS device has the potential for increased yields over its silicon counterpart, believes the

firm. XsunX had previously (only last August) abandoned plans to build a \$40m amorphous silicon thin-film solar module factory.

XsunX believes that their unique approach also reduces a significant challenge that has faced the CIGS industry in the past: maintaining cell performance while scaling commercial production. "Approaches to mass-scale production of CIGS thin-film cells today introduce processing defects that significantly reduce cell performance," says chief technology officer Robert Wendt. "Because we are leveraging stationary small-area, high-rate, production technologies and not scaling up to large-area processing, we're able to strive for laboratory-metric conversion efficiencies."

In the next stage of development, XsunX will evaluate technical data concerning performance and conversion efficiency (continuing to fine-tune each cell layer, based on input from small-area devices) as well as optimizing engineering designs.

www.xsunx.com

CIGS PV maker Ascent working with metal roofing provider EnergyPeak

Ascent Solar Technologies Inc of Thornton, CO, USA, which manufactures flexible thin-film photovoltaic modules based on copper indium gallium diselenide (CIGS), has developed new building-integrated photovoltaic (BIPV) products with variable widths for the US standing seam metal roof market.

The work to optimize the new metal roof solution was part of an existing agreement with EnergyPeak of Moon Township, PA, which is a marketing segment of CENTRIA Services Group. Both firms expect the testing of BIPV products to proceed through first-half 2010, with the intent to purchase modules for projects in second-half 2010.

"We are pleased to publicly announce our existing relationship with Ascent," says Rick Mowrey, director of marketing & business development for EnergyPeak and CENTRIA. "We look forward to testing PV products from Ascent that can meet the needs of our metal roof industry," he adds.

"Metal roofing systems are an ideal end-market solution of our unique, lightweight and flexible PV modules," says Ascent's CEO Farhad Mogadam. With a short-term total addressable market of 10 million square feet of BIPV per year and 100 million square feet long-term, EnergyPeak is an 'ideal' partner.

www.energypeak.com

Ascent Solar hires VP of manufacturing

Ascent Solar has hired Zane Rakes as VP of manufacturing operations, bringing 16 years of experience in high-volume manufacturing systems, inventory management, manufacturing automation and global supply chain management.

"Zane has a proven track record of leadership in establishing and scaling up high-volume production facilities," says president & CEO Farhad Moghadam. Most recently, Rakes led construction, installation, start up and production ramp up of two solar module factories with a total capacity of 474MW while completing the project on time and on budget, he adds.

Prior to joining Ascent Solar, Rakes was director of operations for Concentrated Solar Power and Photovoltaics at SCHOTT Solar Inc. Previously, he was at Intel for over 15 years, holding various manufacturing positions. Most recently, he was a plant manager for Intel's operations in Colorado Springs.

"Zane brings the experience, skills and contacts necessary to ramp up our production from Fab 2 and evaluate potential expansion

possibilities going forward," says Moghadam (himself a former manager at Intel).

Last March, Ascent expanded from its initial facility in Littleton, CO (with a 1.5MW manufacturing line) by opening its new 30MW-capacity headquarters in Thornton (aiming to add 180-200 jobs over two years).

"Ascent Solar has a truly lightweight, flexible unique thin-film technology that can transform the way solar is used in many ways," says Rakes. "I look forward to leading the manufacturing expansion and technological optimization."

● Dr Prem Nath, senior VP of production operations, has retired after more than 30 years in the thin-film industry.

Nath led manufacturing efforts since 2006 and helped to establish its roll-to-roll production capability. He led Ascent to full end-to-end commercial production at Fab 1 in Littleton, positioning it to ramp to high-volume production at Fab 2 in Thornton.

The firm will continue to have access to Nath's knowledge and experience through consulting.

IN BRIEF

Ascent Solar hires Dow Corning veteran as VP of sales

Ascent Solar has hired Robert 'Bob' Johns as VP of sales, reporting to senior VP of sales & marketing Rafael Gutierrez.

Johns has over 29 years of experience in global sales, customer service, channel partner development and business development. "Bob has the abilities and global experience we need to increase sales velocity and foster new partnerships that will feature our unique flexible lightweight thin-film solar modules," says Gutierrez.

Johns spent 29 years with Dow Corning Corp, where he held numerous director-level positions in the Specialty Chemicals and Advanced Technologies & Ventures Businesses. As global director of New Business Programs, responsibilities included a portfolio of new business teams focused on high-growth markets including solar, compound semiconductors and other emerging high-priority programs. Most recently, based in Shanghai, he led Dow Corning's Global Customer Service organization while serving as a member of the Global Commercial and Greater China Councils. Earlier at Dow Corning, he served in sales and marketing roles in electronics, solar and defense markets.

Johns has a BBA in Management from Western Michigan University, and is an alumnus of the Executive Development Program at the Kellogg School of Management of Northwestern University.

Ascent's flexible solar technology is suited to a diverse set of products and customer opportunities, believes Johns. "I look forward to helping lead the sales and customer development effort as we move forward to expand the reach of our unique products."

www.ascentsolar.com

Ritek invests \$24.8m more in CIGS joint venture PVNext

Taipei-based Ritek Corp, Taiwan's second biggest optical disc maker, has made an additional investment of NT\$800m (US\$24.8m) to increase its stake to 40% in Taiwan-based PVNext Corp, its 50:50 joint venture formed in October 2008 with crystalline silicon solar cell maker Scheuten Solar Holding BV of Venlo, The Netherlands.

PVNext is based on Ritek's technology for making copper indium gallium diselenide (CIGS) thin-film photovoltaic (PV) modules, and is headed by Ritek's CEO Gordon Yeh. The strategic alliance with Scheuten aimed to allow Ritek more active involvement in developing photovoltaics through expanded production of solar cells.

The additional investment is being made because PVNext is issuing new shares to raise extra paid-in capital of NT\$2bn, says Ritek.

Previously, in late July, the National Development Fund of the Taiwan Cabinet (the central government's venture capital arm, which is used to promote the development of target industries) invested NT\$500m (US\$15.3m) in 20 million new shares issued by PVNext (at NT\$25 per share). This represents a 28.59% stake (shrinking the stakes of Scheuten and Ritek to 42.26% and 23.15%, respectively). This is the fund's first investment in solar cells since announcing support for Taiwan's green-energy sector last April. Proceeds were put towards

enhancing PVNext's module manufacturing by procuring production equipment. PVNext has since completed installation of all CIGS equipment.

At October's PV Taiwan 2009 event, Ritek launched Taiwan's first 600mm x 1200mm CIGS thin-film PV modules, which have an energy-conversion efficiency of 17% (the highest achieved in Taiwan so far, it is claimed, and close to the 20% of monocrystalline silicon). In early December, Ritek said that PVNext had achieved pilot production. PVNext plans to start volume production in first-quarter 2010, with initial annual output capacity of 30MW.

www.ritek.com

www.scheuten.com

GSE unveils thin-film PV charger with USB connection

At January's Consumer Electronics Show (CES 2010) in Las Vegas, Global Solar Energy Inc (GSE) of Tucson, AZ, USA, which makes copper indium gallium diselenide (CIGS) thin-film photovoltaic cells for both glass modules and flexible substrates, added universal serial bus (USB)-enabled SUNLINQ portable solar chargers to its product line up.

Global Solar claims that the SUNLINQ line is the only solution for portable solar power for any type of outdoor needs. This new feature can charge and power batteries for any mobile electronic device capable of connecting and charging via a USB interface, allowing consumers to keep their devices charged and ready to use at any time, from any location.

Equipped with flexible solar cells, the SUNLINQ USB Mini and USB Plus solar chargers are lightweight, convenient and easy to use, says Global Solar, delivering reliable solar power generation for any device with a USB port (including mobile phones, PDAs, iPods, and electronic readers like the Kindle). Unlike most solar chargers which rely on an integrated battery to



Global Solar's USB-enabled SUNLINQ charging a handheld device.

store power, the USB Mini and USB Plus deliver energy directly to the device's battery, providing a faster and more efficient charge, claims the firm.

Features and capabilities include the following:

- Lightweight, flexible solar cells mean the charger can be laid out or attached to better optimize sunlight and make for easier carrying.
- Originally designed to meet military specs, all of Global Solar's portable chargers offer a tough, weather-resistant, nylon rip-stop backing.
- Voltage regulation is standardized to 5V to meet USB charging specs.

● Due to high efficiency, SUNLINQ portable chargers power even under cloudy or overcast skies, suiting any region or outdoor activity.

"The proliferation of power-hungry portable electronics and our mobile society continue to drive demand for lightweight portable solar chargers to deliver power on the go, wherever you are," says North American sales manager Jim Kimbrough.

"With the addition of our SUNLINQ USB Mini and Plus, Global Solar can address the growing list of more than 2 billion electronic devices capable of charging via USB technology."

Global Solar has been delivering lightweight, portable solar chargers for ten years. The USB Mini and Plus are designed for consumers who can simply plug their device's USB adapter directly into the SUNLINQ's standard USB A-type receptacle, eliminating the need to purchase a separate car charger adapter for connectivity and charging.

The USB Mini and USB Plus solar chargers are available to consumers, select resellers and qualified manufacturers.

www.globalsolar.com

Sofradir wins €2.5m follow-on IR detector contract for European earth observation mission

Sofradir of Châtenay-Malabry, near Paris, France, which manufactures mercury cadmium telluride (HgCdTe, or MCT) infrared detectors for military, space and industrial applications, has won a further €2.5m contract to provide a second batch of 15µm-pitch multi-linear short-wave infrared (SWIR) arrays for the space-borne Global Monitoring for Environment and Security (GMES) initiative, which is a joint undertaking of the European Commission and the European Space Agency (ESA).

The order follows a previous €6.7m contract from satellite and space equipment supplier Astrium SAS in November 2008 to custom-design a three-band SWIR for the GMES Sentinel-2 mission. Sofradir says that the high levels of reliability and performance achieved with this first batch led to the new order. The MCT-based IR detectors are replacing competing technology previously used in European space projects. The latest multi-linear SWIR arrays are for the Multi-

Spectral Instrument (MSI), an earth observation instrument onboard each of the Sentinel-2 satellites. Sofradir will start delivering flight models for the two Sentinel satellites by mid 2010.

Sentinel-2 will provide a powerful and fully operational information capability in the frame of the Global Monitoring for Environment and Security (GMES) initiative (a joint undertaking of the European Commission and the European Space Agency). The mission is designed as an optical high-resolution multi-spectral mission to provide sustained operational land services for a period of at least 15 years, involving a series of several satellites.

The Sentinel-2 Multi-Spectral Instrument is a filter-based push-broom imager that provides imagery in 13 spectral channels with spatial resolutions ranging from 10m to 60m and fast revisit allowed by a 290km swath width (the strip of Earth scanned by the satellite). The instrument is required to operate over a wide

spectral range extending from the visible near-infrared (VNIR, 400–1100nm) to the short-wave infrared (SWIR, 1100–2500nm) spectral range.

The firm is involved in a growing number of satellite and space missions, covering applications such as earth mapping, environment and disaster monitoring, meteorology and planet exploration. Sofradir's MCT IR detectors are in orbit in the French military earth observation satellites Helios IIA and IIB (the latter was launched last December). Performance tests in early January show that the IR detectors are performing well. Sofradir's IR detectors are also being used on the European Space Agency (ESA) Venus Express satellites and the French MoD SPIRALE satellites. The firm's detectors for Japanese space agency (JAXA) SGLI/G-COM (Second Generation GLI/Global Change Observation Mission) are currently in the engineering model phase.

www.sofradir.com

ODIS wins \$750,000 AFRL contract for monolithic infrared imaging and readout integrated circuits

ODIS Inc (Opel Defense Integrated Systems) of Shelton, CT, USA, which designs communications transceivers, optoelectric integrated platforms and infrared sensor type products for military and industrial applications, recently received a \$750,000 award to develop 'Monolithic Infra-Red Pixel Structures Enabled by Thyristor-HFET EO Logic'.

Infrared technologies currently require cryogenic cooling to operate and use independent readout integrated circuits. In contrast, ODIS' technology has been developed to provide an integrated approach to IR imaging combined with transistor readout circuits.

Chief scientist Dr Geoff Taylor says that, by incorporating these technologies on the same epitaxial structure, the electro-optic operation should enable high-sensitivity infrared imaging in an uncooled environment with significantly improved operating speeds and off-chip communications.

The technology not only has the potential to produce cost savings for the US Air Force and Space Missile Command, says president Leon (Lee) Pierhal. "We expect enhanced reliability and higher resolution for current and future satellite missions. In addition, the technology should be able to reduce the cost and improve

performance for several commercial markets which become viable with this new capability."

At the heart of the technology is ODIS' new, patented planar optoelectric technology (POET) semiconductor fabrication process, which is based on a novel III-V materials structure. POET supports monolithic fabrication of ICs containing active and passive optical elements, together with high-performance analog and digital elements, allowing economical integration of many optical devices together with dense, high-speed analog and high-speed, low-power digital elements in monolithic ICs, says ODIS.

www.opelinc.com

SEI explains polarization clues to optimal GaN green laser stripes

Laser stripes along the semi-polar $[\bar{1}014]$ direction are preferred over $[\bar{1}2\bar{1}0]$ for lower threshold current and longer wavelength in green laser diodes, reports **Mike Cooke**.

Japan's Sumitomo Electric Industries (SEI) has been studying optical polarization of light emitted from green laser diode (LD) structures as a guide to the optimal construction of laser stripes [Takashi Kyono et al, Appl. Phys. Express, vol3, p011003, 2010].

SEI has registered recent successes in using gallium nitride (GaN) substrates with the semi-polar $\{20\bar{2}1\}$ surface plane to create LDs with 531nm true green (520–570nm) pulsed laser emission as well as continuous wave (cw) operation at 520nm. SEI produces these substrates using hydride vapor phase epitaxy (HVPE).

By using these substrates, the researchers have been able to grow high-indium-content quantum well (QW) layers with high quality to access the longer green wavelengths, compared with lasers that emit in the near-ultraviolet to blue wavelength ranges (375–470nm) using nitride semiconductors with various combinations of aluminum (Al), indium (In) and gallium (Ga).

The effect of using semi-polar substrates is to reduce the internal electric fields arising spontaneously and when the material is strained (piezoelectricity). This results in smaller blue-shifts between the non-lasing and lasing states.

