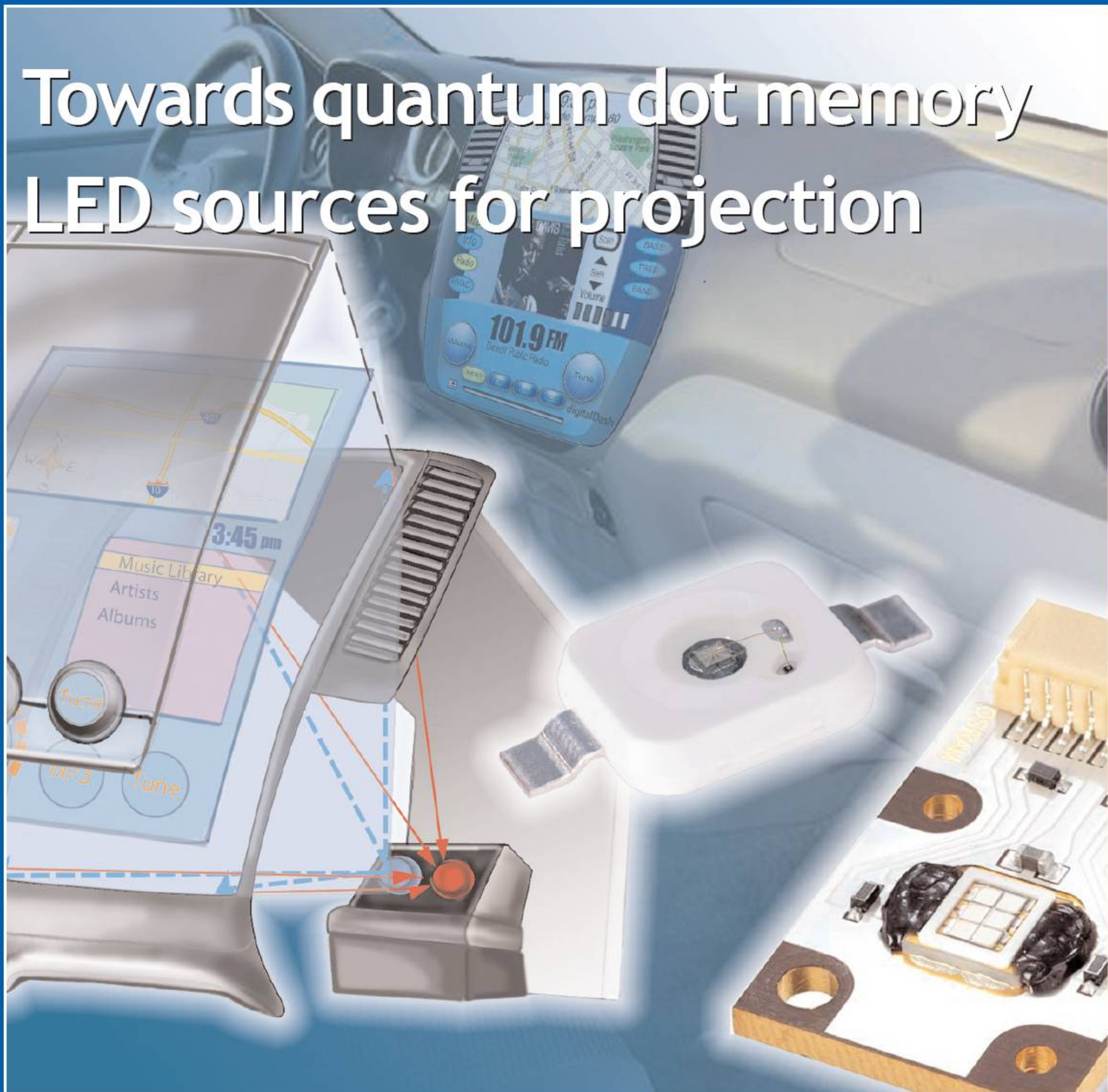


Towards quantum dot memory LED sources for projection



Skyworks qualifies WIN • Avago claims smallest RF amplifier
Veeco buys web coating tool maker • IBM to develop CIGS PVs

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p12 Avago WaferCap 0402-packaged chip uses the first wafer-level chip-scale package (CSP) for RF devices.



p30 Cree's new multi-chip XLamp MC-E LED, demonstrated at the Lightfair International event in Las Vegas, NV at the end of May.



p37 CIP's R-EAM-1550-LS, which is claimed to be the industry's first reflective electro-absorption modulator.



Cover: Digital Dash's RTD (reconfigurable tactile display), which is the first multi-touch interface that incorporates physical controls with a curved display surface, uses Osram Opto Semiconductors' Ostar Projection LED modules and IR Dragon infrared emitters as LED light sources.. **p28**

Opto integration progresses while IBM enters CIGS PVs

Following May's announcement of the proposed merger between optical communications component makers Finisar Corp of Sunnyvale, CA and Optium Corp of Horsham, PA (last issue, page 47), both firms have since reported record quarterly revenue: \$121m and \$45m, respectively, after annual growth of 25% and 35% (see this issue page 39). Sales of 40Gb/s products are multiplying rapidly, helping to cut net losses due mainly (in Optium's case) to costs from product development, production ramp-up and facility relocation. The merger is expected to boost profitability further.

Meanwhile, after announcing its roadmap for photonic integration at March's OFC/NFOEC event (reported in the April issue, page 48), Infinera has complemented its indium phosphide-based active (optoelectronic) photonic integrated circuit (PIC) technology by unveiling its new silica-based passive PICs at June's NXTcomm08 event in Las Vegas, incorporated in its new ILS2 DWDM system (see this issue, page 40).

Hybrid optical integration of indium phosphide-based optoelectronic chips on a silica-on-silicon is highlighted in the European Union-funded collaborative research project APACHE (Agile Photonic Integrated Systems-on-Chip Enabling WDM Terabit Networks), which started in April (see page 36). One of the consortium partners — CIP (The Centre for Integrated Photonics) of Ipswich, UK — has also launched what it reckons is the first commercial reflective electro-absorption modulator (R-EAM).

Regarding photovoltaic developments, the Prometheus Institute has forecasted that thin-film solar production will now grow above even its aggressive forecasts of 2007, multiplying nine-fold from 1 GigaWatt this year to more than 9 GigaWatts in 2012 (see page 42). Apart from cadmium telluride — with which CdTe PV maker First Solar is "the big story of 2008" — the institute reckons that copper indium gallium diselenide (CIGS) PVs will be "the big story of 2009" (although amorphous silicon should comprise the largest section of the thin-film PV market by 2012).

Correspondingly, the latest large firm to enter the CIGS PV market is computer manufacturer IBM, which is to collaborate with process equipment maker Tokyo Ohka Kogyo on developing solution-based processes, materials and equipment for print coating flexible CIGS solar cells (page 44). Likewise, process equipment maker Veeco has extended its thin-film solar equipment product line by acquiring Mill Lane Engineering, which makes web coating systems for manufacturing CIGS solar cells.

Meanwhile, materials supply is also being addressed, specifically by expansions in production capacity for both CdTe (by American Elements) and GaAs-on-germanium PVs (by SRA and Voltaix) — see pages 18–19 — illustrating the growth in all types of solar technology.

● Developments in gallium arsenide and gallium nitride microelectronics at June's IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta will be covered in detail in our next issue.

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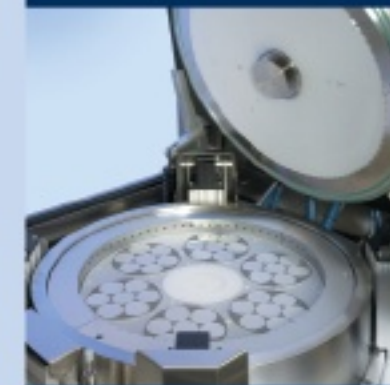
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Optoelectronics market to grow at 12% to \$31bn by 2013

After falling 2% in 2007 to \$15.9bn, the optoelectronics market is set to grow 9.3% to \$17.4bn in 2008, then at a compound annual growth rate (CAGR) of 12% to \$31.2bn in 2013, according to market research firm DataBeans Inc.

High-volume applications (e.g. DVD systems and digital cameras) are being joined by applications in cars, medical instruments, and lamps.

DataBeans predicts that optoelectronics revenue growth over the next five years (to 2013) will continue to be driven by the communications segment (a CAGR of 15%), followed by lighting and other consumer applications (14%), medical applications (13%) and automotive applications (12%).

In the automotive market, LEDs are being used extensively in interior lighting and, due to advances in technology, use in exterior illumina-

tion will become mainstream, reckons the market research firm. In addition, image sensors (found mainly in mobile phone and digital cameras) are also making their way into vehicles, adding extra safety features such as lane departure warning and rearview/blind spot assistance.

In medical electronics (a fast-growing segment of the industrial market) optoelectronics are being used in oncology, endoscopy, and imaging. Also, cosmetic surgery

and dermatology represent a quickly advancing market for medical lasers.

LED lamps are set to grow in many markets, says DataBeans. While demand for LEDs in backlighting will continue to be strong, applications that use LEDs as replacements for more traditional lighting sources offer a chance for significant growth, as manufacturers continue to advance performance of white LEDs, concludes the firm.

<http://databeans.net>

Worldwide optoelectronics revenue forecast by market segment (in \$m).

	2006	2007	2008	2009	2010	2011	2012	2013	CAGR
Automotive	511	498	514	567	612	707	814	921	12%
Computer	2726	2598	2803	2881	3025	3294	3549	3859	7%
Consumer	6360	6369	6912	7651	8613	9924	11,626	13,078	14%
Communications	4853	4753	5303	6348	7076	7903	9328	10,798	15%
Test & measurement	602	632	679	773	850	904	1008	1082	10%
Process Control	401	387	423	448	475	520	555	570	6%
Medical	160	193	216	261	275	314	346	395	13%
Mil/Aero	70	63	69	70	78	89	99	110	10%
Other Industrial	596	406	450	452	399	364	378	398	-2%
Total	16,280	15,898	17,370	19,451	21,403	24,020	27,701	31,211	12%

WDM sales surpass SONET/SDH as metro demand surges

In first-quarter 2008, sales of wavelength division multiplexing (WDM) systems were \$1.4bn, surpassing those of SONET/SDH multiplexers for the first time, according to market research company Dell'Oro Group's 'Optical Transport Quarterly Report'.

Within the WDM market, the WDM metro segment grew 47% on a year ago and outperformed the DWDM long-haul segment.

"With Internet traffic growing at

such high rates, service providers have to build optical networks that can handle enormous traffic volumes today yet can continue to scale in the immediate future," says Shin Umeda, VP of Optical Transport research. "WDM systems can clearly handle those requirements more economically than legacy SONET/SDH multiplexers," he adds. "Manufacturers continue to improve the attractiveness of WDM systems by incorporating advanced

optical and packet technologies such as ROADM [reconfigurable optical add-drop multiplexers], 40Gb/s, and Ethernet."

Also, the WDM metro market was highly fragmented in Q1/2008, with seven vendors accounting for over 80% of the market, but with none commanding more than 15% revenue share. Cisco was the market leader, followed closely by Alcatel-Lucent and Nortel.

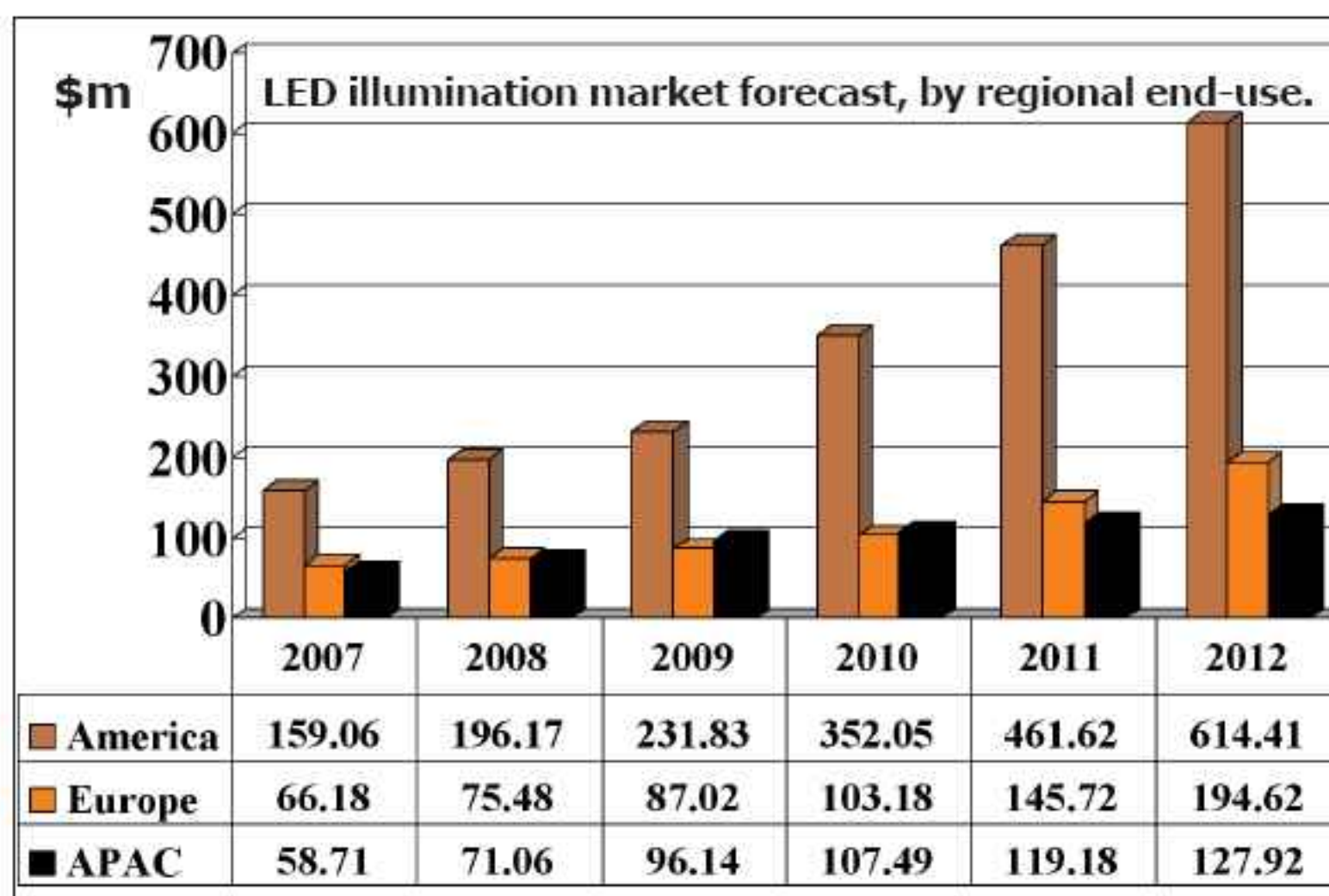
www.DellOro.com

Solid-state lighting sales for packaged LEDs to more than triple by 2012

The global market for solid-state lighting (SSL) illumination incorporating LEDs will more than triple from \$283.95m in 2007 to \$936.95m in 2012, despite strongly rising unit growth being partially

offset by the continuing decline in average selling prices, according to a new forecast from market research firm ElectroniCast Consultants.

The Americas represented a 56% share of worldwide consumption in 2007 (\$159m) and will almost quadruple to 65.6% (\$614.41m) by 2012.



The European market will almost triple from \$66.2m to \$194.6m, but still lose market share slightly from 23% to 21%.

The Asia Pacific region (APAC) will grow from \$58.71m in 2007 to \$127.92m in 2012, but drop from 21% to 13.6%, reckons the firm.

www.electronicast.com

Data communications transceiver market to reach \$13.4bn in 2013

The market for data communications transceivers will grow by about 335% from \$4.0bn in 2008 to \$13.4bn in 2013, according to a new report from market analyst firm Communications Industry Researchers Inc (CIR).

Important new opportunities include the following factors:

- With prices for copper-based 10 Gigabit Ethernet (10GigE) less than \$200 per port and the need to aggregate GigE throughout the enterprise network, CIR expects that this new networking standard is on the cusp of a major ramp up. Shipments of 10 GigE transceivers will be valued at \$7.1bn by 2013, when high-end business PCs will sport 10GigE interfaces.

- In 2008, about 2% of the 10GigE market is represented by copper ports, with almost all being CX4

formats. By 2013, almost 45% of 10GigE ports will be copper and will use the new 'T' format, while on the fiber side the LRM standard will take off and account for \$1.7bn in sales.

- Fueled by new regulatory requirements and Web 2.0 applications, the Fiber Channel transceiver market will exceed \$1bn by 2010 and reach \$3.3bn by 2013, with up to 75% accounted for by the new 16Gb/s Fiber Channel standard.

Among the companies discussed in the report are: Avago, Finisar, Fujitsu, Hitachi Cable, Intel/Emcore, JDSU, Luxtera, MergeOptics, OCP/Oplink and Opnext.

A second report on the telecom transceiver and transponder market is being issued in early July.

www.cir-inc.com

IN BRIEF

Transceiver market to grow eight-fold in 10 years

Global consumption of hybrid and monolithic integrated edge-emitter laser diode (EELD) fiber-optic transceivers will grow eight-fold from \$3.24bn in 2007 to \$25.7bn in 2017, according to a new forecast from market research firm ElectroniCast Consultants. In 2007, America led the market, with a 42% share.

Monolithic EELD transceivers (now in advanced development) will achieve an 11% penetration of global integrated EELD transceiver consumption in 2012, and advance to 42% penetration (\$10.6bn) by 2017 as they displace hybrid EELD transceivers, reckons the firm.

In 2007, single-channel EELD transceivers represented 27% of global consumption value, while 2-12 channel transceivers accounted for 55% (\$959m). However, the

single-channel value share will expand to 38% (\$4.7bn) in 2017 (regaining the market lead), with 2-12 channel transceivers dropping to 34% and 16-128 channel transceivers holding a 28% share.

Consumption of active plus passive parts and devices in the global production of EELD-based transceivers will grow at an average rate of 23% per year, from \$544m in 2007 to \$4.32bn in 2017. Application-specific integrated circuits (ASICs), EELDs, passive optical interconnect links, and connectors will lead this sector of the market, the firm forecasts.

www.electronicastconsultants.com

Monolithic EELD transceivers will...displace hybrid EELD transceivers

IN BRIEF

RFMD extends supply agreement with Selex Galileo

RFMD has signed a strategic supply agreement (worth about \$20m through 2013) that expands on an agreement signed in 2001 between defense electronics supplier Selex Galileo of London, UK and a division of the former Filtronic Compound Semiconductor Ltd (acquired by RFMD in February). The agreement is expected to encompass multiple components, including GaAs pHEMT MMICs supporting electronically scanned (ESCAN) radar and Active Electronically Scanned Array (AESA) radar applications for defence programs.

"We operate in a highly competitive market, so it is crucial that we align ourselves strategically with the best possible suppliers who will allow us to deliver on our challenging business goals," says Norman Bone, Selex Galileo's senior VP of Radar and Advanced Targeting. "RFMD's diverse portfolio of state-of-the-art semiconductor technologies, combined with their RF systems expertise, made them an obvious choice," he adds. "We look forward to forging a stronger and more successful relationship."

Bob Van Buskirk, president of RFMD's Multi-Market Products Group, added: "Selex Galileo is one of Europe's leading defense electronics suppliers, and they are a highly valued customer for RFMD."

RFMD says that it aims to expand its aerospace & defense business in Europe and is strengthening its commitment to support European aerospace and defense customers with high-performance components developed and manufactured at its (ex-Filtronic) Newton Aycliffe, UK-based subsidiary.

www.selexgalileo.com

TriQuint adds distributor Digi-Key to boost global access to RF products

TriQuint Semiconductor Inc of Hillsboro, OR, USA says that its range of packaged RF products for wireless and network communications applications will now be available more quickly and easily after entering into a global distribution agreement with Digi-Key Corp of Thief River Falls, MN, which claims to be the fastest-growing electronic components distributor in North America.

Adding Digi-Key supports TriQuint's strategy of increasing and simplifying access for communications manufacturers to its portfolio of RF power and filter devices, says TriQuint's director of global distribution Jim DeBord.

"Their web portals will give our worldwide customers the opportunity to place and track orders 24/7," says DeBord. "That supports TriQuint's strategy to provide simpler, faster access to our wide product range."

Offering more than a million products from 400 name-brand manufacturers, Digi-Key is now ranked as the 5th largest electronics distributor among more than 300 based in North America.

"We are delighted to broaden our semiconductor product portfolio by partnering with TriQuint," says Digi-Key's president and chief operating officer Mark Larson.

www.digi-key.com

ZTE Supplier of the Year Award for TriQuint

TriQuint has received the 2007 Supplier of the Year Award from telecom equipment and network provider ZTE Corp of Shenzhen, China for its performance on cost, quality, delivery and service.

ZTE uses multiple TriQuint products, including the highly integrated Quantum Tx Module family (in its growing line of ultra-low-cost handsets for emerging markets) and the Hadron PA Module family (in its high-end WEDGE-enabled handsets).

"TriQuint is a key supplier to ZTE Corp and we deeply appreciate their consistent, high-quality products, reliability and commitment to customer service," says Weibing Tian, VP of ZTE KangXun. "Their highly integrated RF solutions lower ZTE's bill-of-materials and work seamlessly with the silicon transceivers."

ZTE is one of the fastest-growing original device manufacturers in China, says TriQuint's VP of sales Todd DeBonis.

www.zte.com.cn

Anadigics names Israel sales rep

Anadigics Inc of Warren, NJ, USA has selected MTI Engineering Ltd as the representative in Israel for its complete line of wireless and broadband RF semiconductor products.

Established over 30 years ago, MTI provides consultation and representation to electronics companies worldwide. "Developing a strategic sales agreement with a leading manufacturing rep such as MTI enables Anadigics to engage new customers in the growing broadband and wireless communications

market around the world," says Marcus Wise, Anadigics' VP marketing & sales for Broadband Products. MTI's sales expertise in communications products provides help to establish and build Anadigics presence in Israel, he adds.

"Anadigics' robust product portfolio of broadband and wireless products will enable MTI to provide leading-edge RF solutions to our telecoms customer base," says MTI's general manager Adi Peleg.

www.anadigics.com/

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Anadigics launches power doubler line amplifier for deep fiber migration

Anadigics Inc of Warren, NJ, USA has launched the ACA2420 power doubler line amplifier, a high-output-power device that is designed to ensure optimal video and data delivery in deep fiber HFC (hybrid fiber coax) architectures and other cable TV deployments that minimize the use of cascaded system amplifiers.

"Cable operators are improving the customer experience with a migration to deep fiber node scenarios, whereby the number of subscribers on each node is reduced, thus increasing the available bandwidth for high-definition TV, interactive gaming, and video-on-demand," says Ron Michels, senior VP and general manager of Anadigics' broadband business. "The ACA2420 combines high output power with low distortion to meet the stringent demands of next-generation 1GHz fiber-deep nodes and system amplifiers."

The ACA2420 supports high output power levels (of +58dBmV/channel) up to 1GHz, providing a higher-quality signal over longer distances compared with amplifiers with lower-output-power handling capabilities, the firm claims.

Signal integrity is assured by the ACA2420's high crash point, which allows the device to maintain low carrier-to-intermodulation noise (CIN), composite triple beat (CTB), and composite second order (CSO) distortion.

Available in a 16-pin surface-mount package, the ACA2420 consists of two parallel amplifiers with low distortion and low noise figure that are optimized for use in a balanced configuration. The device provides 21.5dB of RF gain and a superior gain flatness of ± 0.2 dB, operating from a single 24VDC power supply.

The ACA2420 power doubler line amplifier is available at \$24.28 in quantities of 1000 units.



ACA2420 power doubler line amplifier.

WCDMA PA for LG camera phone

Anadigics is also shipping production volumes of its AWT6277 WCDMA power amplifier (PA) modules to LG for its new Viewty (LG-KU990) 5 megapixel professional-level camera phone (available in the UK).

Designed for feature-rich mobile handsets, the AWT6277 HELP WCDMA PA includes Anadigics' HELP technology, which reduces WCDMA average power consumption by 50%, says the firm. Combined with low leakage current in shut-down mode, the AWT6277 delivers longer battery life and additional talk-time-two key metrics for mobile handset designers.

The 4mm x 4mm x 1.1mm surface-mount PA incorporates matching networks optimized for output power, efficiency, and linearity in a 50 Ω system, which reduces device footprint and the need for external components (suited super-thin designs). The AWT6277 is enabled by the firm's patented InGaP-Plus HBT technology, which combines InGaP HBT and pHEMT devices on the same die.

www.anadigics.com



Anadigics' AWT6277 WCDMA PA.

Mitsubishi Electric improves noise figure in Ku-band GaAs HEMTs for satcoms

Tokyo-based Mitsubishi Electric Corp has launched the MGF4935AM full-mold package low-noise Ku-band GaAs high-electron-mobility transistor (HEMT), suitable for use in the first stage of low-noise amplifiers in direct broadcast satellite (DBS) reception systems and very small aperture terminal (VSAT) systems.

HEMTs are used in low-noise amplifiers for reception converters, which receives Ku-band waves from satellites (downlink: 12GHz; uplink: 14GHz) and convert them into 1-2GHz for the signal processing circuitry). The growth in satellite communications systems is creating larger demand for such transistors, says the firm.

Mitsubishi Electric says that, by improving chip performance and optimizing the package structure, the noise figure (NF_{min}) has been improved by 0.05dB to 0.45dB compared to the previous model (the full-mold package MGF4934BM), allowing use in the first stage of amplifiers. The associated gain (G_s) is 12.0dB ($f=12$ GHz, typical). The recommended bias condition is $V_{ds}=2$ V, $I_d=10$ mA.

With an industry-standard 4-pin full-mold package, an unchanged foot pattern from the previous model can shorten development time for satellite communications equipment makers, the firm reckons. Mitsubishi Electric also claims that the full-mold package HEMT is lower priced than other types of HEMT, and that use in the first stage of amplifiers improves cost performance in satcom equipment.

The sample price is 25 yen. Production volumes are targeted at 4 million units per month.

Mitsubishi Electric says that, in future, it will add to its lineup of full-mold packaged low-noise GaAs HEMTs through improvements in gain and noise characteristics.

<http://global.mitsubishielectric.com>



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IN BRIEF

Kopin in compliance

Nasdaq has notified Kopin Corp of Taunton, MA, USA, which makes GaAs HBT epiwafers and liquid-crystal CyberDisplays, that it is back in compliance with Marketplace Rule 4310(c)(14) after filing its Q1/2008 Form 10-Q report with the Securities and Exchange Commission (SEC).

Kopin had delayed filing while reviewing a Request for Mediation from a customer, a privately held firm in the European Union that had made claims relating to certain representations and actions of an employee of a Kopin subsidiary.

On 19 May, Kopin received a Nasdaq Staff Determination letter threatening delisting from The Nasdaq Stock Market on 28 May. After Kopin appealed to the Nasdaq Listing Qualifications Panel, delisting was stayed pending a hearing on 17 July before the Nasdaq Hearings Panel. That has now been cancelled.

www.kopin.com

Skyworks qualifies WIN for pHEMT foundry

Skyworks Solutions Inc of Woburn, MA, USA, which manufactures linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has approved WIN Semiconductors Corp of Tao Yuan Shien, Taiwan as a foundry partner.

Skyworks says that, due to heightened demand for its products, WIN has already started production to provide it with GaAs foundry.

