

LEDs driving MOCVD boom Using polarization in nitrides



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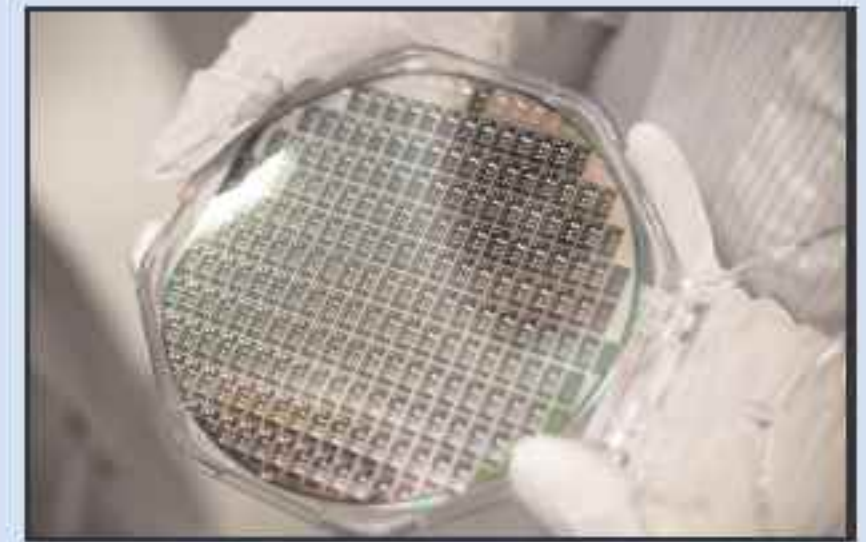
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Editorial	2
News	
Markets	4
LED market to grow to \$14.8bn by 2015	
Microelectronics	8
Anadigics celebrates 25th anniversary • Inphi opens UK Design Center • Better, smaller source/drain contacts for III-V logic	
Wide-bandgap electronics	20
Nitronex raises \$16m for expansion	
Materials and processing equipment	25
Precision Flow Technologies to double staffing • Atlumin and Floridienne partner • SAFC Hitech appoints new president • JPSA expands	
LEDs	38
Taiwan LED makers expand to meet backlighting demand • Cree's XLamp XM claims 160lm/W record • Osram's UX:3 chip boosts power	
Optoelectronics	48
Tilting at higher laser temperature stability	
Optical communications	62
MIT reports first room-temperature germanium laser • Leti demos CMOS-compatible laser source • News from OFC 2010	
Photovoltaics	62
Amonix raises \$129.4m • EU project PRIMA aims to boost efficiency • Chevron starts project to test thin-film PV technologies	
Market focus: Sapphire	70
Sapphire market to exceed \$200m in 2010 despite downturn Yole Développement surveys the sapphire substrate market.	
Market focus: MOCVD	72
Material shortages take the edge off LED boom Strategy Analytics forecasts greater competition among reactor makers.	
Technology focus: Advanced silicon	74
Tyndall claims first junctionless transistor 'Wedding ring' gate around silicon nanowire targets sub-10nm CMOS.	
Technology focus: Nitride transistors	76
Seeking ultra-low ohmic path to high-frequency nitride transistors Low contact resistance targets sub-micron HEMTs with recessed gates.	
Technology focus: Nitrides	78
Polarization technology for HEMTs and LEDs Techniques for using spontaneous and strain-dependent polarization electric fields in nitrides to positive effect in transistors and LEDs.	
Technology focus: UV LEDs	82
Going deep for UV sterilization LEDs Progress on shortening wavelength of commercial LEDs to 250nm.	
Suppliers' Directory	90
Event Calendar	96
Advertisers' Index	96



p13 Anadigics ringing the closing bell at the NASDAQ Stock Market to celebrate its 25th anniversary.



p52 MIT has fabricated the first room-temperature direct-bandgap Ge-on-Si laser, which emits via an edge-emitting waveguide at about 1.6µm.



p67 Chevron's three-year Project Brightfield is to compare seven PV technologies, including Sharp, CdTe firm Abound, CIS firm Solar Frontier, and CIGS firms MiaSolé and Solibro.



Cover: PT Tricomm Aerocitra's Solarens lighting fixtures at a toll booth on Indonesia's first LED-lit toll road, which uses Golden DRAGON Plus LEDs from German LED-maker Osram Opto Semiconductors in 307 road lamps along road sections plus 126 lamps in eight toll gate stations. **p44**

Demand outstripping supply while capacity ramps

The upcoming annual CS MANTECH event (this year in Portland, Oregon) provides an opportunity not just for networking but also taking stock of progress in technology and business development since the last event.

This time last year, the compound semiconductor industry was emerging from one of its worst-ever quarterly dips in Q1/2009, with revenues for many firms (in both RFICs and optical communications) falling 15–30% or more (even worse than the 15% average drop in revenue in Q4/2008),

Since then, all sectors have seen more-rapid-than-expected and sustained recoveries, with many firms' revenues in Q3 or Q4/2009 rebounding back above their former levels. For RFIC makers in particular, Q1/2010 revenues (to be reported in detail next issue) show large year-on-year recoveries (51% for RFMD, 38% for Skyworks, 52% for TriQuint, 43% for Anadigics). Meanwhile, driven by the uptake of LEDs in large numbers in LCD backlights for laptops and TVs, LED maker Cree has reported 78% year-on-year revenue growth.

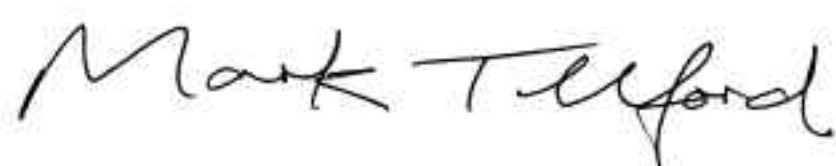
Supplying MOCVD reactors for both microelectronic and optoelectronic applications, both Aixtron and Veeco grew revenue year-on-year by a massive 234% and 160%, respectively (with the latter's MOCVD-related LED & Solar revenues up more than five-fold), as expanding and newly founded Asian LED makers in particular place large-scale orders. Indeed, according to trade organization SEMI, Asia — which already has the vast majority of the world's 91 LED fabs (including 40% of them in Taiwan) — will account for most of the 11 new LED fabs worldwide in 2010–2011 (see page 5). Taiwan is expected to add more than 100 MOCVD reactors this year, while in Korea Samsung alone is adding 50.

According to market research firm Strategy Analytics in the article on page 72, more than 250 new MOCVD reactors will come on-line in Taiwan and Korea this year. To meet global demand, Aixtron can assemble 100 systems per quarter now and targets 150 per quarter by end 2010, while Veeco targets capacity of 120 per quarter by late 2010, suggesting combined annual capacity of more than 1000 systems in 2011.

Such expansion may help to alleviate shortages in LED chips. However, in the meantime, the supply of materials, including both metal-organic (MO) precursor chemicals and substrates, may present greater constraints, according to Strategy Analytics. After previous pricing pressure, MO suppliers have been deterred from risking investment. Consequently, demand for trimethylgallium (TMG) now outstrips supply by as much as 40%, leading to price rises.

Likewise, with prices of sapphire wafers already having risen by 20% in Asia, a shortage of the substrates is forecast for second-half 2010 by not only Strategy Analytics but also Yole Développement (see article page 70). However, Yole reckons that sapphire shortages will ease in early 2011 as suppliers ramp up capacity, aided by the continuing migration from 2" to 3" and 4" sapphire (and 6" by Samsung and Showa Denko in a few years).

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

Regular issues contain:

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

Semiconductor Today (ISSN 1752-2935) is published free of subscription charge in a digital format 10 times per year by Juno Publishing and Media Solutions Ltd, Suite no. 133, 20 Winchcombe Street, Cheltenham GL52 2LY, UK. See: www.semiconductor-today.com/subscribe.htm

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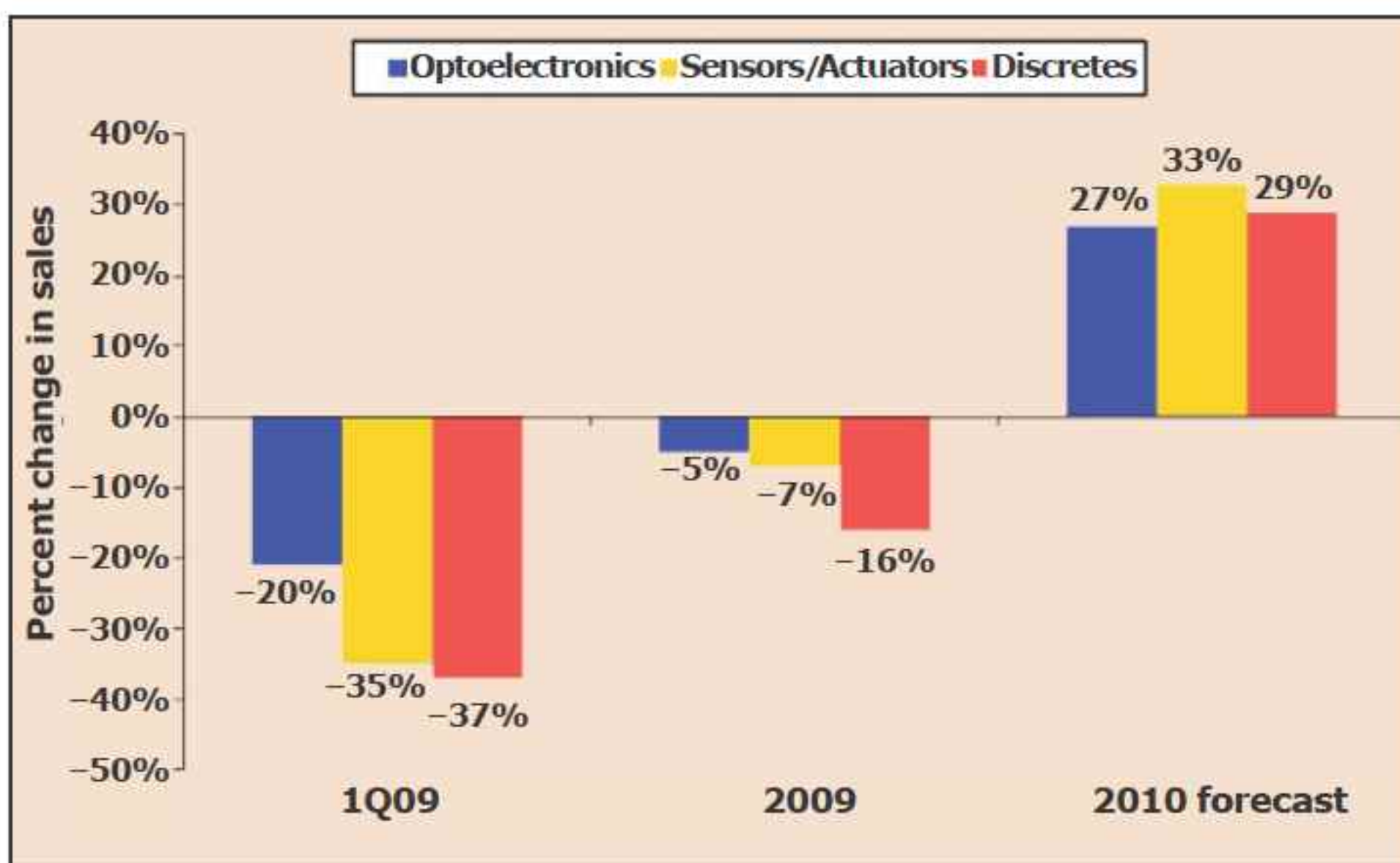
Opto, sensors and discretes to hit record sales in 2010

After an horrific first-quarter 2009, semiconductor sales of optoelectronics and solid-state sensor devices staged dramatic turn-arounds and finished the full year with declines of just 5% and 2%, respectively, from record revenues in 2008, according to market research firm IC Insights Inc's '2010 Optoelectronics, Sensors, and Discretes (O-S-D) Report' (which excludes integrated circuit sales).

In particular, the optoelectronics market was aided by continued double-digit growth of LED sales throughout the 2009 downturn year due to strong demand for high-brightness devices in LCD-TVs and new solid-state lighting applications. Consistently higher growth rates enabled optoelectronics sales to exceed discretes by more than \$3bn in 2009, after exceeding them for only the first time in 2008 (and being only a quarter to a half the dollar volume of discretes in the 1980s and 1990s).

Recoveries in discrete semiconductors and actuator devices were also impressive in the final three quarters of 2009, but those market segments still fell by 16% and 12%, respectively, in 2009.

The turnaround in 2009 was driven mostly by the replenishment of inventories at systems manufacturers once their markets stabilized following the sharp falloff in product demand in the depth of the 2008–2009 recession. In almost all O-S-D product categories, sequential quarterly sales growth rebounded in Q2/2009 by 20–40% from the economically depressed levels in Q1/2009. Those increases continued through the rest of the year, turning 2009 into a modest setback for optoelectronics and the sensor/actuator markets. However, the discretes market segment—including power transistors—faced a greater uphill climb out of the early slump in 2009 and finished the year



Q1 sales slumps and full-year performance in 2009, and 2010 forecast for O-S-D market segments.

with a decline of 16%—its second worst drop in 25 years behind the 25% plunge in the 2001 semiconductor recession. In particular, power transistors now account for 55% of revenues generated by discretes, with 42% coming from MOSFET and IGBT products in 2009.

Strong recovery momentum is expected to continue in 2010 with optoelectronics, sensors/actuators, and discretes markets all reaching record revenues, with combined O-S-D revenues rising 29%—the highest one-year increase since early last decade. Optoelectronics will rise 27% to \$23.3bn, sensors/actuators 33% to \$6.8bn, and discretes 29% to \$19.7bn. Within the sensors/actuators segment, sales of devices made with micro-electro-mechanical systems (MEMS) technology are forecast to grow fastest of all, at 34% to \$5.6bn in 2010, after declining 5% in 2009 to \$4.2bn.

In 2010, the strong sales growth in optoelectronics, sensors/actuators, and discretes will be driven by the ongoing recovery in demand for portable electronics, consumer products, high-speed networks,

notebook PCs, cell phones, industrial & medical equipment, and automotive systems, according to the report. During the 2009–2014 forecast period, combined O-S-D sales are expected to rise at a compound annual growth rate (CAGR) of about 13%, compared to 12% for IC sales, driven by the greater growth rates for MEMS-based accelerometers, gyroscope devices, actuators, pressure sensors, high-brightness LEDs, CMOS image sensors, and optical-network laser transmitters.

By 2014, optoelectronics sales are expected to exceed discrete revenues by nearly \$10bn, with strong growth being driven by image sensors, LED-based solid-state lamps, and laser transmitters for fiber-optic networks. In particular, CMOS image sensors have overtaken CCDs in total revenue and are forecast to represent 71% of units in the image sensor market by 2014.

Overall, O-S-D revenues will account for 17% of the total \$419bn semiconductor market in 2014, it is forecast, compared to 16% of \$238bn in 2009 and about 13% a decade ago.

www.icinsights.com

LED industry entering fast growth stage in 2010

SEMI sees at least 11 new opto/LED fabs in 2010–2011

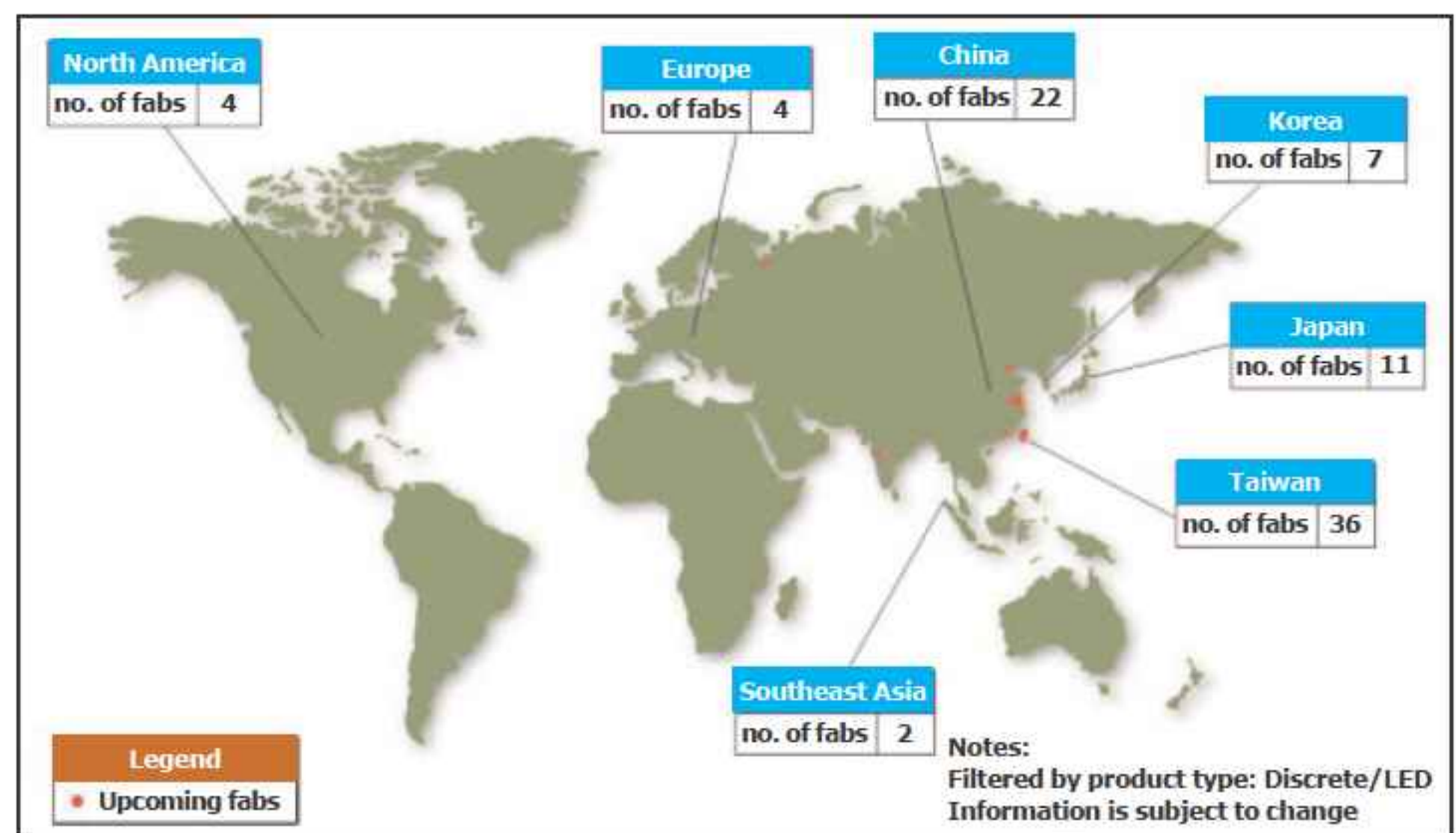
Driven by applications like LED-backlit TVs and solid-state lighting, expansion in LED manufacturing and new facility projects have mushroomed worldwide, according to Clark Tseng (senior manager market analyst, SEMI Taiwan) in SEMI's 'Opto/LED Fab Watch database', which tracks about 180 fabs worldwide (91 LED; 89 opto-related). Japan has the most opto/LED fabs overall, but the regions with the most LED fabs are Taiwan (with as much as 40%), Japan and China.

Even in the downturn of 2009, seven new LED fabs came online, while SEMI expects at least five new opto/LED fabs in 2010 and six more in 2011, respectively, mostly in China and Taiwan but also in Japan, India, and Russia too.

While Taiwan has the largest capacity share of LED manufacturing, Epistar and many other Taiwanese LED epitaxy/chip-makers still plan to expand their capacity this year to meet rising demand that is 20–30% above existing LED supply, says Tseng. New MOCVD system additions this year in Taiwan are expected to exceed 100 units. However, the bottleneck and hence lengthening lead-times for MOCVD system delivery may bring uncertainty to capacity expansion plans, says Tseng.

LED chip consumption is being driven by LED-backlit displays, with aggressive investment plans seen recently from leading LCD panel suppliers. In Korea for example, due to strong internal demand for LED-backlit modules, Samsung LED plans its fastest ever LED capacity expansion by installing an extra 50 MOCVD tools, raising its total to an estimated 150 by year-end, reckons Tseng.

On the other hand, Taiwan's LCD panel makers are rapidly moving upstream. AU Optronics' LED subsidiary Lexstar is planning a fast expansion this year after its recent merger with LED packaging firm and



Dedicated LED fabs. Source: SEMI Opto/LED Fab Watch Database 2010.

fellow AUO subsidiary Lighthouse. Also, New Chimei Innolux Corp will continue its investment along the LED supply chain, where they already have Chi Mei Lighting Technology for epitaxy and GIO Opto and Advanced Optoelectronic Technology for packaging.

These new investments by panel makers are derived from wanting to secure their own supply of key components and also building closer vertical integration along the supply chain. However, this may represent a challenge in the long term to dedicated LED epitaxy/chip-makers, which will be vying for the same market segment with these big LCD panel makers, says Tseng. But SEMI still does not expect to see any oversupply of LEDs in the near future, as LED backlighting is boosted from both the rate of adoption of LEDs in panels and also from the growth of large panel shipments.

The fast-growing LED market has also caught the attention of leading semiconductor firms, notes Tseng. In late March, Taiwan Semiconductor Manufacturing Co Ltd (TSMC), the world's biggest silicon foundry, announced its entry into the LED sector by breaking ground on construction of an LED lighting R&D center and wafer fab in Hsinchu-

based Industrial Science Park. Investment in plant and equipment is expected to reach NT\$5.5bn (\$170m) in the first of two phases (with equipment move-in scheduled for fourth-quarter 2010 and volume production for first-quarter 2011). This is small relative to TSMC's planned total capital expenditure of \$4.8bn this year. However, this brings the LED market to a new level where one may see more large companies or conglomerates entering the sector, says Tseng.

Despite all these new LED investments emerging, leading LED chip maker Nichia of Japan is poised to maintain its leadership in the LED industry, reckons Tseng, since it announced plans to quadruple its LED production with a new fab currently under construction and expected to come on-stream in early 2012.

"We do see some similarity of LED industry compared to the early stage of semiconductor industry," comments Tseng. "The LED industry is set to enter the growth stage of its life cycle," he adds.

"Moving forward, we expect to see more global firms enter that LED industry supply chain, and this will help to bring down costs and improve productivity."

www.semi.org

GaN power management chip market \$183m by 2013

Driven by rapid growth in the high-end server, notebook, mobile handset and wired communication segments, the gallium nitride power management semiconductor market will rise from virtually nil in 2010 to \$183.6m by 2013, according to market research firm iSuppli.

"The technology represents an attractive market opportunity for suppliers by providing their customers with capabilities that may be out of the reach of present semiconductor process materials," says analyst Marijana Vukicevic.

iSuppli says that, in the past two years, several events have made GaN the rising star in power management semiconductors. First, the use of silicon has reached its practical limits in power management. Also, there have been major breakthroughs in growing GaN layers on silicon. Power designers also want to develop more efficient systems and to update their high-voltage products to waste less electricity.

Component suppliers have recently begun offering GaN parts. For example, power semiconductor device maker International Rectifier Corp of El Segundo, CA, USA



GaN power management semiconductor revenue (US\$m).

released its first GaN technology-based point-of-load (POL) solutions in February, while Efficient Power Conversions Corp (EPCC), also of El Segundo, is placing all its bets on GaN technology, releasing 10 power MOSFET devices this month.

The adoption of GaN devices will be driven by the improved efficiency and small form factors enabled by the material, reckons iSuppli. Such benefits are in particularly high demand for portable electronic products (e.g. mobile PCs and smart phones) as well as providing advantages for power-hungry electronic equipment such as enterprise servers and wired communications infrastructure equipment.

"As the technology advances and the cost of manufacturing GaN technology drops in 2012 and 2013, the technology will begin to steal market share away from conventional MOSFETs, driver ICs and voltage regulator ICs," forecasts Vukicevic.

"First adoption of GaN devices most likely will be among servers, which always demand high-performance devices and often are one of the first product areas to accept new technologies that improve performance," she adds. "Over the next three years, the bulk of device volume likely will be driven by notebooks, as the power savings and smaller form factor delivered by GaN will be in high demand."

www.isuppli.com

However, adoption of GaN technology for these applications in 2010 and 2011 will be slow due to the high cost of parts using the material, says iSuppli.

LED market to grow to \$14.8bn by 2015

The LED market will grow rapidly to \$14.8bn by 2015, driven by demand for efficient and larger electronic displays for TVs, lighting fixtures, notebooks and mobile handsets, according to 'Light Emitting Diode (LED): A Global Market Report' from Global Industry Analysts Inc (GIA). The focus on energy conservation is also expected to promote the uptake of LEDs in residential and commercial sectors.

Although high prices restricted the initial use of LEDs to a small group of applications (decorative lighting, exit signs, architectural lighting and entertainment lighting), the LED market is now relatively broad in terms of end-use and encompasses notebook PCs, LCD TVs, residential

and commercial lighting, handsets, and signals and displays, says GIA. Improvements in luminous efficacy and application technologies for LEDs led to their use in backlights, landscape lighting, traffic lights, and automobile lights. Also, due to rising environmental concerns, most governments are focusing on phasing out incandescent lights and replacing them with LED lights.

Short-term growth is likely to be propelled by the growing popularity of LED TVs and notebooks, while the general lighting segment is expected to drive market growth in the long run, says the report. Mobile phones emerged as the leading end-use market (with more than 25% share of value sales for

2009), while LCD TV is expected to post the fastest growth in terms of volume sales. The market is also expected to benefit from rapid technological advancements that are expected to bring down the number of chips per box as well as the average selling price of LEDs.

Although the global economic crisis impacted the LED market significantly in 2009, leading to a sales decline in major LED end-use sectors such as mobile phones, large outdoor displays and automotive, the decline was partly offset by the increasing use of LEDs in segments such as backlights for notebook PCs and LCD TVs, apart from the lighting sector, concludes the firm.

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RF71xx passes 100m

RFMD has surpassed 100 million units in shipments of its RF71xx family of 2G dual- and quad-band transmit modules in under a year, making it one of RFMD's most successful launches.

"The rapid success of the RF71xx family of transmit modules highlights RFMD's sharp focus on product leadership and the strength of our customer diversification efforts, particularly among handset makers in Asia," says Cellular Products Group president Eric Creviston. "RFMD continues to develop new product derivatives of the RF71xx family, and we expect ongoing design win activity and market share gains in emerging markets across handset manufacturers and global platform providers."

Each product is designed to meet the front-end needs of emerging-market handsets, including reduced size, improved efficiency and ESD protection. Modules are pin-to-pin compatible across the entire family, enabling users to produce dual-, tri- or quad-band GPRS or EDGE handsets from a single platform (an industry first).

RFMD tops ranking of cell-phone PAs and front-end modules

RF Micro Devices Inc of Greensboro, NC, USA has maintained its number one position as both worldwide leading supplier of mobile phone power amplifiers and front-end modules, as well as the leading supplier of mobile phone RF devices in 2009 (based on revenue), according to Gartner Dataquest's report 'Market Share Analysis: Mobile Phone Application-Specific Semiconductors, Worldwide, 2009'.

Dataquest also says that RFMD was the world's 8th largest supplier of overall cell-phone application-specific semiconductors in 2009 (based on revenue). RFMD's 2009 revenue in the category grew to \$712m, highlighting it as one of only four firms in the report to achieve year-on-year growth in the category.

"Dataquest's independent research findings highlight RFMD's product leadership and the continued success of our customer diversification efforts," comments Eric Creviston, president of RFMD's Cellular Products Group (CPG). "We are committed to expanding our leadership position in cellular RF components by delivering breakthrough prod-

ucts and leveraging our relationships with the world's top-tier mobile device manufacturers and cellular platform providers."

RFMD says that it is capitalizing on major global secular growth trends and continues to enjoy strength in

RFMD was the 8th largest supplier of cell-phone application-specific semiconductors in 2009

CPG, supported by strong 2010 handset unit volumes, expanded participation across customer and channel partner programs, and increasing adoption of connected devices (including smart phones and

3G devices). Also, RFMD's Multi-Market Products Group (MPG) is seeing a broad-based recovery across its diversified end-markets, led by applications in smart energy AMI (advanced meter infrastructure), defense and power, point-to-point backhaul, WiMAX/WiFi CPE, electronic toll collection in China, and catalog/standard products.

www.rfmd.com

www.gartner.com

RFMD adds single-chip ISM-band variable-data-rate FSK transceiver with integrated PA for data-intensive wireless media applications

RF Micro Devices has launched the ML2730, a single-chip, fully integrated 2.4GHz frequency shift keyed (FSK) transceiver with integrated power amplifier (PA) and low-noise amplifier (LNA) and selectable data rates (576kbps, 1.152Mbps, 1.536Mbps, 1.755Mbps and 2.048Mbps) in a 40-pin QFN package (6mm x 6mm x 0.9mm).

Expanding RFMD's portfolio of ISM-band single-chip transceivers covering 900MHz, 2.4GHz and 5.8GHz, the ML2730 is optimized for a variety of wireless media applications (audio, video and data) operating in the 2.400-2.485GHz unlicensed ISM (industrial, scientific

& medical) band. The transceiver is mode selectable for operation with digital cordless phones (DSSS-DCT or DECT) and higher-data-rate (up to 2.048Mbps) streaming applications like wireless audio and video, and is suitable for a variety of radio-controlled applications.

The ML2730 incorporates a dual-conversion, low-IF receiver with all channel selectivity on chip. IF filtering, IF gain, and demodulation are performed on-chip, eliminating external IF filtering or production tuning. A post-detection filter and a data slicer are integrated to complete the receiver.

The transmitter uses an adjust-

ment-free closed-loop modulator, which modulates the on-chip VCO filtered data. It includes an up-conversion mixer, a buffer/pre-driver, and a PA to yield a typical output power of +21dBm. A fully integrated fractional-N synthesizer is used in both receive and transmit modes.

Power supply regulation is also incorporated, providing circuit isolation and consistent performance over supply voltages of 2.8-3.6V.

By integrating the PA and LNA on a single chip, the ML2730 enables users to develop robust wireless links with improved sensitivity and output power while reducing both costs and board size, says RFMD.

RFMD features Ember ZigBee technology in FEMs for smart energy

RF Micro Devices has teamed with Ember Corp of Boston, MA, USA to introduce ZigBee front-end modules (FEMs) for smart grid applications that give utilities and consumers more control over how they monitor and save energy. ZigBee is a global wireless networking standard for monitoring and control in applications such as energy management, safety and security, lighting and appliances.

RFMD says that its new ZigBee FEM product family enables customers to bring new ZigBee products to market faster, while dramatically reducing the number of components required and the size, cost, and power consumption of smart grid FEMs.

While the firm's newest FEMs can be used with any ZigBee application, the product family initially targets smart grid and smart energy applications such as smart meters, demand response, and home area network (HAN) devices. Beyond smart energy, they are also designed for industrial applications and any other wireless sensing and control applications that demand low power consumption, high performance and proven reliability.

The new ZigBee FEM family includes the RF6525, RF6515, and RF6535, which are optimized to operate with the Ember EM300 Series system-on-chips (SoCs) — EM351 and EM357 — as well as Ember's EM250 SoC and EM260 network co-processor.

The EM300 Series is Ember's next-generation ZigBee chip family, and the world's first ARM Cortex-M3 based ZigBee SoC, packing what is claimed to be the industry's highest wireless networking performance and application code space into the lowest power-consuming chip-set. The EM250 and EM260 ZigBee are the most deployed family of ZigBee semiconductors, delivering high RF performance, sensitivity and transmit power for long range and 802.11 immunity.

"RFMD and Ember are leveraging each other's expertise to deliver high-performance, highly integrated ZigBee solutions that reduce design cycle times, lower costs, and accelerate time-to-market," says Bob Van Buskirk, president of RFMD's Multi-Market Products Group (MPG). "Large-scale smart energy projects are forecast to grow rapidly, with particular demand anticipated in low-power wireless IC technologies like ZigBee," he adds.

"RFMD anticipates our collaboration with Ember will directly benefit our smart energy customers while supporting continued growth in the burgeoning smart energy marketplace," Buskirk continues. "These diversification efforts, and RFMD's other diversified growth initiatives currently underway, highlight the embedded value in our strategic mission to extend and leverage our leadership in RF components and compound semiconductors into multiple industries."

"By teaming with RFMD we are further simplifying ZigBee development for OEMs and bolstering our partner ecosystem to include a global leader in high-performance RF components," says Ember's CEO Bob LeFort. "Fine tuned to work with the Ember platform, RFMD's ZigBee FEMs deliver impressive size reduction and outstanding performance, thereby enabling faster, easier development of smart energy products worldwide," he comments.

Ember's ZigBee networking systems (chips, ZigBee protocol software and tools) simplify the complexity of integrating embedded software, networking and RF for developing low-power, wireless products in smart energy, connected home and other remote monitoring and control applications, the firm says. Since its inception, Ember has been future-proofing customers and partners like RFMD with advanced features.

www.ember.com

Skyworks releases Sustainability Report

Skyworks has released its 2009 Sustainability Report, a voluntary document that addresses its commitment to operating under business practices that help to protect the needs of future generations and minimize its environmental impact. Skyworks says that the report also highlights improvements that it has made in multiple areas, ranging from environmental to labor, health and safety, ethics, and business management systems.

Since 2005 (the initial reporting year), Skyworks has improved energy efficiency by 26%, water efficiency by 44%, and hazardous waste efficiency by 84%. CO₂ emissions per production unit have also been cut by 10%, with further efficiency improvements expected in the coming years, particularly given the shift in 2009 away from manufacturing processes that use the most greenhouse gases.

At a higher level, in 2009 more than 99% of Skyworks' product sold was environmentally preferred, or products that meet lead (Pb)-free and restriction of hazardous substances (RoHS) standards, among other global regulatory requirements. In addition, the firm's sustainability programs continue to be aligned with the multiple requirements of the Electronics Industry Code of Conduct (EICC).

"Skyworks' 2009 Sustainability Report demonstrates that smart, sustainable business practices also make good business sense," says VP of worldwide operations Bruce J. Freyman. "While many of our customers require their supply chain partners to maintain robust sustainability programs, Skyworks often exceeds these requirements, even as we continue to grow our business," says Freyman. "Our goal is to ensure that we operate in a sustainable and successful manner — respecting people and the environment."

www.skyworksinc.com/downloads/green_initiative/skyworks_sustainabilityreport.pdf

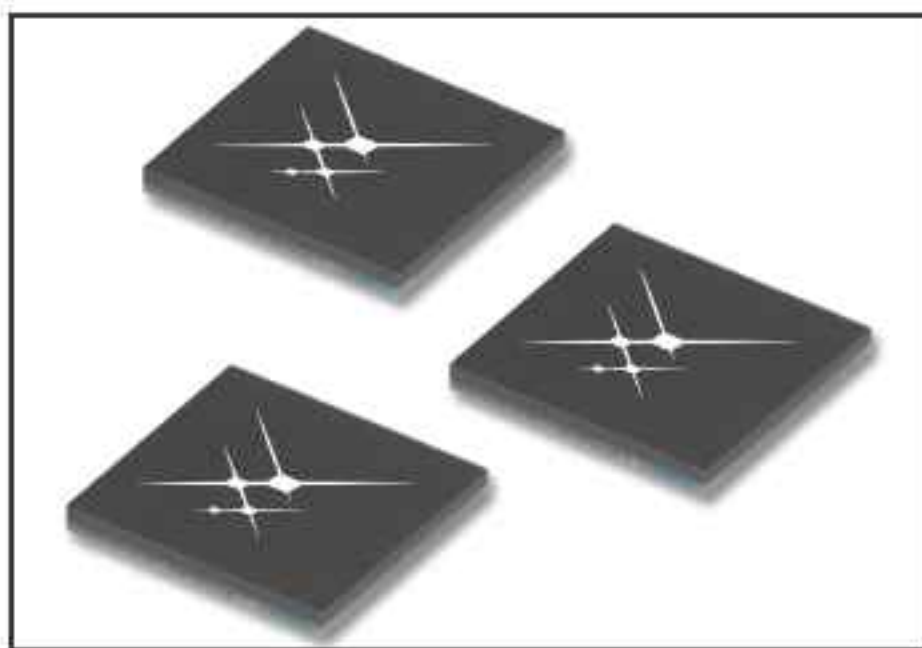
Dual-band WCDMA PA modules with integrated coupler

Skyworks Solutions has introduced three 4mm x 5mm dual-band WCDMA power amplifier modules (PAMs) with an integrated directional coupler, eliminating the need for any external couplers.

Only two decoupling caps are needed outside the PA, making it a very clean and easy design/layout, says the firm. Additional benefits include the same pin-out for all three devices, allowing single-phone-board support of multiple frequency combinations, and an internal daisy chain coupler with a single CPL out port.

The single gallium arsenide monolithic microwave integrated circuit (MMIC) contains all active circuitry in the module. The MMIC contains on-board bias circuitry, as well as input and inter-stage matching circuits. Output match into a 50-ohm load is realized off-chip within the module package to optimize efficiency and power performance.

The fully matched, 14-pad, surface-mount PAMs suit all wideband



SKY77195, SKY77196 and SKY77197.

code division multiple access (WCDMA) handset and datacard applications and enable a variety of compatible baseband/RF architectures. The modules also meet the stringent spectral linearity requirements of high-speed downlink packet access (HSDPA) data transmission with high power-added efficiency.

- The SKY77195 has full WCDMA Band I (1920–1980MHz) and Band VIII (880–915MHz) coverage, with high power-added efficiency for power output to 27.5dBm (Band I) and 28dBm (Band VIII).

- The SKY77196 has full WCDMA Band II (1850–1910MHz) and Band V (824–849MHz) coverage, with high power-added efficiency for power output to 28.5dBm (Band II) and 28dBm (Band V).

- The SKY77197 has full WCDMA Band I (1920–1980MHz) and Band V (824–849MHz) coverage. It meets the stringent spectral linearity requirements of WCDMA transmission, with high power added efficiency for power output to 28.25dBm (Band I and Band V).

The PAMs are manufactured using Skyworks' InGaP GaAs heterojunction bipolar transistor (HBT) BiFET process, which provides for all positive voltage DC supply operation while maintaining high efficiency and good linearity. No VREF voltage is required. Power down is accomplished by setting the voltage on VENABLE to zero volts. No external supply-side switch is needed, as typical 'off' leakage is a few microamperes with full primary voltage supplied from the battery.

WCDMA PA modules with integrated daisy chain coupler

Skyworks has launched five small, low-profile 3mm x 3mm x 0.9mm power amplifier modules (PAMs) with an integrated daisy chain directional coupler for next-generation platforms, eliminating the need for any external coupler.

The single gallium arsenide monolithic microwave integrated circuit (MMIC) contains all active circuitry in the module, including on-board bias circuitry as well as input and inter-stage matching circuits. Output match into a 50-ohm load is realized off-chip within the module package to optimize efficiency and power performance.

The fully matched 10-pad surface-mount PAMs support all required modulations for a given frequency band, including CDMA, WCDMA and LTE handsets and datacards, as well as enabling a variety of compatible baseband/RF architectures. The modules meet

the stringent spectral linearity requirements of high-speed downlink packet access (HSDPA), high-speed uplink packet access (HSUPA), and long-term evolution (LTE) data transmission with high power-added efficiency, says Skyworks.

Details of the five new power amplifier modules are as follows:

- the SKY77701 has full Band I (1920–1980MHz) coverage, with efficiency of 40% at power output of 28.25dBm;

- the SKY77702 has full Band II (1850–1910MHz) coverage, with efficiency of 40% at power output of 28.6dBm;

- the SKY77703 has full Band III, IV, IX, X (1710–1785MHz) coverage, with efficiency of 40% at power output of 28.4dBm;

- the SKY77704 has full Band V (824–849MHz) coverage, with efficiency of 40% at power output of

28.25dBm; and

- the SKY77705 has full Band VIII (880–915MHz) coverage, with efficiency of 40% at power output of 28.5dBm.

The PAMs are manufactured using Skyworks' InGaP GaAs heterojunction bipolar transistor (HBT) BiFET process, which provides for all positive voltage DC supply operation while maintaining high efficiency and good linearity. Primary bias is supplied directly from any three-cell Ni-Cd, a single-cell Li-Ion, or other suitable battery with a low-voltage output of 3.2–4.2V. No VREF voltage is required. Power down is accomplished by setting the voltage on VENABLE to zero volts. No external supply-side switch is needed, as typical 'off' leakage is a few microamperes with full primary voltage supplied from the battery.

www.skyworksinc.com

Widest frequency range integrated synthesizers for 3G/4G base-stations

Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has introduced what is claimed to be the industry's first suite of high-performance broadband synthesizers spanning ultra-wide-frequency ranges from 375MHz to 5.6GHz.

Skyworks says that the SKY73134, which is designed to cover all GSM, WCDMA and LTE frequency bands with one device, supports the world's leading 3G and 4G base-station providers including Ericsson, Huawei, ZTE, Alcatel/Lucent, and Nokia/Siemens, and can deliver very stringent requirements all on a single silicon die.

The SKY73134's performance allows radio designers to support increasing levels of voice and data traffic volumes, enables design flexibility across multiple applications, and is applicable for use in microwave-link and software-defined radios. Skyworks says that, with the addition of the new synthesizer, it continues to broaden its infrastructure and linear products portfolio. At a higher level, it is also capitalizing on mobile Internet applications — supporting both handsets as well as infrastructure networks.

According to Cisco, mobile data traffic volumes are projected to increase at a compounded annual growth rate of 131% from 2008 to 2013. Mobile operators will hence need to begin to install new base-stations, routers and backhaul network equipment starting now to avoid network traffic jams and to preserve highly profitable data service revenue. Furthermore, upgrades and expansion to existing infrastructure will be needed, requiring increased analog and mixed-signal content. Skyworks says that the SKY73134 addresses these needs with one common



device for all platforms.

The new synthesizer enables users to implement a one-chip solution for all frequencies versus more than ten different discrete solutions — significantly reducing board size requirements, cost, and streamlining customer supply logistics, says Wesley Boyd, director of marketing.

The SKY73134 is a wideband integer-N frequency synthesizer with an approximate 6GHz locking range. The very small 5mm x 5mm device includes four differential voltage-controlled oscillators (VCOs) which, by applying internal VCO frequency division, continuously cover the output frequency from 0.375 to 5.6 GHz.

The integrated phase noise from 100Hz to 100kHz measures less than 0.6° RMS at 960MHz frequency. In addition, the phase noises at 100kHz, 1MHz and 3MHz frequency offsets are -115dBc/Hz, -143 dBc/Hz and 150dBc/Hz respectively, suiting GSM/EDGE, CDMA/WCDMA and LTE base-station transceivers.

The SKY73134 is controlled by a bi-directional read/write serial-to-parallel interface which allows flexible device configurations that may be locked with an external VCO or external PLL (phase-locked loop), or be used as a divider chain only. The device is also a key building block for any radio system design including backhaul, military and satellite applications that require a combination of high performance, low power and multi-purpose features.

Volume production will start in April.

IN BRIEF

Skyworks names TowerJazz Supplier of the Year

Specialty foundry TowerJazz of Migdal Haemek, Israel and Newport Beach, CA, USA has received the 2009 Supplier of the Year Award from Skyworks Solutions Inc of Woburn, MA, USA, which manufactures linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment.

TowerJazz says it received the award based on its quality, cycle time, flexibility, customer service, and cost improvements. In addition, for the second consecutive year, TowerJazz received the Skyworks' Best Supplier Award for External Foundry.

Skyworks, a TowerJazz customer since 2002, utilizes a broad set of the foundry's processes, including mixed-signal CMOS, RFCMOS, BiCMOS and SiGe BiCMOS, to develop products such as transmit/receive modules, power amplifier controllers, switch controllers, linear devices, and wireless LAN solutions.

"We applaud TowerJazz on its continued dedication to meeting our supply chain requirements and providing quality technology and design enablement services," said Bruce J. Freyman, VP, Worldwide Operations for Skyworks. "TowerJazz was recognized as our best overall supplier because it excelled in various areas. Throughout the difficult downturn and rapid rebound in 2009, TowerJazz delivered strong support in meeting our demands to deliver high quality, leading-edge devices to our customers quickly," he adds.

www.towerjazz.com

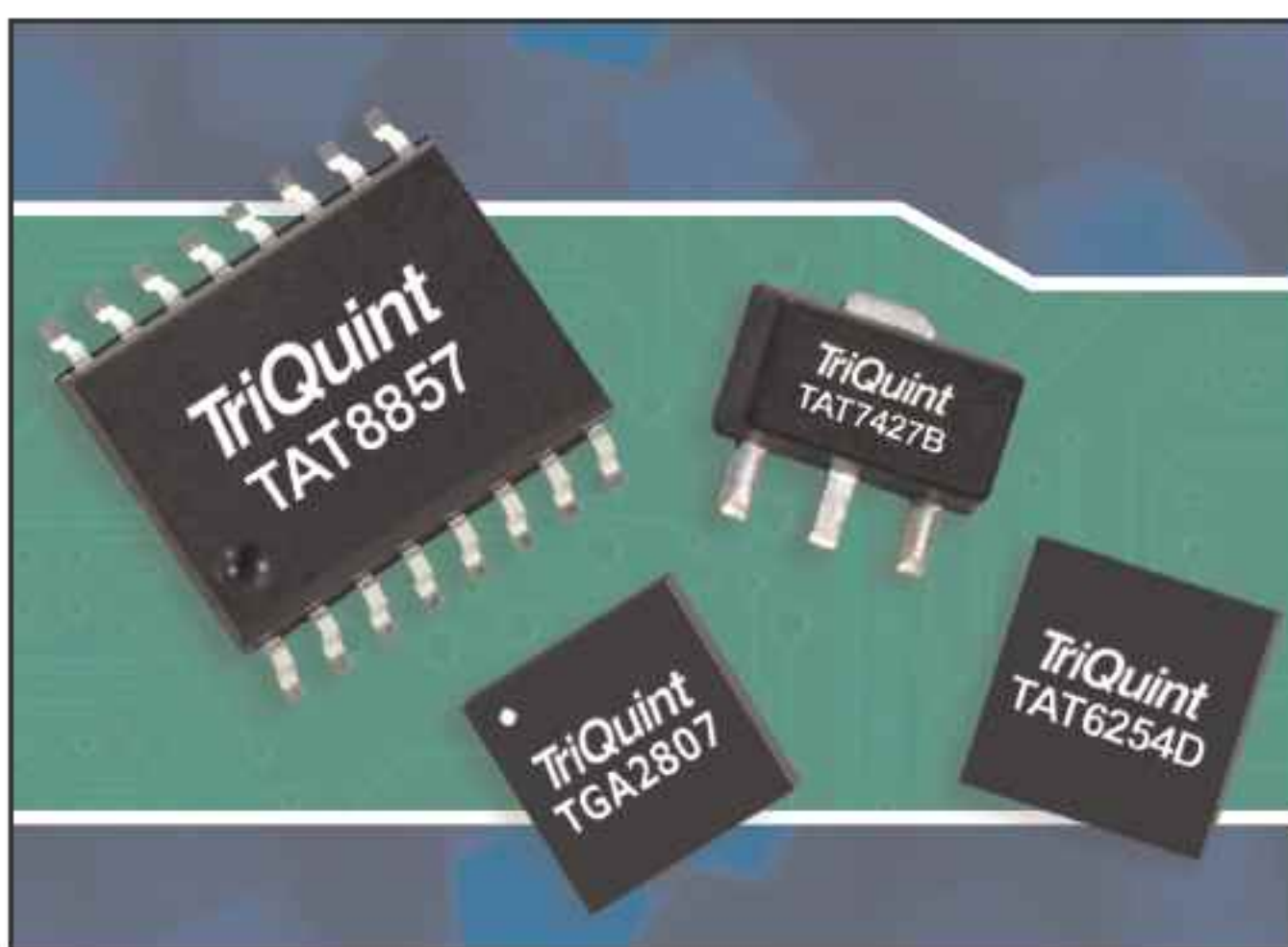
TriQuint's TriAccess CATV/FTTH products supporting convergence of telecom services in China

At the China Content Broadcasting Networks (CCBN) conference in Beijing (22–25 March), RF front-end product maker TriQuint Semiconductor Inc of Hillsboro, OR, USA launched its TriAccess line of cable TV (CATV) and fiber-to-the-home (FTTH) products into the China market, including low-power-consumption on-chip linearized ICs, low-noise receivers and stable home amplifiers.

The firm says TriAccess products support the China State Council 'Three into One' initiative for competitive, world-class high-speed broadband connectivity, increasing efficiency and lowering overall costs for EDGE QAM/DOCSIS 3.0, FTTH, cable TV infrastructure and subscriber premises cable systems.

The Chinese government's support for telecom, TV and internet convergence increases the opportunity for traditional CATV network operators, broadcasters, internet service providers and telecom companies to compete or combine services to gain market share and better serve subscribers, TriQuint says. This move toward convergence means that, to achieve success, system operators need to add low-cost, high-bandwidth technologies to their networks, a process made easier and more efficient with TriAccess products, claims the firm. The name TriAccess is derived from the three ways that TriQuint products help CATV engineers to create improved broadband 75Ω access: better efficiency, better linearity and smaller-size devices for CATV/FTTH systems.

"TriAccess on-chip linearized solutions have been shown to help CATV network manufacturers develop more efficient products that use less power," says Ting Xiong, TriQuint's country manager for China. "At the same time, TriQuint products enable higher-speed connections, or a larger service area for converged video, voice and high-speed internet," he adds.



TriQuint's CATV products, including the TAT8857 integrated power doubler and RFoG-based TAT6254D.

"TriAccess amplifiers and filters provide end-to-end solutions for all major segments of the 75Ω."

TriQuint says TriAccess devices for EDGE QAM/DOCSIS 3.0, CATV infrastructure, subscriber (home) amplification and FTTH give manufacturers and product designers simplified RF connectivity that supports a large variety of wideband services such as HDTV, high-speed data and video on demand (VOD).

● **EDGE QAM/DOCSIS 3.0 amplifiers:** The TriAccess product portfolio is designed to facilitate high-speed wideband CATV connections for a more efficient use of the cable TV spectrum. Products include what is claimed to be the world's first on-chip linearized amplifier (the TAT7467H), which is designed with reliable GaAs pHEMT technology and offers 40%+ efficiency for lower operational costs and enhanced competitiveness. TriAccess products, including TGA2807-SM for slightly higher output levels, also meet stringent DOCSIS 3.0 specifications.