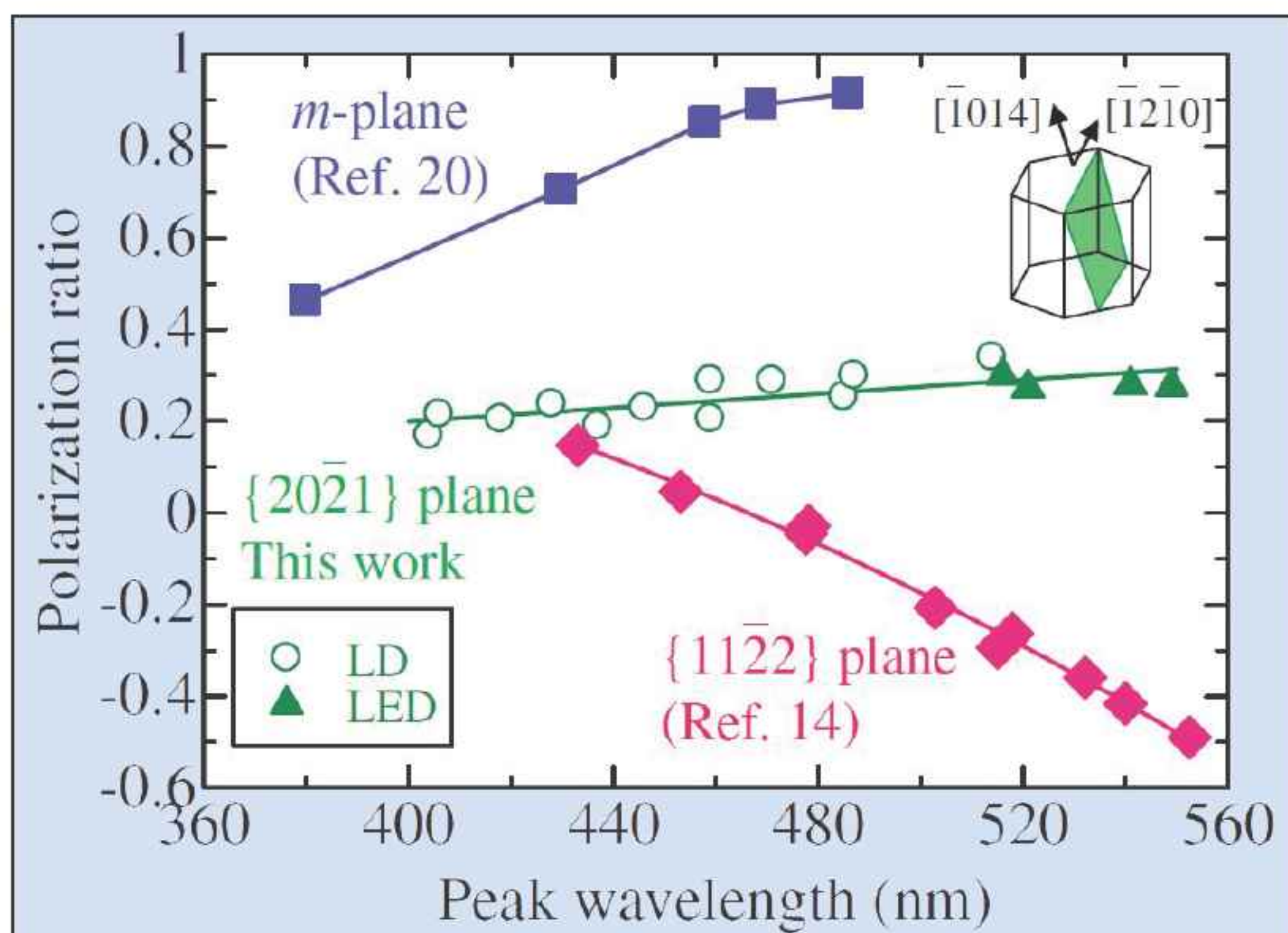


Figure 1. Polarization ratio vs peak wavelength under a current density of $7.4\text{A}/\text{cm}^2$, compared with results of other groups using m -plane MQWs with 3nm wells (Rohm, photoluminescence) and $\{11\bar{2}2\}$ plane 3.1nm single QWs (UCSB/Mitsubishi, electro-luminescence with current density $10\text{A}/\text{cm}^2$).

In the latest research, SEI scientists have studied the polarization ratio dependence under electro-luminescence (EL) with peak wavelength and current density to help determine the best laser strip orientation on $\{20\bar{2}1\}$ substrates.

The LD structure consists of a series of layers grown using MOCVD: n-type GaN buffer, n-type InAlGaN cladding, n-type InGaN waveguide, multiple QW (MQW) active region (3x 3nm InGaN wells, 2x GaN barriers), p-type AlGaIn electron blocker, p-type InGaIn waveguide, p-type InAlGaIn cladding, and p-type GaN

contact. The same structure — without the cladding and waveguides — has also been used for light-emitting diode (LED) structures. The aim of the LED structures was to see the effect of strain on polarization.

Both epitaxial wafer structures were processed into surface-emitting structures for pulsed EL measurements. A semi-transparent p-type electrode was used on the surface, while an n-type electrode was deposited on the back-side of the wafer.

The polarization ratio shows a small increase as the peak wavelength increases (Figure 1).

In fact, a higher polarization ratio would be advantageous for lasing and it was found that miscutting the substrate in the m-plane

direction increased it to 0.49 at 513nm with a +4° angle and decreased it to 0.12 with a -4° angle at 516nm. The researchers were somewhat surprised by this result, since previously reported theoretical calculations had suggested only a slight effect from such miscutting.

Also, the polarization for the non-miscut LDs with current density was

almost constant up to 0.74kA/cm². In addition, the stronger polarization component was found to have a slightly longer wavelength (Figure 2). This is interpreted as being due to the stronger component resulting from an optical transition between the conduction band and the highest valence band (lower photon energy and hence longer wavelength).

Another interesting observation is that the LED structures are on the same trend line as the LD structures. Researchers

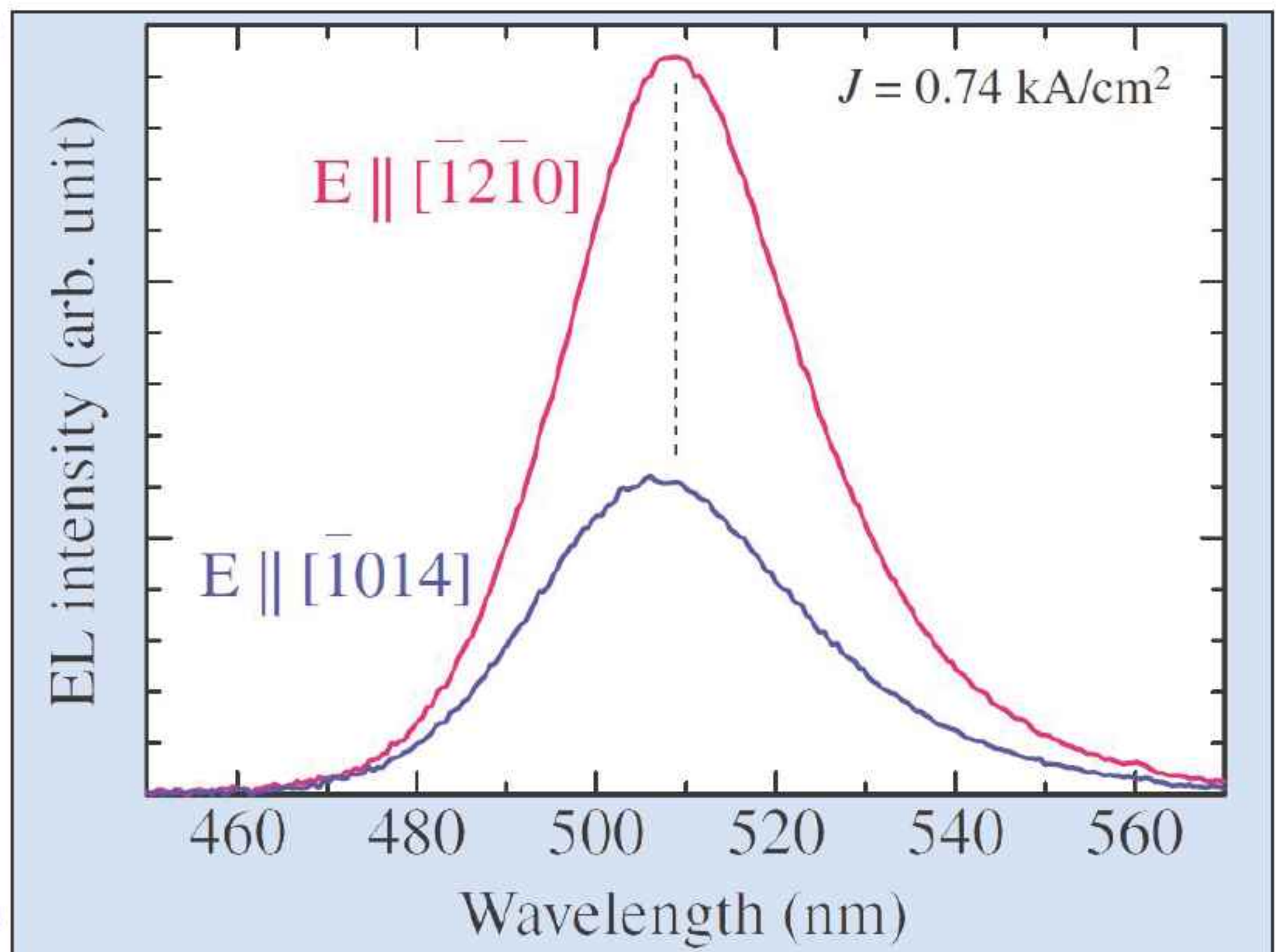


Figure 2. Polarized EL spectra of green LED on $\{20\bar{2}1\}$ plane GaN substrate at 0.74kA/cm² current density.

$[\bar{1}014]$ stripes lased at a longer wavelength: 512nm rather than 503nm. This wavelength increase is not due solely to the wavelength difference between the polarization components, but is due rather to the lower threshold voltage, meaning that there is a lower blue-shift in going from spontaneous to stimulated emission

at University of California Santa Barbara and Rohm found a shift towards positive polarization values for $\{11\bar{2}2\}$ plane LDs over comparable LEDs due to strain relaxation from defect introduction. The SEI researchers suggest their use of lattice-matched InAlGa_N cladding was responsible for the suppression of strain relaxation effects that can modify electronic band structures.

The SEI researchers conclude from their work that a laser stripe along the $[\bar{1}014]$ direction is to be preferred over a $[\bar{1}2\bar{1}0]$ direction. To confirm this, they constructed LDs with these stripe directions. The threshold current with $[\bar{1}014]$ stripes was a quarter that of $[\bar{1}2\bar{1}0]$ stripes. In addition, $[\bar{1}014]$ stripes lased at a longer wavelength: 512nm rather than 503nm. This wavelength increase is not due solely to the wavelength difference between the polarization components, but is due rather to the lower threshold voltage, meaning that there is a lower blue-shift in going from spontaneous to stimulated emission.

"Based on these analyses, we have adopted such device designs for our green LDs and have achieved 520–531nm lasing, as reported in detail in the previous studies," the researchers comment. ■

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The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

Producing more light than heat from quantum cascade lasers

Wall-plug efficiencies of QCLs have been boosted from 35% to 40–50%.

Two separate groups have reported increased wall-plug efficiency (WPE) for quantum cascade lasers (QCLs) in *Nature Photonics* [published online 10 January 2010, Peter Q. Liu et al, <http://dx.doi.org/10.1038/NPHOTON.2009.262>; Yanbo Bai et al, <http://dx.doi.org/10.1038/NPHOTON.2009.263>].

One group (Peter Q. Liu et al) involves scientists from Princeton and John Hopkins universities, along with researchers at QCL specialty company AdTech Optics Inc of City of Industry, CA, USA. This group has designed and implemented an 'ultra-strong coupling' strategy to achieve WPEs of 40–50% when operated in pulse-mode at temperatures less than 160K (Figure 1). The ultra-strong coupling aims to achieve efficient transport of electrons into the active regions of the QCL. Normally, this is limited by the interface-roughness-induced detuning of resonant tunneling.

The other group (Yanbo Bai et al) is at the Center for Quantum Devices at Northwestern University. This team uses a single-well injector to achieve 53% WPE (Figure 2) at 40K (Figure 3) with an emitting wavelength of 5 μ m. "In other words, we demonstrate a quantum cascade laser that produces more light than heat."

QCLs use thousands of layers of wells and barriers to create sub-bands in a cascade of stages consisting of successive injector and active regions. The injection uses resonant tunneling. Both groups used InGaAs wells and InAlAs barriers. Electron transitions between the sub-bands result in the emission of photons.

Although internal quantum efficiencies can reach 80% at low temperature, WPEs up to now have been limited to around 35% or less, excluding cooling requirements (such as the energy needed to produce liquid helium or nitrogen for cryogenic work).

QCL frequencies can range from terahertz to the mid-infrared (350–2.7 μ m wavelengths). Mid-IR QCLs could be used as light sources for molecular detection for environmental or medical monitoring.

The Princeton/John Hopkins/AdTech group based their work on recent theoretical calculations by some of the team suggesting that interface-roughness-induced detuning of the resonant tunneling is a more important limiting factor for electron transport and gain in QCLs than broadening of the radiative transition that had previously been blamed for poor performance. To overcome the poor coupling, the researchers used much thinner injection barriers ($\sim 10\text{\AA}$, rather than 30–40 \AA).

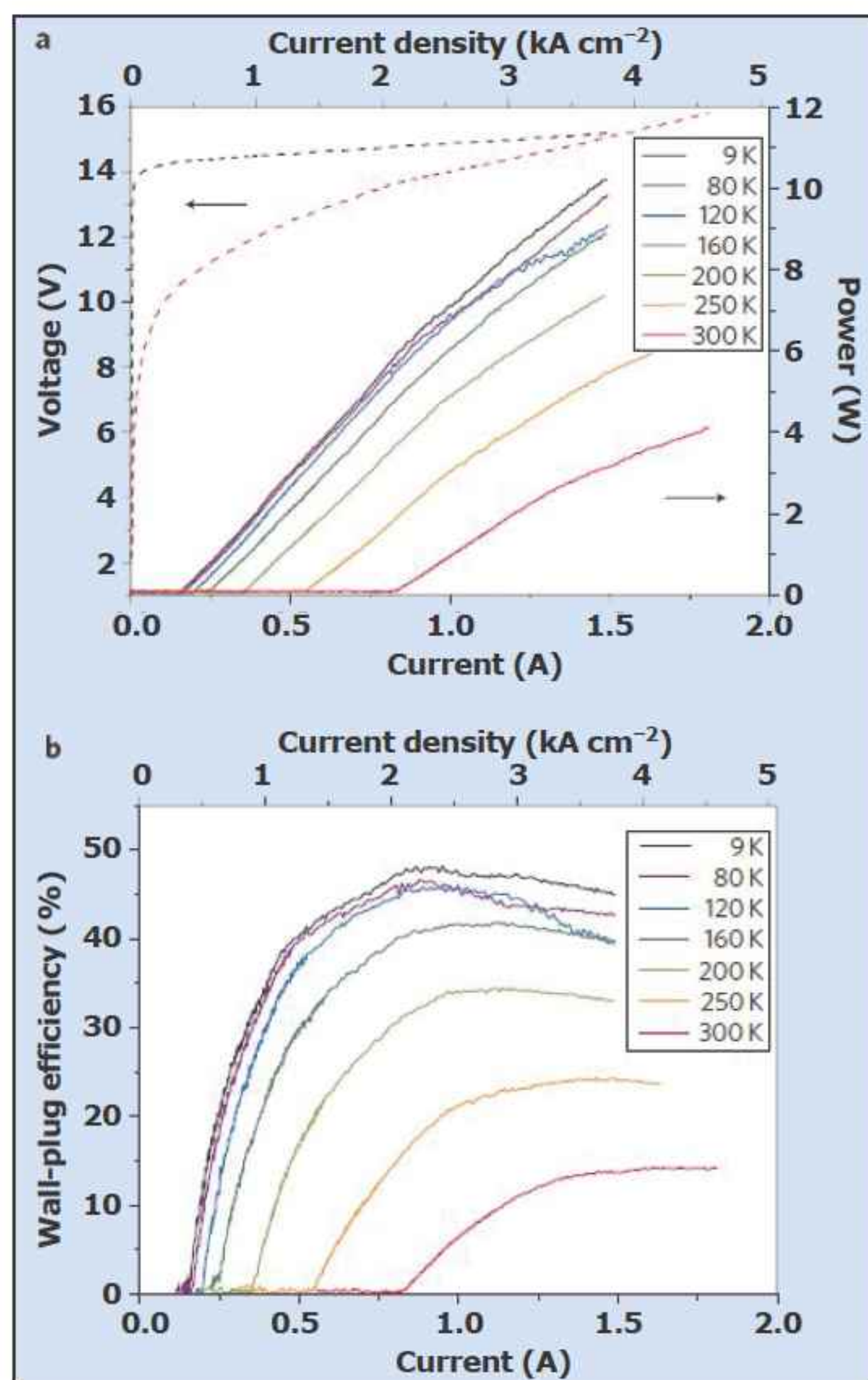


Figure 1. Pulsed light-current-voltage measurements (a) and extracted WPE (b) for Princeton/John Hopkins/AdTech QCL.