Skyworks also recently (in mid-April) extended its GaAs HBT purchase and supply agreement with epiwafer foundry Kopin Corp of Taunton, MA, USA.

WIN is said to be the world's largest pure-play GaAs RFIC and MMIC wafer foundry services provider. The firm has two 6" wafer fabs in operation, and recently bought land for a third.

"Skyworks is pleased to begin production at WIN as a source for our proprietary pHEMT manufacturing

process, and is also leveraging their other unique specialty III-V process technologies as we continue to diversify our product portfolio into new market areas," says Bruce Freyman, Skyworks' VP of worldwide operations. WIN also provides HBT, BiFET and mHEMT processes. "WIN's technical capabilities and aggressive approach to capacity investment will complement our internal wafer fabs as we continue to expand our hybrid manufacturing strategy to offer best-in-class cost structure, flexibility, and stability of supply for our customers," Freyman adds.

"Skyworks' expectations for quality and product performance are among the highest in the industry," says Bob Donahue, WIN's executive VP of sales & marketing. "We look forward to continuing to build our relationship as we ramp production and partner on other GaAs technologies."

www.winfoundry.com

Skyworks launches front-end technology supporting Qualcomm's CDMA2000 and HSDPA architectures

Skyworks has announced several new front-end solutions supporting Qualcomm's newest code division multiple access (CDMA) and high-speed downlink packet access (HSDPA) enhanced data for GSM evolution (EDGE) reference platforms:

- The SKY77166 is a 450MHz power amplifier (PA) for CDMA handsets and wireless local loop (WLL) applications in a 4mm x 4mm package — the smallest in the industry for applications in this frequency range, the firm claims. Skyworks is also working on a next-generation product, designed to support certain Qualcomm chipsets, that will drastically improve talk times in this growing market.

- The SKY77183 (a 3mm x 3mm PA for the cellular band) and the SKY77184 (a 3mm x 6mm dual-band PA for cellular and PCS bands with integrated coupler) are Skyworks' first PAs with full bypass mode. Routing the input signal directly from input to output bypasses the PA at low powers. This enables optimal operation at low output power levels and eliminates the need to supply current to the amplifier stages, yielding significant savings in average battery current, the firm claims.

- The SKY77336 power amplifier module (PAM) is designed in a compact 5mm x 5mm form factor for quad-band cellular handsets for GSM, GPRS and EDGE.

At a higher level, this is the first time Skyworks is working directly with Qualcomm on handset platforms targeted for next-generation multimode handset manufacturers.

"When combined with our core front-end capabilities, together we plan to deliver feature-rich, best-in-class solutions to a number of the world's leading handset OEMs and smartphone suppliers," says Skyworks' president and CEO David J. Aldrich. The chipsets will support multiple wireless platform customers.

Mobile devices incorporating these designs should be available later this year.

www.skyworksin.com

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Avago claims first RF CSP solution and smallest RF amplifier

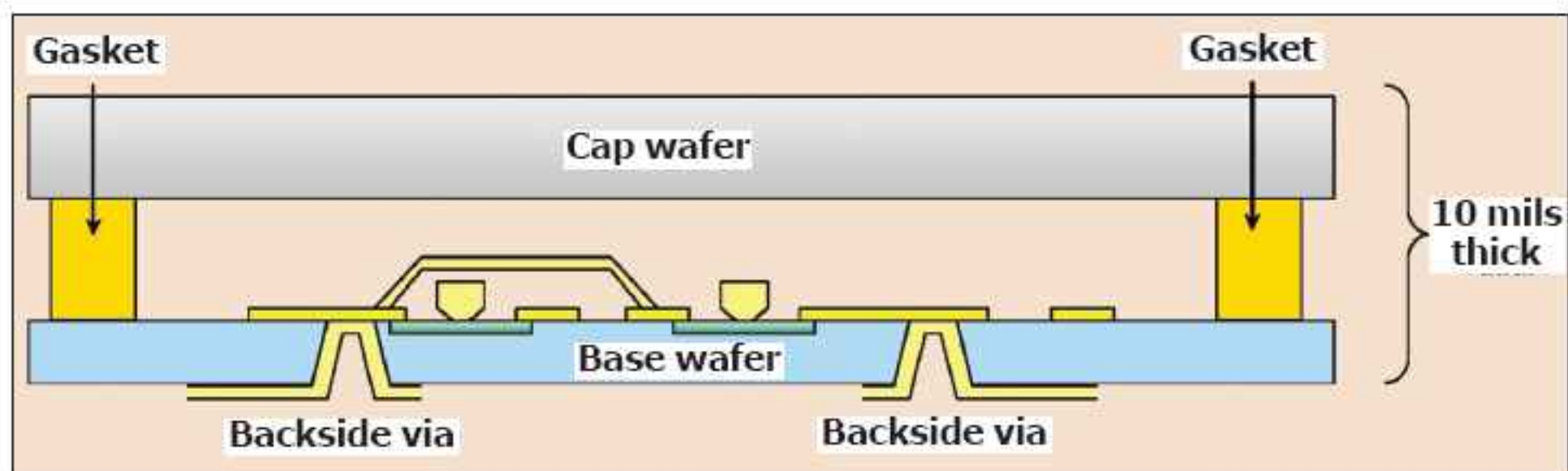
Avago Technologies of San Jose, CA, USA claims that its new WaferCap technology uses the industry's first wafer-level chip-scale packaging (CSP) for RF devices, creating the world's smallest RF amplifier. The VMMK-2x03 series, in a 0402-size package — more familiar as the form factor for surface-mount technology (SMT) capacitors — is now sampling and will be generally available in Q4/2008.

Avago has previously fabricated three-quarters of a billion 0402-packaged discrete devices for its line of thin-film bulk acoustic resonator (FBAR) RF filters for cell-phone handsets by using a micro-electro-mechanical system-like (MEMS-like) wafer-level capping technique. Avago has now adapted the technique for RF amplifier chips to be batch packaged cost effectively using standard processing techniques at its 6" GaAs fab in Fort Collins, CO.

To adapt the devices to the 0402 package, Avago lays down a wafer-scale gasket that isolates each chip en masse while still on the wafer, then bonds a second blank GaAs capping wafer on top, effectively encapsulating each chip.

Creating an air cavity above the chip's circuitry (rather than a layer of traditional dielectric material) enables higher-frequency operation. Also, via-holes through each chip route all I/Os (inputs-outputs) to contacts on the backside of the GaAs device wafer. As well as removing the need for costly wire bonding, the RF transitions suffer almost no signal loss and minimal parasitic capacitance. This improves performance over conventional plastic-packaged amplifiers, where substantial parasitics from bond wires limit the operating frequency.

RF performance is also improved by direct contact between the chip and the package substrate, and by the reduced RF signal path length and hence electrical resistance compared to typical SMT designs. It also improves heat transfer from the device to the assembly by



Cap wafer provides the lid. Base wafer incorporates active device with outside I/O connections made through hermetic vias. The gasket is a patterned polymer.

removing the intervening package. The improved thermal condition and reduced number of bond wires greatly increase reliability.

After capping, the bonded wafers can be diced and the chips are ready to use, without a lead frame. So, WaferCap allows packaging of RF chips in a leadless 0402-size package (thinner than standard plastic packaging).

The VMMK-2x03 measures just 1mm x 0.5mm by 0.25mm high, occupying just 10% of the board area and 5% of the volume of a standard SOT-343 package. In some cases, it can more than halve the PCB area occupied by an RF device.

Also, instead of using a flip-chip and solder-bump technique (which would invert the ground plane of chips on a PCB, interfering with their RF properties) the wafer-level CSP technique enables the chip to remain right-side-up on the PCB. The chips can then be used directly in an SMT assembly using standard equipment to mount and solder the devices directly onto a board.

The elimination of wire bonding gives the flexibility and simplicity to fit a WaferCap packaged device using traditional mass-production pick & place or chip shooter machines in a variety of positions in a wide range of RF architectures. The dimensions and performance levels provide a new level of design flexibility in device placement that will change the way RF designers think about wireless product designs, reckons Bryan Ingram, senior VP and general manager for Avago's wireless semiconductors division.

With miniature package dimensions and no wire bonds, the VMMK-2x03 series' fully matched SMT design is optimized for 500MHz to 12GHz frequencies (with potential to reach the 100GHz frequency range), suiting a variety of radio designs.

The family provides high gain, high IP3, low NF and integrated 50Ω I/O matching networks to simplify system design. Covering five frequencies from 500MHz to 12GHz, the amplifiers can be used in many roles in radio systems, such as mobile devices, radios, sensors and military communication applications. Their flexibility in size and high-frequency performance also suit applications such as wireline, fiber-optic, base-station, CATV, and instrumentation.

The family of devices includes:

- VMMK-2103: a 0.5–6GHz broadband matched LNA with bypass/shut-down mode using a single control pin;
- VMMK-2203: a 1.0–10GHz broadband matched LNA with high gain of 15dB at 5GHz;
- VMMK-2303: a 0.5–6GHz low-voltage broadband matched LNA supporting 1.8–3.3V;
- VMMK-2403: a 2.0–4GHz high-linearity matched amplifier with 2.5dB NF;
- VMMK-2503: a 1.0–12GHz broadband high-linearity matched gain block with flat gain performance of up to 8GHz.

Pricing is less than \$1 in volume.

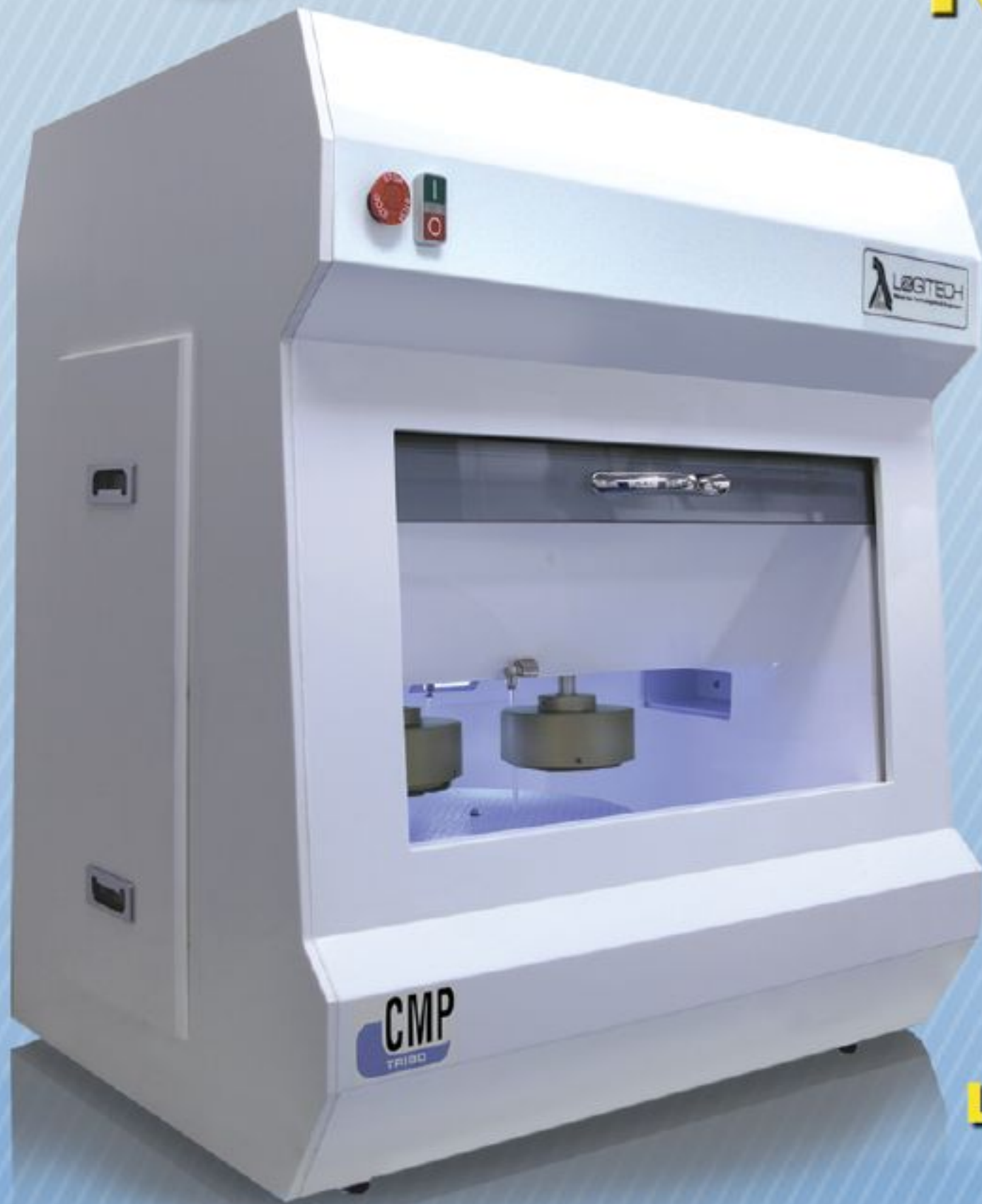
Avago is also planning WaferCap CSP 0402-packaged products with higher levels of integration in the future, says marketing manager Titus Wandinger.

www.avagotech.com/rf

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MMIC Solutions secures £2.7m round-A funding

MMIC Solutions Ltd of Ledbury, UK has secured £2.7m in round-A funding from new investor YFM Group, joined by existing investor Scottish Enterprise (via the Scottish Venture Fund) along with others including NESTA (the National Endowment for Science, Technology and the Arts) and the Advantage Early Stage Growth Fund (AEGF).

MMIC Solutions was formed in 2004, and raised seed funding of more than £1.5m in March 2007. The firm designs and manufactures modules and subsystems for commercial millimeter-wave applications.

Wavelengths of 1–10mm have similar dimensions to those of the components, interconnects, and the module packaging itself, resulting in resonance effects and spurious signals that can severely degrade performance and even prevent modules functioning altogether, says the firm. Such millimeter-wave products are usually manually assembled and tuned, requiring

experience and skill (often with considerable rework). MMIC Solutions claims that its technology (developed by QinetiQ UK Ltd of Malvern, UK since the late 1980s and licensed exclusively in August 2005) controls the spurious signals and resonance effects, enabling automated assembly and low cost.

Millimeter waves can penetrate a few millimeters of most clothing fabrics. Imaging therefore allows detection and identification of metallic and non-metallic materials (including weapons, explosives and illegal goods) concealed under clothing. The firm says that this ability is generating much interest, with systems being deployed at many commercial and civic infrastructure locations, as well as at airports in the US and Europe. MMIC Solutions made its first customer shipments in May 2007 (the MSi105 direct detection receiver for a security imaging system operating at 94GHz).

The firm is also developing low-cost modules for high-capacity communications links supporting data rates of 1Gb/s and more, and operating in unlicensed and 'light-licensed' bands between 60 and 80GHz.

"Demand for our innovative technology continues to grow in applications such as weapons detection and high-bandwidth communications. This significant investment allows us to expand our team and production capabilities to address the many opportunities our customers are presenting" says CEO Rodger Sykes.

MMIC's engineering activity is in Ledbury, near QinetiQ, but the firm is registered in Scotland, where it has its operational capability. "By establishing its UK production operations in Scotland, MMIC Solutions joins the growing number of cutting-edge technology companies choosing Scotland as their base," says Scottish Venture Fund investment manager Jonathan Lloyd-Hirst.

www.mmicsolutions.com

Comtech awarded \$2m of orders for high-power amplifiers

Comtech Telecommunications Corp says that its subsidiary Comtech PST Corp in Melville, NY, USA has received \$2m of orders from a domestic prime contractor to continue production of broadband, solid-state, high-power radio signal jamming amplifiers.

The power amplifiers, which use gallium nitride (GaN) transistors, offer improved efficiencies over wider bandwidths, mandated by current jamming systems.

"We remain committed to supporting this important program by investing in advanced technology solutions that enhance the performance of our amplifiers," says Comtech Telecommunications Corp's president and CEO Fred Kornberg.

www.comtechpst.com

Plextek designs X-band power amplifier MMICs for radio and radar

Electronics and communications design consultancy Plextek of Cambridge, UK has completed the design of 2W and 4W X-band power amplifier (PA) MMICs for a UK electronics component supplier. Preliminary data sheets are available and samples will follow shortly.

Both MMICs cover the entire X-band (8–12GHz) and are available as bare die, packaged components or connectorized modules for use in applications such as point-to-point and point-to-multi-point radios and radars. An advantage of the PAs is that they will not be subject to the restrictions of the US Government's International Traffic in Arms Regulations (ITAR), as fabrication, design and supply are undertaken by non-US firms.

The X-band PAs are 50Ω matched and require no external components.

An on-chip active biasing network allows the use of a fixed gate bias potential and helps compensate for performance variation with temperature and process spread. The amplifiers are fabricated on a robust 0.5µm gate-length power PHEMT process that is suited to high-volume production.

"Plextek has offered MMIC design services to its clients for over 10 years and carried out the design of over 30 MMICs," says the firm's director of RF Integration, Liam Devlin.

"We are already in discussions with the same client about future MMIC developments, including broadband (6–18GHz) digitally controlled phase-shifters, digitally controlled attenuators and power amplifiers," Devlin adds.

www.plextek.co.uk

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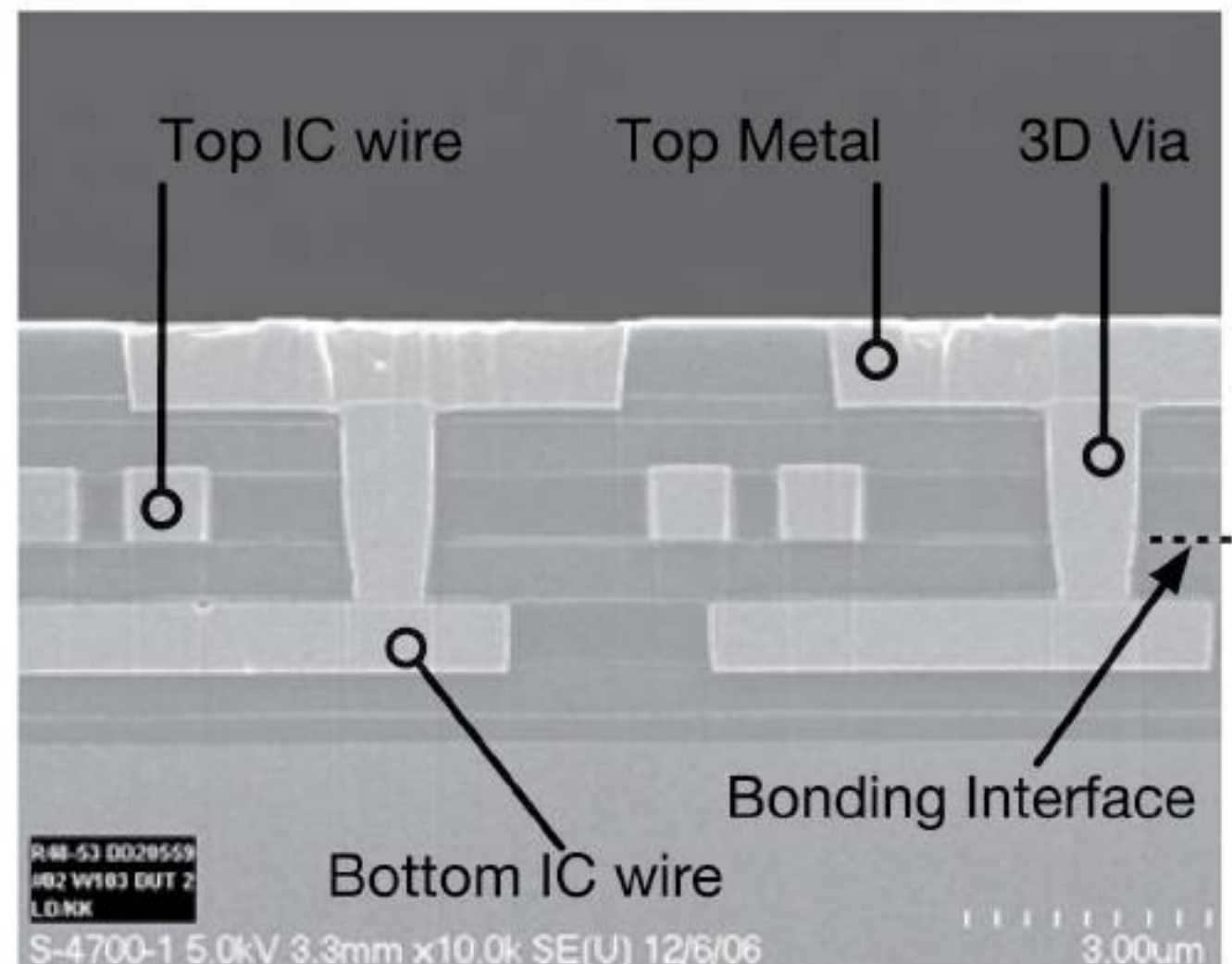
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AFRL awards SemiSouth \$4.9m 'Task Order 3' for SiC development

The US Air Force Research Laboratory (AFRL) at Wright-Patterson Air Force Base in Dayton, OH has awarded SemiSouth Laboratories Inc of Austin, TX 'Task Order 3', totaling \$4.9m, against a previously won Small Business Technology Transfer (STTR) award. This is part of a five-year STTR, Phase III contract awarded in 2006 for the development of SiC power semiconductor devices for harsh environments.

After delivering on previous task orders focused on the design and reproducible manufacture of SiC-power semiconductors, 'Task Order 3' focuses on design advances, device reliability and manufacturing qualification for the SiC devices in preparation for critical military applications.

The latest task order also funds the development of prototype reference designs for power conversion systems in high-temperature or high-performance applications using the SiC devices. One target application is AFRL's More Electric Aircraft (MEA) initiative, which requires high-efficiency and high-temperature transistors that can only be realized by using SiC. "Many of the Department of Defense (DoD) applications are limited by energy efficiency," says chief technology officer Dr Jeffrey B. Casady. "In MEA applications, removing size and weight is absolutely critical for mission integrity. The energy-efficient, rugged nature of SiC-based power electronics enables smaller, lighter, and faster aircraft."

Both the design and production work for the award are performed in the facility in Starkville, MI (where SemiSouth was founded in 2000). "We've received broad support for this effort across DoD, as well as clear vision and support from the Mississippi Congressional delegation, in particular US Senators Thad Cochran and Roger Wicker," Casady remarks.

www.semisouth.com

Delphi team awarded \$5m DOE funding to halve size and cost of electric propulsion inverters

Mobile electronics and transportation system provider Delphi Corp of Kokomo, IN, USA has been awarded \$5m by the US Department of Energy (DOE) as lead contractor of an industry-government team to develop next-generation propulsion inverters for hybrid electric vehicles. The partners in the team were originally chosen by the DOE in May 2007.

Propulsion inverters provide phased AC power for hybrid vehicle traction motors and generators, as well as auxiliary pumps and drives. They enable precise control over power flow from the battery to the electric motor. One or more motors can be combined with another power source like a gasoline or ethanol engine, an engine-generator, or a fuel cell to propel the vehicle at higher efficiency than conventional engine technology.

The smaller inverter is lower cost and will be used in next-generation high-efficiency hybrid electric vehicles (HEVs) and 'plug-in' hybrids (PHEVs). In the longer-term, the inverter will be used for fuel cell vehicles (FCVs).

The DOE and Delphi view the project as a key element of a strategic, public-private partnership to achieve the lower-cost technologies needed for such hybrid vehicles to become more broadly accepted in the US.

In addition to the \$5m in DOE funding, the Delphi-led research and design team will contribute \$3m. The \$8m project seeks to more than halve the cost and size of the inverter for electric propulsion systems.

"We have assembled a team of highly qualified industry leaders and national laboratories to identify and develop the key technologies needed for an electric propulsion inverter that meets or exceeds the DOE performance and cost targets," says Thomas Goesch, managing director of Delphi's Power Electronics PBU.

The main team members include: Delphi for inverter design, packaging, thermal management, mechanical

integration, build, test and assessment of cost to manufacture; SiC materials supplier Dow Corning Corp of Midland, MI and device maker GeneSiC Semiconductor Inc of Dulles, VA for SiC-on-silicon power semiconductor devices; General Electric for high-temperature thin-film DC buss capacitors; Argonne National Laboratory for ceramic capacitors; and Oak Ridge National Laboratory for the characterization of power semiconductor devices, modeling, simulation and evaluation of alternative inverter topologies, and system testing.

Dow Corning has been developing SiC technology for more than 15 years. In 2003 it acquired SiC substrate maker Sterling Semiconductor Inc and formed Dow Corning Compound Semiconductor Solutions (DCCSS), which in 2004 built a new SiC plant in Auburn, MI. DCCSS is developing the manufacture of device-quality SiC substrates up to 100mm (4-inches) in diameter (funded by Office of Naval Research contracts of \$3.6m awarded in December 2005 and \$4.2m in December 2007). GeneSiC develops SiC-based devices (such as rectifiers, field-effect transistors, and bipolar devices, as well as particle & photonic detectors) for high-temperature, radiation and power grid applications.

In addition to reducing the cost and size of the inverter system, Delphi aims to enable the system to operate at normal engine coolant-loop temperatures of 105–120°C to help reduce other system costs and the space needed to cool existing inverters. "This will result in development of inverter building blocks that will be readily scalable to a wide range of power levels, enabling the necessary economies of scale for lower cost," says A.J. Lasley, chief engineer for advanced HEV and powertrain electronics.

www.delphi.com



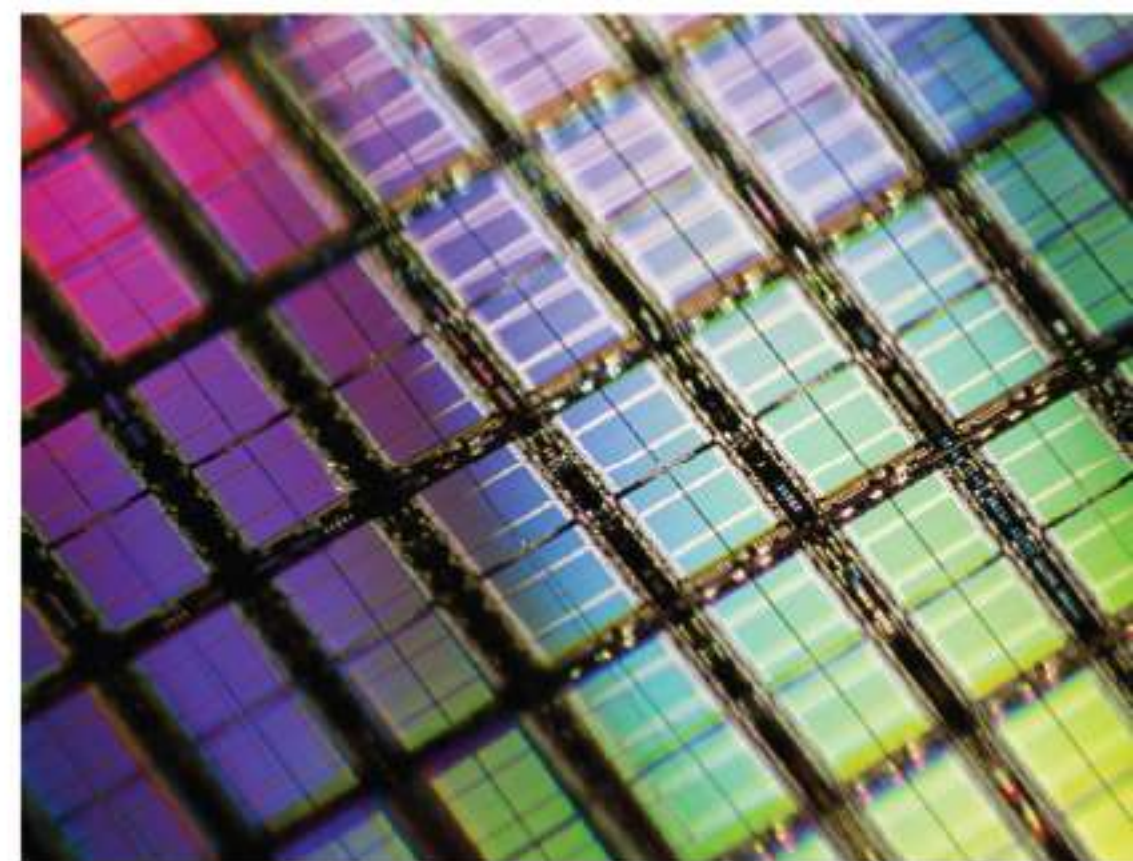
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SRA agrees germanium and gallium leachate supply deals

In late May, Strategic Resource Acquisition Corp of Toronto, ON, Canada agreed to sell a significant portion of future germanium (Ge) and gallium (Ga) smelter leachate from the first two years of production at its mid-Tennessee zinc mining complex (MTM) near Gordonsville, TN, USA to Recapture Metals Ltd of Peterborough, ON (a supplier of recovered high-purity gallium). On an annualized basis, total leachate from the smelter is expected to be in excess of 12,000 tonnes per year (tpy).