● **FTTH & RF over Glass (RFoG):** To better compete, incumbent cable operators and new market entrants need solutions that effectively provide HDTV, digital voice and high-speed internet by leveraging existing network equipment and cable modems. The most effective way to

deliver the highest bandwidth capability over existing networks is with FTTH, including systems using RFoG; these solutions are particularly beneficial for new construction and network upgrades. The TriAccess line includes products like the TAT6254D that are specifically designed to support the needs of the RFoG specification.

● **CATV Infrastructure:**

The TriAccess portfolio now offers solutions at the die, packaged die and multi-chip module levels. The new design of the high-gain TAT8858 (integrated push-pull amplifier), combined with the TAT8857 (integrated power doubler), suit CATV infrastructure applications, providing the economy of GaAs-based design and superior efficiency performance, says TriQuint.

● **Home/subscriber amplifiers:** The TriAccess line of high-performance ICs (drop amplifiers) for subscriber applications offers multiple gain levels that cost-effectively enable central gateway and multi-room architectures as well as MOCA (Multimedia over Coax Alliance) and Ethernet over coax applications. The new TAT7430B and TAT7427 provide increased gain (22.5dB and 18.0dB, respectively) to complement the TAT7461 16dB product; all devices meet stringent distortion requirements. TriQuint says that its CATV subscriber/home solutions give manufacturers the ability to increase network performance to meet the new home architecture standards desired by leading MSOs.

Samples and evaluation boards are available for TriAccess products now in release.

www.triquint.com

Anadigics celebrates 25th anniversary by ringing NASDAQ closing bell

Broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA celebrated its 25th anniversary in late April by ringing the closing bell at the NASDAQ Stock Market.

Founded in 1985, Anadigics has built its reputation on designing and manufacturing high-performance radio frequency integrated circuit (RFICs) technology. The firm says that it has latterly focused on enabling the telecoms industry's move into fourth-generation (4G) technologies by delivering RFICs that significantly improve product design and functionality for wireless communications. The company also provides technology for broadband and cable television (CATV) applications.

Milestones for Anadigics over the last 25 years include the following:

- 1985: Founded by Ron Rosenzweig, George Gilbert and Charles Huang, producing 3-inch GaAs wafers for use in RFICs designed primarily for military applications, direct satellite broadcasting, and later the cable TV market.
- 1988: First patent issued, for current bleeder amplifiers with positive feedback.
- 1993: The first GaAs IC manufacturer to achieve ISO certification (ISO9001).

- 1995: Becomes a publicly traded company on the NASDAQ stock market.
 - 1997: Designs and manufactures the first commercial dual-band, dual-mode GaAs power amplifier for the cellular and PCS market.
 - 1999: Opens first industry's 6-inch analog GaAs wafer fab.
 - 1999: Manufactures the first indium gallium phosphide (InGaP) heterojunction bipolar transistor (HBT) technology on 6-inch wafers to be used in products for cellular and PCS handsets.
 - 2004: Development of InGaP-Plus, the first low-cost manufacturable GaAs-based BiFET (bipolar field-effect transistor) process, monolithically integrating two types of transistors on the same chipset (enabling high-volume production of commercial MMICs at low cost).
 - 2005: Surpasses the 25 million mark in shipping InGaP HBT power amplifiers for LAN applications.
- "Customers continue to raise the bar in terms of product innovation, new applications, and high-speed, reliable connectivity, and we will continue to rise to the occasion, delivering quality products to market with the right performance at the right time," comments president & CEO Mario Rivas.

www.anadigics.com



Anadigics' president & CEO Mario Rivas (second from left).

IN BRIEF

TriQuint wins ZTE 'Supplier of the Year' award for third year

RF front-end product maker TriQuint Semiconductor Inc of Hillsboro, OR, USA has received a 'Supplier of the Year' award from wireless communication system equipment maker ZTE Corp of Shenzhen, China.

ZTE annually recognizes top suppliers for cost, quality, delivery and service performance. TriQuint has achieved recognition for the third consecutive year, while experiencing a compound annual growth rate of 70% with ZTE.

"TriQuint had excellent performance in the areas of on-time delivery and business co-operation in 2009," says Zeng Zhaoxiang, vice general manager of ZTE Kang Xun. "TriQuint made outstanding contributions in enhancing the whole delivery performance of ZTE," he adds.

"TriQuint is committed to providing ZTE with quality products and excellent service as together we address the growth challenges inherent in the dynamic telecommunications industry," says Tim Dunn, VP Mobile Devices at TriQuint. "We look forward to continuing to supply ZTE with high-quality radio-frequency solutions for wireless communications."

One of the largest telecom equipment makers, ZTE says it sees healthy demand for its wireless handsets and data cards continuing this year, and that it expects subscriber growth for TD-SCDMA (a Chinese wireless communication standard for 3G) to rise by 500%. TriQuint supplies RF solutions to ZTE including power amplifiers, SAW filters, and multi-function integrated modules for all wireless communication standards including GSM/GPRS, EDGE, CDMA, WCDMA and TD-SCDMA.

www.triquint.com/rf

www.zte.com.cn/en

Quarterly growth accelerates to 24% for Hittite

For first-quarter 2010, Hittite Microwave Corp of Chelmsford, MA, USA, which designs and supplies analog and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems, has reported revenue of \$54.2m, up 24.1% on \$43.7m last quarter (accelerating from growth of just 5.3% that quarter) and up 41.9% on \$38.2m a year ago.

About 44.3% of total revenue (\$24m) came from customers in the USA and 55.7% (\$30.2m) from outside the USA, compared to 50:50 in Q4/2009 (i.e. just \$21.8m from outside the USA, leading to 39% growth in Q1/2010). "Q1 was a solid start to the year," says chairman & CEO Stephen Daly.

Gross margin of 73.4% was up from 71.5% a year ago but down from 74.8% last quarter. However, operating income was \$25.1m (46.3% of revenue), up from \$19.8m (45.5% of revenue) last quarter and \$15.7m (41.1% of revenue) a year ago.

Net income has risen from \$10.2m a year ago and \$13.4m last quarter to \$16.1m. During the quarter, total cash and cash equivalents grew by \$17.7m to \$238.2m.

"In addition to our strong financial results, we launched 32 new and innovative products [up from 30 in Q4/2009] including one new product line [ultra-compact, 1–7.6GHz varactor-tuned, MMIC filters for pre-selection in multi-band communication systems, wideband radar, and in test & measurement equipment]," says Daly. "These and our other recently introduced new products will help us to build on our competitive advantage in the markets we serve," he adds.

For second-quarter 2010, Hittite expects revenue to grow a further 7–11% to \$58–60m and net income to rise further to \$17–18m.

www.hittite.com

Inphi opens UK Design Center to speed R&D on 100Gbps analog interface ICs

Inphi Corp, which develops high-speed analog communications ICs (using indium phosphide, gallium arsenide, silicon-germanium or bipolar silicon as well as CMOS), has opened the Inphi UK Design Center at Preston Deanery, Northamptonshire to accelerate its R&D on interface devices targeted at 100Gbps networks, as well as to synchronize its technology initiatives with strategic partners and customers worldwide. The new office is Inphi's first design center outside the USA, where it has two sites at Westlake Village (outside Los Angeles) and Sunnyvale, CA.

With Mike Harwood as director of the new Inphi UK, Inphi has assembled a UK team that will leverage its core competencies in advanced analog circuit design, signal integrity, power management, packaging and process technologies to create a new class of high-speed interface devices.

Inphi provides interface components that operate at critical interfaces within cloud computing environments, addressing the bandwidth, capacity and power issues faced by data centers and 40Gbps/100Gbps networks.

"Establishing our UK center allows us to capitalize on the area's enormous cache of talent and knowledge," says the company's president & CEO Young Sohn. Northamptonshire was chosen as the site of the design center because of the area's legacy of mixed-signal design talent from Plessey Caswell, Texas Instruments and Phoenix.

"This move will form the next step in our worldwide growth and augments our leadership in innovative designs, dedication to excellence in product development, and commitment to advancing industry standards," Sohn continues.

After graduating in Physics from Trinity College, Oxford University, Harwood has accumulated 20 years of experience in microelectronics design. He was the architect of several generations of Texas Instruments' physical layer devices and SerDes IP (the last development being a 12.5Gbps long-reach SerDes on a 65nm process), and was elected a Distinguished Member of Technical Staff at TI in 2001. He subsequently co-founded HSZ Consulting (specializing in microelectronics for high-speed data communications), which has worked for Inphi on the feasibility of concepts, developing techniques to solve design problems, and process evaluation. "His experience will no doubt help us scale our operations," comments Sohn.

"They've had a positive track record, strong [double-digit] growth for the last five years, and offer a best-in-class portfolio of products," says Harwood of Inphi. "The opening of Inphi UK demonstrates the company's commitment to becoming a global technology leader, investing in key talent and customers worldwide."

Inphi has a diverse portfolio of more than 150 products for the server and storage, networking and communications infrastructure, as well as test & measurement markets. Commercial firsts include: the first DDR3-1600 memory interface buffer, the first load-reduced DIMM isolation memory buffer, the first 25GHz IC in plastic, the first 43Gbps differential Mach-Zehnder driver, the first 50Gbps multiplexer, and the first 43Gbps transimpedance amplifier. Customers include more than 200 global memory module suppliers, transponder manufacturers, and telecom and test & measurement original equipment manufacturers.

www.inphi.com

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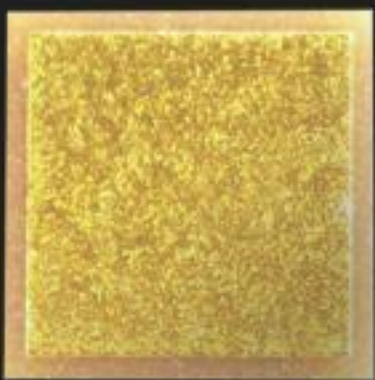


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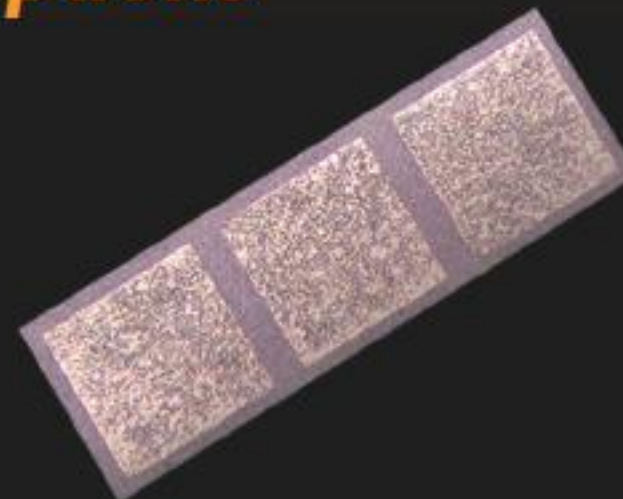
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SiBEAM secures \$36.5m in Series D funding 60GHz CMOS chipsets targeted at WirelessHD

Fabless semiconductor firm SiBEAM Inc of Sunnyvale, CA, USA, which develops millimeter-wave (mmWave) solutions and high-speed wireless communications platforms, has closed \$36.5m in Series D funding led by Foundation Capital and joined by all of SiBEAM's original investors including US Ventures Partners (USVP) and New Enterprise Associates (NEA), as well as new investors Lux Capital and Hatteras Funds. Best Buy Inc and Cisco have also contributed strategic equity investments to support SiBEAM's growth and propel its second-generation 60GHz wireless high-definition chipsets into the mainstream consumer electronics market, as well as to fund future projects for personal computing and mobile devices.

Founded in 2004, SiBEAM claims to be the first firm to build 60GHz chipsets using CMOS silicon technology. With technology designed for consumer electronics manufacturers, PC manufacturers, network infrastructure providers and others to incorporate into their next-generation product lines for wireless communications, the first application is based on the WirelessHD standard.

As a founding member of the WirelessHD Consortium (which includes 50 leading firms in the consumer electronics and personal computing industries), SiBEAM is aiming to drive the architecture and semiconductor implementation for the distribution and presentation of

high-definition content in the consumer electronics and personal computing markets, and claims that its OmniLink60 Technology is the first WirelessHD-based solution capable of streaming lossless, uncompressed high-definition video, audio and data.

"SiBEAM continues to deliver on its promise to bring high-quality, lossless wireless high-definition capabilities to the A/V home entertainment market," says Foundation Capital's general partner Adam Grosser. "Their team has executed well on its plans and has brought in nearly all leading CE [consumer electronics] manufacturers as customers through its work with the growing WirelessHD Consortium," he adds.

"This market adoption further supports our confidence in SiBEAM's technology and the team's capabilities to drive and solidify the company's leadership in the exciting and high-growth wireless connectivity market."

SiBEAM's 60GHz semiconductor solutions with OmniLink60 Technology have won awards including (most recently) a 2010 Design Vision award in the semiconductor components category. The second generation of SiBEAM's WirelessHD chipsets — brought into mass pro-

duction earlier this year — represents the firm's move into mass-market applications with low-cost, low-power functionality. The latest chipsets also support advanced features demanded by the current consumer electronics market including 3D, HDCP and DTCP content protection that can be designed into A/V receivers, home theater-in-a-box systems, Blu-ray players, set-top boxes, media center PCs, and consumer laptops. "SiBEAM has become the indispensable technology innovator in wireless home networking," reckons Lux Capital co-founder & managing partner Peter Hebert.

"This round of financing is a significant milestone for SiBEAM as it demonstrates the continued growth of our business and potential for significant investment return, even in a challenging economy," says the firm's president & CEO John LeMoncheck. "With these funds, we can grow our business toward profitability in the burgeoning wireless A/V market," he adds. "SiBEAM continues to receive extensive interest from CE and PC manufacturers worldwide that are eager to integrate simple, cost-effective and high-quality wireless streaming capability into their products."

SiBEAM says that it is hence currently expanding global sales and manufacturing operations to support its increased growth rate and customer demand for wireless A/V connectivity solutions.

www.sibeam.com

AWR sets up Korea direct sales, support and marketing

High-frequency electronic design automation (EDA) software tool provider AWR Corp of El Segundo, CA, USA has expanded its global presence by establishing a direct sales, support and marketing office in South Korea. To better serve the region's growing customer base,

Kyung Hwa Kim has been appointed country manager of AWR Korea Co Ltd.

"Kim's commitment to customer satisfaction, his extensive EDA experience, and his profound knowledge of the business in Korea make him an excellent choice to

spearhead AWR's direct expansion in the Asia Pacific region," says Ron Patston, AWR's VP of Asia Pacific operations. "AWR Korea will be able to more effectively provide support and related services to our customer base," he adds.

www.awr.co.kr

VectraWave's first 40G circuit designed using TowerJazz's SiGe

Fabless company VectraWave SA of Les Loges en Josas, France, which provides RFICs and system-in-package devices for optical and microwave communication equipment makers, has designed its first 40Gb/s high-speed coder circuit using a silicon germanium (SiGe) BiCMOS process.

Specialty foundry TowerJazz of Migdal Haemek, Israel says that VectraWave chose its SBC18HX process over indium phosphide (InP) — the traditional material of choice for 40G circuits — due to its advantage of integrating digital circuits on the same die, enabling lower cost, lower power consumption, better temperature compensation and smaller total board area. SBC18HX also provides a wide variety of optimized process options and a well defined path to higher performance while maintaining existing analog IP, says TowerJazz.

VectraWave is developing a family of products including 43Gb/s high-speed logic integrated circuits with a sub-family of 43Gb/s high-speed coders, including demonstrating a unique NRZ to RZ-DPSK coder operating at up to 43Gb/s in a surface of less than 1mm². Applications include data synchronization and fiber transmission. The markets for VectraWave's devices are high-speed logic circuits for RF communication equipment, long-haul/ultra-long-haul and metro access 10–100Gb/s optical networks. Its family of high-speed coders allows the conversion of 5–43Gb/s NRZ standard bit rates to the specific coding format required by the optical fiber transmission link.

VectraWave's 40G devices are using TowerJazz's SBC18HX process variant with 155GHz f_T NPN transistor technology. Future opportunities for next-generation products include leveraging the foundry's 200GHz process for further high-speed logic functions

and improved performance. Since SiGe BiCMOS is manufactured using mainstream 200mm wafers, new 40G circuits can leverage all of the advantages of this process to deliver superior reliability and ruggedness, says TowerJazz.

In contrast, InP chip fabrication is generally on 75mm wafers (and occasionally on 100mm wafers) and is subject to brittleness and reliability concerns, claims the firm.

"By choosing TowerJazz as our foundry partner, we were able to realize many advantages with their SiGe BiCMOS process over traditional InP solutions, including reduced cost, lower power consumption and smaller die size," says VectraWave's co-founder & president Yan Haentjens. "We also enjoyed the benefits of the company's high degree of flexibility, reliability and support," he adds. "We required a partner that was focused on high-speed process technologies with a long-term roadmap that aligned with our product needs." The fact that TowerJazz offers successive generations of its SiGe BiCMOS process should help VectraWave to continue developing designs as it focuses on capturing market share with next-generation products, the firm reckons.

"Our range of technology and features allows them to create differentiated high-speed products while taking advantage of our modular 0.18µm SiGe BiCMOS platform," comments Chuck Fox, TowerJazz's senior VP of worldwide sales & marketing. "This type of partnership with VectraWave is significant as it enables them an industry first, and we look forward to maintaining our relationship to produce their latest products, which are smaller and more energy efficient than previous generations," he adds.

www.vectrawave.com

www.towerjazz.com

IN BRIEF

IO Semiconductor closes multi-stage funding

Fabless semiconductor startup IO Semiconductor Inc of San Diego, CA, USA has completed an undisclosed amount of multi-stage funding with a private investor.

The firm was accepted into San Diego's EvoNexus incubator last July and has since been supported with furnished office space, utilities, mentoring and educational opportunities. "EvoNexus is dedicated to supporting young high-tech companies as they grow into self-sustaining companies contributing to the San Diego economy," says EvoNexus executive director Cathy Pucher.

The new investment provides the company with the capital to move from its current stage of technology development through volume production, said IO Semiconductor CEO Mark Drucker.

IOsemi was formed in 2008 and is focused on the development of a silicon CMOS-based technology for high-performance inputs and outputs (I/Os) in multi-band, multi-mode cellular handsets that offers performance levels equal to or better than materials like gallium arsenide, without sacrificing the inherent integration and economic advantages associated with CMOS.

I/Os, whether IEEE1394, Bluetooth, HDMI, Cell Phone, SATA, USB 3.0 or WiFi, operate either in the Gigahertz speed range or transfer data at Gb/s.

All of these high-performance I/O's present system designers with new and difficult design challenges. IOsemi is developing technologies and products which will reduce these design challenges and in turn address this multi-billion dollar market.

IOsemi expects to introduce its first products in 2011.

www.iosemi.com

Better, smaller source/drain contacts for III–V logic

Ultra-thin insulator layer reduces Schottky barrier height

Stanford University researchers have been trying to overcome the limitations of traditional contacts to III–V logic transistors by using single metals with an ultra-thin insulating interlayer rather than alloys [Jenny Hu et al, *J. Appl. Phys.*, vol107, p063712, 2010]. The scientists hope that their work could lead to practical and scalable non-alloyed low-resistance ohmic contacts for III–V metal-oxide-semiconductor field effect (MOSFET) and high-electron-mobility (HEMT) transistors with implanted source/drain contacts, and for tunable barrier heights for III–V Schottky barrier FETs (SB-FETs).

The problem with alloyed contacts is that they can diffuse up to hundreds of nanometers after deposition, creating possible short-circuits. This limits the density at which such contacts can be placed to the order of a micron, far from the desired 20nm or less that is needed to enhance the performance of silicon logic in future commercial devices.

Alloyed contacts are used to create ohmic source/drain contacts for low-resistance current flow into and out of the devices. However, single-metal/III–V contacts tend to have Schottky diode behavior, with low resistance in one direction but a barrier to current flow in the other.

The Schottky barrier needs to be less than 0.1eV for adequate flow of on-current. In the case of III–V materials, the Schottky barrier is increased due to pinning of the Fermi energy level and metal-induced gap states (MIGS) at the interface as a result of the more ionic nature of such semiconductors compared with silicon.

Stanford has been applying the idea of putting an ultra-thin layer of insulator between the metal and semiconductor to reduce the Schottky barrier height. This proposal has been applied before to group-IV semiconductors: in silicon in 2004

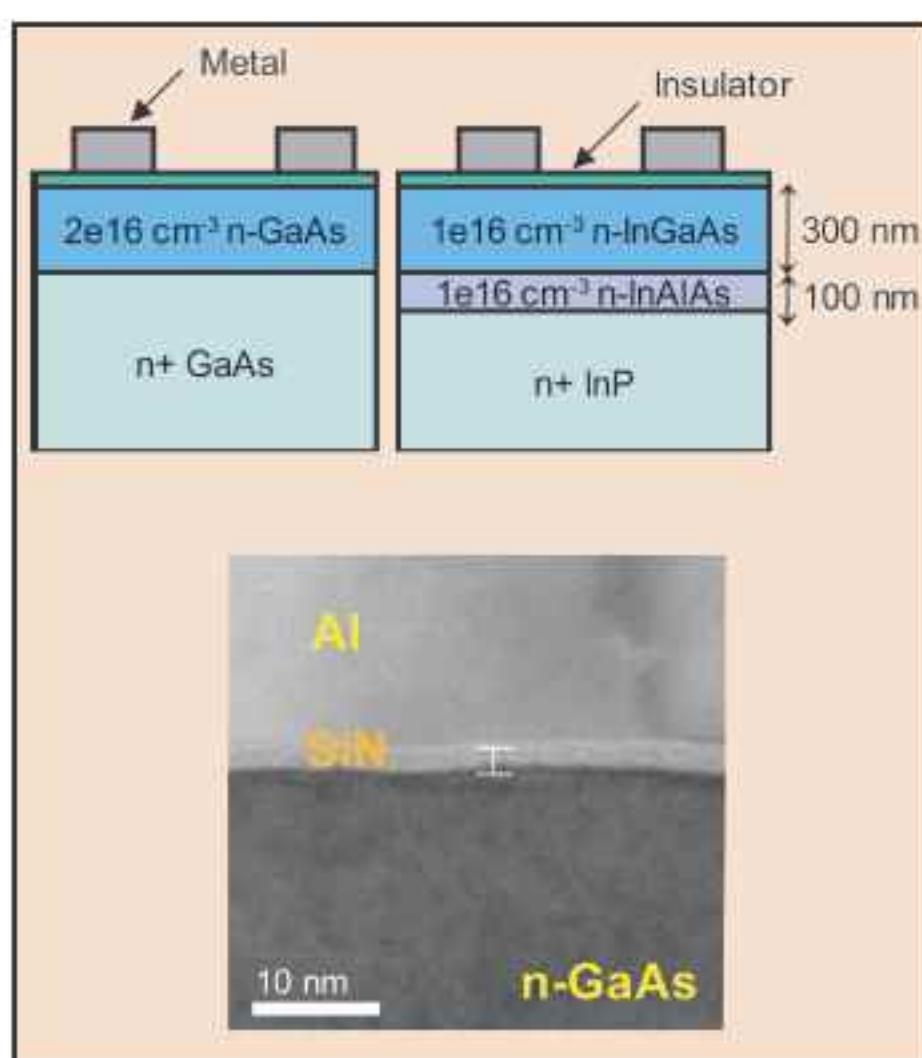


Figure 1. Contact structure (a), and cross-sectional TEM image (b) of Al/SiN/n-GaAs contact, illustrating an amorphous, uniform SiN film.

by intellectual property company Acorn Technologies in Palo Alto, CA, USA and in 2009 at the University of Texas-Dallas, and in the past couple of years on germanium by the University of Tokyo and by Stanford itself. However, the Stanford group believes it is the only one so far to apply these ideas to III–V/metal contacts.

The Stanford work involved metal contacts on lightly doped gallium arsenide and indium gallium arsenide ($\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$) with ultra-thin interlayers of silicon nitride (SiN) and aluminum oxide (Al_2O_3) insulator (Figure 1). A variety of metals

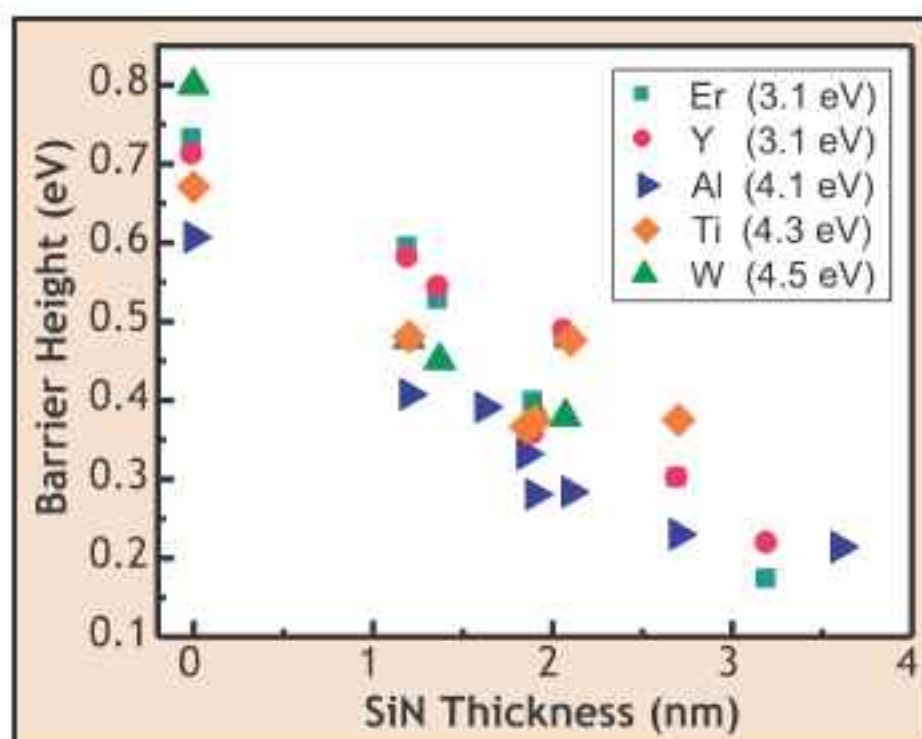


Figure 2. Effective Schottky barrier height extracted from diode measurements from 233K to 353K using thermionic emission model.

were tested: yttrium, erbium, aluminum, titanium and tungsten.

It is not known exactly why the ultra-thin insulator layer acts to lower the Schottky barrier, rather than just increasing parasitic resistance. By studying the dependence of contact resistance on insulator thickness, the researchers find that SiN is a better candidate for Schottky barrier reduction with Al/GaAs.

Simulations based on a fully self-consistent non-equilibrium Greens function (NEGF) using the effective-mass approximation suggest that increasing the doping from the $2 \times 10^{17}/\text{cm}^3$ of these experiments to $1 \times 10^{19}/\text{cm}^3$ would reduce the specific contact resistance from the measured $2.0 \Omega\text{-cm}^2$ to a projected $10^{-7} \Omega\text{-cm}^2$.

Measurements of the effective Schottky barrier height were extracted based on a thermionic emission model for a wide variety of metals and SiN thicknesses (Figure 2), giving values down to $\sim 0.2\text{eV}$, close to the required values of less than 0.1eV. The researchers believe that further reduction may be possible through use of other dielectric materials.

The researchers also discuss two possible models for the effect of the insulating layer on the Schottky barriers that depends either on changes in metal-induced gap states, or on bond polarizations. On the basis of their work, the Stanford researchers comment: "Currently, the mechanism appears to be from the formation of a positive dielectric dipole, where the ideal dielectric forms a maximum dipole with a minimum band offset to the semiconductor, to achieve the lowest possible contact resistance."

The Stanford work was supported in part by the Focus Center Research Program, Intel and the US National Science Foundation (NSF).

<http://link.aip.org/link/JAPIAU/v107/i6/p063712/s1>

Author: Mike Cooke.



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RFHIC launches 20W molded GaN-on-SiC power amplifier covering 20–1000MHz

RFHIC Corp of Suwon, South Korea, a manufacturer of gallium nitride and gallium arsenide active RF & microwave components and hybrid modules mainly for the telecom and broadcast markets, has introduced a molded GaN-on-SiC power amplifier generating 20W and covering the frequencies 20–1000MHz.

The RWS05020-10 is based on gallium nitride on silicon carbide (GaN-on-SiC) transistors, providing good reliability at high temperature, as well as 36dB of gain and a typical 43dBm @ P3dB with 50% efficiency. Moreover, the physical size is just 2.1" x 1" x 0.5".

"RWS05020-10 is a miniaturized wideband amplifier, a newly developed hybrid," says chief technical officer Dr Samuel Cho. RFHIC has incorporated pin types for both DC and RF port to make the product easy to use, he adds. The RWS05020-10 also has a bolted-down structure and operates at 28V with 51dBm @ OIP3.

RFHIC says that, as GaN devices are actively evolving, reliability is improving while they are also



RFHIC's RWS05020-10 amplifier.

becoming more cost-effective. In addition, the firm has been developing more thermally robust designs, and the substrate material has been migrated from silicon to silicon carbide (SiC), enhancing reliability and efficiency further, directly addressing the increasing 'green' concerns of both policy makers and end users (who are also calling for smaller systems, without sacrificing performance). In particular, for sub L-band frequencies, there are many obstacles to be overcome in order to shrink the size of power amplifiers.

Last June, RFHIC entered an agreement for Cree Inc of Durham, NC, USA to supply GaN-on-SiC transistors for RFHIC's GaN HEMT amplifier product families. Cree and RFHIC also entered into a marketing cooperation agreement to enable deeper market penetration of GaN HEMT solutions by leveraging Cree's MMIC foundry capability coupled with RFHIC's capabilities in packaging, amplifier integration and volume assembly.

"We initially pursued a GaN-on-Si HEMT approach, but converted our product line and future direction to Cree's GaN-on-SiC HEMT technology based on its superior thermal and electrical characteristics as well as its outstanding robustness and reliability," said Cho at the time. "The combination of Cree's and RFHIC's core strengths will accelerate GaN HEMT market penetration in the cellular infrastructure, two-way communication, CATV amplifier, and a variety of other emerging market segments," added Jim Milligan, Cree's director of RF and Microwave products.

RFHIC launches GaN pallet amplifier for LTE/WCDMA RRH systems with variable output power optimized for DPD interlocking

South Korea's RFHIC Corp has launched the RTP-21010 GaN pallet amplifier based on internally matched GaN-on-SiC device and Doherty technology for LTE/WCDMA remote radio head (RRH) systems.

When combined with DPD interlocking, the amplifier produces over 40% efficiency over the entire frequency band of 2100–2180MHz, 45dB gain and 10W at LTE/WCDMA 4-channel at 28V.

The RTP-21010 has a built-in DC/DC function, isolator, coupler, thermo pad and connectors all within small dimensions of 2.4" x 4.5" x 0.86". The amplifier produces different output powers according

to input voltage: 10W@28V, 16W@36V, and 20W@47V.

Doherty amplifiers based on LDMOS silicon show irregular efficiency at 80MHz bandwidth, and require various models for various systems due to the different requirements on ACPR (adjacent channel power ratio) when the power level is lower than 10, according to chief technical officer Dr Samuel Cho. Also, LDMOS has a low efficiency of 20–24% (even with DPD inter-locking) and device size is large, he adds.

However, the barrier to the telecoms market for GaN has always been its cost, says Cho.

RFHIC has hence aimed to cut GaN amplifier cost by using die supplied by Cree Inc of Durham, NC, USA for almost all the GaN transistor processes. Such cost reduction enables GaN solutions to be viable for telecom applications such as RRH, while the small size of the devices and heat-sinks contributes to greatly improved efficiency, adds Cho.

The RTP-21010 is applicable to RRH, BTS and repeaters with 80MHz bandwidth coverage and various outputs from 35 to 40dBm for operating conditions of 1-channel to 6-channel LTE/WCDMA.

www.rfhic.com

GaN-on-Si power transistor maker EPC makes available SPICE models

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA has made available on its web site SPICE models for all of its enhancement-mode gallium nitride on silicon (GaN-on-Si) power transistors (launched recently).

TSPICE, PSPICE and LTSPICE device models have been developed to help designers of GaN-based power conversion circuits and systems to understand the value of the firm's new power transistor family and to reduce their time-to-market with benchmark products. The free downloads are available at:

<http://epc-co.com/epc/ToolsandDesignSupport/DeviceModels.aspx>

EPC has also written an application note to help users understand enhancement-mode GaN transistor capabilities and the applicability of the SPICE models, available at:

http://epc-co.com/epc/documents/product-training/Circuit_Simulations_Using_SPICE.pdf

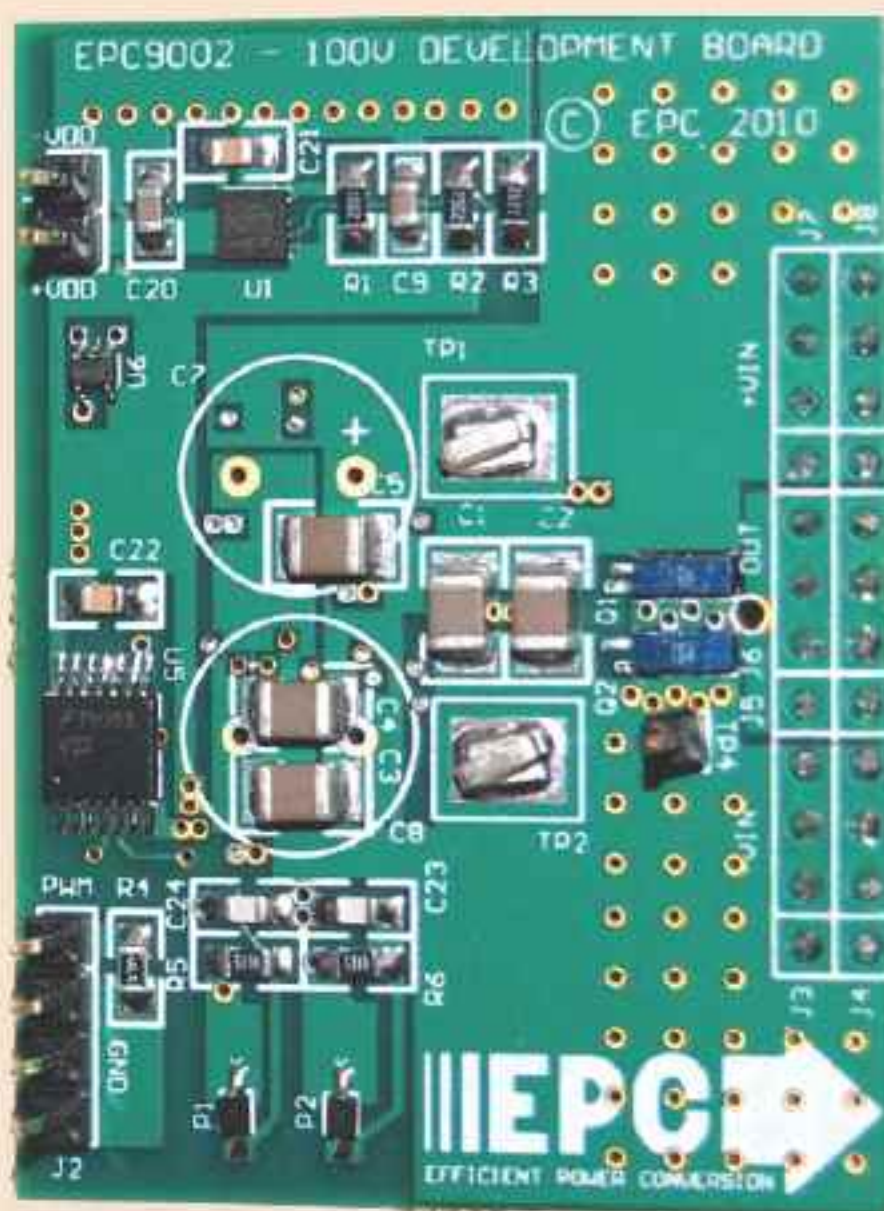
EPC claims to be the first firm to introduce enhancement-mode GaN-on-Si transistors as power MOSFET replacements in applications such as servers, netbooks, notebooks, LED lighting, cell phones, base-stations, flat-panel displays, and class-D audio amplifiers. Device performance is many times greater than the best silicon power MOSFETs, the firm adds.

EPC introduces development board for E-mode GaN-on-silicon transistor

Efficient Power Conversion Corp has introduced the EPC9002 development board, which the firm says will make it easier for users to get started designing with EPC's 100V enhancement-mode GaN-on-silicon transistor products.

The EPC9002 offers 50V maximum input voltage, 7A maximum output current, half bridge with on-board gate drives, and features the EPC1001 100V GaN power transistor. EPC says that the board's purpose is to simplify the evaluation process of the EPC1001 GaN power transistor by including all the critical components on a single board that can be easily connected into any existing converter.

At 2" x 1.5", the EPC9002 development board contains not only two EPC1001 GaN transistors in a half-bridge configuration with gate drivers, but also an on-board gate drive supply and all critical components and layout for optimal switching performance. There are



The EPC9002 development board, featuring the EPC9002 transistor.

also various probe points to facilitate simple waveform measurement and efficiency calculation.

EPC9002 development boards are priced at \$95 each.

www.digikey.com/Suppliers/us/Efficient-Power-Conversion.

IN BRIEF

IR opens plant for high-rel products

International Rectifier Corp (IR) of El Segundo, CA, USA, which makes power management devices using both silicon and GaN, has opened a new plant in San Jose.

The new 35,000ft² site is DSCC-certified Class H and Class K, and AS9100, ISO9001 qualified to design and make ruggedized hybrid DC-DC converters for IR's HiRel business unit.

"Leveraging IR's 20 years of heritage in high-reliability applications, and working in partnership with our expert team of designers in Denmark, our new San Jose facility will play a pivotal role in the manufacture and supply of high-reliability DC-DC converters to the space, aerospace, military and heavy-duty industrial markets," says John Conley, VP of operations & engineering, HiRel business unit.

The investment underlines IR's commitment to the design and manufacture of power management solutions for high-reliability markets, says Fred Farris, VP of sales & marketing, HiRel unit.

The HiRel San Jose-based group is supported by a design center in Skovlunde, Denmark for spacecraft power system designs and complex power conversion system solutions, and a silicon design center in El Segundo.

IR says that its high-reliability products, ranging from standalone discrete components to complex hybrid power module assemblies and rugged DC-DC converters, use leading-edge power technology which, together with demanding environmental specifications, help space, military, commercial aircraft, heavy-duty industrial and medical device design engineers meet their toughest design challenges.

www.irf.com

Nitronex raises \$16m for expansion

GaN-on-Si RF power transistor maker to meet demand

According to a filing with the US Securities and Exchange Commission (SEC), Nitronex of Durham, NC, USA, which makes gallium nitride on silicon (GaN-on-Si) RF power transistors for the commercial wireless infrastructure, broadband and military markets, has raised \$16.47m in a private stock offering from its four main existing venture capital backers: Alloy Ventures, ARCH Venture Partners, Intersouth Partners, and Diamondhead Ventures.

It's the third round of financing from those investors, who have invested more than \$50m, according to CEO Charlie Shalvoy in a report in the Triangle Business Journal. Nitronex has received almost \$100m in total since being spun out of North Carolina State University in 1999, including \$21.8m in funding in June 2006 (leading to commercial availability of its first chips in late 2006). In 2007, the firm moved from Raleigh, NC to its current 69,000ft² facility after Durham County offered a

\$100,000 grant as an incentive (with Nitronex saying it would invest \$24m in the facility and create 200 jobs in the first five years after the move). In January 2008, the firm closed on \$7.5m in financing, and in April 2009 raised \$4m through a debt offering.

In another report, in The News & Observer, Katrin Burt of Durham-based Intersouth Partners says that the new funding will be used to expand Nitronex's operations so that it can take advantage of new market opportunities. "Over

The new funding will be used to expand Nitronex's operations so that it can take advantage of new market opportunities... Over the last year or so, we have seen the industry become much more accepting of GaN as a material

the last year or so, we have seen the industry become much more accepting of gallium nitride as a material," she adds. Shalvoy says Nitronex is raising funds now because customers that had been considering Nitronex's chips are starting to ramp up their purchases as they incorporate the technology into the next generation of products.

Nitronex currently employs about 60 staff in Durham, but Shalvoy says the firm will be hiring engineers for R&D as well as sales & marketing staff (including a sales director for Europe) as the firm plans to boost sales of its chips into both military and commercial applications.

Already, in mid-March, Nitronex recruited a director of North American Sales and appointed three sales representative firms: TAI Corp (in Maryland and Virginia); Tri-Tech Electronics (in upstate New York); and Thom Luke Sales (in Arizona and New Mexico) — see below.

www.nitronex.com

Nitronex adds North American sales director and sales reps

Nitronex has recruited Diane DuVall as director of North American Sales, and appointed three sales representative firms as part of its strategy to expand sales and customer support in North America.

Most recently, DuVall set up sales, marketing and operations across the US and Canada at Navman Wireless. She has also held senior sales director positions at Jazz Semiconductor, Skyworks Solutions and Conexant Systems.

DuVall comments that she is joining Nitronex at a key time of its growth and will help bring a strategic account sales focus. "This appointment demonstrates Nitronex's overall dedication to having a world-class sales force,"

says Gary Blackington, VP of sales. "We are committed to accelerating our penetration into the North American Military Communications and Electronic Warfare markets, and we continue to support the strong gallium nitride market growth."

To assist DuVall in accelerating the sales and customer support activities, Nitronex's three new sales representative firms in North America are: TAI Corp (in Maryland and Virginia); Tri-Tech Electronics (in upstate New York); and Thom Luke Sales (in Arizona and New Mexico).



"Nitronex's GaN technology is important to TAI's penetration into the military customers in our territory," says TAI's president Ed Mihok. "Nitronex is one of the fastest-growing RF device companies in our territory," adds Tri-Tech's president Jeff Pauly. "Nitronex's unique approach to putting GaN on Si combined with our innovative approach to selling will provide a valuable resource within our customer base," reckons Thom Luke Sales' managing partner Joe Marvin.

"The companies we are partnering with are vital to the rapid implementation of our strategic sales and marketing plans," says Blackington. "They all have proven track records for success."

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VPE

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InSb

VCSEL

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ISO9001:2000, Certificate No.: FM 26963
ISO14001:2004, Certificate No.: EMS 502245

Advantech Wireless Broadband uses GaN for high-density power amplifiers

Advantech Advanced Microwave Technologies Inc (Advantech Wireless Broadband) of Montreal, Quebec, Canada has launched a new range of solid-state power amplifiers (SSPAs) and block-upconverters (BUCs or SSPBs) that takes advantage of the compact size and light weight of using gallium nitride technology.

Advantech believes that its new G series of 50W, 100W and 250W products are the world's smallest Ku-band devices of their type. Due to the margins that their designers have been able to reserve between the operational and maximum specified parameters for the core devices (such as operating temperature and voltages), the reliability of the new products shows a much increased MTBF (mean time between failures), compared to equivalent gallium arsenide devices, of more than 80,000 hours.

"After much research and development, we can now say that we have harnessed the power of this technology and can deliver the benefits to our customers," says president & chief operating officer Vagan Shakhgildian.

Advantech Wireless Broadband designs, manufactures and deploys networking solutions for broadband connectivity, broadcast solutions and backhaul requirements using satellite and terrestrial wireless communications. Products include: VSAT/DVB-RCS hub & terminals, SSPA, block-upconverters, frequency converters, satellite modems, mobile antenna systems, antenna controllers, PDH, Ethernet and SONET radios.

www.AdvantechWireless.com

BC's GaN-based military RF power amp delivers 100W at 20–305MHz

BC Systems Inc of Setauket, NY, USA, which designs and manufactures switching and linear power supplies, power control products, and solid-state RF power amplifiers using device technologies including gallium nitride RF power transistors, has introduced the Model RF40015, an RF power amplifier designed for defense applications in which broadband frequency coverage of 20–305MHz and RF output power of at least 100W in Class AB operation is desired in a compact, rugged package.

The RF40015 combines GaN RF power transistors with the firm's design and fabrication techniques to deliver high RF power density in a module measuring only 5.5 inches x 4.5 inches x 1.6 inches and weighing less than 2 lb. It has extremely fast blanking speed of less than 5 μ s, giving what is claimed to be excellent noise performance and low standby power

consumption, as well as efficiency of at least 30% and the ability to deliver its full RF power output into VSWR (voltage standing wave ratio) of 2.5:1.

The amplifier incorporates a custom DC-to-DC converter designed and manufactured by BC Systems that is highly efficient and allows the amplifier to operate from a 26–30 VDC power source. The unit is fully protected for over-current and over-voltage conditions, and has an operating temperature range of -20°C to $+85^{\circ}\text{C}$ (-45°C to $+95^{\circ}\text{C}$ non-operating). The device can be specified with an integrated low-power sampling port for RF output monitoring as well as a directional coupler.

BC Systems says that it can customize the DA Module to meet various military standards as well as for parameters such as operating frequency range, mounting configurations, and connector type.

BC Systems launches 20W GaN-based RF power amplifier for military applications

BC Systems has introduced its DA Module, an RF power amplifier (PA) for defense applications, such as manpack and man-portable communications, and electronic warfare systems that combine optimum power supply/RF PA integration, a frequency range of 25–1000MHz, and RF output power of at least 20W in an enclosure measuring only 4.5 x 3 x 0.6 inches and weighing less than 1lb.

Based on GaN RF power transistors that combine high RF power density with broadband frequency coverage, the PA is designed to be operated in Class AB mode, is unconditionally stable over all combinations of load impedance and phase conditions, and can operate at full RF output power into a VSWR of 2.5:1. It has extremely fast blanking speed of

less than 5 μ s to achieve excellent noise performance and low standby power consumption, and efficiency is at least 30%.

The DA Module's custom DC-to-DC converter allows the PA to operate from a 22–34 VDC power source, and full protection is provided for over-current and over-voltage conditions. Operating temperature range is -20°C to $+85^{\circ}\text{C}$ and non-operating temperature range is -45°C to $+95^{\circ}\text{C}$. The amplifier can be specified with an integrated low-power sampling port for RF output monitoring as well as an internal directional coupler.

The DA Module can be customized to meet various military standards as well as customer-specified mounting, configuration, and performance parameters.

www.bcpowersys.com.

Precision Flow Technologies to double staffing

C9's SiC contract from DoD providing funding

Precision Flow Technologies of Saugerties, NY, USA, which designs and makes ultra-high-purity process gas delivery systems, gas purge and mixing systems, says that it is to more than double its staffing (from about 185 currently) by creating 190 new jobs at Tech City in Hudson Valley. This is said to be the largest jobs expansion associated with The Solar Energy Consortium (TSEC), of which Precision Flow Technologies is one of 15 member firms (including manufacturers, installers and tooling companies).

"Hudson Valley is well on its way to becoming a major leader in the growing solar energy sector," said Congressman Maurice Hinchey, who was present at the announcement together with Ulster County executive Mike Hein, TSEC president & co-CEO Vincent Cozzolino and Tech City owner Alan Ginsberg. Precision Flow Technologies and other firms have leased 250,000ft² of space at a former IBM plant in Tech City in the past year, adding or committing to 1000 jobs overall, says Ginsberg in a report in the Poughkeepsie Journal.

Hinchey helped to establish TSEC in 2007 as an industry-driven, non-profit organization that provides leadership, organization, resources, and support for the establishment of a solar industry research and manufacturing cluster in the New York Hudson Valley region. He has since secured more than \$31m in federal funding for the consortium and its partners. This includes \$8.4m for Precision Flow (and its prime customer, silicon carbide wafer maker C9 Corp of Wilton, NY), helping it to speed its expansion into TechCity. An extra 31 construction jobs will also be

created for a period of 26 weeks during a \$1.2m upgrade of the Tech City facilities, where a 40,000ft² manufacturing plant is being constructed for Precision Flow Technologies.

The funding secured on behalf of Precision Flow and C9 is being used to advance energy technologies with the Department of Defense that aim to enhance the use of solar arrays, hybrid electric vehicles, and other energy-efficient applications. Specifically, last December saw approval under the 2010 Defense Appropriations bill for a \$2.8m contract to improve semiconductor-grade silicon carbide (SiC) material for semiconductor/solar manufacturing, targeting widespread applications not only for the military (e.g. boosting battery life for powering hand-held and back-pack devices for troops, recharging unmanned reconnaissance platforms, and developing hybrid vehicles) but also for the private-sector power utilities, automotive, aerospace and computer industries.

Funding is being paid through primary subcontractor L-3 Communications to fellow subcontractors NanoDynamics-88 and C9, which will both use fourth subcontractor Precision Flow Technologies to develop equipment for producing solar wafers. Of the total funding, C9 is receiving about 60%. Precision Flow Technologies is receiving at least 80% of this 60%, according to C9.

C9 is a privately funded firm founded in 2005 by executives at three New York companies: chief technology officer Dr C.G. Wang (president and CEO of device R&D firm Nanodynamics-88); president & chief executive officer

Kevin Donegan (CEO of Amtrade, which brings military R&D technologies to the commercial market); and chief operating officer and senior VP Frank Falatyn (president & CEO of manufacturing services firm FALA Technologies). C9's focus is bringing Nanodynamics-88's semiconductor technologies to market. The primary technologies include: SiC-based devices that are claimed to be defect-free (with epitaxial quality products 'equivalent to those currently found in standard semiconductor wafer processing'); SiC/silicon-on-insulator (SOI) wafers; specialty thermal materials; and harsh-environment products.

In concert with its expansion, Precision Flow Technologies says that it is adding jobs mainly in manufacturing but also including engineers, management and administrative positions. "We are hiring at the rate of five to seven a week in manufacturing and several more in engineering," according to president & CEO Kevin Brady in the Poughkeepsie Journal report.

TSEC says that it will continue to work with Precision Flow's management team as they grow their businesses by providing solar related products and equipment, according to Cozzolino. "As PFT has grown, they have provided business opportunities to several other TSEC partner companies, creating jobs elsewhere in our region," he adds. "The Hudson Valley is rapidly becoming a hub for solar energy, with TSEC and Tech City leading the way," comments Hinchey.

www.precisionflow.com

www.poughkeepsiejournal.com/article/20100420/BUSINESS/4200311/Precision-Flow-creates-190-jobs

IN BRIEF

Accel-RF ships first mm-wave reliability test system

Accel-RF Corp of San Diego, CA, USA has added to its family of RF reliability and performance characterization test systems by shipping and installing its first millimeter-wave test system.