This gave a coupling strength of $\sim 10\text{meV}$ as opposed to 2–4meV for traditional designs.

The QCLs were grown on indium phosphide (InP) substrates using MOCVD and strain-balanced layers of $\text{In}_{0.66}\text{Ga}_{0.34}\text{As}/\text{Al}_{0.69}\text{In}_{0.31}\text{As}$ well/barriers. Ridge waveguides were constructed of width 13.5–21.5 μ m.

The wavelength of the laser radiation was $\sim 4.5\mu\text{m}$ at 80K and $\sim 4.7\mu\text{m}$ at room temperature (300K). The characteristic temperature for the slope efficiency (T_1) was 330K, much better than the usual values of less

than 300K. The threshold, however, had a poor characteristic temperature (T_0) of ~ 125 K. This was blamed on the low two-LO-phonon voltage defect used in the injector design, favoring low-temperature operation and limiting performance at higher temperatures.

Continuous wave (CW) operation showed maximum WPE values of about 30% and output power of 4.5–6W

at less than 80K. The lower performance is due to the lack of an efficient heat removal and packaging design for CW operation.

Northwestern has also concentrated on the injector regions for improving QCL performance at low temperature. The researchers point out that many of the features of long injector designs are there to enable higher-temperature operation. Such injectors have to cope with effects such as thermal back-filling that are not a problem at cryogenic temperatures (i.e. less than 80K). Northwestern's QCLs are designed for low-temperature/ high-efficiency operation and use a single-well injector (Figure 3).

Another design move is to use only three wells (single phonon resonance) rather than the more usual four wells (double phonon resonance) in the active region. This reduces the voltage defect for turn-on and turn-off per stage, reducing operating voltage and hence power consumption. The period of the QCL structure is 22.1nm as opposed to ~ 50 nm used for this wavelength range in devices designed for room-temperature operation.

For the construction of lasers from an 80-stage QCL structure on n-InP substrates, a 6 μ m buried ridge was used. Since shorter cavities do not much affect the threshold but do have higher slope efficiency, a 2mm rather than a 5mm cavity length (often used for high-temperature operation) was chosen. Testing was carried out with 200ns pulses and a duty cycle of 5% (250kHz repetition rate). At 80K, the threshold current density and voltage were 05.kA/cm² and 0.27V, respectively. The slope efficiency was 0.17W/A. Under temperature variation, the WPE peaks at 53.1% at 40K (Figure 2).

The leader of Northwestern's work, professor Manijeh Razeghi, comments that the low-temperature research started as 'a side project' to see how high the efficiency could be pushed. "Theory said that high efficiency was possible, but it just hadn't been done before."

The Center for Quantum Devices, of which Razeghi is director, is one of three groups currently funded by the US Defense Advanced Research Program Agency (DARPA) to improve the room-temperature QCL efficiency under the Efficient Mid-Wave Infrared Lasers

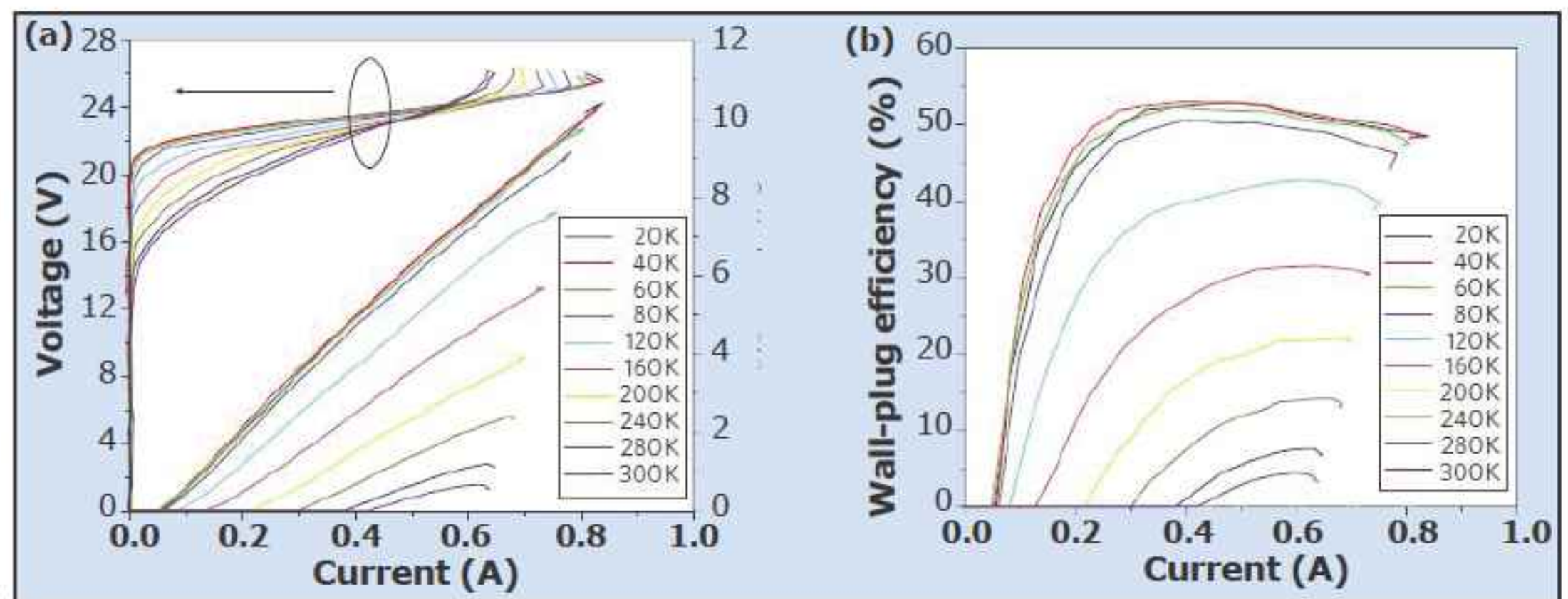


Figure 2. Pulsed L-I-V results (a) and extracted WPE (b) for Northwestern QCL.

(EMIL) program. She comments: "Similar to our low-temperature work, we have the highest efficiencies of any group to date (23% pulsed, 18% continuous). This project is ongoing, with the eventual aim to get 50% efficiency at room temperature as well." ■

<http://dx.doi.org/10.1038/NPHOTON.2009.262>

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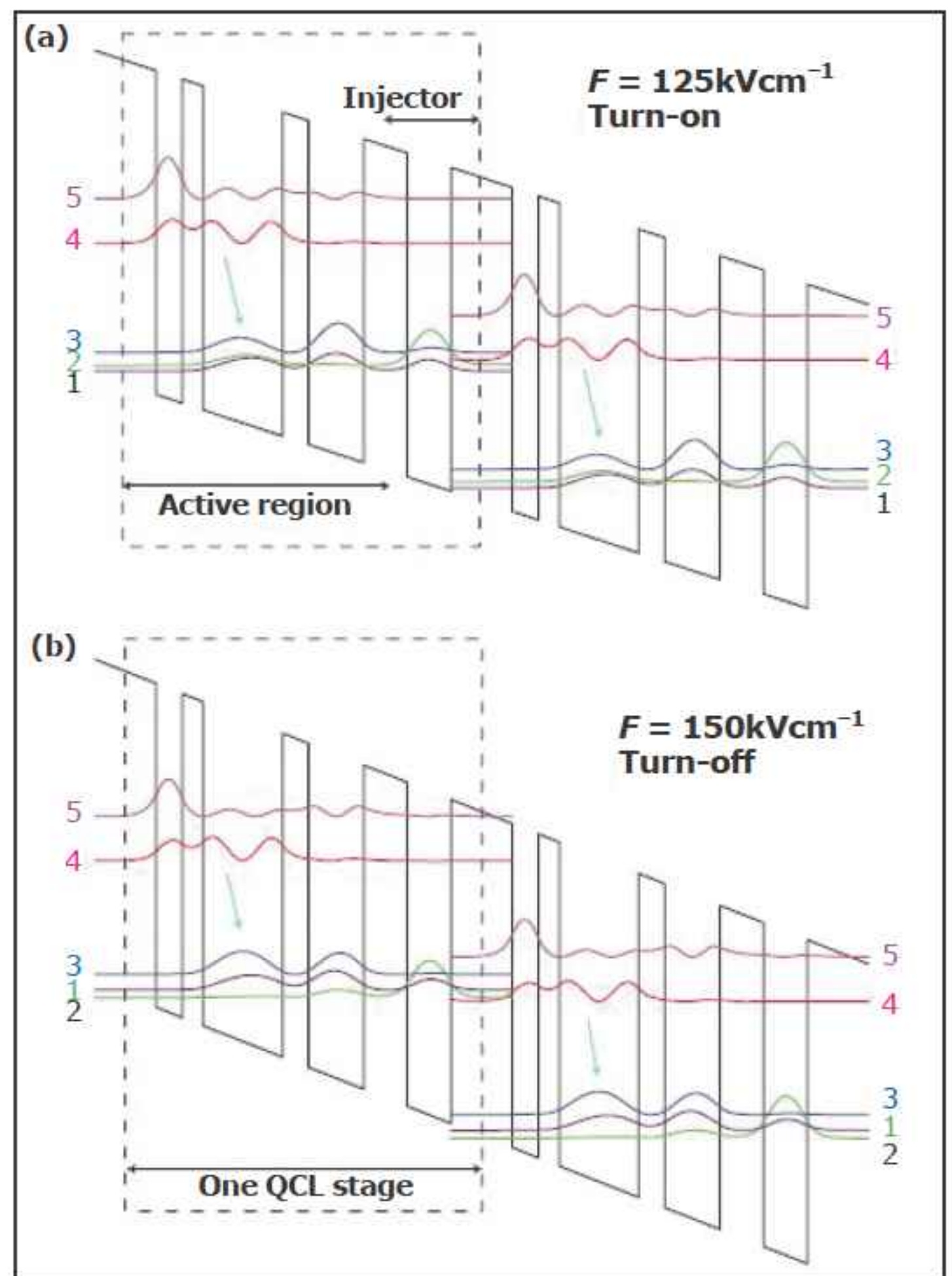


Figure 3. Conduction band and wavefunction diagram for Northwestern's single-well injector design with simulations carried out at turn-on (a) and turn-off (b). Wells and barriers consisted of $\text{In}_{0.66}\text{Ga}_{0.34}\text{As}$ and $\text{Al}_{0.64}\text{In}_{0.36}\text{As}$, respectively.

Direct wafer bond route to III-V field-effect transistors

Japanese researchers have been developing direct wafer bonding (DWB) to transfer III-V semiconductor-on-insulator (III-V-OI) materials onto silicon with a view to creating new field-effect transistors to replace silicon complementary metal-oxide-semiconductor (CMOS) devices [Yokoyama et al, Appl. Phys. Express, vol2, p124501, 2009]. The research team consists of scientists from the University of Tokyo, Japan's National Institute of Advanced Industrial Science and Technology (NAIST), and Sumitomo Chemical.

While DWB has been used to create optoelectronic devices on silicon, the creation of III-V transistors using the technique faces a number of challenges. To compete with coming ultra-thin-body silicon-on-insulator (SOI) CMOS, the III-V materials would have to be incorporated into a similar format. Ultra-thin-body III-V material quality is very sensitive to damage created by the bonding process. Further problems arise in creating suitably doped source/drain (S/D) regions.

The researchers worked with one of the most promising materials for nMOSFETs — indium gallium arsenide (InGaAs). MOCVD was used to grow a 100nm-thick layer of $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ on a 2-inch diameter indium phosphide wafer (Figure 1). The insulating buried silicon dioxide (BOX) layer was grown on top of the InGaAs using electron cyclotron resonance (ECR) plasma sputtering. The ECR process was chosen over traditional plasma-enhanced chemical vapor deposition (PECVD) as giving better controllability and atomic-level flatness (a root-mean-square surface roughness of about 0.2nm) when used on III-V semiconductor material. By growing the BOX on the InGaAs before bonding, one can maintain a good InGaAs/BOX inter-

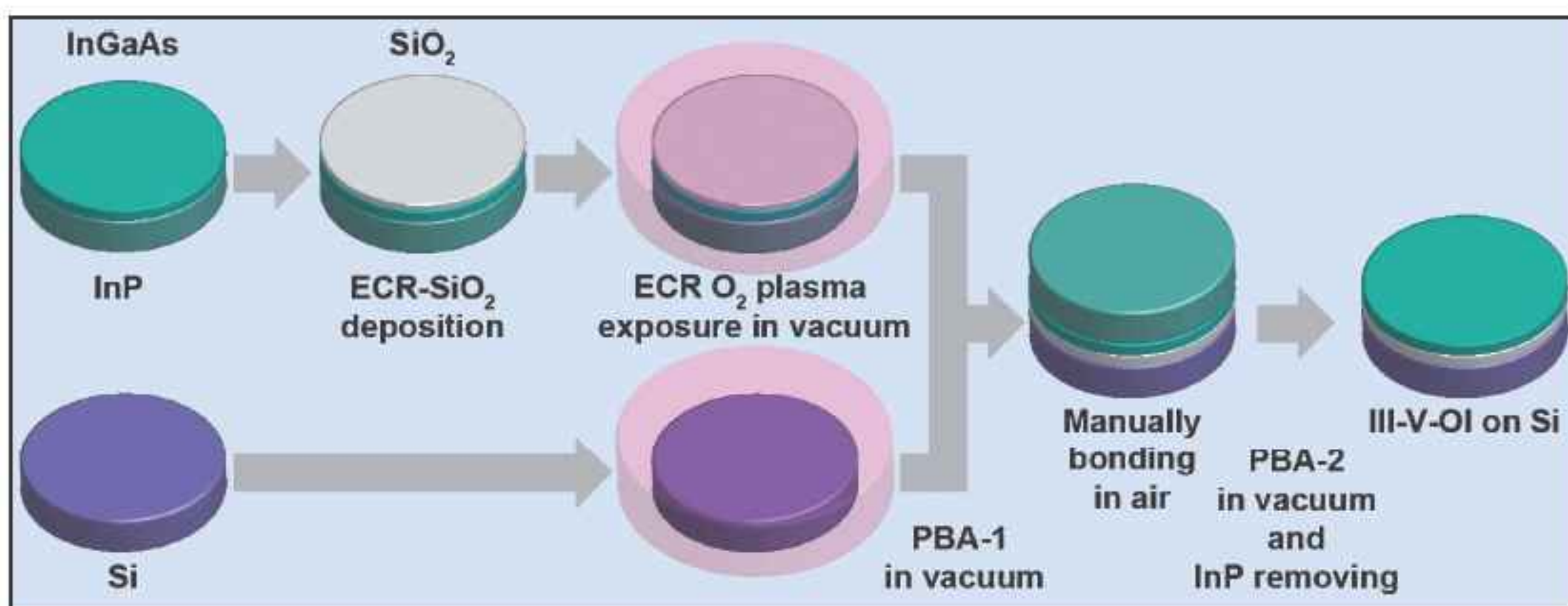


Figure 1. DWB process for integrating thin-body III-V-OI channel layer on a Si wafer. PBA-1 and PBA-2: pre-bonding annealing and post-bonding annealing, respectively.

face. An oxygen plasma treatment is used to further enhance the bonding energy between the BOX and the silicon substrate. The silicon and BOX/InGaAs/InP wafers were then bonded manually in air. The InP wafer was then removed using a (1000:1 InP:InGaAs) selective etch in hydrogen chloride solution, leaving the InGaAs surface layer.