SRA acquired the complex in December 2006 (consisting of five zinc mines and a mill), formerly operated by Pasminco. It has a 28 year history of continuous operation from 1975 to 2003, producing one of the world's highest-quality zinc concentrates. At a mill recovery rate of about 94.6%, a concentrate was produced grading 64.5% zinc (near the theoretical maximum of zinc in concentrate), 0.05% gallium and 0.04% germanium.

Prior to being placed on care and maintenance due to historically low metal prices, MTM was the largest zinc mining operation in continental USA. The resources in the mines and additional mineral rights acquired are estimated to contain over 26 million tons of zinc resources.

However, historically, processing of leachate was limited to Ge recovery and excluded any value for Ga due to technological limitations of former processing methods. Now, Recapture will use its processing capability to further increase economically payable Ga.

In May 2007, SRA closed an initial public offering and contracted Dynatec Mining Corp of Richmond Hill, ON to manage the restart of mining (in December) and milling

(this March), as well as the first two years of operations.

Most zinc concentrate production in the first five years has been allocated (with the remainder reserved for spot market sales). In November, SRA agreed to sell a major portion of MTM's production (up to 90,000 tons annually over five years) to Nyrstar SA/NV (the world's largest producer of zinc metals and alloys). Its smelter, just 100 miles west in Clarksville, TN, is where the concentrate was processed previously. Regular shipments to Clarksville started in April, and were expected to reach 5000 tons per day in June, then 7500 tons per day by fall. Nyrstar is returning the residue (rich in both Ge and Ga by-products) to SRA.

The Nyrstar agreement allows SRA to develop technology for optimizing the recovery of Ge and Ga. In October 2007, SRA entered into a technology development agreement with mineral R&D firm Drinkard Metalox Inc (DMI) of Charlotte, NC, USA to evaluate and recommend processes to optimize the recovery from zinc concentrate smelter residues of by-products including Ge and Ga.

In the meantime, concurrent with the plan to develop a processing facility to maximize recovery, the agreement with Recapture Metals enables SRA to realize immediate contributions for Ge and Ga, says SRA's CEO Victor Wyprysky. "Access to state-of-the-art technology to optimize both metals will strengthen SRA's position in the global marketplace."

Processing of leachate was limited to germanium recovery and excluded any value for gallium

Also, in early June SRA entered into a tri-partite, two-year memorandum of understanding with New York-based Amlon Resources Group LLC (a diversified metals and industrial byproducts management group) and a Chinese end-user group for the sale of 5000tpy of Ge/Ga-rich leachate in the first year and more in the second year (with advance payment starting this fall). The agreement is subject to the approval of a trial shipment of leachate, and should be finalized by September.

SRA has now effectively provided for the sale of the majority of its Ge/Ga-rich leachate into 2010.

"This agreement further realizes the economic value of both our germanium and gallium, a marked improvement over the history of the mid-Tennessee mining complex, as no credits were ever received for

SRA expects MTM to be the largest source of Ge and Ga in continental USA

gallium," says Wyprysky. SRA reckons that the Ge and Ga could also indirectly lower the cost of zinc produced, making MTM one of the lowest-cost zinc mining operations in the world, as well as providing a diversified revenue source.

Once in full production, SRA expects MTM to be not only the largest zinc producer but also the largest source of Ge and Ga in continental USA, producing about 35,000kg of each (currently trading at about \$1400 and \$500 per kg, respectively).

SRA also plans to explore and develop additional properties and redeploy cash flow to pursue a strategy of acquisitions.

www.sra-corporation.com
www.recapturemetals.com
www.amlonresources.com

Voltaix expanding germane capacity

Specialty materials manufacturer Voltaix LLC says that it is expanding its germane manufacturing capacity to meet growing demand in the solar and semiconductor industries.

Continuous improvements in the germane plant in the firm's North Branch, NJ facility have increased throughput by more than 200%.

In addition, Voltaix plans to complete the installation and commissioning of a second, previously constructed skid-mounted germane production plant — with a capacity of about three times that of the current plant — which should be operational at a new site in the next 15 months. The expansions collectively will increase Voltaix's germane manufacturing capacity to more than 50 tons per year.

"These expansions provide the capacity and production redundancy our current and future customers need to support growth of their germane-based manufacturing technologies," says Voltaix's chief operating officer Matt Stephens.

"Germanium significantly improves thin-film solar device efficiencies, enables strained silicon technologies for computer CPUs [central processing units], and is central to newly emerging germanium channel and gate applications," he adds.

"We are committed to serving the market needs for germane through continuous improvement of our capacity, supply chain redundancy, and product quality."

www.voltaix.com

IN BRIEF

American Elements expands CdTe capacity

American Elements of Los Angeles, CA, USA says it has further expanded its cadmium telluride (CdTe) production capacity to meet growing demand for solar panels and quantum dot applications.

At full capacity, the new facility can deliver over 150 metric tons annually. Small quantities for testing and qualification are currently available.

The expansion will also increase American Elements' production capacity for several other telluride and selenide compounds and crystal materials, such as cadmium selenide and zinc telluride, and thin-film coating materials for use in solar applications.

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SAFC Hitech launches vapor-phase metalorganic distribution system and large-scale bubbler

At the 14th International Conference on MOVPE in Metz, France, SAFC Hitech launched the EpiVapor metalorganic vapor-phase distribution system, which eliminates localized tool bubblers and temperature control units (TCUs) by delivering vapors from highly volatile and sensitive pyrophoric liquids directly to MOCVD systems (enabling cost savings).

An extension of the firm's EpiFill bulk liquid delivery technology, EpiVapor provides gas-phase delivery of chemical vapors such as trimethylgallium (TMG) and trimethylaluminum (TMA) directly to multiple deposition tools in a safe, reproducible way. Flexible enough to connect to up to eight independent tools, the continuous delivery of metalorganic vapors offers an uninterrupted fabrication of devices, the firm says. The system's design ensures precursor flux stability in hydrogen (or other inert carrier gases) throughout the life of the ampoule, while adjustable parameters ensure that processes can be run at full capacity without stoppages to change out the tool bubblers. This optimizes process efficiency, reduces operational costs and increases safety, without compromising performance levels, the firm claims.

"As the MOCVD industry moves into high-volume manufacturing, overall cost of ownership (COO) has become an important consideration in cost control," says president Barry Leese. "Reducing the cost of transporting metalorganic chemicals to the tool plays a significant part in reducing overall COO," he adds. "The reliable, flexible and highly controllable dosimetry of organometallic precursors is of paramount importance in production environments where downtime is prohibitively expensive. The success we have seen with our EpiFill technology for pyrophoric materials motivated us to develop a vapor distribution system," he says. "With the introduction of the EpiVapor system we are reducing

both system down time and the amount of hardware used per tool, eliminating the need of multiple temperature controller units and enabling automation and bulk chemical change-out in an arrangement that can be tailored for the specific requirements of the customer."

The EpiVapor features a user-friendly LCD touch screen display that shows the process flow diagram and user interface. The touch screen displays information including bulk tank liquid levels, valve configurations, fluid and vapor flow paths and system pressure/vacuum — simplifying the operation of the unit in both automatic (auto) and manual (service) modes — as well as an alarm screen, recipe screens, programmable set points and multilevel password protection for added security.

The chemical section of the system consists of a cabinet that is enhanced for the use of pyrophoric materials with smoke detectors, audible and visual alarms, a watchdog system for automatic operation, optional UV/IR flame detector, 110% containment spill tray, and a manifold with fail safe pneumatic valves. The system is both S2-93/98 and S2-0200 certified and is CE marked.

Other components built into the system include a pressure transducer, pressure controller, a Venturi vacuum generator, a vaporizer bubbler fitted with continuous and fixed-level sensors, and a TCR2000R temperature control unit (TCU).

Applications include:

- precursor vapor delivery for production MOCVD/ALD deposition systems;
- TMG delivery for MOVPE of heterojunction bipolar transistors (HBTs) and high-brightness LEDs (HBLEDs);
- delivery of TMG and DEZ (diethyl zinc) for MOCVD of solar cells;
- TMA delivery for ALD of Al_2O_3 high-k dielectric for logic, memory, and MEMS devices; and
- other high-volatility III-V and silicon precursors.

* Bubbler for larger lot sizes

SAFC Hitech has also launched the OM700 bubbler, which offers a cost-efficient migration path to controlled delivery of organometallic precursors for larger lot sizes (enabling a reduction in process downtime, combined with increased safety controls).

The firm claims the OM700 offers reliable and controllable dosimetry of highly sensitive organometallic precursors, such as TMG, TMA and TEG (triethylgallium), in production environments where downtime is prohibitively expensive. The large capacity, which supports up to 13kg of precursor, reduces the frequency of container change-outs, minimizing downtime and bubbler manipulation safety hazards by enabling larger batch sizes. Also, the bubbler's flux stability covers operating temperatures from $-10^{\circ}C$ to $+30^{\circ}C$, ensuring processes can run at peak efficiency.

These combined advantages in a production environment result in reduced operational costs without compromising performance. In existing large bubbler technology, maintaining temperature control can be difficult because conventional heater baths are used. Also, the size of the bubbler is restricted to that of the installed bath. Instead, the OM700 has an independent heating jacket and thermal control system that enable an increased volume to hold over 9 liters of metal alkyl, while maintaining strict temperature and operational controls.

"As the demand for higher throughput and process efficiency grows, more efficient methods for precursor delivery will be required," says R&D director Dr Peter Heys. "We are seeing significant demand in this area, and the OM700 complements our range," he adds. "Our EpiFill system has been proven for many years, and our new EpiVapor unit builds on this technology for true, large-scale operation, with the OM700 now offering an attractive intermediate solution."

www.safchitech.com

First Nano ships first turnkey UHV-CVD system for silicon-germanium nanowire research to CEA Grenoble

First Nano, a division of CVD Equipment Corp of Ronkonkoma, NY, USA, has shipped a silicon-germanium (SiGe) chemical vapor deposition system to CEA Grenoble, France. The EasyTube 3000, Easy Gas and Easy Exhaust systems were configured specifically for SiGe nanowires, together comprising the first commercial turnkey system offered for this type of material growth, the firm believes.

The system will be used within the Minatec center in Grenoble by the Silicon Nanoelectronics Photonics and Structures (SiNaPS) laboratory, which was established in 2000 as part of the Institute for Nanoscience and Cryogenics' Department of Basic Research into Condensed Matter (INAC-DRFMC) and Service de Physique des Matériaux et Des Microstructures (SP2M). The lab focuses on

researching the physics and optics of low-dimensional silicon-based nanostructures and their applications to the emerging fields of nanophotonics and nanoelectronics.

The SiNaPS lab will use the system to further develop research programs on semiconductor nanowires, in close collaboration with the Laboratoire des Technologies de la Microelectronique (LTM) and the Centre National de la Recherche Scientifique (CNRS), which also took part in funding the system.

"The purchase of the EasyTube 3000 will enlarge the spectrum of our research with the growth of heterostructured nanowires, their doping, and with the possibility to extend the growth to a wide variety of other materials thanks to the liquid precursor kits," says CEA engineer Pascal Gentile.

"Our projects cover fundamental aspects (growth, carrier transport...) as well as potential applications (nano-electronics, solar energy, nanophotonics, MEMS and sensors," he adds.

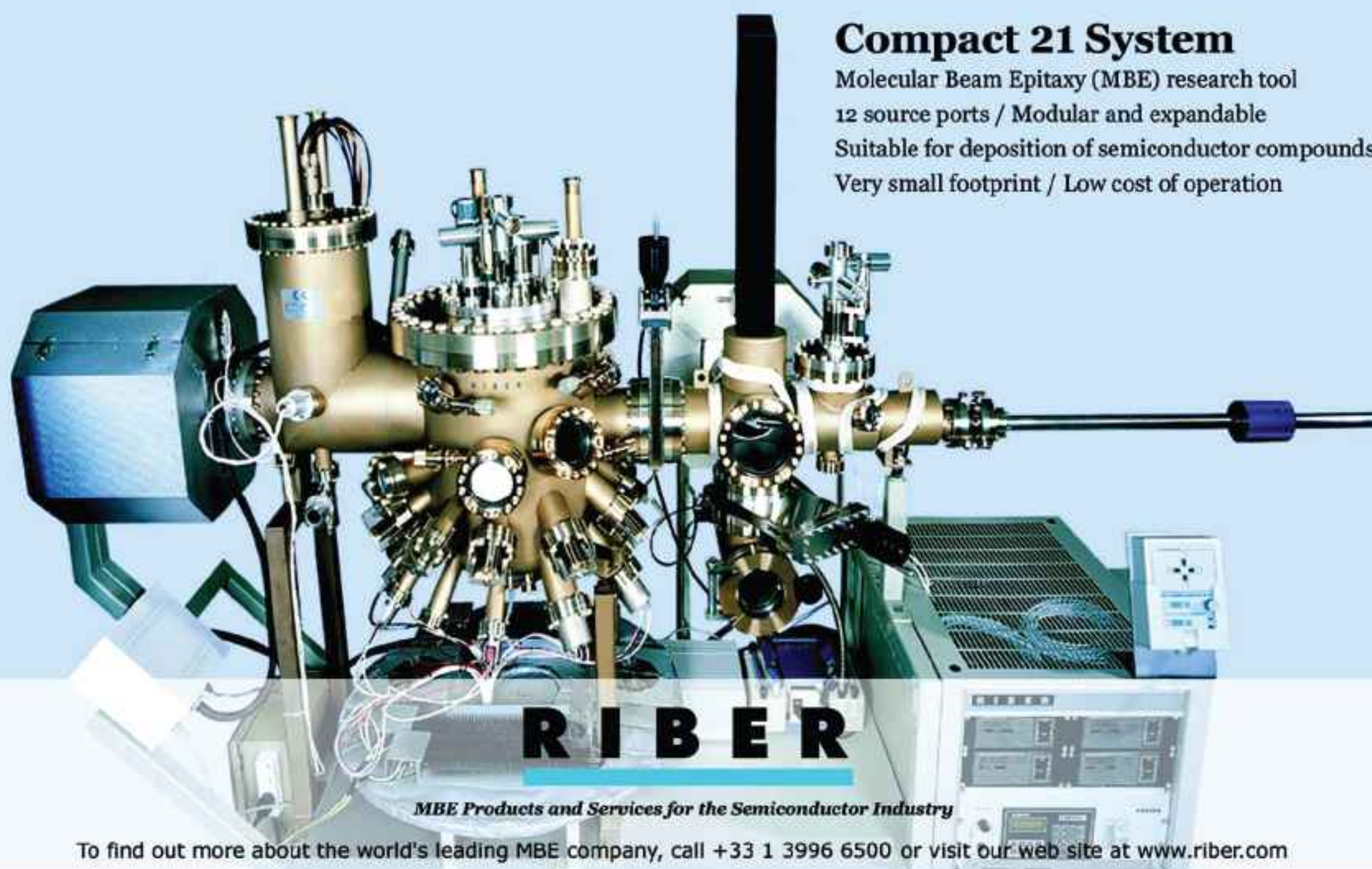
To date, SiGe nanowires have been produced in a few research laboratories by ultra-high-vacuum CVD (UHV-CVD). However, First Nano says that it remains a challenge to control the diameter, length, uniformity and purity of the synthesized SiGe nanowires because of their low dimensionality. The EasyTube ET3000 system provides precise control of pressure, chemical delivery and temperature for SiGe nanowire synthesis, says Gary Dyal, First Nano's director of marketing & sales.

<http://cvdequipment.com>
www-drfmc.cea.fr

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IN BRIEF

Ubilux orders six reactors for HB-LEDs

Taiwanese start-up Ubilux has ordered six Aixtron MOCVD reactors for the manufacture of ultra-high brightness (UHB) LEDs based on AlInGaP (red and yellow) and GaN (blue and green).

Included in the order are several Planetary Reactor and Close Coupled Showerhead (CCS) CRIUS systems, for delivery in stages until the end of this year. The systems will be installed in Ubilux's new LED production fab, which is due to be operational within six months.

"We have our sights set on the booming market for solid-state backlighting applications including digital cameras, mobile phones, LCD monitors and TVs," says Ubilux's president Dr Henry Chen.

VPEC orders reactors for pHEMT and HBT epiwafers

Visual Photonics Epitaxy Corp (VPEC) of Ping-Jen City, Taoyuan, Taiwan has placed a repeat order for AIX 2600G3 MOCVD reactors, to be installed alongside existing Aixtron systems, for the production of pHEMT and HBT epiwafers.

Founded in 1996, VPEC's principal products are HBT and PHEMT epiwafers for wireless communication applications, high-brightness LED epiwafers and chips for industrial and commercial applications, and Zn-diffusion-ready PIN epiwafers for fiber-optic communication applications.

"To meet booming demand from our customers, we are expanding our production capacity for high-performance transistor wafers," says Dr James Huang, general manager of VPEC's Microelectronic Products business unit.

www.vpec.com.tw

Veeco acquires web coating system maker

Veeco Instruments Inc of Plainview, NY, USA has extended its thin-film solar equipment product line by acquiring Mill Lane Engineering of Lowell, MA, a privately held manufacturer of web coating systems for flexible solar panels with about 20 staff.

Veeco is paying \$11m, plus potential additional payments based on the satisfaction of specific future conditions (including certain order, sales and profit levels). Mill Lane has an existing multi-unit order for web coating systems from a manufacturer of thin-film copper indium gallium diselenide (CIGS) solar cells, says Veeco. The new division has been named Veeco Solar Equipment Inc, and will be managed by Veeco senior VP Dr Piero Sferlazzo.

Mill Lane's web coating and vacuum engineering expertise will combine with Veeco's existing thin-film deposition technologies, such as ion beam and physical vapor deposition and thermal sources, to address the

equipment needs of thin-film solar manufacturers, says Sferlazzo. "This investment complements Veeco's existing deposition technologies, expanding our product offerings for the emerging thin-film solar market," adds CEO John R. Peeler. "While many of today's solar panels are based on silicon technology, thin films offer low manufacturing costs and the promise of higher photovoltaic efficiencies."

Mill Lane is not expected to have a material impact on Veeco's Q2/2008 revenue guidance of \$102-110m. However, it is expected to impact earnings guidance due to the addition of operating expenses. Also, earnings will be impacted by an extra amortization expense as well as a potential in-process R&D charge. In second-half 2008, Mill Lane is forecast to add \$10-15m to Veeco's revenues but not to have a material impact on earnings.

www.veeco.com

Genesis orders two more Aixtron CRIUS MOCVD reactors

Genesis Photonics Inc of Southern Taiwan Science-Base Industrial Park in Tainan has ordered two CRIUS Close Coupled Showerhead (CCS) MOCVD reactors (in 31x2"-wafer configuration) from Aixtron for making ultra-high-brightness (UHB) nitride LED products. The reactors will be installed alongside Genesis Photonics' existing CCS systems.

"Ever since Genesis was founded [in 2002] we have been using the CCS systems," says chairman David Chung. "Genesis decided to install two more advanced systems to further boost performance and yield rate of GaN epiwafers," he adds. Chung explains that Genesis therefore decided to migrate all of

its outstanding epitaxy technology needs to the large-scale CCS technology of the CRIUS system.

Genesis previously ordered a 19x2"-wafer CCS reactor in 2005, followed by six more in Q4/2006 as part of a long-term purchase agreement. The firm subsequently said this February that it aimed to increase its monthly production capacity of epiwafers from 25,000 units in 2007 to 40,000 units by the end of 2008 (raising its monthly capacity of LED chips to 300m units). It also said that it aimed to increase its number of MOCVD reactors from 19 to over 25 units by the end of 2008.

www.g-photonics.com

Crack-free AlGa_N/Ga_N on 200mm Si(111)

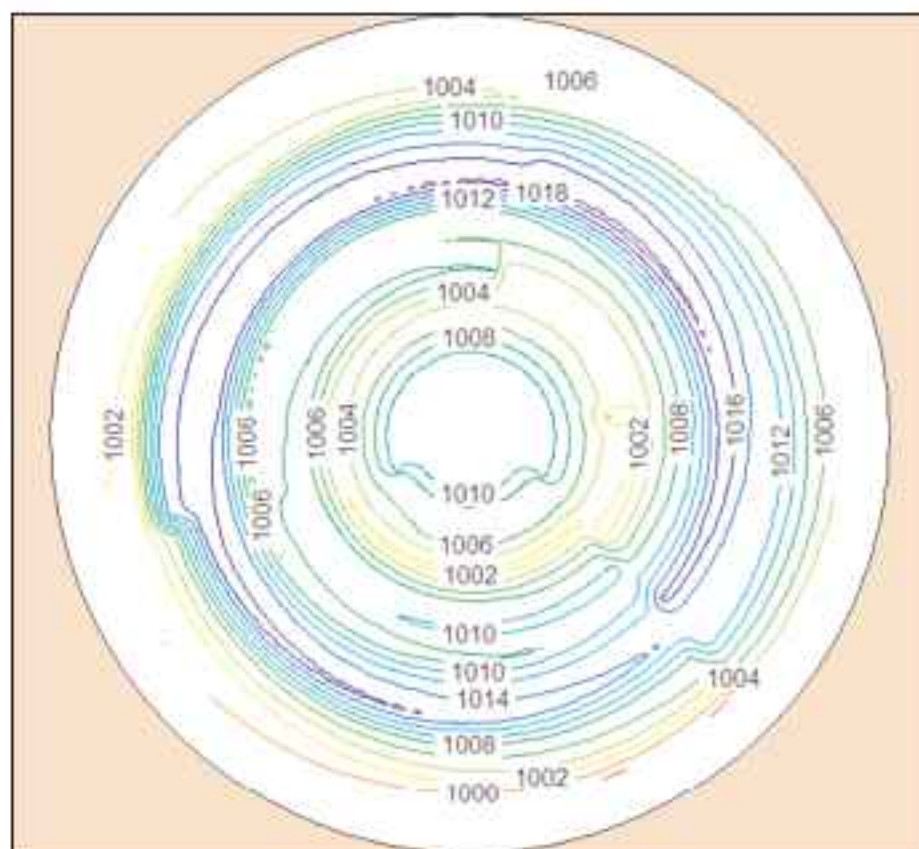
In its user meeting at the 14th International Conference on MOVPE in Metz, France, reactor maker Aixtron, together with research center IMEC of Leuven, Belgium, presented what is claimed to be the first crack-free AlGa_N/Ga_N heterostructures grown on 200mm (111) crystal orientation silicon wafers.

"There is a strong demand for Ga_N-based solid-state switching devices in the field of power conversion," said Marianne Germain, program manager of IMEC's Efficient Power program. However, due to a lack of commercially available Ga_N substrates, Ga_N heterostructures are typically grown on sapphire or costly silicon carbide wafers.

"Bringing Ga_N devices to a level acceptable for most applications requires a drastic reduction in the cost of this technology. And that is only possible by processing on large-diameter Si wafers," Germain said. As well as having a thermal conductivity of up to half that of SiC, silicon is attractive as it is less costly, and is available in large quantities and large wafer sizes: "150mm, and then 200mm are the minimum wafer sizes we need to fully leverage today's silicon processing capabilities," she added.

But, until now Si wafers with the required (111) surface orientation were only available with a diameter up to 150mm. "The demonstration of Ga_N growth on 200mm Si wafers is an important step towards processing Ga_N devices on large Si wafers," reckons Germain.

The 200mm Si wafers were custom made by MEMC Electronic Materials Inc using the Czochralski growth (CZ) method. CZ wafers are suited to switching applications with large breakdown voltages. For such devices, performance is independent of the resistivity of the silicon substrate.



Thickness uniformity map of a 1µm Ga_N layer deposited on 200mm Si(111) using an AlN/AlGa_N buffer.

The AlGa_N/Ga_N heterostructures were grown in Aixtron's application laboratory using a 300mm-wafer CRIUS MOCVD reactor. A standard layer stack was used that had already been demonstrated on 100 and 150mm Si(111) substrates. First, an AlN layer was deposited, followed by an AlGa_N buffer, which provides compressive stress in the 1µm thick Ga_N top layer, then a 20nm AlGa_N (26% Al) layer, before capping with a 2nm Ga_N layer.

In-situ measurements at IMEC showed that Ga_N and AlGa_N layers showed good crystalline quality, as measured by high-resolution x-ray diffraction (HR-XRD), as well as excellent morphology and thickness uniformity with a standard deviation well below 1% over the full 200mm wafers (5mm edge exclusion).

However, due to the large size of the silicon wafer, bowing is still quite large (in the range of 100µm). Nevertheless, IMEC believes that an optimized buffer layer can reduce bowing significantly. "We aim to further develop the growth process and to qualify the wafers to be compatible with Si-CMOS processes," Germain concludes.

www.imec.be

www.aixtron.com

IN BRIEF

Fraunhofer ISE orders reactor for GaAs-on-silicon multi-junction solar cell R&D

Aixtron has received an order from the Fraunhofer Institut für Solare Energiesysteme (Fraunhofer ISE) in Freiburg, Germany for a 300mm Close Coupled Showerhead (CCS) CRIUS MOCVD reactor, to be used for R&D on GaAs-based multi-junction solar cells on silicon, within the scope of the BMBF project 'III-V-Si'.

Fraunhofer ISE has operated an AIX 2600G3 Planetary Reactor for more than 10 years. "Now we would like to start focusing on single large-wafer processes on Si," said Dr Frank Dimroth, head of the III-V-Epitaxy and Solar Cells group.

www.ise.fhg.de

Mitsubishi Electric installs Aixtron MOCVD reactor for blue-violet lasers

Mitsubishi Electric Corp (MELCO) in Japan has begun operation with a new AIX 2600G3 HT MOCVD reactor from Aixtron, installed and commissioned in 11x2" wafer configuration for the development and volume production of Ga_N-based blue-violet lasers for use in high-density optical storage and related applications.