The turn-key system independently performs RF life-tests and accelerated-aging performance characterization tests on 8–16 devices simultaneously. The system stresses components with elevated temperature; fixed, pulsed, or stepped DC bias; and elevated CW or pulsed millimeter-wave power to frequencies beyond 77GHz.

"Accel-RF introduced a High Power System to test application-specific gallium nitride power devices and MMICs [monolithic microwave integrated circuits] last year," says founder & president Roland Shaw.

"Now our new millimeter-wave systems significantly broaden the capability to perform RF characterization and aging effects on new compound semiconductor as well as traditional device technologies," he adds.

Accel-RF designs and manufactures reliability test equipment for compound semiconductor manufacturers, military component manufacturers, defense contractors, and the tri-services wide-bandgap component teams. "Accel-RF now has RF reliability systems for applications ranging from cell phones, to WiFi, to radar, to satellite and military communications," says Shaw. "These systems are not only available but installed and providing a capability for our customers to find and improve the reliability and performance degradation of their products."

www.accelrf.com

Atlumin and MCP Wellingborough combined to exploit synergies

MCP Group SA of Tilly, Belgium, which supplies minor metals products and chemicals including bismuth, is merging its Wellingborough UK operation (Mining Chemicals & Products Ltd) into its subsidiary Atlumin Energy Inc of New Hartford, NY, USA.

Founded in 1929, Mining Chemicals & Products Ltd supplies advanced materials (primarily made from indium, gallium, selenium and tellurium) to sectors including the automotive, compound semiconductor, photovoltaic, battery, and flat-panel display industries. MCP Wellingborough also provides reclaim and recycling services.

With plants in Germany, the UK, and the USA, Atlumin Energy manufactures materials for the renewable energy market (including solar module makers) — such as cadmium, copper, gallium, indium, molybdenum, selenium, and tellurium — with products ranging from key elements, alloys, and specialty chemicals, to engineered fabrications, such as sputtering targets. Atlumin also offers recycling and reclaim programs.

Led by Atlumin president Gregory Phipps, the combined entity will operate under the name Atlumin Energy, while the MCP brand name will be retained for existing products. Atlumin and MCP Wellingborough have complementary core competencies that will enable the combined organization to provide a more complete and streamlined solution, the firm reckons. Atlumin/MCP products and services extend from sourcing and refining through fabricating and reclaiming of specialty metals-based products (the 'Atlumin Materials Loop').

"Adding Atlumin leadership and supporting additional investment in Wellingborough accelerates and broadens the MCP Wellingborough value proposition," says MCP Group's CEO Laurent Raskin. "By leveraging the diversified operations and employee skill sets of

both organizations, this combined company is well positioned in a marketplace full of opportunities."

The primary goals of Atlumin's integration of MCP's Wellingborough operations are the expansion of development capabilities and manufacturing capacity. The integration should enable faster customization to deliver against specific needs of customers in rapidly changing markets, reckons the firm. Certain products and services will be manufactured at facilities in both Atlumin/MCP Wellingborough, UK and Sunnyvale, CA, USA.

Atlumin's establishment of multiple facilities with copy-exact manufacturing and quality management is part of a long-term strategy to reduce supply risks for customers and to streamline logistics.

"Through this integration, we're creating a world-class leader in

This is another step in our strategy to compress the material supply chain

specialty materials and metals," reckons Phipps. "By combining MCP Wellingborough's lean, high-volume manufacturing platform with Atlumin's innovative development and attentive

account teams, the net result will be best-in-class manufacturing on a global basis," he claims. "The complementary synergies will substantially increase our business scale and expand our customer base... This is another step in our strategy to compress the material supply chain and offer increased system-level efficiency to our customers."

The combined organization will benefit from complementary technologies, a strong management team, and a shared focus on reliability and quality, says the firm. Synergies through the integration are also expected to make operations leaner and faster.

www.mcp-group.com

Atlumin and Floridienne partner on supply and reclaim

Aiming to solidify its position as a source for procuring, fabricating and reclaiming cadmium-containing materials, Atlumin Energy of New Hartford, NY, USA (a subsidiary of metals supplier MCP-Group that supplies minor metal-based products to solar module makers) has established a partnership with Belgium-based Floridienne (said to have been the largest cadmium supplier and reclaimer for over 30 years).

Atlumin's partnerships with both MCP and Floridienne allow it to provide what is claimed to be a unique turnkey solution for all minor metals used by solar manufacturers in both cadmium telluride (CdTe) and copper indium gallium diselenide (CIGS) technologies.

The Floridienne partnership aims to enable cost and time savings for solar module makers. Previously, the supply chain involved several organizations, each handling part of the cycle. Now, by managing regulatory details in what is said to be an

environment friendly closed-loop system, Atlumin can source, refine, fabricate and supply products.

"This gives us opportunity to further compress the supply chain," says president Gregory Phipps.

"Our clients can focus on their core technology and development while we streamline and manage the supply chain... Our new partnership helps solar manufacturers to minimize their capital investment and increase watts per unit cost."

Atlumin says that a key issue with cadmium in solar applications is the potential environmental impact, if mishandled. The firm has a closed-loop system for all its minor metals, ensuring maximum use and reuse, while Floridienne has a reputation for clean materials processing. "The unwavering commitment of both Atlumin and Floridienne to environmental responsibility is based on known, well defined and controlled processes," says Floridienne's managing director Simon Vlajcic.

"The most gratifying result of our new partnership with Atlumin is the ability to assure solar manufacturers and their clients that environmental issues are being managed by two highly committed companies supplying the solar industry."

With plants in Germany, the UK and the USA, Atlumin makes materials for the renewal energy market, including solar module makers. Products range from key elements, alloys and specialty chemicals to engineered fabrications such as sputtering targets. Metals include cadmium, copper, gallium, indium, molybdenum, selenium and tellurium.

Floridienne has activities in minor metals, chemicals, biotechnology, agro-foods and venture capital investments. As well as Cd-based materials for solar, battery and metallurgical applications, it makes and reclaims zinc-, lead- and nickel-based materials.

www.atlumin.com

www.floridienne.be

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CVD Equipment reports sixth consecutive profitable year, despite 42% revenue drop

CVD Equipment Corp of Ronkonkoma, NY, USA has reported profitable results for the sixth consecutive year in 2009. However, net earnings of \$179,000 were down on 2008's \$632,000.

Revenue was \$10.57m, down 41.7% on 2008's \$18.15m due to: (i) delays or reductions in capital expenditures by potential customers due to the unfavorable economic conditions; and (ii) a significant contract from a CVD division customer being breached during fourth-quarter 2009 (accounted for under the percentage of completion contract method of revenue recognition). If the firm had been able to continue recognizing revenue from that contract, revenue for 2009 would have been about \$14.14m (down 22.1% on 2008).

"The difficult economic conditions experienced in 2009 have not continued into 2010," notes president & CEO Leonard Rosenbaum. "Our quotation activity is very high and new order levels have increased... We believe this trend will continue to increase in subsequent quarters."

CVD Equipment operates three divisions. As well as the Stainless Design Concepts Division (which makes ultra-high-purity gas and chemical delivery systems) and the Conceptronic/Research International Division (which supplies reflow ovens and rework stations to the PCB assembly market and ball attach ovens for back-end semiconductor packaging), the CVD/First Nano Division consists of the CVD product group (which designs and builds pilot and production equipment for custom CVD processes) and the First Nano product group (which makes EasyTube equipment for growing nanowire, nanotube and thin-film materials) as well as an Application Laboratory (where it develops processes and solutions for commercializing emerging technology in the nano/solar fields and develops/optimizes custom material manufacturing processes).

"Our decision to focus on the CVD/First Nano product lines for our long-term revenue growth and profitability is still proving to be successful despite the conditions

we experienced in 2009," Rosenbaum continues. "Our EasyTube product line is widely accepted and continues to expand by serving university and research laboratories, startup companies, and quality control departments throughout the world in fields such as nanotubes (carbon and boron nitride), graphene, nanowires (zinc oxide, gallium nitride, silicon), solar cells, MEMS (micro-electro-mechanical systems), energy, semiconductors, and LEDs," he says. "Our newest offering, the SiQC system, is helping to analyze the feedstock to solar polysilicon facilities. Our Application Laboratory is providing research and the further implementation of our business plan to offer nano and solar companies assistance in accelerating the commercialization of their next generation of products on CVD production equipment platforms," Rosenbaum adds. "We will continue to expand our technology, products, and customer base, and the revenues for 2010 should improve over 2009."

www.cvdequipment.com

Sintec distributing MTC's PBN and CVD SiC in Europe

Ceramic component maker Morgan Technical Ceramics (MTC), a division of UK-based Morgan Crucible Company plc, has entered into an exclusive European distribution agreement with Kennametal Sintec Keramik (UK) Ltd of Newport, UK. Since the beginning of March, Sintec has been distributing both MTC's pyrolytic boron nitride (PBN) and CVD silicon carbide (SiC) materials for use in semiconductor manufacturing.

"We continually look at ways to improve our processes, and by working with Sintec we will be able to shorten lead times, meaning customers will receive products sooner," says MTC's general manager Phil McGraw. "Previously parts were shipped from our site in Hudson,

USA, but Sintec has a local customer service organisation in the UK and Germany that is able to offer faster response times to our European customers."

MTC says that PBN suits compound semiconductor manufacturing because it offers intrinsic purity, superior mechanical strength and thermal stability. It is a non-toxic, non-wetting material that does not react with acids, alkalis, organic solvents, molten metals or graphite. PBN also has bulk impurity levels of less than 100 parts per million, with metallic impurities of less than 10 parts per million. It also withstands high temperatures (1800°C in vacuum and 2000°C in nitrogen), without deformation, making it

suitable for furnace components and melting vessels.

MTC's Performance SiC is used for semiconductor processing equipment manufacturing and is available in two grades: ultrapure and low electrical resistivity. Using a chemical vapor deposition (CVD) manufacturing process, both ultrapure and low-electrical-resistivity Performance SiC outperform conventional materials in hostile chemical and plasma environments, it is claimed. Its high purity, stiffness, thermal shock resistance and thermal conductivity also suit a variety of demanding semiconductor processing applications, the firm adds.

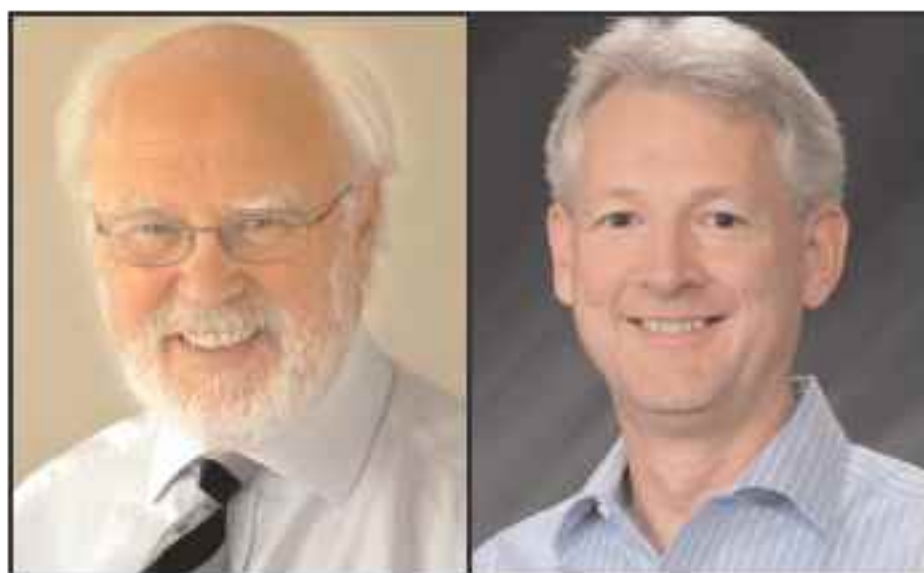
www.morgantechnicalceramics.com
www.sintec-keramik.de/

SAFC Hitech appoints new president, succeeding Leese

Chemical manufacturer SAFC Hitech of St Louis, MO, USA (a business of SAFC within the Sigma-Aldrich Group) has appointed Philip Rose as president, succeeding Barry Leese (who retired on 1 April). Rose will be based at SAFC Hitech's facility in Haverhill, MA, USA.

Rose joins after 20 years with competitor Rohm & Haas (acquired by Dow Chemical in 2009), where he worked in senior roles in R&D, marketing, operations and business development in the USA, Japan and South Korea (most recently as global marketing director for Dow Electronic Materials' display technologies unit in Seoul).

"SAFC Hitech has established itself as a leading materials supplier in the electronics industry," says Rose. "Despite generally slow conditions in the global economy in 2009, the business performed well in the final quarter of the year, and the longer-term outlook remains positive," he



Leese (left) and Rose (right).

adds. "Our goal is to continue to develop the chemistries, the expertise, the tools and methodologies that will facilitate future generations of electronics. The foundation is in place for us to continue to grow our leading portfolio of materials and services."

Epichem was founded in 1983 in Bromborough, UK. The British Technology Group (BTG) was a 28% shareholder in Epichem, with Barry Leese and Graham Williams holding the balance. The firm's aim was to serve selected speciality chemical niches, such as the silicon

and III-V electronic materials markets. Epichem first concentrated on silane (which at the time was not manufactured in Europe), providing the income to invest in III-V technology, with MOCVD (then a promising production technology) requiring very high-purity metal-organics. Under Leese's leadership, Epichem went on to become a leading provider of metal-organics, precursors and gases to the electronics industry. Epichem was acquired by Sigma-Aldrich in February 2007 and integrated into its SAFC Hitech operations, of which Leese was made president.

"Leese was instrumental in supporting and enabling the seamless integration of the former Epichem business into the Hitech business segment," comments SAFC president Gilles Cottier. "His experience during the transition proved invaluable."

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IN BRIEF

R&D reactor orders from India and USA

Further to the issue of its Q1/2010 results, at the end of March Riber received two orders from India and the USA for MBE reactors to be used in R&D.

Following delivery of a first order in 2009, EPIR Technologies Inc of Bolingbrook, IL, USA is increasing its number of Riber MBE systems by acquiring an MBE32 research machine (which is the foundation of Riber's research systems portfolio, with hundreds sold to customers worldwide).

EPIR addresses the civilian and defense sectors, specializing in optoelectronic materials and sensors such as infrared detectors (using mercury cadmium telluride) and, more recently, biosensors and solar cells (working with partner Sunovia Energy Technologies Inc of Sarasota, FL on cadmium telluride on silicon solar technology). The MBE32 system will boost EPIR's ability to develop and produce epitaxial materials.

Riber has also sold an EPINEAT research system to a major research institute in India, enabling the lab to increase its development capacities for the design of GaAs-based III-V components such as lasers, power electronics and RF communications.

Riber says that the MBE system is optimized for GaAs processing and provides greater added value than alternative metal-organic chemical vapor deposition (MOCVD) technologies, especially for high-output performance in the fabrication of complex heterostructure layers.

The firm says that, as a further stage of its growth in emerging countries, the order strengthens its position in the Indian market and more generally in the Far East (the fastest-growing regions of the semiconductor industry).

www.riber.com

Riber reports Q1 revenue up 11% year-on-year; order backlog rises 30%

For first-quarter 2010, Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported revenue of €2.9m, up 11% on €2.6m a year ago.

This was despite delivering the same number of research machines as in Q1/2009 (two) — representing systems sales down 8% from €1.2m a year ago to €1.1m — and sales of cells and sources falling 57% to €0.2m compared to Q1/2009's exceptionally high €0.5m.

Growth was driven by the development of services and accessories sales under the Riber and VG brands, by 71% from €0.9m a year ago to €1.6m. Riber says that the year-on-year growth affirms its policy of developing services activities, which generate recurring revenue.

Order backlog at the end Q1/2010 was €9.1m, up 30% on a year ago. This includes seven machines to be delivered this year, including one production machine sold at the end of March to a Russian manufacturer.

Riber will provide full-year guidance at the end of first-half 2010.

Riber sells production MBE reactor to Russia's Connector Optics

Riber has sold an MBE49 production system to optical component maker Connector Optics LLC of St Petersburg, Russia.

Connector Optics was established in 2009 and owns intellectual property rights for the production of 850/980nm ultra-high-speed (up to 40Gb/s) vertical-cavity surface-emitting lasers (VCSELs) and photodetectors for data transmission via local-area networks (LAN), storage-area networks (SAN), active optical cables (AOC), supercomputers, and optical interconnects (USB 3.0, 4.0).

The MBE49 reactor acquired by Connector Optics will be installed in a new facility in St Petersburg, and dedicated to making VCSELs and photodetectors for optical data communications.

Riber says that its systems provide great flexibility in processing large-size substrates (multiple 4-inch and multiple 6-inch wafers) for growing III-V semiconductor based nanostructures. In particular, due to its unique deposition quality, mono-atomic precision and high purity level, the MBE49 is by far the system most adapted to the production of highly

demanding nitride-based optical components, the firm adds.

"We were impressed by the performance of the Riber MBE machines and by the quality of the optical device structures obtained using the MBE49," says Connector Optics' CEO Leonid Karachinsky. "The reputation of Riber and the total installed base of Riber pro-

Due to its unique deposition quality, mono-atomic precision and high purity level, the MBE49 is by far the system most adapted to the production of highly demanding nitride-based optical components

duction machines around the world illustrate its foremost expertise in the nanotechnology industry," he adds. More than 180 production systems have been installed worldwide (dedicated to optical component design and to the mass production of radio-frequency components).

Veeco sells MOCVD tools to Seoul Optodevice and Genesis Photonics

Epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview NY, USA says that its TurboDisc K465i gallium nitride MOCVD system has been selected by Korea's Seoul Optodevice Co Ltd (SOC) to expand its high-brightness LED capacity. Joining orders placed in 2009, SOC placed a multi-tool order in second-quarter 2010, with all tools scheduled to ship this year.

A division of LED maker Seoul Semiconductor, SOC was founded in 2002 and developed what are claimed to be the first AC LEDs. It is now also supplying deep UV LEDs.

The firm already uses Veeco high-productivity MOCVD systems, which are "the lowest cost-of-ownership tools on the market", comments SOC's CEO Seyong Oh.

"This recent order from a top LED manufacturer is further evidence of Veeco's growing market share, particularly in Korea where we are the

leading provider of MOCVD tools," comments Bill Miller, senior VP & general manager of Veeco MOCVD.

Also, in Q1/2010, Veeco received orders for multiple TurboDisc K465i systems from Taiwan's Genesis Photonics Inc (GPI).

Founded in 2002, GPI focuses on providing GaN-based LED epiwafers and chips for lighting, display, backlight, and automotive lamp applications, as well as powerful LED chips for scientific, industrial and research applications. GPI will use the new systems to ramp up capacity to meet demand for HB-LEDs.

GPI's chairman & CEO David Chung says that its existing Veeco systems have been helping it to achieve brightness higher than the industry average. "The K465i gives GPI the technology to surpass their LED brightness roadmap objectives," adds Miller.

www.veeco.com

Aixtron MOCVD tools boost Changelight ROY UHB-LED ramp

In Q2/2010, German deposition equipment maker Aixtron is shipping two more MOCVD tools (ordered in Q4/2009) to Changelight Co Ltd in Xiamen Torch Industry Park of China's Fujian Province.

A year after Changelight received its first AIX 2600G3 Planetary Reactor system, the new AIX 2600G3 IC multiwafer production tools will be used for large-scale manufacturing of red, orange and yellow (ROY) ultra-high-brightness (UHB) LEDs.

"A further pair of AIX 2600G3 systems will underpin the next step in our company strategy to become the leader of the Chinese optoelectronics industry," says Changelight's general manager professor Wang Xiang Wu, who has a decade of experience working on Planetary reactors. "Changelight is working hard to provide the very best products for China's solid-state lighting program."

www.aixtron.com

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SPTS announces shipments of \$40m in Q1/2010

Integration of UK Division and relocation of Thermal Products Division to boost gross margin and efficiency

SPP Process Technology Systems Ltd (SPTS) of Newport, Wales, UK, the plasma etch & deposition equipment subsidiary of Sumitomo Precision Products Co Ltd (SPP), has announced shipments of \$40m in first-quarter 2010.

SPTS was formed by SPP last October to merge predecessor firm Surface Technology Systems plc (STS) together with assets acquired from Aviza Technology Inc, including Newport-based single-wafer process equipment subsidiary Aviza Technology Ltd (ATL) and Aviza's Scotts Valley-based Thermal Products business (which provides spare parts,

upgrades, and new or remanufactured systems to existing customers of Watkins Johnson, SVG, and Aviza furnaces and APCVD systems).

Q1 shipments included a broad range of etch, CVD and PVD single-wafer tools, as well as new and refurbished furnaces and thermal product upgrades. In addition to strength in their traditional MEMS (micro-electro-mechanical system) and image sensor markets, the TSV (through-silicon via) and compound semiconductor markets exhibited rapid growth, particularly in LED applications. Of particular note was a resurgence of activity in STS brand products, accounting

for a significant portion of Q1 shipments.

"We see continuing strong customer interest in all product lines, with our system book-to-bill ratio in excess of 1.3:1 during the first quarter," notes president & CEO William Johnson.

"In addition, as we complete the integration of our UK Division and relocate the Thermal Products Division to a new facility in San Jose during the second quarter, we expect to see significant improvement in gross margin and operating expense efficiency as we enter the second half of the year," he adds.

www.stsystems.com

Plasma-Therm joins Fab Owners Association

Plasma process equipment maker Plasma-Therm LLC of St Petersburg, FL, USA says it has joined the Fab Owners Association (FOA), an international, non-profit, mutual benefit corporation founded in 2004 and composed of semiconductor and MEMS manufacturers, along with industry suppliers.

Through quarterly meetings, FOA members work collaboratively to discuss problems and provide solutions on issues relevant to the semiconductor manufacturing industry. "Members like Plasma-Therm are extremely important to our trade association: they bring tomorrow's solutions to our device maker members today," says FOA's executive director L.T. Guttadauro.

Through active membership participation, Plasma-Therm says it will provide insight into common practices and offer solutions to problems in dry etch and PECVD technologies. "The Fab Owners Association gives key industry players a valuable forum to discuss relevant issues and share solutions that will benefit technological advancement in many different markets," says Plasma-Therm's CEO Abdul Lateef.

Plasma-Therm offers both dry etch & PECVD technologies, catering to various specialty markets, including photomask, solid state lighting, thin-film head and compound semiconductor applications.

www.waferfabs.org

Plasma-Therm launches Mask Etcher MLS

Plasma-Therm has introduced its Mask Etcher MLS (Manual Load System), the latest product in its Mask Etcher series.

MLS allows photomask makers to smoothly transition from wet etch to more advanced dry etch for 250-180nm technology nodes. Its concept, design and implementation also allows it to be upgraded all the way to the 90nm node.

"We want to be a key business partner for our customers and offer simple and cost effective opportunities to expand as their needs and technological requirements grow," says Ed Ostan, executive VP of sales & marketing.

www.PlasmaTherm.com

South Korean LED maker orders VERSALINE PECVD systems

Plasma-Therm says that it has sold three VERSALINE PECVD systems to a leading South Korean LED maker.

As additional orders that complement other Plasma-Therm systems currently installed at the LED

maker's fabrication plant, the tools were purchased to meet capacity expansion needs for high-quality dielectric film deposition. The systems use Plasma-Therm's fully integrated EndpointWorks, which facilitates accurate and repeatable

real-time endpoint process control. "The innovative drive within the LED industry has been consistently pushing to perfect cost-efficient and energy-efficient lighting solutions," says executive VP of sales & marketing Ed Ostan.

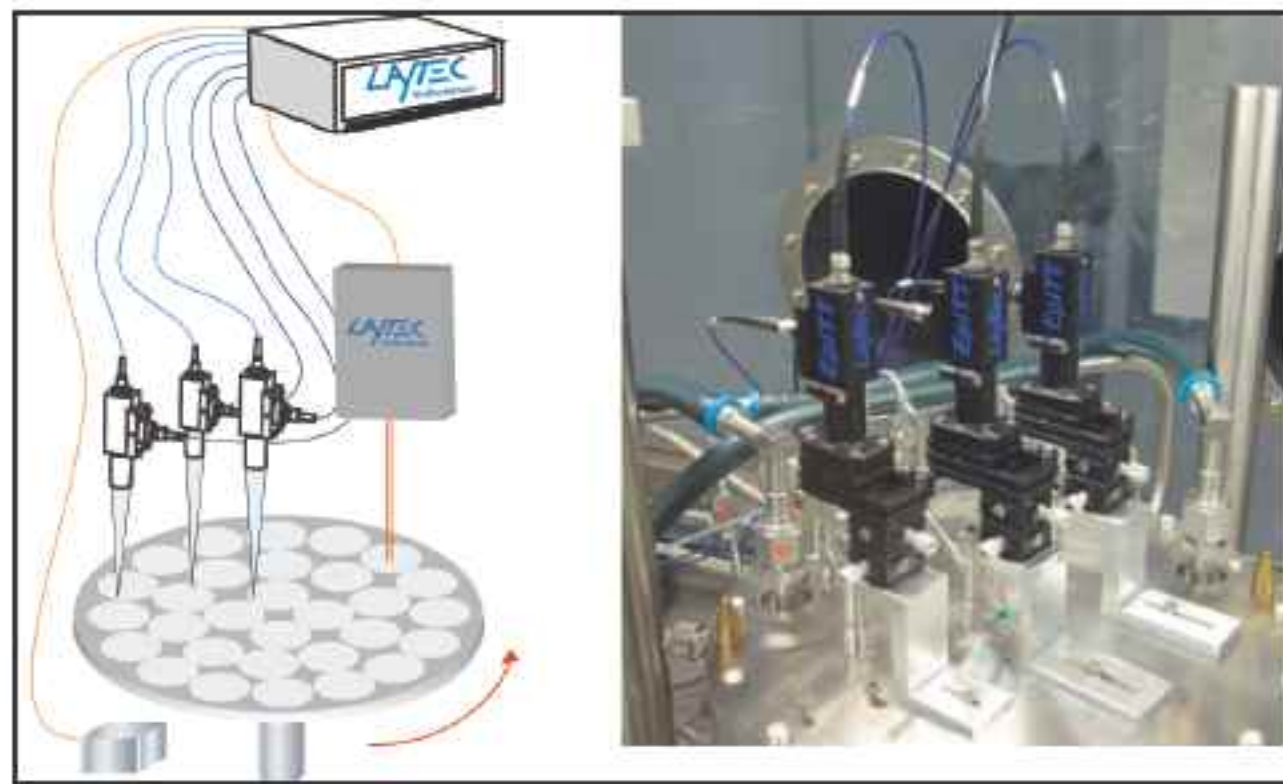
LayTec sells first EpiCurveTriple TT

LayTec GmbH of Berlin, Germany, which provides in-situ optical metrology equipment for thin-film processes, has sold its first EpiCurve Triple TT tool to a leading LED maker in the USA.

The in-situ system will be used for GaN-based LED production in a multiple-ring MOCVD reactor.

LayTec says that the unique combination of a Curve optical head for wafer bowing control and three EpiTT heads for temperature and reflectance measurements will be the first metrology system of this kind.

EpiCurveTriple TT is designed specifically for applications in large showerhead-type MOCVD reactors such as CRIUS for GaN LED production and GaN/Si applications. As in LayTec's EpiTriple TT, the three EpiTT heads of the EpiCurveTriple TT measure reflectance and emissivity-corrected pyrometry at three different radial positions and enable absolute temperature control of growth on all heating zones of the susceptor. The accuracy of the



EpiCurve Triple TT on a 30x2" CCS reactor (left). First example of EpiTriple TT (without Curve optical head) installed on a CCS reactor (right).

temperature measurement after calibration by LayTec's new AbsoluT tool is better than $\pm 1\text{K}$. Online growth-rate analysis with accuracy of up to $\pm 0.001\text{nm/s}$ is also possible.

The Curve head also suits strain control and wafer bow measurements, helping to minimize bowing-related non-uniformities in GaN LED production on 4" and larger wafers.

● LayTec invites all its customers to its 13th in-situ seminar, at the 15th International Conference on Metal Organic Vapor Phase Epitaxy (IC MOVPE XV) in Lake Tahoe on 24 May. www.tms.org/Meetings/Specialty/icmovpe-xv

LayTec adds business development manager for China and Taiwan

LayTec has strengthened its sales team by recruiting Tom Thieme as its new manager for business development in China and Taiwan. With LayTec's market share in Asia growing, Thieme will coordinate sales activities, strengthen the firm's cooperation network, and work directly with customers and distributors in China and Taiwan.

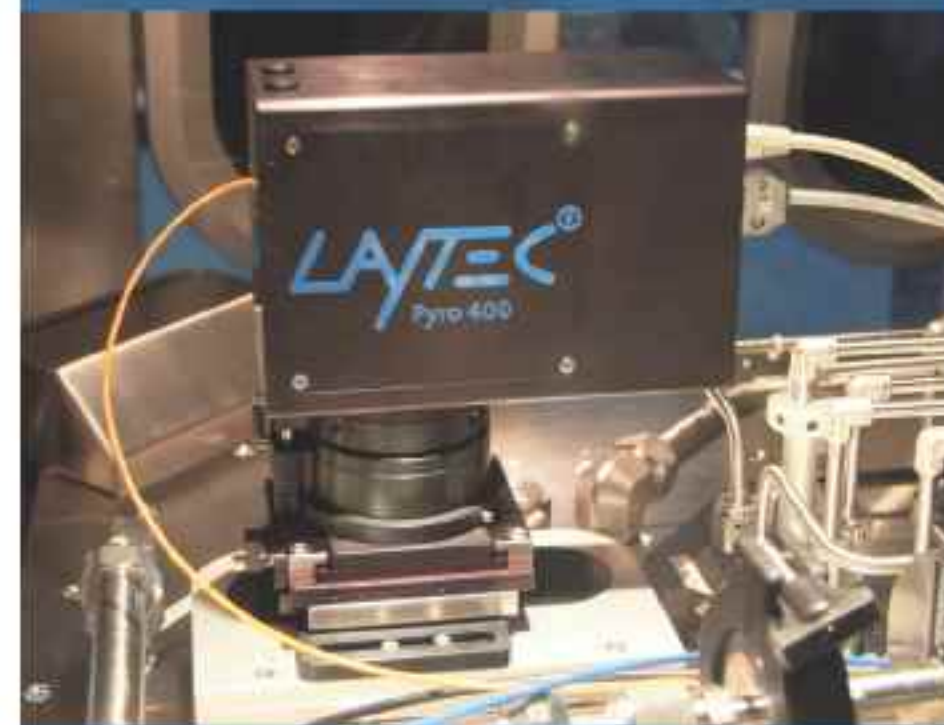
As well as having a technical and scientific background as a graduate in process engineering, Thieme has 14 years of experience in international sales and marketing. He has previously worked at Atotech (part of the Total Group), focusing on electro-

chemical process solutions for the electronic and semiconductor industries. He also has experience in product integration, establishing and managing product portfolios, customer networking, and relationship management.

● Since January 2009, LayTec's staff has grown by more than 20%, and the firm continues to grow. Positions are currently offered for an experimental physicist (R&D), a constructing engineer (R&D), a service engineer (customer support), software developer, physicist (Bachelor of Science), and a software & system tester. www.laytec.de/careers.html

Real GaN surface temperature

LayTec's groundbreaking new product Pyro 400 finally makes real wafer surface temperature measurements of GaN possible. It offers deep insight into surface temperature changes caused by carrier gas, rotation speed and reactor pressure variations as well as wafer bowing effects. This quantum leap in GaN temperature measurement provides immediate access to emission wavelength variations and thereby provides huge benefit for yield enhancement in future GaN-based LED production.



The Pyro 400 in-situ system can be used in combination with the EpiCurve® TT for simultaneous bowing control.

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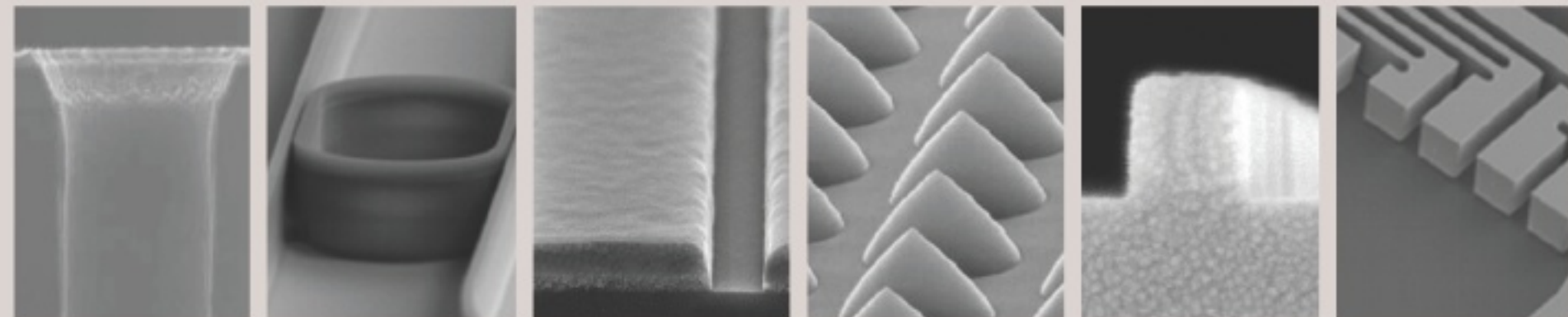
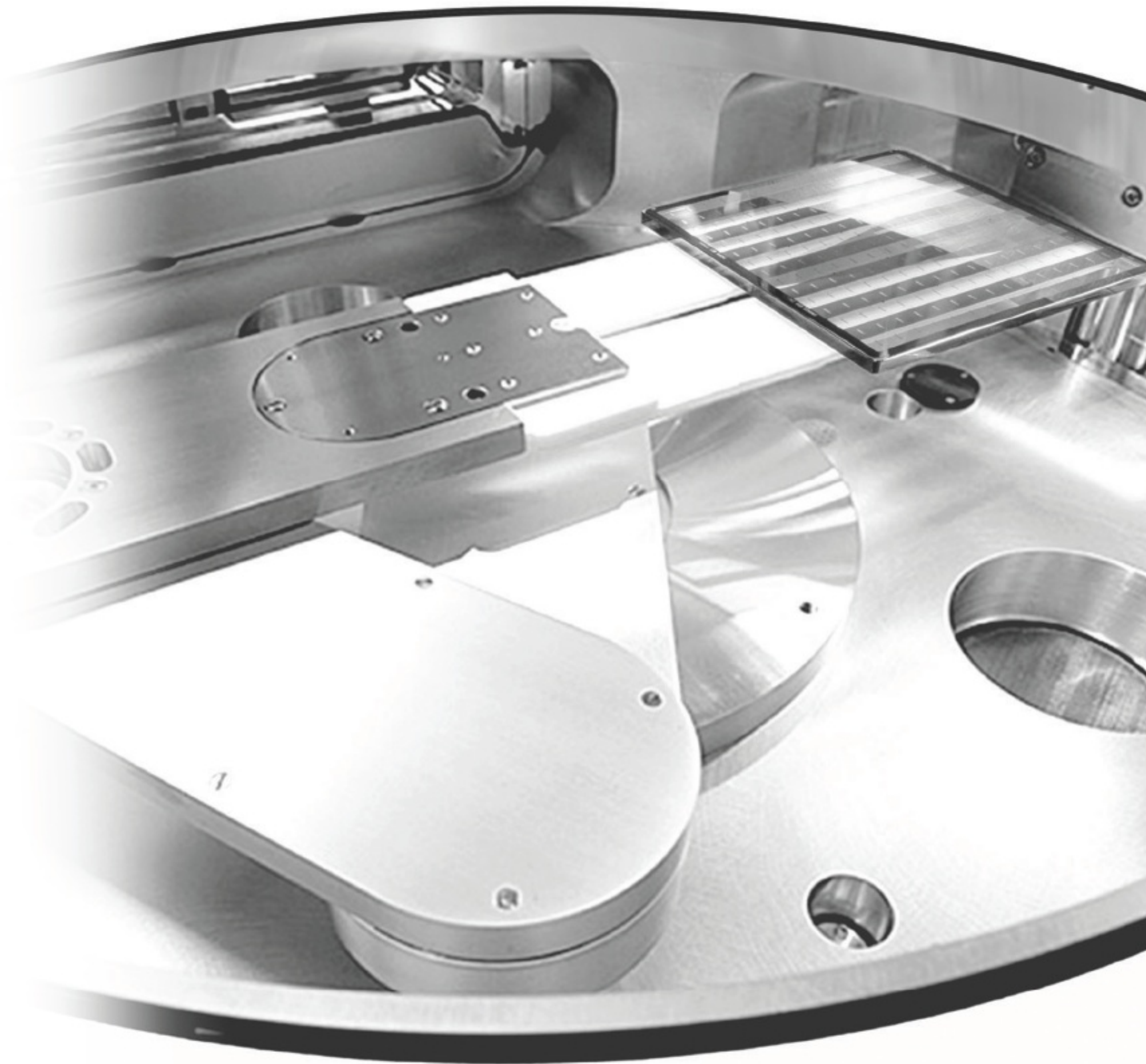


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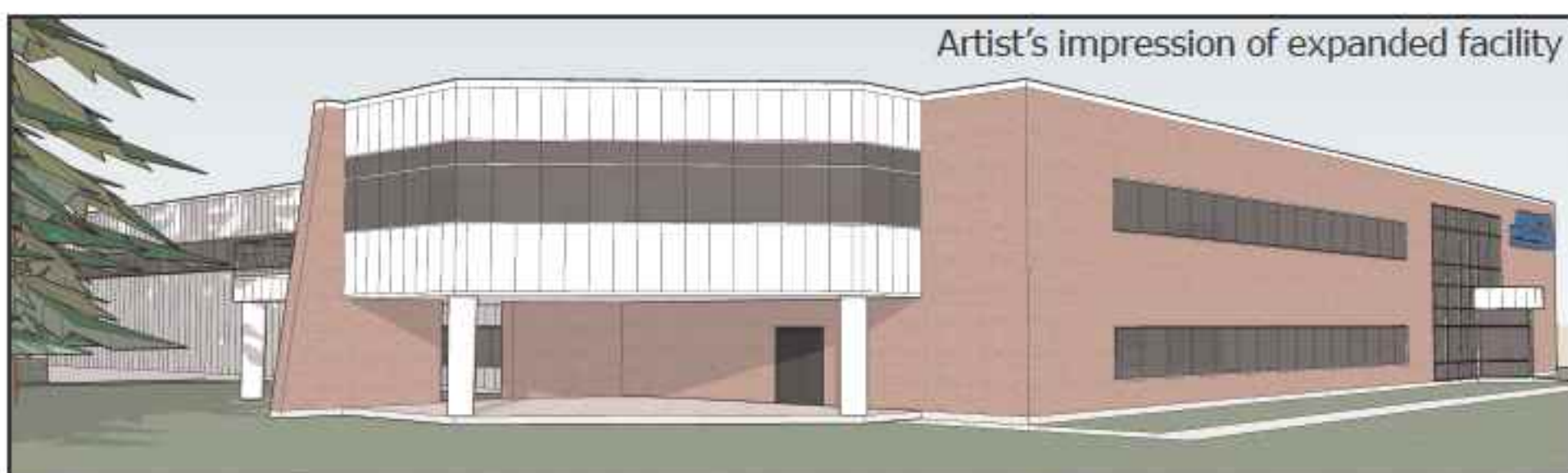
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JPSA starts expansion, driven by LED market growth

JP Sercel Associates Inc (JPSA) of Manchester, NH, USA, which makes UV laser-based materials processing workstations for wafer processing and micromachining, has begun construction on the first phase of its 20,000ft² facility expansion, which will enable JPSA to meet increasing demand for its LED and solar laser processing systems, as well as its excimer laser micromachining systems.

The expansion will double the size of the existing laser production area used for manufacturing JPSA's high-throughput, high-precision laser micromachining systems. It will also provide cleanrooms, R&D laboratories for developing micromachining applications, and ergonomic office space for accommodating the firm's growing customer service and engineering teams.



Artist's impression of expanded facility

"JPSA has seen a significant ramp up in demand for our high-throughput LED scribing and LLO [LED lift-off] systems, driven by the high growth of the LED market," says president Charlie Cuneo. "JPSA has already doubled capacity for 2010 and increased staff by over 30%... This expansion is necessary to provide more manufacturing space for our growing laser systems business."

The expansion's design will conform to the Leadership in Energy and Environmental Design (LEED) Green Building Certification System

developed by the US Green Building Council (USGBC), to encourage environmental quality design.

JPSA's products and services include UV excimer, DPSS (diode-pumped solid-state) and ultra-fast laser micromachining systems, UV and VUV laser beam delivery systems, laser materials processing development, optical damage testing, and excimer laser refurbishment services. JPSA operates a laser job shop as well as a systems engineering and manufacturing business.

www.jpsalaser.com

Seoul Optodevice buys Candela CS20 to optimize epi productivity

Process control & yield management solutions provider KLA-Tencor Corp of Milpitas, CA, USA says that Korea's Seoul Optodevice Company Ltd is the latest LED maker to adopt its Candela CS20 platform.

KLA-Tencor says that the sale marks the growing importance of defect inspection for MOCVD, and reinforces the firm's continued focus on LED inspection.

Defects from epitaxial and substrate processes can impact yield and field reliability. Critical epi defects include pits, cracks, topographic anomalies and surface non-uniformity, while substrate defects can include particles, scratches and stains. KLA-Tencor says that its Candela CS20 system is uniquely designed for the inspection of transparent materials (gallium nitride and sapphire) with the simultaneous detection of surface reflectivity, topography, scatter and phase signatures. The automated inspection system, with real-

time classification, provides actionable data for effective process control, adds the firm.

"Inspection results from the Candela CS20 will enable us to optimize epi processes and improve productivity," says Seoul Optodevice, which reckons that adoption of this process control strategy will provide improved product quality and consistent performance.

"LED market growth is slated to be greater than 35% year-over-year," notes Jeff Donnelly, group VP of KLA-Tencor's Growth and Emerging Markets division. "We are making significant investments in products that specifically address LED manufacturing needs," he adds. "This investment, combined with our extensive experience in process control solutions, enables us to bring superior products to market rapidly to address the industry's cost and technology roadmaps."

www.kla-tencor.com

China laser scribing patent for JPSA

JPSA has been awarded a patent in China covering the unique laser scribing technology used by JPSA Laser. The same technology has already been patented in the USA, Taiwan, Korea, and Japan.

JPSA's scribing technology permits what is claimed to be an industry-leading 2.5µm kerf, providing more die per wafer, higher throughput, less debris, minimized heat affected zone (HAZ), and faster return on investment (ROI), says the firm, adding that the ChromaDice system also increases throughput and yield.

"This patent protects our growing presence in China's laser scribing market," says chief technology officer Jeffrey Sercel. "JPSA has long been in the forefront of advancing new laser techniques for LED and semiconductor manufacturing, and we look forward to providing more of our high-precision laser systems to manufacturers in China."

Edwards' new Zenith range incorporates iXH vacuum pump and Atlas gas abatement

UK-based Edwards has expanded its Zenith range of integrated exhaust management systems with a new offering incorporating its iXH harsh process vacuum pump and Atlas family of gas abatement solutions.

"Advanced semiconductor manufacturing processes have created new vacuum technology challenges, while environmental concerns are leading to tighter regulation of the gases exhausted during the semiconductor manufacturing process," says Mike Allison, managing director, sales & service, Edwards. "At the same time, economic imperatives are driving semiconductor manufacturers to seek opportunities to lower the [cost of ownership] CoO of their tools, as well as reduce overall manufacturing costs. Both the Atlas abatement system and the iXH pump were designed to meet these latest manufacturing requirements, while delivering



Edwards' new Zenith system.

lower system CoO, reduced utility costs, improved ease-of-use and extend maintenance cycles."

All components in the Zenith system are completely integrated, and each function is supported by a control interface. The Zenith range provides full internal distribution, as well as regulation and monitoring of all services. Furthermore, a Zenith exhaust management solution can reduce system footprint by up to

70% and can reduce utility hook-ups by over 60%, says the firm.

The iXH series of dry pumps for harsh processes offer greater process capability and reduced CoO compared to previous-generation Edwards pumps. They feature a wide temperature range, which helps minimize by-product accumulation; greatly increased powder-handling capabilities; and a unique Gas Buster technology; as well as innovative pump seal technology. iXH systems can also expand process windows, helping to improve yields.

The Atlas combustion-based abatement family of systems are tailored to the needs of individual semiconductor manufacturing processes, such as CVD and etch. They consume half the fuel of previous-generation abatement systems, thereby significantly reducing operating costs, adds Edwards.

www.edwardsvacuum.com

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Taiwan LED makers expand to meet backlighting demand

Huga Optotech raises US\$112.5m to fund new capacity

Taiwanese LED firms are expanding their manufacturing capacities to capitalize on the huge market potential from the growing popularity of LED TV and LED lighting, according to a report in the Taiwan Economic News.

LED chip maker Huga Optotech Inc has completed a capital increase plan via a private placement, enabling it to raise a further US\$112.5m. This is almost equivalent to its paid-in capital, which was boosted from US\$76.2m to US\$110.7m early last December, including US\$16.61m from selling a 4.9% stake in the firm to Taiwan's Inventec Corp (the world's fourth-largest notebook PC maker) as well as issuing convertible bonds worth about the same amount to existing shareholder Everlight Electronics Co Ltd (Taiwan's largest LED packaging firm).

Huga said at that time that it was preparing to add 39 new MOCVD systems to its production lines, expanding LED chip manufacturing capacity to 2 billion units a month, targeting blue and green LEDs at the booming market for LED backlights, especially for liquid-crystal display (LCD) TVs.

Fellow LED chip maker Bright LED Electronics Corp has also received excess subscription to its capital increment plan, which generated US\$59m in new funding (also nearly equivalent to its paid-in capital of US\$61m). Other Taiwanese LED makers that have also recently increased their capital include Formosa Epitaxy Inc, Unity Opto Technology Co Ltd, Tekcore Co Ltd, and Epistar Corp. From early 2009 up to now, Taiwan's LED industry has raised US\$625m in capital, its greatest amount ever.

The market potential for LEDs has also attracted major electronics firms in Taiwan — including not only Inventec but also Hon Hai, AU Optronics and Lite-On, as well as the world's top two silicon wafer foundries Taiwan Semiconductor

Manufacturing Corp (TSMC) and United Microelectronics Corp (UMC) — to buy into LED firms. VentureTech Alliance (majority owned by TSMC) has invested US\$40m in LED chip and lighting product maker Bridgelux Inc of Sunnyvale, CA, USA (gaining a seat on its board of directors) while others, such as AU Optronics, have established LED subsidiaries.

Some local firms have set their sight on the mainland China market. For example, in March LED epiwafer and chip-maker Epistar Corp teamed with Taiwan-based LED packaging firm Lite-On Technology Corp and a Chinese home-appliances maker to establish an LED manufacturing plant in Changzhou City, Jiangsu Province, with a total investment of US\$120m. Meanwhile, Epistar and UMC plan to build a joint 50:50 LED epiwafer

plant in China's Shandong Province, with Epistar producing epiwafers and UMC focusing on

downstream applications. The first phase of the plant has a registered capital of US\$16m. Also, in early March, Taiwanese DRAM memory chip maker Powerchip Semiconductor said that it is investing US\$15m to establish an LED epiwafer and chip manufacturing plant in Xuzhou, Jiangsu Province.

A major factor behind the investments in LEDs is the rapidly rising demand generated since second-quarter 2009 by the growing popularity of liquid-crystal display (LCD) TVs using LED-based backlighting (i.e. 'LED TV'), due to the merits of their compact size (and hence thinner screens), low power consumption, and higher color saturation, compared with traditional LCD TVs that use CCFL (cold-cathode fluorescent lamp) backlighting sources.

Samsung debuted LED TVs in 2007, and the product caught on in second-quarter 2009, helping it to become one of first industries to recover from the global recession. Global sales of LED TVs are expected to reach 36.5 million units (20% of total LCD TV sales of 170 million) in 2010, and rise to 184 million by 2015 (72% penetration), according to market research firm DisplaySearch.

Penetration rates of LED backlighting of computer screens are also increasing rapidly: from 61% at the end of 2009 to 84% by end 2010 for notebook PCs, and from 5% at the end of 2009 to 17% by end 2010 then 44% by 2012 for monitors.

Investor interest in LEDs has also been whetted by the rapid expansion in demand for LED-based solid-state lighting, due to growing environment-protection awareness and the continuous drop in pricing (at a rate of about 30% per quarter), according to the report in the Taiwan Economic News.

As a result, market players foresee tremendous growth potential for the global LED market in the coming years, from US\$8bn currently. The report reckons that Taiwan is well positioned to tap that potential, due to its well-established LED component industry (which ranks first worldwide in output volume and second in output value at US\$1.5bn in 2008, for a 20% global market share, trailing only Japan).

Epistar, for example, is the world's largest red LED and third largest blue LED epiwafer supplier, with more than 50% global market share for LED TV backlighting devices. Also, of the world's top five LED makers, Epistar is the only one specializing in upstream epitaxy production (with 1100 patents, including those still pending).

http://news.cens.com/cens/html/en/news/news_inner_32062.html

Penetration rates of LED backlighting of computer screens are also increasing rapidly



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Lumileds China tunnel lighting yields 60% energy savings

LED-based lighting using LUXEON Rebel LEDs from Philips Lumileds of San Jose, CA, USA in two new highway tunnels in central China is saving up to 60% in energy consumption and related costs over fixtures built with traditional light sources, according to Lumileds' distribution partner Future Lighting Solutions. Future Lighting supplied engineering assistance and LED inventory management to Xi'an Liming Electronic Technology Co Ltd, which developed the 3900 fixtures involved in the project.

Xi'an Liming, which is one of China's largest suppliers of outdoor LED lighting as well as manufacturing LED tunnel lighting, worked with the engineering team at Future Lighting Solutions to ensure that the fixtures would meet national tunnel lighting standards as well as have a sustainable LED supply. Future's services included LED part and color bin selection, optical simulations, lens testing, advanced CCT binning to provide the desired 5000K color temperature, and bonded inventory for LED availability.

"Future's help in designing and optimizing these tunnel fixtures was instrumental in our ability to both meet and exceed the national standards for this kind of lamp, and thereby win the lighting contract for these two tunnels," says Xi'an Liming general manager Yijing Mu. "More tunnel construction projects are on the drawing board, and we are now well-positioned to bid on those additional projects."