Among the characterizations of the resulting InGaAs layer, it was found that the Hall (electron) carrier mobility was $\sim 7000\text{cm}^2/\text{V-s}$, which compares reasonably with a bulk InGaAs value of $\sim 11,000\text{cm}^2/\text{V-s}$. The mobility of electrons in bulk silicon is about $1500\text{cm}^2/\text{V-s}$.

The DWB III-V material was used to create back-gated III-V-OI MOSFETs (Figure 2). The S/D consisted of gold-germanium contacts, while

the gate was aluminum deposited on the back side of the silicon. The gate length at this stage is a massive $500\mu\text{m}$ (state-of-the-art silicon is pressing on downward to 32nm and smaller). The channel width was $100\mu\text{m}$.

The effective mobility in the resulting nMOSFETs was measured at $1200\text{cm}^2/\text{V-s}$, corresponding to a 1.9x enhancement factor over comparable silicon nMOSFETs.

The researchers conclude: "These results indicate that the present DWB technique is quite promising for integrating ultra-thin-body or multi-gate III-V-OI MOSFETs on the silicon CMOS platform as the ultimate CMOS transistors."

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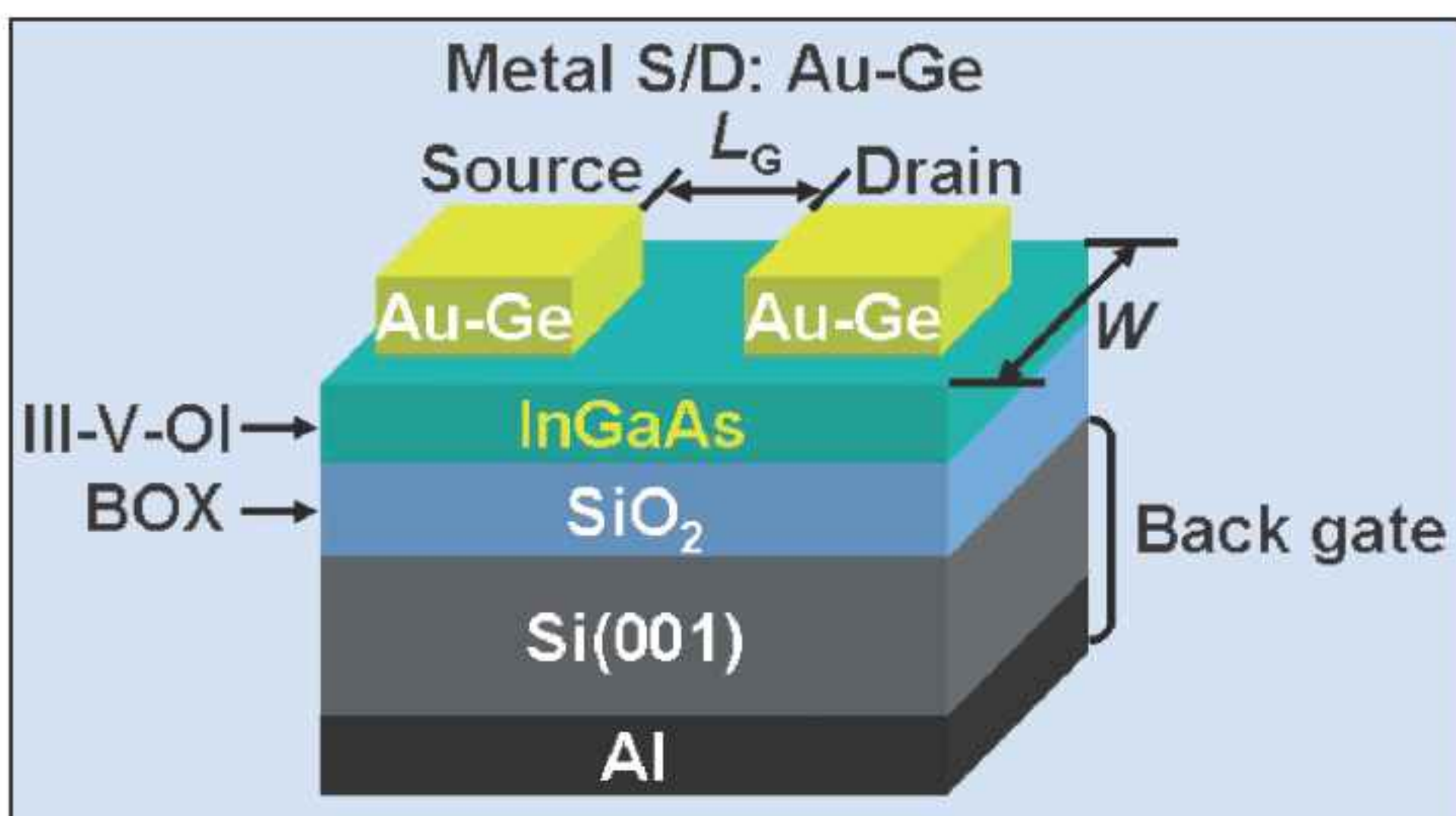


Figure 2. Metal S/D thin-body III-V-OI nMOSFET on Si wafer with back-gate.

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Dielectrics at the III-V logic starting gate

The IEEE's International Electron Devices Meetings of the past few years have seen an increasing development of III-V semiconductor channels for use as silicon logic enhancers. Last December, the focus for IEDM 2009 shifted from the demonstration of the benefits of high mobility and integration with silicon substrates to developing the gate stack. **Mike Cooke** reports.

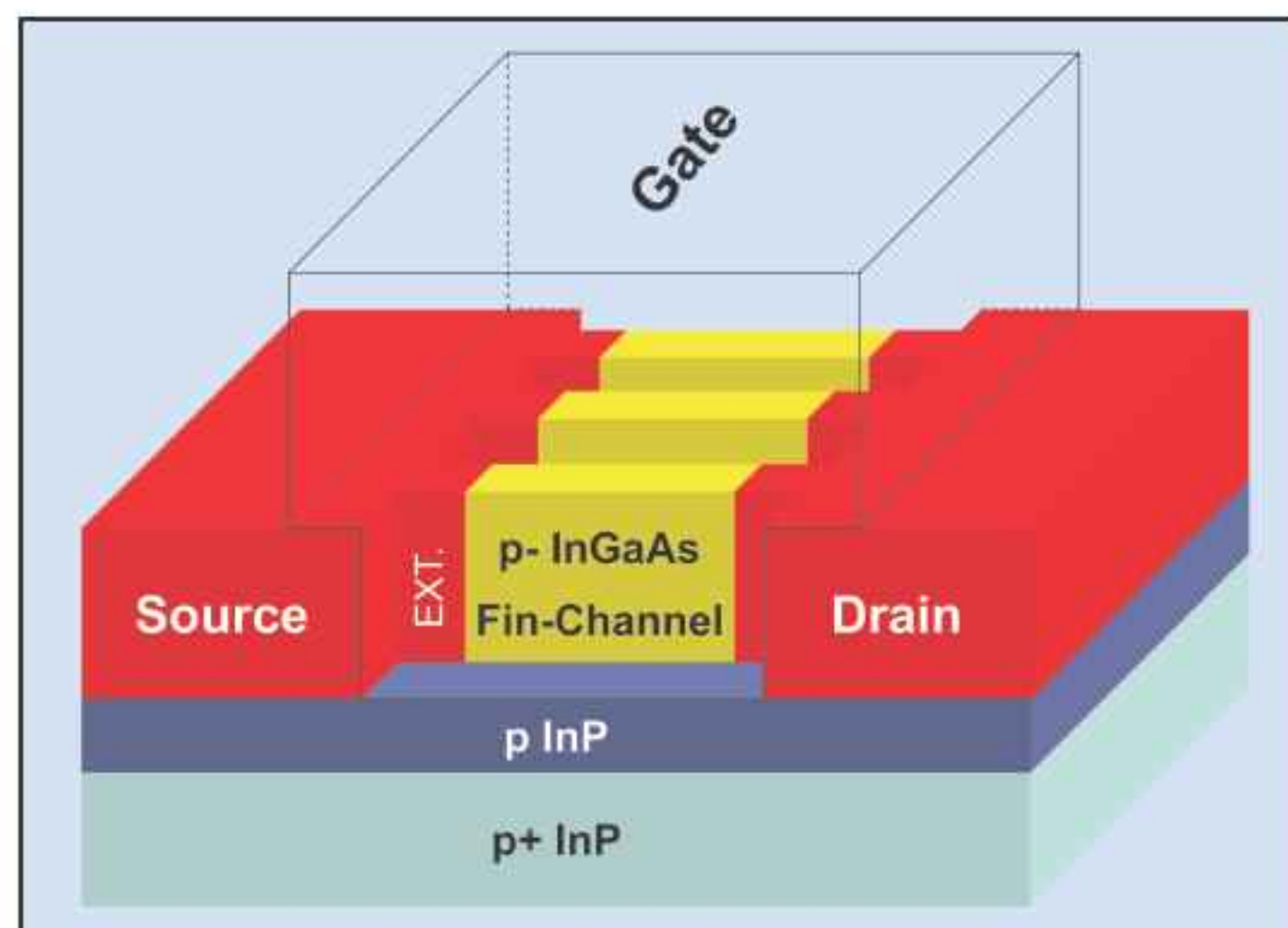


Figure 1. Schematic of Purdue's InGaAs FinFET.

A wide range of electron device developments (that also shifts with the years) gets to be reported and discussed each December at the IEEE's International Electron Devices Meeting. About half of the work tends to be mainstream silicon CMOS with potential application in the next few years. Some sessions look into the far future (2020s and beyond), for which the present interest seems to be mainly focused on carbon-based devices — nanotubes and graphene.

Here we will focus on the medium-term issue of gate dielectrics for use with III-V logic devices designed to solve (for a time) many of the problems raised by the continuous shrinking of CMOS devices on silicon according to the schedule set out in the International Technology Roadmap for Semiconductors (ITRS). The development of nitride and silicon carbide power transistors will be the subject of a future article.

The mainstream logic industry (e.g. Intel) is looking to III-V materials such as indium gallium arsenide (InGaAs) and indium antimonide (InSb) to create channels with higher drive currents on the basis of higher charge-carrier mobility. The complementary metal-oxide-semiconductor/silicon (CMOS) circuits used in the logic industry need both n-type nMOS and p-type pMOS field-effect transistors (FETs), where inversion layer channels have current carriers that have negative ('electron') and positive ('hole') charge, respectively.

While hole mobility in silicon is reduced by a factor of three compared with that of electrons, the situation is often much worse with the III-V contenders for CMOS enhancement (typically, a factor of 20–100 lower). It seems likely that germanium channels will be used for high hole mobility, although some recent modeling work — involving Stanford University, Intel and the US Naval Research Lab [1] — suggests that a strained indium gallium antimonide (InGaSb) combination could achieve better hole mobility. Experiments with $\text{In}_{0.41}\text{Ga}_{0.59}\text{Sb}/\text{GaSb}$ resulted in the highest reported hole mobilities, at 3x that achieved with uniaxially strained silicon.

The higher electron mobility of bulk InGaAs (more than $8000\text{cm}^2/\text{V}\cdot\text{s}$) compared with bulk silicon ($\sim 1500\text{cm}^2/\text{V}\cdot\text{s}$) leads to larger currents in the on-state. However, off-state performance needs to be much improved to meet the requirements of the International Technology Roadmap for Semiconductors (ITRS). Off-state short-channel effects (SCEs) in InGaAs kick in much faster due to its narrower bandgap and higher dielectric constant (k) compared with silicon.

FinFETs

Wrap-around gate structures, such as those around the fin channels in FinFETs, provide better electrostatic control of the off-state. This requires highly challenging etch processes with low surface damage

and a good interface with high-k gate dielectrics. Dry (plasma) etch of III-V materials such as InGaAs can be particularly tricky.

Purdue University is claiming the first 'well behaved' inversion-mode (i.e. normally-off) indium gallium arsenide (InGaAs) FinFET (Figure 1) with gate lengths down to 100nm [2]. The gate dielectric comprised aluminum oxide (Al_2O_3), deposited using atomic layer deposition (ALD) techniques. The fin height was 40nm.

The researchers report much better control of SCEs, compared with normal planar InGaAs MOSFETs, resulting in improved sub-threshold slope (SS, 34% better with 100nm gate length, compared with planar devices), drain-induced barrier lowering (DIBL, reduced from 480mV/V to 180mV/V) and threshold voltage (V_T) roll-off (about 30% that of a planar device), along with less degradation of these properties at raised temperature (up to 360K).

In related work, Purdue has developed a new hydrogen bromide (HBr) pre-treatment, along with retrograde channel structuring and halo-implantation, to improve the InGaAs/high-k dielectric interface for planar MOSFETs [3]. Both the FinFET and the planar MOSFET work were led by Purdue doctoral student Yanqing Wu.

Although the ultimate aim would be to create InGaAs FinFETs on silicon substrates up to 300mm diameter and beyond, the Purdue researchers used a 2-inch indium phosphide substrate for the 'proof-of concept' device (Figure 1). The device layers were grown using molecular beam epitaxy (MBE). A heavily doped InP layer was grown beneath the $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ channel to reduce punch-through of current in the off-state and current leakage through the substrate. One negative effect of the high doping was worse junction leakage due to the non-optimized contacts that were used.

An Al_2O_3 dielectric 'encapsulation layer' was then grown to a thickness of 10nm using an ASM F-120 reactor. The source and drain regions were created using selective ion implantation of Si through the dielectric into the InGaAs followed by rapid thermal annealing (RTA) to activate the Si doping.

The fin structures were created using a combination of wet and dry etch techniques, resulting in damage-free sidewalls. The dry etch used a boron trichloride (BCl_3)/argon (Ar) plasma. An electron-beam lithography resist (ZEP-520A) was used as a mask for the etch process. The surface layer damage from the dry etch was removed using a 3 second dip in a dilute sulfuric acid/hydrogen peroxide $\text{H}_2\text{SO}_4:\text{H}_2\text{O}_2:\text{H}_2\text{O}$ solution. The researchers believe a more sophisticated process is needed to create more vertical side-walls (Figure 2).

The Al_2O_3 encapsulation was removed with a buffered-oxide etch (BOE) solution. The Al_2O_3 dielectric was then re-grown as a 5nm gate dielectric film after an ammonium sulfide ($(\text{NH}_4)_2\text{S}$) surface preparation.