"Our previous experience with our existing Aixtron G3 MOCVD tools has confirmed the high quality of the engineering, service and process technology," says MELCO. "Those systems have performed very well for the manufacture of AlGaInP-based high-power red lasers."

<http://global.mitsubishielectric.com>

IN BRIEF

JPSA opens Malaysia service and support office

J. P. Sercel Associates of Manchester, NH, USA has opened a customer service and support office in Malaysia, headed by Chuan Ki (C.K.) Foo in Penang, focusing on the combined territories of Malaysia, China, and Singapore. It will provide service, installation and training, and stock spare parts for customers of JPSA's laser workstations for wafer processing and micromachining.

Foo was previously senior field service engineer for the Malaysia installation of Besi Die Handling, Laurier & Datacon divisions.

"We will be able meet increased demand and provide excellent service and timely support to all of our Asian customers," says sales & marketing director Rick Slagle.

www.jpsalaser.com

New StratEdge facility ISO certified

StratEdge of San Diego, CA, USA has received ISO 9001:2000 certification for its new facility, which opened last November in an expansion from its former headquarters (also in San Diego), where it had been based since the firm was founded in 1992.

The new facility serves as the firm's international headquarters as well as its center for R&D, design, manufacturing, and assembly & test services for its line of ceramic, low-cost molded ceramic and metal packages.

The 15,000ft² facility contains a Class 100 manufacturing area for precision bare die assembly of packages. The main manufacturing lines are thick-film printing, furnace operations, plating, and microelectronics assembly, which includes component attachment, wire bonding, and electrical test.

www.stratedge.com

LayTec In-situ Monitoring Award goes to Helmholtz Center's Döscher

At the 14th International Conference on Metalorganic Vapor Phase Epitaxy (IC-MOVPE 2008) in Metz, France, the first LayTec In-situ Monitoring Award (plus a cheque for €1000) was presented by Thomas Zettler, president of in-situ optical sensor firm LayTec GmbH of Berlin, Germany,

to Henning Döscher for his contribution to "In-situ quantification of the surface domain structure of thin GaP films grown on Si(100)".

The work is a result of the collaboration of Döscher and Thomas Hannappel of the Helmholtz-Center Berlin for Materials and Energy with Bernardette Kunert, Kerstin Volz and Wolfgang Stolz of Philipps-University Marburg, Germany.

An independent committee recognized Döscher's talk as pioneering



Döscher (center) with IC-MOVPE committee.

work in fundamental research that will have a profound impact on developing III-Vs on silicon for future CMOS generations and solar cells.

The award will be granted every 2 years at ICMOVPE to recognize outstanding results in the development and control of MOVPE by applying optical in-situ sensors and to further encourage their application in both research and industry.

www.laytec.de

Tegal reports third quarter of profit

Compared to the year-ago quarter, for fiscal Q4/2008 (to end March) plasma etch and deposition system maker Tegal Corp of Petaluma, CA, USA has seen rises in revenue (up 19.5% from \$6.2m to \$7.4m), gross margin (from 31.5% to 50.6%), operating income (-\$2m to +\$0.8m) and net income (-\$2m to +\$15.2m, although this included \$15m mainly from the settlement of a fee dispute with company attorneys).

For fiscal 2008 (compared to 2007), Tegal saw rises in revenue (up 47.9% from \$22.3m to \$32.9m), gross margin (from 24.8% to 42.6%), operating income (-\$13m to +\$1.6m) and net income (-\$13m to +\$18m).

"Fiscal 2008 was the culmination of a successful three-year effort to turn our company around," says chairman, president and CEO Thomas Mika. "We were fortunate this year to be able to overcome a strong headwind in the semiconductor capital equipment market, due largely to

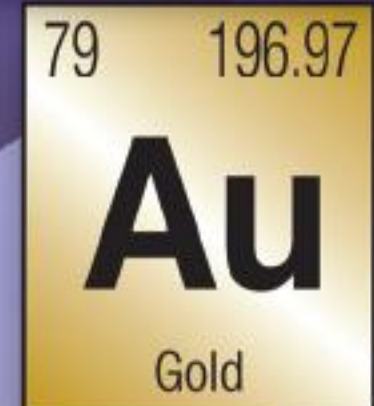
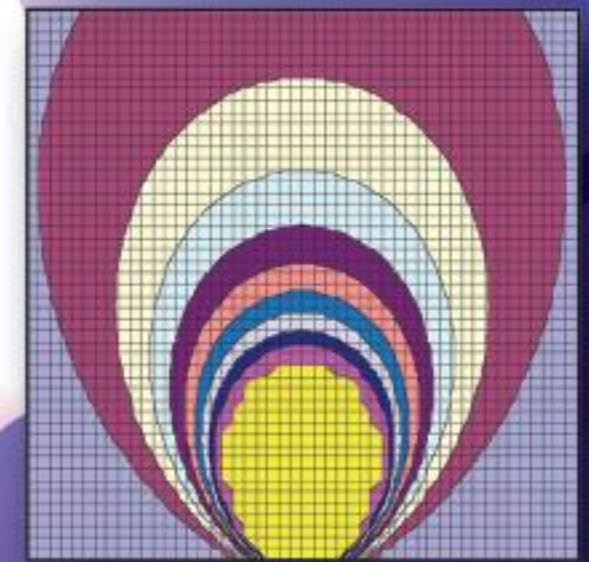
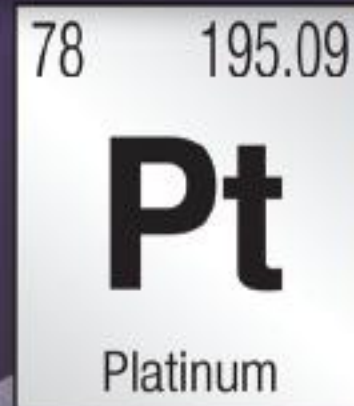
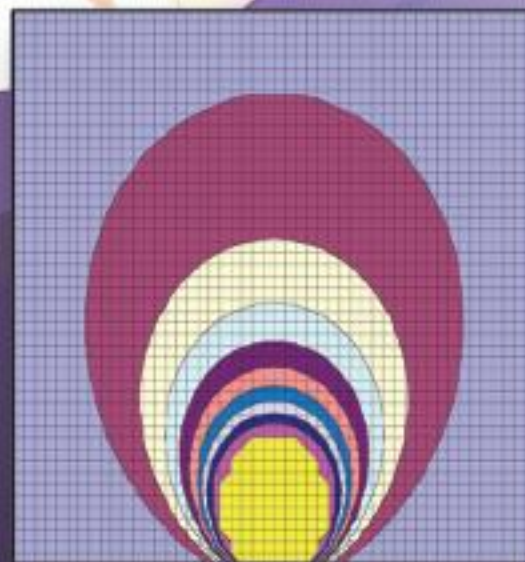
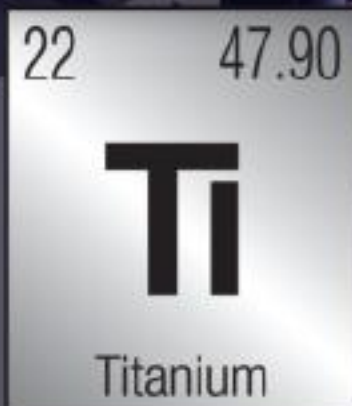
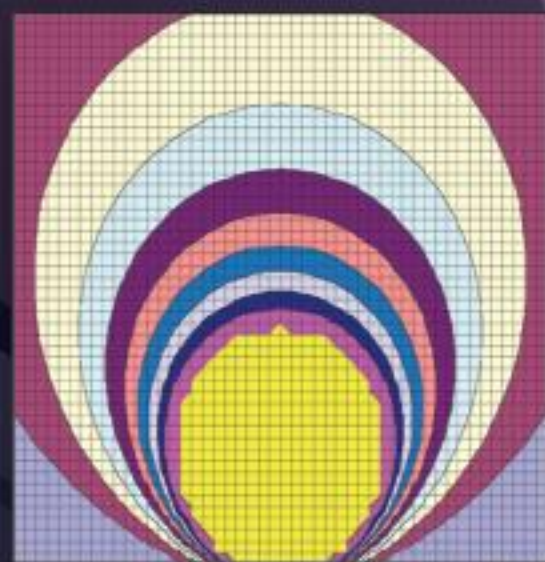
our focus on faster-growth, non-mainstream device markets. Compared to many of our competitors, including companies much larger than Tegal, we are in an enviable position of having a relatively strong balance sheet, a lean organization, and the needed flexibility to prosper in a challenging environment."

In March, Tegal signed a distributor agreement with Shanghai-based WESI Technology (China), a joint-venture between distributor WKK and ECI Technology Inc, for the sales, service and technical support of its products in China and Taiwan.

Also, following the fiscal year-end, Tegal announced a beta-site agreement with a high-brightness LED maker that will include the shipment early in fiscal second-quarter 2009 of a Compact 360 NLD cluster tool (a 200mm/300mm-capable bridge tool supporting Tegal's patented nano-layer deposition processes).

www.tegal.com

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Honeywell sells sapphire business to China's Silian

At the end of April, US-based firm Honeywell International Inc agreed to sell the sapphire manufacturing unit of its Honeywell Electronic Materials business in Victoria, BC, Canada to China Silian Instruments Group Co Ltd of Chongqing in a signing ceremony attended by the vice-mayor of Chongqing city, Xiaoping Tong.

The Honeywell business uses the Czochralski process to grow sapphire crystals, from which it fabricates products ranging from rodstock and blanks through to finished components such as windows, domes, and 2-4"-diameter substrates for epitaxial applications, particularly GaN-based high-brightness LEDs.

Silian says that there is a serious shortage in supply of sapphire substrates (especially at large diameter and high quality) for the global LED epiwafer and chip manufacturing industry.

Chairman Xiaobo Xiang reckons that the firm that possesses the



core technology and capability to make high-quality sapphire wafers will be able to break through this core bottleneck in the LED industry and play a key role in the global supply chain.

Silian says it will continue sustainable development of the sapphire business in Canada, orienting it as the European-American market center and global R&D center. The firm also aims to maintain stability in staffing and in the supply chain, and to boost the unit's capability for producing high-quality sapphire wafers. Meanwhile,

another, larger-scale sapphire facility will be built in Chongqing, targeting its product output at the China and Asia-Pacific markets. The facilities in Canada and Chongqing will be complementary.

Based on the core sapphire wafer technology, Silian is aiming to become a vertically integrated LED maker by building a complete LED supply chain, from basic material to finished products. Silian says that, starting this year, it will therefore build an LED industrial park with an area of 66.7 hectares (0.66km²) in the Caijia Industrial Zone, integrating research, sapphire substrate production, chip packaging, and integrated product manufacturing. Production is scheduled to start in 2012, targeting annual revenue exceeding RMB10bn (\$1.4 bn). The leaders of the Chongqing Municipal Committee and Government have attached great importance to the project, says Silian.

www.sicc.com.cn

www51.honeywell.com

Sapphire substrate maker to expand to crystal growth

Sapphire substrate supplier CrystalQ Group B.V., which is based in a former Philips Semiconductors production facility in Stadskanaal, The Netherlands, has attracted investment from Sustainable Energy Technology Fund (SET Fund), EPT/Benno Wiersma and E2 Cleantech. The latest venture funding builds on previous investments by the firm's management and NOM Finance (part of N.V. NOM, the Investment and Development Agency for the Northern Netherlands).

CrystalQ takes bulk sapphire from external suppliers and slices and polishes it using a proprietary technique to produce high-quality 2-6"-diameter substrates for the

production of RF chips and white LEDs. "Lighting currently accounts for 19% of the worldwide electricity demand," says E2 Cleantech director Casper Heijsteeg. "LED lighting will over time contribute to a more sustainable usage of energy."

CrystalQ's general manager Joris Barendregt says that the latest investment will speed the firm's expansion, specifically by supporting its entry into the growth of its own bulk sapphire crystals. "The proceeds will be used to expand CrystalQ's manufacturing base and will fuel the ambition of CrystalQ to become one of the global leaders in supplying sapphire wafers," adds Erik Boersma, a business partner at

EPT/Benno Wiersma.

N.V. NOM's CEO Siem Jansen reckons that, in the last few years, CrystalQ's 'impressive' results have proved that it has allocated its investment in the right way.

"It delivers the required quality while continuously working on improvements and innovations in the process," he says. "CrystalQ has now attracted important partners who will both financially and strategically contribute to multiplying the activities on the former Philips premises in Stadskanaal. In terms of facilities and required workforce, they are at an excellent location," he concludes.

www.crystalq.nl

Nitride Solutions wins UCSB start-up prizes

In this year's University of California, Santa Barbara (UCSB) Technology Management Program New Venture Competition at the end of May \$25,000 was distributed between five winners in different categories. Winning \$10,000 and \$5,000 in the 'Most Fundable Idea' and 'Dow Materials Use' categories, respectively, was the startup Nitride Solutions of Santa Barbara, CA, USA.

Currently, nitride-based LEDs are optimized for the blue spectrum, and relatively high performance can also be obtained in the UV-A (long wave, 400–315nm) spectrum. However, manufacturing material for UV-B (medium wave, 315–280nm) and UV-C (short wave, or germicidal, 280–100nm) LEDs has proven difficult to optimize, yielding low-quality LEDs not exceeding 1% in efficiency and 1000 hours in lifetime. This has inhibited the expansion of LEDs into the short-wavelength UV market, where many large-scale opportuni-

ties exist, says the firm.

Nitride Solutions is therefore dedicated to commercializing a process developed in UCSB's engineering labs for the manufacture of high-quality aluminum nitride (AlN) substrates, enabling the fabrication of low-cost, high-efficiency and long-life UV LEDs (for sterilizing medical devices or biological detection) and electronic devices that are currently unavailable.

Nitride Solutions' chief technology officer Troy Baker obtained a PhD in materials engineering on 'Hydride Vapor Phase Epitaxy of Semipolar Gallium Nitride' under advisors Shuji Nakamura, Steven DenBaars and James Speck in UCSB's Nitride Crystal Growth Laboratory. He has also co-authored several patents on GaN and AlN HVPE growth and characterization and related topics. Business affairs director David Pricco is finishing a degree at UCSB in business and economics (with emphasis on technology entrepreneurship).

Chief technical advisor Dr David Bour is an Agilent Fellow in Photonics and an Elected IEEE Fellow (with over 200 published papers and 60 patents in the areas of nitride and LED development as well as semiconductor materials growth). Previously, he was chief scientist at LED maker Bridgelux of Sunnyvale, CA. Executive advisor Bruce Allen has 26 years experience as a chief executive, project manager and research scientist on spacecraft technology R&D programs, including as founder and CEO of Intersol Corp (which developed micro-gravity metal alloy furnace designs under the NASA Materials Processing in Space Program). Board member and management and financial advisor Muriel Taylor founded her first company in 1988 and has held executive positions in four enterprises with 150–500 employees and revenues of \$30–90m.

<http://NitrideSolutions.com>

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Osram launches Ostar Projection SMT LED for pico-projectors

Osram Opto Semiconductors of Regensburg, Germany has launched a more compact and efficient version of its Ostar Projection LED light source that uses surface mount technology, enabling it to be integrated into pico-projectors such as those now being incorporated in cell phones.

The new Ostar Projection SMT LED measures just 5.8mm x 4.7mm x 1.5mm and, in contrast to its predecessor, does not have additional connectors or board for dissipating heat. The latest mini version is therefore suited to applications where space is limited, such as in pico-projectors, which can be either integrated directly into cell phones or attached to them as accessories. Due to SMT technology, the new Ostar Projection now suits standard solder processes.

A pico-projector needs just one Ostar module, which contains four 1mm² RGB chips (two green, one red and one blue). As an



Osram Opto's Ostar Projection SMT LED light source for pico-projectors.

alternative to this RGB version, the Ostar Projection SMT is also available with four ultra-white chips. Depending on the color, the chips

are based on thin-film (ThinGaN) technology and are designed for optimum efficiency, the firm says. They are co-located with protective diodes on a ceramic carrier with a monolithic glass window that provides cover and protection.

As embedded versions with external dimensions of 1.5cm x 3cm, pico-projectors with the mini LED provide a system brightness of 10lm for a consumption of 1W. As accessory versions, pico-projectors measure 7.5cm x 7.5cm and can be operated with a higher wattage, achieving higher brightness values of more than 15lm.

Osram Opto claims that, with its high efficiency and compact dimensions, the Ostar Projection SMT not only suits pico-projectors but is also providing fresh impetus for applications in the general lighting sector.

Samples are available, with volume production due to start in the fall.

www.osram-os.com

Osram partners on Shenzhen LED street lamp project

Osram Opto Semiconductors Asia Ltd (a Hong Kong-based subsidiary of LED-maker Osram Opto Semiconductors GmbH of Regensburg, Germany) has formed a partnership with China's Shenzhen SED Industry Co Ltd to launch an LED street lamp project in mainland China. Lamps will be installed initially on a road in Shenzhen High-Tech Industrial Park.

Shenzhen SED (a subsidiary of state-owned China Electronics Corp) is a manufacturer involved in the design, development, production and sales of LED street and tunnel lighting fixtures. Their LED street lamps and tunnel lamps all use Osram Opto's Golden Dragon with lens LEDs. Emitting maximum light from the



An LED street light from China Electronics Corp

smallest possible source, Osram Opto says that its Golden Dragon with lens LEDs offer high brightness over a full-color spectrum, consume 80% less electricity, and can last for up to 50,000 hours (versus 1000-2000 hours for incandescent lamps).

"We consider this project with Shenzhen SED to be an exciting milestone towards making more cost- and energy-effective lighting

a reality in mainland China," says Osram Opto Semiconductors Asia's chief executive officer Dr Alfred Felder. "Our collaboration with Shenzhen SED validates our efforts in this area."

The project is expected to pave the way for more LED street lighting partnerships across the Asia Pacific region, where awareness of the energy-saving benefits of LED lighting is growing, says Osram. In particular, China's Ministry of Science and Technology is pushing to replace traditional incandescent lighting with more energy-efficient LED alternatives and has set an objective of achieving energy savings of RMB260bn (\$37.8bn) by the year of 2015.

www.sedind.com

Emerging Standardization for Sapphire Substrate Inspection

By Frank Burkeen

Senior Product Marketing Director at KLA-Tencor
Frank.Burkeen@kla-tencor.com

The HBLED industry continues to thrive driven by market demand from mobile devices, automobiles, computer screens, and niche exterior and interior lighting applications. As HBLED device technology evolves and fabrication techniques become more advanced, defect detection and process control are critical to improving device yields. Sapphire substrate contaminants such as particles, scratches, pits, bumps, stains and residues from CMP processing are known to impact subsequent epi deposition processes and substantially degrade device performance and yield. As such, the need for higher quality sapphire substrates is of critical concern for HBLED device manufacturers.

The adoption of optical surface analyzer (OSA) technology is gaining momentum for use in HBLED manufacturing, specifically sapphire substrate inspection.

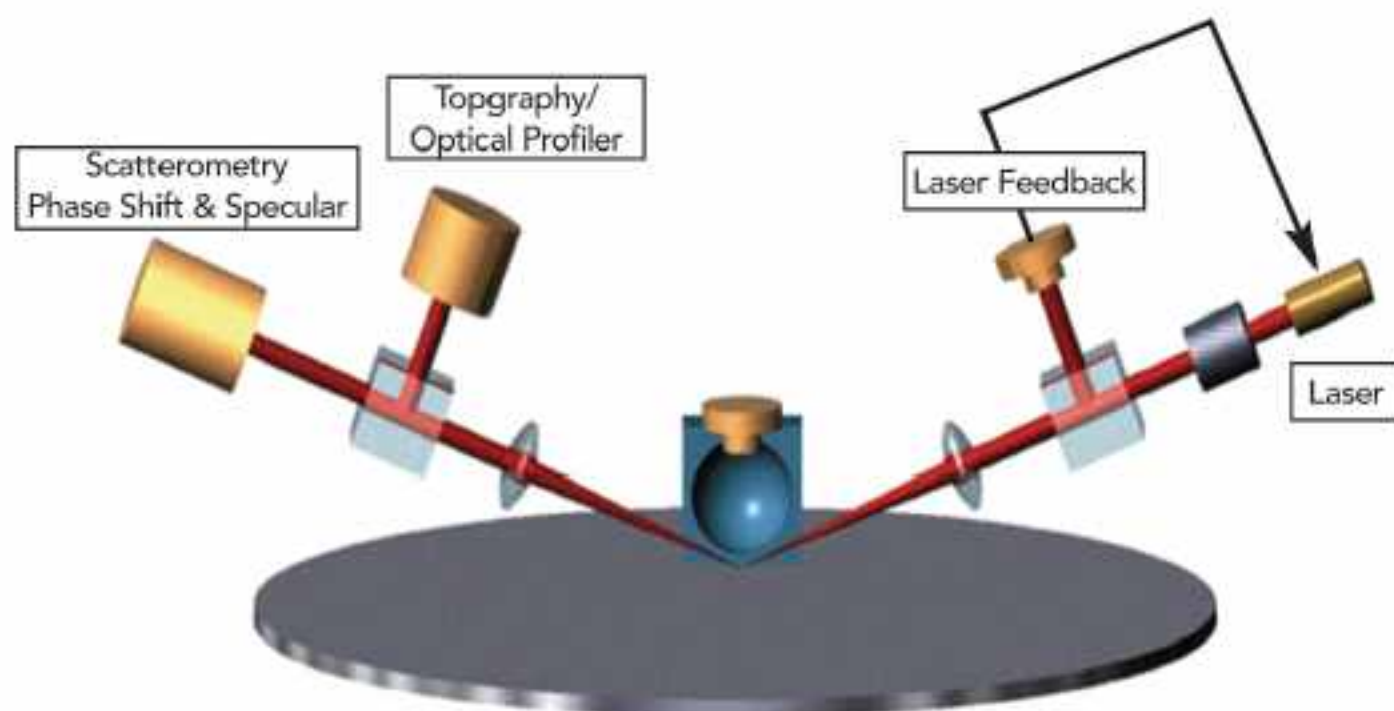


Figure 1: OSA technology combines four signal detection channels, enabling a wide range of inspection applications.

The design of OSA technology combines reflectometry, optical profilometry, scatterometry, and phase shift to measure topographic variations and detect a wide variety of surface defects. The inspection method achieves full surface coverage in minutes to produce high-resolution imaging, wafers maps, and automated defect classification.

At a throughput exceeding 40wph, an OSA system is the only wafer inspection method amenable to volume production and capable of advanced inspection of transparent sapphire substrates. Other inspection tools based solely on scatterometry cannot effectively measure transparent materials due to scattered light interference from the backside of the substrate. An OSA system is designed specifically for defect detection and classification of transparent materials including sapphire, GaN, SiC, and glass.

Figure 2 illustrates a sapphire substrate defect map after OSA inspection. Particles, scratches, pits, and stains are detected and classified in user-defined bins. The defect traceback images show a scratch as detected in the topography channel and two different types of stains as detected in the phase channel.



Scratches are known to transfer to the subsequent epi layer thereby degrading or killing device performance. Substrate stains have been reported to cause poor epi layer adhesion or result in rough epi morphology.

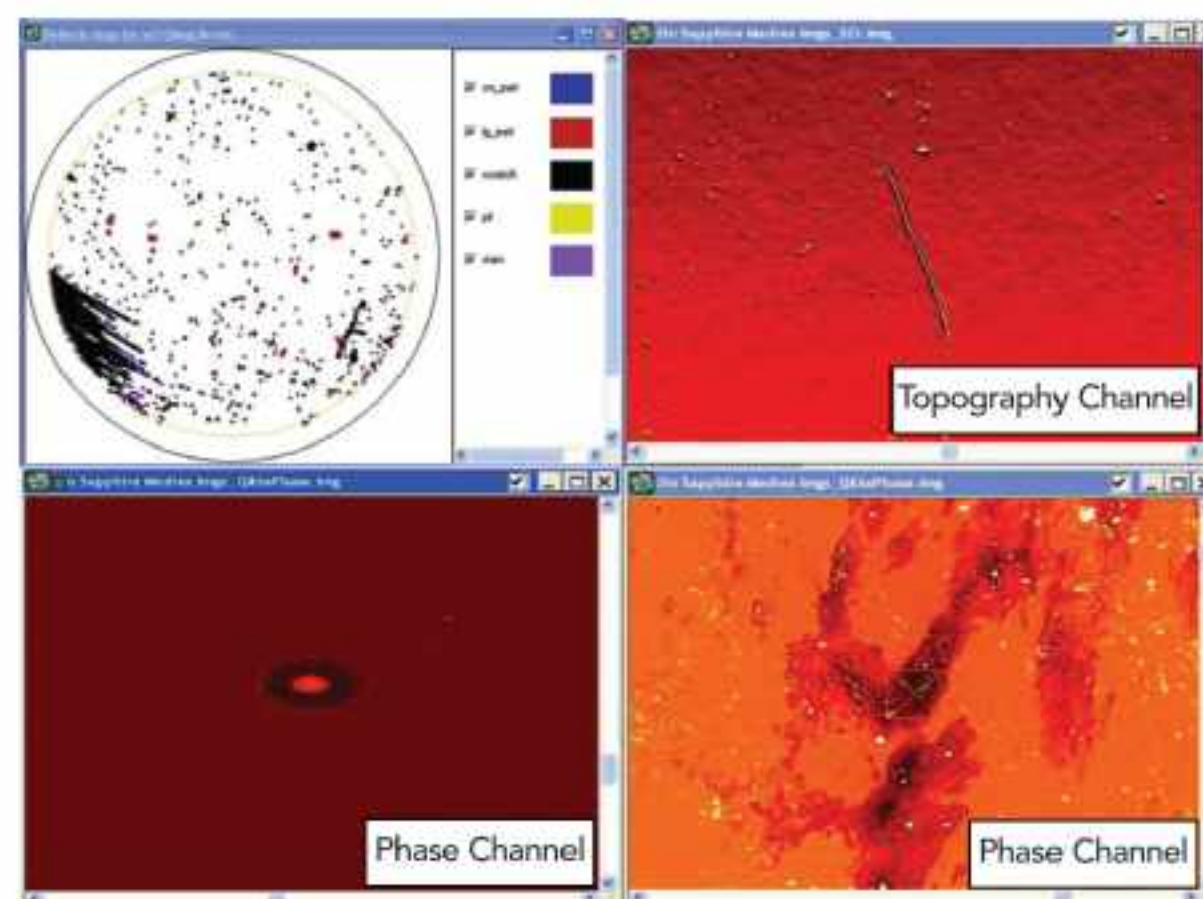


Figure 2: KLA-Tencor's Candela™ OSA defect map and traceback images of scratches and stains as detected in topography and phase channels, respectively.

As HBLED competition tightens and margins are squeezed, manufacturers are relying more on automated OSA inspection technology for process control and yield improvement. The emergence of sapphire substrate reclaim is also driving the need for advanced automated inspection. As supply is strained and material costs rise, the sapphire reclaim business is becoming more prevalent — whether for captive consumption or merchant supply. The reclaim business is even more dependant on OSA inspection as reworked material is highly susceptible to yield impacting defects.

Optical surface analyzer technology is setting the benchmark for automated inspection of sapphire substrates, and is emerging as the industry standard for overall sapphire quality control. HBLED device manufacturers and sapphire substrate suppliers are together converging on OSA inspection specs for quality assurance. Moreover, manufacturer's utilizing OSA technology are the beneficiaries of higher quality sapphire substrates passing distinct inspection specs.