The fixtures are providing illumination for the Xinkailing and Wangzhuyuan No. 2 tunnels of the Liu'an-to-Wuhan highway, which is a north-south extension of the Shanghai-to-Wuwei mainline (one of the country's key east-west arteries). Running the entire 4.7km (2.9 mile) combined length of the two tunnels, the lighting was a joint project of Xi'an Liming Electronic Technology and the Anhui Province Huanyu Highway Construction Development Co Ltd.

Each 50W and 100W tunnel lamp contains 42 and 72 LUXEON Rebel LEDs, respectively. In addition to energy savings, advantages over

conventional light sources such as fluorescent, metal halide and low-pressure and high-pressure sodium include a 60,000-hour+ life and the ability to withstand the shock and vibration of the tunnel environment (reducing replacement, servicing and labor costs as well as lane closures).

Future Lighting Solutions says that other benefits of using LEDs include better color rendering for improved driving visibility and safety, less yellowing of the lamp fixture from baked-on dust and pollution because of the LEDs' low heat production, and 'green' features such as ROHS compliance and mercury- and lead-free construction.

"This installation highlights the environmental and maintenance benefits of using LUXEON LEDs for tunnel lighting, as well as LEDs' ability to deliver the brightness and uniform roadway illumination required," says Winter Chan, VP of sales Greater China for Future Lighting Solutions.

www.FutureLightingSolutions.com

Future Lighting LED distribution deal extended to light engines

Netherlands-based Royal Philips Electronics is expanding its existing ten-year exclusive distribution agreement for LUXEON LEDs between its LED-making business Philips Lumileds of San Jose, CA, USA and LED lighting components provider Future Lighting Solutions via a new arrangement that will offer a broad range of LED lighting component solutions (including LED driver ICs, LED modules and other key components) for OEM customers to develop further into finished products.

Philips and Future aim to cooperate more closely to strengthen their provision of product choice, design support, logistics and other services to accelerate and enable LED solutions.

Under the Philips LED licensing program, Future Lighting Solutions will become a direct supplier of basic LED light engine components, which can be used — with the cooperation of Philips — by licensees of the program to help to qualify their finished luminaires under the program's no-royalty-due provisions.

"This agreement will enable our customers to further speed their time to market, reduce their total systems costs, and sim-

Future Lighting Solutions will become a direct supplier of basic LED light engine components, which can be used by licensees of the program

plify their supply chain by sourcing devices from one partner," says Gerry Duggan, executive VP of Future Lighting Solutions' parent firm Future Electronics. "This is another important step in our mission to accelerate the adoption of solid-state lighting."

As the exclusive supplier of Lumileds' high-power LUXEON LEDs, Future Lighting Solutions says that it is providing a growing portfolio of support services for LED lighting designers and OEM manufacturers of LED lighting products, ranging from engineering consultation and concept development to online tools that automate many of the calculations involved in designing and optimizing solid-state lighting applications.

www.philipslumileds.com

Seoul Semiconductor plans Q4 launch of 150lm/W Acriche LED as 100lm/W enters production

LED maker Seoul Semiconductor says that it will begin production in late 2010 on a new lamp capable of luminous efficacy of 150lm/w (surpassing available DC LEDs).

The firm also says that, in first-quarter 2010, a 100lm/w version of its patented Acriche AC-powered lamp entered mass production.

Seoul Semiconductor says that production of the Acriche LED has become more important since the European Union began enforcing a ban on the sale of incandescent light bulbs of more than 100W last September and legislated against the use of existing inefficient electric light bulbs in all countries in the future.

The firm says that its Acriche LEDs are more efficient than halogen lamps, incandescent light bulbs and fluorescent lamps, and claims that they are the only light source that can be driven by a common alternating current (AC) power source without the need of an AC-DC converter (making it more energy- and cost-efficient than DC LEDs).



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

Two of the world's three largest lighting companies have already chosen the Acriche 100lm/w for use in lighting applications. In addition, more than 100 firms are beginning to expand the applications.

"With the results of these developments, Seoul Semiconductor enhances its reputation as an environmentally friendly LED company by speeding up the development of Acriche products with high efficiency and high reliability required in the LED lighting market," says senior vice president S.M. Lee.

www.acriche.com

Digi-Key to distribute Seoul Semiconductor's LEDs worldwide

Seoul Semiconductor has entered into a global distribution agreement in which Digi-Key Corp (which claims to have the industry's broadest selection of electronic components available for immediate shipment) will distribute the full range of its products, from the smallest DC LED to Acriche (claimed to be the world's first AC LED). The range will be available via Digi-Key's websites (and will be featured in future print and online catalogs).

"With technology breakthroughs increasing brightness, or lumens per watt, at lower price points, the interest in LEDs continues to grow

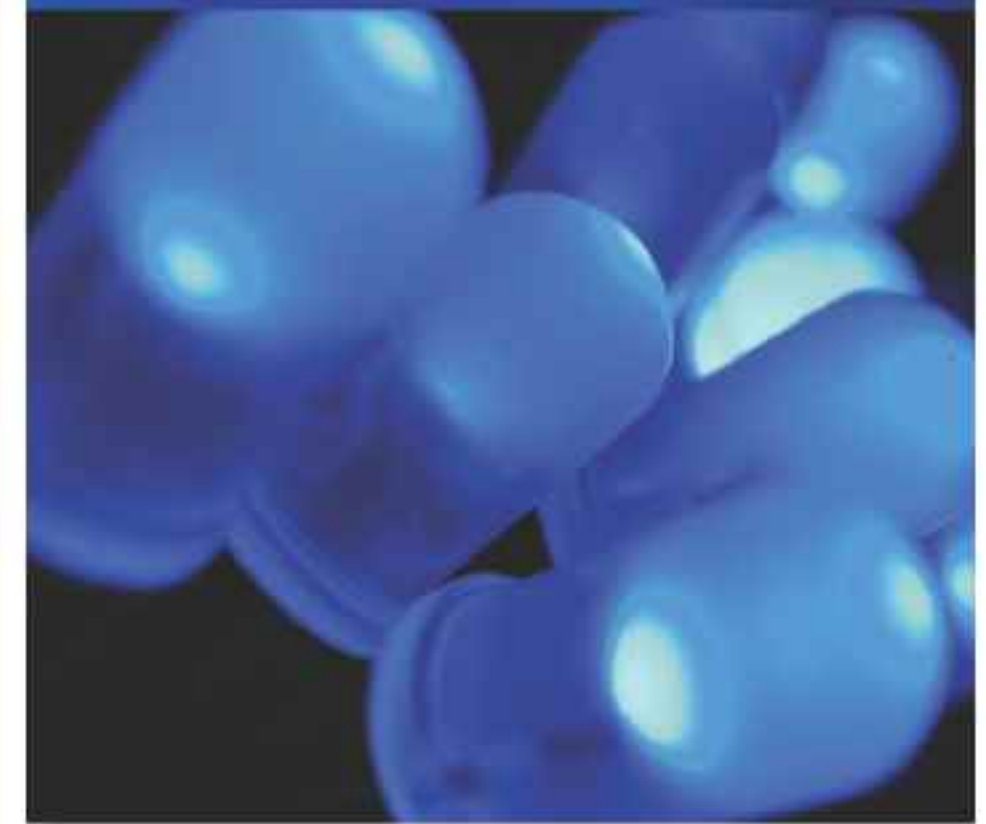
dramatically," says Dave Doherty, Digi-Key's VP of semiconductor product. "With products such as Seoul Semiconductor's Acriche AC LED, we are confident a global partnership will benefit our customers," he adds.

"We are pleased to partner with a distribution leader such as Digi-Key on a product opportunity where demand is growing with increasing intensity," says Brian Wilcox, Seoul's VP of North American sales. "The Digi-Key Lighting Partners Program will link our customers to the entire eco-system surrounding the LED, helping them get to market faster."

www.digikey.com

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Cree's new XLamp XM LED claims record efficacy of 160 lumens per Watt at 350mA drive current

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has introduced the XLamp XM LED, a single-chip lighting-class LED platform with record efficacy of 160 lumens per watt at 350mA, claims the firm. The XM also delivers 750 lumens at 2A (equivalent to the light output of a 60W incandescent light bulb at less than 7W).

A cool-white XM LED driven at 350mA can produce 160 lumens at 160lm/W, says Cree. Furthermore, the new platform has a larger footprint than the firm's XP family. It also offers the unique combination of very high efficacy at very high drive currents: at 2A, an XM LED produces 750 lumens at 110lm/W. The thermal resistance of

the XM platform is 2°C per Watt, which is a 350% improvement over Cree's flagship range of XLamp XP-E LEDs.

Samples of the XM LED are available for order now with standard lead times, and commercial availability is targeted for Fall 2010.

www.cree.com

XP-C range expanded with high-power royal blue, blue, green, amber, red-orange and red LEDs

Cree has expanded its family of high-power color LEDs with the availability of XLamp XP-C color LEDs in royal blue, blue, green, amber, red-orange and red. The new XP-C LEDs are 10–50% brighter than Cree's previous mid-range color LEDs.

XLamp XP-C color LEDs are designed for 0.5–1W operation and

can provide a cost-effective solution for many color lighting applications, says the firm. XP-C LEDs are also often compatible with existing optical designs, potentially reducing system design costs.

"Cree continues to expand design options within our industry-leading XLamp XP LED family," says Paul Thielen, director of marketing, LED

Components. Cree offers a broad portfolio of color LEDs, from high-brightness LEDs for the signage and entertainment industries to high-power LEDs for applications including architectural, color-changing, stage, emergency vehicle and transportation, all in a wide range of price-performance levels, the firm adds.

Cree claims widest viewing angle for red–green–blue oval LEDs in outdoor video screen applications

Cree has announced commercial availability of the C4SMK family of red, green and blue 4mm oval LEDs.

The additions to the Screen Master Cree LED series deliver what is said to be the widest viewing angles available on the market along with tightly matched radiation patterns for video screen applications.

The blue and green C4SMK 4mm LEDs offer a viewing angle of 115° in the horizontal axis and 65° in the vertical axis, while the red C4SMK 4mm LED has a viewing angle of 110° in the horizontal axis and 60° in the vertical axis, as is customary in the industry.

"These new high-brightness LEDs can enable video screen manufacturers to deliver an even better view-



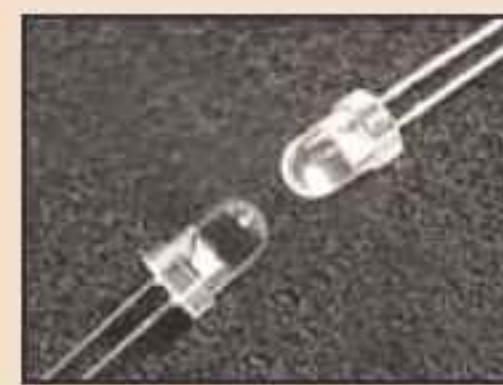
Cree's new C4SMK family of red, green and blue 4mm oval LEDs, adding to its ScreenMaster series.

ing experience for their customers," says Paul Thielen, Cree's director of marketing, LED Components.

www.cree.com/products/ledlamps_hb.asp

5mm round amber HB-LEDs for signage in transportation

Cree has announced commercial availability of its new 5mm round amber



LEDs for transportation signage.

The new line of high-brightness LEDs features minimum viewing angles of either 15° or 30° and is designed to meet the stringent requirements of the global transportation signage markets.

Cree says that the 15° (C503B-AAS-015) high-brightness LEDs offer a minimum intensity of 12,000mcd. The 30° (C503B-ACS-030) high-brightness LEDs offer a minimum intensity of 5860mcd.

Modules bring TrueWhite technology to lighting makers

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has introduced a new class of products designed to accelerate the adoption of LED lighting by traditional lighting fixture makers and speed time-to-market for their new LED-based fixtures.

With the new line of LED module products, Cree says that customers will now have access to its TrueWhite technology, allowing them to deliver efficient, high-quality light in a compact, easy-to-use product. "TrueWhite technology is already installed in thousands of locations, including restaurants, retail stores, and others that demand both high-quality light and energy-efficiency," says chairman & CEO Chuck Swoboda.

The first product is the Cree LED Module LMR4, created to overcome common design issues that manufacturers have faced when trying to incorporate LED solutions into their lighting fixtures.

The LMR4 uniquely integrates driver electronics, optics and primary thermal management, making the



compact module drop-in-ready. Designed to last 35,000 hours while consuming just 12W of power, it delivers 700 lumens at a warm-white color temperature of 2700K with a color rendering index (CRI) of more than 90. Fixture makers have the option to include a specially designed heat sink to accommodate specific high-heat applications, such as downlights for insulated ceilings.

The LMR4 (120V) is UL recognized and the LMR4 (230V) complies with multiple international standards. Fixture makers seeking ENERGY STAR qualification will have access to specification and performance data, including LM-80 reports, which

can speed regulatory approvals.

"We've never seen or worked with any LED product as simple as the Cree LED Module," says Miroslav Masar, LED Department director at lighting fixture maker OMS Ltd of Dojc, Slovakia. "We anticipate our new downlight will be available in summer 2010—and that's less than six months from when we started working with prototypes of the module," he adds. "In a fast-paced industry like lighting, this is a keen advantage for us."

The LMR4 can be ordered now for general availability this summer, and sample evaluation kits are available now.

At the Light + Building 2010 show in Frankfurt, Germany (11–16 April), demonstrations were shown at Cree's booth. The LMR4 has also been designed into demonstration fixtures seen at the booths of Disano, OMS, and LTS.

www.cree.com/modules

Zumtobel launches TrueWhite fixtures

At April's Light + Building show in Frankfurt, Germany, Zumtobel Group of Dornbirn, Austria launched three LED fixtures based on TrueWhite technology, the latest result of an ongoing multi-year collaboration with Cree agreed in October 2008.

Available from May, the fixtures will include:

- PANOS INFINITY, a family of professional LED downlights with up to 2800 delivered lumens at 77lm/W luminaire efficiency;
- CRAYON, an LED downlight delivering 1000 lumens; and
- VIVO LED-R, an LED spotlight and pendant family.

"This new product launch demonstrates the enormous advantages of solid-state lighting over conventional sources," says Ty Mitchell, Cree's VP & general manager, LED Lighting.

www.zumtobel.com

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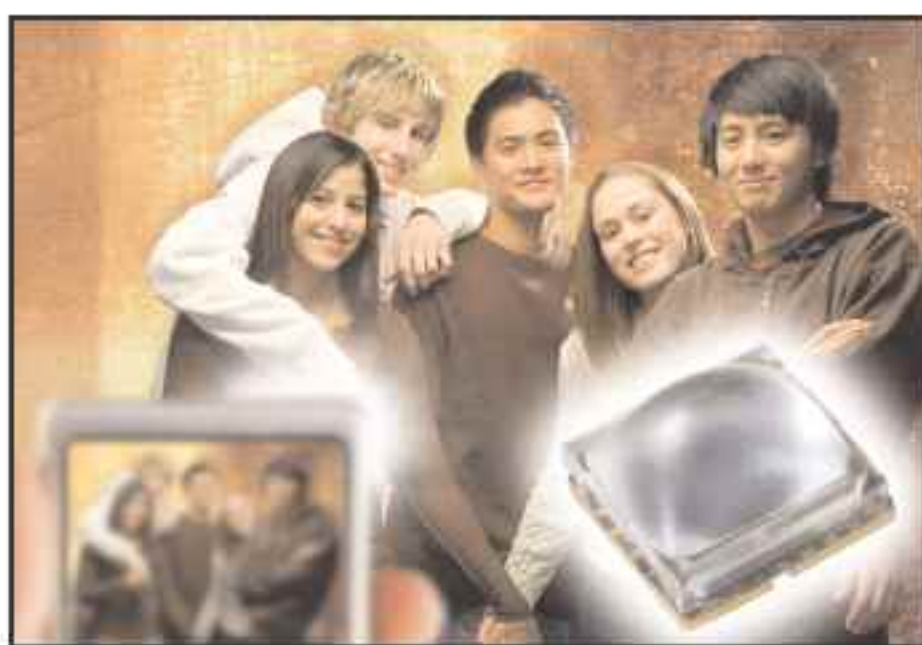
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Osram's UX:3 chip boosts power from small area

Osram Opto Semiconductors GmbH of Regensburg, Germany says that, due to using new UX:3 chip technology coupled with an optimized lens, the latest version of its OSLUX LED for flash applications has an area of just 3.9mm² and a height of 2.5mm (compared with 3mm previously) and brightness boosted by 50% (from 100 lux to 150 lux) compared with the first-generation OSLUX.

In addition, the light is more evenly distributed over the surface and can illuminate a wider area compared to previous chip technologies. Also, the common dead spot in the center of the illumination area is completely absent.

Osram says that the new UX:3 chip technology makes the LED capable of handling high currents while generating more light from the chip. The new OSLUX is also much more efficient at high cur-



Osram Opto's OSLUX LED for use in mobile-phone camera flashes.

rents than previous LEDs and offers high luminous efficacy in a small area, adds the firm.

"OSLUX is perfect for the fast-growing design-based smart phone and cell phone segment," says Gunnar Klick, marketing manager Consumer at Osram Opto. "Even extremely thin phones can now be equipped with a powerful LED flash."

The OSLUX is available with two different lenses that determine the

percentage of center brightness (20% or 40%) distributed to the corners of the flash area. At a distance of 1m, the flash uniformly illuminates the subject in a rectangular area (90cm, or about three feet, diagonal), which is sufficient to produce sharp pictures even in low light conditions, says the firm. The selected lens is integrated in the LED and matched to the beam characteristics of the top-emitting UX:3 chips.

Osram says that, with the new OSLUX, its LED portfolio for flash applications is better tailored to meet the demands of mobile and slimline applications requiring small but powerful light sources. Alternatively, for users wishing to supply their own lens packages, Osram also offers the CERAMOS LED, which it claims is one of the brightest lens-free flash LEDs on the market.

Golden DRAGON Plus used for Indonesia's first LED-lit toll road

Osram Opto Semiconductors says that its Golden DRAGON Plus LEDs have been deployed by PT Tricomm Aerocitra's Solarens lighting solutions in the 9.7km-long West 1 section of Jakarta's Outer Ring Road that comprises Indonesia's first LED-lit toll road. The LEDs, installed in 307 road lamps along road sections plus 126 lamps in eight toll gate stations, should provide uniform and comfortable lighting for drivers, says Osram.

"Uniformity affects visibility and so is very important in street lighting," says Irvin Busser, director of PT Tricomm Aerocitra. "With the stability and reliability of Golden DRAGON Plus LEDs, our Solarens road lamps and toll gate station lamps improve roadway visibility and improve driver, patrol and toll gate staff safety."

The LED-based luminaires are also expected to achieve 65% power saving compared to 150W high pressure sodium (HPS) lamps



Solarens lighting fixtures using Osram Golden DRAGON Plus LEDs installed in toll gate stations in Indonesia's first LED-lit toll road.

(important for a fast-developing country like Indonesia, says Osram Opto). Furthermore, the Golden DRAGON Plus LED has a lifetime of up to 50,000 hours, cutting service hours and maintenance costs (especially

suiting such a busy road).

Concerns over climate change and the desire to use energy resources more efficiently are driving countries around the world to adopt innovative and sustainable approaches in their infrastructure development, says Osram Opto.

According to Strategies Unlimited's study 'LED Lighting Fixtures', LED lamps will be the sole replacement for traditional lamps by 2012. Also, from 2008 to 2012, the market for LED lighting will have a compound annual growth rate (CAGR) of 28%.

"This project, with installation of LED road and toll gate lighting, has set a good showcase for the future of LED lighting in Indonesia," comments Kai-Chong Cheng, marketing director of Osram Opto Semiconductors Asia Ltd. "With this good application example, the adoption of LED lighting will accelerate in the country," he believes.

www.osram-os.com

System integrators added to LED Light for You network

German LED maker Osram Opto Semiconductors says that, in addition to existing partners from optics, thermal management and electronics (OTE), its internet-based LED Light for You (LLFY) partnering network (established in May 2008) now includes system integrators.

Osram Opto says that system integrators make it easier for end users to use pioneering LED technology for various lighting solutions. They form the professional interface between the customer and the application, linking customers to appropriate OTE specialists for their specific requirements, while acting as coordinators between OTE specialists in all three optics, thermal management and electronics sectors. If requested to

do so, system integrators can also coordinate all activities necessary for completion of a customer's project, offering support for end users at all stages.

"The network therefore offers a complete solution from a single source for various target groups such as architects, luminaire manufacturers and anyone interested in LED technology," says Sebastian Lyschick, LLFY project manager at Osram Opto. "As a link between LED users and specialists from the OTE sectors, the system integrator can coordinate entire projects or various aspects of such projects."

Specialist system integrators are available for a wide variety of lighting solutions, such as those for architectural applications, for applications in the signage industry,

and for the design of LED luminaires. For example, in the architectural sector it is lighting planners who take on this role. At present, there are 13 system integrators among about 80 partners currently active throughout the world, says Osram Opto.

The system integrator concept improves the service and customer satisfaction levels of the LLFY network, claims the firm. The network provides a clear roadmap in the highly fragmented LED market, supports potential users of LED technology, and helps find expert partners for partial and complete projects, it adds. Osram assures that it certifies LLFY partners in accordance with strict quality guidelines.

www.ledlightforyou.com

First large-scale LED street-lighting deployment in Italy

LEDs with a luminous efficacy of 100lm/W from Osram Opto Semiconductors are being used for what is claimed to be the first large-scale deployment of LED street lighting in Italy. Several hundred Archilede luminaires are now installed in the northern Italian cities of Piacenza, Lodi and Alessandria.

Designed and produced by iGuzzini for ENEL Sole, the new Archilede street luminaire uses Osram Opto's Golden DRAGON Plus LEDs, with a color temperature of 6000K. The LED's color rendering provides a natural color impression that can enhance safety and security, says Osram Opto. Archilede is available in three versions, with 84 LEDs (giving an output of about 100W), 59 LEDs (70W) and 39 LEDs (55W).

Due to their directional nature, LEDs eliminate stray light and reduce overall light pollution. In addition to high efficiency, Osram Opto's LED also has a long life (60,000–100,000 hours, depending on operating conditions), giving lower maintenance costs.

The small dimensions of the LEDs have given iGuzzini's designers creative freedom, says Osram Opto. The luminaire itself was developed specifically for street-lighting requirements (for use on any type of roadway) and has its own individual, contemporary design.

With its intelligent control system and various programming options, the LED street luminaires are capable of automatically shining more light in one direction (depending on the volume of traffic) or of shining more light on a roadway crossing than other areas of the road, for example. It is also possible to customize the lighting for different 'user groups' (e.g. pedestrians, cyclists or motor vehicles) and to adapt lighting specifically for them.

Compared with the sodium vapour and mercury vapour lamps widely used in street lighting, LED luminaires achieve energy savings of 40–60%. Extrapolated to 1000 lamps with 84 LEDs each, this equates to savings in CO₂ uptake of more than 6600 trees compared

with conventional sodium vapour lamps, reckons Osram Opto.

"Even though the initial investment costs of an LED street-lighting system is higher than a conventional lighting system, over a few years time the LED system will end up costing less due to the high efficiency, long operating life and low maintenance costs," says Markus Klein, senior director SSL at Osram Opto.

"With Osram Opto Semiconductors' high-performance LEDs, we are able to provide local authorities with street luminaires that are attractive looking on the one hand and represent a sustainable solution on the other; as well as electricity costs, they also drastically reduce CO₂ emissions and maintenance requirements," says iGuzzini's president Adolfo Guzzini.

The Archilede was exhibited at the Light+Building 2010 trade fair in Frankfurt, Germany (11–16 April), together with LED streetlamps from Hess, Siteco and Leipziger Leuchten.

www.iguzzini.com

IN BRIEF

First ultraviolet PhlatLight LED launched

Luminus Devices has launched its first big-chip ultraviolet (UV) LED based on the firm's PhlatLight (Photonic Lattice) technology. The PhlatLight UV CBT-120 is suited to a diverse range of industrial processes, from epoxy, ink, paint, laminate and adhesive curing to semiconductor processing, says the firm.

Based on Luminus' large monolithic chip platform, the UV CBT-120 has a power density of 1W/mm², offering extremely high optical output of 10W at 390nm, and suiting UV applications that demand a high-flux of UV photons.

"Traditionally, industrial curing applications have been forced to use high-wattage, high-intensity lamps due to the level of optical power density required for these applications," says chief technology officer Alexei Erchak.

"Now, with the release of the UV CBT-120, a solid-state lighting solution is available that can reach the requisite power levels and provide a new level of process control that is safe and reliable," he adds.

The UV CBT-120 features high-thermal-conductivity packaging, with a junction to heat-sink thermal resistance of only 0.7°C/W, so it can reliably be driven to the demanding power levels necessary for industrial processing, says Luminus. The energy-saving, environmentally friendly light source lasts over 10,000 hours, it is claimed, compared with 1000–2000 hours in traditional high-intensity discharge lamps.

Samples of the UV CBT-120 are available now. Full production is expected later in 2010.

www.luminus.com

Luminus joins Next Generation Lighting Industry Alliance

Luminus Devices of Billerica, MA, USA, which makes LED solid-state light sources for illumination use, has joined the Next Generation Lighting Industry Alliance (NGLIA), an organization that partners with the US Department of Energy (DOE) to speed adoption of solid-state lighting in general lighting applications. Luminus' leadership will work closely with members on a diverse set of activities in support of core technology research, product development and manufacturing.

"NGLIA includes the world's leaders in solid-state lighting, adoption and design, and we look forward to working closely with member companies to increase research, development and manufacturing technologies and methods of environmentally conscious lighting," says Luminus' president & CEO Keith T. S. Ward. "By working with member companies, NGLIA is achieving profound success in developing energy-efficient and cost-effective solid-state lighting solutions that will lower global electrical consumption."

PhlatLight (Photonic Lattice) LEDs are used in lighting applications that require high brightness and efficiency, wide white color palette, high color rendering, and very long life. Indoor and outdoor general lighting applications include street lighting, entertainment, architecture, automotive, medical and dental, avionics, manufacturing and machine vision, ultraviolet (UV), as well as projection display and digital signage markets.

Currently, 16 private for-profit firms active in solid-state lighting research, development, infrastructure and manufacturing in the USA have membership of NGLIA, including: 3M, Acuity Brands Lighting, Applied Materials, CAO Group, Corning, Cree, Eastman Kodak Company, GE-Lumination, Light Prescriptions Innovators, LSI Industries, Luminus Devices, OSRAM Sylvania, Philips Solid-State Lighting Solutions, QuNano, Ruud Lighting and Universal Display Corp.

www.nglia.org

Luminus launches ballasts optimized for lighting-class PhlatLight LEDs

At April's Light + Building event in Frankfurt, Germany, Luminus launched its new ballast line, which includes four ballasts designed to interface with its SST-50, SST-90 and CSM-360 PhlatLight LEDs.

Ballast solutions for 1mm² LEDs are abundant in the marketplace, but Luminus says that its 'big chip' technology LEDs have unique electrical requirements that must be carefully considered. At the heart of the electronic power system driving the LEDs, the ballasts are designed to provide ready-made electrical/lighting solutions that reduce complexity and speed time to market. With a voltage range of 3–48V and a current range of 1.75–3.2A, they

are suited to Luminus' large monolithic chip platform.

"This is a significant product line extension both for Luminus and our customers in the application of lighting," claims Dirk Fieberg, Luminus' program manager, LED Drivers. The new optimized electrical solutions will allow users to reap the benefits of Luminus' big chip technology, he adds. A benefit for Luminus is that the new product line provides the firm with added revenue growth.

The new LB-030-15, LB-030-09, LB-060-15 and LB-150-48 ballasts all take universal AC input, have at least IP64 ingress protection, are RoHS compliant and CE certified.

Seattle to lead DOE Municipal Solid-State Street Lighting Consortium

The US Department of Energy (DOE) says that Seattle City Light (the ninth largest public electric utility in the US) is to lead a new national effort to promote the installation of energy-efficient LED street lights. With City Light's manager of streetlight engineering Edward Smalley as director and \$200,000 in DOE funding, the Municipal Solid-State Street Lighting Consortium will share technical information, performance results and residents' feedback about LED street-lighting demonstrations with participating communities (cities, power providers, and government entities) from coast to coast.

"Interest in LED street lighting is surging across the country, fueled in part by Recovery Act funding for municipal energy efficiency improvements," says DOE program manager Jim Brodrick. "As communities look to this technology to cut energy consumption, reduce their carbon footprint and lower operating costs, this national consortium will share valuable information so they can make smarter, more informed decisions about the equipment they buy," he adds. "Seattle City Light will lead this national effort to disseminate best practices and lessons learned, building a repository of valuable field experience and data that will significantly accelerate the learning curve for buying and implementing high-quality, energy-efficient LED street lights."

During the next year, City Light will be responsible for recruiting at least 50 other communities to join the consortium and share their experiences through national and regional meetings, webcasts, web-based discussion forums, and other means.

Primary membership is open to municipalities, power providers, building owners, and decision makers investing in street and area lighting.

Advisory membership is solicited from organizations with a known history for promoting lighting quality and power efficiency.

Guests, including manufacturers and consultants, may be invited to present information on selected topics at consortium meetings and will have the opportunity to review draft specifications.

The consortium aims to disseminate best practices and lessons learned via national and regional meetings, webcasts, web-based discussion forums and other means. The first webcast is planned for 6 May and all interested parties are invited to attend.

With over 34 million street lights in use across the USA, the DOE estimates that promoting the use of LED technology has the potential to save communities more than \$750m a year in energy costs alone.

Seattle will install 5000 LED streetlights this year and a total of 40,000 during the next five years (replacing almost half of the 84,000 existing sodium-vapor streetlights). "This is a good step to upgrade our infrastructure, to save money and conserve energy," says Seattle mayor Mike McGinn.

"Providing our neighborhoods with adequate, reliable lighting is absolutely critical," adds Seattle City Council member Bruce Harrell, chair of its Energy, Technology and Civil Rights Committee. "It's a matter of public safety, as well as smart, energy-efficient business practice."

City Light reviewed over 100 models of LED street-light fixtures and tested nine as part of pilot projects in the Capitol Hill, West Seattle and South Park areas. In surveys, 85% of respondents approved of the lights.

"In 2005, Seattle City Light became the first large US utility to reach net zero greenhouse gas emissions and has maintained that status for five years," says superintendent Jorge Carrasco. "Adding LED street lights to our system will not only lower energy consumption but also reduce the number of vehicle trips required for maintenance, because the equipment lasts three times longer."

www.ssl.energy.gov/consortium.html



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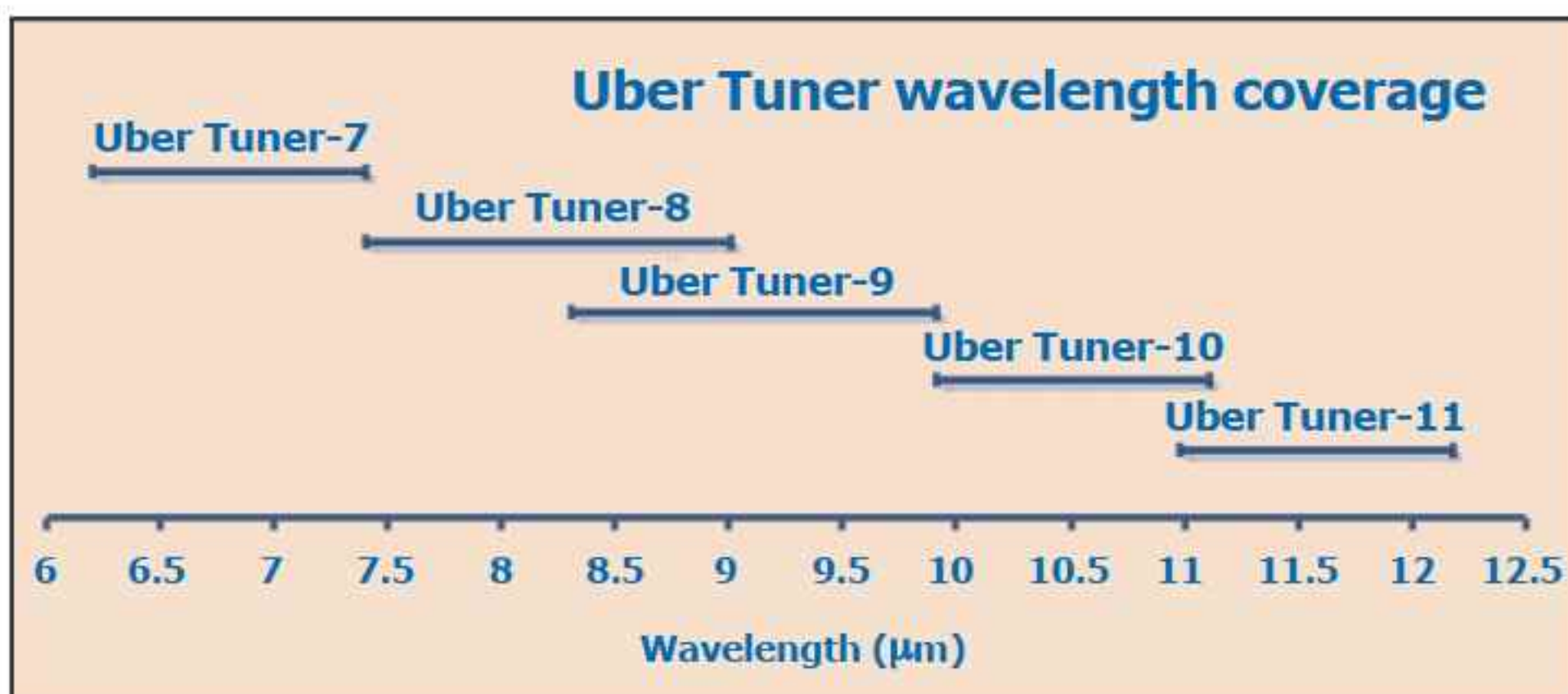


Daylight launches range of pulsed external-cavity quantum cascade lasers each tunable over 250cm^{-1}

Daylight Solutions Inc of Poway, CA, USA, which makes molecular detection and illumination systems as well as spectroscopic laser sources, has launched the Über Tuner series of broadly tunable pulsed external-cavity quantum cascade lasers (ECqCL), providing up to 250cm^{-1} or $1.6\mu\text{m}$ of continuous tuning in a single laser head. The complete series offers gapless coverage from $6.2\mu\text{m}$ to $12.2\mu\text{m}$.

Daylight's previous generation of pulsed lasers is capable of guaranteed tuning ranges of 75cm^{-1} , so Über Tuner represents a new standard in commercially available broad tunability in the mid-IR, says the firm.

Combining Daylight's patented ECqCL technology and recent advances in broadly tunable quantum cascade (QC) gain media with the Über Tuner cavity allows precision tuning over the broadest



Just five Über Tuner broadly tunable lasers can cover the entire 6.2–12.2μm mid-IR spectrum.

wavelength range available to date, it is claimed.

"We are delivering on our strategic plan to expand wavelength coverage in evermore flexible packages," says CEO/CTO Dr Timothy Day. "The Über Tuner is productizing performance that our customers have asked for again and again," he adds. "We are pleased to make

such broad tuning available as a standard product."

The Über Tuner series of lasers will serve users working in stand-off detection, near-field microscopy, and hyperspectral imaging, as well as more traditional liquid- and solid-state spectroscopies, says the firm.

www.daylightsolutions.com

Thorlabs launches 1310 and 1550nm turnkey broadband SLD benchtop sources for imaging applications

Photonic product maker Thorlabs Inc of Newton, NJ, USA has introduced the S5FC series of benchtop superluminescent diode (SLD) light sources, which integrate proprietary indium phosphide (InP) SLDs made by Covega (now Thorlabs Quantum Electronics, TQE, since its acquisition from Gemfire Corp in March 2009) with Thorlabs' all-inclusive benchtop platform.

Thorlabs hence now offers turnkey broadband SLD sources for use in optical coherence tomography (OCT), imaging systems, and fiber-optic gyroscopes (FOG). Each benchtop is available in 1310nm and 1550nm wavelength versions with SM (single-mode) and PM (polarization-maintaining) fiber and is equipped with FC/APC



Thorlabs' turnkey broadband SLD benchtop light source, available in either 1310nm- or 1550nm-wavelength versions, for imaging applications.

bulkhead connectors for easy coupling. Typical power output ranges from 2.5mW to 30mW.

An intuitive LCD interface enables users to view and set the current

and temperature for each fiber-coupled laser independently, which provides high temperature stability. The laser source also includes a USB connection for remote laser adjustment and rear analog inputs to modulate output with an external signal.

Each source includes a rear panel interlock, keylock power switch, and independent enable buttons. Users can easily configure the interlock to trigger when doors open, disabling the lasers and providing a key safety feature when operating in high-traffic facilities. To prevent damage, the unit is also equipped with a microcontroller, which will disable the output if the input settings exceed the laser limits.

www.thorlabs.com

Tilting at higher laser temperature stability

Russian and German researchers have produced edge-emitting lasers with much improved temperature stability of wavelength and threshold current [N Yu Gordeev et al, *Semicond. Sci. Technol.*, vol25, p045003, 2010].

Temperature stability is desirable for diode lasers that operate in varying temperature conditions for applications such as telecom and datacom transmitters, frequency conversion and solid-state laser pumping. Normal edge-emitting lasers can have significant redshifts occurring over a few degrees since the wavelength tends to be determined by the energy bandgap, which tends to narrow at higher temperatures. If such a laser is being used to excite a gain medium in a diode-pumped solid-state (DPSS) laser, the efficiency of the system may drop dramatically as the diode goes off-wavelength.

The tilted-wave lasers (TWLs) produced by the Russian/German team have a separate cavity that determines the laser wavelength (Figure 1). Much better temperature stability is possible because the main source of wavelength shift is that of refractive index, whose effect is much smaller than that of the bandgap. A similar improvement in stability is seen in vertical-cavity surface-emitting lasers (VCSELs) for the same reason.

The researchers were based at two centers in St Petersburg, Russia, and one in Berlin, Germany: Ioffe Physical-Technical Institute, Academic Physics and Technology University, and Technical University of Berlin. Funding was provided by the European Union's Seventh Framework (FP7) and various Russian programs and personal grants.

The laser structure was grown by MOCVD on n-type gallium arsenide (n-GaAs) (100) crystal orientation wafers. Two indium gallium arsenide (InGaAs) quantum wells (QWs) were grown inside a 600nm GaAs waveguide. The cladding and contact consisted of 600nm p-type

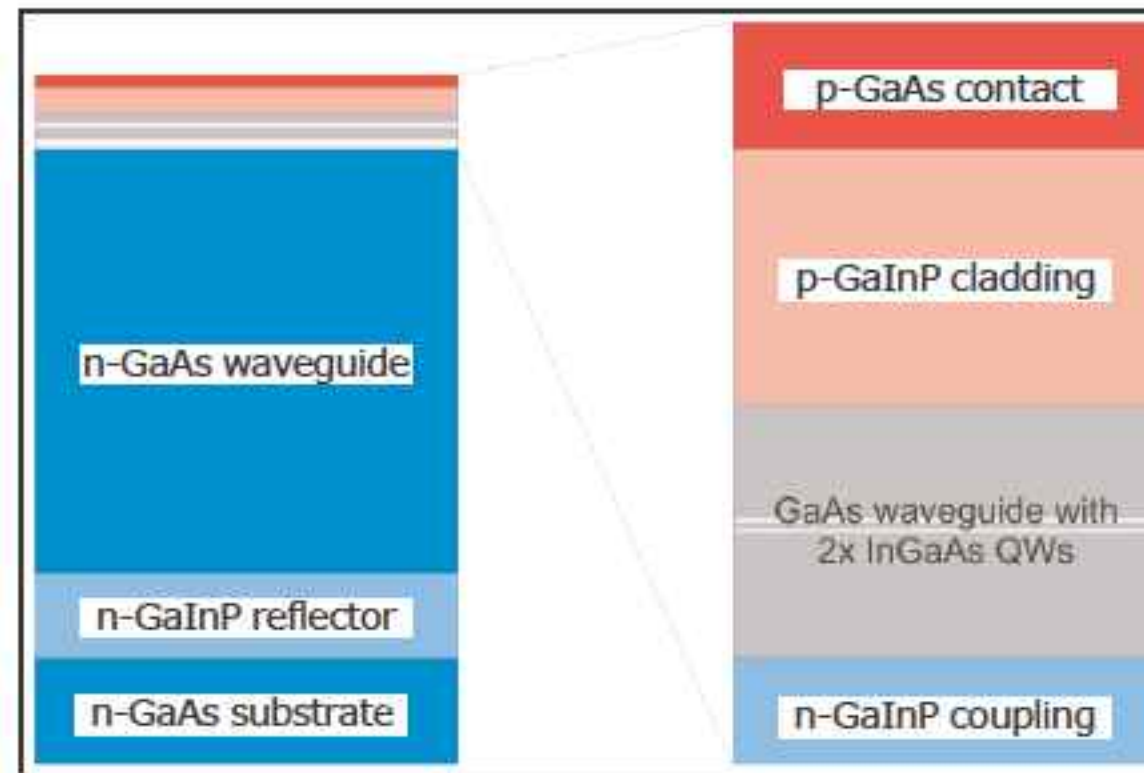


Figure 1. Tilted-wave-laser structure (left) with detail (right) of active region.

gallium indium phosphide (p-GaInP) and 300nm of p-GaAs, respectively.

Beneath the active layer was a 10 μ m n-GaAs waveguide that was coupled to the active layer by a 250nm thick n-GaInP layer. This second waveguide was grown on top of a 2 μ m n-GaInP reflecting layer, grown on the substrate.

Broad-area lasers made from these wafers had threshold currents as low as 200A/cm² and room-temperature lasing wavelengths in the range 964–1010nm, dependent on cavity length. The internal quantum efficiencies reached up to 84%, with intrinsic losses down to 2.2/cm.

Ridge lasers with 4 μ m-wide shallow mesas were produced by etching through the contact and part of the cladding. The samples were mounted p-side down on copper heatsinks. Testing was carried out in the temperature range 15–60°C.

The far-field laser pattern has two weak satellite features in the lateral direction, but two lobes (around +30°, -40°) in the vertical direction. These characteristics are related to

the way that the laser light leaks from the active region into the coupled waveguide at an angle and then is emitted from the lower waveguide facet.

While the differential quantum efficiency (DQE_{diff}) decreased significantly with temperature (Figure 2a), threshold current was much more stable. The characteristic temperature for the threshold current (T_0) was more than 500K. This compares with T_0 for normal QW edge-emitting lasers of less than 200K.

The disparate behavior of the DQE and T_0 may result from temperature dependence of mirror losses in the structure, but further investigation is required to confirm this.

The lasing wavelength shifts only 1.5nm over 20–50°C (Figure 2b). This gives a temperature coefficient (d/dT) of 0.05nm/K. This beats a recent report of 0.08nm/K for the lowest value for any broad-area semiconductor lasers without feedback gratings emitting above 900nm. Outside the 20–50°C range, the laser wavelength shifts by discrete amounts as new modes of the system become dominant: at 15°C the wavelength is 999.85nm, compared with the 20°C value of 1012.45nm.

The researchers believe that the window of temperature stability could be increased by a broader gain spectrum and a wider separation between the matched TWL wavelengths by reducing the thickness of the coupled waveguide.

<http://dx.doi.org/10.1088/0268-1242/25/4/045003>

Author: Mike Cooke

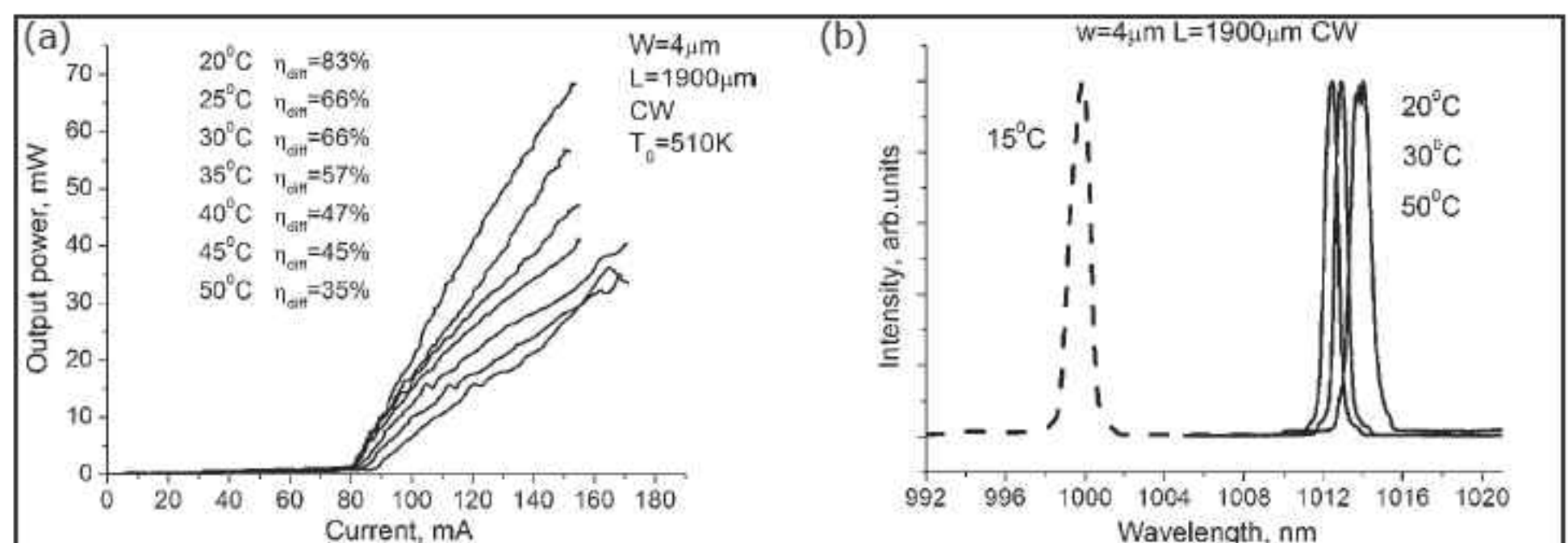


Figure 2. Temperature dependence of light-current curve (a) and spectra (b).

GigOptix grows 54% in 2009, but margins hit by ChipX Growth of 60–70% expected in Q1, followed by 10% in Q2/2010

For fourth-quarter 2009, GigOptix Inc of Palo Alto, CA, USA, which designs modulator and laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials as well as polymer electro-optic modulators, has reported revenue of \$3.1m, down 4% on \$3.3m a year ago. However, excluding the impact of the one-time revenue adjustment of \$1.3m from a change in billing rates under government contracts, non-GAAP revenue would have been \$4.4m, up 35%.

On a non-GAAP basis, gross margin has fallen from 66% a year ago to 38%, reflecting the impact of acquiring analog and mixed-signal custom ASIC supplier ChipX Inc of Santa Clara, CA last November and its historical lower gross margin.

Operating expenses have risen from \$2.4m to \$4.3m, due mainly to ChipX and a full quarter of expenses from the operations in Bothell, MA of polymer electro-optic modulator maker Lumenta Corp (acquired on 9 December 2008).

Net loss has risen from \$0.1m to \$2.8m.

Despite the industry slowdown, full-year 2009 revenue was \$14.8m, up 54% on \$9.7m in 2008 (which was more than triple 2007's \$3.2m), or \$16.1m non-GAAP (up 67%). Shipments for optical telecoms rose 40%, reflecting increased market share. In addition, GigOptix sold its first polymer-based modulator products.

On a non-GAAP basis, gross margin has fallen from 65% a year ago to 55%. Net loss has risen from \$3.6m to \$4.4m.

However, during 2009, total leased Bay Area office space (including ChipX) was halved from about 30,000ft² to 15,000ft², and headcount was cut from 115 to 85. Despite this, Q4/2009 operating expenses were still \$7m, up on \$4.2m a year ago. Nevertheless, during Q4, GigOptix's cash position rose from \$2.8m to \$3.6m.

"2009 and thus far in 2010 have been eventful periods in the history of GigOptix as we have continued to grow our revenues, made several differentiating breakthroughs with our technology, added top industry executives to our team, and continued to execute on our organic growth and acquisition strategy through the ChipX Inc transaction," says chairman & CEO Dr Avi Katz.

The management team has been strengthened by adding senior personnel from leading semiconductor firms, including chief financial officer Ron Shelton (formerly CFO with Cirrus Logic and Alliance Semiconductor) and VP of global optical sales Jay de la Barre (formerly with Sierra Monolithics Inc, which is now part of Semtech).

The acquisition of ChipX has broadened GigOptix's product portfolio with analog-mixed signal CMOS ASIC platform technology and products, boosting the firm's presence in the military, aerospace and instrumentation markets, and providing qualified supplier status with key customers as well as cross-selling opportunities of GigOptix's RF products.

Rapid consolidation of acquired firms (and in particular their engineering groups) provides the ability to continuously grow product lines, GigOptix says. During 2009, more than ten new 10, 40 and 100Gb/s products were launched, which will contribute to revenue in 2010.

"Since GigOptix's inception in July 2007, our goal was to acquire enough complementary technologies in the high-speed optical communication market to be capable of offering our customers a meaningful one-stop shop of innovative technologies and products," says Katz. "We have a strong product base with valuable intellectual property comprising every aspect of the optical communications value chain, including drivers, modulators, receivers, amplifiers and analog mixed-signal ASICs," he adds.

"Recently [on 23 March], we announced a significant alliance with Sanmina-SCI, to manufacture our proprietary polymer-based modulator, which has been evaluated to be stable at the industry-standard 85°C for 25 years reliability conditions, for many 40Gb/s and 100Gb/s formats... These products are expected to be shipped for production starting late 2010," Katz continues. "The polymer-based modulators have several meaningful advantages over current modulator technology and products, including expansion capability to speeds beyond 100Gb/s, a significantly smaller footprint, lower power consumption, and the fact that they are manufactured using standard CMOS fabrication technology, making them very cost competitive."

Also, during Q4/2009, GigOptix:

- delivered electro-optical (EO) polymer material to leading semiconductor and computer manufacturers as part of development efforts to facilitate the move from electrical to optical on-chip interconnects for high-speed CMOS circuits;
- entered pre-production (as well as a joint project targeting super-computing) with the LX8400, a 40Gb/s DPSK polymer modulator (the polymer material was proven to be stable at the two extreme operating temperatures of 85°C and 30K/–243°C, respectively, for extended periods without performance degradation);
- production released the GX3240, a high-gain, high-bandwidth limiting amplifier in a 3mm x 3mm QFN package for 40Gb/s DQPSK optical receivers and microwave use;
- began sampling 100Gb/s DP-QPSK drivers and 40Gb/s DPSK and DQPSK drivers and receiver amplifiers to leading telecom customers (for production in second-half 2010);
- introduced second-generation CX7800 hybrid ASIC technology in 65nm CMOS, which saves firms on

► average \$500,000 in non-recurring engineering (NRE) and tooling costs per product derivative, GigOptix says.