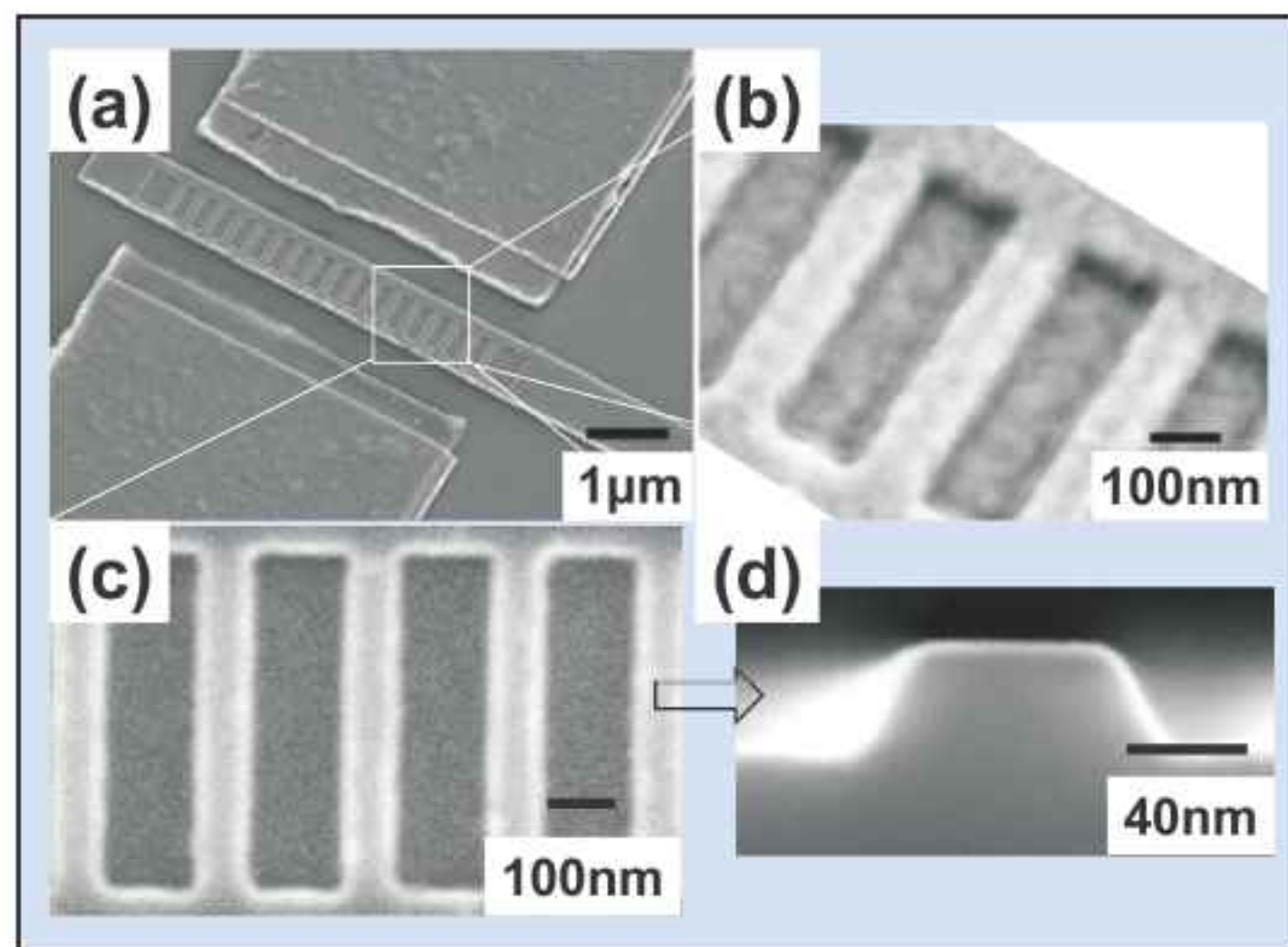


Figure 2. Tilted SEM image of Purdue's FinFET device. (b) Zoomed-in image of channel region covered with gate dielectric and metal. (c) SEM image of the fin structure after dry etching. (d) Cross sectional SEM image of fin after dry etching.

Electron-beam evaporation and lift-off was used to form the source/drain contacts using AuGe/Ni/Au layers. The gate was Ni/Au, created similarly.

The improved sub-threshold slope (SS) for the device is taken as an indicator of the 'damage-free' nature of the etch process of the fin. Normally, planar device interface trap densities can be estimated from the variation of SS values with temperature. Since the FinFET cannot have better surface quality than the planar device, the better overall SCE behavior must impact the SS performance. However, the very good SS values obtained indicate high-quality interfaces, enabling the researchers to declare that the dry/wet etch process is 'damage free'. By making suitable extrapolations, the Purdue team estimates an upper limit on the average interface trap density (D_{it}) of $1.7 \times 10^{12}/\text{cm}^2\text{-eV}$.

The Purdue researchers also claim to be the first to grow hafnium dioxide (HfO_2) dielectric on fin-structures, in work yet to be published. HfO_2 dielectric is among the leading contenders for use as high-k dielectric on traditional CMOS transistors. Companies such as Intel and IBM have both proposed its use.

Composite stacks

The focus for Intel's latest reported work on InGaAs channels has been the gate contact, and particularly reducing leakage through using high-k dielectric insulation, rather than a Schottky contact [4]. A composite gate stack on $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}$ was made (Figure 3) using 4nm of tantalum silicon oxide (TaSiO_x) and 2nm of indium phosphide. The dielectric was applied using atomic layer deposition (ALD) on the upper barrier rather than directly on the well to maintain the channel mobility (measured at

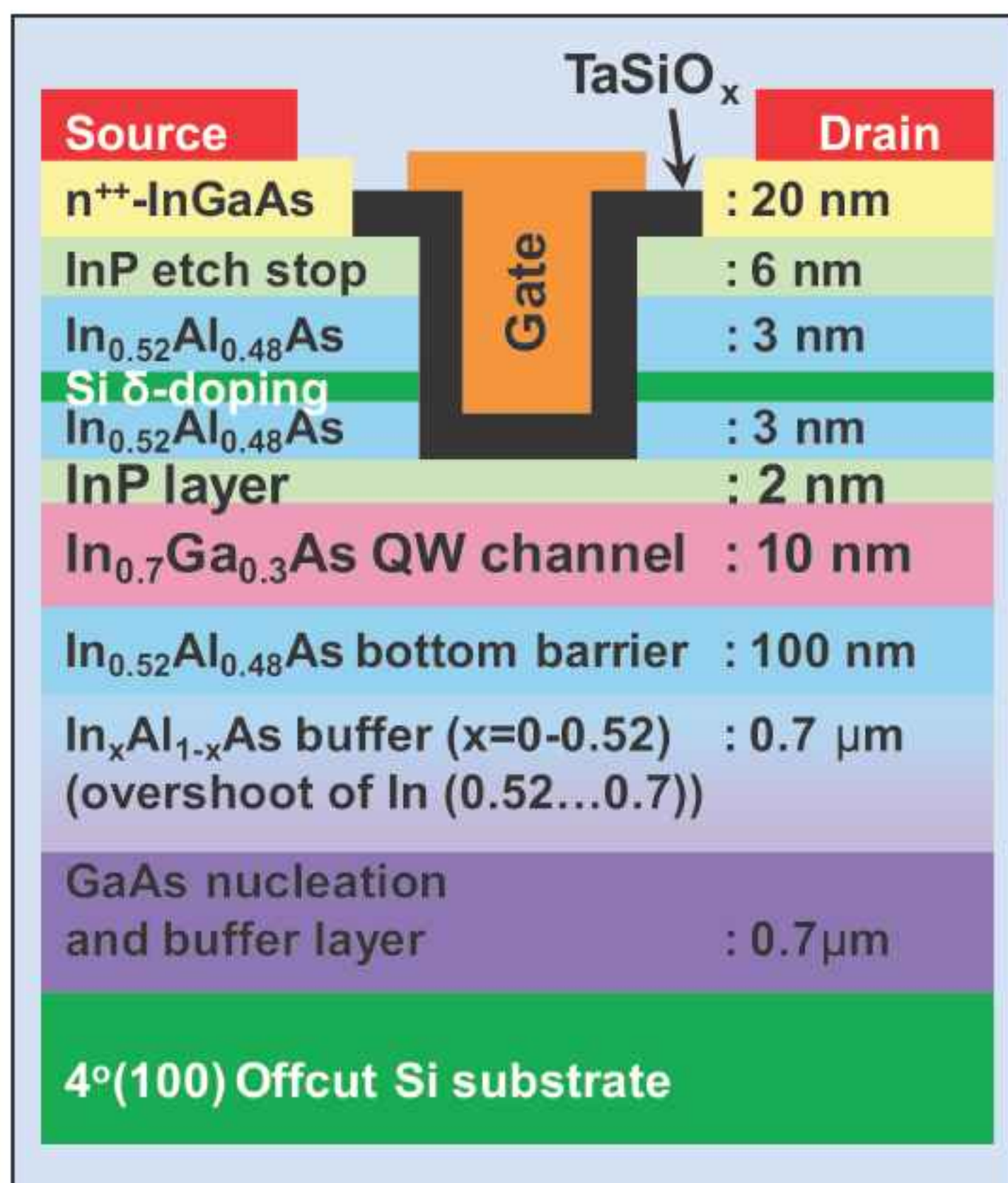


Figure 3. Schematic of $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}$ QWFET on silicon with 2nm InP upper barrier layer and a 4nm TaSiO_x high-k gate dielectric, forming composite TaSiO_x -InP gate stack. Reprinted by permission of Intel Corp, Copyright Intel Corp.

10,000 $\text{cm}^2/\text{V}\cdot\text{s}$ at 300K with no parallel conduction). The process steps to produce the stack consisted of cleaning, and then depositing a thin transition layer and then the dielectric.

A quantum well channel was used in a field-effect transistor (QWFET) format with a physical gate length of 75nm. Capacitance-voltage measurements give an electrical oxide thickness (t_{OXE}) of 22Å. Control devices with a Schottky gate managed a t_{OXE} of only 33Å. The dielectric reduced the gate leakage by a factor of more than a thousand.

The drive current was 0.49mA/ μm and the peak transconductance was 1750 $\mu\text{S}/\mu\text{m}$ at a V_{DS} of 0.5V, which are the highest reported values for III-V QWFETs with high-k gate dielectric, according to the researchers. Comparing the devices with strained silicon MOSFETs, one finds a 3.5x effective electron velocity.

Intel is also continuing to work on $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}$ 80nm QWFET devices with a Schottky gate contact [5], comparing logic performance against that of advanced strained Si 40nm MOSFETs with supply voltages of between 0.5 and 1.0V, at constant I_{off} (Figure 4). The effective electron velocity in the QWFET channel is 4.6–3.3x that in a comparison strained silicon device. This enables a 65% drive current gain at an operating voltage (V_{CC}) of 0.5V and 20% at 1.0V, despite the 2.5x

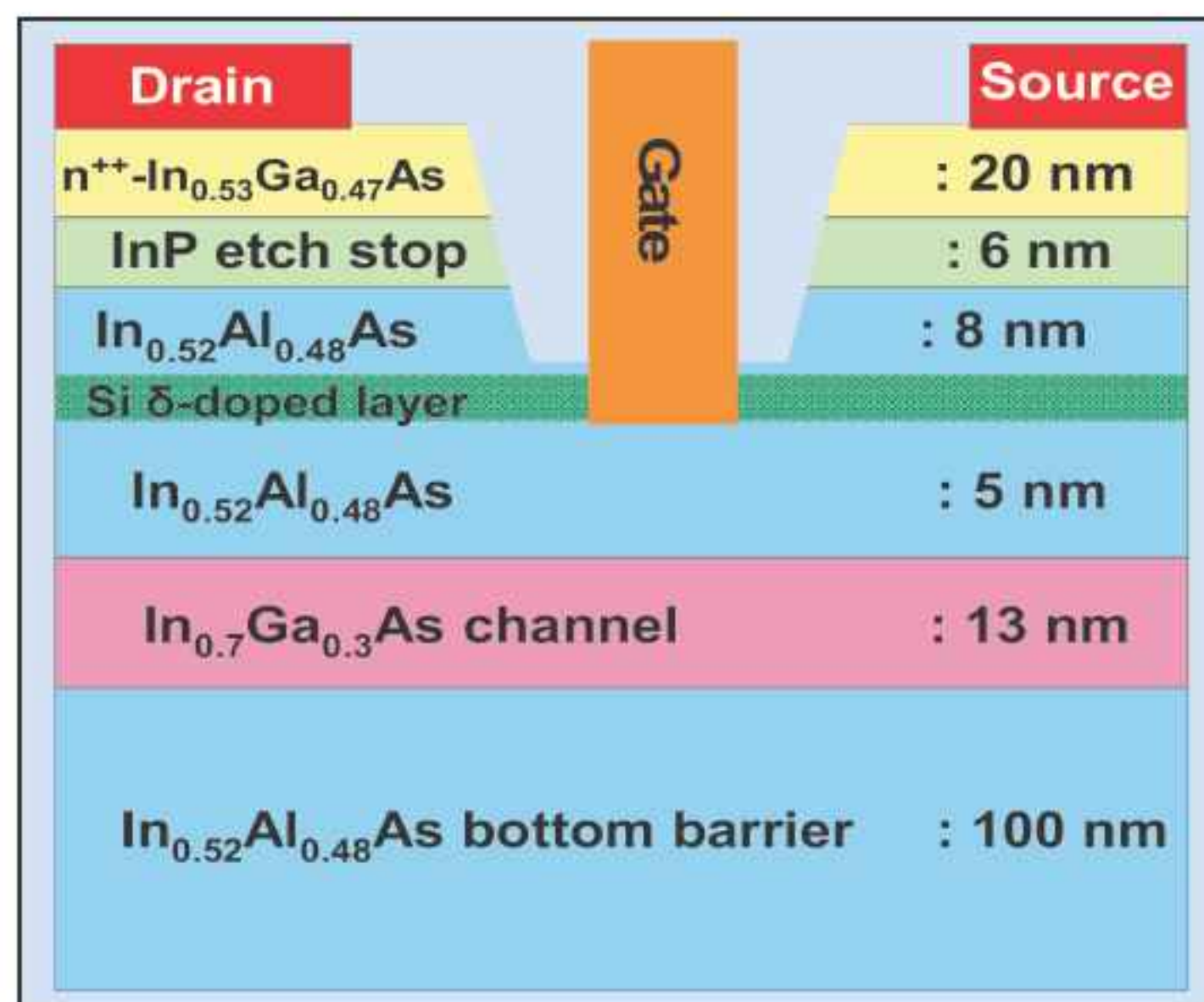


Figure 4. Schottky-gate $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}$ QWFET with remote delta doping (Si doping $\sim 8 \times 10^{12}/\text{cm}^2$) and Pt gate electrode. Reprinted by permission of Intel Corp, Copyright Intel Corp.

lower charge density in the QWFET channel. Despite the longer gate length, the QWFET shows improved gate delay properties over the strained Si MOSFET. Temperature dependence studies indicate that the charge carriers in the QWFET suffer from phonon surface roughness scattering, so the device is not in the ballistic regime. This means that the mean free path is less than the distance of travel in the QWFET device.

The Intel work was carried out jointly with researchers from epiwafer foundry IQE in Pennsylvania. The Intel contribution was based in Oregon. IQE's facility produced the semiconductor layer structures as InGaAs QWFET epiwafers grown on Si substrates using molecular beam epitaxy (MBE). Intel then used the blanket epiwafers for their transistor design and fabrication.

IQE also provided material for the research by Purdue University [2, 3], and for work by Cornell and Penn State universities [6]. The Cornell/Penn State research included an IQE representative in the author list. This research involved $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ vertical inter-band tunnel field-effect transistors (TFETs) with a 100nm channel length. A high-k/metal gate was used, aiming for ultra-low-power devices. The TFET device had an 'on-current' of 20 $\mu\text{A}/\mu\text{m}$ at 0.75V, and a large on-off current ratio of 104, given the channel length of 100nm. A six-transistor (6T) TFET SRAM cell with virtual ground assist was demonstrated.