Optical surface analysis technology enables manufacturers and suppliers to automate defect inspection and define objective-controlled process control limits. OSA technology can be employed at incoming substrate inspection, post-clean inspection, and after epi and film deposition processes.

To learn more, go to:
www.kla-tencor.com/candela

Cree demos multi-chip MC-E LED

At the Lightfair International event in Las Vegas, NV at the end of May, Cree demonstrated the newest addition to its XLamp LED family.

The multi-chip XLamp MC-E retains the same 7mm x 9mm footprint as Cree's existing XLamp XR family LEDs while providing four times the light output of the existing XR-E. This is the highest lumen output for a package of this size, Cree claims.

The combination of size and power is designed to enable new applications and reductions in overall system cost compared to other LED packages. At 9.8W, the XLamp MC-E provides up to 790lm at 6000K and up to 605lm at 3000K.

The MC-E was demonstrated in both cool and warm white colors, and in both indoor and outdoor luminaires at the booths of Acuity Brands Lighting, KramerLED, and Light Engine. Secondary optics for the MC-E were also demonstrated by Carclo, Fraen, and Ledil/Marubeni.

"For added design flexibility, our new line of KramerLED luminaires integrates the MC-E LED from Cree in combination with our proprietary



Cree's multi-chip XLamp MC-E LED.

NanoOptic refractors," says Kramer Lighting president Al Ruud. "This combination of technology ensures each LED is used to its fullest potential for unsurpassed control, uniformity, and intensity," he claims.

"Cree's XLamp MC-E LED is a lighting-class solution designed to enable applications that require high lumen output in a small footprint," says Norbert Hiller, Cree's VP and general manager for lighting LEDs. "Customers can increase design flexibility and reduce overall system cost over other, lower-flux-output LED packages, without compromising on quality."

Cree and Toyoda reach patent deal

LED makers Cree Inc of Durham, NC, USA and Toyoda Gosei of Aichi, Japan have entered into an agreement providing the firms (including wholly owned affiliates) with access to each other's patented LED chip and packaged LED technology (including white LED technology). They have also agreed to discuss 'have made' rights for future chips.

The firms both hold broad and substantial optoelectronic patent portfolios. The agreement will make it easier for both to develop and manufacture LED products without concern for the other's patents.

"Cree and Toyoda Gosei are responsible companies that respect the intellectual property rights of others and strive to enhance the development of LED technology," says Chris James, Cree's VP of marketing & business development. "The agreement highlights the importance of intellectual property in the LED market and helps to alleviate the IP concerns of LED customers."

www.toyoda-gosei.com

www.cree.com

Bridgelux ships low cost-per-lumen LED chip

Bridgelux Inc of Sunnyvale, CA, USA has made its NLX-5 high-power GaN LED chip commercially available.

As the firm's fifth-generation chip, the NLX-5 offers 15–20% performance improvement over its predecessors. Embedded in a customer's standard cool-white LED package, it provides a typical light output of 85–90lm (at 350mA). As a result, it delivers industry-leading cost-per-lumen performance for warm-white, cool-white and RGB (red-green-blue) applications, it is claimed.

The firm says that it continues to improve the performance of its LED chips based on a low-cost manufacturing technology that has been abandoned by others in the industry in favor of thin-film LED architectures, which ultimately are more complex and costly. "By merging our innova-

tive chip designs with traditional sapphire-based LED chip architectures, we've increased LED performance on a very robust, high-yield technology platform," says R&D director Steve Lester.

Many firms believe that high light extraction is only possible with removal of the sapphire substrate, but Bridgelux has achieved higher performance without sapphire removal and its typically negative impact upon yield and cost, he adds.

"Based on current R&D results, we project that, by later this year, we can provide an additional 10–15% improvement—with further antici-

Bridgelux has achieved higher performance without sapphire removal

pated performance improvements continuing over the next 12 months, utilizing this same high-power LED technology platform."

The NLX-5 will provide a low cost-per-lumen solution to help speed market adoption of solid-state lighting applications into the general lighting market, says the firm. It claims that its chip technology is not only lower in cost to manufacture but also easier and more cost-effective to integrate into lighting products, either as single- or multi-chip LED packages.

The NLX-5 is suited to general lighting applications, such as street lights, architectural down lights, MR-16 lamps, as well as mobile phone and digital camera flash applications.

www.bridgelux.com

Consumer electronics firms Sony, Sanyo, Exceed and Lucky Light license Rothschild LED patents

Four consumer electronics firms, Sony Corp, Sanyo Electric Co Ltd, Exceed Perseverance Electronic Ind Co Ltd, and Lucky Light Electronics Co Ltd, have agreed to license patents owned by Gertrude Neumark Rothschild, professor emerita of Materials Science and Engineering at Columbia University.

The agreements follow an investigation instituted on 20 March by the US International Trade Commission (ITC) based on a complaint ('In the matter of Short-Wave Light Emitting Diodes') filed by Rothschild alleging infringement by 31 firms of patent 5,252,499 (covering a method of producing GaN-based semiconductors for LEDs and laser diodes emitting in the blue, green, violet and ultraviolet end of the spectrum).

The complaint seeks to bar importation into the USA of a wide range of consumer electronics products incorporating infringing devices. These include video players using Sony's Blu-ray format, Motorola Razr mobile phones and Hitachi digital camcorders, as well as instrument panels, billboards, traffic lights and data storage devices. Other firms cited include Blu-ray DVD player makers Matsushita Electric Industrial (Panasonic), LG Electronics Inc and Samsung Group and HD DVD player manufacturer Toshiba Corp, as well as Nokia Corp, Sony Ericsson Mobile, Pioneer, Sanyo Electric Co, and Sharp Electronics.

License agreements were signed with Rothschild by LED makers Seoul Semiconductor Co Ltd of Korea and Everlight Electronics Co Ltd of Taipei in April and Epistar Corp of Hsinchu, Taiwan in early May.

"The latest licensing agreements are important milestones in this case," says Albert L. Jacobs Jr, an intellectual property partner with legal representatives Dreier LLP. "Rothschild made a seminal breakthrough in understanding the doping

requirements necessary for the production of the blue, green, violet and UV LEDs and LDs on a commercial and efficient scale that are essential to today's consumer electronics."

Rothschild began her research career in private industry, working with Sylvania Research Laboratories in Bayside, NY in the 1950s and later at Philips Laboratories in Briarcliff Manor, NY before joining Columbia as a professor of materials science

in 1985. She conducted R&D in the 1980s and '90s into the electrical and optical properties of wide-bandgap semiconductors that is claimed to have been pivotal in the development of short-wavelength emitting (blue, green, violet and UV) diodes now used in consumer electronics.

Recognized by the American Physical Society as a Notable Woman Physicist in 1998, Rothschild was elected as a Fellow of the American Physical Society in 1982. Earlier this year, she was honored by Philips Electronics, which endowed the new Philips Electronics Chair in the Department of Applied Physics at Columbia's Fu Foundation School of Engineering and Applied Science.

On 10 March, an action brought before the US District Court for the Southern District of New York by Rothschild was settled by LED maker Philips Lumileds of San Jose, CA, USA, giving the firm a non-exclusive license. Previously, after patent complaints filed elsewhere starting in 2002, LED makers including Germany's Osram Opto Semiconductors and Japan's Nichia and Toyoda Gosei also settled with Rothschild over alleged patent infringement. A separate case against LED maker Cree Inc of Durham, NC, USA is pending.

www.dreierllp.com

IN BRIEF

Seoul Semi design ruled invalid

Japan's Nichia Corp says that on 22 May the Korean Intellectual Property Tribunal (IPT) ruled that design registration no. 364186 (relating to a side-view LED) of Korean LED maker Seoul Semiconductor Co Ltd is invalid.

The tribunal found that the registration was similar to a prior art design registration no. 294490-2 of Nichia.

The invalidation action was filed by Nichia against Seoul Semiconductor on 24 July 2007.

www.nichia.com

Acriche's UL Mark

Seoul Semiconductor's Acriche A2 and A3 series of LED lighting sources have been tested, evaluated and found to be compliant to specifications required to bear the Underwriters Laboratories Inc (UL) Component Recognition Mark.

In December, Acriche received the European Union's CE-Marking and German TUV certification for product and environmental safety standards. Seoul Semiconductor says the latest safety designation confirms that Acriche meets the most stringent global standards for product component safety.

"As the technology and efficiency of LEDs improve, luminaire manufacturers will be able to choose from a broader set of components, giving them more flexibility to design products that meet the market needs," says Eli Puszkar, general manager of UL's lighting strategic business unit.

"Many customers have asked for the reassurance of UL for our Acriche products," says Jing Mo, director of technical operations. By participating in UL's Component Recognition Program, customers can design products confident that they will be safe, he adds.

www.seoulsemicon.com

Lumileds reducing number of warm-white color bins

As part of a roadmap to deliver a supportable supply of color-consistent, white power LEDs for general lighting, Philips Lumileds has introduced Lumiramic phosphor technology, reducing the number of color bins for its warm-white Luxeon Rebel LEDs.

“For all the acknowledged benefits of power LEDs, such as efficiency, sustainability, and durability, we believe that providing a supportable, high color-quality supply of white LEDs is the single biggest challenge facing the power LED industry,” says CEO Michael Holt.

The binning of white LEDs is a ‘work-around’ to manage the variation in white color and tint that result from current manufacturing processes, but the inefficiencies of binning create vulnerability in the supply chain, says the firm.

Lumiramic uses a ceramic phosphor plate and Lumileds’ thin-film flip-chip (TFFC) technology.

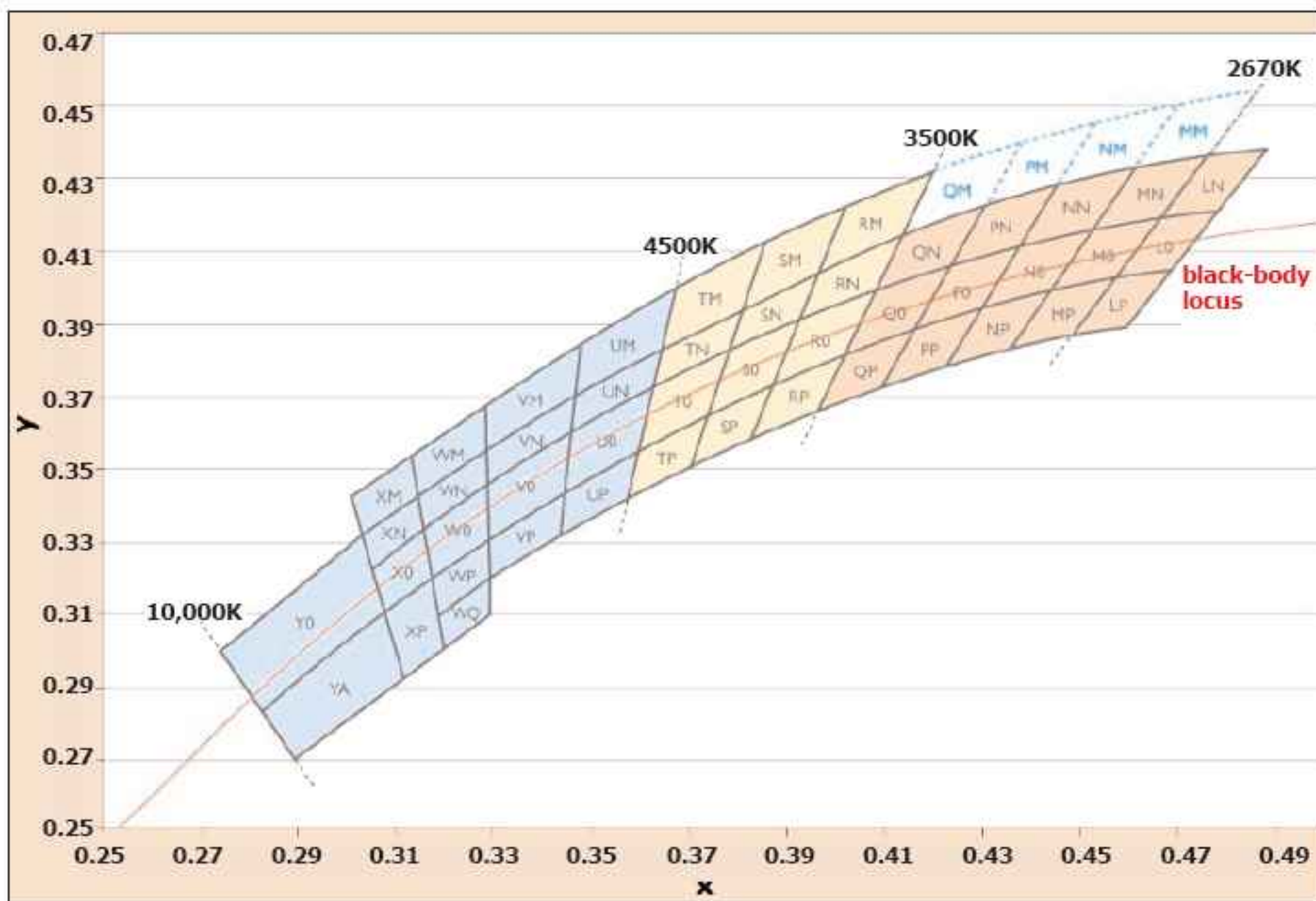
The process matches royal-blue (pump) TFFC die that have been characterized and sorted by wavelength to pre-measured ceramic phosphor plates (Lumiramic). By matching plates of appropriate thickness with the correct wavelength of TFFC die in advance of final manufacturing, a specific correlated color temperature can be targeted. For the first time, this puts the manufacturer in control of the color temperature and tint, allowing production variance to be minimized, says Lumileds.

Binning of white LEDs is a ‘work-around’ to manage the variation in white color and tint

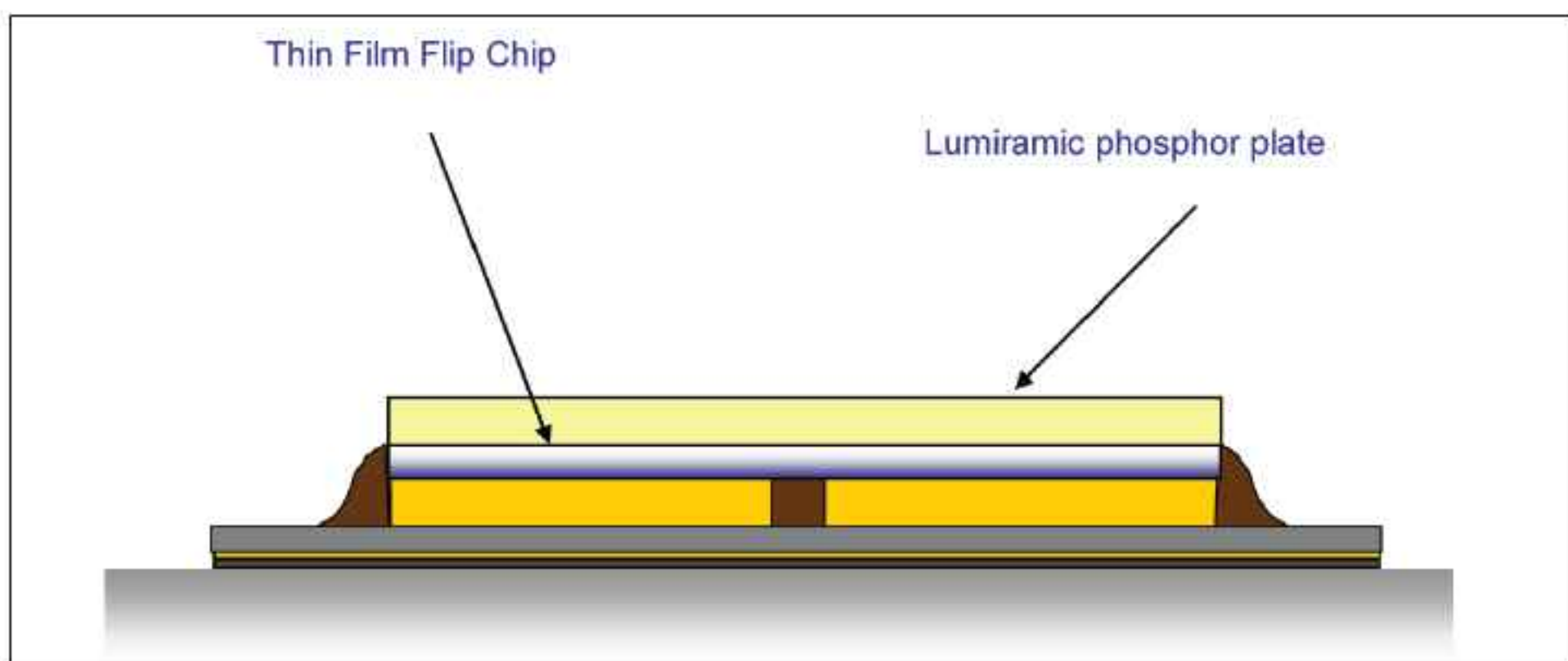
The firm is now turning its attention to a similar reduction in bin spaces for neutral- and cool-white Luxeon Rebel products. After this, the process to remove additional bins and shrink remaining bins will begin. The technology should result in a single row of white bins along the black-body locus, each sized to represent a total space of no more than three MacAdam ellipses.

The technology should result in a single row of white bins along the black-body locus, each sized to represent a total space of no more than three MacAdam ellipses.

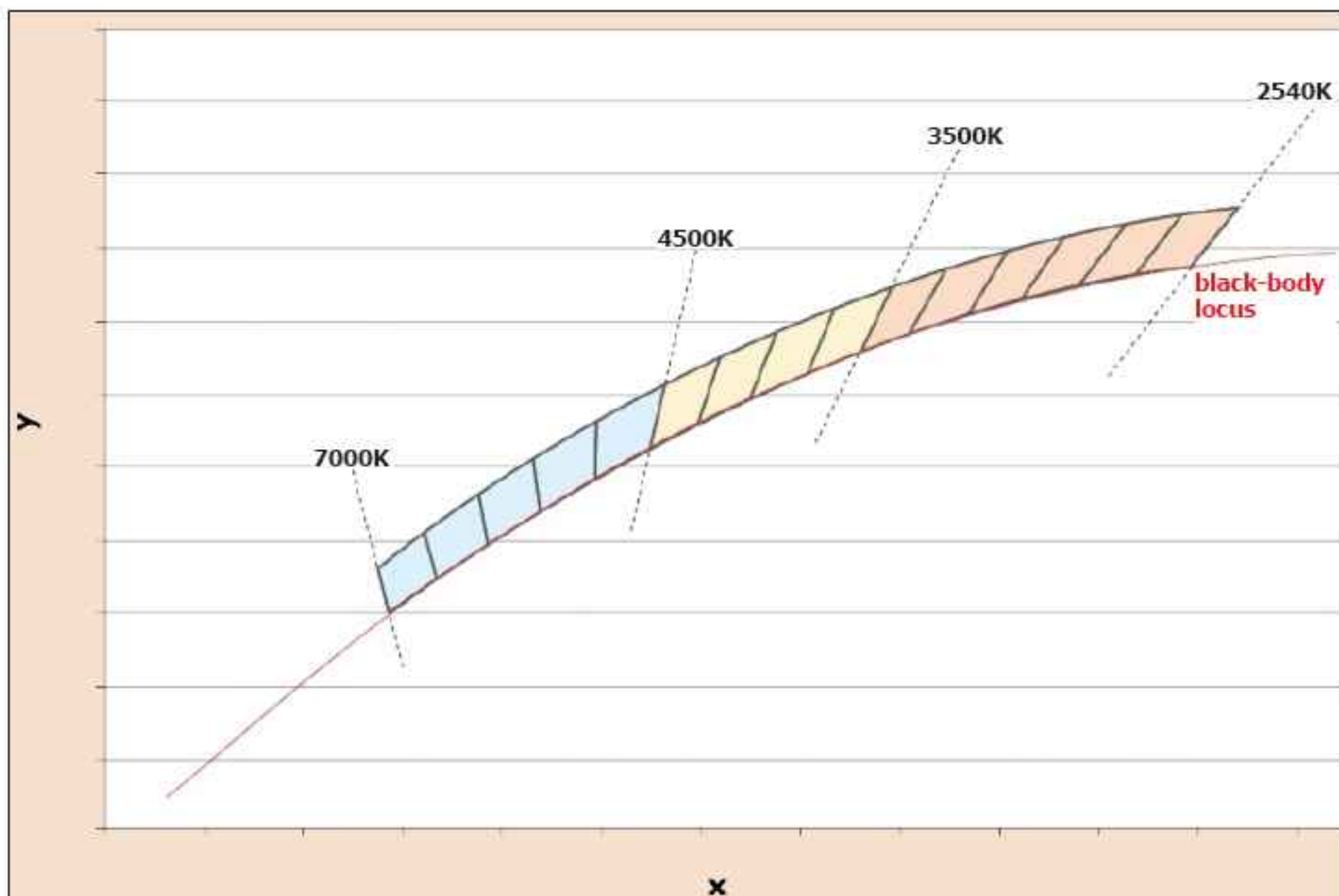
www.philipslumileds.com



Top right: warm-white bins eliminated immediately for Luxeon Rebel.



Luxeon TFFC die with Lumiramic phosphor plate.



White binning chart with full implementation of Lumiramic technology.

Luxeon Rebel LEDs used in Philips' downlight modules

May's Lightfair International event in Las Vegas saw the North American debut of new, highly efficient solid-state lighting solutions for the general lighting market from Philips of The Netherlands that use Luxeon Rebel power LEDs made by its subsidiary Philips Lumileds of San Jose, CA, USA.

Both the Fortimo and Lexel downlight modules (DLMs), with accompanying thermal and power systems, enable lighting OEMs to quickly and easily equip the architectural and specification communities with complete white and tunable downlight solutions, the firm says.

Fortimo modules can potentially reduce energy consumption by up to 50% compared to existing compact fluorescent lamps (CFLs), and Lexel modules can deliver perfectly controllable illumination, it is claimed.

The Fortimo DLM 1100 uses 18 royal-blue Luxeon Rebel LEDs and



Philips' Fortimo solid-state downlight module and electronic driver.

a remote phosphor lens at the top of a mixing chamber to create a white-light module delivering 1100lm of light output at an efficiency of 62lm/W. A second version of the Fortimo module delivers 2000lm at 45lm/W. Initially introduced with a correlated color temperature (CCT) of 4000K, the use of different remote phosphor lenses allows for the possibility of additional white CCT options in the future.

By using royal-blue Luxeon Rebels, Fortimo maximizes photonic energy directed at the remote phosphor lens.

Careful matching of the wavelength of the LEDs to the phosphor's characteristics in turn maximizes the module's light output and efficacy. The small 44mm x 82mm x 83mm Fortimo footprint allows modules to be integrated with a wide range of reflector solutions used in downlights.

Luxeon Rebel also lights the tunable white Lexel DLM-1000 module. Also designed for downlight luminaires, the Lexel DLM delivers 1000lm of light and has a tunable white-point between 2700–6500K with excellent consistency and a color rendering index (CRI) of at least 80.

Both the Fortimo and Lexel downlight modules are made possible by the small size and high flux of Luxeon Rebel LEDs, Lumileds claims. The Fortimo DLMs also use the ability of the Luxeon Rebel to be driven at currents of 350–1000mA, so that usable light can be maximized and system design simplified.

www.philipslumileds.com

SDK shipping 80lm/W red LED chips

Tokyo-based Showa Denko KK (SDK) has started commercial shipment of AlGaInP ultra-bright red LED chips with a luminous efficiency of 80 lumens per Watt (lm/W), which is up 40% on its existing level and is claimed to be the highest on the market.

The high efficiency is attributed to the improved shape and arrangement of electrodes, as well as the improved chip surface treatment. The new product makes it possible to reduce the number of LED lamps while maintaining the same level of brightness, the firm says.

The chips are currently used mainly in outdoor displays, but applications being developed include automotive parts (rear lights, interior lighting) and LCD backlighting for flat-panel TVs. To meet growing demand, SDK aims to further improve the brightness of AlGaInP LED chips as well as provide them in a range of colors, such



SDK's AlGaInP ultra-bright 80lm/W red LEDs, which are now shipping.

as red, orange, yellow and yellowish green, and in different sizes (as required by particular customers).

SDK is expanding its ultra-bright LED operations — consisting of AlGaInP LED chips and indium gallium nitride (InGaN) blue/green LED chips — as part of its ongoing Passion Project to develop a new 'growth-driver' business.

www.sdk.co.jp

Group IV appoints VC and corporate development experts

Group IV Semiconductor of Ottawa, ON, Canada, which is developing silicon-based light emitters for solid-state lighting, has appointed Bruce Day and Louis P. Desmarais to its board.

Day sits on the boards of both Integrated Asset Management Corp and fiber-optic component maker JDS Uniphase. He was formerly VP corporate development at Rogers Communications Inc (involved mainly in mergers, acquisitions, divestitures and taxation).

Desmarais is general partner and CEO of Garage Technology Ventures Canada, following several years as general partner of Skypoint Capital Corp. Group IV aims to benefit from his knowledge of the financial services sector and his work with many early-stage technology firms.

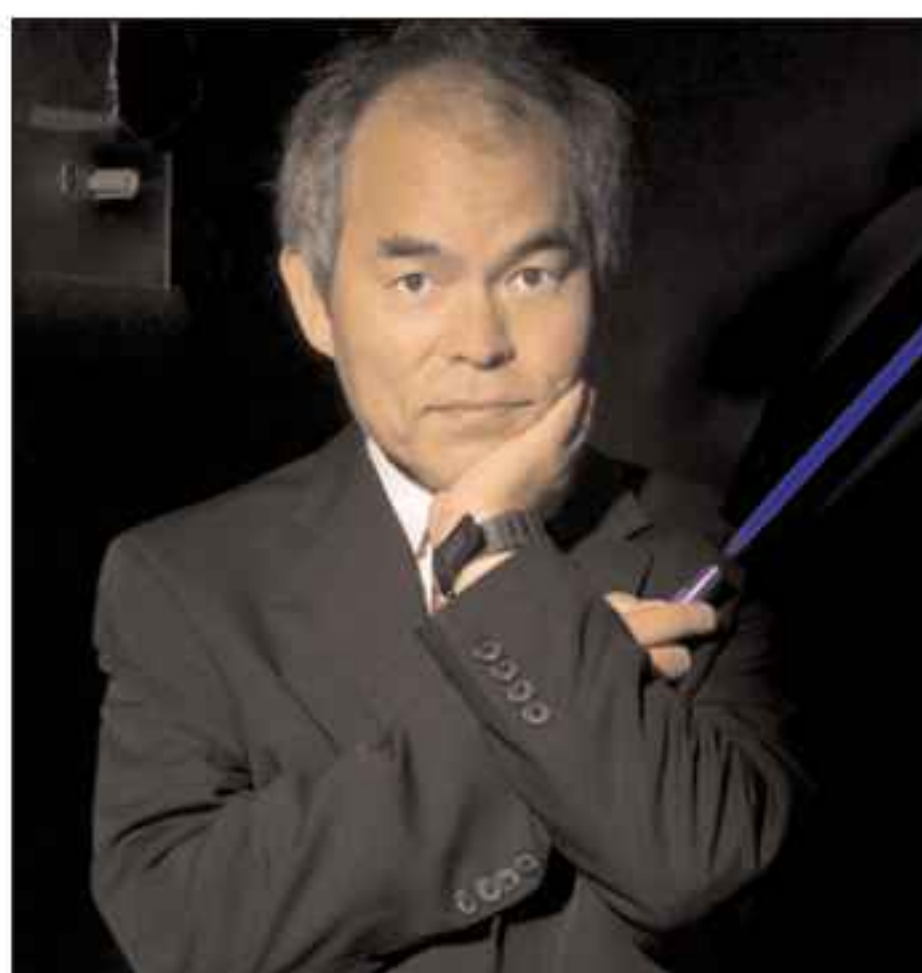
www.groupivsemiconductor.com

UCSB's Nakamura to receive Prince of Asturias Award

Professor Shuji Nakamura (director of University of California, Santa Barbara's Solid-State Lighting and Energy Center) is to receive the 2008 Prince of Asturias Award (Technical and Scientific Research category).