"While our 2009 fourth quarter and annual financial results are reflective of a technology innovator in transition, we are optimistic about our growth trends for the first half of 2010 and beyond," comments chief financial officer Ron Shelton. "In the fourth quarter we recorded a reserve of \$1.3m against our government contracts revenue due to changes in estimated contract billing rates. While the reserve was recorded in the fourth quarter, and hence adversely impacted the total revenue and gross margins recorded in this quarter, it relates to revenue recognized throughout all four quarters of 2009. The company will work closely with the government agencies to arrive at a mutually satisfactory resolution of this adjustment, a process that in normal circumstances should have occurred at the beginning of 2009," Shelton explains. "In addition, in the fourth

quarter, we incurred several one-time charges related to our acquisition of ChipX, our continued efforts to cut costs and our commitment to exercising strong financial control over our business... these measures have put us in an excellent position to grow our business in 2010 as we strive towards achieving profitability in the near future," he adds.

"We see solid indications of growth, fruits of our last two years of consolidation, and traction in organically developing our products and our customers," comments Katz. GigOptix expects revenue of \$5-5.3m (90% from product shipments) for first-quarter 2010 (up 60-70% on Q4/2009), followed by growth of at least 10% sequentially for second-quarter 2010.

"As we continue to integrate operations, focus on cost reduction initiatives and increase sales of newer, higher-margin products, gross margins should trend higher than 50% during 2010 [compared to Q4/2009's 38%]," Katz believes.

GigOptix starts shipping 100G DP-QPSK driver to tier 1 telecom OEM

GigOptix has begun shipping its high-performance 100G DP-QPSK driver to an unnamed tier 1 telecom OEM.

The shipment signifies the culmination of more than two years of joint development of the driver, which is claimed to be the first monolithic solution available for the next-generation 100G DP-QPSK DWDM market.

"We decided more than two years ago to align our 100G development with our customer's requirements and, given our prior history of both providing high-performance solutions and delivering on our commitments, we were chosen as a preferred partner to deliver drivers into their 100G platform," says chief technology officer Andrea Betti-Berutto.

"The demand for 100G transport technology in long-haul networks is being driven by telecom service

providers seeking to handle increased customer traffic and bandwidth demands in a cost-effective manner," says VP of marketing Pdraig O'Mathuna. "The telecom industry has embraced 100G DP-QPSK DWDM optical network transport, since it provides a cost-effective system solution and system vendors are now developing and beginning to deliver 100G products," he adds. "Deployment has been accelerated by internet content providers demanding more bandwidth to support the surge of data traffic being driven by their large data centers."

Market research firm Ovum has forecasted that the 100G DP-QPSK DWDM lineside market will launch in 2010 and increase at a compound annual growth rate (CAGR) of 140% to more than 16000 units by 2015.

www.GigOptix.com

IN BRIEF

GigOptix advisory board gains Benhamou Global Ventures general partner

Anik Bose, a general partner at Benhamou Global Ventures, has joined GigOptix's advisory board, focusing on the firm's strategic growth through mergers and acquisitions as well as business development in China.

Bose has previously headed the business development functions at communications technology firms such as 3Com as well as biotech-focused firms such as Monsanto, managing a \$250m corporate venture fund, spearheading dozens of venture capital investments, and executing numerous spin-out transactions as well as several large M&A transactions over \$1.4bn in value. In particular, in communications technology, Bose architected the launch of the fastest-growing Asian networking company (H3C — 3Com's joint venture with Huawei), which achieved annual revenues of over \$700m and a market valuation of \$1.8bn within 36 months of launch.

"GigOptix has been demonstrating a new and aggressive rollup strategy model since their inception in July 2007," comments Bose. "The moves that they have made during this down market are extraordinary and have demonstrated solid growth based on a financially driven approach," he adds.

"GigOptix has made many strategic moves since our inception, however at this point in our growth we are looking to future M&A transactions as well as other strategic alliances in various geographical regions to continue the growth of the company," says chairman & CEO Dr Avi Katz.

<http://benhamouglobalventures.com>

Germanium lines up bands for laser action

Researchers in the Electronic Materials Research Group at Massachusetts Institute of Technology (MIT) have manufactured a direct energy bandgap in germanium (Ge) on silicon (Si) [Jifeng Liu et al, *Optics Letters*, published online 26 January 2010], enabling construction of what is claimed to be the first room-temperature direct-bandgap Ge-on-Si edge-emitting laser. Emission is at wavelengths of about 1600nm (1.6 μ m), in the L band for fiber-optic communications (1565–1625nm). The conventional C-band is slightly shorter (1530–1565nm).

The hope is that MIT's technology will provide an easier route to integration of lasers and mainstream electronics, since germanium is already used in CMOS processes.

Normal germanium is ruled out as a useful laser material since its bandgap is indirect — meaning that the valley of the conduction band does not line up with the peak of the valence band in the electron wave-vector (k) space (Figure 1). Simple transitions creating light can only change wave-vector by an amount of the order of the wave-vector of the light ($\sim 1/\text{wavelength}$) — a value that is effectively zero for visible light ($\sim 2 \times 10^{-4}/\text{\AA}$), and even smaller for infrared ($\sim 1 \times 10^{-4}/\text{\AA}$), compared with the wave-vector range deriving from the crystal lattice ($\sim 1/\text{lattice spacing}$, $\sim 0.2/\text{\AA}$).

MIT has been working for a while on how to create a direct bandgap in germanium. Theoretical work reported in 2007 suggested that tensile strain and n-type doping could achieve this. Since then, direct-gap photoluminescence and optical gain at room temperature have been demonstrated.

Now, an edge-emitting waveguide lasing device has been created using tensile-strained n+-doped Ge. The Ge waveguide layers were grown selectively on the silicon wafer using ultra-high-vacuum chemical vapor deposition (UHVCVD) with silicon dioxide used

Figure 1. (a) Electrons can be excited from valence band (green) to conduction band (red), allowing free movement in crystal. In conduction band, electrons quickly adopt the lowest-energy states (right-hand well). In indirect-bandgap material, crystal momentum of the lowest-energy state is misaligned with that of the valence band (yellow and black arrows), so electron will not emit a photon on losing energy. (b) MIT fills up lower-energy state with extra electrons from phosphorous atoms, which they add to the Ge. (c) When electron is excited into the conduction band, it leaves behind a 'hole' in the valence band. The researchers inject pairs of electrons and holes into the germanium. (d) When injected electrons find the lower-energy state occupied, they spill over into the other direct state; realigned with the holes, they release extra energy as photons.

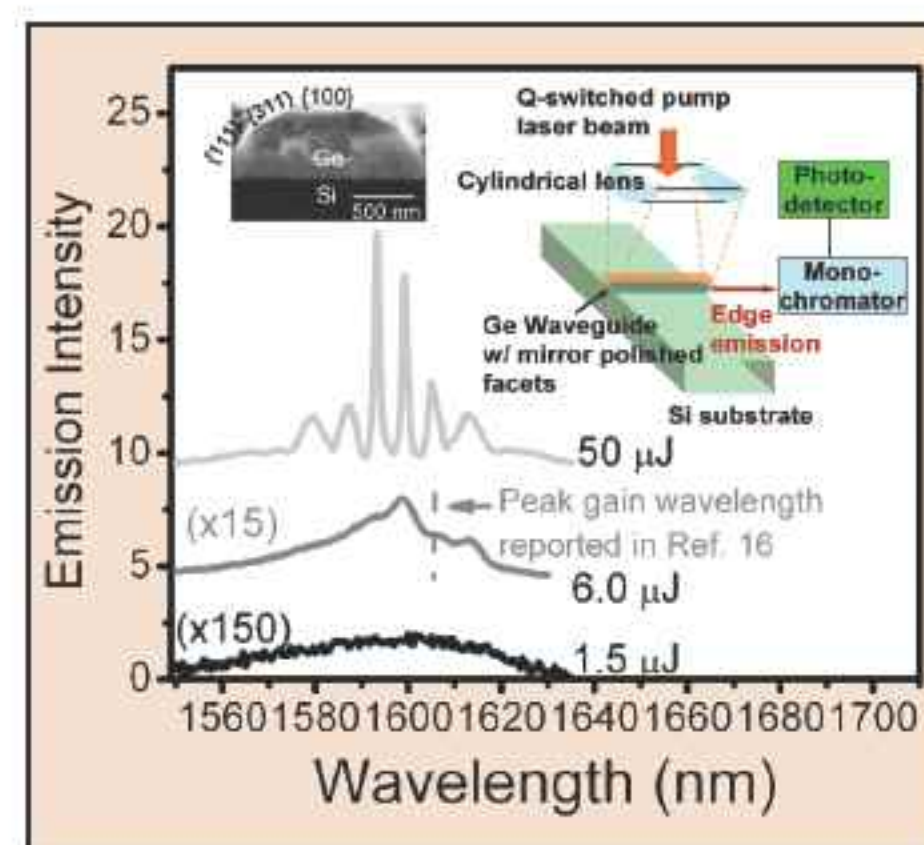


Figure 2. Edge emission spectra of Ge waveguide with mirror polished facets under 1064nm excitation from a Q-switched laser (spectral resolution of measurement, 2nm). Three spectra at 1.5, 6.0 and 50 μ J/pulse pumping power correspond to spontaneous emission, threshold for lasing, and laser emission, respectively. Inset: cross-sectional SEM of Ge waveguide and schematic of experimental setup for optical pumping.

as a mask (Figure 2). The 0.24% tensile strain was introduced through cooling the Ge to room temperature from a relaxed state at 650°C. This reduces the direct gap to 0.76eV, while the indirect gap is normally about 0.66eV. In-situ doping with $1 \times 10^{19}/\text{cm}^3$ phosphorus compensated for the remaining difference. It is hoped in future to increase even further the level of doping, increasing power efficiency.

The lasing was shown through optical pumping (Figure 2) with excitation by a Q-switched laser emitting 1064nm radiation (1.5ns pulse, 50 μ J/pulse, 1kHz repetition).

Funding for the project comes from the Si-Based-Laser Initiative of the Multidisciplinary University Research Initiative (MURI), sponsored by the Air Force Office of Scientific Research (AFOSR).

<http://photonics.mit.edu>
www.opticsinfobase.org/ol/abstract.cfm?uri=ol-35-5-679

Author: Mike Cooke.

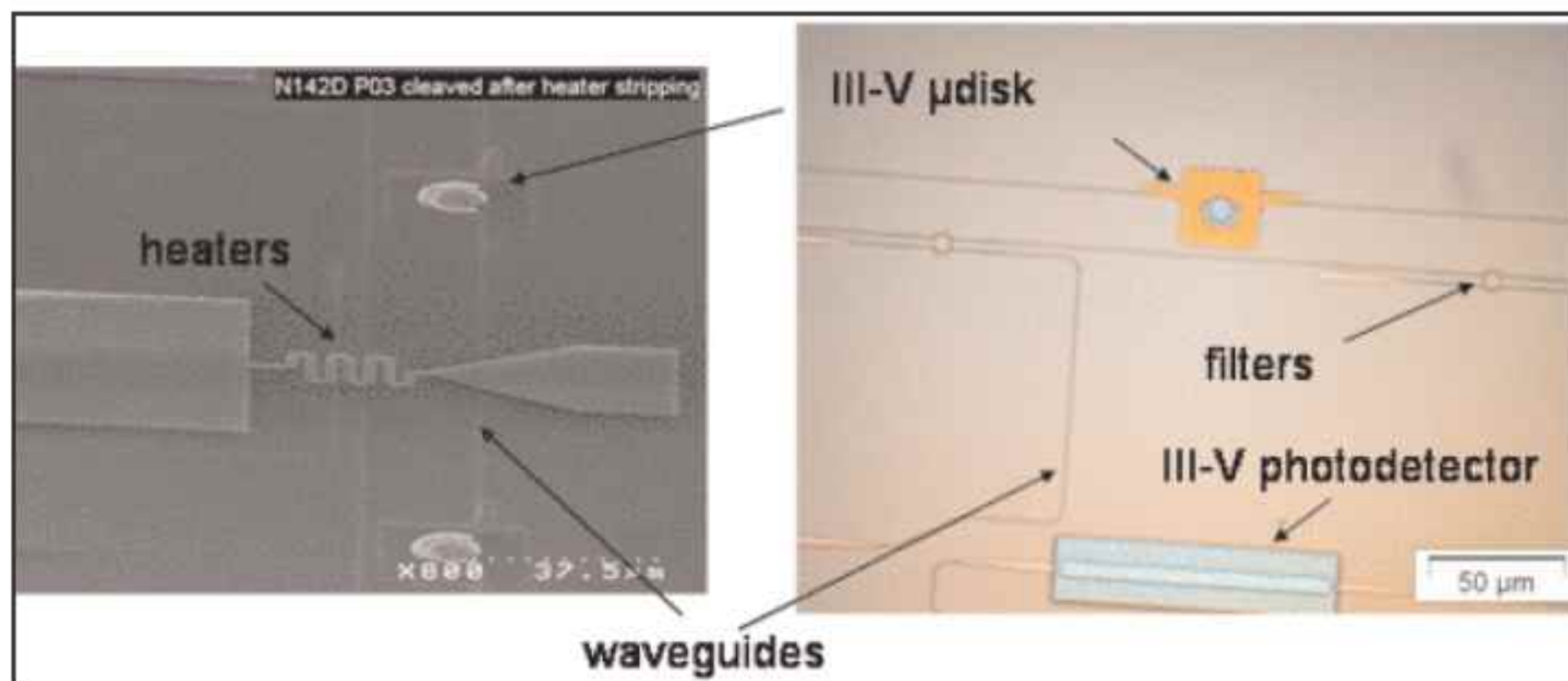
Leti demos fully CMOS-compatible laser source coupled to silicon waveguide

WADIMOS project results presented at SPIE Photonics Europe

Leti of Grenoble, France, the Laboratory for Electronics & Information Technology of the French government's research and technology organization CEA, has demonstrated a fully CMOS-compatible laser source coupled to a silicon waveguide, which is claimed to be a major milestone toward the WADIMOS project's goal of fabricating silicon photonics circuits in CMOS foundries for an optical network-on-chip (optoNoC).

WADIMOS (Wavelength Division Multiplexed Photonic Layer on CMOS) is a three-year EU-funded research project (with a total budget of €3.2m) that started in January 2008 and aims to demonstrate a photonic interconnect layer on CMOS. The project is coordinated by international research center IMEC of Leuven, Belgium, which is designing ultra-compact SOI (silicon-on-insulator) waveguide circuits for routing and demultiplexing, as well as contributing to fabrication of the sources and their integration with the waveguides.

Leti's role is to develop the integration process and fabricate the photonic layer, including the III-V based microsources, in a standard CMOS pilot line. Other project partners include European chip-maker STMicroelectronics (which is investigating the viability of optical networks-on-chip and is designing the required CMOS circuits), MAPPER Lithography (a spin-off of Holland's Delft University that is developing a massively parallel e-beam writing system, and is responsible for the system studies related to the terabit optical link), INL-Lyon Institute of Nanotechnology (which is involved in the design and fabrication of the microsource arrays, as well as contributing to the optoNoC system studies, and is



Microdisk laser, detector and passive routing circuitry.

responsible for designing the optical routers), and UNITN-Trento University (which is designing optical WDM circuits based on coupled ring resonators).

WADIMOS partners presented the results at the SPIE Photonics Europe 2010 event in Brussels, Belgium (12-16 April).

Working with a circuit design from INL and Imec, Leti completed the specific process studies for the laser source to adapt and modify standard III-V materials process steps that would comply with a CMOS environment, replacing gold-based metal contacts with a Ti/TiN/AlCu metal stack.

Leti says that the enormous computing power of multi-processor systems and manufacturing tools being considered will require data transfer rates of more than 100Tb/s.

These data rates may be needed on-chip, e.g. in multi-core processors, which are expected to

The enormous computing power of multi-processor systems and manufacturing tools being considered will require data transfer rates of more than 100Tb/s

require total on-chip data rates of up to 100TB/s by 2015, or off-chip, e.g. in short-distance data interconnects, requiring up to 100TB/s

Optical interconnects also allow for extra flexibility through the use of WDM

over a distance of 10-100m. Optical interconnects are the only viable technology for transmitting these

amounts of data, Leti asserts.

Besides a huge data rate, optical interconnects also allow for extra flexibility through the use of wavelength division multiplexing (WDM). This feature may help to realize more intelligent interconnect systems such as the optical network-on-chip system that the WADIMOS project is also investigating.

WADIMOS aims to build a complex photonic interconnect layer incorporating multi-channel microsources, microdetectors and different advanced wavelength-routing functions directly integrated with electronic driver circuits. It also aims to demonstrate the application of such electro-photonic ICs in two representative applications: an on-chip optical network and a terabit optical datalink.

<http://wadimos.intec.ugent.be>

Kotura demos silicon photonics mux/demux for 0.5Tb/s

Kotura Inc of Monterey Park, CA, USA, which has been designing and manufacturing application-specific silicon photonics components for the communications, computing, sensing and detection markets for more than four years, has demonstrated its Echelle grating mux and demux for 500Gb/s wavelength division multiplexing (WDM) applications. The 0.5Tb/s demo marks completion of the second year of the three-year program TERAPICS, and was performed at InP-based optical chip and component maker CyOptics Inc of Lehigh Valley, PA (Kotura's partner in the program).

Together with CyOptics, in October 2007 Kotura was awarded \$5.9m by the US Commerce Department's National Institute of Standards and Technology (NIST) Advanced Technology Program (ATP) to fund the

three-year TERAPICS project to develop next-generation Terabit photonic integrated circuits that use a combination of monolithic and hybrid integration to reduce hundreds of individual components in 100–1000Gb/s Ethernet systems to less than 10 components. Kotura aimed to develop integrated silicon photonics chips to serve as the mounting platforms for laser and receiver arrays, as well as providing multiplex and de-multiplex functions.

Designed and fabricated by Kotura, the 12-channel mux and demux chips directly couple light from laser arrays and detectors into a single fiber, simplifying the packaging and eliminating the need for dozens of lens, isolators, laser monitors and thermo-electric coolers (TECs).

"Kotura has designed a large variety of WDM chips with small footprint,

low cross-talk and low polarization-dependent loss," says chief technology officer Mehdi Asghari. "We have successfully fabricated designs from 4 to 40 channels, supporting wavelengths from 1200 to 1600nm and channel spacings from 20 to 100GHz," he adds. "The ATP-CyOptics chips contain hybridization features for the laser arrays, a Gaussian filter on the laser side, and a flat-top filter on the detector side."

"While much of the industry is developing 40 and 100Gb/s Ethernet solutions, the next major step will be 500Gb/s and 1 Terabit," says VP of marketing Arlon Martin.

"Server blades with multi-core CPUs and 10Gb/s I/O ports are becoming more common, accelerating the need for higher speeds in the core of the data center."

www.kotura.com

CyOptics demos record 500Gb/s TOSA/ROSA

InP-based optical chip and component maker CyOptics Inc of Lehigh Valley, PA, USA, has demonstrated an industry-first 0.5Tb/s (500Gb/s) transmit optical subassembly (TOSA) and receive optical subassembly (ROSA) targeting next-generation Ethernet. The photonic integrated circuit (PIC) components combine monolithic and hybrid integration to deliver 500Gb/s in a single TOSA/ROSA pair.

While the IEEE is expected to ratify a standard for 100G Ethernet by mid-2010, initial industry and standard-body discussions have already started on how to make the next step to 1 Tb/s to meet demand for optical bandwidth, says CyOptics. The 500G demo is part of completion of the second year of the three-year program Terabit Photonic Integrated Circuit (TERAPIC). Its final goal targets demonstration of optical laser and receiver components for transmission speeds of up to 1Tb/s (1000Gb/s) by end 2010.

The TOSA encompasses 12 electro-absorptive modulated lasers (EMLs)

with wavelength channels from 1270 to 1380nm on a 10nm-channel grid. Lasers are grouped in three arrays, each monolithically integrating four EMLs. Each EML has a typical small-signal bandwidth of >30GHz, allowing non-return-to-zero (NRZ) operation at 43Gb/s. The three EML arrays are flip-chip bonded to a planar lightguide circuit (PLC), which serves as the mounting platform and provides the optical multiplexer (mux) function. The ROSA couples the signal through an optical PLC-based de-multiplexer (demux) to 12 high-speed PIN detectors with a 3dB bandwidth of more than 50GHz and a continuous-wave responsivity of 0.8A/W. Package dimensions are 22mm x 22mm for the TOSA and 30mm x 26mm for the ROSA.

CyOptics leverages its high-speed InP device technology to fabricate the 40G EML array and 40G PIN detectors, and its highly automated hybridization and planar packaging platforms for assembly of TERAPIC components. The PLCs for the demo used silicon-on-insulator (SOI)

technology designed and fabricated by silicon photonics component maker Kotura, CyOptics' partner in the ATP/NIST project (see above). For future commercialization of the TERAPIC technology, CyOptics intends to also leverage its in-house silica PLC platform.

The transmission tests were performed over 2km of single-mode fiber (SMF) with each channel tested at 40Gb/s. For the demo, a commercial semiconductor optical amplifier (SOA) was used in front of the ROSA to boost the signal. Each channel was tested to be error free to 10^{-11} BER (bit error rate), with most 10^{-12} BER. Total cross-talk was measured to be 1–2dB. The channel spacing of 10nm was chosen to enable TOSA operation without a thermo-electric cooler (TEC) in order to reduce overall power dissipation. Instead of a TEC, resistive heating can be used to limit the temperature excursions and to enable an operating range of the TOSA from -5°C to $+75^{\circ}\text{C}$.

www.cyo.com

Infinera grows for a fourth quarter

For first-quarter 2010, Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has reported revenue of \$95.8m, up 6% on \$90.2m last quarter and up 44% on \$66.6m a year ago.

The top five customers included Level 3, two additional established carriers, and two of the world's largest internet content providers. Level 3 and one of the leading internet content providers were 10% or greater customers (at 22% and 16% of revenue, respectively).

"Our solid first-quarter results demonstrate that market demand remains strong for Infinera's PIC-based networks, which provide the optical industry's most cost-effective solution and most advanced intelligent bandwidth management capabilities," says president & CEO Tom Fallon.

Gross margin has risen from 30% a year ago and 38% last quarter to 39%. Net loss of \$20m is down from \$24.3m a year ago but up from \$18.7m last quarter. During the quarter, Infinera generated \$2.3m of cash from operations.

"We grew revenue for the fourth

consecutive quarter, improved gross margins for the third consecutive quarter, and had record bookings for the second quarter in a row," notes Fallon. "Against the backdrop of an improving technology spending environment, business activity is healthy across all our major markets and customer segments."

Infinera's customer count grew by five (three North American, one European and one Asian) to 74. The new Asia-based client (one of Japan's top three service providers) has begun Infinera deployments in both Asia and North America.

"We continued to grow our footprint across an expanded set of market opportunities," adds Fallon.

One new ATN win this quarter raises total ATN customer count to seven (six of which are existing DTN customers).

Infinera also won expanded footprint with existing customers including a significant new opportunity with a tier-one account for a Latin American deployment, as well as an expanded relationship with another customer that will include participating in a series of large overbuilds in a global capacity expansion.

www.infinera.com

Infinera obtains TL 9000 certification

Infinera says that its major facilities in the USA and India have achieved certification according to TL 9000, an international standard for quality processes in the telecoms industry (including requirements for all major management and measurement systems).

Compared with ISO 9001 certification (achieved by Infinera in 2007), there are 50 additional requirements in TL 9000 registration. Certification is evidence of Infinera's commitment to build a sustained business around its PIC technology, says Lonny Orona, VP of customer service & corporate quality.

The firm comments that TL 9000 registration represents continued emphasis on customer relationships, reliability of products and services, enhanced product life-cycle, tracking customer requirements through design and development, telecom-specific performance measurement, service requirements, benchmarking data, comprehensive disaster recovery and long-term commitment to continuous improvement. The certification demonstrates that Infinera's systems meet the quality and reliability requirements of the most demanding telecom networks, the firm adds.

www.tl9000.org/index.html

IN BRIEF

Photonic integrated circuit developer Fred Kish made an OSA fellow

At the OFC/NFOEC 2010 conference and exhibition in San Diego (23–25 March), Dr Fred Kish, senior VP of the Optical Integrated Components Group at Infinera, was named a fellow of the Optical Society of America (OSA), becoming the fourth Infinera team member to receive this honor.

According to the OSA, Kish is elected a fellow for his contributions to the development and commercialization of the first practical (commercial) monolithic large-scale InP photonic integrated circuits (PICs) and to the development and commercialization of high-efficiency transparent-substrate AlGaInP LEDs.

Kish joined Infinera in 2001 to lead the development and commercialization of the first large-scale commercial PICs. Last year, the Infinera optical integrated components effort, managed by a team led by Kish, produced PICs accounting for more than 40% of all the long-haul optical transmission capacity shipped worldwide, according to analyst reports.

● Infinera's development team in Ottawa, Canada has been joined by John McNicol, a senior technologist and engineer known for playing a leading role in innovations in the wireless and optical networking industries, says the firm. Over the past decade, McNicol played a key role in the introduction of advanced modulation techniques into Nortel's optical systems. Infinera says that he will be critically involved in the development of its next-generation optical networking systems.

www.osa.org/aboutosa/awards

Neophotonics files for \$115m IPO

NeoPhotonics Corp of San Jose, CA, USA has filed a registration statement with the US Securities and Exchange Commission (SEC) for an initial public offering of up to \$115m shares of common stock (to be listed on the New York Stock Exchange under the ticker symbol 'NPTN').

Founded as NanoGram Corp in October 1996 before changing name in 2002, the firm's principal stockholders are funds affiliated with Oak Investment Partners, Draper Fisher Jurvetson, Concord Investments Co, ATA Ventures and International Finance Corp.

NeoPhotonics is a developer and vertically integrated manufacturer

of photonic integrated circuit (PIC)-based components, modules and subsystems for bandwidth-intensive, high-speed communications networks. Products include active semiconductor, passive PLC (photonic lightwave circuit) and MEMS (micro-electro-mechanical system) multi-dimensional switching functions in a single product, with integration enabled by nanomaterials and nanoscale design and fabrication technologies. The firm has ISO 9001:2000 certified engineering and manufacturing facilities in both Silicon Valley (where it has 140 staff) and Shenzhen, China (where it has 2168 staff, making 2308 in total at

the end of 2009). In 2009, revenue was \$155m and the firm's net loss was \$6.8m.

NeoPhotonics says that the rapid growth of bandwidth-intensive content, including HD and 3D video, music, social networking, video conferencing and other multimedia, is driving the demand for high-bandwidth products.

The firm says it plans to use the net proceeds of the IPO for working capital, to continue to expand its existing business (including perhaps acquiring complementary businesses, products, services or technologies), and for general corporate purposes.

www.neophotonics.com

NeoPhotonics launches 10G PON transceivers and 100/40Gbps ICR

At the Optical Fiber Communication Conference & Exposition and National Fiber Optic Engineers Conference (OFC/NFOEC 2010) in San Diego in March, NeoPhotonics launched a new line of 10G PON transceivers, compliant with the ITU-T G987.2 and IEEE 802.3av networking standards, to augment its portfolio of GPON and GEAPON modules used in fiber-to-the-premise (FTTP) networks.

The pluggable 10G OLT and ONU transceivers enhance NeoPhotonics' existing line of GPON and GEAPON modules for optical line terminals (OLT) and optical networking units (ONU), which are deployed in central offices (CO) and at customer premises (CPE), respectively. Together, the OLT and ONU devices form a broad portfolio of small-form-factor transceivers for 10G PON systems makers.

"These 10G PON transceivers complement our current portfolio of FTTP products," says CEO Tim Jenks. "Our NG PON transceiver line meets the performance and reliability requirements for triple-play access networks and builds on our experience in several segments of the optical access market."

The ITU-T G987.2-compatible transceivers support data rates of 10G in the downstream direction and 2.5G burst mode transmission in the upstream direction covering nominal link budgets of 29dB and 31dB. The IEEE 802.3av-compatible transceivers support data rates of 10G in the downstream direction and 1G burst mode transmission in the upstream direction covering link budgets of up to 30.5dB.

The OLT transceivers are offered in the XFP form factor, whereas the ONU transceivers are in the SFP+ form factor. Monitoring features allow early fault location and reduced downtime in system operation.

NeoPhotonics also announced initial availability of its Integrated Coherent Receiver (ICR) for 100/40Gbps transmission systems. The ICR is an integrated intradyne receiver based on the firm's photonic integrated circuit (PIC) technology.

The ICR provides advanced demodulation to analyze the state-of-polarization and optical phase of a phase-modulated signal relative to an externally supplied optical reference, enabling recovery of the phase-polarization constellation of

100Gbps dual polarization quadrature phase-shift keyed (DP-DQPSK) format signals. In addition, the ICR incorporates four sets of high-sensitivity balanced photodiodes with four differential linear amplifiers to provide four output channels at 32 Gbaud data rates. A second version performs the same function for 40Gbps applications.

"We utilize our hybrid PIC technology to combine an integrated dual 90° Hybrid Coherent Mixer with four balanced photodiodes and the requisite linear amplifiers in a single compact package," says chairman & CEO Tim Jenks.

"NeoPhotonics is actively contributing to developments in the Optical Internetworking Forum (OIF) 100G project, particularly with respect to the Integrated Photonics Receiver," says Wupen Yuen, VP of R&D.

The firm showcased its products at the OFC/NFOEC conference, where the OIF sponsored a Product Showcase to display components, modules, and/or other hardware supporting the OIF's 100G project focused on Integrated Photonics Transmitters and Receivers.

www.oiforum.com



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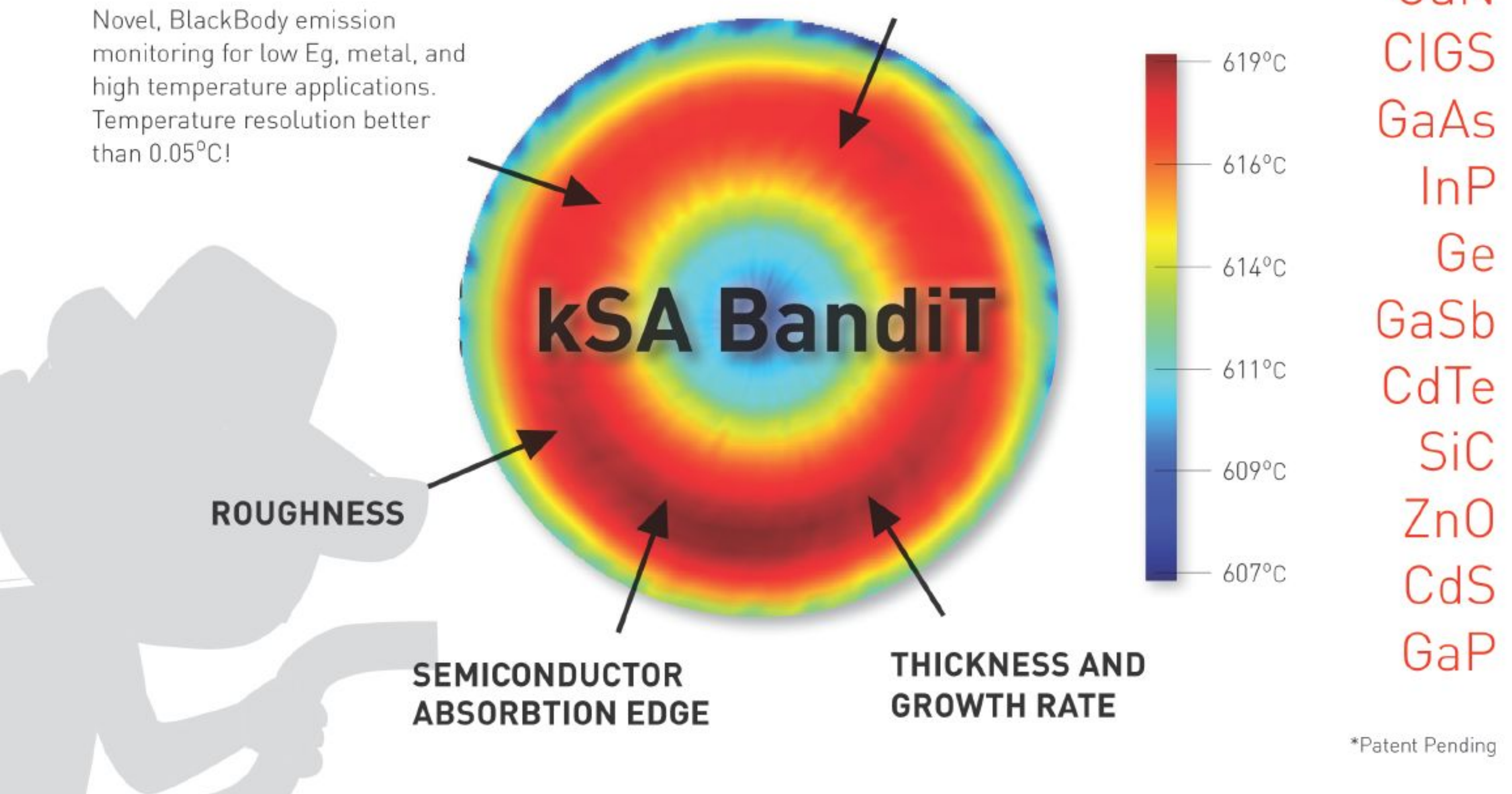
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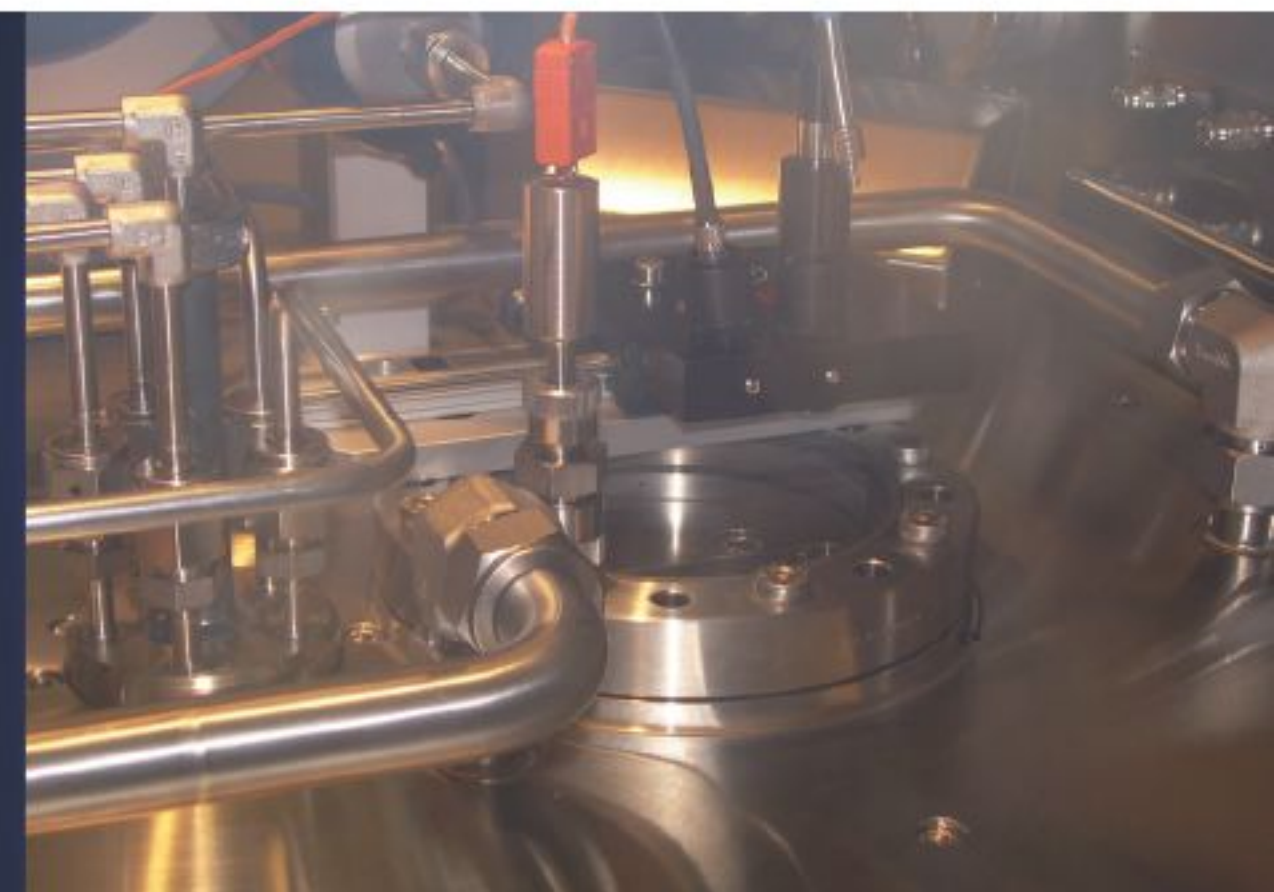
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Picometrix adds shift for hybrid assembly of 40G products

Picometrix LLC of Ann Arbor, MI, USA, a subsidiary of Advanced Photonix Inc (which designs and makes silicon, InP- and GaAs-based photodetectors, subsystems, and terahertz instrumentation), has added a second shift for hybrid assembly of its 40G NRZ client-side, 40G DPSK and DQPSK lines of high-speed optical receivers (HSOR). The firm claims that it offers the industry's most complete line of 40G high-speed optical receiver solutions for both client-side and line-side modulation formats, including NRZ, RZ, DPSK, DQPSK, ODB and DP-QPSK.

Picometrix is also shipping pre-production versions of its 100G line of high-speed optical receivers, incorporating the firm's patented photodiodes and proprietary amplifiers.

"Demand for voice, Internet, HDTV, and wireless requires increased bandwidth and increased speed including telecom infrastructure expansion for 10G, 40G and 100G requirements, and both 40G and 100G line-side products serve their respective market niche in the network infrastructure," says president & CEO Rick Kurtz. "100G line-side product adoption is being accelerated by demands to interconnect large

data centers, like those at Google and Facebook," he adds. "Traditional service providers are still in the early stages of evolving their networks to handle the demands of high-definition video and delivery of content anytime, anywhere. These next-generation wireline and wireless networks will require deployment of 40G and 100G to deliver this content, which is expected to grow annually by more than 25%," Kurtz continues. "API's addition of the second shift is in response to this increase in demand for our high-speed optical receivers."

www.advancedphotonix.com

Oplink constrained by labor and materials shortages

For fiscal Q3/2010 (to end-March), Oplink Communications Inc of Fremont, CA, USA had sales of \$33.6m, up 3% on last quarter's \$32.7m and 9% on \$30.8m a year ago.

Though down on \$3.1m last quarter, net income of \$2.6m was higher than expected and an improvement on a net loss of \$114,000 a year ago.

Oplink closed the quarter with cash, cash equivalents and investments of \$184.8m (up from \$168.7m at the end of June 2009).

"Despite a shorter quarter, we reported solid revenue and earnings for the period," says CEO Joe Liu.

"We continue to invest in expanding capacity and improving lead times

to meet a stronger demand environment, but production ramp-up remains challenging due to labor and materials shortages," he notes. "We expect improved capabilities in the coming quarters."

For fiscal Q4/2010 (to end-June), Oplink expects revenue of \$35-38m.

www.oplink.com

Finisar overtakes JDSU for lead in WSS ROADM market

Fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has been named market-share leader in WSS ROADM components in second-half 2009 in a first edition report by Infonetics Research that tracks the reconfigurable optical add/drop multiplexer (ROADM) optical network equipment market and the wavelength selective switch (WSS) components within it (measured by channel spacing and degree-count).

"Since the launch of Infonetics' wavelength-selective-switch component reporting, JDSU had been the market share leader, but in the second half of 2009, Finisar took the lead, based on the strength of its 50GHz WSS shipments," notes Infonetics analyst Andrew Schmitt. "The transition from 100GHz to

50GHz channel spacing is accelerating, with the 50GHz segment expected to account for all future revenue and unit growth in the WSS market."

Finisar's WSS portfolio includes the DWP 50, DWP 100, and DWP 100e — all fully integrated high-performance intelligent modules offering flexible and upgradeable WSS functionality for advanced reconfigurable network applications. A key enabler of this highly programmable platform is the firm's unique Liquid Crystal on Silicon (LCoS) switching technology, which has been used to produce what is claimed to be the industry's most feature-rich and cost-effective WSS modules. Inherent in LCoS technology is the capability to deliver next-generation flexible grid architectures that

enable carriers to future-proof their networks as data rates increase.

"The fastest-growing segment in optical networking is the WSS ROADM market," says VP of marketing Rafik Ward. "As the ROADM market expands, Finisar is poised to meet the demands of our customers through our 100GHz, 50GHz, and flexible grid offerings," he adds.

"The flexibility of Finisar's offering between 100GHz and 50GHz and flexible grid architecture is a key feature as we migrate our rings/spans from current 100GHz to 50GHz grid in phases and later introduce higher-data-rate lambdas beyond 100G on some of our network spans," says Shamim Akhtar, director of Network Engineering at Comcast Corp.

www.finisar.com/roadm

micro-ITLA expands ClearLight tunable laser platform

Emcore Corp of Albuquerque, NM, USA, which makes components and subsystems for the broadband, fiber-optic, and solar power markets, has expanded its telecom DWDM product portfolio — powered by its proprietary ClearLight tunable external-cavity laser (ECL) technology platform — with the launch of its new micro-ITLA (integrable tunable laser assembly), which was demonstrated at March's Optical Fiber Communication event (OFC 2010).

Designed to meet the needs of 40 and 100Gb/s line-cards and transponders, features include narrow linewidth, low noise, frequency fine tune and high output power, while providing the full functionality of the ITLA multi-source agreement (MSA) in a quarter-size form factor and with half the power consumption.

This next step in product density is enabled by Emcore's ClearLight technology, which builds on several generations of the firm's tunable products (which have over 500 million total field hours). "The Emcore ECL laser has always been the device of choice for next-generation 40 and 100Gb/s systems," claims micro-ITLA product line manager Heino Bukkems. "The size-reduced micro-ITLA enables the emergence of smaller 40 and 100Gb/s transponders," he adds. "Our experienced engineering team and a deep understanding of our core technology have

The size-reduced micro-ITLA enables the emergence of smaller 40 and 100Gb/s transponders

made this highly differentiated product possible."

The micro-ITLA is Emcore's third ClearLight-powered product, joining the tunable TOSA (transmit optical sub-assembly) and tunable XFP products launched last year. "The modularity and flexibility of our technology platform enables a wide array of product variants and next-generation enhancements simply through the substitution of a few standard components," says Rob Stone, marketing director for Emcore's Fiber Optics division. "We can then integrate our ClearLight optical engines at different levels, all the way from TOSA and laser assemblies, to transceivers and transponders to meet the specific needs of our customers."

www.emcore.com

Active optical cables show five failures in 1bn hours of operation

Emcore has announced reliability results for its fielded 20Gb/s active optical cables.

High-performance computing systems require guaranteed reliable, high-bandwidth, low-latency communication paths to connect up to thousands of processing nodes, says Emcore. Traditionally, these pathways are implemented using copper cables. But, due to their bulk, weight and limited transmission distance, copper cables often constrain the physical size and performance of these server clusters. In contrast, Emcore Connects Cables' active optical cables are compact, lightweight, and allow greater reach between processing nodes than traditional copper cables.

According to a recent report by LightCounting, sales of active optical cables in the last three years were more than 150,000 units, with Emcore shipping most of that volume. The reliability of Emcore Connects Cables over that period was better than 5 FITs (five failures in 1 billion hours of device

operation), demonstrating the suitability of 850nm vertical-cavity surface-emitting laser (VCSEL) array technology and multimode optical fiber for high-performance data computing applications, the firm says.

"Our current generation of 40Gb/s active optical cable is based on the same technology, and we expect the same high-reliability performance of these newer products," comments Chris Wiggins, director of Emcore's Enterprise Business Group.

Emcore Connects

Sales of active optical cables in the last three years were more than 150,000 units, with Emcore shipping most of that volume

The reliability of Emcore Connects Cables over that period was better than 5 FITs

Cables are bidirectional communications links converting four lanes of electrical signals into optical ones by modulating four monolithically integrated VCSELs operating at 850nm wavelengths. The optical signals are carried by thin multimode optical fiber strands to the opposite end, where they are converted back to electrical signals by a four-channel photodetector array. The use of high-bandwidth, low-loss optical fibers allow the information to be transmitted at distances of more than ten times greater than that of copper cables.

The Emcore Connects Cables product family with CX4 and QSFP interfaces is currently being sold in high volume for applications including InfiniBand, Ethernet, Fibre Channel and PCI. The cables come in lengths up to 100m and operate at speeds of up to 40Gb/s. In April, the firm expects to sample the next-generation 150Gb/s CXP form-factor optical cable based on the same technology platform.

www.emcore.com

IN BRIEF

First 40G coherent MSA transponder module

CoreOptics Inc of Nuremberg, Germany and San Jose, CA, USA, which designs and manufactures 10/40/100Gbps optical networking subsystems, has introduced a 40Gb/s 300-pin MSA compliant transponder module based on its coherent detection technology, which offers the lowest network cost of any available 40G technology, the firm claims, by enabling dispersion compensation module (DCM) free transmission for more than 2000km on standard single-mode fiber.

The product platform's key features are enabled by CoreOptics' coherent detection digital signal processing (DSP) technology, which offers better performance in CD and PMD impairment mitigation for 40G compared to current modulation schemes incorporating DPSK or DQPSK, claims the firm.

"Our SurPass hiT 7300 Transport platform was designed to meet service providers' distance and capacity needs, while enabling a completely dynamic, flexible and transparent network infrastructure," says Dr Bernd Schumacher, head of Nokia Siemens Networks' optical networks business unit. "By incorporating CoreOptics disruptive 40G coherent technology, we have been able to dramatically lower the total investment cost of building and operating transport networks," he adds.

"As service providers networks need to scale rapidly to stay ahead of the exponential growth in the video traffic, our OEM customers are in high demand for 40G/100G interfaces that enable them to reduce the cost of their network elements while enabling disruptive value-add services for the end users," says CoreOptics' chairman, president & CEO Hamid Arabzadeh.

www.CoreOptics.com

First integrated 40G 300-pin tunable transponder with DCM and EDFA

As the latest complement to its 10Gb/s Free Light family of tunable NRZ and RZ transponders, optoelectronic component, module and subsystem maker Civcom of Petach Tikva, Israel has made available what is claimed to be the first integrated 40Gb/s DPSK transponder (built specifically to address the challenging market demands for additional network capacity, according to VP of worldwide sales & marketing Yair Itzhar).

Exhibited at March's Optical Fiber Communication/National Fiber Optic Engineers Conference (OFC/NFOEC) in San Diego, the 40Gb/s TRX transponder module, which is compatible with the 300-pin MSA standards and I2C standards, uses a widely tunable laser covering the entire C-band, and will be made available in two different packages:

- small form factor (5" x 5"), featuring the standard DPSK modulation format and optional integration with an erbium-doped fiber amplifier (EDFA); and
- standard multi-source agreement (MSA) size (7" x 5"), featuring integrated tunable DCM (dispersion compensation module) and EDFA functionality.

"By integrating our tunable optical dispersion compensation component within the module, manufacturers can effectively increase dispersion tolerance of the transponder while reducing overall cost," says Itzhar.

The firm says the TRX DPSK module increases dispersion tolerance from the standard $\pm 40\text{ps/nm}$ to as high as $\pm 640\text{ps/nm}$. The introduction of an integrated EDFA increases the dynamic range to 20dB.

www.civcom.com

Oclaro launches Telcordia-qualified 40G RZ-DQPSK transponder

Optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has introduced its first 40G RZ-DQPSK indium phosphide (InP)-based transponder qualified to Telcordia standards. Delivering high-performance in a low-cost, 300-pin multi-source agreement (MSA) platform, the new TL9040 transponder modules are already shipping to tier-one customers for next-generation field deployments.

"Our new 40G transponders demonstrate Oclaro's commitment to continually increase the bandwidth and functionality of the network while reducing costs to the end-user," said Paul Johnson, 40G Modules product line manager. "By incorporating our highly-successful Indium Phosphide technology into an Industry MSA footprint, we have been able to achieve substantial cost reductions and, at the same

time, increase the overall performance of the system."

Oclaro's new multi-rate adaptable 43Gbps RZ-DQPSK transponder is a long-reach, 300-pin transponder module suitable for wideband tunable, C-band applications requiring -150ps/nm to $+150\text{ps/nm}$ dispersion tolerance in noise loaded link applications, offering a significant improvement in OSNR (optical signal-to-noise ratio) over legacy DPSK systems designed around a 50GHz channel spacing.

The new 40G transponders are the latest addition to Oclaro's portfolio of products that power metro/regional network infrastructure. Oclaro adds that the 40G transponders have undergone rigorous testing to Telcordia standards, including 2000 hours of active endurance, damp heat, temperature cycling, and shock and vibration testing.

www.oclaro.com

JDSU launching ROADM and tunable XFP products for agile optical networks

Optoelectronic chip and module maker JDSU of Milpitas, CA, USA is to continue to expand its family of reconfigurable optical add/drop multiplexer (ROADM) and tunable XFP optical products to increase the capabilities of agile optical networks (AONs) by introducing a series of new devices for network equipment manufacturers (NEMs) over the next six months.

"Bandwidth capacity requirements continue to increase, requiring a great degree of flexibility in the network," says Craig Iwata, senior director of marketing for JDSU's Communication & Commercial Optical Products (CCOP) business segment. "To support this level of agility, all of the components within an optical network must also be agile," he adds. "We've collaborated with our customers on a mix of new products that will help them get the most agility out of every network node in the most cost efficient way possible."

As businesses and consumers use more on-demand applications such as video, increasing volumes of network traffic are entering networks in unpredictable ways, says JDSU. NEMs and service providers are evolving their networks to more sophisticated architectures that can flexibly support this traffic.

New products from JDSU will enable colorless and directionless architectures, enabling any add/drop port to be switched to any degree in the ROADM node.