Common process step

The IMEC semiconductor research center based in Belgium has been studying a common gate stack solution (Figure 5) for InGaAs/Ge structures [7]. The researchers see integrated high-mobility channels with high-k dielectric gate stacks as "a leading

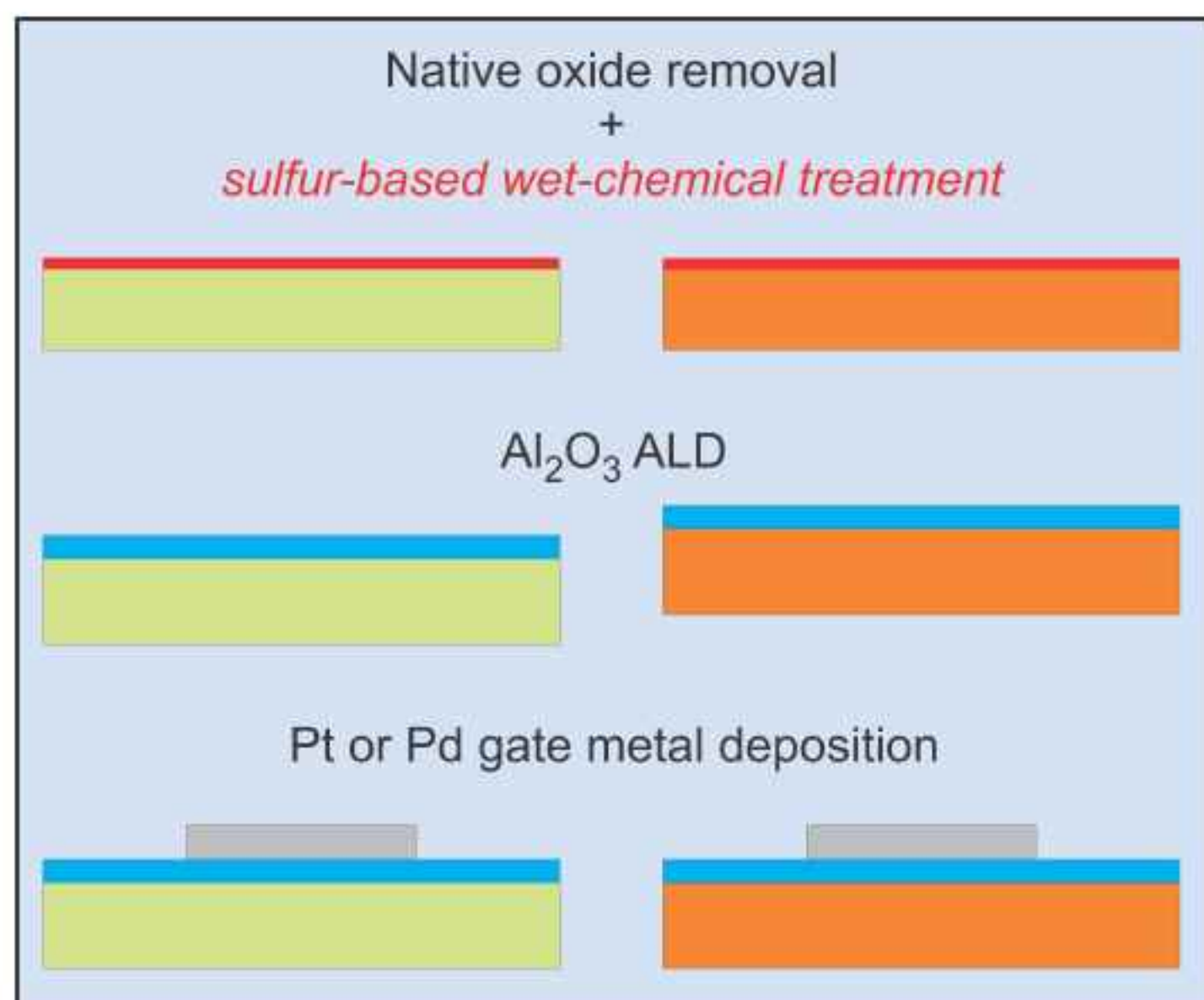


Figure 5. Common Gate Stack (CGS) process for InGaAs/Ge MOS devices developed by IMEC.

candidate for the next-generation technology on and beyond the 16nm node". The ITRS has renounced the idea of a simple 'node' for describing technology pacing in its latest edition (2009). The physical gate length for microprocessors is expected to reach 15.3nm in 2016; and, for the half-pitch for metal lines (the traditional ITRS 'node' measurement), 15.0nm in 2018.

The aim of IMEC's research is to find a route to providing common gate stacks for InGaAs n-MOSFETs and Ge p-MOSFETs to combine into CMOS circuitry. The team's approach is to use a sulfur-based wet chemical pre-treatment and then use atomic layer deposition (ALD) of aluminum oxide (Al_2O_3) to give the gate dielectric. The researchers want to find a feasible solution for both InGaAs/Ge CMOS process integration and progressive equivalent oxide thickness (EOT) scaling.

Although the ultimate aim must be to deposit gate dielectric on InGaAs and Ge channels on one substrate, the IMEC experiments used separate InGaAs and Ge substrates on which to create MOS capacitors and transistors. The surface preparation consisted of cleaning and oxide removal followed by wet chemical treatment with ammonium sulfide ($(\text{NH}_4)_2\text{S}$) solution.

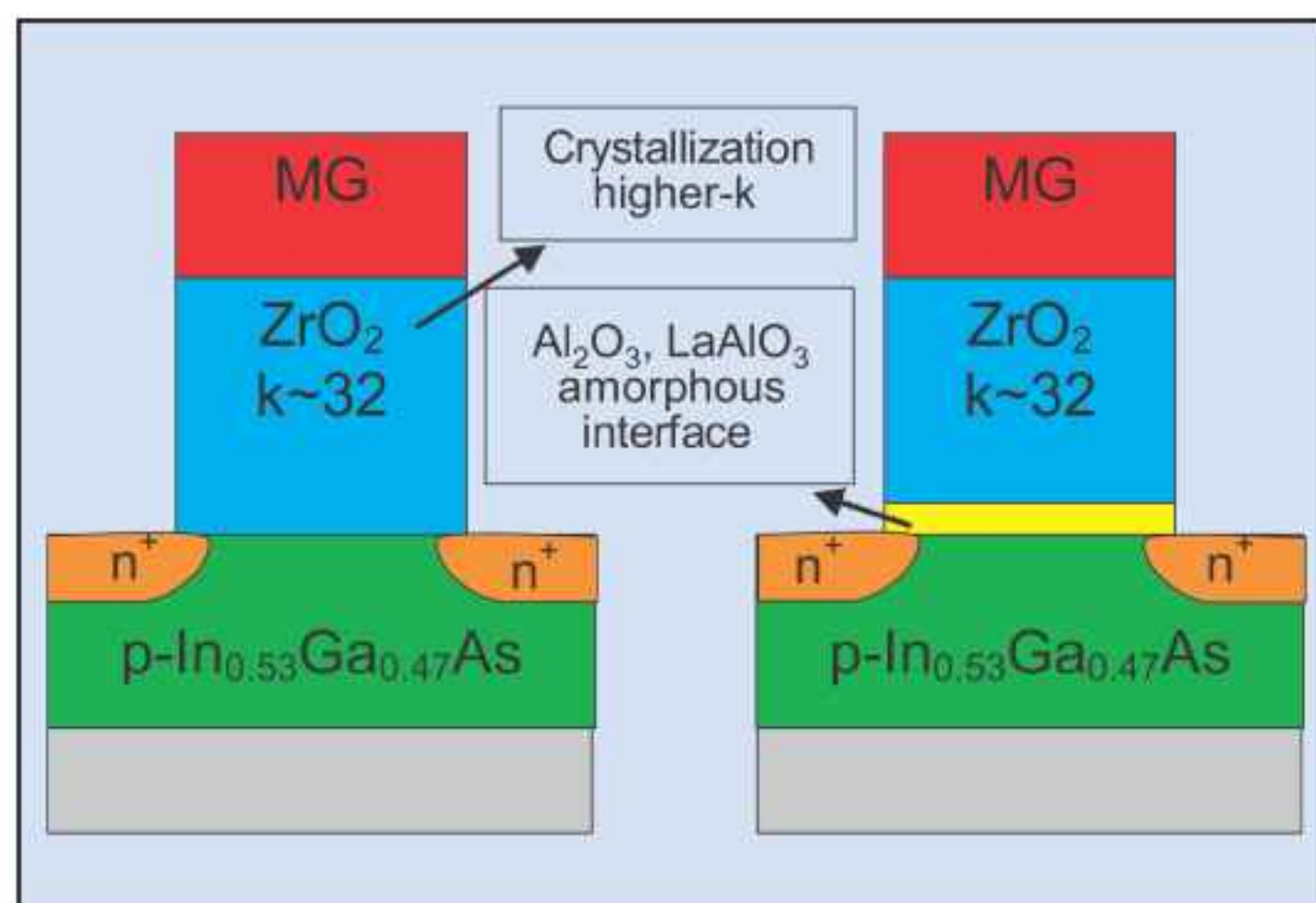


Figure 6. 'Cartoon' of SEMATECH nMOSFETs using zirconia dielectric. Various thicknesses (0.3 to 2nm) of ALD Al_2O_3 or LaAlO_3 interlayer were deposited prior to ZrO_2 deposition. TiN/TaN was used as the metal gate (MG).

The Al_2O_3 was deposited at 300°C with a thickness of 8nm on Ge and 10nm on InGaAs. A post-deposition anneal in forming gas (N_2/H_2) was carried out at 400°C. The capacitor/gate electrodes consisted of 'high-work-function metal'.

The interface traps in the two systems were investigated using capacitance-voltage (CV) and conductance-voltage (GV) measurements. Near the Ge valence band edge, the interface trap density (D_{it}) was relatively low at $3 \times 10^{11}/\text{eV}\cdot\text{cm}^2$, increasing towards the conduction band edge to a high value of more than $1 \times 10^{13}/\text{eV}\cdot\text{cm}^2$. For InGaAs, a relatively low D_{it} of $1 \times 10^{12}/\text{eV}\cdot\text{cm}^2$ was found near the conduction band, increasing to more than $2 \times 10^{13}/\text{eV}\cdot\text{cm}^2$ near the valence band.

These are appropriate characteristics for creating MOSFETs on the two materials. MOSFETs with 10 μm gates were constructed that had peak hole (Ge) and electron (InGaAs) mobilities of 400 $\text{cm}^2/\text{eV}\cdot\text{s}$ and 1300 $\text{cm}^2/\text{eV}\cdot\text{s}$, respectively. These values are comparable to separate mobility records for Ge and InGaAs channel technologies of 445 $\text{cm}^2/\text{eV}\cdot\text{s}$ and 1600 $\text{cm}^2/\text{eV}\cdot\text{s}$, respectively.

Table 1. Comparison of ZrO_2 , 1nm $\text{Al}_2\text{O}_3/\text{ZrO}_2$, and 1nm $\text{LaAlO}_3/\text{ZrO}_2$ on $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$.

Interlayer		ZrO_2	Al_2O_3	LaAlO_3
Interface state trap density, D_{it} @ $E_v = +0.42\text{eV}$	$10^{12}\text{eV}^{-1}\text{cm}^{-2}$	2.03	-0.7	0.7
Interface fixed charge density, Q_f	10^{12}cm^{-2}	7.8	2.4	—
Border trap density, Q_{br}	10^{19}cm^{-3}	7.5	2.6	—
Hysteresis/ capacitance equivalent thickness (CET)	MV/cm	2.53	2.17	1.27
Interface trap charge density, Q_{it}	10^{12}cm^{-2}	6.9	4.6	—
Dielectric constant, k		-32	-7	-12
Threshold voltage, V_t	V	-0.12	0.07	—
Transconductance (Gm) x CET	$\mu\text{S}\cdot\text{nm}$	3359	5883	—

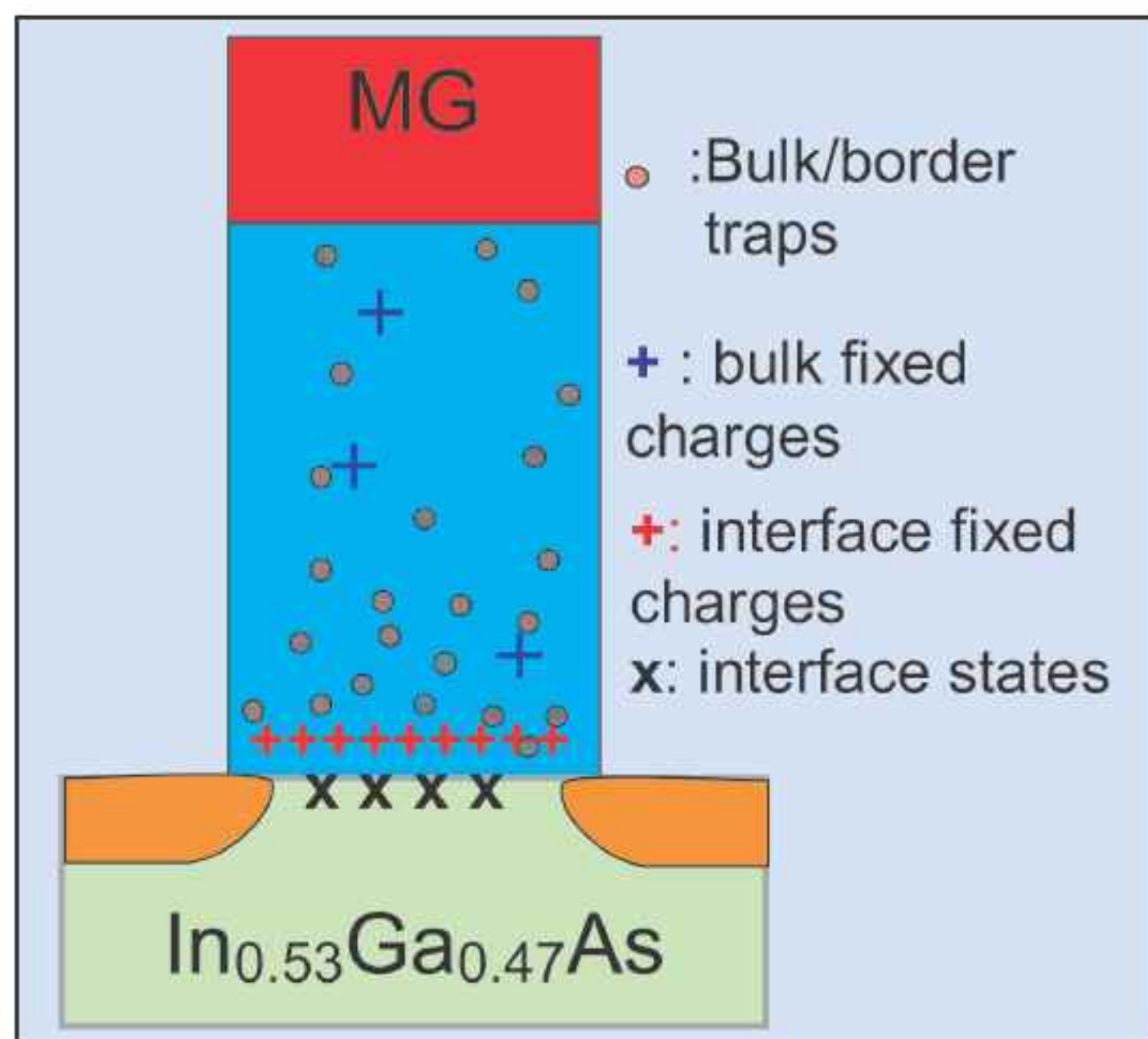


Figure 7. Schematic of charge/trap types including fixed charge, traps and interface states. Image courtesy SEMATECH.

Zirconia

The SEMATECH research consortium has been working with a number of universities on zirconium dioxide (ZrO_2) as a gate dielectric for InGaAs channels. The universities are UTexas-Austin, SUNY-Albany, Oklahoma and Texas State [8].

The SEMATECH research has found that putting an interlayer of amorphous lanthanum aluminum oxide (La) AlO_x before the ZrO_2 (Figure 6) can reduce the densities of various imperfections (Figure 7, Table 1) such as border traps (3x), effective fixed charges (1.5x) and interface traps (1.5x). The net effect of using this gate stack is a 50% improvement in drain current (I_d) and a 75% increase in transconductance (G_m). ALD was used to deposit the dielectric layers, producing MOS capacitors and long-channel nMOSFETs.

Although much work has been carried out on InGaAs using Al_2O_3 as dielectric, the researchers note that this material has a relatively low dielectric constant (7–9) for the needs of logic devices below 16nm. The dielectric constants of $LaAlO_2$ and ZrO_2 are higher: ~12 and ~32, respectively.