The Prince of Asturias Foundation awards the Technical and Scientific Research prize annually to "the individual, work group or institution whose discoveries or research represent a significant contribution to the progress of humanity in the fields of mathematics, physics, chemistry, biology, medicine, earth and space sciences, as well as their related technical aspects and technologies".

Nakamura shares the award with carbon nanotube pioneer professor Sumio Iijima (of NEC and Meijo University, Japan), organometallic chemistry professor Tobin Marks



Shuji Nakamura of UCSB.

(of Northwestern University), chemistry professor George Whitesides (of Harvard University) and drug delivery system and tissue engineering pioneer professor

Robert Langer (of Massachusetts Institute of Technology).

Nakamura's development of blue, green, and white LEDs and the blue laser diode also won the 2nd Millennium Technology Prize (the world's biggest technology prize) in 2006 (the first winner, world-wide web developer Tim Berners-Lee, also shared the Prince of Asturias Award for Technical and Scientific Research in 2002.)

Recipients in each category share a €50,000 (\$77,000) stipend, as well as each being presented with a medal and a Joan Miro sculpture (commissioned specifically for the awards, which began in 1981). The awards will be presented later this year in Oviedo by Crown Prince Felipe of Spain, the Prince of Asturias.

<http://engineering.ucsb.edu>

FAST-DOT ultrafast laser project kicks off

On 2–3 June, 37 participants attended the 'kick-off' launch meeting for the new four-year collaborative project FAST-DOT ('Compact ultrafast laser sources based on novel quantum dot structures'), which is funded by a €10.1m (£8m) grant within the European Community's Seventh Framework Programme.

The project aims to develop portable, low-cost, reliable, highly efficient ultrashort pulse and ultra-broadband tunable laser sources, based on novel semiconductor nanostructure clusters (QDs), for critical biomedical applications.

The FAST-DOT consortium comprises 18 complementary European research groups and companies involved in QD science, QD devices, system integration and biophotonics, including: 11 research groups — Greece's University of Athens and the Foundation for Research and Technology-Hellas, Italy's Politecnico di Torino, the UK's University of Sheffield and University of Dundee, Lithuania's Vilnius University, Germany's Technische Universität Darmstadt, Spain's Institut de

Ciencias Fotoniques Barcelona (ICFO), Finland's Tampere University of Technology, the Swiss Federal Institute of Technology (ETH Zurich), and Sweden's Royal Institute of Technology; and seven industrial partners — M-Squared Lasers Ltd of Glasgow, UK, France's Alcatel Thales III V lab, Time-Bandwidth Products AG of Zurich, Switzerland, and Germany's TOPTICA Photonics AG in Munich, Philips Technologie GmbH in Aachen, QD light-emitter manufacturer Innolume GmbH in Dortmund, and Molecular Machines and Industries GmbH in Eching.

According to team leader University of Dundee, the new lasers will be much smaller and more efficient than current lasers (which are not portable and are heavy on energy consumption) and will be designed for use in microscopy and nanosurgery, where high-precision cutting, imaging and treatment therapies will be made possible.

"A step change improvement in the cost, size and robustness of ultrafast lasers is needed before

they can benefit biomedical applications fully," says Dr Graeme Malcolm, CEO of M-Squared Lasers. "Technologies developed by FAST-DOT will enable these lasers to migrate from the bench-top to hospitals and laboratories," he adds. The lasers will mean that surgeons and life scientists will have access to much higher-performance and lower-cost lasers than are currently available and should open up new application areas for lasers in biomedicine.

"This project will revolutionize the use of lasers in the biomedical field, providing both practitioners and researchers with pocket-sized ultrahigh-performance lasers at a substantially lower cost which will make their widespread use affordable," says Dundee University professor Edik Rafailov.

Almost 100 man years of effort will be directed towards the research throughout the partnership. In particular, the funding will enable the creation of five new research posts at University of Dundee.

www.fast-dot.eu

QPC wins \$750,000 contract for high-power fiber-laser pump engines for airborne directed energy weapons applications

QPC Lasers Inc, which manufactures high-power lasers for the consumer electronics, industrial, defense, and medical markets, has been awarded a \$750,000 contract to develop and deliver BrightLase high-power fiber-laser pump engines to a US government Department of Defense customer for airborne directed energy weapons applications. This award is a follow-on contract to several previous awards which, in conjunction with QPC's ongoing contract with this US government customer, totals \$2.5m since 2007.

"QPC's chip-based semiconductor lasers offer three unique elements crucial in achieving a truly deployable high-energy laser weapon: high power, compactness and light-weight efficient design," says Dr Jeffrey Ungar, co-founder & CEO. "Today's high-energy lasers are based on inefficient and bulky traditional technologies such as chemical

lasers, but the future belongs to these more efficient and compact diode-pumped lasers," he adds. "As we continue our development of these cost-effective high-power laser prototypes, we continue to expand our capabilities in other commercial markets for our technologies, such as consumer electronics and medical, and to identify potential new customers around the world."

The new contract allows QPC to further increase the power from levels targeted in previous contracts and accelerates development and delivery of high-power laser prototypes for potential deployment on the customer's platforms. Under a previous and related contract, in April QPC delivered a BrightLase high-power laser to the same customer.

The prototypes use three of QPC's proprietary semiconductor laser technologies that are designed to

achieve a ten-fold reduction in cost, size, and weight compared to conventional laser technology:

- * Low-cost, high-power HPSEL chip technology that enables QPC to place hundreds of high-brightness surface-emitting lasers onto a single chip, which should enable products to achieve high power and brightness with size, cost, and weight savings of more than 10x compared with conventional laser technologies, the firm reckons.

- * Rugged military fiber-coupled module production capability designed for reliable operation in demanding military environments applications.

- * BrightLase high-power, high-brightness lasers designed to produce laser beams more than ten times brighter than conventional semiconductor lasers used in industrial and medical applications.

www.qpclasers.com

QPC becomes founding member of 3D@Home Consortium

QPC has become a founding member of the 3D@Home Consortium, launched in April by the US Display Consortium (USDC) of San Jose, CA, USA and display-focused publishing and consulting firm Insight Media to speed commercialization of affordable in-home 3D entertainment.

The 22 founders include board-level members Philips and Samsung, leadership-level member Walt Disney Studios Home Entertainment, and 19 other members: Thomson, IMAX, TDVision, 3DIcon, Corning, Planar Systems, SeeReal, 3ality, DDD, In-Three, Quantum Data, Sensio, Fraunhofer Institute IMPS, Sim2, Setred, Universal Studios Home Entertainment, Holografika and Volfoni in addition to QPC.

QPC say its BrightLase on-chip laser technology offers a compact, low-cost and high-efficiency visible laser solution designed to enable a new generation of laser displays for high-growth consumer electronics

markets (compatible with most technology formats, including LCoS, DLP, LC and micro-mirror micro-display devices). Last November, QPC announced a \$12m contract for Generation III BrightLase chip technology for laser TV applications.

"QPC has already begun engaging the laser display market with visible lasers based on our BrightLase technology," says CEO Dr Jeffrey Ungar. "3D-enabled displays using this technology will create an even more immersive experience for the user and allow BrightLase-based visible lasers to be exploited to their full commercial capacity."

"This strong international group of founding companies is a testament to the wide-spread interest and possibilities in stereoscopic 3D home entertainment," says USDC's CEO Michael Ciesinski. "We expect many more to join in the coming months."

The 3D@Home Consortium has three main short-term goals:

- creating and publishing useful technical roadmaps;
- developing educational materials for consumer and retail channels;
- facilitating the development of industry standards and their dissemination.

"We see a host of new opportunities for cooperation and innovation on the horizon — not only for display providers, but for those within every facet of the 3D technology chain," says USDC's chief technology officer Dr Mark Hartney.

Driven by 3D digital cinema, the hardware, software, content and delivery mechanisms are being developed to bring 3D entertainment into the home. The value of DLP, PDP and LCD TVs sold in 2008 capable of showing HD-quality stereoscopic 3D content should exceed \$2bn, attracting the interest of many players, says Insight Media's president Chris Chinnock.

www.3dathome.org

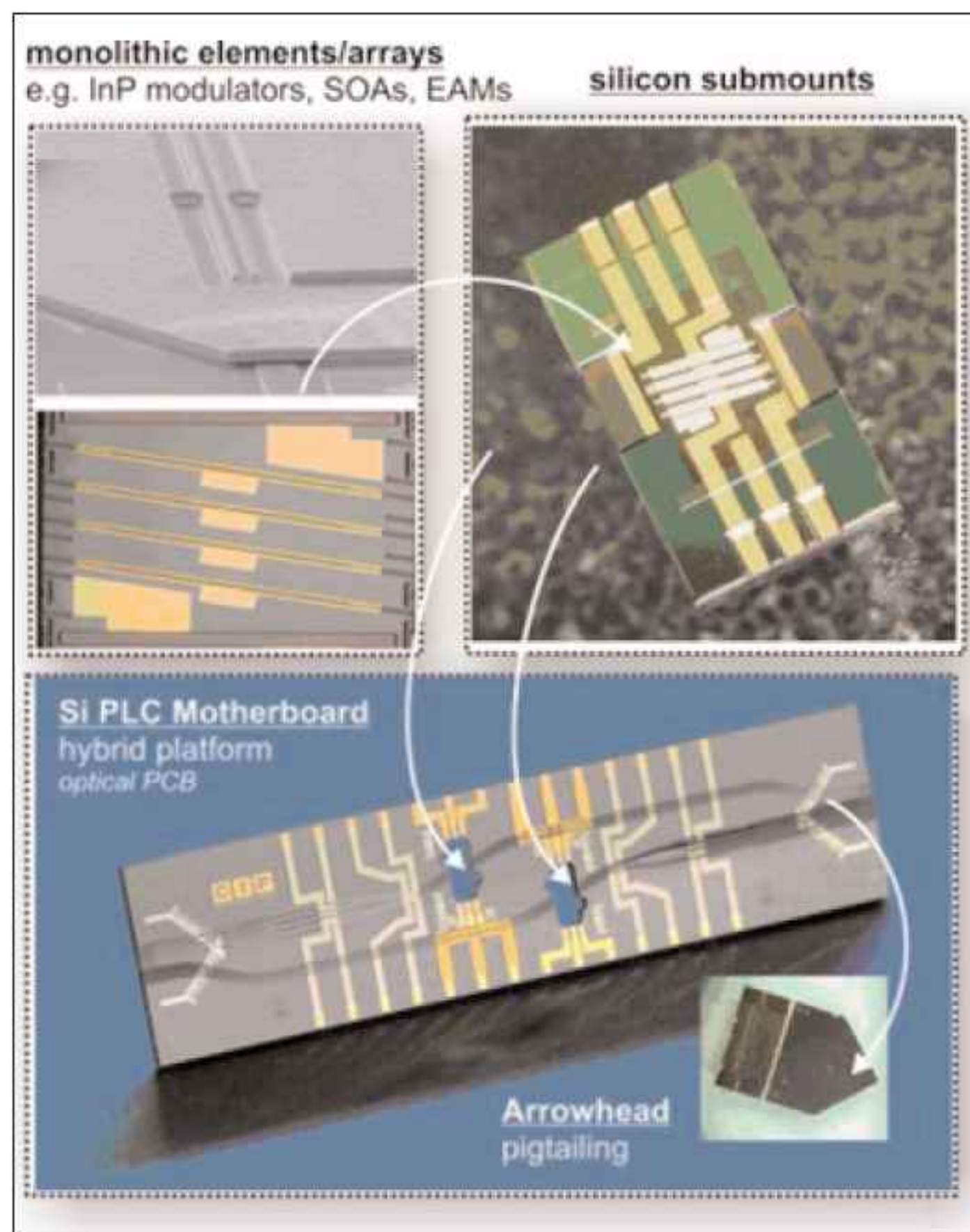
EU hybrid optical integration project to develop modules for 100Gb/s networks

April saw the start of the new three-year collaborative research project APACHE (Agile Photonic Integrated Systems-on-Chip Enabling WDM Terabit Networks), which is part-funded by €3m (\$4.7m) from the European Union under its 7th Framework Program (FP7).

APACHE aims to plug a major gap in the optical module roadmap — the lack of cost-effective, high-performance, multi-channel components for high-speed optical communications systems, such as emerging 100 Gigabit Ethernet.

To cut the costs of high-capacity (>100Gb/s) wavelength division multiplexing (WDM) networks, APACHE will develop novel compact and scalable photonic integrated components capable of generating, modulating, regenerating and receiving optical signals encoded by both amplitude — on-off keying (OOK) — and phase — differential phase-shift keying and quadrature phase-shift keying (DPSK, QPSK).

APACHE gathers a consortium that spans the optical networks supply chain, ensuring that the technologies under development can be realised commercially, and will satisfy a real application need. Consortium partners are: optical component and sub-system fabricators CIP (The Centre for Integrated Photonics) in Ipswich, UK and the Heinrich Hertz Institute (HHI) in Berlin, Germany; telecom system manufacturer Ericsson of the UK and Sweden;



Hybrid integration of InP chips on silica-on-silicon.

photonic component simulation software designer Phoenix Software of The Netherlands; and Greece's Institute of Communication & Computer Systems, National Technical University of Athens (ICCS/NTUA, project co-ordinator) and the Athens Information Technology (AIT) research center in Greece.

APACHE aims to build on advances in hybrid photonic integration techniques by assembling arrays of high-performance devices (monolithically integrated on InP chips) onto a common planar silica-on-silicon hybrid integration platform by using passive alignment.

"Hybrid integration of photonic arrays is key to realising practical, scalable, high-performance optical modules, since only this approach allows optimization of the optical, electrical and thermal performance," says the project's technical manager, Dr Graeme Maxwell of CIP. "Adopting a 'monolithic on hybrid' approach also reduces costs, especially with increasing scale, since the piece-parts for assembly can be yielded at a much earlier stage of the manufacturing process compared to the fully monolithic approach."

The optical sub-systems that are being developed will take hybrid integrated photonic technology and extend it to meet the emerging performance requirements of next-generation optical networks. "Reducing the power and footprint of optical subsystems is becoming

increasingly important as optical networks grow to meet expanding data capacity requirements. APACHE aims to target power reduction by developing un-cooled active optoelectronic arrays that do not greatly sacrifice optical performance."

In addition, different optical network topologies such as point-to-point, ring and mesh with ROADM functionality, different traffic load and growth predictions will be considered. This analysis will be used to identify possible schemes for incorporation of the developed APACHE modules into new DWDM system architectures.

www.ict-apache.eu

CIP launches first reflective electro-absorption modulator

CIP Technologies of Martlesham Heath, Ipswich, UK, which manufactures photonic hybrid integrated circuits and InP-based optoelectronic chips, devices, arrays and modules for the communications and defence markets, has launched what is believed to be the first commercial reflective electro-absorption modulator (R-EAM), enabling developers of access network and other communications applications to implement innovative system architectures, the firm claims.

Potential applications of the new indium phosphide-based R-EAM-1550-LS include 10Gb/s wavelength division multiplexing (WDM) passive optical networks (PONs), and a simple means of linking radio antennas to a high-speed optical cable (creating 'remote antenna' radio-over-fibre networks) to extend the coverage of high-data-rate wireless technologies.

"The demand for higher and higher bandwidths is insatiable," says chief technology officer David Smith. "The challenge is to find low-cost architectures and components that can deliver progress cost-effectively," he adds. "Reflective EAMs are potentially a breakthrough in this search, offering system builders a power-efficient and low-cost means of extending ultra-high-speed optical fiber networks into the consumer domain."

The R-EAM-1550-LS operates at C-band wavelengths (1550nm) and has a very low optical insertion loss of 3.5dB (typical). It will also operate with low drive voltages, and has low polarization-dependent loss (0.3dB typical).

Design features on the die have been incorporated to optimize manufacturability and yield, and simplify coupling to optical fibre. This economy is aided by the



CIP's R-EAM-1550-LS reflective electro-absorption modulator.

device's need for only a single optical fiber connection. It also dissipates very little power and will operate uncooled in some configurations, reducing the total electrical power for many target applications, claims CIP.

The R-EAM-1550-LS provides high-speed transmission capability by reflecting and modulating a 'seed' light that is transmitted throughout the network, and will comfortably operate at data rates up to 10Gb/s, as will be needed in next-generation optical access networks. Using an arrayed waveguide grating (AWG), light from the multi-wavelength seed source can be split into different wavelengths for use in different segments of the network, e.g. in fibre-to-the-home/premises (FTTH/FTTP) access network architectures.

Such an architecture allows an R-EAM to deliver dedicated multi-gigabit optical data transmission facilities for clients without the

expense of a tunable wavelength source. In addition to minimizing the costs of the bidirectional (BIDI) fiber-optic assembly required for client premises, this approach allows one standard BIDI to be manufactured and installed for all users. CIP says that it is already heavily involved in development work and trials in this general area, because of its novel reflective SOA (semiconductor optical amplifier), which was launched in 2005. The R-EAM-1550-LS expands the architectural possibilities of WDM-PON (passive optical networks) to users that require operation at 10Gbit/s.

For applications in wireless networks, R-EAMs make it possible to extend the coverage of a wireless access point with a network of remote antennas. For example, a single fiber-optic cable could easily support 32 antennas operating on different wavelengths, providing a low-cost means of extending the coverage of short-range, high-data-rate wireless technologies around a building or plant. Because of the passive way in which R-EAMs can operate, the cost of remote nodes could be extremely small, as in their simplest form they can be fabricated with just an R-EAM and a simple antenna and operate without any need for local power. As the R-EAM will also operate as a photodiode, these passive nodes can provide both uplink and downlink capabilities.

CIP is supplying the new device in a butterfly package, including thermoelectric cooler, for engineering trials and initial applications. Other packages are available to order (to suit a target application) and can be manufactured by either CIP or its volume-manufacturing partners.

www.ciphotonics.com

Such an architecture allows an R-EAM to deliver dedicated multi-gigabit optical data transmission facilities for clients without the expense of a tunable wavelength source

Finisar ships 250,000th SFP+ optical transceiver

Fiber-optic component and sub-system maker Finisar Corp of Sunnyvale, CA, USA has shipped its 250,000th SFP+ optical transceiver from its portfolio of 8Gb/s and 10Gb/s products. The firm claims that this early milestone, achieved within 12 months of the first customer shipment, is a first in the industry.

Finisar's SFP+ product portfolio includes transceivers targeted at 8Gb/s Fiber Channel and 10Gb/s Ethernet applications over both multi- and single-mode fiber for datacenter, inter-campus link and access network. The transceivers are intended for use in datacom networking equipment such as Fiber Channel switches, Ethernet switches, NIC cards, Host Bus Adaptors (HBAs), and storage array systems.

"We believe this achievement by Finisar indicates the steady growth in the industry we have been predicting over the last several years," says Dr Vladimir Kozlov, principal analyst at LightCounting. "We expect this trend to continue as fiber becomes the media of choice for delivering broadband services."

The SFP+ standard was developed to extend the original SFP-MSA (multi-source agreement) with capabilities for supporting faster data-rate transmissions and better suppression of EMI (electro-magnetic interference). Its smaller size and lower power consumption enable higher port count densities. The standard also provides a more uniform mechanical outline to guarantee consistency of components, as well as an enhanced electrical specification to allow OEMs to take advantage of high-speed, low-power ICs that were not available when the original MSA was drafted.

www.finisar.com

SEI starts integrated production of optical devices and transceivers at new plant SPEC in China

Optical component and module maker Sumitomo Electric Industries Ltd (SEI) of Tokyo, Japan said in late April that it had expanded its optical device and transceiver manufacturing capacity with the start-up of its new integrated production site Sumitomo Electric Photo-Electronics

Components (Suzhou) Ltd (SPEC) in China (established in April 2007).

The new facility adds an additional 155,000ft² to SEI's existing five optical component/module manufacturing plants.

Fiber-optic components such as optical devices and transceivers have not only expanded to public communication applications and optical local-area networks (LANs) but also to Fiber-to-the-Home (FTTH). This market continues to grow at 15% per year. SEI has been developing and manufacturing fiber-optic components, mainly in Japan, for more than 20 years. In April, SEI shipped its 10 millionth transmitter/receiver/transceiver.

SEI says that it established SPEC in order to achieve a stable supply of fiber-optic components and modules corresponding to the growth in the market as well as the need to provide customers worldwide with shorter lead time.

SEI says that SPEC is initially producing low-bit-rate optical transceivers, for which demand is the greatest for public communications and optical LANs applications. Later this year, SPEC will start producing high-bit-rate transceivers, demand for which is expected to increase dramatically in the future.

According to SEI, the new plant brings the following advantages:



Sumitomo Electric Photo-Electronics Components (Suzhou) Ltd (SPEC) in China.

- Integrated production — production of the light source transmitter optical sub-assembly (TOSA) and detector receiver optical sub-assembly (ROSA) at the upper end of the process and the assembly and inspection of the optical transceiver at final process has previously been conducted at separate plants in Japan, whereas the new plant enables SEI to manufacture components and modules in one location;
- the additional manufacturing capabilities will enable shorter lead times, meeting the demands of customers aiming to reduce their inventory levels;
- increased production capacity — as SEI is continuing production at its plants in Japan, SPEC will raise SEI's production capacity by 50% by March 2009.

www.sei.co.jp



SEI's devices (top) and transceivers.

Optium grows 30% year-on-year to record \$45m revenue

For its fiscal third-quarter 2008 (ended 3 May), Optium Corp of Horsham, PA, USA, which designs and manufactures optical subsystems supporting core to the edge applications, has reported record revenue of \$45m. This is up 30.3% on \$34.5m a year ago and 11.7% on last quarter's record \$40.3m, driven by sequential growth across all product lines: 10Gb/s and 40Gb/s, wavelength-selectable switch (WSS) reconfigurable optical add/drop multiplexer (ROADM), and analog & cable TV.

Revenues grew sequentially by 29.5% for 40Gb/s products and by 44% for ROADM products, collectively rising to 24% of revenues (up from 18% last quarter and just 3% a year ago).

"Our third quarter results reflect the benefits accruing from solid execution of the growth initiatives we have focused on for fiscal 2008, including customer diversification and expanding our product portfolio and production capacity to address high-growth segments of the optical communications market,"

says chairman and CEO Eitan Gertel. "We passed our WSS ROADM capacity target of 1000 units per quarter while continuing to expand our breadth of ROADM offerings, such as our high-resolution 50GHz ROADM platform. We continue to expand overall WSS ROADM capacity," he adds.

"In 40Gb/s, we took advantage of being first to market with volumes of our DPSK 300-pin module for line-side applications, with total 40Gb/s revenues reaching 5% of revenues in the quarter."

Net loss was \$0.7m, compared to \$0.8m last quarter and income of \$3.4m a year ago. This is due mainly to operational expenditures related to the accelerated ramp of 40Gb/s and ROADM product lines and production capacity in anticipation of future sales (incurring dupli-

We took advantage of being first to market with volumes of our DPSK 300-pin module for line-side applications

cate leasing costs after an early move to a new facility in the US, as well as a new lease for relocating its Australian facility later this year), higher levels of stock-based compensation, as well as \$614,000 of expenses related to the proposed merger transaction with Finisar Corp of Sunnyvale, CA, USA (announced in mid-May).

For its fiscal fourth quarter, Optium expects revenue of \$47-49m, driven by continued execution and solid growth trends in the optical communications sector. "In addition, with a significant portion of our new product line investments well underway, we are more focused than ever on demonstrating continued improvement in profitability," says Gertel.

"We will also be working diligently toward regulatory and shareholder approval of our proposed combination with Finisar Corp through an all-stock merger. We currently anticipate closing the transaction during the third calendar quarter," concludes Gertel.

www.optium.com

Finisar grows 25% year-on-year, driven by 10/40Gbps

For its fiscal Q4/2008 (to end April), fiber-optic component and sub-system maker Finisar Corp of Sunnyvale, CA, USA has reported record revenue of \$121m, up 7% on \$112.7m last quarter and up 25% on \$96.6m a year ago.

Network Tools revenue was \$9.6m (up 15% on \$8.4m a year ago but down from \$9.8m last quarter). Optics revenue was \$111.4m (up 8% from \$103m last quarter and 26% on \$88.2m a year ago). This includes:

- \$31.2m from 10/40Gbps applications (up 7% on \$29.1m last quarter and a massive 110% on \$14.9m a year ago) and
- \$50.6m from 1-8Gbps LAN/SAN applications (up 12% on \$45.4m last quarter but just 11% on \$45.7m a year ago).

Gross margin fell from 38.2% last quarter to 37.4%, mainly due to an unfavorable product mix (less revenue from Network Tools; more from short-distance LAN/SAN applications).

Net loss has been cut from \$16m a year ago and \$10.6m last quarter to \$8.7m. On a non-GAAP basis, net income has grown from \$2.3m a year ago and \$6.7m last quarter to \$7.9m. Also, EBITDA (earnings before interest, taxes, depreciation and amortization) was \$17m, despite investing \$9.5m in capital expenditure.

Rawls highlights the future potential for growth and profitability from the merger with Optium

"While fiscal 2008 was a challenging year for us at the top line, it was extremely gratifying to see us recover and set new revenue records for the company in the last half of the year," says chairman and CEO Jerry Rawls. "Demand for our products for both 10-40Gbps and shorter-distance LAN/SAN applications continues to be healthy during these uncertain economic times."

Rawls also highlights the future potential for growth and profitability from the proposed merger (announced in mid-May) with Optium Corp of Horsham, PA, USA, which designs and manufactures optical subsystems supporting core to the edge applications for use in telecom and cable TV network systems.

www.finisar.com

Infinera introduces passive PICs in new optical line system

At June's NXTcomm08 event in Las Vegas, Infinera Corp of Sunnyvale, CA, USA unveiled its first major new product since the launch of its DTN, a flexible ROADM (reconfigurable optical add-drop multiplexer) and DWDM (dense wavelength division multiplexing) digital optical network system for long-haul, regional, and metro core networks that incorporates Infinera's own large-scale, InP-based active photonic integrated circuits (PICs) integrating optoelectronic devices such as lasers, modulators, and photodiodes.

In contrast to the Infinera Line System 1 (ILS1) that provides photonic transport and amplification for either 40 or 80 DWDM wavelengths in the DTN, the next-generation high-capacity, ultra-long-haul Infinera Line System 2 (ILS2), shipping from this summer, incorporates technology based on Infinera's second platform for photonic integration, its new highly integrated all-optical planar lightwave circuits (forming passive PICs).

With the ILS2, Infinera is launching two passive PICs, designed to deliver benefits similar to the existing active PICs, including greater density of functionality in a smaller space, reduced power consumption, simplified manufacturing, and enhanced reliability. "This is doing on the passive optical side what we've already achieved on the active PIC side," says Geoff Bennett, director of product marketing.