ROADMs add, drop, and switch wavelengths within an agile optical network. New ROADM products to be introduced over the next six months (tailored to meet various requirements) include the following:

- Mini 50GHz High Port Count WSS — offering an increased port count of 23 ports with the same size and

performance as the 1x9 Mini 50 WSS, enabling increased cost efficiencies in a compact form factor for applications requiring high numbers of add/drop ports and colorless and directionless applications;

- Mini 100GHz Low Port Count WSS — 1X2 and 1X4 WSSs designed to provide high performance but lower cost points for smaller-sized 100GHz applications;

- Mini 50GHz Low Port Count WSS — offering 1X2 and 1X4 WSSs designed for high performance at lower cost points for smaller-sized 50GHz applications.

Tunable XFP transceivers (for sending and receiving signals within agile optical networks) provide a dramatically smaller, pluggable and cost-effective solution compared to older transceiver products, and are transforming available fixed XFP ports into tunable interfaces, says JDSU. New tunable XFP products should provide performance enhancements, and include the following:

- Linear Tunable XFP+ Transceiver — providing an extended reach of 200km and enhanced tolerance to fiber impairments;

- Enhanced Tunable XFP Transceiver — providing increased power for metro and regional applications and improved optical signal-to-noise ratio (OSNR) performance; and

- Zero Chirp Tunable XFP Transceiver — designed to support long-haul applications.

The new products, as well as JDSU's entire AON portfolio, were displayed at the Optical Fiber Communication Conference & Exposition and National Fiber Optic Engineers Conference (OFC/NFOEC 2010) in San Diego, CA, USA (23-25 March).

www.jdsu.com

Oclaro adds XTLS 4x1 50GHz wavelength selective switches

After acquiring WSS provider Xtellus of Denville, NJ, USA last December, optical component, module and sub-system maker Oclaro Inc of San Jose, CA, USA has added an XTLS 4x1 50GHz wavelength selective switch (WSS) to its portfolio of 50GHz-spacing WSS module products.

Oclaro says that the new module complements its existing 2x1 and 9x1 50GHz WSS family to fit a broadening spectrum of reconfigurable optical add-drop multiplexer (ROADM) applications. By employing 50GHz, WSS users can double the switching capacity of their network systems in a flexible and cost-effective manner, the firm adds.

"We are seeing an increased demand for 50GHz-spacing WSS products to support higher-capacity optical networking systems," says Dr Krishna Bala, executive VP of Oclaro's WSS division. "By exploiting a common optical platform we can satisfy our customers' requirements for different granularities of WSS at both 50GHz and 100GHz spacing," he adds.

● Reverse stock split targets institutional investors

After previously obtaining stockholder authorization, Oclaro's board of directors approved a 1-for-5 reverse split of its common stock, effective on 29 April. The stock began trading on NASDAQ on a split-adjusted basis on 30 April, under the temporary trading symbol 'OCLRD'. The trading symbol will revert to 'OCLR' after about 20 trading days.

"By executing a reverse stock split, we believe the higher share price will appeal to a broader universe of institutional investors," says Couder. "We also believe a lower share count [cut from about 212 million to 42 million] will better reflect the progress of our anticipated earnings improvements on a per share basis."

www.oclaro.com

OPEL's revenues shrink 60% in Q4/2009 while focusing on demonstration projects

... but production being ramped up for 2010–2011 order backlog

OPEL International Inc of Shelton, CT, USA and Toronto, Ontario, Canada, which makes high-concentration photovoltaic (HCPV) panels (as well as both roof- and ground-based dual- and single-axis solar trackers for mounting them), says that its net loss increased from \$1.9m in Q3 to \$3m in Q4/2009, on revenue of just \$61,730 (down 60% on Q3's \$156,000 and 93% on \$939,440 a year ago). Full-year 2009 revenue was \$608,000, down 60% on \$1.5m in 2008 (when the firm transitioned from a development-stage company, after being founded in December 2000). Net loss almost doubled from 2008's \$5.1m to \$9.8m in 2009. However, the balance sheet remains in a strong liquidity position, with no debt, stresses the firm.

The decline in revenue is attributed to the global economic downturn causing many planned funding sources for solar projects worldwide to be either suspended or cancelled, leading to a difficult environment to secure loans and credit lines. OPEL says that it recognized this environment towards the end of 2008 and hence implemented a strategy to preserve cash (a strategy that will continue into the foreseeable future). For example, in Q4/2009 OPEL started a small pre-production run of its Mk-I HCPV panels at a large contract manufacturer, allowing it to meet the volume required to fill its orders for 2010 delivery. The firm says that this strategy has allowed it to start to reduce the costs of its HCPV solar panels to ensure competitiveness as the market for larger HCPV projects starts up in late 2010 and 2011. The aim is to emerge from the downturn with a strong customer base and growing momentum.

So, despite the downturn, OPEL chose not to postpone its development programs and focused in Q3–Q4/2009 on installing 363kW of

panels and dual-axis trackers at its 440kW utility-scale solar grid field at Vilalba del Arcs in the Tarragona region of northwestern Spain, as well as hosting potential customers there. This is the first project of the Betasol Energias Alternativas S.L. joint venture between Belgium-based subsidiary OPL Solar Europe SPRL (OSE) and Spanish solar integrator Fuerza Solar S.L., formed to install solar grid fields for sale to third-party power providers that can receive the Spanish Government solar feed-in tariff. The firm's first fully operational solar grid field has allowed OPEL to demonstrate to potential customers the viability of its HCPV panels for generating solar electricity at utility-scale levels (e.g. proving their functionality and output compared to incumbent silicon-based solar panels). While 330kW was already connected to the grid and generating power by end 2009, revenue from Betasol (including about \$1m from the

363kW installed in 2009) will be realized in 2010 once the full 440kW project is completed and sold to a third party. On 9 March, the Spanish Government awarded OPEL the feed-in tariff of 28.1 Euro-cents for 25 years on the Vilalba del Arcs installation. The existing 330kW plant is now being offered for sale. Commencement of the fourth and final 110kW section of the 440kW installation is awaiting customer funding.

In a second Betasol project, OPEL has also agreed to install a 2.375MW solar farm at a further location in Spain. A local Spanish bank has provided the \$1.5m Aval (guarantee) for the project, which is due to begin installation in late 2010. The completed solar field will be sold to a third party that will provide electrical power to the Spanish grid.

OPEL adds that it is actively cultivating high-profile customers and projects in several European countries that have active feed-in tariffs. ➤

Connecticut Green Business Award

At a reception at the Yale School of Forestry & Environmental Studies Kroon Hall on 24 February hosted by Daniel C. Esty (director of the Yale Center for Environmental Law and Policy), OPEL Solar was one of 25 firms to receive a 2010 Connecticut Green Business Award (selected by Business New Haven & CONNTACT.com).

The award recognizes the firm's contributions to driving Connecticut's green economy with its HCPV panel technology, its solar tracker systems, and its creation of 'green' jobs in the State of Connecticut.

In March 2009, OPEL Solar completed the first solar rooftop tracking system for the Linden Elementary School in Plainville, CT. For this project, the firm won grants from the Connecticut Clean

Energy Fund and from the US Treasury Grant Program created by the American Recovery and Reinvestment Act.

OPEL Solar's recent international achievements include completion of one of the first commercial HCPV installations generating electricity in Spain.

The firm's installations are built using its Mk-I HCPVs mounted on dual-axis trackers. The combination of OPEL's HCPV panels (based on GaAs triple-junction solar cells produced by Boeing-Spectrolab) and precision dual-axis trackers results in higher power production per unit of land (acre/hectare) than silicon or thin-film flat panels with a potential to increase photovoltaic yields by up to 40%, claims the firm.

► So far in 2010, OPEL and its installation partner Tecneira have been awarded a 1MW installation by the Portuguese Government. OPEL will use its HCPV panels and dual-axis trackers while Tecneira will handle the balance of the system installation (which will start in 2010 and end in 2011).

Also, in March 2009, OPEL completed Connecticut's first rooftop tracker-mounted solar installation, a 131kW system at Linden Street School in Plainville, CT (now supplying a significant portion of the school's electricity, and reckoned to eliminate 79 tons of carbon emissions over the next 20 years). OPEL retains ownership of the \$1.1m system and will receive payment for electricity generated through a power purchase agreement (PPA) with the Plainville School System over the next 20 years. For the project, OPEL received a cash reimbursement of \$526,500 from the Connecticut Clean Energy Fund and, as a part of the American Recovery & Reinvestment Act, received an additional cash payment, in lieu of a tax credit, from the US Federal Government for 30% of the net cost (amounting to about \$179,000 in Q4/2009).

During 2009, OPEL also focused on forging relationships with large engineering, procurement and construction (EPC) companies and power producers. This has begun to pay off, says the firm, with an increase in quoting activity during the last two quarters along with orders for HCPV panels and tracker systems. Financing of solar projects is starting to pick up, and the US alternative energy stimulus package, individual State incentive programs, as well as the revised Ontario Standard Offer, will stimulate growth, it reckons. OPEL has worked to grow its customer base in all of these locations, which should yield projects from those relationships and continue to build its backlog of business for 2010 and 2011. "With our new relationships and increased opportunities in the marketplace, we are poised to expand prospective installation requests in 2010," reckons chief financial officer Michael McCoy.

OPEL reiterates that it now has several significant orders on its backlog to deliver in 2010 and 2011, a fully commissioned solar installation in Spain with an approved tariff rate to be sold to a customer in 2010, and two new SBIR (Small

Business Innovation Research) grants from the US Department of Defense to fund the activities of OPEL Defense Integrated Systems (ODIS) — including a \$750,000 contract since 1 January to continue development of infrared sensor technologies for the US Air Force and the Space Missile Command — which collectively provide sufficient cash and revenue growth to support itself over the next 12 months and beyond, even if the economic down-turn should continue.

The firm adds that its current cash balances and other liquid resources are sufficient to fund expansion, inventory purchase commitments and research programs for the foreseeable future.

OPEL comments that, during 2010, it aims to: ramp up US production for its tracking system; identify a US-based contract manufacturer to increase HCPV panel production capacity; establish dealer and representative networks in Mexico, Canada and the USA; and aid prospects for US solar legislation favoring HCPV incentives and other solar-related financial opportunities, such as feed-in tariffs or State and Federal grants.

www.opelinc.com

OPEL partners with Portugal's Tecneira on 1MW plant

OPEL Solar has signed an agreement with Tecneira S.A. of Porto Salvo, Portugal, the renewable energy firm of power plant developer ProCME Group (which is part of Spain's ACS Group, one of the world's largest firms in services and construction) and gained their first HCPV solar project win.

Established in 2001, Tecneira's main business is the production of electricity from renewable power sources (focusing on the development of solar photovoltaic, wind farms, biomass, and wave energy projects) and its commercialization and supply to the public electrical grid. In particular, Tecneira develops opportunities in HCPV, from micro-generation to large-scale utility solar systems.

Portugal is aggressively moving into CPV solar energy, comments OPEL Solar's CEO Robert Pico. In mid-March, Portuguese Prime Minister José Sócrates announced the government's commitment to renewable energy goals by 2020. As part of that, in the preliminary phase of projects OPEL Solar and Tecneira were awarded a 1MW CPV power plant installation (in Alqueva in the Moura Region of southern Portugal), which will be eligible for the Portuguese feed-in tariff (FIT).

"OPEL Solar's technology was viewed as one of the most innovative and utility-scalable to achieve Portugal's solar energy goals for CPV," Pico claims. "Tecneira believes in the competitive advantages that OPEL

Solar's HCPV technology offers," adds Tecneira's CEO Alda Delgado.

OPEL Solar will build the installation with its Mk-I HCPV solar panels mounted on dual-axis trackers. "Putting the HCPV panels on solar trackers will optimize the electrical production for this solar power plant," adds Delgado. According to OPEL Solar, combining its HCPV panels and dual-axis trackers results in higher power production per unit of land than silicon or thin-film flat panels, with the potential to increase photovoltaic yields by up to 40%.

"We look forward to working with OPEL Solar on this first installation and other projects in the future," says Delgado.

www.tecneira.pt

Amonix raises \$129.4m in Series B funding CPV firm to speed system deployment and expand capacity

Amonix Inc of Seal Beach, CA, USA, which makes concentrated photovoltaic (CPV) systems using III-V multi-junction cells, has raised \$129.4m in a Series B financing round led by Kleiner, Perkins, Caufield & Byers. Other investors include Adams Street Partners, Angeleno Group, PCG Clean Energy & Technology Fund, Vedanta Capital LP, New Silk Route, and The Westly Group, as well as existing investor MissionPoint Capital Partners.

Amonix previously raised \$25m in Series A funding from Goldman Sachs Group and MissionPoint Capital, and received \$15.6m in grant funding via the US Department of Energy's Solar America Initiative (SAI). In 2010, the firm also received

\$9.5m in stimulus funding as part of the federal Recovery Act's Advanced Energy Manufacturing Tax Credit, which should lead to 269 new clean energy manufacturing jobs in Nevada and 167 new jobs in Arizona. Amonix says that it will use the latest proceeds to accelerate deployments of its CPV systems and expand manufacturing capacity.

The new round of funding reinforces Amonix's long-term commitment to its customers and projects in the field, says the firm's CEO Brian Robertson. "Our customers can rely on our strengthened balance sheet, committed corporate partners, proven track record in the field, and an industry-leading warranty package.. Customers will realize the benefit through lower-

cost financing," he adds.

"Amonix CPV systems have emerged as the lowest-cost solar technology for sunny and dry environments," says Kleiner, Perkins, Caufield & Byers partner Ben Kortlang. "Developers and utilities are choosing Amonix systems because of their 15-year track record in the field, high reliability, ease of deployment and industry-leading efficiency." In the Amonix system, plastic Fresnel lenses collect sunlight and concentrate it to 500 times, allowing 39% efficiency at the cell level (DC current) and 23-25% at the system level (AC current) in volume production. In record demonstrations, cell efficiency has exceeded 41%.

www.amonix.com

Spire to provide PV module making line to Solartech Plant could be converted from silicon to thin-film PVs in future

Spire Corp of Bedford, MA, USA, which provides production equipment and turnkey production lines for manufacturing photovoltaic (PV) cells and modules as well as engineering, procurement, and construction (EPC) services for solar systems, has entered into a contract to provide a turnkey PV module manufacturing line to Solartech Renewables LLC.

Solartech was formed in 2009 to set up a plant for making PV panels and array configuration hardware in the Tech City complex in Kingston, NY. The facility is described as a team effort between Solartech, Spire and The Solar Energy Consortium (TSEC).

The line will include Spire's equipment, process knowledge, training and module certification assistance. Solartech will begin production using Spire's 60-cell, 220W module design.

When completed in 2010, the plant will have an annual capacity of more than 12MW of solar panels. At this capacity utilization rate, the project should create more than

100 new full-time permanent jobs.

"We chose Spire because they are renowned for their technology and unfailing support," comments Solartech's CEO Todd Roberts. "As an American company, they also have the best ability to understand our needs and support us throughout the launch and ramp up of the factory."

Solartech plans to enter the solar market using proven polycrystalline silicon production technology. However, most of the manufacturing processes for polycrystalline solar panels are also needed for thin-film panels (and even prospective polymer and nanotech panels). Conversion of the factory to thin-film technologies in the future — e.g. amorphous silicon (aSi), copper indium gallium diselenide (CIGS) or cadmium telluride (CdTe) — could therefore be accomplished with additional capital investment and a relatively modest expansion in floor space, reckons the firm.

Solartech adds that the last step

of the manufacturing chain (configuration of the panels into arrays in the field to produce usable power) is largely the same regardless of the underlying technology used to design and produce the solar panels. So, proprietary configuration hardware and designs will be applicable to all current and future solar panel designs, and hence proprietary intellectual property will continue into the future even as underlying panel material and design technologies mature, reckons the firm.

"Solartech is responding to the need for more US-based manufacturing for PV modules," says Spire's chairman & CEO Roger Little. "With the federal and state incentives for PV systems now in place, the US market has become the fastest growing in the world. It is projected to be more than 2GW by 2011, with as much as a 1GW shortfall of US-based manufacturing," he adds.

www.spirecorp.com

www.solartechrenewables.com

SolFocus 235kW plant to provide 28% of Alice Springs Airport's electricity

SolFocus Inc of Mountain View, CA, USA says that its Australian renewable energy development partner Ingenero Pty Ltd of St Lucia, Queensland is to install a 235kW power station using 28 SolFocus 1100S concentrator photovoltaic (CPV) arrays to provide solar power at Alice Springs Airport in the Northern Territory of Australia. The power station will deliver about 600MW-hrs of electricity directly to the airport's internal electricity grid (about 28% of its demand and equivalent to the power used in about 70 homes in Alice Springs).

"Alice Springs is the ideal location for CPV technology, and Ingenero is proud to be able to bring SolFocus technology to Australia for the first time," says Rodger Whitby, Ingenero's general manager of Generation.

Under the Australian government's AUS\$94m Solar Cities program, the project will receive \$1.132m from the Australian government (about half of the total project cost). The power station will be located near the Alice Springs Airport terminal, and should reduce the airport's carbon emissions by about 470 ton of carbon dioxide per year. Construction is expected to be complete by the end of third-quarter 2010.

"As a major electricity user in Alice Springs, this project is an ideal way to demonstrate our commitment to harnessing the benefits of renewable energy," says Ian Kew, CEO of Northern Territory Airports. "The SolFocus advanced CPV technology provides the potential for reduction of power costs within the next few years," he adds.

"The Alice Springs Airport solar project is paving the way for SolFocus CPV technology in Australia and will demonstrate how scalable CPV technology can deliver unrivalled energy output in hot, sunny regions with less impact on the surrounding environment than standard solar panels," says SolFocus' chief technology officer Steve Horne.

Australia's solar energy consumption represented 0.1% of the country's total primary energy consumption for 2007-2008, with solar thermal water heating being the predominant form of solar energy use to date (according to March's report 'The Australian Energy Resource Assessment'). "This pioneering solar project at Alice Springs Airport is just the beginning of a solar transformation in Australia that will harness the continent's abundant sunlight to deliver low-cost, renewable energy," adds SolFocus' president & CEO Mark Crowley. "SolFocus is optimistic about Australia's solar market and is confident that CPV technology is well-matched with Australia's territories and dynamic environment."

SolFocus' CPV design uses a system of patented reflective optics (curved mirrors) to concentrate sunlight 650 times onto gallium arsenide-based solar cells (on germanium substrates) that have high solar energy conversion efficiency (approaching 40%, more than twice that of traditional silicon solar cells). Like its smaller SF-1000S system (approved by the CEC in September 2008), the firm's second product (the SF-1100S, launched that November) uses about a thousandth of the active solar cell material compared to traditional silicon-based PV panels, but boosts panel conversion efficiency from 18% to more than 25%.

SolFocus claims that, in solar-rich regions like Australia and the southwest USA, its CPV technology yields significantly more energy than other technologies, as well as having an extremely light environmental footprint (involving a small land footprint with dual-use potential, and no permanent shadowing or wildlife corridor disruption).

www.solfocus.com

www.ingenero.com.au

IN BRIEF

First Solar sells 30MW PV project to Southern Company and Turner Renewable Energy

First Solar has sold a 30MW (AC) solar power project to Southern Company and Turner Renewable Energy. Financial terms of the transaction were not disclosed.

The Cimarron I Solar Project is adjacent to the Vermejo Park Ranch in northern New Mexico. First Solar developed the project and is providing engineering, procurement and construction (EPC) services. It will also provide operation and maintenance services under a 25-year contract. Using about 500,000 photovoltaic modules, the facility will supply power to about 9000 homes (or 18,000 residents) and displace more than 45,000 tons of CO₂ per year.

"The Cimarron I project is yet another example of First Solar's capability to realize utility-scale solar projects," says CEO Rob Gillette. "Combining the required technology, manufacturing, project development and EPC expertise enables First Solar to be a leader in sustainable energy development," he claims.

Construction of the project began in March, with completion and commercial operation expected by the end of 2010. The project will create over 200 jobs at the peak of construction.

First Solar says that electricity generated by the plant will serve a 25-year power purchase agreement with the Tri-State Generation and Transmission Association, a not-for-profit wholesale power supplier to 44 electric cooperatives serving 1.4 million customers across Colorado, Nebraska, New Mexico and Wyoming.

www.firstsolar.com

EU project PRIMA aims to boost PV efficiency

The semiconductor research institute IMEC in Leuven, Belgium says that it has started work, together with its project partners, on PRIMA, a project under the EU's 7th framework program for ICT (FP7). The project's goal is to improve the efficiency and cost of solar cells through the use of metallic nanostructures. In addition to project coordinator IMEC, the partners involved are Imperial College in London, UK, Sweden's Chalmers University of Technology, Belgium's Photovoltech, QuantaSol Ltd of Kingston-upon-Thames, UK, and Australian National University.

Certain nanostructured metallic surfaces show unique characteristics, says IMEC: they can absorb and intensify light at specific wavelengths, because the incoming light results in a collective oscillation of the electrons at the metal's surface. This phenomenon (plasmonics) has

many promising applications. It can be exploited to transmit optical signals through nanosized interconnects on chips, in nanoparticles that recognize and interact with biomolecules, or in solar cells.

With solar cells, metallic nanostructures can boost the absorption of light into the cell's photoactive material. And with enhanced light absorption, it is possible to produce cells with less base material, hence making them thinner and cheaper. IMEC says that metal nanostructures can also improve the absorption in various types of cells, e.g. crystalline silicon cells, cells based on high-performance III-V semiconductors, or organic and dye-sensitized solar cells.

PRIMA's aim is twofold. First, the project wants to gain insight into the physical mechanisms of metallic nanostructures, and how they can improve the light absorption of

the solar cell's material. Second, the project's partners want to study how these structures can best be integrated into the production of solar cells. For this, they will test a number of structures, benchmarking them against state-of-the-art solar cells. The performance and applicability of these cells will then be assessed by solar cell firms participating in the project.

IMEC says that European science has traditionally been a leader in the fields of both photovoltaics and plasmonics, and this project should help to maintain Europe's strong position. Moreover, it should provide the participating industrial partners with a competitive advantage, with the aim of creating employment and sustainable economic growth in Europe while simultaneously contributing to a reduction in the emission of greenhouse gases.

www.imec.be

Mn-doped GaN PV cell absorbs in UV, visible and infrared

At the 57th Spring Meeting of the Japan Society of Applied Physics, a Japanese research group led by Kyoto Institute of Technology associate professor Saki Sonoda presented a prototype nitride-based photovoltaic (PV) cell that can generate electricity from a wide wavelength band including ultraviolet light, visible light and infrared light, according to a report in Nikkei Electronics.

Since its bandgap energy is large (3.4eV), gallium nitride (GaN) only absorbs short wavelengths and is transparent to longer visible wavelengths. Recently, many researchers have added indium (In) to GaN-based PV cells in the aim of narrowing the bandgap and enabling it to absorb visible light. However, in such cases, multi-junction cells using materials with different ratios of indium, for example, are necessary for the conversion of a wide wavelength band of light into electricity.

However, Sonoda found that adding 3d transition-metal elements including manganese (Mn) to transparent wide-bandgap compound semiconductors such as GaN enabled the development of a highly efficient PV cell by using a single-junction cell rather than a multi-junction cell. Specifically, when Mn is added until its component ratio reaches between several percent and 20%, the absorbing coefficient is increased for a wide wavelength band of light, including ultraviolet, visible and infrared. Currently, the conversion efficiency of the new PV cell is low, but its open voltage (V_{oc}) is as high as 2V.

The research group also added a variety of 3d transition metals other than Mn and obtained similar results in many cases. By choosing the additive elements appropriately, even aluminum nitride (AlN) — which has a very large bandgap — could be made to absorb in the visible wavelength range, Sonoda says.

This time, the cell was prototyped by adding cobalt to p-type GaN. Its V_{oc} is 2V or more at 1 sun (i.e. no light concentration). In general, when a single-junction cell has a V_{oc} of 2V or more, its bandgap is large and only the short-wavelength part of visible light (blue, green, etc) can be converted into electricity, but this does not apply to the new cell.

On the other hand, the short-circuit current density of the PV cell is about $10\mu\text{A}/\text{cm}^2$, about a thousandth that of a typical crystalline silicon PV cell. Because the cell and electrodes are separated, the electrical resistance of the p-type GaN connecting them is very large, Sonoda says.

In this case, it was not possible to accurately measure the output current, because photolithography systems could not be used to fabricate the cell. As a result, the conversion efficiency is only slightly higher than 0.01%. Nevertheless, improvements are expected.

www.kit.ac.jp/english

Chevron starts project to test thin-film PV technologies

Energy firm Chevron Corp of San Ramon, CA, USA has announced the start of the three-year-long Project Brightfield at a former oil refinery site near Bakersfield, CA that has been repurposed to test and compare the performance of seven emerging photovoltaic technologies provided by independent solar companies (six thin-film and one crystalline-silicon).

"Brightfield represents one of the most comprehensive solar energy tests of its kind and is an innovative approach to evaluating new technologies," claims Des King, president of Chevron Technology Ventures (the division of Chevron USA Inc that identifies, evaluates and demonstrates emerging technologies). The site will measure the energy produced by each solar technology and monitor how weather elements (such as temperature, rain, wind and humidity) affect the panels' performance. "Testing competing technologies side by side means that we can better understand their potential application at other Chevron facilities," adds King.

The 7700 solar panels on the 8-acre site will generate about 740kW of electricity, which will be directed to the local utility grid as well as to Chevron's oil production operations at the Kern River Field. "Chevron has operated in the San Joaquin Valley for more than a century," says Bruce Johnson, VP of Chevron's San Joaquin Valley business unit. "Throughout this time, our engineers have developed breakthrough technologies that have helped make us the leading oil and gas producer in the state," he adds.

The firms demonstrating thin-film technologies are Abound Solar, MiaSolé, Schüco, Solar Frontier, Sharp, and Solibro, while the crystalline-silicon technology is provided by Innovalight. Each can access data about its technology, find out how well it performs in various conditions, and compare it against a benchmark solar technology — an

unnamed brand of commercially available PV technology — that has also been installed on the site.

- MiaSolé of Santa Clara, CA was founded in 2001 and raised \$300m in venture financing, but started shipping copper indium gallium diselenide (CIGS) thin-film photovoltaic panels to customers only last December. It has now installed modules at the Brightfield site providing 200kW of power (marking MiaSolé's first commercial project in California). MiaSolé says that its CIGS PV panels convert 10.5% of sunlight into electricity. Products are designed specifically for large-scale rooftop and ground-mount installations for utilities, independent power providers, and industrial scale deployments.

- Cadmium telluride (CdTe) thin-film PV panel maker Abound Solar of Loveland, CO (formerly Colorado State University spin-off AVA Solar from January 2007 until March 2009) raised \$104m in equity financing in 2008 and started its first commercial-scale (65MW) manufacturing plant last April. It is providing Brightfield with a 190kW commercial-scale ground-mount PV array of Abound AB1 modules which, in combination with a Schneider Electric Xantrex GT250 central inverter, will produce 300MWh per year.

- Solibro GmbH was formed in November 2006 to combine the CIGS PV technology of Solibro AB (which was spun off from R&D at the Ångström Solar Center of Sweden's Uppsala University in 2001) with commercial and industrial backing of silicon PV maker Q-Cells of Bitterfeld-Wolfen, Germany (of which it became a wholly owned subsidiary within Q-Cells Modules last June). Solibro shipped its first products in 2008. Production capacity expanded from 15MW to 45MW in 2009 and should ramp up by another 90MW to 135MW by the end of 2010.

- Solar Frontier (a subsidiary of Tokyo-based oil refiner Showa Shell

Sekiyu called Showa Shell Solar until March) had been working on copper indium selenide (CIS) PV technology since 1993 before starting commercial production of modules at 20MW/year in 2007 and adding a 80MW/year second plant last June. It is now planning to spend ¥100bn (\$1.1bn) to build a third, 900MW plant that will open in mid-2011 (boosting capacity ten-fold to 1GW).

- Germany's Schüco, which makes aluminum, steel and solar components, has developed a US presence over the past three years and exhibited its thin-film PV modules at the Intersolar North America 2009 conference last July.

- Japanese consumer electronics maker Sharp makes traditional silicon solar cells, but also makes III-V-based thin-film PV cells. The firm aims to boost its thin-film PV manufacturing capacity six fold to 1GW by 2010, and to deliver 6GW by 2014.

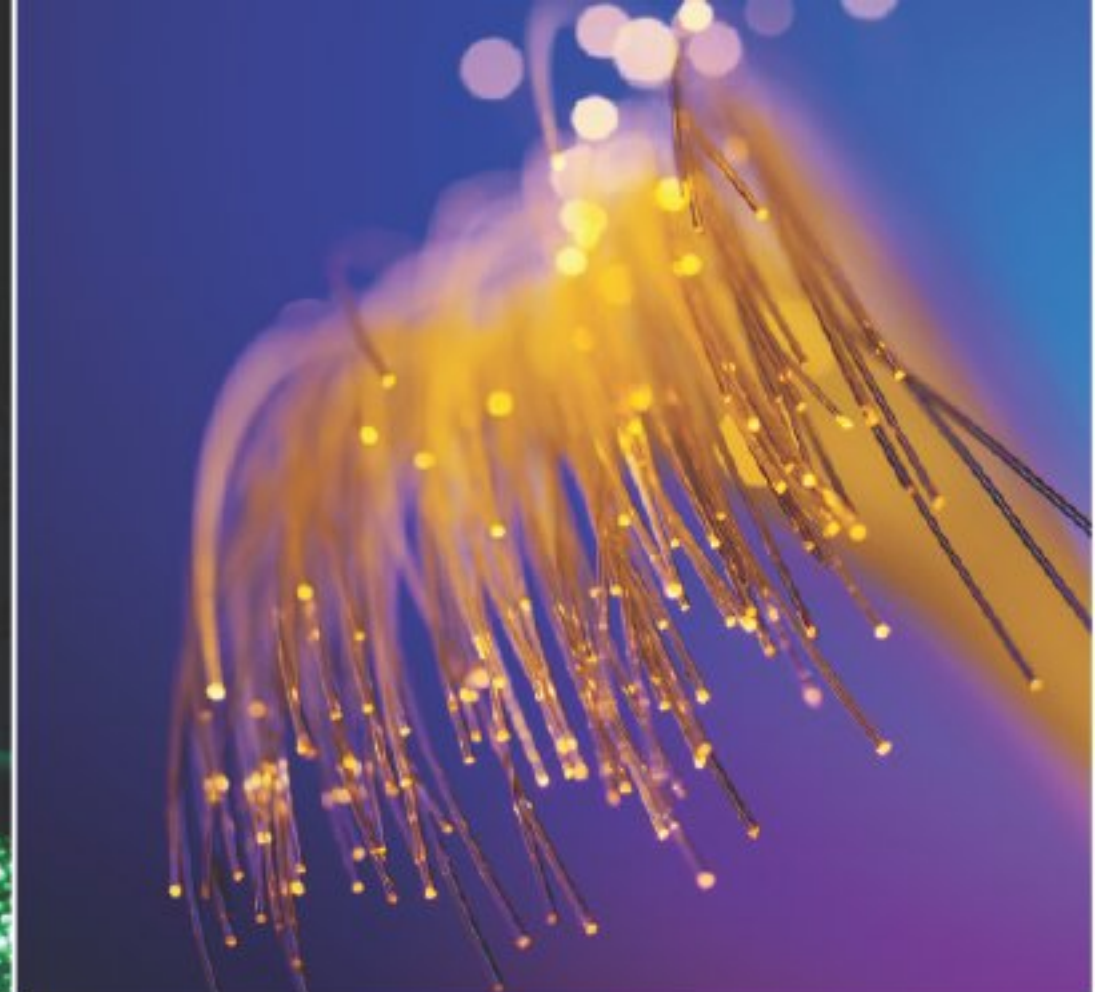
- Founded in 2002, Innovalight of Sunnyvale, CA makes proprietary photovoltaic silicon ink that can produce 18%-efficient PV cells via high-throughput atmospheric inkjet-based processing.

At the end of the three-year Project Brightfield, Chevron aims to decide which of the technologies to integrate into its facilities worldwide.

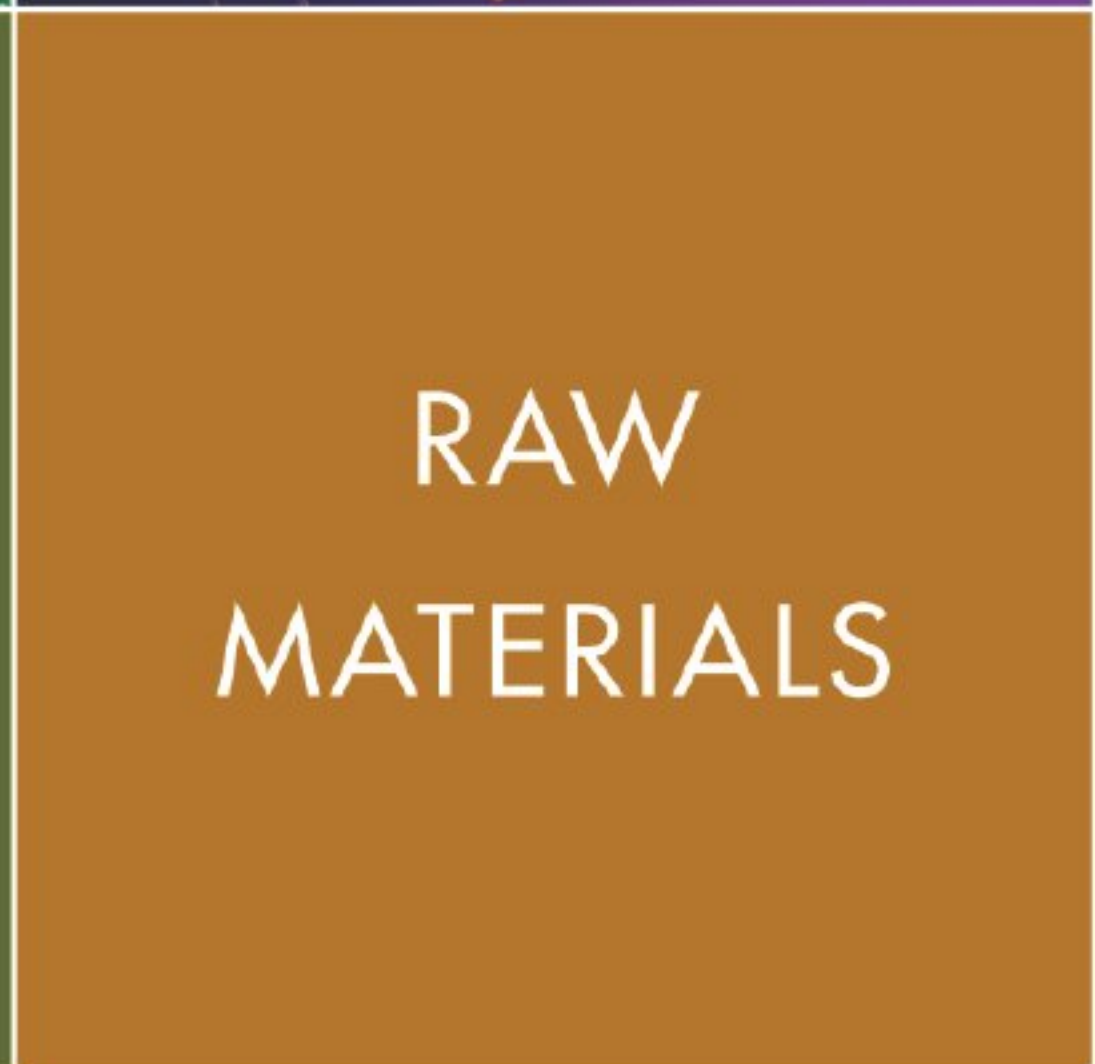
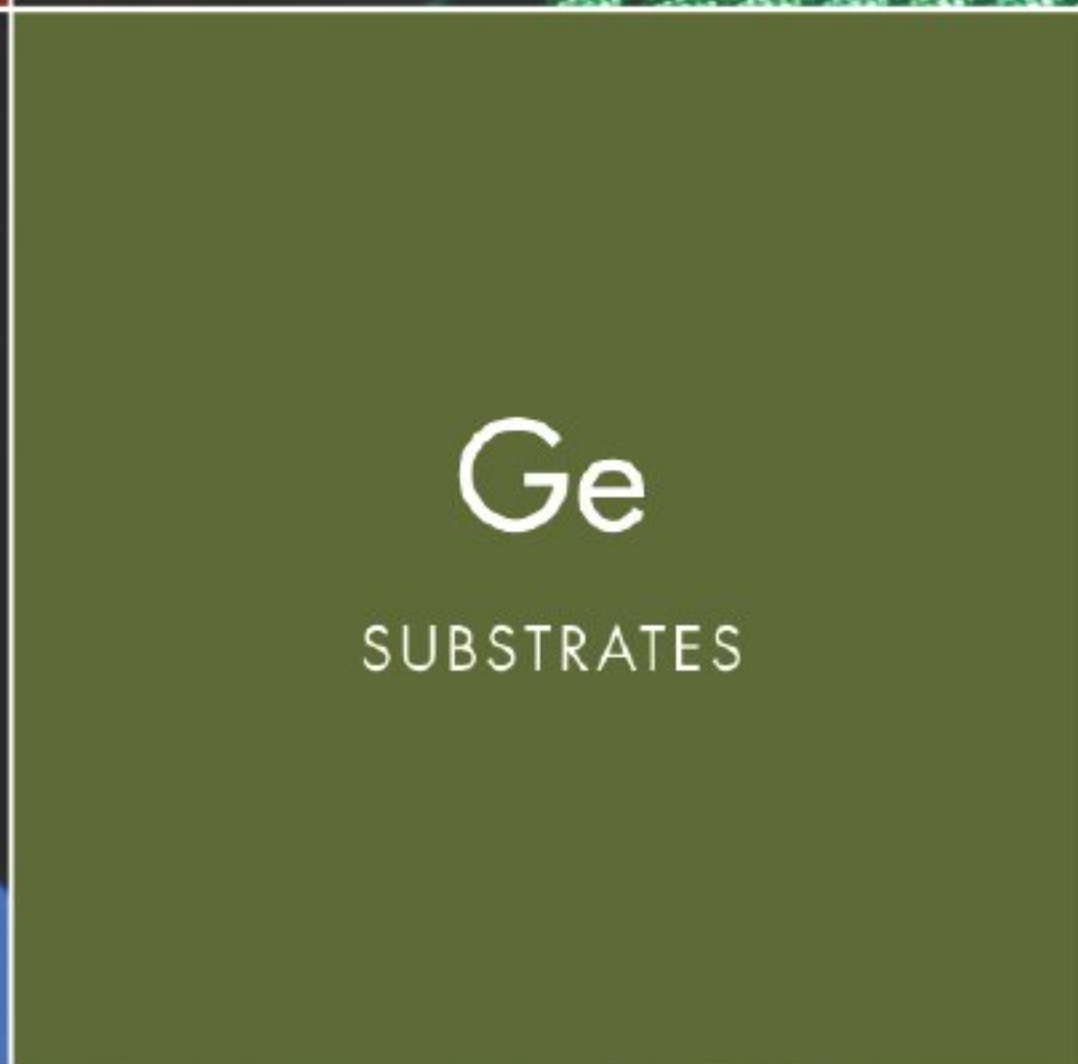
Brightfield is Chevron's second completed project that repurposes an existing asset to integrate renewable power. The first was a wind farm on a former Texaco refinery site near Casper, Wyoming (where 11 wind turbines generate 16.5MW of power). A third project — a 1MW concentrating photovoltaic (CPV) installation at a former Chevron Mining Inc facility near Questa, NM — will use CPV systems from Concentrix Solar GmbH of Freiburg, Germany (as announced on 24 February), and is due to be completed by the end of 2010.

www.chevron.com

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Sapphire material market to exceed \$200m in 2010 despite downturn

Yole Développement's **Philippe Roussel** surveys the sapphire substrate market, both 2–4" for the booming LED market as well as prospects for 6" and above.

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

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

As a result, a 55% drop in revenue has been seen for r-plane sapphire wafers.

2" sapphire price as low as ever but shortage risk could generate turbulence

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

For 2010, Yole forecasts a price rise of about 5% across the board. However, this will be unevenly distributed through the different diameters. Yole expects the 2-inch price to rise by up to 40% in 2010, whereas the price for 3-inch and 4-inch sapphire

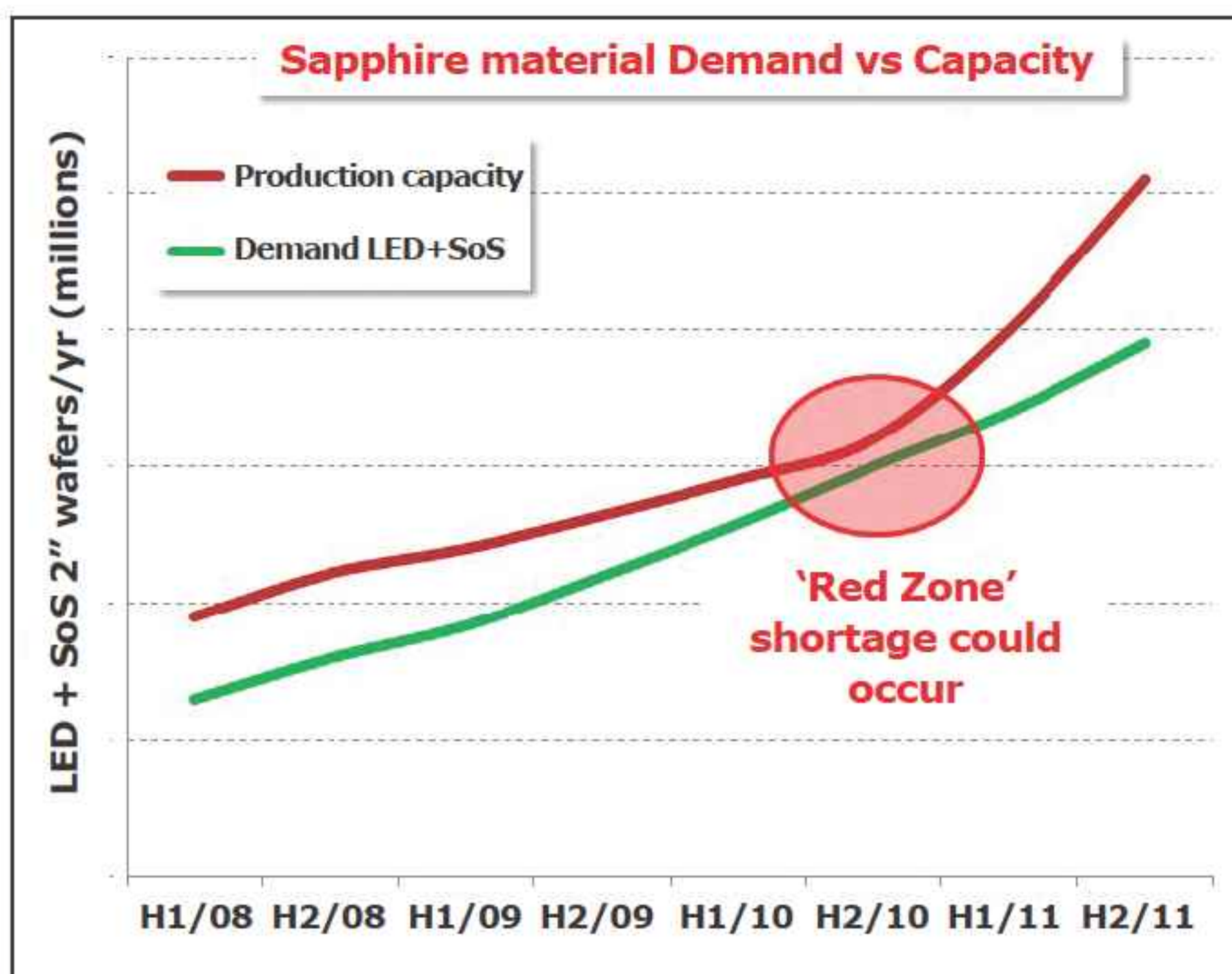


Figure 1: Evolution of sapphire material demand and capacity.

should remain stable compared to their low of 2009 and actually decrease by 20% compared to their average selling price (ASP) through 2009, explains project manager Dr Philippe Roussel.

The tremendous demand created by the success of LED-backlit TVs will strain the entire industry. LED makers need to quickly ramp up capacity, and it is estimated that equipment vendors will have to deliver more than 400 new reactors in 2010. With installation and setup time of 3–6 months plus another 3–6 months to qualify the chips, equipment or chip manufacturers might end up being the weak point in the supply chain.

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

early 2011 with the full production ramp-up of sapphire producers.

Is 6-inch sapphire economically viable for LEDs?

Last year saw the introduction of the first industrial tools running 6-inch diameter sapphire for LED manufacturing. It is still unclear how 6-inch sapphire can bring a strong added-value to LED manufacturing costs, as the market price of this diameter substrate remains very high compared to the \$/sq. inch costs for 2-inch and 4-inch wafers. Yole ran its proprietary Sapphire Growth Cost Model tool and found that only the Kyropulos and EFG (edge-defined film fed growth) techniques could generate a sub-\$6/square inch c-plane wafer cost for 6" diameter sapphire, which again is very expensive compared to smaller-diameter materials.

Japan captures almost half the business

With a market share of more than 44%, Japanese sapphire producers again led the sector in 2009. Kyocera and Namiki are now generating more than \$100m in sapphire revenues for both substrates and non-substrate (optical applications) products, while Shinkosha and Sumitomo Metal Mining are also among the top 12 players.

In the USA, Rubicon has faced a severe downturn in the r-plane segment, as its main client Peregrine Semiconductor drastically cut its orders. In Europe, Russia's Monocrystal plc remains the number one player.

Vision of the future

From the point-of-view of wafer usage, the LED industry is now clearly moving towards larger substrate diameter. c-plane 3-inch and 4-inch sapphire already represents about 35% of the total surface area shipped. In addition, 6-inch sapphire is now becoming a reality, and has already been announced by Samsung and Showa Denko for launch in the next couple of years. Yole expects commercial production of 6-inch sapphire to begin by early 2011 as prices drop. "We don't yet see an 8-inch demand," says Roussel. However, r-plane

The LED industry is now clearly moving towards larger substrate diameter. c-plane 3-inch and 4-inch sapphire already represents about 35% of the total surface area shipped. In addition, 6-inch sapphire is now becoming a reality

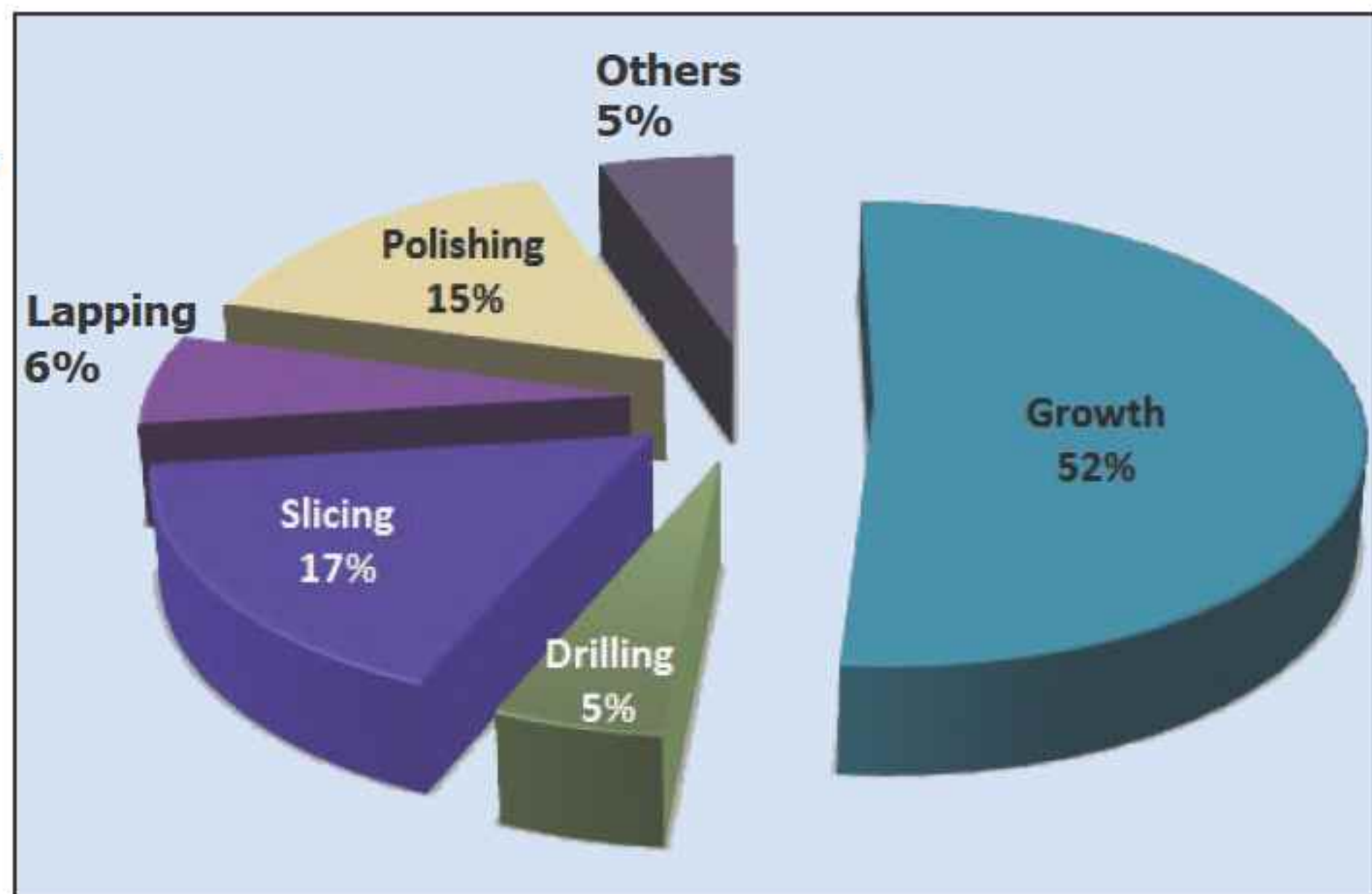


Figure 2: Typical manufacturing cost breakdown for 200,000 2" c-plane sapphire wafer per year (grown by the Kyropulos technique).

sapphire for SoS is now entering the 8-inch stage and should represent more than 50% of production by 2013. Nevertheless, nitride LED business will continue to drive the major part of sapphire substrate volume.

Other alternative substrates remain in the R&D stage. While still not ready to deliver top performance, Yole considers silicon to be the most serious contender to sapphire, as demonstrated by Osram's recent acquisition of a non-exclusive license for Azzurro Semiconductors' GaN-on-Si technology. The transition to a silicon platform might become more appealing if the sapphire material shortage was to last more than a year and if large-diameter wafers (6-inch) fail to reach a price point that could significantly decrease LED manufacturers' total cost of ownership.