The reliability of the stacks was evaluated using positive- and negative-bias temperature instability

- MBE growth of $In_{0.53}Ga_{0.47}As$ and $In_{0.7}Ga_{0.3}As$ substrate
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- **In-situ PH_3 -passivation**
- MOCVD high-k deposition and *in-situ* PDA
- Sputter TaN deposition 150nm
- Lithography
- Gate etch and high-k etching
- Si implantation ($50KeV/1 \times 10^{14} cm^{-2}$)
- **S/D activation @ RTA 600°C 60s, 700°C 10s, 750°C 5s**
- S/D and backside contacts
- Metal alloy annealing @ RTA 400°C 60s

Figure 8. Process flow of self-aligned InGaAs channel MOSFET with plasma- PH_3 passivation process developed by Singapore researchers.

(P/NBTI) cycle stress measurements of the threshold voltage. Use of an Al_2O_3 interlayer was found to improve the stress performance over just ZrO_2 , but a $LaAlO_2/ZrO_2$ stack was even better.

Phosphine passivation

Singapore researchers (National University and the institutes of Microelectronics and of Materials Research and Engineering) have been looking at phosphine (PH_3) passivation techniques for use before dielectric deposition on InGaAs channels [9]. Previously, it had been a kind of mystery why such a treatment leads to improvement, since one might expect a disturbance of doping levels in the semiconductor layers.

However, the team has found from AFM and XPS measurements that what is achieved is a phosphorous nitride layer, rather than a replacement of arsenic atoms in the channel. The technique was then used to create high electron mobility in a metal gate/high-k dielectric inversion-mode InGaAs NMOSFET fabricated by a self-aligned gate-first scheme (Figure 8).

The InGaAs materials (53% In and 70% In) were grown on InP substrates using MBE. For the passivation and dielectric deposition, an ultra-high-vacuum (UHV) multi-chamber CVD system was used. This enabled a sequence of steps to be carried out without breaking the vacuum (including a post deposition anneal). The plasma passivation consisted of 1% PH_3 in nitrogen (Table 2). MOCVD was carried out to give layers of HfO_2 from $Hf(OC(CH_3)_3)_4$ precursor in oxygen, or hafnium aluminate ($HfAlO$) from $HfAl(MMP)_2(OiPr)_5$.

One passivation regime (sample B in Table 2) gave a 3x increase in drain current for HfO_2 dielectric and 10x for $HfAlO$ over samples where AFM and XPS results reveal that a P_xN_y layer does not form (samples A and C). Thermal stability of the process under rapid thermal annealing

Table 2. Process conditions of one-minute plasma- PH_3 passivation by Singapore researchers.

Sample no.	Temp (°C)	Plasma power (W)	Pressure (Torr)
A	430	200	0.7
B	430	200	0.3
C	550	No plasma	10
None		No treatment	

up to 750°C was confirmed for enabling S/D activation, as used in self-aligned MOSFET production. In fact, higher-temperature annealing with HfO₂ dielectric leads to lower equivalent oxide thickness (EOT) values, possibly due to a densification effect. Gate leakage is also much reduced (Figure 9).

Characterization of a 600nm (0.6µm) gate nMOSFET with HfAlO dielectric showed a peak mobility of 2557cm²/V-s at an effective electric field of 0.24MV/cm. The maximum transconductance at 1V drain voltage was 378mS/mm. A drive current of 851mA/mm was measured with a gate bias of 3V and a drain voltage of 2V.

Although HfAlO results for thermal stability of EOT and HfO₂ nMOSFET characterizations are not reported in the IEDM paper, Dr Lee Sungjoo (S.J. Lee), one of the leaders of the work, reports that similar results have been obtained in these cases. ■

SEMATECH research has found that putting an interlayer of amorphous (La)AlO_x before the ZrO₂ can reduce the densities of various imperfections such as border traps (3x), effective fixed charges (1.5x) and interface traps (1.5x)

Mike Cooke is a freelance technology journalist who has worked in the semiconductor & advanced technology sectors since 1997.

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7. Lin et al, session 13.3
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9. Oh et al, session 13.6

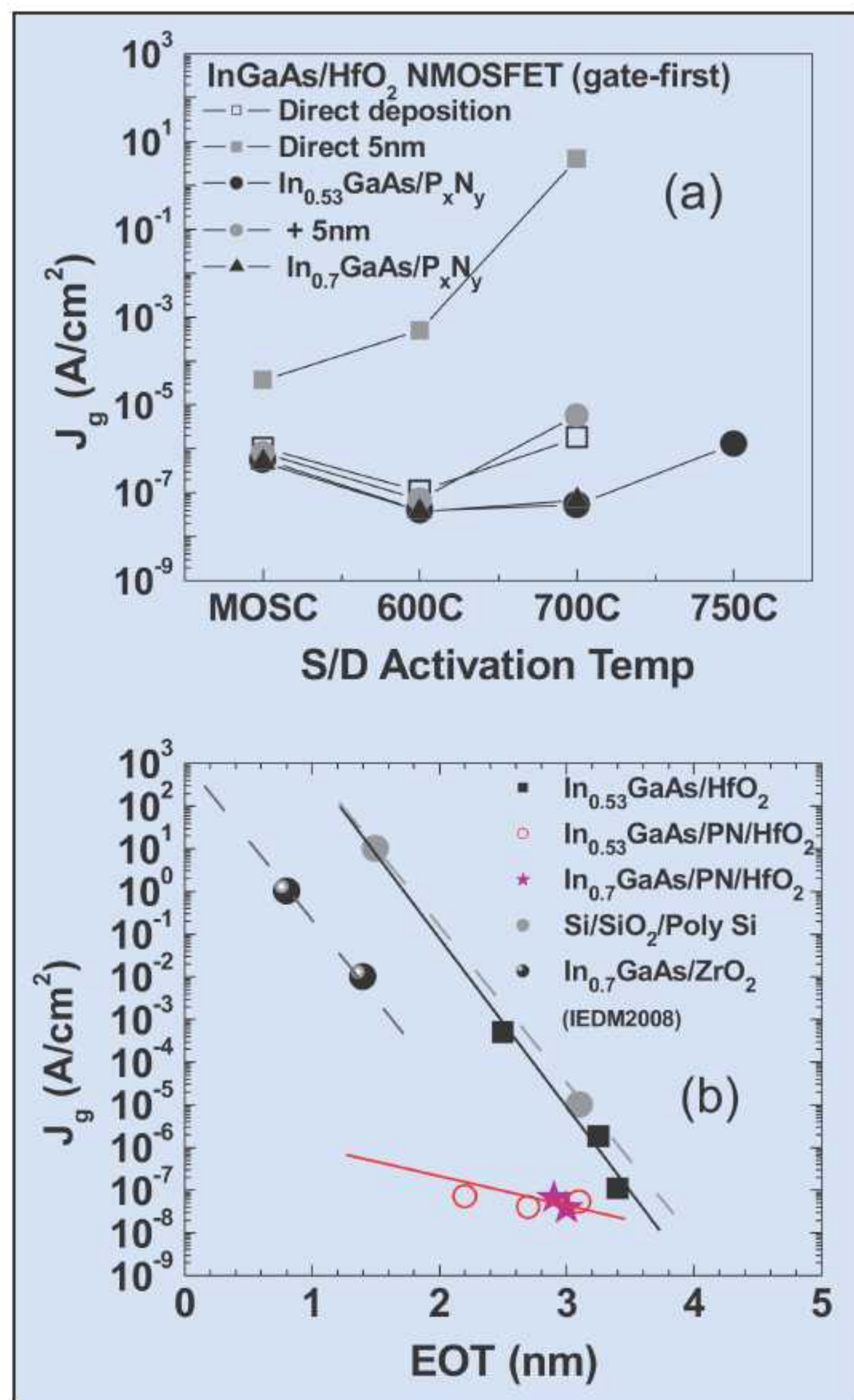


Figure 9. (a) Gate leakage current density (J_g) for Singapore HfO₂/InGaAs MOS capacitors vs S/D activation temperature and (b) comparison with reported results.

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InGaAs modeling contracts

Due to the increasing interest in indium gallium arsenide (InGaAs) as a material for high-speed logic channel in nanoelectronics, there is a need to characterize the possible performance of the material at smaller geometries. Mike Cooke reports on some of the studies presented at last December's International Electron Devices Meeting (IEDM 2009).

Massachusetts Institute of Technology (MIT) has been working with a number of groups on developing models for the InGaAs material system to extend the roadmap for semiconductor electronics beyond the traditional complementary-metal-oxide-silicon (CMOS) transistors of the mainstream semiconductor industry.

One part of this work has been extracting InGaAs parameters from HEMT structures, although they are "quite far in structure from an ideal logic III-V MOSFET" [1]. Despite this, parameters derived from such work can be used in simulators to predict the potential of various III-V MOSFET logic structures before construction, suggesting fruitful avenues for research.

A problem in using HEMTs in this way is that smaller 'scaled' devices are hard to construct — for example, the gate leakage is often much larger than for MOSFETs. MIT has developed an inverted HEMT structure (Figure 1) that reduces the gate leakage by two orders of magnitude, opening up gate lengths below 30nm.

The main change from a normal HEMT is that the silicon doping of the barrier InAlAs layer is placed further from the channel than is usually the case — i.e. at 8nm rather than 3nm. The creation of the gate in a triple recess process eliminates the dopant layer under the gate, giving a dopant-free InAlAs barrier to the channel.

The devices that were produced had gate lengths in the range 130–30nm. The resulting devices exhibited

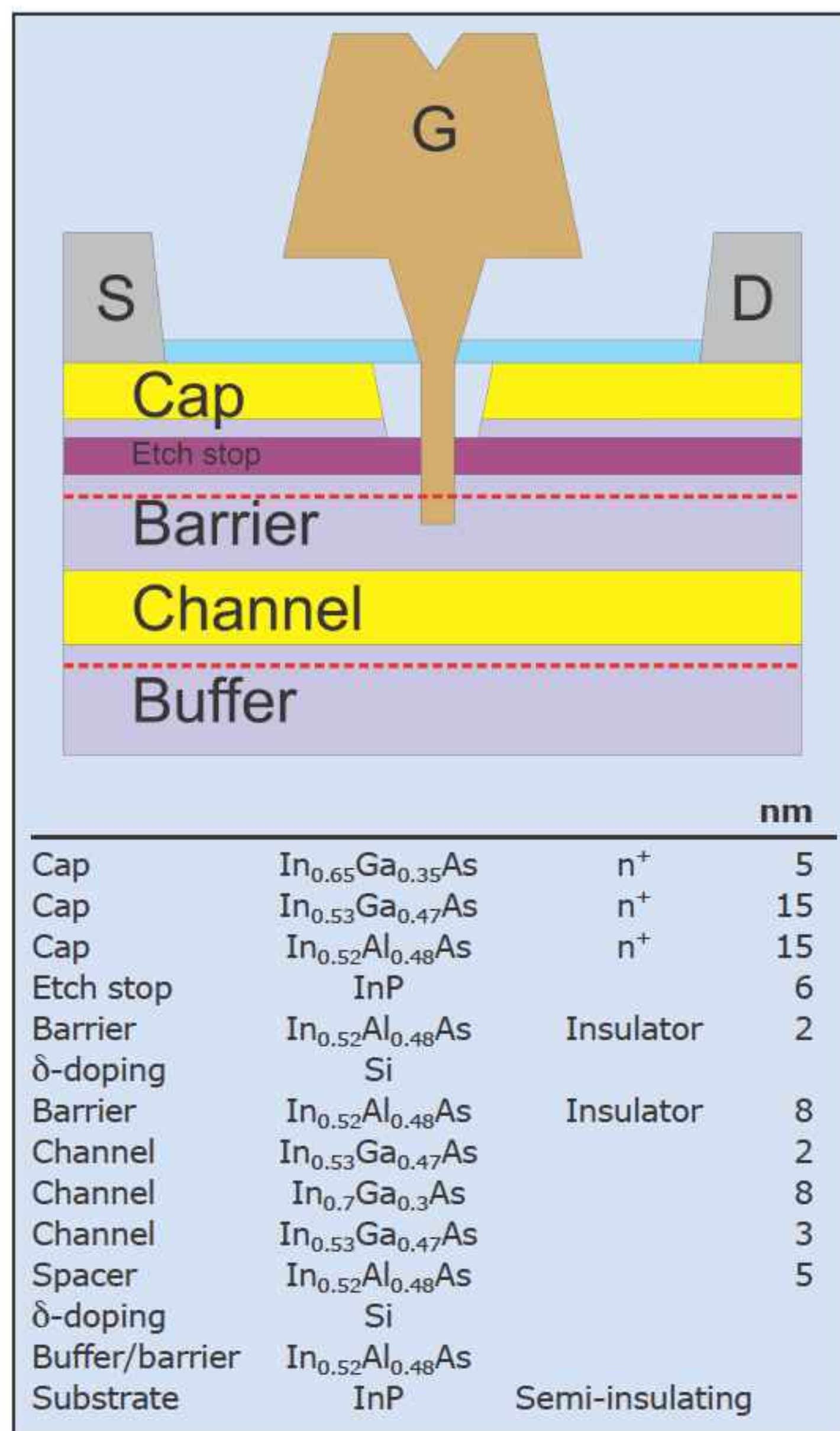


Figure 1. Heterostructure (table) and schematic (top) of InGaAs Inverted HEMT, featuring delta-doping in the top InAlAs layer that is etched away in the intrinsic device.

improved I_{ON}/I_{OFF} ratios compared with traditional HEMTs (Figure 2). One trade-off of having the upper silicon doping further from the channel is that the I_{ON} figure for the inverted HEMT is a little lower than for the traditional device.