The passive PICs are based on a technology platform acquired in early 2007 with PLC start-up Little Optics (based near an existing Infinera engineering team in Annapolis Junction, MD), which developed and patented the high-index silica-like material Hydex. This allows waveguides with a bend radius as tight as 10µm (about a hundredth that in conventional silica-on-silicon PLCs), enabling denser integration of devices in PICs. Also, integration allows the elimination of more than 90% of the fiber couplings and discrete packages

found in non-PIC based systems. The PICs are hence about 100 times smaller (less than 1cm² in area) but with much greater functionality.

The PICs integrate passive devices such as multiplexers, interleavers, variable optical attenuators and waveguides, and a precision filter function enables the use of a 25GHz grid (twice the channel-spacing density of ILS1). This enhancement in spectral density allows transmission of up to 160 DWDM channels of light within the C-band on a single fiber, enabling greater capacity.

Of the two new PICs, WaveMux is a precision multi-wavelength multiplexer/demultiplexer (integrating the functionality of more than 40 devices on a single chip) that supports 25GHz channel spacing. WaveLocker is a wavelength-management device with a continuous gain-flattening filter function, integrating the functionality of more than 10 devices on a chip.

With Infinera's PICs integrating 10 DWDM channels on a pair of chips, the firm's systems can turn up 10 channels at a time, simplifying the installation and provisioning process, and making 160 channel systems easier to manage, it is claimed.

This can deliver scalability up to 1.6Tb/s of total optical capacity using the 10Gb/s DTN line cards, 6.4Tb/s once Infinera introduces its next-generation line cards operating at 40Gb/s, and 8Tb/s via 80 channels operating at 100Gb/s each (for a new industry standard in optical capacity on a single fiber, it is claimed).

As well as enhancing capacity and flexibility, the ILS2 extends optical reach up to 2500km by augmenting Infinera's existing range of erbium-doped fiber amplifier (EDFA) modules with a new range of

co-pumped and counter-pumped, distributed Raman amplification modules. This can enable greater economies in networks with spans that traverse very long distances with no need to drop traffic. Extended reach also enables greater single-span distances (valuable for applications such as festoon networks or to enable hut-skipping).

Raman amplification leverages technology from the acquisition two years ago of assets of Corvis Corp in Columbia, MD (now combined with Little Optics to form a center of excellence in Annapolis Junction).

"With the ILS2, we sought to take the features and capabilities of Infinera's first optical line system to new levels, and create a system with some of the best performance metrics in the industry, while still retaining all the rapid service delivery and plug-and-play capabilities of digital optical networks," says Chris Liou, VP of product management.

In March, analysts Heavy Reading estimated that Infinera had a four-year lead over the rest of the industry in photonic integration technology. "The company established itself as the world leader in photonic integration with its initial PIC pair, launched in 2004," says senior analyst Sterling Perrin. "In 2008, the company is proving that it continues to lead in PIC innovation — first with its active PIC roadmap announced earlier in the year and now with its new passive PICs."

"The relative lack of market investment earlier this decade is threatening to jeopardize DWDM systems' 13-year success in enabling exponential declines in capital expenditure per bit per kilometer of network backbone capacity," reckons Dana Cooperson, VP network infrastructure at market research firm Ovum. "Infinera is one vendor that has stepped up investment in innovation to put the market back on the road to exponential improvements," she adds. "The ILS2, together with the 400G PIC announced in February, widens Infinera's addressable market

The relative lack of market investment earlier this decade is threatening to jeopardize DWDM

and maps out the company's strategy for scaling DWDM to the next level of economical backbone capacity."

"Integration is the only known technology that can improve the capacity of a network while simultaneously delivering benefits in terms of cost per bit, reliability, scalability, speed of operation, density, and power consumption," says Infinera's chief marketing and strategy officer Dave Welch. "Our passive PICs, based on a different platform from our active PICs, demonstrate that PIC technology can be applied to multiple materials, and to multiple points in the design of an opti-

PIC technology can be applied to multiple materials, and to multiple points in the design of an optical network

cal network. We believe that photonic integration is still at a relatively early stage in its life as a key technology for optics."

● SAVVIS Inc, which provides IT infrastructure services for business applications, has selected the ILS2 line system to upgrade its regional optical network in California.

Also, at NXTcomm08, the ILS2 was chosen for an EOS Award. The prize for Technology Innovation in Optical Networking is in recognition of "significant innovations, including the implementation of 160 DWDM channels in the C-band", made possible by the use of passive PIC technology. EOS Award winners represent "the best and most promising advancements to the network-enabled voice, video, and data ecosystem," says NXTcomm executive director Wayne Crawford. www.nxtcommshow.com
www.infinera.com

Infinera wins order for Deutsche Telekom's pan-European network

Infinera has won an RFQ (request for purchase) for a DWDM system from Deutsche Telekom (DT), one of the world's largest telecom carriers, to upgrade its pan-European network. The system's digital optical network architecture, which uses large-scale InP-based photonic integrated circuits (PICs) combining the functions of dozens of discrete optical devices into a single pair of chips, will provide improved scalability, flexibility, and speed of service delivery.

As part of its global network, DT's pan-European network spans almost 9000km and links Germany with most major European markets. For the backbone of the new network, DT's order includes the ILS2 (Infinera Line System 2) system (launched at June's NXTcomm08 event in Las Vegas), which offers up to 160 DWDM (dense wavelength division multiplexing) channels at C-band wavelengths, extends optical reach to 2500km, and enables

future capacity scalability up to 8Tb/s on a fiber. ILS2 works with Infinera's current photonic integrated circuits (PICs), which put 100Gb/s of DWDM capacity on a pair of chips, and will be compatible with future-generation PICs, including the 400Gb/s PICs announced in February (for production in 2009).

"We selected the Infinera system to prepare for the next generation of international network operations and to help our customers to take advantage of this innovative and highly efficient solution with the most flexibility, quickest service provisioning and complete remote capabilities," says Wolf Pueschner of global networks, Deutsche Telekom.

"This award makes clear that the benefits of PIC-based digital optical networks are powerful and realizable by carriers across the full range of geographies, markets, and applications," claims Infinera's CEO Jagdeep Singh.

IN BRIEF

Guidance for 2008 cut from 25% to 10%

Infinera has reaffirmed its Q2/2008 guidance (given on 22 April) for revenues of \$88-90m (expecting at least two new customers, not including DT). "Our expected Q2 results and the recently announced DT win demonstrate that Infinera continues to win in the DWDM marketplace," says president & CEO Jagdeep Singh.

However, its initial preliminary revenue guidance for Q3 is for a drop to \$75-80m. This is due to indications that the existing North American customer base will purchase less product than previously expected (related to the timing of new network builds at existing customers and the sales cycle with potential new customer wins, along with a product transition associated with Infinera's new ILS2 system). Hence Infinera has cut its outlook for full-year 2008 year-on-year revenue growth on 2007's \$309.3m from 25% (to \$386m) to about 10% (to \$340m).

"While the preliminary outlook for our fiscal third quarter is lower than anticipated, we do not believe we have lost any existing customers, we do not believe that we have yielded any market share, and we are confident we will continue to add new customers during the rest of the year," says Singh. The win with Deutsche Telekom and ongoing engagements with other leading carriers worldwide give the firm continued confidence in the strength of its long-term strategy and growth outlook, he adds.

As a result of the initial deployment of the DTN system with DT, Infinera expects to incur one-time charges of about \$4m in Q2-Q3/2008. Infinera will announce full Q2 results on 22 July.

www.infinera.com

Thin-film PV market 9GW in 2012

Thin-film solar production will grow from 1GW this year to more than 9GW in 2012, forecasted the Prometheus Institute for Sustainable Development at a recent Greentech Media conference. "We project increased penetration of all technologies — cadmium telluride (CdTe), copper indium gallium diselenide (CIGS) and amorphous silicon (a-Si) — above even our aggressive forecasts in 2007," says the institute's president Travis Bradford.

CdTe films, led by First Solar, comprise the largest portion of the thin-film market. Bradford expects the firm's costs to fall from less than \$1.25 per watt to less than \$1 per watt by 2009. However, those costs could be subject to the price of glass, which in turn depends on energy prices, he cautions. Also, the cost of tellurium (a mining byproduct of zinc) has increased. "There are some difficulties. But First Solar will continue to do well."

The big story of 2009 is likely to be CIGS, reckons Bradford. Even though no companies have yet produced CIGS films in significant volumes, the technologies have potential, he says. "Many of these [technologies] are ready to go. In some cases, it takes as much as a third of the capital less than First Solar to build a plant," he adds. "We know how many companies are putting in multi megawatts of CIGS in 2009... Just like polysilicon was the big story of 2007 and First Solar is the big story of 2008, we believe in 2009 the big story will really be CIGS."

CIGS PV makers Global Solar Energy Inc (GSE) of Tucson, AZ, Nanosolar of San Jose, CA, Miasolé of Santa Clara, CA, and HelioVolt Corp of Austin, TX have all announced plans to expand production in the last few months.

Meanwhile, Prometheus expects amorphous-silicon films — such as those made by Applied Materials

and Oerlikon — to stumble slightly in 2008 and 2009, as technologies get debugged and verified, before taking off in 2010. By 2012, amorphous silicon should comprise the largest segment of the thin-film market, with 4.5GW of production, with CIGS second at 2.6GW.

The Prometheus Institute also expects the top thin-film producers in 2012 (by manufacturing capacity) to be First Solar (CdTe, 1.39GW), then Miasolé (CIGS, 0.9GW), Sharp (a-Si, 0.8GW), Nanosolar (CIGS, 0.49GW), United Solar (a-Si, 0.36GW), Moser Baer (a-Si, 0.32GW), HelioVolt (CIGS, 0.28GW) and GSE (CIGS, 0.23GW).

"There are so many technologies, even if we're wrong in one bucket, in one technology, there are a lot of different ways to hit 4GW in 2010 and our projections in 2012," Bradford concludes.

www.prometheus.org

www.greentechmedia.com

Singapore's Mentarix receives first-round funding

Singapore-based photovoltaic component startup Mentarix Pte Ltd has received first-round financing after local seed fund BAF Spectrum Pte Ltd took a 30% stake in the firm.

"We want to aggressively fund technology companies that can increase the viability of alternative energy," says investment lead and BAF managing director Francis Chua, who is taking a seat on Mentarix's board of directors. Mentarix is the second firm in the field of clean technologies funded by BAF, which has committed more than US\$14m for early-stage Asian ventures and is partly financed through the Business Angel Scheme (BAS) operated by the government-linked agency SPRING SEEDS Capital Pte Ltd.

"BAF Spectrum shares our long-term vision in building a vertical solar-hydrogen industry business," says Mentarix's founder and CEO Chee Khar Chit.

By using quantum dot technology and photonic technology, Mentarix plans to design and manufacture products that can increase photovoltaic cell operating efficiency by at least 20% from their relative baseline. The products will come in the form of a thin film attached to existing solar cells to change the incoming sunlight's characteristics so that it is more easily absorbed (eliminating the need to equip the system with any extra mechanical structures). Mentarix aims to deliver a series of products improving the operating efficiency of any photovoltaic cell with minimum disruption to the existing production process. The technology is applicable to both traditional crystalline silicon cells as well as thin-film cells based on cadmium telluride/cadmium sulfide (CdTe/CdS), copper indium gallium diselenide (CIGS) and amorphous silicon.

Mentarix's founders have track records in delivering large-scale infrastructure projects. Also, the firm is working with the Nanyang Polytechnic in Singapore, where a team of experts will assist in developing and commercializing products.

"Chee Khar Chit is giving up a well-paying job in Malaysia to relocate to Singapore to start this project on a full-time basis," says Chua. "The Singapore government's recent financial incentives and the existing eco-infrastructure to nurture start-up technology companies through SPRING and other agencies are clearly important pull factors."

The PV efficiency enhancement component market is currently a 'green-field' segment in the solar energy industry, says Mentarix, but is forecasted to be €500m by 2020. As a 'first mover', Mentarix aims to take 'significant' market share.

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IBM and Tokyo Ohka Kogyo to co-develop CIGS PVs

IBM Corp of Yorktown Heights, NY, USA and process equipment maker Tokyo Ohka Kogyo Co Ltd (TOK) have agreed to collaborate on jointly developing processes, materials and equipment for the production of more affordable and easier-to-install thin-film CIGS (copper indium gallium diselenide) solar cell modules.

Currently, about 90% of photovoltaic (PV) cells use silicon, but their greater thickness and weight limit how they can be deployed. In contrast, CIGS solar cells can be 100 times thinner than silicon-wafer solar cells, can be deposited on either inexpensive glass substrates or flexible substrates, and are suitable for the use on the tops and sides of buildings, tinted windows, and other surfaces.

The most common CIGS manufacturing process is co-evaporation, in which active chemicals are immersed in a solution before removal in a vacuum. Using a co-evaporation process, in April the US Energy Department's National Renewable Energy Laboratory increased the efficiency record for CIGS PV cells to 19.9% (nearing the record for multicrystalline silicon cells of 20.3%). However, no firms have yet approached this in manufacturing, where cells must be quickly mass produced in a cost-effective manner.

Existing thin-film CIGS products on the market (e.g. from Nanosolar Inc of San Jose, CA, Miasolé of Santa Clara, CA, HelioVolt Corp of Austin, TX and Global Solar Energy of Tucson, AZ) have efficiencies of 9–10%. In May, HelioVolt said that it had achieved 12.2% in a 'champion cell' using its reactive transfer printing process (which is faster than co-evaporation), while Global Solar expects to achieve 13–14% this year.

However, based on work done about 10 years ago on flexible electronics, IBM Research has now developed a new, non-vacuum, solution-based manufacturing process for CIGS solar cells that involves dissolving chemicals in a liquid and then drying them, doesn't require as much energy to run, and is faster than co-evaporation, it is claimed. Solution processing allows printing onto a rolled backing of a flexible module or a glass plate, eliminating many of the high-energy and equipment-intensive processes typical of conventional PV manufacturing. The firm is targeting efficiencies of about 15% and higher.

Combining IBM's technology with the coating technique and the high-purity chemicals of TOK (building on its experience of both semiconductor and LCD panel manufacturing) has the potential to bring large-scale production of thin-film solar cells to market, the firms say.

"Our goal is to develop more efficient photovoltaic structures that would reduce the cost, minimize the complexity, and improve the flexibility of producing solar electric power," says Dr Tze-Chiang Chen, VP of Science and Technology at IBM Research. "IBM's technology combined with TOK's expertise in equipment design and manufacture, have the potential to broaden the use of alternative energy sources," he adds.

Combining IBM's technology with the coating technique and the high-purity chemicals of TOK has the potential to bring large-scale production of thin-film solar cells to market

"This joint development is a great opportunity to expand the applications of our technologies into the photovoltaic industry," says TOK's president & CEO Yoichi Nakamura.

IBM has already built a prototype device, according to a Reuters report. Once made at large volumes on a glass substrate, the cells are expected to deliver electricity at less than the long-targeted cost of \$1 per watt at peak times. "I think that if we can get to a module cost of less than \$1 per watt, and be able to keep a handle on the system costs, then one should be able to get to grid parity [the level at which solar power is competitive with traditional forms of electricity generation]." Photovoltaics still need roughly a twofold improvement in efficiency, he adds.

However, the firms do not plan to manufacture solar modules themselves, but aim to develop technology that can be licensed to manufacturers within the next two to three years. "We've already been in discussions with photovoltaic manufacturers," said Supratik Guha, who leads IBM Research's PV activities. "There are problems to be resolved," he said, "but this is the time we're starting to talk to them."

IBM intends to provide more technical detail of its solutions-based process in an advanced-material paper within a month, says Guha.

* IBM says that it is exploring four main areas of PV research:

- using current technologies to develop cheaper and more efficient silicon solar cells;
- developing new solution-processed thin-film PV devices;
- concentrator PVs (CPVs); and
- future-generation PV architectures based on nanostructures such as quantum dots and nanowires.

www.ibm.com/green

www.tok.co.jp

Flash fast forward to quantum dot memory

Non-volatile memory in the form of NAND Flash is now driving development in the silicon semiconductor industry. However, this technology can only continue on the back of adaptation to ever higher densities. Dr Mike Cooke surveys the coming changes and looks at how III-V quantum dots offer the prospect of fast non-volatile memory.

A bewildering array of technologies has been used to support the memory and storage needs of electronics over the years, from paper tapes and punched cards to semiconductor-based products. Many factors play a part in deciding which technology is used for a particular level of storage; some of the most important are read/write speeds, storage density, endurance, reliability and, finally and often most importantly, cost. These requirements, like so much in life, are usually contradictory. The engineering problem is to find the optimal combinations for specific applications.

In a PC, the memory close to the central processor unit (1st and 2nd level cache) must be fast but not particularly dense or high capacity. The technology of choice for these applications is static random access memory (SRAM), which is volatile (data disappear when the equipment is turned off). The working memory of a PC needs high density and high capacity in addition to high speed. Dynamic random access memory (DRAM) meets these requirements, but is even more volatile than SRAM — it needs to be constantly reminded of the information it contains since its retention is of the order of milliseconds.

To retain information when equipment is turned off requires some form of nonvolatile memory. In the PC, the standard technology for this is the magnetic hard disk drive. This provides high capacity, a moderate density of information, but a slower read time. More recently, semiconductor-based Flash memory has become increasingly popular for highly compact consumer applications such as mobile phones and other portable devices such as mp3 players and digital still cameras. Flash offers high and increasing storage densities, but rather slow write and erase times. This is a

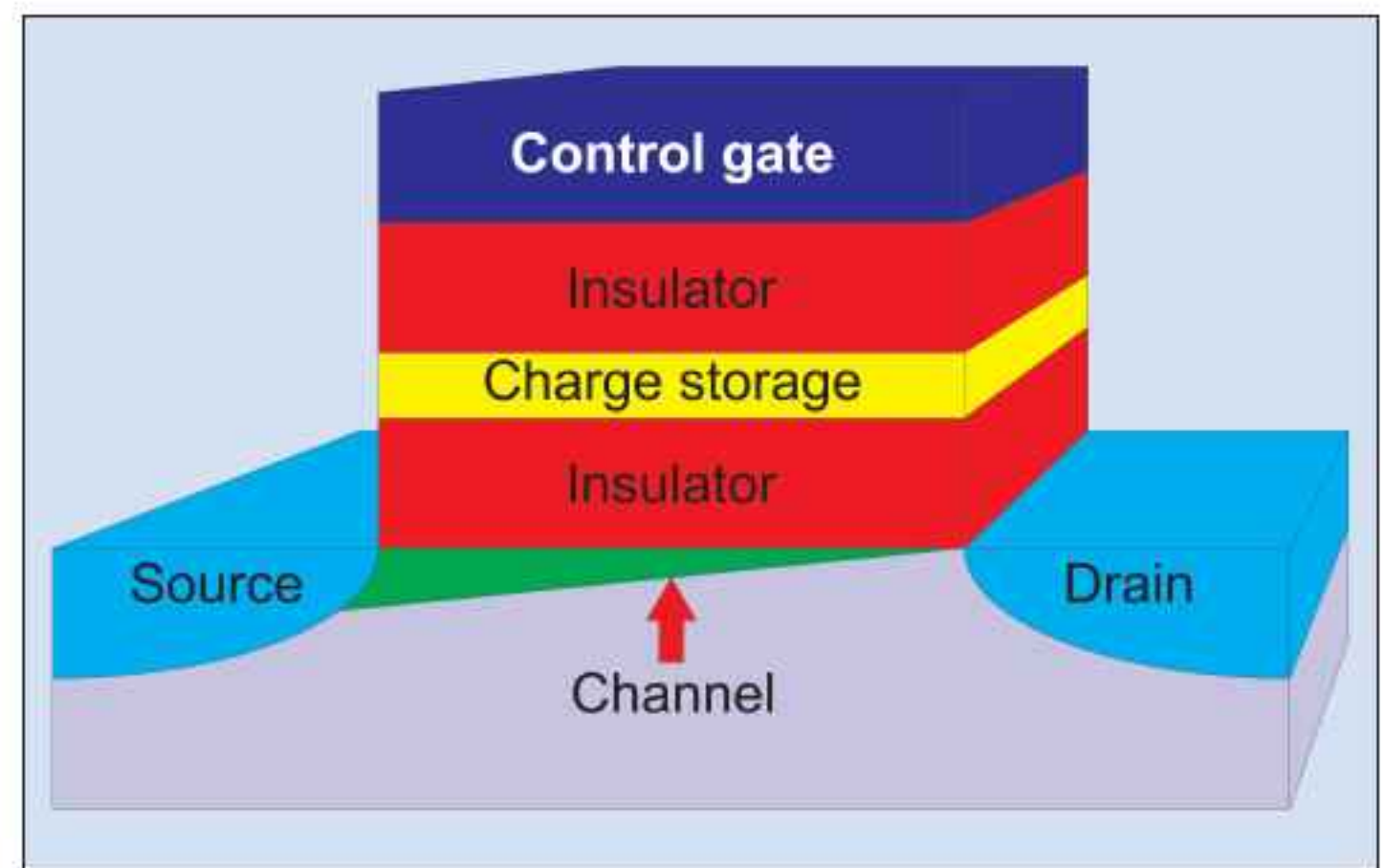


Figure 1. Schematic of Flash memory transistor.

disadvantage in many applications such as video camcorders. Although Flash is used for such video storage, the device usually contains a DRAM buffer to contain the raw data, which then takes some time to transfer to nonvolatile form when filming stops, often blocking continued use of the camera until the process is finished.

Flash storage

A basic Flash memory transistor is similar in structure to those used in complementary metal oxide semiconductors (CMOS) (Figure 1). The main addition is a charge-storage layer between the gate electrode and the channel. The presence or otherwise of charge in this layer affects the electric field in the channel and hence the threshold voltage needed on the control gate for increasing the channel's carrier concentration and hence its conductivity. The read operation for the memory/charge state consists effectively of a relatively simple and fast current-sensing measurement. If a number of different charge states can be separated with different threshold-voltage windows, multi-bit memory devices become possible.

The difficult part for operating Flash is to change the memory state — that is, to write or erase charge from the storage layer. This operation stresses the material structure and leads to degradation and failure over time. In general, the transfer of holes (in contrast to electrons) is more damaging, so commercial Flash memory and related devices depend on electron storage. One needs to arrange the structure so that it can retain charge for long periods (more than ten years) and can be rewritten many times. ▶

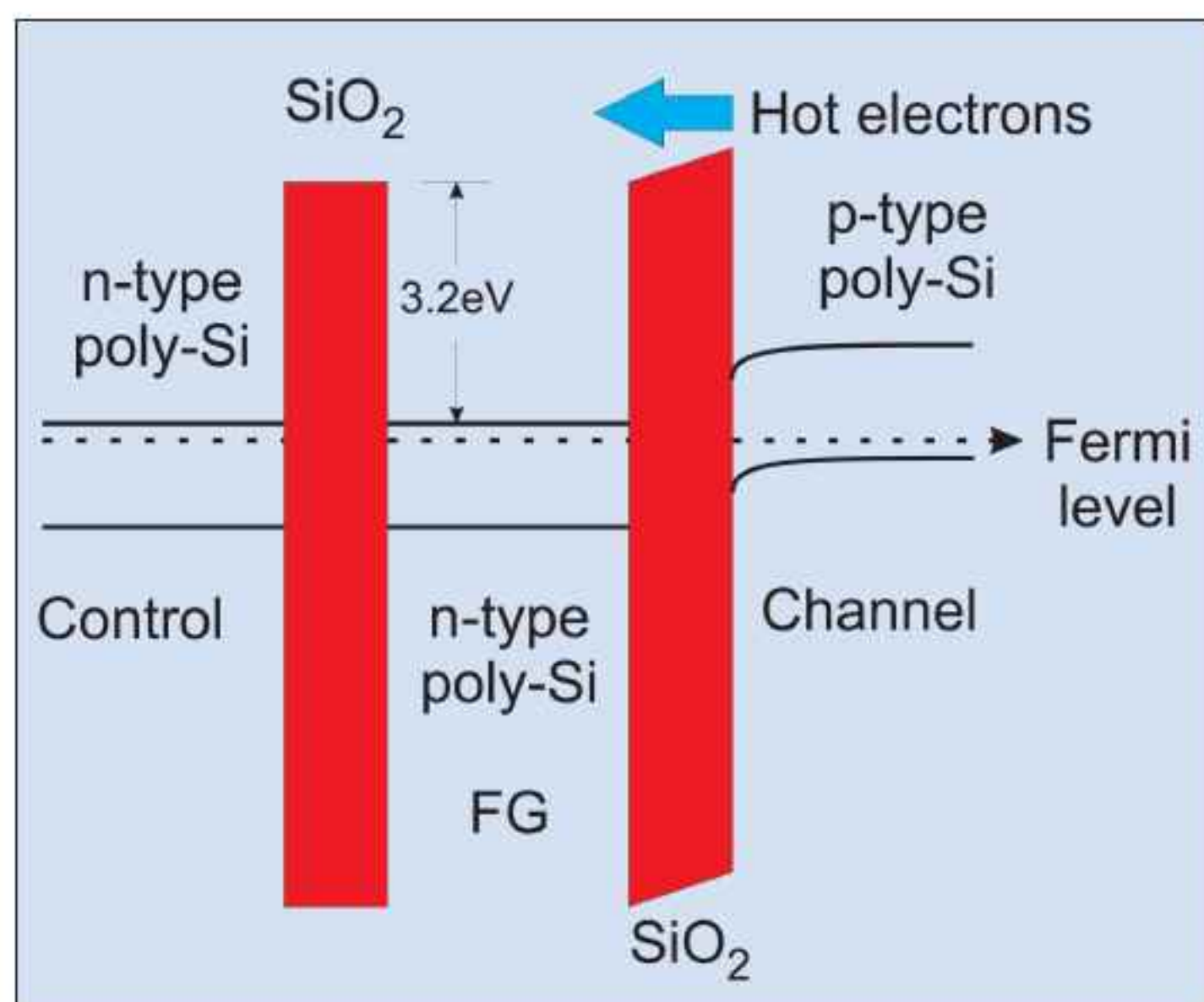


Figure 2. Band structure of floating-gate (FG) Flash memory. Hot electrons are those with enough energy to cross the insulating barrier.

Faster write/erase operations lead to increased stress and hence greater device degradation. Present Flash devices are limited to write/erase operations of at best tenths of milliseconds, while the systems that they service often have clock speeds of up to gigahertz (GHz, or 1000MHz). Of course, things can be sped up by arranging parallel write/erase operations. Hence, one can have devices with 20Mbit/s and even 80Mbit/s data transfer rates. The different arrangements come under such labels as NOR and NAND Flash, which have different strengths and weaknesses from an applications perspective. NOR offers true random access of memory bits, but lower numbers of write/erase cycles, and is often used to hold program code that needs upgrade options (firmware). Denser NAND is preferred for holding data such as digital images, music and video.

A traditional Flash memory storage layer consists of a conducting polysilicon 'floating gate' that is insulated from the control gate electrode and the conducting channel by an insulator such as silicon dioxide dielectric. A variation is SONOS memory, which uses a stack consisting of silicon-oxide-nitride-oxide-silicon where charge is stored on trap states in an insulating silicon nitride (or oxynitride) layer. In floating-gate Flash, ONO (oxide-nitride-oxide) is also often used instead of the SiO₂ insulator, but then one must be careful that charge storage is on the gate and not in the nitride layers.