After taking a serious hit in 2009, SoS business will resume its growth driven by the attractive performance of Peregrine's Ultra CMOS technology and a growing end market. In addition, Peregrine's strategy of moving to a fabless model and granting multiple licenses is easing the concerns of potential users that now have access to multiple sources for their components. In the long term, this will favor the emergence of alternative SoS-based technology, further increasing adoption. However, the progress of traditional GaAs or even CMOS-based technologies still needs to be monitored carefully. ■

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Material shortages take the edge off LED boom

It's boom-time in the LED industry. But while the unexpectedly sharp upturn in demand will mean a shortage of key materials during 2010, in the longer term there will be greater competition among MOCVD equipment vendors, and an acceleration of the emerging solid-state lighting market, writes Michael Hatcher.

The year 2010 will go down in compound semiconductor history as one of the great 'boom' years. Upwards of 250 new MOCVD reactors are likely to come on-stream in the LED manufacturing hot-beds of Taiwan and Korea — the two centers of the LCD TV backlighting industry that is primarily driving the current ramp.

Sales staff at Aixtron and Veeco Instruments have never had it so good: every quarter sees new records set for MOCVD-related orders, and with those deliveries now being fulfilled revenues are heading in the same, sharply upward, direction. With new fabs under construction and the likes of TSMC now entering the LED market, it's a situation that is set to continue.

But the boom presents its own challenges, and one trend that we are already starting to see is increased competition for the incumbent MOCVD equipment suppliers. For more than a decade now, Aixtron, Veeco and Taiyo Nippon Sanso have dominated the scene, with a combined market share consistently in excess of 95% in the past five years. Smaller suppliers such as EMF and Structured Materials have found a market in niche applications and customized equipment, but they do not supply the mass-production systems that are required for volume LED epiwafer fabrication.

The incumbents already face a stiff challenge in meeting the unprecedented and rising demand. Both Veeco and Aixtron exploit largely out-sourced production models that allow them to scale volumes rapidly up and down as demand requires. The two companies have stepped up capacity recently. Right now Aixtron is able to assemble 100 MOCVD systems each quarter, and is aiming to increase this to 150 by the end of 2010 — should such demand arise. Veeco's capacity target has been lifted to 120 systems per quarter, which it should be able to support by late 2010, suggesting a combined annual capacity in excess of 1000 systems in 2011.

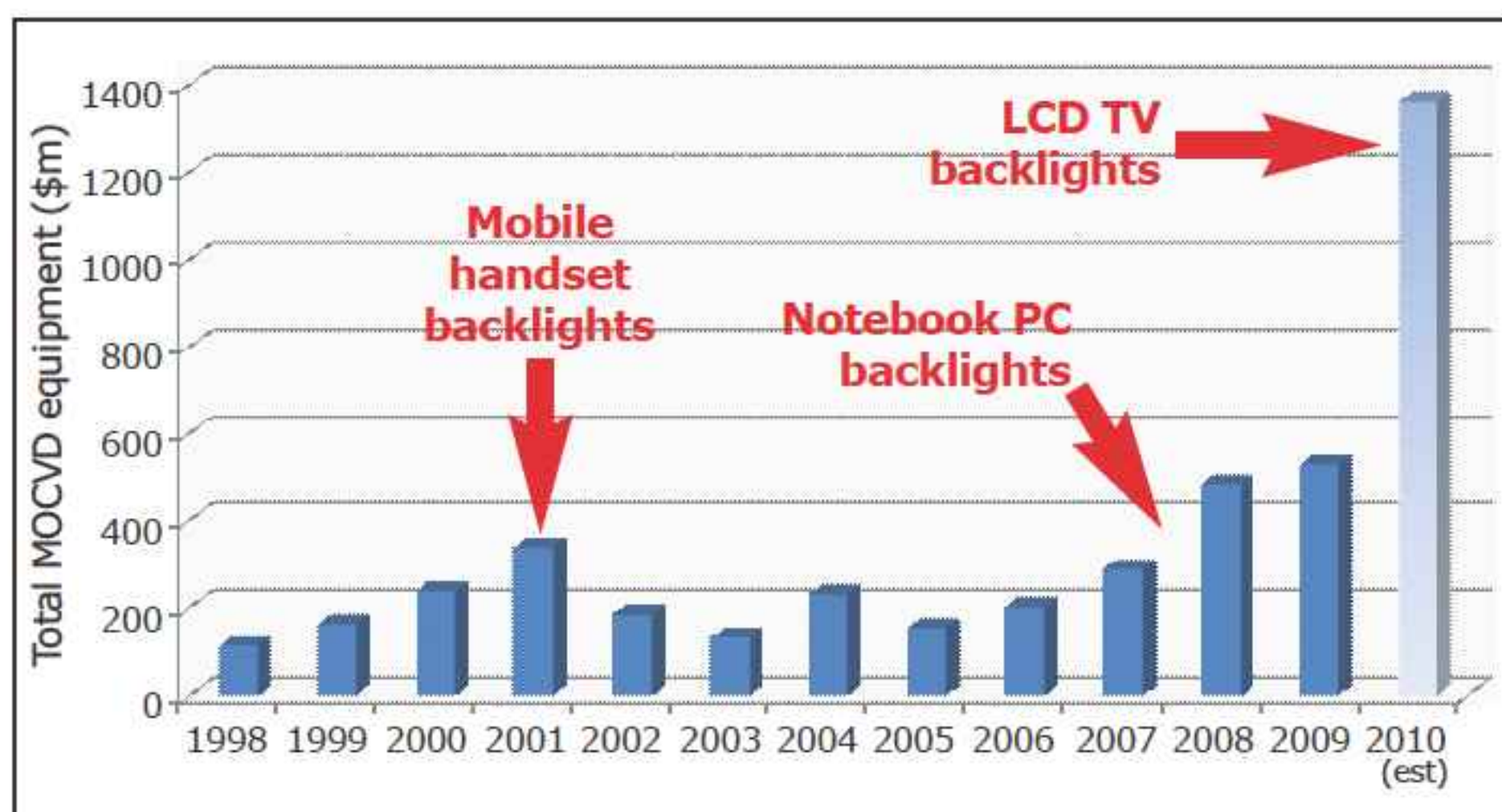


Fig 1: The spike in MOCVD reactor sales prompted by the LCD backlight unit boom dwarfs previous spikes seen for mobile handset and notebook PC backlights, as so many more LEDs are required to produce high-quality TV images. Source: Aixtron/Strategy Analytics.

Can they achieve that capacity increase and meet the surging demand? Possibly. But they will certainly have more competition as we move out of 2010 and into 2011. Korea's Jusung Engineering and Integrated Process Systems (IPS) Ltd, along with China's Jason Qingdao and the lurking giant Applied Materials, have all made moves into the MOCVD sector. The sudden expansion of the TV backlighting market for LEDs (expected to comprise half the HB-LED market by 2013) may have caught those new entrants by surprise — within two years the capacity required to service that market will have been largely deployed, as LED backlight units become a standard technology in LCD TVs, and the present window of opportunity will have closed.

Consolidating their lead positions, first Veeco and then Aixtron updated their MOCVD equipment offerings in early 2010. A new flow design from Veeco improves cross-wafer deposition uniformity, enabling less waste of high-performance LED die through the binning stage. Aixtron's update to the 'IC' platform adds significant capacity to each reactor, with a susceptor arrangement providing room for up to 56 2" wafers or 14 4" wafers.

The potential challengers have been taken by surprise by the LCD TV ramp, and although they do have an opportunity to enter the market as supply tightens, they will be looking more realistically to the future investment cycle of solid-state lighting to make their mark. Those challengers are taking significantly different approaches. Applied Materials is working on a hybrid HVPE and MOCVD tool and, in general, equipment that emphasizes rapid throughput, while Jusung has fielded a tool to Korea's Epi-valley with room for more than 100

2" wafers. As always, refining new technologies to provide the required level of uniformity and consistency will take time, and industry talk suggests that the tools fielded by Applied are not yet ready for the task.

While the LCD TV investment cycle will come and go at the MOCVD equipment level, that will not be true of the materials required to make LEDs, which will need to step up significantly. Demand for trimethylgallium (TMG) in particular has picked up strongly (40–50%) as the slew of new MOCVD chambers is switched on for volume production, and there is now a big gap between demand for MO materials and the amounts that suppliers are able to provide. This capacity squeeze is likely to prove more of a drag on the LED market in the short term than any limits on the supply of epitaxy equipment. In fact, demand for TMG already outstrips supply by as much as 40%, with prices rising quickly. Some LED epiwafer producers, and in particular those based in Taiwan, are struggling to retain sufficient supply.

To a significant degree, this is the fault of the market itself, and in particular those who have battered down the price of MO materials over the years. As a result, suppliers have been unable — or unwilling — to risk making an investment in additional MO capacity. After many a false dawn in LCD backlighting applications and years of diminishing profit margins, this position should not be surprising. Now that the dawn of LED TV backlights has arrived for real, those suppliers are unable to ramp up to meet demand with immediate effect.

Manufacturers in Taiwan, where prices have historically been under the greatest pressure and supply contracts have typically been short-term in nature, have to adjust to a new reality. Unlike the first major ramp in LED production, for mobile handset backlights, the Taiwanese are not the dominant customers and cannot call the shots as before. This time, it is the Korean giants Samsung and LG, along with Seoul Semiconductor,

Table. LED LCD TV backlight expansion (inches).

	2009	2010
BenQ	None	21.5, 23.6
LG	42, 47, 55	19, 22, 26, 32, 37, 42, 47, 55, 60
Panasonic	None	37, 42
Philips	42, 46	40, 42, 46
Samsung	32, 40, 46, 55	19, 22, 26, 32, 40, 46, 55, 60, 65
Sharp	32, 40, 46, 52	19, 22, 32, 40, 46, 52, 60, 63
Sony	46, 52, 55	32, 40, 46, 52, 55, 60
Vizio	47, 55	16, 19, 22, 23, 26, 32, 37, 42, 47, 55, 72

Source: Aixtron, Strategy Analytics

who are calling the tune. With deep pockets, they are able to absorb the increased MO costs and now appear to be favored by suppliers of critical materials.

Such a position does of course raise the possibility of additional competition at the MO level. After all, the need for materials continues long after the MOCVD reactors have been shipped and installed, and there is an opportunity for long-term growth. But MOs are notoriously hazardous products and entering this specialist market is not a decision to be taken lightly. As a result, LED epiwafer manufacturers will likely have to take the increased MO prices on board until suppliers are able to scale up their production facilities.

The LCD TV boom is also now impacting sapphire wafer suppliers, with a shortage likely in second-half 2010. In Asia, prices have already risen 20% and, although sapphire producers aim to add crystal growth equipment, much of this extra capacity will not come on stream for many months. With LED producers increasingly looking to larger-diameter wafers, the shortage is likely to extend across all sapphire wafer sizes.

Clearly there will be some short-term pain, likely for the next 12 months, to go with the record gains, and materials supply constraints will limit LED market growth in 2010. But the extra capacity will ultimately provide greater economies of scale, just as extra competition among equipment suppliers will deliver performance improvements to impact LED yields in a positive way.

These trends will be crucial to cutting the cost of high-performance LED production to a level that pushes the cost per lumen figure for solid-state lighting significantly lower. The LED industry is embarking on a 2–3 year period of rapid growth and faces a new set of challenges as outlined above. When it emerges from that period, solid-state lighting will quickly provide the next cycle of investment among what is likely to be a more diverse range of device, equipment and materials companies. ■

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Tyndall claims first junctionless transistor

'Wedding ring' gate around silicon nanowire targets sub-10nm CMOS.

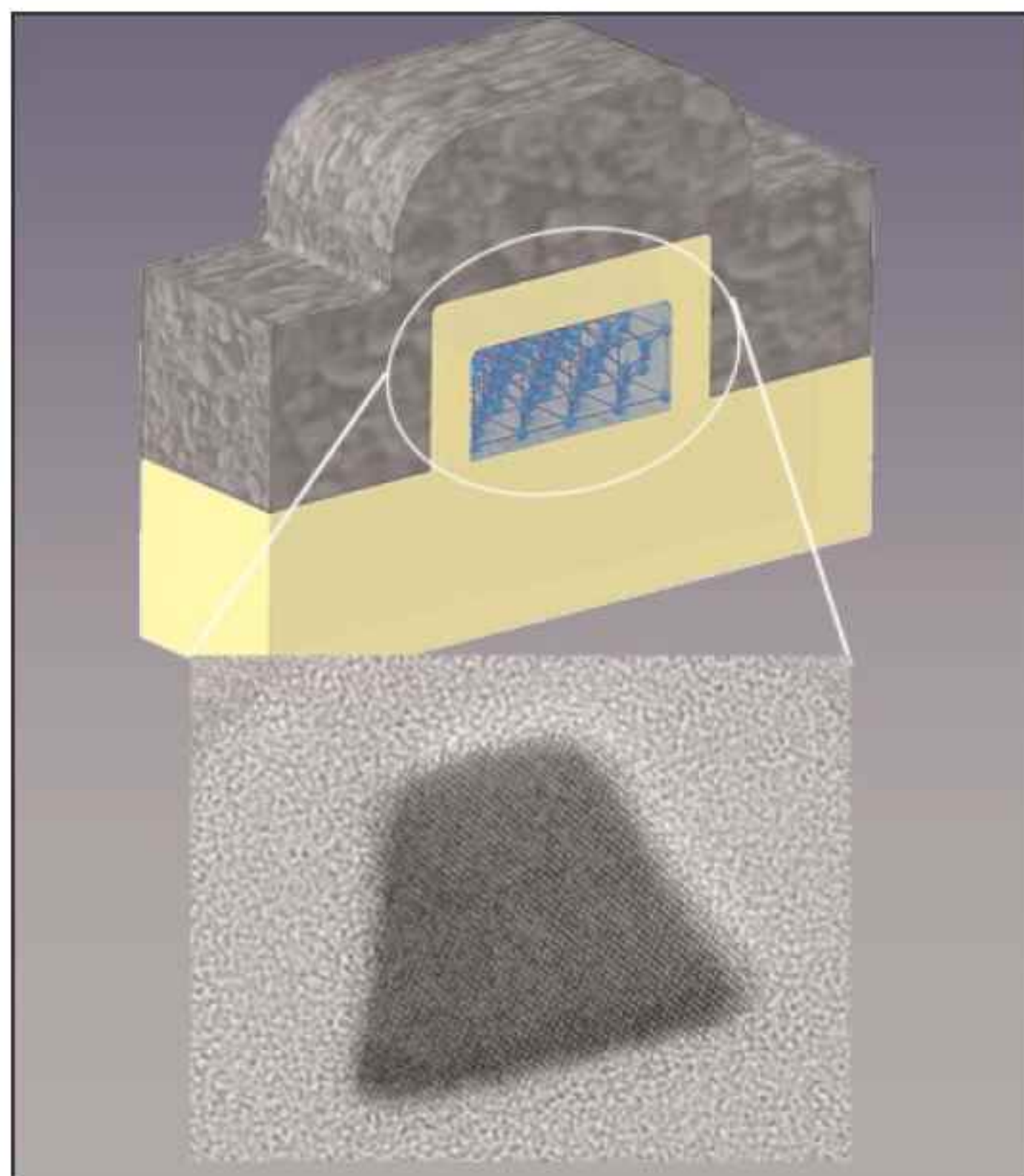
Researchers at Tyndall National Institute in Cork, Ireland led by professor Jean-Pierre Colinge have reported in *Nature Nanotechnology* how they have designed and fabricated what is claimed to be the first junctionless transistor, which could significantly reduce power consumption and simplify the fabrication process for silicon chips, it is reckoned.

Existing transistors are based on junctions formed by adjacent layers of semiconductor material with different dopant-atom-induced polarities. Since controlling the junction allows current in the device to be turned on and off, it is the precise fabrication of this junction that determines the characteristics and quality of the transistor and is a major factor in production costs. However, as the distance between junctions drops below 10nm, extraordinarily high doping concentration gradients become necessary. Because of the laws of diffusion and the statistical nature of the distribution of the doping atoms, such junctions require increasingly complex and costly fabrication processes.

Tyndall's new transistor consists of a silicon nanowire (about 30nm across just 10nm thick), and it has no junctions and no doping concentration gradients, since current flow is controlled by a 'wedding ring' gate structure around the wire. "These structures are easy to fabricate even on a miniature scale, which leads to the major breakthrough in potential cost reduction," claims Colinge.

Another key challenge for the semiconductor industry is reducing the power consumption of complex transistors, with minimizing current leakage one of the main challenges. The new transistors — which can be made to have full CMOS functionality — have near-ideal sub-threshold slope, extremely low leakage currents, and less degradation of mobility with gate voltage and temperature than classical transistors, Tyndall claims. "They have the potential of operating faster and using less energy than the conventional transistors used in today's microprocessors," says Colinge.

The junctionless transistor resembles the first ideal transistor structure, proposed in 1925, but to-date no-one had been able to fabricate it, continues Colinge.



Cross section of silicon wire with wrap-around insulator and overlaid gate.



He attributes Tyndall's junctionless transistor to the ability to fabricate a silicon nanowire with a diameter of just a few dozen atoms using electron-beam writing techniques and commercial silicon-on-insulator (SOI) wafers.

Professor Jean-Pierre Colinge. "We are beginning to talk about these results with some of the world's leading semiconductor companies, and are receiving a lot of interest in further development and possible licensing of the technology," says Tyndall's CEO, professor Roger Whatmore.

The work was funded by Science Foundation Ireland, and is also underpinned by substantial investments in Tyndall by the Department of Enterprise Trade and Employment and the Higher Education Authority.

www.nature.com/nnano/journal/vaop/ncurrent/full/nnano.2010.15.html

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Seeking ultra-low ohmic path to high-frequency nitride transistors

Low contact resistance targets sub-micron HEMTs with recessed gates

A 'very low ohmic contact' of $0.1\Omega\text{-mm}$ has been made to nitride semiconductor high-electron-mobility transistor (HEMT) structures produced at University of California Santa Barbara [Nidhi et al, Jpn. J. Appl. Phys., vol49, p021005, 2010]. The researchers comment:

"Ultralow ohmic contact resistance of $0.1\Omega\text{-mm}$ was achieved, which is among the lowest reported values for alloyed contacts to GaN HEMTs".

Nitride HEMTs are attractive for high-frequency power amplification and power switching applications. Low levels of parasitic components such as contact resistances are particularly vital for high-frequency devices and for reducing power consumption. The UCSB work aims to enable sub-micron high-frequency transistors with recessed gates.

The low-resistance contacts were produced by using the nitrogen-face of the top gallium nitride (GaN) layer in a HEMT device structure (Figure 1). Devices more frequently use the gallium-polar orientation of the GaN crystal structure (0001) since it is easier to grow as high-quality layers. However, attracted by the lower contact resistance of N-polar material (000 $\bar{1}$), advances have recently been made in its growth using MBE and MOCVD.

The UCSB structure was grown using MOCVD on (0001) sapphire (4° miscut toward a-plane) with ammonia, trimethyl-gallium and trimethyl-aluminum sources for N, Ga and Al. Silicon was used for n-type doping and iron for creating a semi-insulating buffer with sources disilane and bis(cyclopentadienyl)-iron, respectively.

The channel consisted of a 15nm layer of GaN on top of aluminum gallium nitride (30% Al), creating a two-dimensional electron gas towards the interface. The ohmic

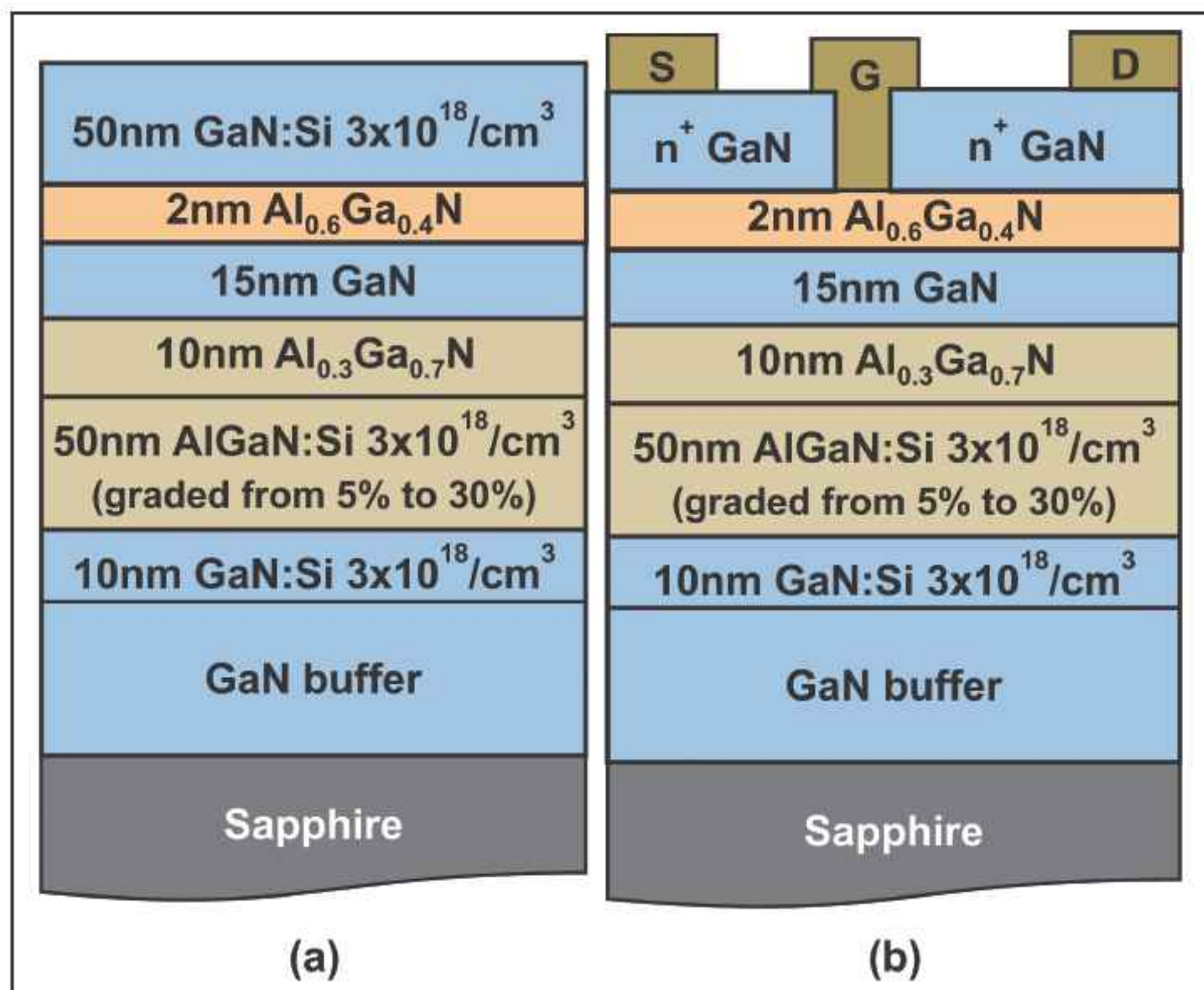


Figure 1. Schematic of UCSB epitaxial layer structure (left) and standard HEMT with recessed gate (right).

contacts were formed by electron-beam evaporation of Ti/Al/Ni/Au. The purpose of the upper AlGaN layer is to serve as an etch stop. Previously, AlGaN has been used as a stop layer for Ga-face GaN etching.

Initial measurements of the UCSB structure, with surface 'ohmic' contacts, demonstrated Schottky-type behavior, "most likely caused by the formation of a polarization-induced Schottky barrier (Φ_B) in the AlGaN due to sign of the polarization".

Ultralow ohmic contact resistance of $0.1\Omega\text{-mm}$ was achieved, which is among the lowest reported values for alloyed contacts to GaN HEMTs

To overcome this problem, the contact regions were etched with boron trichloride/chlorine plasma, removing the top GaN and AlGaN layers. Evaporation was carried out at different angles to increase the side-wall coverage with contact metal (Figure 2). Angled evaporation overcomes mask shadowing effects. The wafer was rotated during evaporation for even coverage. Alloying was carried out at 870°C .

Transfer length measurements (TLM) were made to determine the respective contact resistances, which decreased from $0.5\Omega\text{-mm}$ for 0° evaporation angle down to almost $0.1\Omega\text{-mm}$ at 40° . TLM (also known as transmission line measurement) is used to measure contact resistance by plotting resistance values measured

between pads separated by varying lengths versus the spacing. The vertical intercept gives the contact resistance ($\Omega\text{-mm}$), the slope gives the sheet resistance and the horizontal intercept gives the transfer length.

Since writing the paper, one of the researchers (Nidhi) reports that her group (which is led by professor Umesh K Mishra) has used these 'funnel contacts' in transistors with a deep-recess gate structure, and that the data has been submitted to the International Symposium on Compound Semiconductors (ISCS, Japan, 31 May–4 June 2010). Work on funnel contacts has also been carried out with silicon carbide substrates, where similar results were found.

<http://jjap.ipap.jp/link?JJAP/49/021005>

<http://my.ece.ucsb.edu/mishra/research.htm>

Author: Mike Cooke

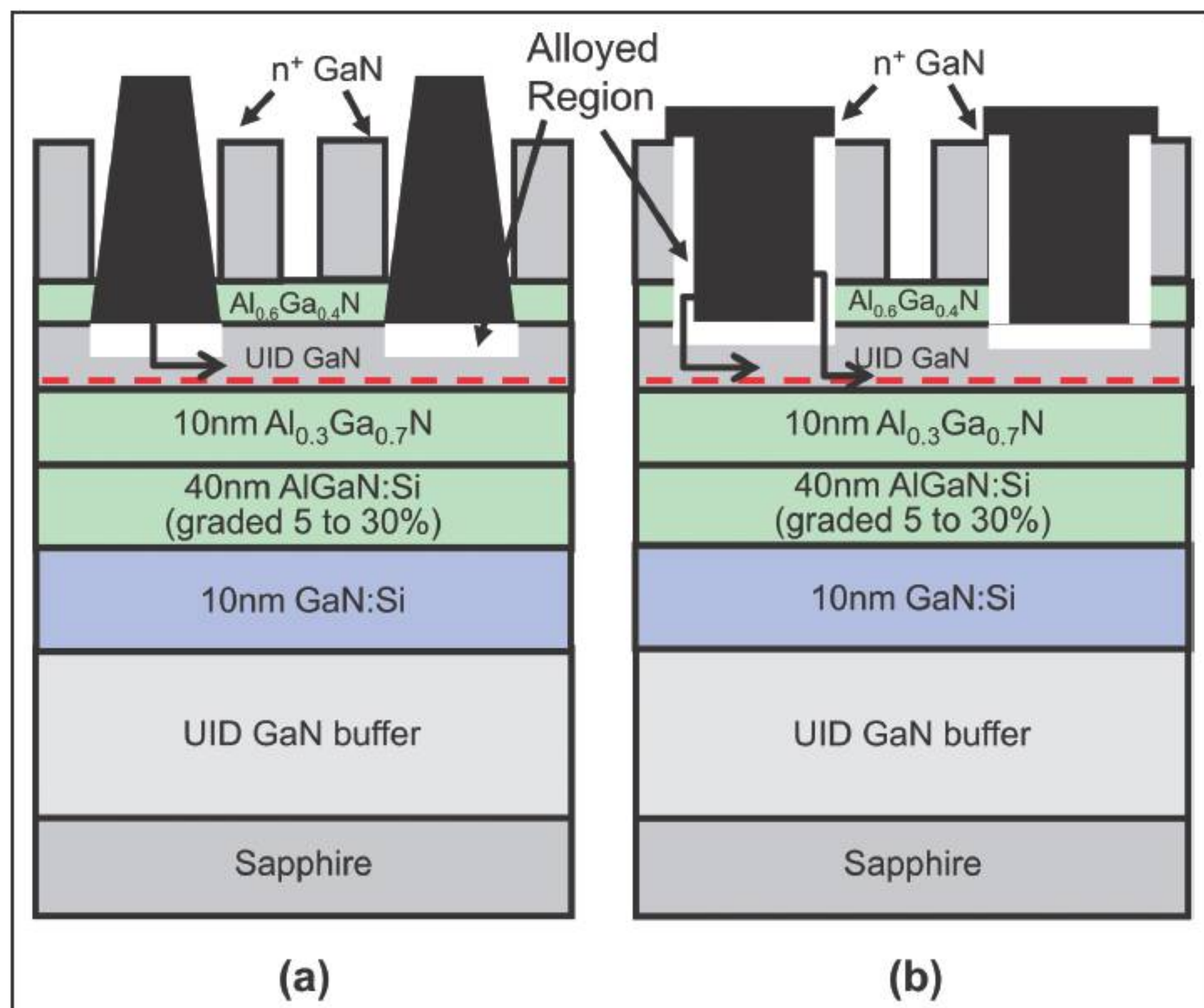


Figure 2. Angled evaporation of contact metals improves sidewall alloy contact and creates a wider current path to channel (left 0° , right 40°).

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Polarization technology for HEMTs and LEDs

University of Notre Dame researchers have been developing techniques to use the spontaneous and strain-dependent polarization electric fields in nitride semiconductor to positive effect in transistors and light-emitting diodes. **Mike Cooke** reports on two pieces of work in this direction.

Polarization in nitride semiconductor devices is often seen as a problem, particularly where light emission is required (lasers, light-emitting diodes). By contrast, University of Notre Dame researchers see opportunities to create highly insulating layers [Yu Cao et al, Appl. Phys. Lett., vol96, p042102, 2010] and p-type doping [John Simon et al, Science, vol327, p60, 2010] for use in high-electron-mobility transistors (HEMTs) and deep-ultraviolet (DUV) devices.

Nitride semiconductor HEMTs are being widely developed for high-speed and high-power applications. The Notre Dame work on insulating layers has focused on blocking leakage through the buffer layer of the HEMT that arises through shallow dopant impurities such as silicon (Si) or oxygen (O) at the interface with the sub-

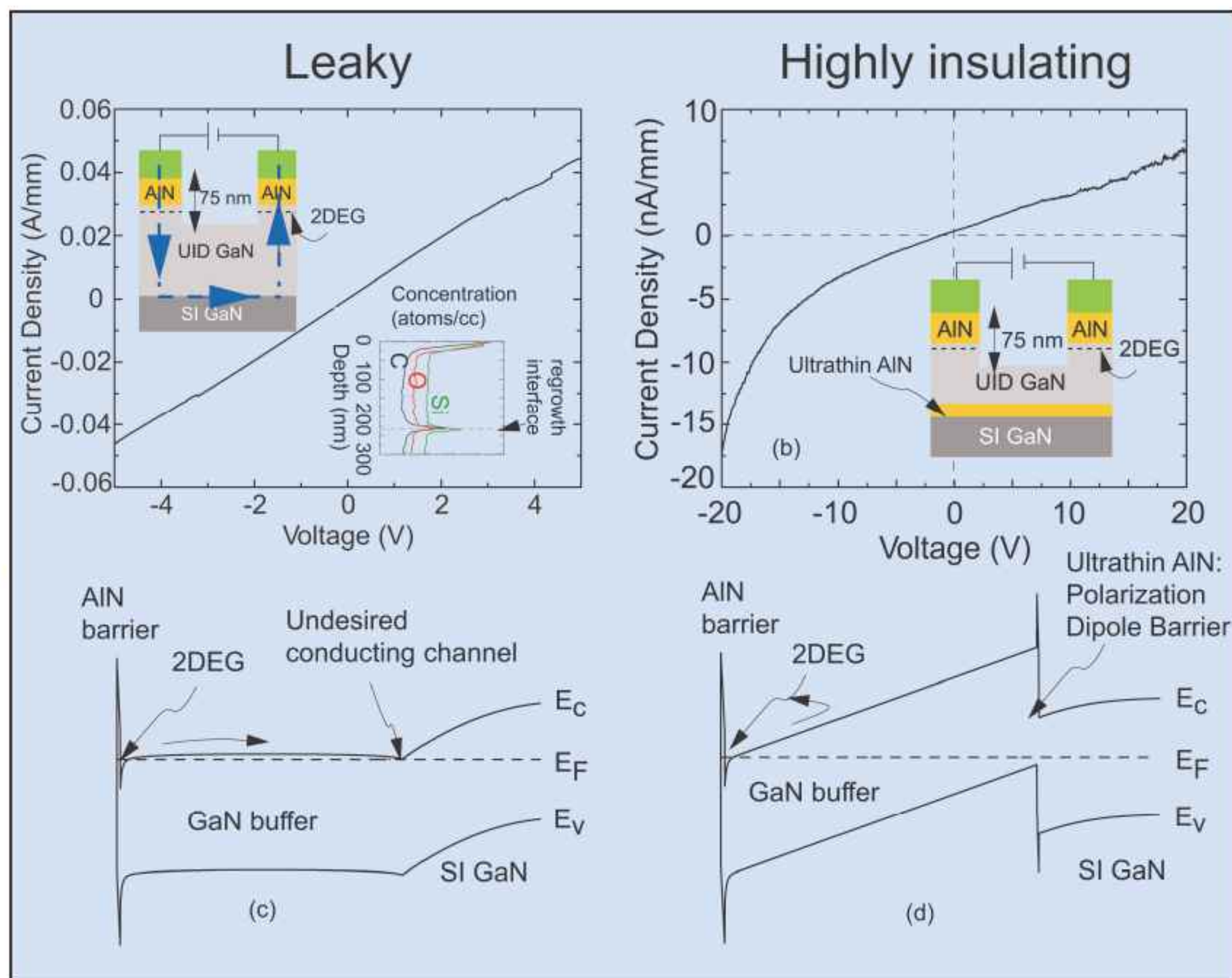


Figure 1. Leakage current density in the buffer vs applied voltage for control sample (a, inset shows SIMS atomic concentrations against depth with strong impurity peaks of silicon, oxygen and carbon at re-growth interface). Using ultra-thin AIN nucleation layer (b) gives much lower buffer leakage. Energy-band diagrams of the two structures from AIN top barrier (left end of diagrams) down to SI GaN template (right end). Adding AIN nucleation layer at right end (d) removes unwanted conduction path in (c).

strate, which can be made of silicon carbide (SiC) or semi-insulating gallium nitride (SI GaN). The presence of this conducting region under the buffer impacts both on/off ratios for digital applications and device speed where high performance is needed.

Notre Dame produced two HEMTs — one designed to show the problem of buffer leakage and the other a solution that uses giant polarization fields in nitride semiconductors to create a highly insulating layer (Figure 1). The devices were grown using radio-frequency (RF) plasma-source molecular beam epitaxy (MBE) on commercial Ga-face GaN templates (2 μ m iron-doped SI GaN layer on sapphire substrate).

For the leaky device (Figure 1, left), two monolayers of gallium were deposited on the Ga-face to create a metal-rich nucleation layer under the $\sim 234\text{nm}$ of unintentionally doped GaN, followed by a 3nm aluminum nitride (AlN) cap. A two-dimensional electron gas (2DEG) forms through polarization effects at the GaN/AlN interface.

For the measurement of buffer leakage, the region of the 2DEG between the electrodes is cut with a reactive ion etch (RIE) so that current must flow through the unintentional paths such as the buffer/template interface. The leaky device has a current flow of $40\text{mA}/\text{mm}$ at $\pm 5\text{V}$. This flow is a factor of 25 smaller than that typical in an on-state GaN HEMT and hence would significantly limit on/off ratios. Secondary-ion mass spectrometry (SIMS) reveals large peaks for carbon, silicon and oxygen — the latter two elements are known to be n-type dopants in GaN.

An insulating device is created by growing an ultra-thin AlN nucleation layer (NL) before the GaN buffer (Figure 1, right). This cuts the leakage to less than $20\text{nA}/\text{mm}$ at 20V . At 4V , the leakage is reduced by seven orders of magnitude (a factor of 10^7) compared with the leaky set-up.

It was found in further experiments that nitrogen-rich growth conditions of the AlN were critical to insulating

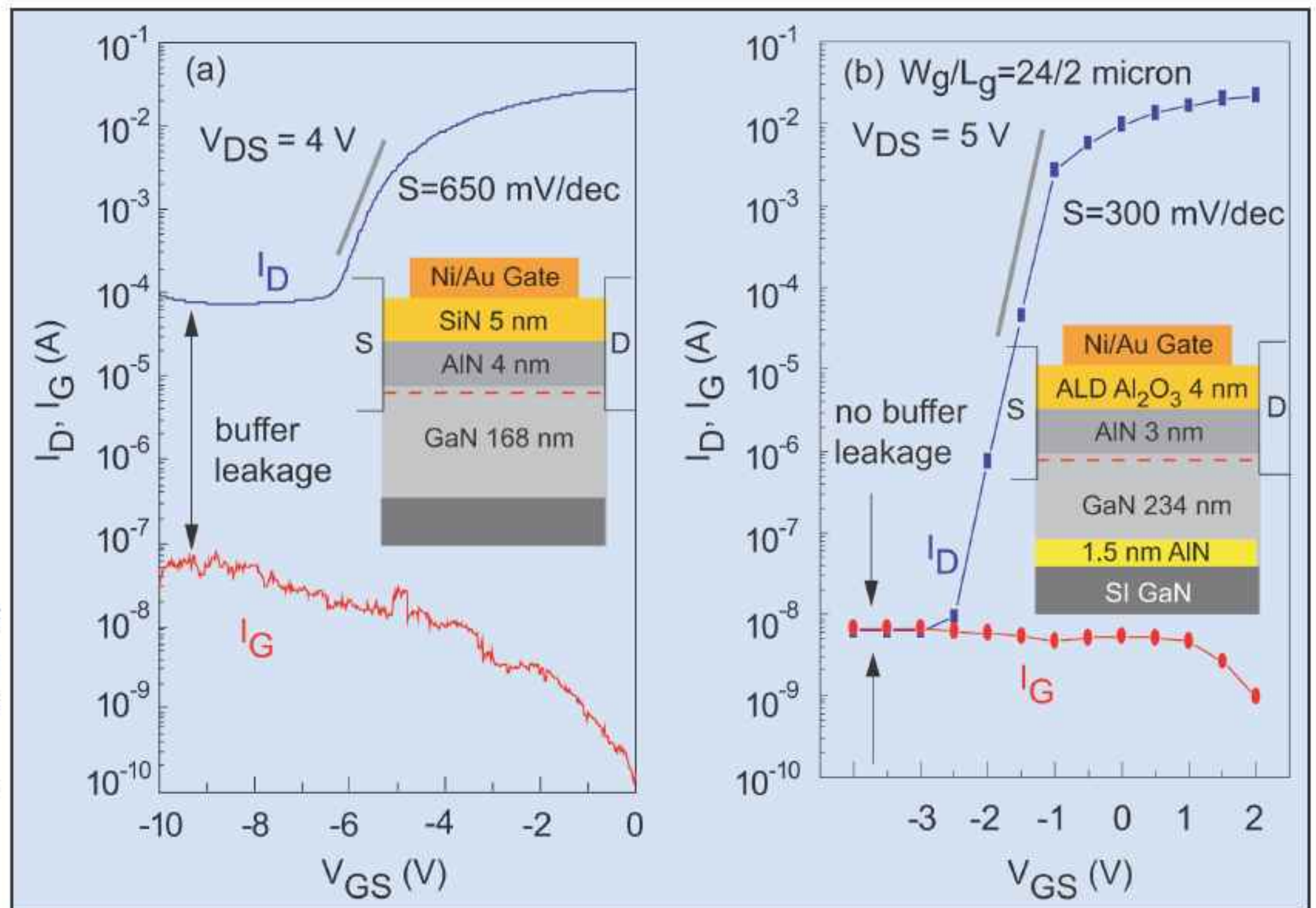


Figure 2. Transfer characteristics of leaky control sample (a) with severe buffer leakage; and of sample with AlN nucleation layer (b), cutting buffer leakage so that it is lower than the gate leakage.

The Notre Dame work on insulating layers has focused on blocking leakage through the buffer layer of the HEMT that arises through shallow dopant impurities such as silicon or oxygen at the interface with the substrate, which can be made of silicon carbide or semi-insulating gallium nitride. This conducting region under the buffer impacts both on/off ratios for digital applications and device speed where high performance is needed

properties. A metal-rich AlN layer leads to leakage, possibly due to diffusion of oxygen and silicon dopant atoms from the re-growth interface into the buffer layer.

Actual HEMTs were built with and without the AlN NL (Figure 2). The on/off ratio improves from about 100 for the leaky device to 10^6 for the device with the AlN NL. The researchers point out that this is a desirable feature for both analog (RF) and digital (power-switching) applications, adding: "In addition, the natural back-barrier introduced due to the band offsets and polarization dipole — as shown in the energy band diagram in Figure 1(d) — can potentially enable reduced short-channel effects for shorter-gate-length HEMTs". The sub-threshold slope is also steeper with the AlN NL: 300mV/dec rather than 650mV/dec .

Among the advantages that Notre Dame sees for its approach are the absence of a dopant, and savings on source materials and in growth time.

Another application of polarization effects being worked on at Notre Dame could be improved p-type doping for nitride semiconductors [John Simon et al, Science, vol327, p60, January 2010]. Although magnesium is commonly used to create such hole conduction in nitride semiconductors, it is generally not as good as the n-type doping achieved with silicon. One particular problem is that the holes have a large activation energy from Mg acceptor levels ($\sim 200\text{meV}$ in GaN), meaning that these impurities are inefficient dopants at room temperature ($300\text{K} \sim 26\text{meV}$). Worse, as the bandgap

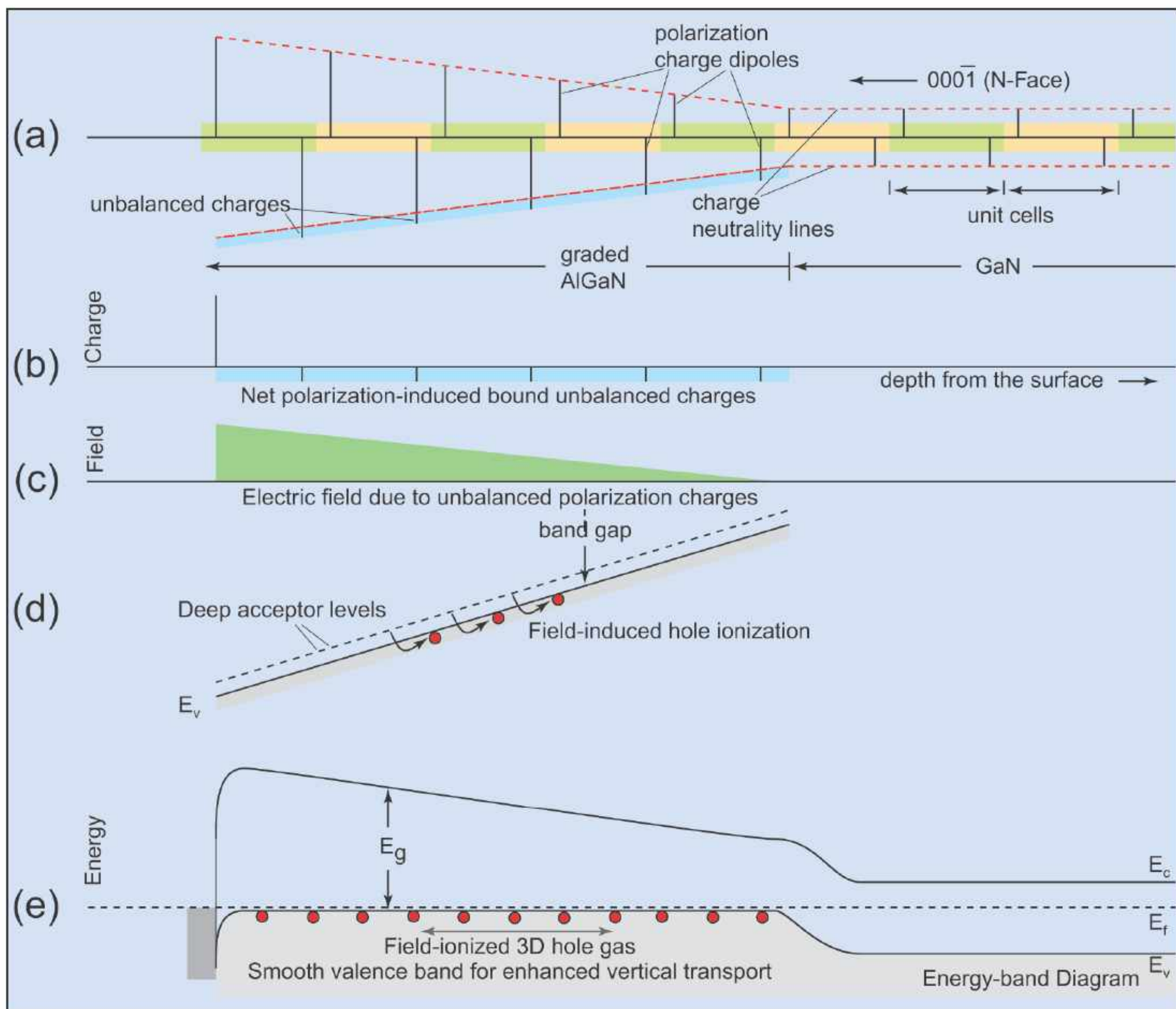


Figure 3. Polarization-induced p-type doping in graded polar heterostructures. Sheets of charge dipoles arise in every unit cell of the crystal (a). Net unbalanced polarization charge (b) leads to the electric field (c). Energy-band bending thus occurs in valence band if holes are not ionized (d). Field ionization of holes results in steady-state energy band (e), with smooth valence band edge without any potential barriers for hole flow (E_f , Fermi level; E_c and E_v , conduction and valence band edges, respectively; E_g , bandgap).

energy is increased (usually by adding aluminum), the Mg activation energy also increases ($\sim 630\text{meV}$ in AlN). The corresponding activation energy values for Si n-doping are 15meV (GaN) and 282meV (AlN).

The Notre Dame work aims at encouraging dopant ionization using the built-in electric polarization fields. The technique has been applied to improving the optical emission from prototype ultraviolet LEDs. The researchers also see application opportunities for bipolar electronic devices.

To avoid the high p-type resistivity (and hence Joule heating) that occurs at higher Al-doping levels, one is usually restricted to $\text{Al}_x\text{Ga}_{1-x}\text{N}$ compositions with Al fractions less than 20%. It is not uncommon to use pure

GaN (0% Al) to avoid these effects in p-type layers. However, this comes at a cost for the emission efficiency of UV, since pure GaN becomes highly absorbing of radiation with photon energies greater than $\sim 3.4\text{eV}$ (wavelengths shorter than $\sim 365\text{nm}$). Also, the use of p-GaN on AlGaIn suffers from reflection from band-structure discontinuities that tends to block holes from entering the active region for UV electron-hole recombination.

Polarization effects are widely used to create two-dimensional (2D) electron gases (and even hole gases) with high sheet densities — these are the basis of high-electron-mobility transistors. These 2D gases have high conductivity in the plane transverse to the epitaxial growth. However, vertical devices such as LEDs need

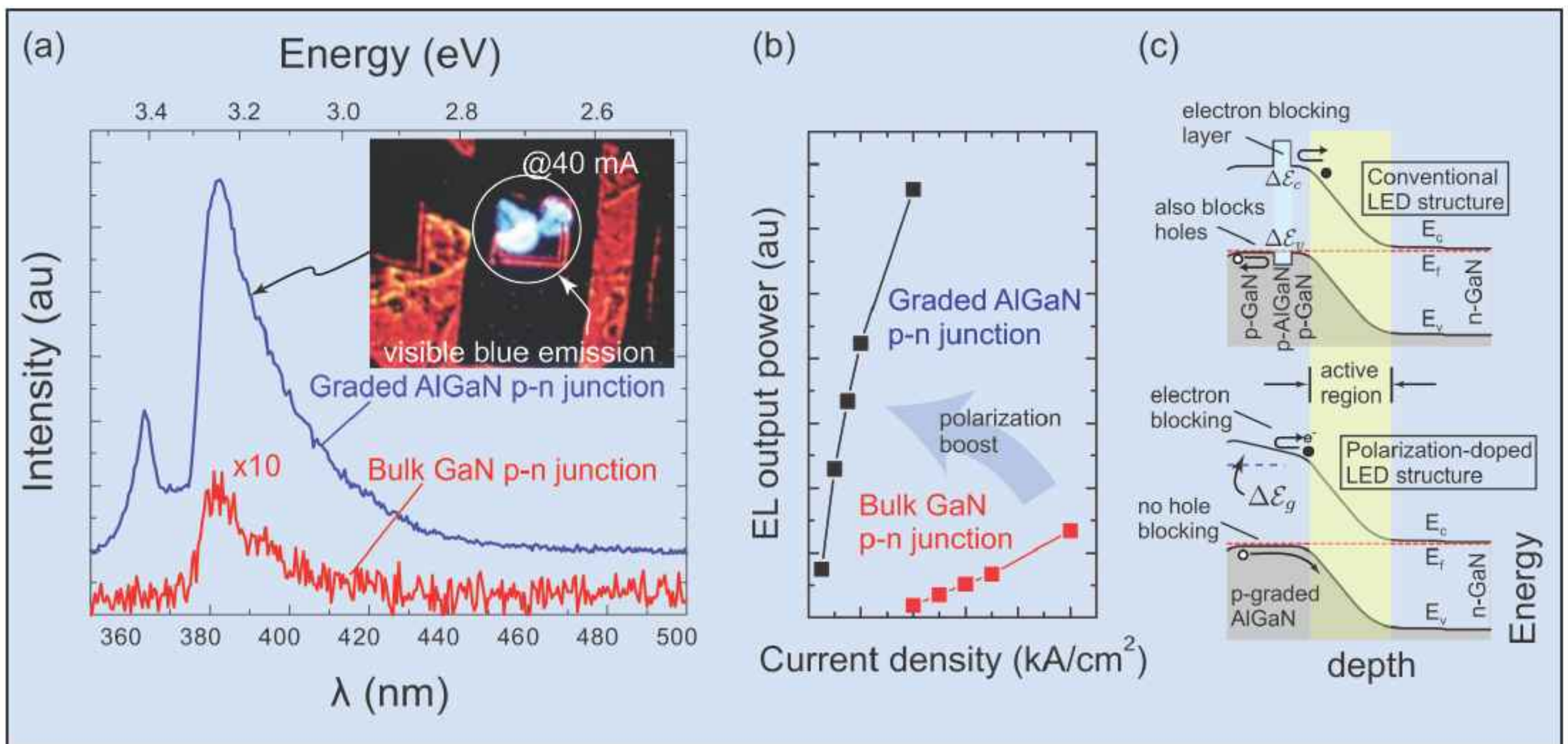


Figure 4. Room-temperature electroluminescence (in arbitrary units) of graded p-type AlGaIn junction and control GaN p-n junction at 40mA drive current (a, inset shows optical microscope micrograph displaying blue part of emission of graded AlGaIn junction). Both samples have an area of 80x150mm. Relative output intensity with increasing drive current for graded AlGaIn p-n junction and control bulk-doped p-n junction (b). Also shown: energy-band diagrams of conventional LED (c) and polarization-doped device (d).

high conductivity in the growth direction. To create 3D electron gases using polarization effects, Notre Dame has in the past used materials with varying composition (grading). In principle, reversing the growth polarity (N [000 $\bar{1}$] instead of the usual Ga [0001]) and the composition grading (GaN to AlGaIn rather than AlGaIn

The researchers also see prospects for using the polarization doping methodology with the more general AlInGaIn system, which would allow more variety for growth direction choice and strain management

to GaN) should result in similarly produced 3D hole gases. One difference however is that, while 3D electrons are easily sourced from the III-nitride surface levels, deep-level traps localize surface holes. These would need to be removed to achieve dopant-free hole conductivity.