Microwave testing of a 30nm-gate device in the frequency range 0.5–40GHz resulted in a cut-off

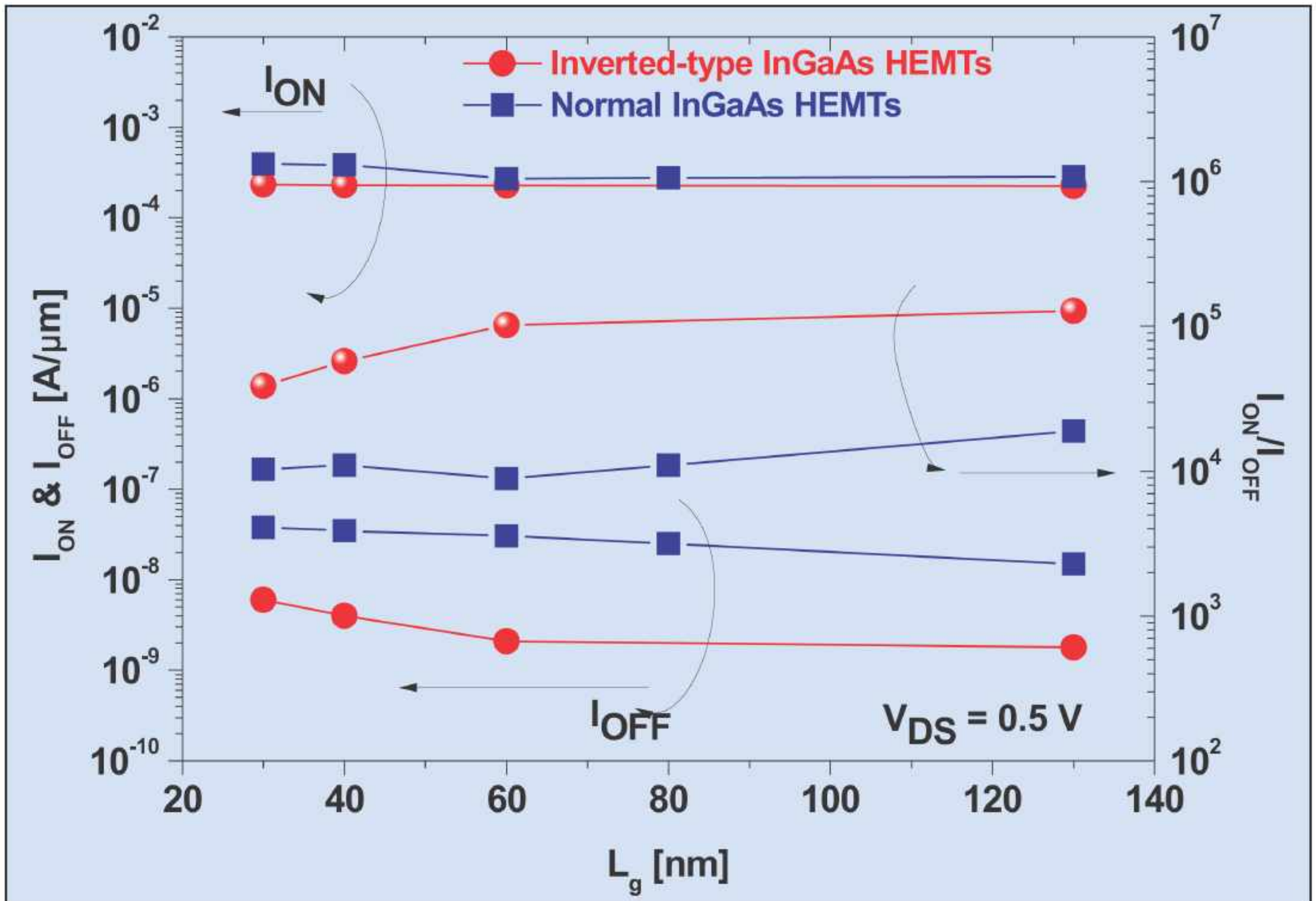


Figure 2. I_{ON} and I_{OFF} as well as I_{ON}/I_{OFF} ratio.

frequency f_T of 500GHz and maximum oscillation frequency f_{max} of 550GHz. These are claimed as the highest reported for inverted-type HEMTs. While the f_{max} is significantly higher than for a normal HEMT, the f_T value is lower for the inverted HEMT. This is attributed to poorer transport properties for the inverted HEMT channel (9800cm²/V-s mobility versus 11,000cm²/V-s for a normal HEMT), resulting from increased surface roughness of the inverted InGaAs/InAlAs interface. It is hoped that improved epitaxial growth processes will mitigate this problem.

Comparing logic performance, a 30nm-gate inverted HEMT with 100nA/μm gate leakage gave a 29% increase in drive current (I_{ON}) compared with a 65nm (35nm gate length) high-performance silicon CMOS technology. The inverted HEMT drive current was also 20% better than a 30nm-gate normal HEMT.

A 30nm-gate inverted HEMT with 100nA/mm gate leakage gave a 29% increase in drive current (I_{ON}) compared with a 65nm (35nm gate length) high-performance silicon CMOS technology

Further III-V FET modeling has been carried out at MIT to explore the effects of quantum capacitance in InGaAs and InAs devices [2]. Quantum capacitance refers to charging effects that arise due to the Fermi level moving within the two-dimensional sub-bands of the quantum well used for the channel in many III-V FETs. Another source of capacitance (centroid) is the more traditional one due to the charge distribution of the inversion layer. In the case of the inversion layer capacitance, a high value is desired, since a low capacitance reduces the available charge carriers needed to make the drive current.

The MIT model provides 'reasonable' agreement with actual InGaAs and InAs FETs of different design. Scaling the model suggests that quantum capacitance will come to dominate the performance of these devices and that thin channel designs will be favored as giving an increase in effective mass, providing the sheet charge density needed for high performance. ■

Mike Cooke is a freelance technology journalist who has worked in the semiconductor & advanced technology sectors since 1997.

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Index

- | | |
|--|---|
| 1 Bulk crystal source materials p118 | 14 Chip test equipment p122 |
| 2 Bulk crystal growth equipment p118 | 15 Assembly/packaging materials p122 |
| 3 Substrates p118 | 16 Assembly/packaging equipment p122 |
| 4 Epiwafer foundry p119 | 17 Assembly/packaging foundry p123 |
| 5 Deposition materials p119 | 18 Chip foundry p123 |
| 6 Deposition equipment p120 | 19 Facility equipment p123 |
| 7 Wafer processing materials p121 | 20 Facility consumables p123 |
| 8 Wafer processing equipment p121 | 21 Computer hardware & software p123 |
| 9 Materials and metals p121 | 22 Used equipment p123 |
| 10 Gas & liquid handling equipment p121 | 23 Services p123 |
| 11 Process monitoring and control p122 | 24 Consulting p123 |
| 12 Inspection equipment p122 | 25 Resources p123 |
| 13 Characterization equipment p122 | |

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Tel: +1 408 875 3000

Fax: +1 510 456 2498

www.kla-tencor.com

13 Characterization equipment

J.A. Woollam Co. Inc.

645 M Street Suite 102,
Lincoln, NE 68508,
USA

Tel: +1 402 477 7501

Fax: +1 402 477 8214

www.jawoollam.com

Lake Shore Cryotronics Inc

575 McCorkle Boulevard,
Westerville, OH 43082,
USA

Tel: +1 614 891 2244

Fax: +1 614 818 1600

www.lakeshore.com

14 Chip test equipment

Keithley Instruments Inc

28775 Aurora Road,
Cleveland, OH 44139,
USA

Tel: +1 440.248.0400

Fax: +1 440.248.6168

www.keithley.com

SUSS MicroTec Test Systems

228 Suss Drive,
Waterbury Center,
VT 05677,
USA

Tel: +1 800 685 7877

Fax: +1 802 244 7853

www.suss.com

15 Assembly/packaging materials

ePAK International Inc

4926 Spicewood Springs Road,
Austin, TX 78759, USA

Tel: +1 512 231 8083

Fax: +1 512 231 8183

www.epak.com

Gel-Pak

31398 Huntwood Avenue,
Hayward, CA 94544, USA

Tel: +1 510 576 2220

Fax: +1 510 576 2282

www.gelpak.com

Williams Advanced Materials

2978 Main Street, Buffalo, NY 14214,
USA

Tel: +1 716 837 1000

Fax: +1 716 833 2926

www.williams-adv.com

16 Assembly/packaging equipment

Ismeca Europe Semiconductor SA

Helvetie 283,
La Chaux-de-Fonds, 2301,
Switzerland

Tel: +41 329257111

Fax: +41 329257115

www.ismeca.com

J P Sercel Associates Inc

220 Hackett Hill Road,
Manchester, NH 03102,
USA

Tel: +1 603 518 3200

Fax: +1 603 518 3298

www.jpsalaser.com

Kulicke & Soffa Industries

1005 Virginia Drive,
Fort Washington, PA 19034,
USA

Tel: +1 215 784 6000

Fax: +1 215 784 6001

www.kns.com

Palomar Technologies Inc

2728 Loker Avenue West,
Carlsbad, CA 92010, USA

Tel: +1 760 931 3600

Fax: +1 760 931 5191

www.PalomarTechnologies.com

TECDIA Inc

2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054,
USA

Tel: +1 408 748 0100
Fax: +1 408 748 0111

www.tecdia.com

Tecdia is a **TECDIA**
manufacturer of
single-layer chip capacitors,
chip resistors, DC boards, bias-Ts,
diamond scribing tools and
dispensing nozzles.

17 Assembly/packaging foundry

Quik-Pak

10987 Via Frontera,
San Diego, CA 92127,
USA

Tel: +1 858 674 4676
Fax: +1 8586 74 4681

www.quikicpak.com

18 Chip foundry

**Compound Semiconductor
Technologies Ltd**

Block 7, Kelvin Campus,
West of Scotland, Glasgow,
Scotland G20 0TH,
UK

Tel: +44 141 579 3000
Fax: +44 141 579 3040

www.compoundsemi.co.uk

United Monolithic Semiconductors

Route departementale 128,
BP46, Orsay, 91401,
France

Tel: +33 1 69 33 04 72
Fax: +33 169 33 02 92

www.ums-gaas.com

19 Facility equipment

MEI, LLC

3474 18th Avenue SE,
Albany, OR 97322-7014, USA

Tel: +1 541 917 3626
Fax: +1 541 917 3623

www.marlerenterprises.net

20 Facility consumables

W.L. Gore & Associates

401 Airport Rd,
Elkton, MD 21921-4236,
USA

Tel: +1 410 392 4440
Fax: +1 410 506 8749

www.gore.com

21 Computer hardware & software

Ansoft Corp

4 Station Square, Suite 200,
Pittsburgh, PA 15219, USA

Tel: +1 412 261 3200
Fax: +1 412 471 9427

www.ansoft.com

Crosslight Software Inc

121-3989 Henning Dr.,
Burnaby, BC, V5C 6P8,
Canada

Tel: +1 604 320 1704
Fax: +1 604 320 1734

www.crosslight.com

**Semiconductor Technology
Research Inc**

10404 Patterson Ave., Suite 108,
Richmond, VA 23238,
USA

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Fax: +1 804 740 3814

www.semitech.us

22 Used equipment

Class One Equipment Inc

5302 Snapfinger Woods Drive,
Decatur, GA 30035,
USA

Tel: +1 770 808 8708
Fax: +1 770 808 8308

www.ClassOneEquipment.com

23 Services

Henry Butcher International

Brownlow House, 50-51
High Holborn,
London WC1V 6EG,
UK

Tel: +44 (0)20 7405 8411
Fax: +44 (0)20 7405 9772

www.henrybutcher.com

M+W Zander Holding AG

Lotterbergstrasse 30,
Stuttgart,
Germany

Tel: +49 711 8804 1141
Fax: +49 711 8804 1950

www.mw-zander.com

TECDIA Inc

(see section 16 for full contact details)

24 Consulting

WSR Optical Device Solutions

P.O. Box 248, Flemington,
NJ 08822,
USA

Tel: +1 908 428 4986

www.wsr-ods.com

25 Resources

SEMI Global Headquarters

3081 Zanker Road,
San Jose, CA 95134,
USA

Tel: +1 408 943 6900
Fax: +1 408 428 9600

www.semi.org

Yole Développement

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10–11 March 2010

Fabrication Challenges in Photonics forum

Network Meeting Center, Santa Clara, CA, USA

E-mail: iams@oida.org

www.oida.org/events/fabrication10

16–18 March 2010

SEMICON China 2010, including SOLARCON China 2010

Shanghai New International Expo Centre (SNIEC), China

E-mail: semichina@semi.org

<http://semiconchina.semi.org/scchina-en>

16–18 March 2010

LASER World of PHOTONICS China 2010

Shanghai New International Expo Centre (SNIEC), China

E-mail: laser@mimi-shanghai.com

www.world-of-photonics.net/en/laser-china/start

17–18 March 2010

2nd Annual Thin Film Solar Summit Europe

Berlin, Germany

E-mail: josh@thinfilmtoday.com

www.thinfilmtoday.com/eu

18–19 March 2010

Invest in Photonics 2010

Regent Grand Hotel, Bordeaux, France

E-mail: ahantiu@invest-in-photonics.com

www.invest-in-photonics.com

21–25 March 2010

Optical Fiber Communication Conference and Exposition and National Fiber Optic Engineers Conference (OFC/NFOEC 2010)

San Diego Convention Center, CA, USA

E-mail: info@ofcconference.org

www.ofcnfoec.org

22–24 March 2010

SEMATECH Surface Preparation and Cleaning Conference (SPCC 2010)

Austin, TX, USA

E-mail: erica.mcgill@sematech.org

www.sematech.org/meetings/spcc

24–26 March 2010

6th Photovoltaic Science Application and Technology (PVSAT-6) Conference and Exhibition

University of Southampton, UK

E-mail: info@uk-ises.org

www.pvsat.org.uk

29–31 March 2010

Semiconductor and Integrated Opto-Electronics Conference (SIOE'10)

Cardiff University, Wales, UK

E-mail: K.A.Shore@bangor.ac.uk

www.astro.cardiff.ac.uk/research/pm/events

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AXT	94	Riber	33
CS MANTECH	109	SAFC Hitech	15
EV Group	61	Tecdia	43
Evatec	59	Temescal	23
III/V-Reclaim	31	Umicore	89
k-Space	65	Veeco Instruments — MBE	11
LayTec	37	Veeco Instruments — MOCVD	IFC
Oxford Instruments Plasma Technology	35		

5–9 April 2010**SPIE Defense, Security, and Sensing 2010**

Orlando, FL, USA

E-mail: customerservice@spie.org**http://**spie.org

5–9 April 2010**2010 MRS Spring Meeting**

San Francisco, CA, USA

E-mail: info@mrs.org**www.mrs.org**

7–9 April 2010**CPV-6: the Sixth International Conference on Concentrating Photovoltaic Systems**

Fraunhofer ISE, Freiburg, Germany

E-mail: info@cpv-conference.org**www.cpv-conference.org**

8–10 April 2010**PV America Expo**

Washington DC, USA

E-mail: swatson@seia.org**www.pvamericaexpo.com**

12–16 April 2010**SPIE Photonics Europe 2010**

Brussels, Belgium

E-mail: CustomerService@spie.org**http://**spie.org/photonics-europe.xml

13–14 April 2010**Photovoltaics Europe 2010**

Dresden, Germany

E-mail: sales@idtechex.com**www.idtechex.com/printedelectronicseurope10**

14–16 April 2010**Lighting Japan: the 2nd LED/OLED Lighting Technology Expo**

Tokyo Big Sight, Japan

E-mail: light@reedexpo.co.jp**www.lightingjapan.jp/english**

19–22 April 2010**Photonica: Lasers, Optics & Application 2010**

ZAO Expocentr, Moscow, Russia

E-mail: es@expocentr.ru**www.photonics-expo.ru/en**

21–22 April 2010**2010 DOE Solid-State Lighting Manufacturing R&D Workshop**

San Jose, CA, USA

E-mail: solidstate@courtesyassoc.com**www.ssl.energy.gov**

22–23 April 2010**2nd Thin-Film Industry Forum 2010 (part of Photovoltaics Thin-Film Week)**

Berlin, Germany

E-mail: info@solarpraxis.de**www.solarpraxis.com/index.php?id=1797**

25–30 April 2010**217th Electrochemical Society Conference (Spring 2010 ECS)**

Vancouver, Canada

E-mail: meetings@electrochem.org**www.electrochem.org/meetings/biannual/217/217.htm**

27–29 April 2010**PHOTON's 6th Photovoltaic Technology Show 2010 Europe**

Stuttgart, Germany

E-mail: info@photon-expo.com**www.photon-expo.com/en/pts_2010_europe/pts_2010.htm**

5–7 May 2010**SNEC 4th International Photovoltaic Power Generation Conference & Exhibition**

Shanghai International Convention Center, China

E-mail: teresawen@sneia.org**www.snec.org.cn**

10–14 May 2010**LightFair International 2010**

Las Vegas Convention Center, NV, USA

E-mail: info@lightfair.com**www.lightfair.com**

16–21 May 2010**8th International Symposium on Semiconductor Light Emitting Devices (ISSLED2010)**

Peking University, Beijing, China

E-mail: issled2010@pku.edu.cn**www.issled2010.com.cn**

17–20 May 2010**2010 CS MANTECH (International Conference on Compound Semiconductor Manufacturing Technology)**

Portland Marriott Downtown Waterfront, OR, USA

E-mail: csmantech@csmantech.org**www.csmantech.org**

19–21 May 2010**SEMICON Singapore 2010**

Suntec, Singapore

E-mail: cchan@semi.org**www.semiconsingapore.org**



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