Two main methods are used to get electrons in and out of the charge storage layer: hot-carrier injection and tunneling. 'Hot carriers' are those in high enough energy states to cross the insulating barriers into the floating gate or nitride charge storage regions. Silicon dioxide, for example, offers an energy barrier of about 3.2eV to electrons between the electrode and floating gate (Figure 2).

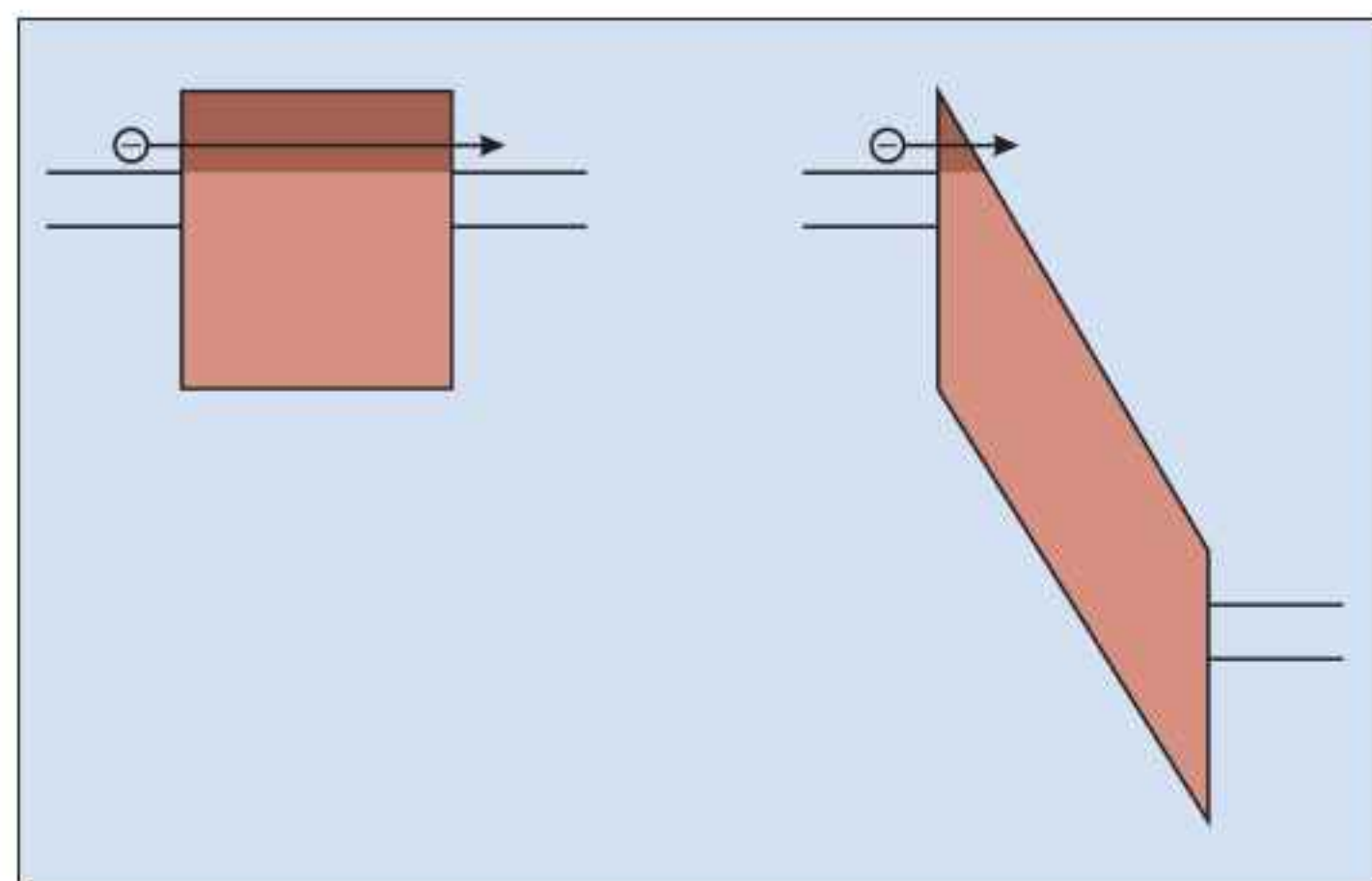


Figure 3. Fowler-Nordheim tunnelling (right): applying an electrical field across an insulating barrier reduces its effective thickness, allowing the transmission of charge out of the storage layer.

One way to create hot carriers is to accelerate electrons from the source to drain and arrange for a control gate potential to deflect them onto the charge storage region. 'Tunneling' refers to the quantum-mechanical effect where part of the electron wave-function can trespass into classically forbidden regions (such as insulation barriers) and hence allows some transmission of electrons — the thinner the barrier, the greater the transmission. For charge retention, one needs the barrier to be sufficient to block off such transmission but, for write/erase operations, applying an electrical field reduces the barrier's effective thickness, allowing charge to escape. This technique is referred to as Fowler-Nordheim (FN) tunneling (Figure 3).

Since it is difficult to use hot-carrier injection to erase the charge state, devices tend to use tunneling for this operation. Tunneling can also be used to push charge into storage, but can be stressful for the device's performance. NAND Flash tends to use tunneling for both write and erase operations, while NOR will often use hot-electron injection from the channel (channel hot-electron injection, or CHEI) to write charge onto the charge trapping layer. System operating voltages of 1.8–5V are converted to the higher voltages of 15–17V that are needed for write/erase by 'charge pump' circuitry.

When first introduced in the late 1980s, Flash tended to lag behind DRAM in implementing advanced technology and consequent density increases. However, in recent years the situation has reversed, with NAND Flash now leading the way. The International Technology Roadmap for Semiconductors (ITRS 2007) puts the expected density for DRAM 'at production' this year at 3Gbits/cm², while in 2015 it is expected to reach 15Gbits/cm². Flash memory densities in 2008 are expected to be of the order of 8Gbits/cm² for single-level memory cell devices and 17Gbits/cm² for two-level cells. The 2015 figures are 40Gbits/cm² and 90Gbits/cm², respectively.

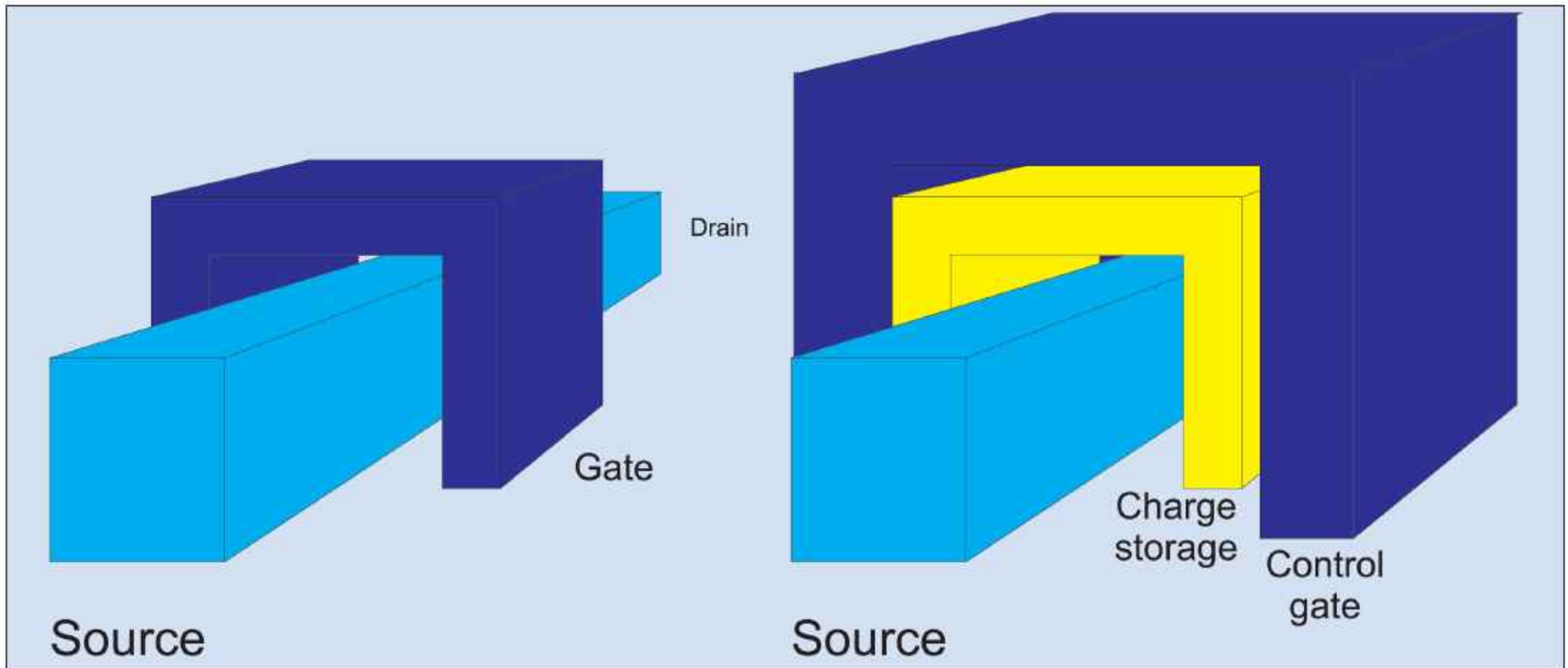


Figure 4. Schematic diagrams of FinFET (left) and FinFlash (right).

A couple of years ago the future was looking bleak for traditional Flash memory, and a number of nonvolatile alternatives were being proposed. The latest International Technology Roadmap for Semiconductors [1] reveals that many of the near-term roadblocks have in theory been cleared.

This has been achieved largely through slight variations of Flash. For example, floating-gate NAND Flash is expected to be pushed aside as the majority technology in favor of some form of charge trapping in a silicon nitride (SiN) layer in about 2010 (the 45nm technology node). Floating-gate NAND Flash could continue to find makers, so long as the ONO insulator structure presently used can be replaced by a high-k dielectric, as is currently taking place in the high-performance CMOS logic domain.

For charge trapping, the two dielectric layers are expected to consist of either traditional SiO₂ or ONO (tunnel) and Al₂O₃ (blocking). The control gates may move to metal from polysilicon, resulting in a metal-Al₂O₃-nitride-oxide-silicon (MANOS) structure. Continued density increase is expected from two-level devices in about 2013, in addition to each transistor being able to store four bits (16 states) from about 2010. The current number of bits per cell is two, with three-bit/cell memories expected next year. All these devices are aiming at nonvolatile data retention of 10–20 years and endurance of 10⁵ write/erase cycles.

Although the ITRS and the manufacturing companies seem to have a workable plan for developing Flash for a few years, the interested parties are still keen to develop the alternatives, such as phase-change memory (PCM), ferroelectric and magnetic nonvolatile memories. However, apart from the development-stage competition, there is also the struggle to create a commercial product from a laboratory proof-of-concept.

Nanocrystals

Another direction is to further vary the existing Flash memory structure or materials. One such variation is to use silicon nanocrystals (Si-NCs) for charge storage. The coverage of this technology in the 2007 edition of the ITRS was somewhat transitional. For a number of years, ITRS has covered development of Si-NCs in its 'Emerging Research Devices' (ERD) section. In 2007, however, the group responsible for this section proposed that Si-NC Flash memory be kicked out of its remit and upstairs into 'Processes, Integration, Devices and Structures' (PIDS). This indicates that the group believes that now is the time for NCs to move from laboratory prototypes to preparing for manufacture.

Discrete charge storage, such as Si-NCs, allows some important potential advantages, such as the use of a thinner tunnel oxide thickness to maintain the necessary charge retention of 10–20 years. A thinner oxide would allow lower program/erase voltages, resulting in less damage, greater endurance for write/erase cycles, and improved reliability. However, there are concerns that non-uniformity of NC deposition could lead to variation in the threshold voltages and therefore less ability to distinguish multi-bit charge states.

In November 2005, Freescale reported a 24Mbit silicon nanocrystal memory in a NOR configuration. STMicroelectronics is also working in this area in collaboration with the Consiglio Nazionale delle Ricerche-Istituto Microelettronica Microsistemi (CNR-IMM) in Catania, Italy, producing a 16Mbit NOR device in 2007 [2] with NC sizes averaging 3nm and 6nm in two samples and NC densities in the range 3–6x10¹¹cm². The larger NCs induced a cell reliability weakness.

One important development has been the independent discovery by Freescale and by CNR-IMM/ST with

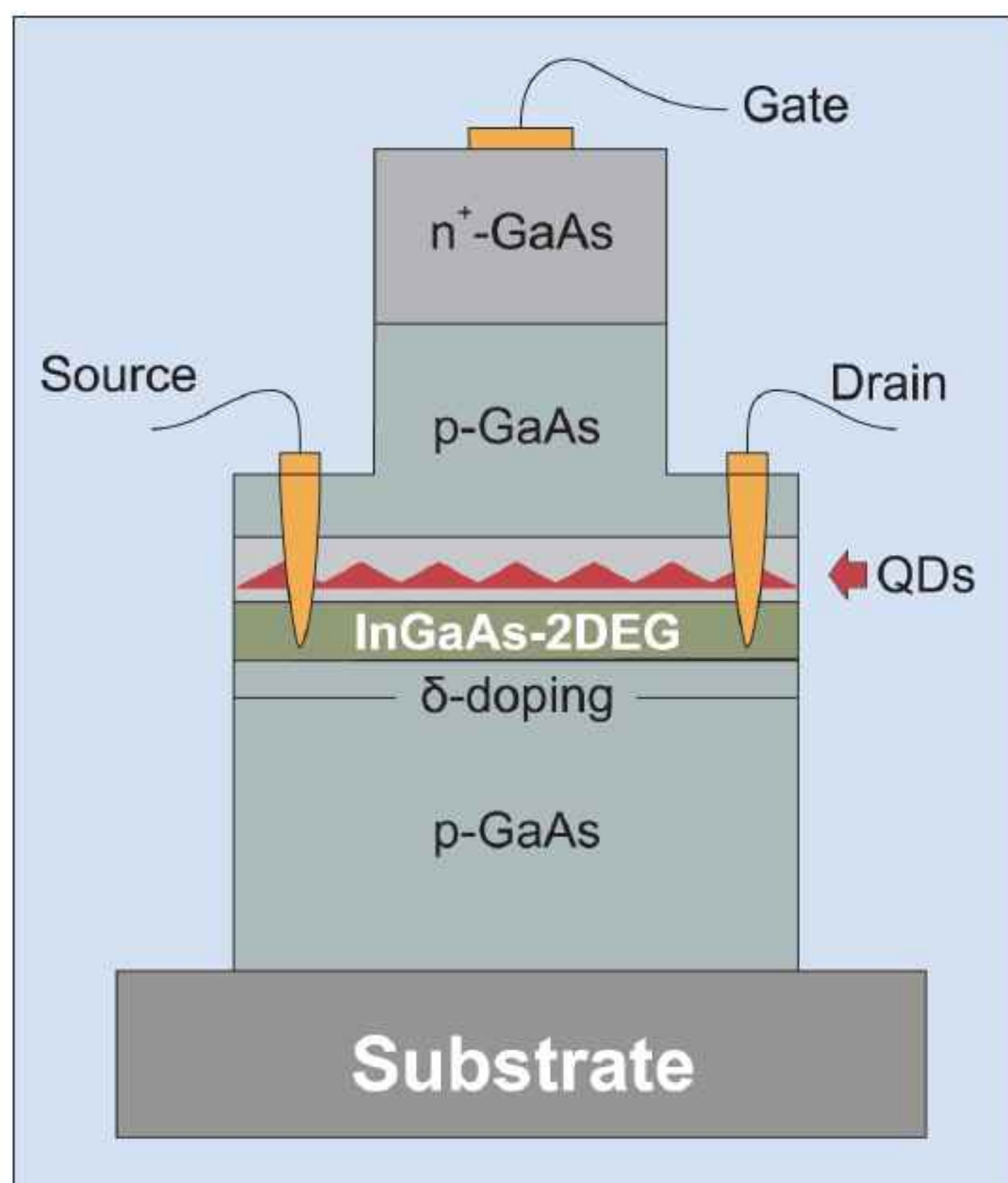


Figure 5. Schematic of quantum dot memory structure used by professor Bimberg's group at TU Berlin.

France's CEA-Leti [3] in the last couple of years that the deposition process is not completely random.

"During the formation of Si-NCs through chemical vapor deposition, a Si-free denuded zone forms around each dot, due to the diffusion of Si atoms on the substrate," says Rosaria Puglisi of CNR-IMM. "This denuded zone limits the number of available nucleation sites, the density of the dots, their size and relative distance, thus making the nucleation a non-random process."

Puglisi and her colleagues describe the state as being partially self-ordered. Compared with the assumption of a random Poisson distribution, the research finds that the presence of a denuded zone surrounding each dot leads to less dispersion from bit to bit of the surface coverage.

"This implies much more favorable projections concerning the ability of the nanocrystal memory concept to meet the scaling targets of future nodes," says Puglisi. "Experimental data on memory window dispersion fully support such a picture."

Another direction taken by CNR-IMM/ST with Belgium's IMEC, CEA-LETI and the University of Pisa has been to put SONOS and silicon nanocrystal charge storage layers into double-gated and triple-gate FinFET structures (Figure 4) [4]. In mainstream CMOS logic, multi-gated transistor devices are designed to reduce 'short-channel effects', allowing better electrostatic

control of the channel. Double-gate devices are expected in about 2011. For Flash, such improved control could be used to improve threshold voltage windows. The CNR-IMM/ST research is aimed at pushing the scaling of Flash memories beyond the 28nm technology node (2015 and after). It is believed that channel lengths down to 10nm may be possible.

Enter III-Vs and quantum dots

While most Flash research focuses on increasing bit densities, some are looking to increase operating speeds towards those of magnetic hard drives and even DRAM. Although this work is still predominantly carried out in silicon, the research group of professor Dieter Bimberg at the Technische Universität Berlin (TU Berlin) is looking to use the much broader capabilities of III-V semiconductor materials for creating near-DRAM performance.

One of the researchers in this group, Martin Geller, comments: "The big advantage of III-V semiconductors, in contrast to group IV materials like Si or Ge, is on the one hand the much better crystalline quality of heterostructures, and on the other the possibility of 'band-structure engineering'.

For band engineering in Si-based electronics, you are limited by the small number of material combinations of Si, SiO₂, SiN, Ge and a limited number of fixed band offsets. III-V materials have many more combinations — such as GaAs, InAs, GaSb, InSb, AlAs,... — not to mention more complex systems like InGaAs, AlGaAs,... These offer much greater potential for solving the long-standing problems of Flash, such as endurance and write/erase times. So, while at the moment every memory proposal that is not based on Si is viewed with skepticism, this may change in the future."

Defects will become a big problem in future memory devices based on 'incoherent' Si or NC material. At highly shrunk feature sizes, leakage currents through defect states become a major obstacle. Here, self-organized coherent materials will be at an advantage.

Professor Bimberg reports that his group already has some connections with industry partners. Along with researchers at Istanbul University in Turkey, TU Berlin has developed quantum dot (QD)

Dieter Bimberg at the Technische Universität Berlin is looking to use the much broader capabilities of III-V semiconductor materials for creating near-DRAM performance

TU Berlin has developed quantum dot (QD) memory structures with writing times of the order of 10ns

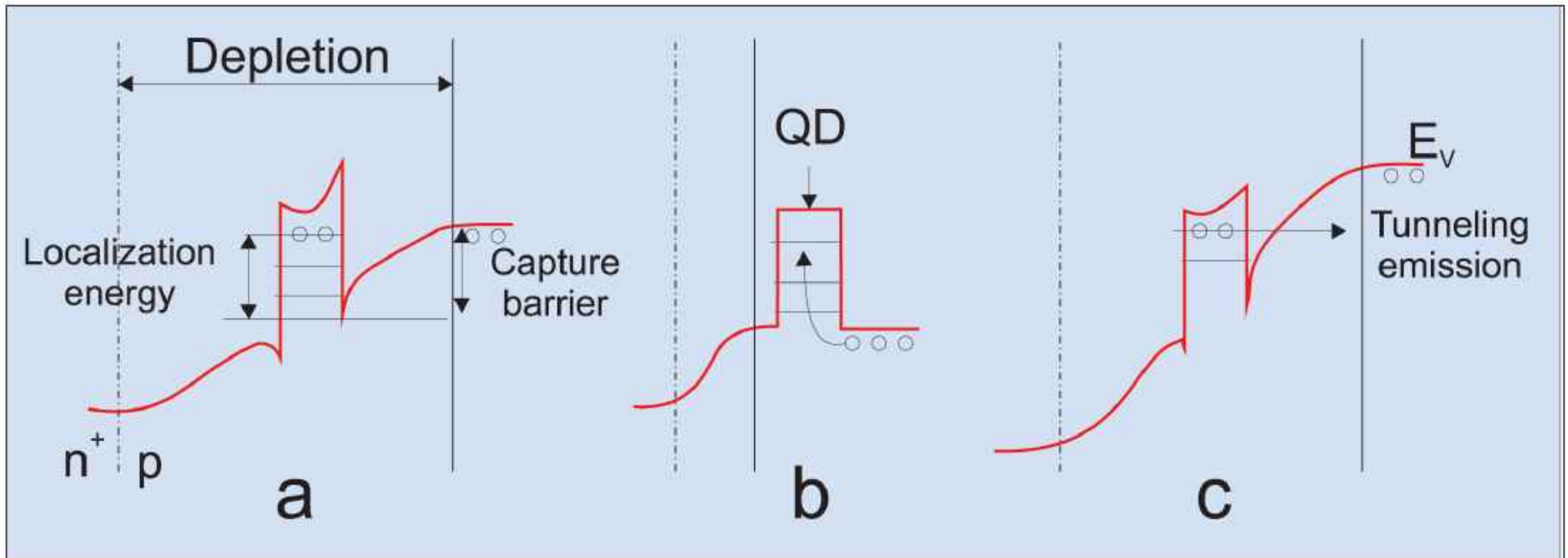


Figure 6. Structure of valence band for biases designed for storage (a), write of hole charge into quantum dot (b), and erase (c). Holes 'float' up to reduce electron energies.

memory structures (Figure 5) with writing times of the order of 10ns [5]. One QD structure had a write time as small as 6ns, while another arrangement was somewhat slower (14ns). Although these devices are limited by the experimental setup and by the cut-off frequencies of RC parasitics, the researchers hope to be able to use the concept to achieve even faster memory write/erase, based on picosecond charge-carrier relaxation times. These speeds compare extremely favorably with Flash's millisecond scale.

The fastest QD memory device was constructed from indium arsenide (InAs) embedded in a p-doped gallium arsenide (GaAs) layer, while the other was based on gallium antimonide (GaSb) embedded in GaAs. QDs are islands of the order of 10–50nm in diameter that 'grow' into more or less pyramidal shapes by self-organization due to the strain caused by the different lattice constants of the materials. An n-doped GaAs layer is then deposited on top of the QDs. The QDs measure about 15nm across. The estimated possible storage density of such devices is about 1TeraByte (1000GB)/inch² or ~160Gbits/cm².

One difference from normal Flash is that in the new QD device the barrier height that retains the charge is varied by using electrical means. A further difference is that, by growing the dots in the depletion region of a pn junction, it is holes that are stored in the QDs. By changing the bias on the depletion region, one can easily vary the barrier height, enabling either retention or the insertion of charge into the QD (Figure 6). Charge removal (erase) is achieved by using tunneling. The read mechanism is similar to that of Flash memory.

One difference from normal Flash is that in the new QD device the barrier height that retains the charge is varied by using electrical means

There is also a hope that QD-based memory will be more robust in terms of memory retention and long-term reliability. A study by the group on hole emission from InAs/GaAs QDs across a Al_{0.9}Ga_{0.1}As barrier, combined with a theoretical extrapolation to other QD systems, suggests that GaSb in an AlAs matrix could yield a storage time of more than 1 million years [6]. A different GaSb/AlAs composition may be needed to give a write speed faster than DRAM.

A study by the group on hole emission from InAs/GaAs QDs across a Al_{0.9}Ga_{0.1}As barrier, combined with a theoretical extrapolation to other QD systems, suggests that GaSb in an AlAs matrix could yield a storage time of more than 1 million years

It is also possible to produce Si/Ge QDs, but TU Berlin researchers found the system to have a storage time of the order of microseconds at room temperature, and no band-structure engineering is possible to improve this significantly. Hence, Bimberg's group has dropped investigation of group-IV QDs for this application.

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Ismaning, 85737,
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Fax: +49 89 96 24 00 122

www.cscleansystems.com

EMF Semiconductor Systems Ltd

(see section 6 for full contact details)

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Tel: +44 (0)1278 420555

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www.iemtec.com

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www.saesgetters.com

11 Process monitoring and control

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Fax: +1 734 668 4663

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Fax: +49 30 3180 8237

www.laytec.de

Optical Reference Systems Ltd

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www.wepcontrol.com

12 Inspection equipment

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www.suss.com

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Fax: +1 512 231 8183
www.epak.com

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www.gelpak.com

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www.williams-adv.com

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Fax: +41 329257115
www.ismeca.com

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Fax: +1 603 518 3298
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Kulicke & Soffa Industries
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Fort Washington, PA 19034,
USA
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www.kns.com

Palomar Technologies Inc
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Fax: +1 760 931 5191
www.PalomarTechnologies.com

17 Assembly/packaging foundry

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San Diego, CA 92127,
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Fax: +1 8586 74 4681
www.quikicpak.com

18 Chip foundry

Compound Semiconductor Technologies Ltd
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www.sslchina.org

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Tokyo, Japan

E-mail: pvj@semi.org

www.pvjapan2008.org/PVJAPAN.var

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15th International Conference on MBE

University of British Columbia, Vancouver, Canada

E-mail: erin.gendron@ubc.ca

www.mbe2008.ca

31 August – 5 September 2008

NUSOD '08: 8th International Conference on Numerical Simulation of Optoelectronic Devices

University of Nottingham, UK

E-mail: eric.larkins@nottingham.ac.uk

www.nusod.org/conf08

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10th China International Optoelectronic Exposition (CIOE)

Shenzhen Convention & Exhibition Center, China

E-mail: nancy@cioe.cn

www.cioe.cn

7–11 September 2007

9th International Conference on Mid-Infrared Optoelectronics: Materials and Devices (MIOMD-IX)

Freiburg, Germany

E-mail: info@miomd-9.de

www.miomd-9.de

14–18 September 2008

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Sorrento, Italy

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www.ieee.org/organizations/society/leos

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Solid-State Circuits Research – 34th European Conference (ESSCIRC-2008)

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21–24 September 2008

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E-mail: iscs2008@iaf.fraunhofer.de

www.iscs2008.com

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San Diego, CA, USA

E-mail: amueller@intertechusa.com

www.ahpsl-conference.com

6–10 October 2008

IWN2008 (5th International Workshop on Nitride Semiconductors)

Montreux, Switzerland

E-mail: iwn2008@epfl.ch

<http://iwn2008.epfl.ch>

7–9 October 2008

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New Trade Fair Centre Stuttgart, Germany

E-mail: ljaeth@semi.org

www.semi.org

12–15 October 2008

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Monterey, CA, USA

E-mail: s.kingston@ieee.org

www.csics.org

13–17 October 2008

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E-mail: info@solarelectricpower.org

www.solarpowerconference.com

16–17 October 2008

LED Japan/Strategies in Light

Tokyo, Japan

E-mail: tcarli@strategies-u.com

<http://sil08.events.pennnet.com>

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