To overcome this problem, Notre Dame uses an intentional Mg-acceptor doping of the N-face graded AlGaIn layer as a hole source for the 3D hole gas (Figure 3). The holes are required to balance the unbalanced polarization charge in the graded AlGaIn layer. One sign of the successful creation of such a hole gas is a weaker temperature dependence of its properties compared with thermally activated Mg-doped p-type ungraded layers.

Notre Dame has carried out growth of such layers and compared their performance with traditional p-type

nitride layers using secondary-ion mass spectrometry and Hall measurements. Further characterization involved x-ray diffraction, in-situ reflection, high-energy electron diffraction patterns and atomic force microscopy.

In addition, LED structures were produced and sub-bandgap emission (Figure 4) was observed (i.e. <3.4eV, >365nm). These emissions are attributed to transitions from deep acceptor levels. One added advantage of the graded structure is that it acts as a natural electron-blocking layer (EBL) (Science Figures 4C and D). In normal LEDs, EBLs are used to avoid over-spill of electrons from the active layer into the p-type layers. Recombination of electrons in p-type GaN is usually non-radiative, reducing the optical output. The graded solution also avoids raising barriers to hole injection into the active layers. These properties may also be useful in future UV laser diode development.

The researchers also see prospects for using the polarization doping methodology with the more general aluminum indium gallium nitride (AlInGaIn) system, which would allow more variety for growth direction choice and strain management. Other semiconductor systems with strong spontaneous and piezoelectric polarization may also benefit from these techniques. This is a particularly interesting possibility for zinc oxide, where any practical p-type doping scheme has proved elusive. ■

Mike Cooke is a freelance technology journalist who has worked in the semiconductor & advanced technology sectors since 1997.

Going deep for UV sterilization LEDs

Researchers and leading nitride semiconductor device firms are looking to shorten the wavelength of commercial light-emitting diodes to ~250nm. Mike Cooke reports on progress and possible applications.

Ultraviolet (UV) light has a wide range of actual and potential applications (Figure 1). Although LEDs and laser diodes have been commercially developed in the near-UV region (less than 400nm), as the wavelength shortens construction of such devices become much more challenging.

Current drivers of 'deep UV' LED development (DUV, loosely shorter than 350nm wavelength, more strictly less than 300nm) is for water treatment and sterilization of medical equipment. UV sterilization/purification systems need to produce photons with wavelengths shorter than about ~260nm, giving them the energy needed to break chemical bonds between corresponding base pairs within deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) polymers of micro-organisms such as bacteria and viruses. Rather than forming the usual hydrogen-bonded thymine-adenine (T-A) base pairs in the DNA double-helix, neighboring thymine pairs on a single chain form covalent bonds, disrupting the genetic code (Figure 2). UV sterilization can therefore be effective against bacteria that are resistant to normal thermal treatments.

The traditional competitor for such applications is radiation from the 254nm emission line of mercury lamps. Particular attractions of LEDs are their compactness and more environment-friendly character when compared with breakable, highly toxic mercury lamps. Further advantages of LEDs when fully developed

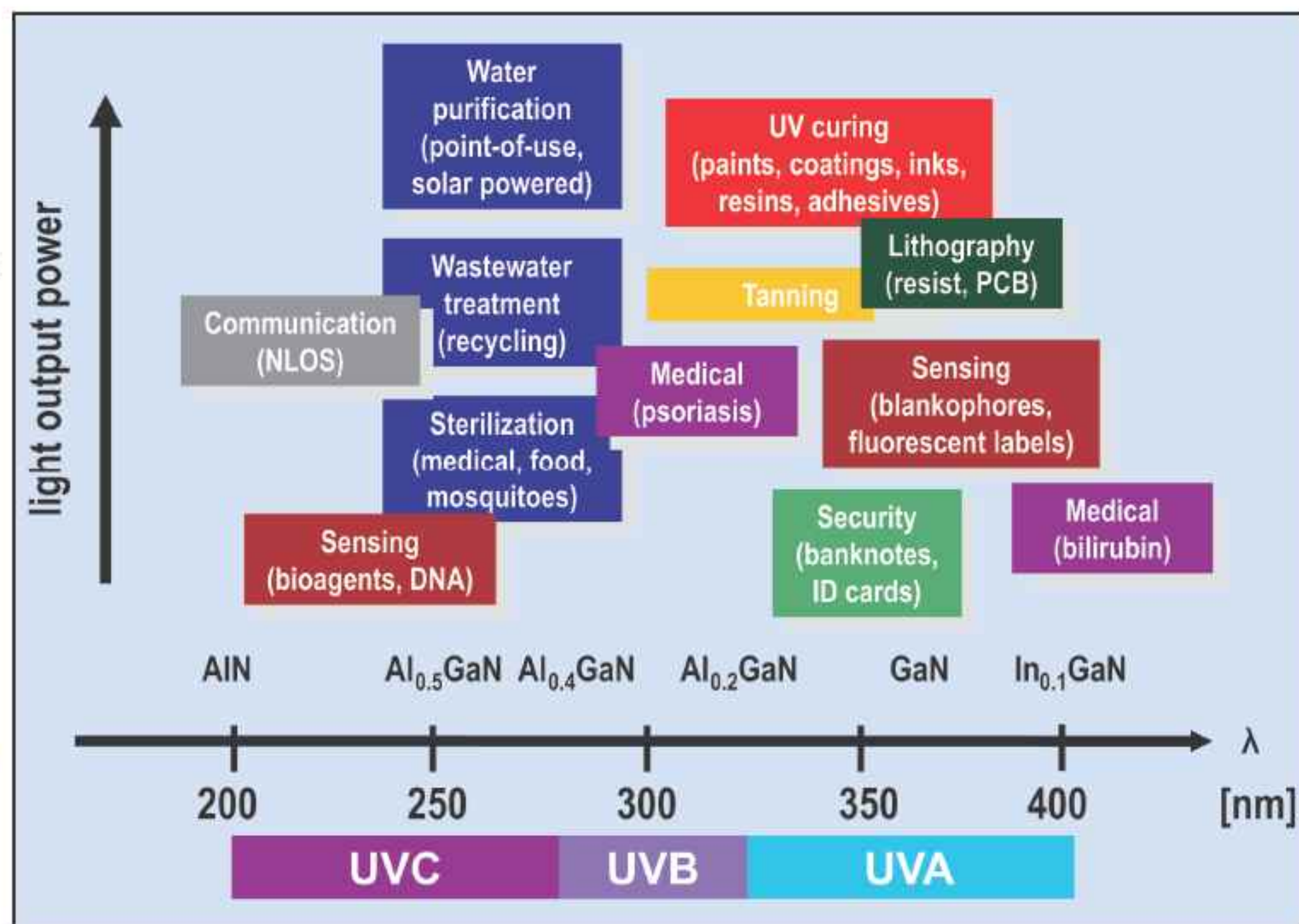


Figure 1. Potential applications for UV LEDs. Image from [1].

should include lower energy consumption, better robustness and longer operation time before failure.

The US and Japan governments have funded a wide range of research towards shorter-wavelength UV LEDs under such bodies as Japan's National Institute of

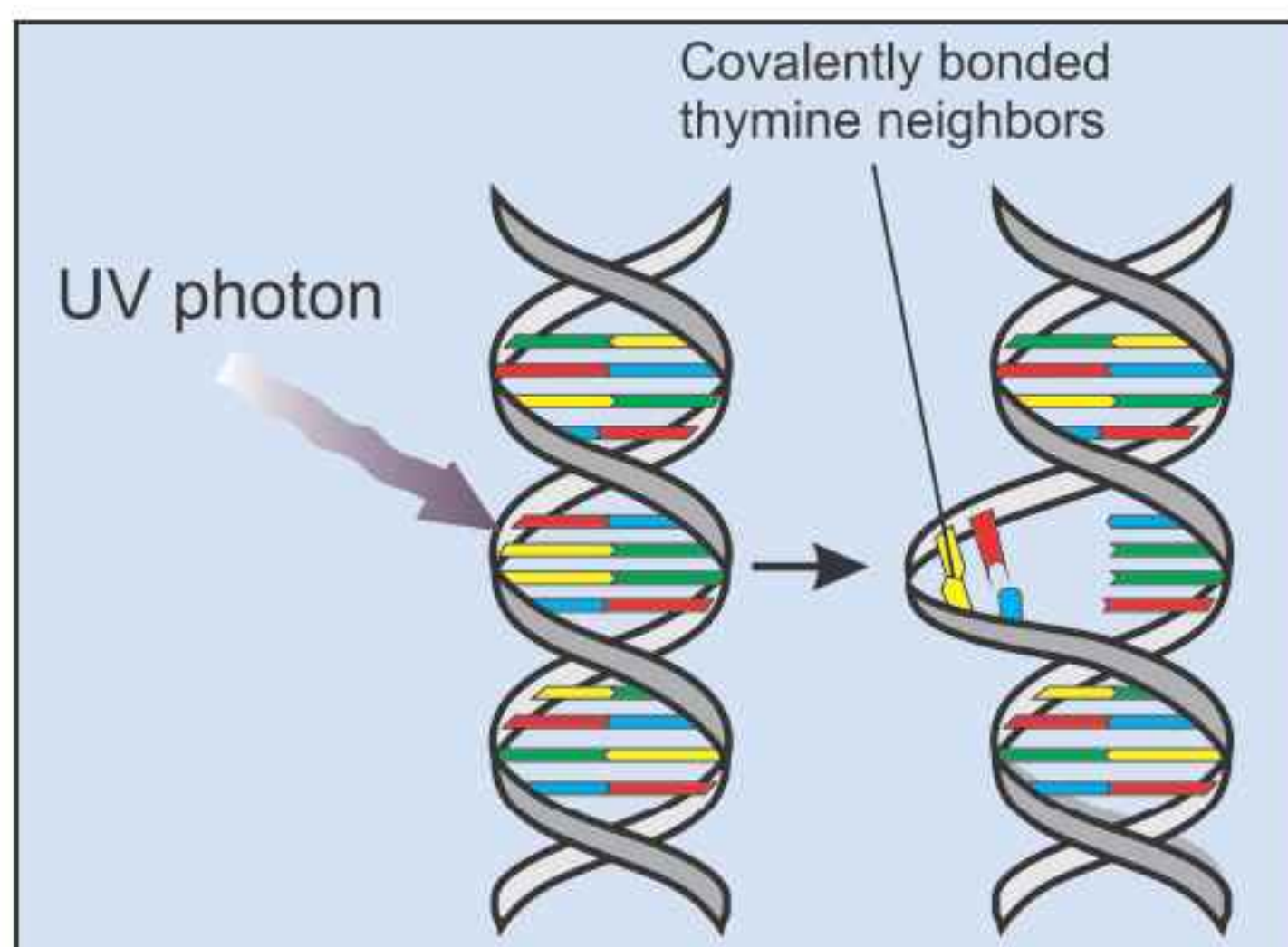


Figure 2. Effect of UV radiation in disrupting thymine-adenine (TA) bonds and creating covalently bonded thymine neighbors. Based on NASA source.

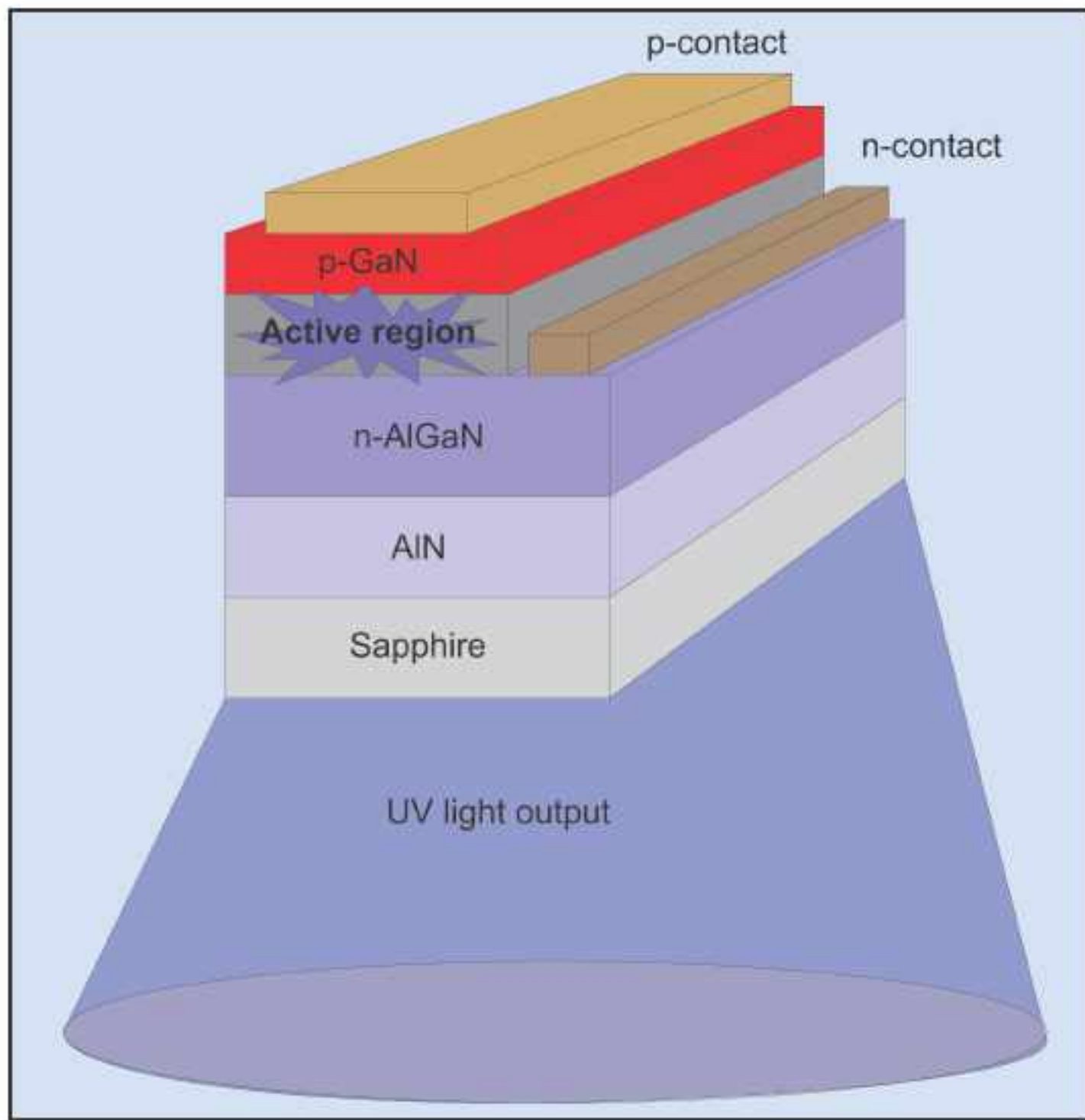


Figure 3. Simple nitride semiconductor UV LED.

Advanced Industrial Science and Technology (AIST) and the US Defense Advanced Research Projects Agency (DARPA). The latter organization set up a Semiconductor Ultraviolet Optical Sources (SUVOS) program in 2002. This year DARPA launched a new effort aimed at Compact Mid-Ultraviolet Technology (DARPA-BAA-10-45@darpa.mil) looking for efficient 'mid-ultraviolet' (200–300nm) emitters. The project is to develop heteroepitaxy, waveguides, cavities and contacts to enable efficient LEDs and chip-scale semiconductor lasers operating at wavelengths below 275nm. It is hoped the resulting devices will achieve small, low-weight, high-output power/efficiency for chemical/biological-agent detectors and portable water purification illuminators.

Structure

Most UV diodes are based on aluminum gallium nitride (AlGaN) alloys in a p-n format (Figure 3). The nitrides are deposited on sapphire substrates that are relatively transparent to UV radiation (down to ~250nm wavelengths, see Figure 4). Silicon is generally used as n-type dopant; magnesium is the p-type acceptor impurity.

The active, UV-emitting region is usually not intentionally doped and may consist of single or multiple wells of narrower bandgap material separated by barriers. Since sapphire is non-conducting, the electrical contacts are made from the "top" of the device, with the p-contact made by depositing

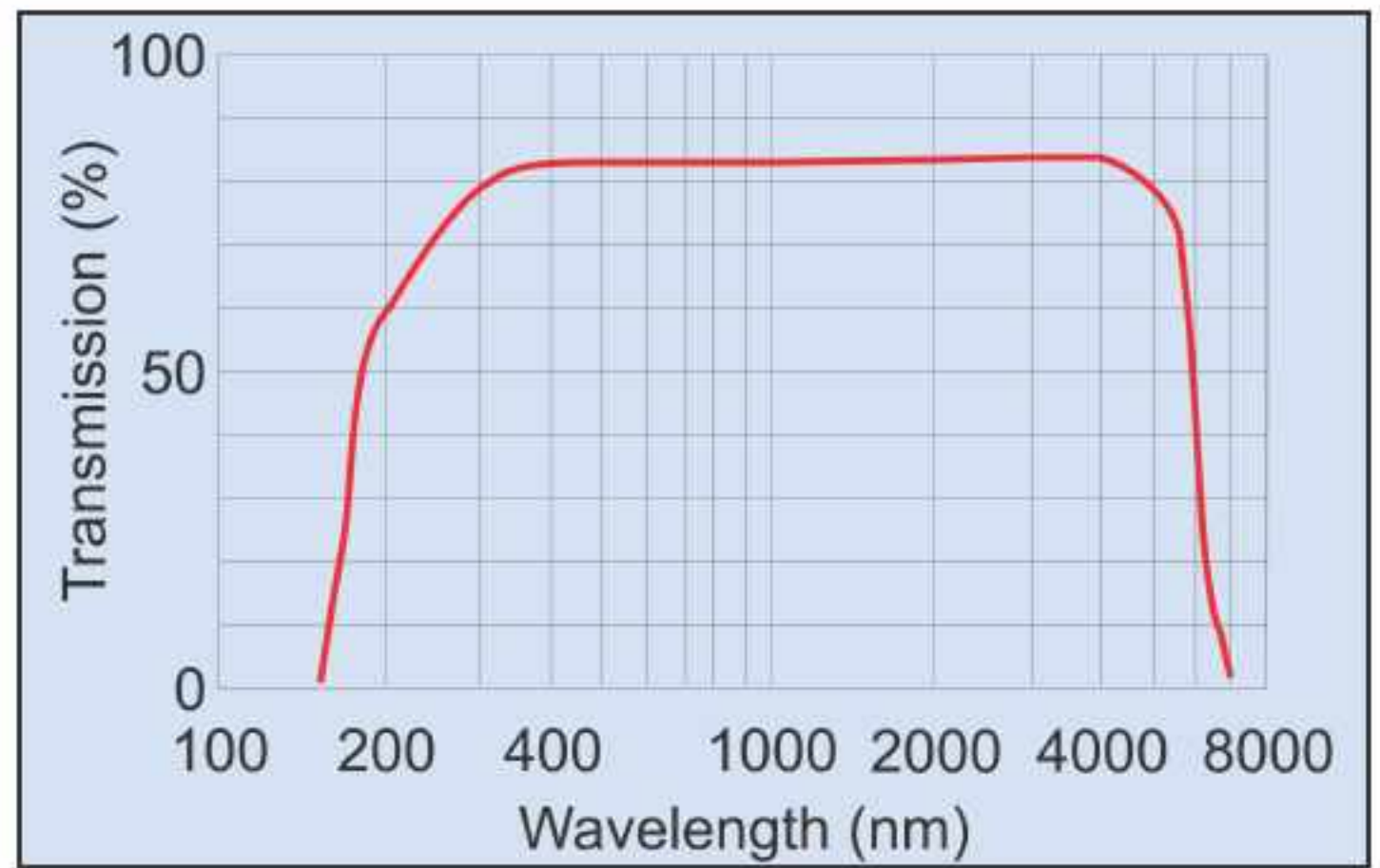


Figure 4. Typical transmission curve for sapphire.

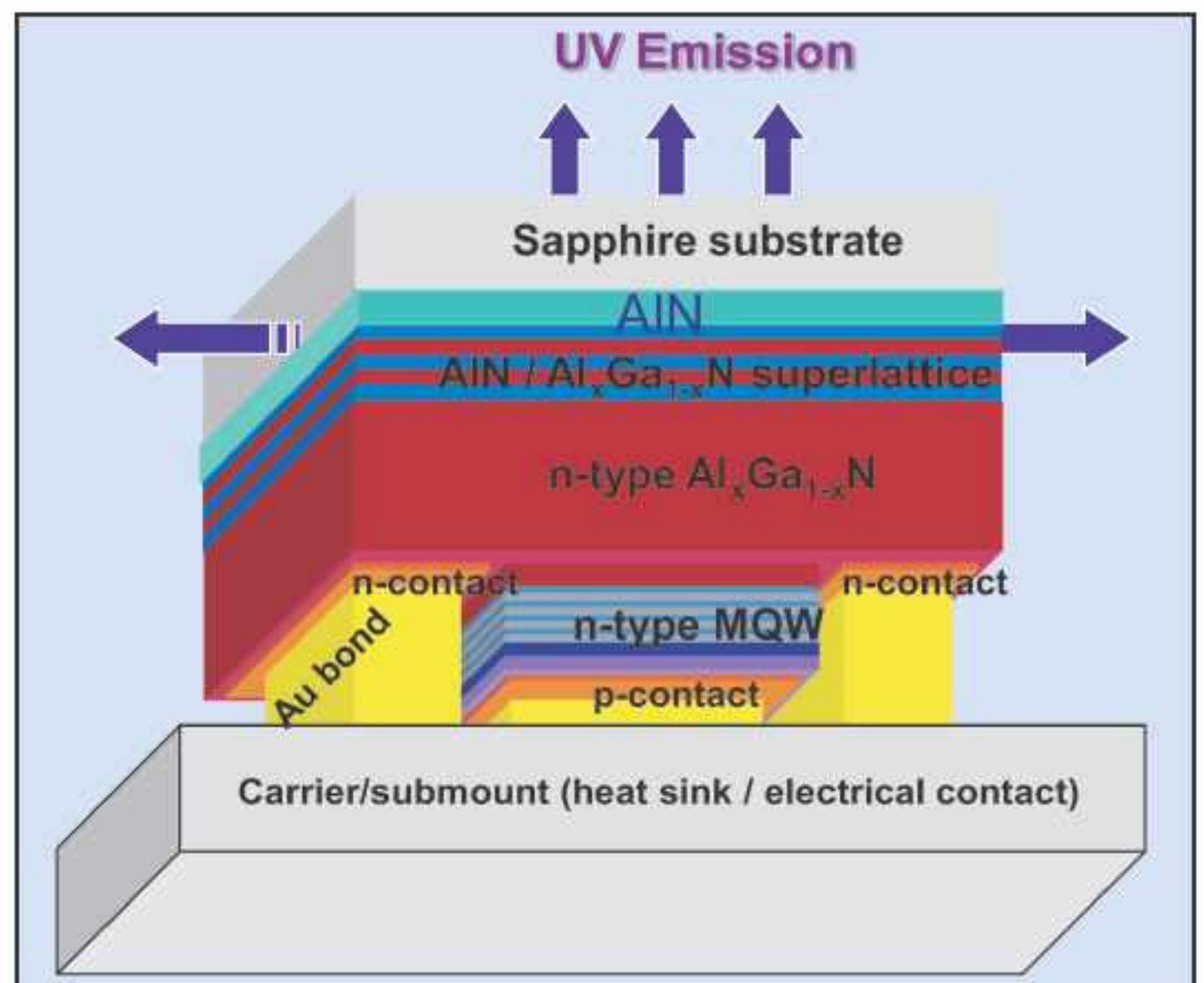


Figure 5. Schematic of flipped UV LED. Image from [2].

suitable material to the p-type layers. The n-contact requires etching through the p-contact and active layers before depositing contact metal alloy. The resulting UV die is flipped onto a submount and packaged with the UV-transparent sapphire substrate uppermost to allow emission from the device (Figure 5).

Table 1. Recent achievements for DUV LEDs. (* @150mA).

[Reference]	Wavelength nm	Output mW	Current mA	Voltage V	EQE %
Saitama [3]	240	1.2	240		0.13
SET [4]	245				0.18*
SET [2]	247	6	300		
SET [4]	247	2	225		0.15*
Saitama [5]	250	4.8	135		1.18
Saitama [6]	258	0.2	10		0.3
Saitama [5]	262	10.4	165		1.54
SET [3]	273	30	700	6.5	
Nichia [7]	281	2.45	20	7.53	2.78
USC [8]	307	20	20		
Dowa [9]	320–350	1.4	20		

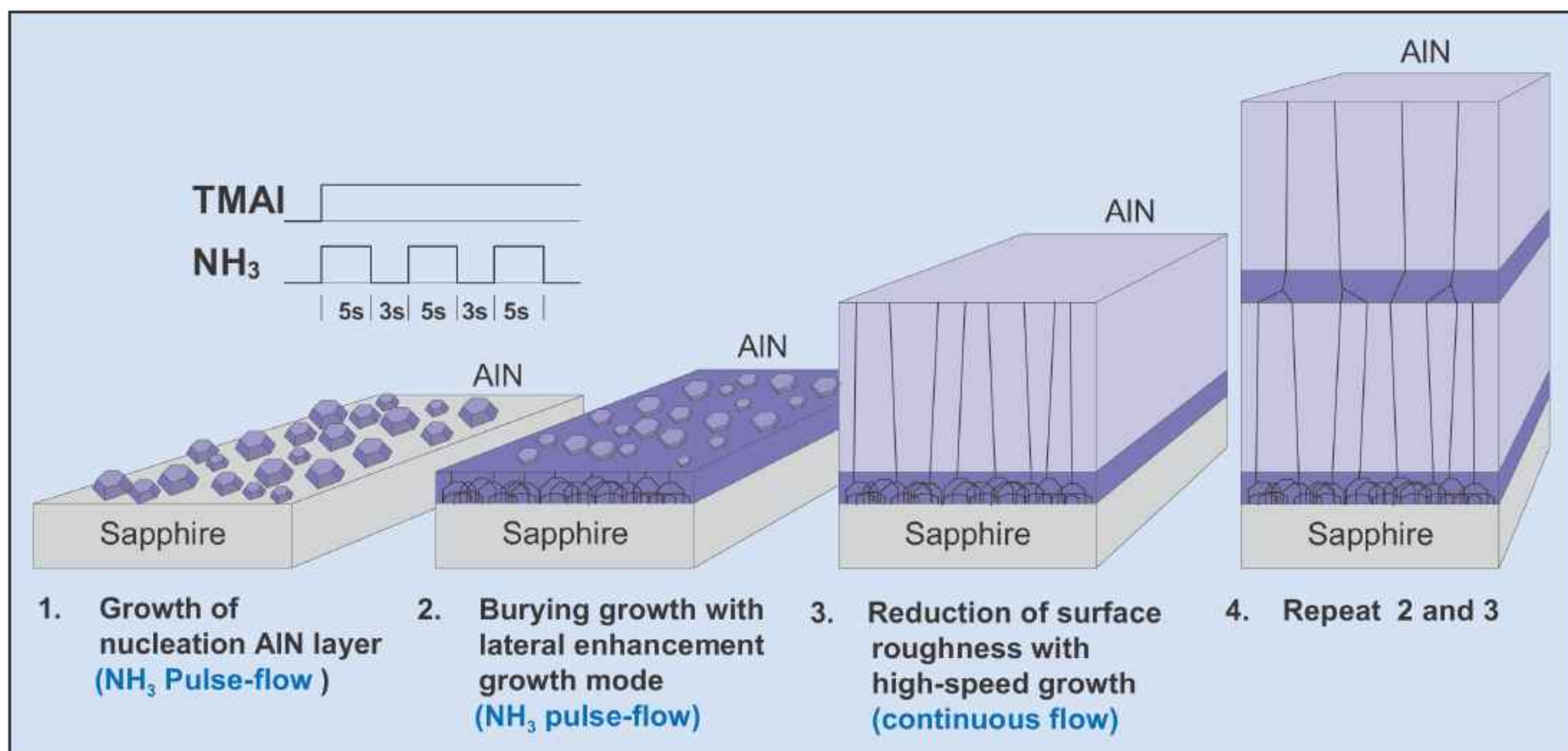


Figure 6. Gas flow sequence and schematic of the growth control used for NH_3 pulse-flow multilayer (ML)-AlN growth technique that aims to reduce threading dislocations and result in crack-free substrates.

To make practical UV LEDs, many features have to be added to these simple concepts to improve the crystal and electrical structure of the materials. These include buffer layers to bridge the lattice mismatch between the sapphire substrate and the AlGaIn material system and electron-blocking layers (EBLs) to maximize the recombination in the active region rather than in the p-contact where non-radiative and unwanted longer-wavelength recombination occurs. Other features such as thermal management, increasing light extraction and improving the performance of the p-contact for hole injection are also vital to improving performance.

Researchers are working hard (Table 1) to bring the relatively low external quantum efficiencies (EQEs) of DUV LEDs (usually less than 2%) nearer to the achievements of visible LEDs (up to 70%).

Substrates/templates

The base 'template' for nitride-based UV LEDs is usually an AlN layer deposited on sapphire wafers. Although aluminum nitride (AlN) crystal substrates

are also possible contenders for UV application, such substrates have yet to be successfully developed.

As is often the case with nitride semiconductors, dislocations from the template that thread through subsequent epitaxial structures are often blamed for the low EQEs. A number of techniques have been developed to reduce the density of these threading dislocations.

Some of these techniques can be quite elaborate, such as epitaxial layer overgrowth (ELOG), where masks are used to restrict the seeding areas for crystal growth. By restricting the number of crystal orientations in the overgrown material, one can significantly reduce the threading dislocations to where the different orientations meet.

From a commercial perspective, simpler is better. Hence, many researchers are seeking improvements in crystal quality that can be directly implemented in the growth chamber, rather than having to use mask and etch.

Sensor Electronic Technology (SET) has patented a proprietary migration-enhanced metal-organic chemical vapor deposition (MEMOCVD) that, combined with conventional MOCVD, it uses to produce its nitride devices. The MEMOCVD technique is based on controlling the duration and waveform of the precursor pulses. The pulses of different precursors may even overlap. This allows the growth temperature to be reduced, giving improved atomic incorporation, surface coverage and thickness uniformity. MEMOCVD has been shown to improve AlGaIn material quality up to 0.75 Al molar fraction.

Researchers based in the city of Saitama in Japan have used low-pressure metal-organic

Table 2. Structure of wells and barriers (x is Al molar fraction) and maximum output power under cw operation for recent LEDs produced in Saitama [3].

Wavelength nm	AlGaIn well x	AlGaIn barrier x	Max. power mW
234	0.74	0.84	0.4
240	0.68	0.8	1.2
254	0.61	0.76	4
264	0.53	0.7	11.6

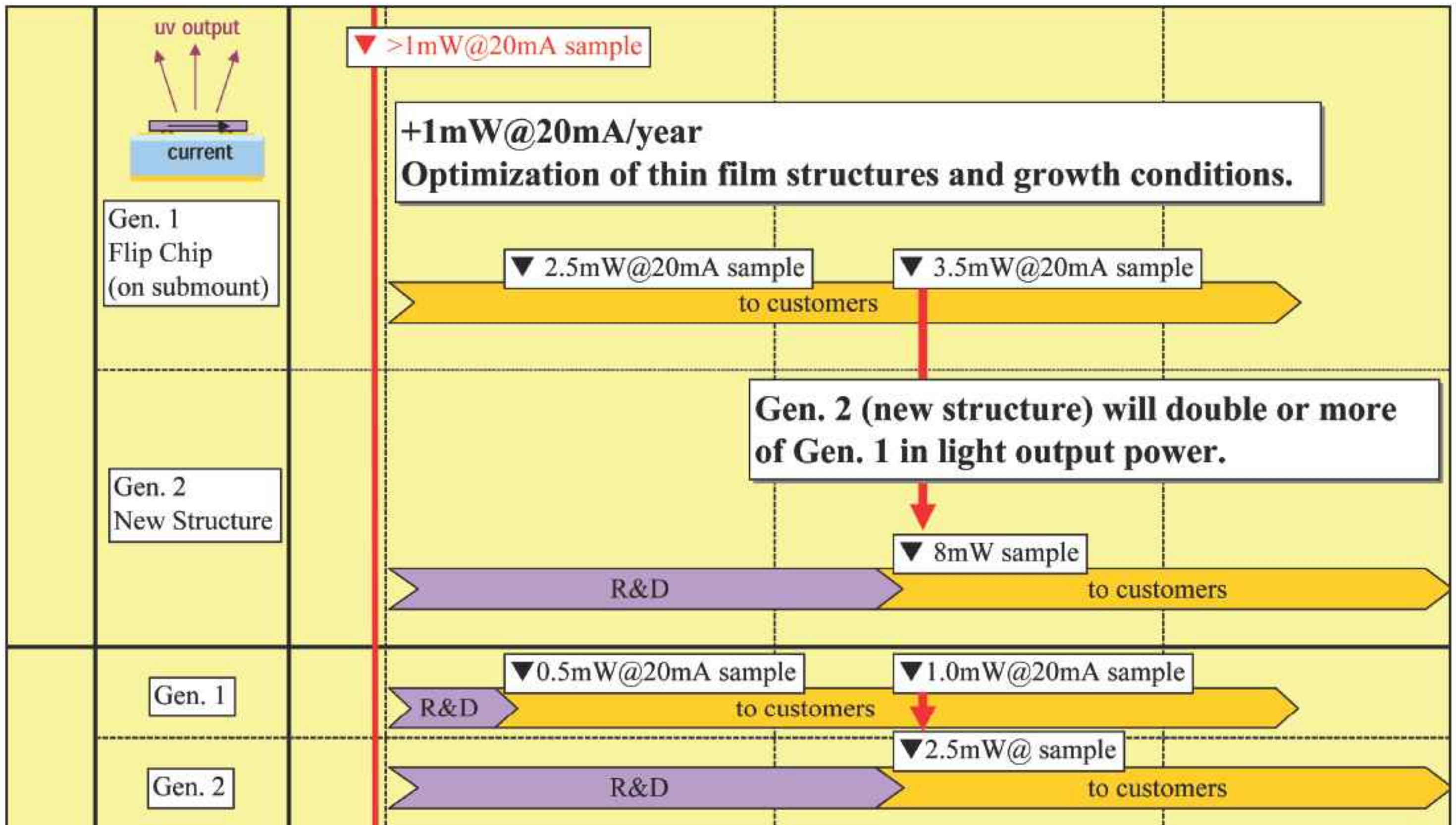


Figure 7. Dowa roadmap (2010–2012) for developing and commercializing shorter-wavelength UV LEDs.

chemical vapor deposition (LP-MOCVD) to grow their DUV LEDs on aluminum nitride (AlN) on (0001) sapphire templates. These AlN buffer layers are grown using a pulsed-flow multi-layer (ML) method using ammonia as the nitrogen source (Figure 6). By alternating pulse and continuous flow growth one can obtain crack-free, thick AlN layers with an atomically flat surface with a stable Al (+c) polarity. The method depends on enhanced precursor migration during the pulse sequence. Edge-type dislocation densities of less than $7 \times 10^8/\text{cm}^2$, as estimated through XRC of 350–370arcsec for the (10 $\bar{1}2$) plane, have been achieved. These researchers are affiliated variously with Institute of Physical and Chemical Research (RIKEN), Saitama University and Japan Science and Technology Agency (JSTA) Core Research of Evolutional Science & Technology (CREST) basic research promotion program.

Last year, these researchers reported progress in using ML templates to improve performance for DUV multi-quantum well (MQW) LEDs (Table 2) with wavelengths as short as 234nm [3]. “High output power” was achieved for 240nm DUV LEDs. Working with Panasonic Electric Works, the team has even achieved wavelengths of 222nm [10]. Panasonic has no AlGaN growth techniques, but it does have large markets with potential for UV LED application, making it a useful partner with a view to making commercial UV LEDs.

The Saitama group has also used AlN/sapphire templates from Dowa Electronics with a 250–350arcsec FWHM (XRC)

for (10 $\bar{1}2$) ω scans, resulting in devices emitting more than 1mW output power in the range 241–282nm. In particular, a 241nm device emitted 1.1mW, while a 256nm LED had a 4.0mW output (both CW at RT).

The ML-AlN process is still developing. RIKEN’s Hideki Hirayama comments: “Our ML-AlN has recently achieved XRC(10 $\bar{1}2$) of 280–300arcsec and the uniformity is good across the 2-inch wafer (50mm). We believe the quality level is the same between our ML-AlN and Dowa’s AlN. Actually, the EQE of 230–250nm UV LEDs show almost the same value when fabricated using Dowa’s AlN as with RIKEN’s ML-AlN.” In addition to marketing 50mm diameter templates with an insulating 1 μm AlN layer on sapphire, Dowa has recently produced its own prototype LED samples emitting in the longer wavelength range 320–350nm with 1.4mW output power at 20mA current and is seeking to start mass production. Technically, the company also hopes to increase the output power and shorten the wavelength (Figure 7), expecting a market worth ‘tens of billions of yen’ to emerge. The nitride semiconductor epitaxial layers are grown using technology developed by Xerox’ Palo Alto Research Center (PARC) in the USA and RIKEN.

Japan’s Nichia Corp has been using thicker AlN buffer layers to improve crystal quality using low-pressure metal-organic chemical vapor deposition (LP-MOCVD) with simultaneous trimethyl-metal and ammonia (NH₃) sources [7]. The deposition did not use any special techniques such as migration enhancement or pulsing. ▶

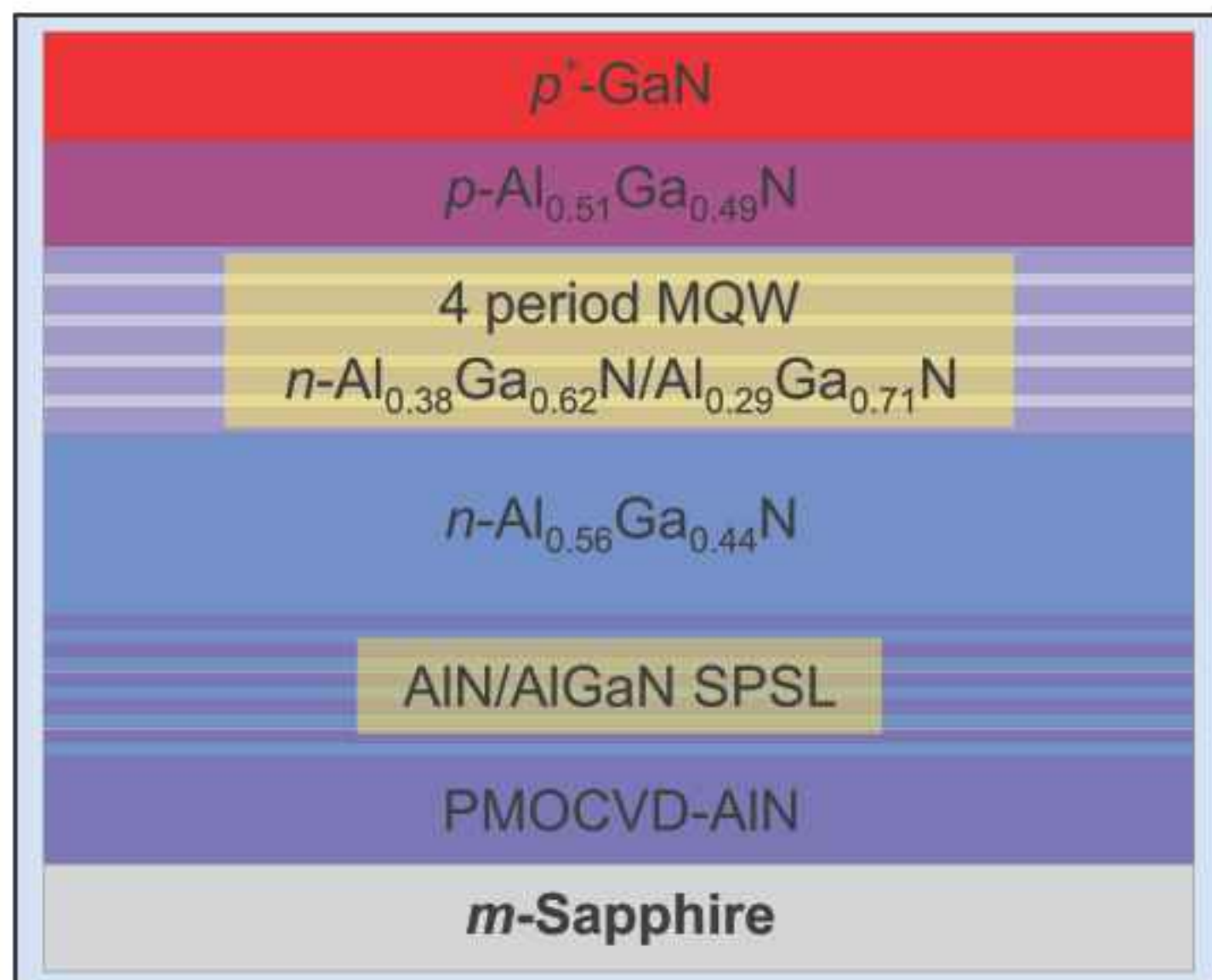


Figure 8. Schematic cross-section of USC/Nitek semipolar deep-UV LED structure.

The thickness of the base AlN layer was $3\mu\text{m}$ and x-ray diffraction analysis gave rocking curve (XRC) full-width at half maximum (FWHM) values of 60arcsec and 600arcsec for the (0002) and (10 $\bar{1}$ 2) crystal planes. The typical (10 $\bar{1}$ 2) FWHM for $1\mu\text{m}$ AlN layers is more than 1000arcsec . After the AlN template, an AlN/AlGaN superlattice was used to relieve strain arising from lattice mismatches before depositing the silicon-doped n-type contact layers.

Non-standard crystal orientation devices have also been developed. By starting with sapphire oriented in a different direction from the standard c-plane, it is hoped to reduce polarization effects that can lower recombination efficiencies by pulling electrons and holes apart. The first researchers to explore this possibility are based in South Carolina and have developed 'first demonstration' semipolar nitride semiconductor 307nm ultraviolet

LEDs [8]. The 307nm wavelength is claimed as the shortest emission wavelength ever reported for a non c-plane III-nitride semiconductor based LED.

In nitride semiconductors grown in the normal 'c-direction', electric fields of the order of several MV/cm can build up due to polarization effects. Compared with longer wavelength indium gallium nitride LEDs (e.g. blue-green), it has been harder to develop such materials for UV wavelengths shorter than 350nm since the wide bandgap aluminum-based nitrides needed tend to form stacking faults and multiple structural phases when grown in non-standard directions.

The research by University of South Carolina and Nitek Inc used m-plane sapphire substrates (Figure 8). A layer of aluminum nitride is then grown using pulsed metal-organic chemical vapor deposition (PMOCVD). A strain-relieving short-period super-lattice (SPSL) of alternating ultra-thin layers of AlN and AlGaN is used to enable crack-free metal-organic chemical vapor deposition (MOCVD) of subsequent layers.

The x-ray diffraction measurements showed that the nitride layers grew in the (11 $\bar{2}$ 2) semipolar direction and that the SPSL was effective in improving the crystallinity of the material above — a typical rocking curve scan of a diffraction peak gave a full-width at half maximum (FWHM) value of 1386arcsec for the AlN template, but for the n-AlGaN contact layer this was reduced to a sharper $\sim 1110\text{arcsec}$.

The output power for the produced LEDs at 20mA DC input was $20\mu\text{W}$, which the researchers find 'reasonable for the first ever demonstration of a semipolar deep-UV LED'. Further work is being carried out to improve the device design and material quality in the hope of increasing optical output powers.

Some companies that produce AlN ceramic materials have also developed AlN/sapphire templates. Dowa is one example. NGK Insulators is another that has devel-

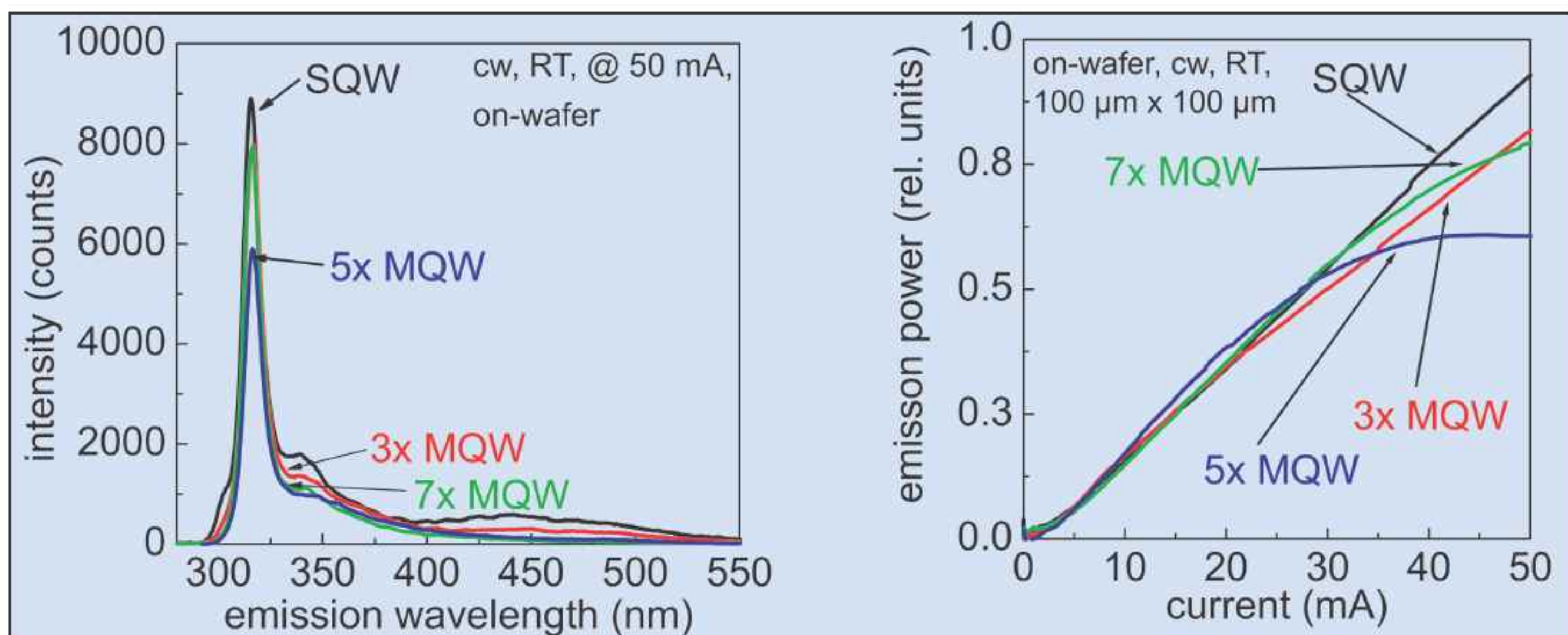


Figure 9. Variations of intensity/output power vs wavelength & current for different numbers of quantum wells.

oped, with Mie University in Japan, a self-produced low-pressure MOCVD system to deposit layers of AlN up to a micron thick on silicon carbide and sapphire [11]. The growth temperature for AlN on sapphire reaches around 1000°C, higher than that for the subsequent epi-layers. XRC FWHM values of 40arcsec and 200arcsec have been achieved for (0002) and (10 $\bar{1}$ 2) crystal planes, respectively, for 1 μ m-thick AlN layers.

Epi-layers

Having made or bought in the AlN/sapphire template, researchers/developers/producers generally turn to or continue traditional MOCVD deposition for the subsequent epi-layers. Technische Universität Berlin and Ferdinand-Braun-Institut für Höchstfrequenztechnik have been looking at different ways to optimize indium-doped AlGaIn heterostructures for UV emission [1]. Among the variations explored in ~320nm devices, the group has looked at the use of AlGaIn interlayers between the active region and the EBL, and variations on the MQW active region.

The effect of an AlGaIn interlayer is to increase the MQW emission and suppress longer wavelength parasitic emissions in the p-type contact region. The MQW was varied both in number of wells (1 to 7) and in layer thicknesses. Increasing the number of wells reduced secondary peaks in the spectrum, but had little effect on the luminescence for continuous wave (cw)/DC currents up to 30mA (Figure 9). The thickness of the QWs had a greater effect, with the maximum output coming from 2.2nm wells.

The Saitama group of institutions has also tried indium-doping of the AlGaIn quantum-well layers [6]. These devices use indium segregation effects, which are thought to enhance emissions through carrier localization in InGaIn UV/blue LEDs.

Electron blocking and p-GaN contacts

Electron-blocking layers (EBLs) usually consist of a thin layer of semiconductor material with an energy bandgap wider than the other materials in the LED structure. The aim is to create a barrier to electrons, while maintaining a low barrier for holes to enter the active region of the device. At very short emission wavelengths, where large energy bandgaps are already being used in the active region, the relative effectiveness of single-layer EBLs is reduced.

A 2.7x efficiency enhancement from using multi-quantum barrier (MQB) electron-blocking layers is claimed for deep-ultraviolet (DUV) nitride semiconductor LEDs developed by the Saitama group [5]. The wavelengths of the devices were in the range 262–250nm, with some of the maximum output powers and EQEs

Table 3. Al composition x of $\text{Al}_x\text{Ga}_{1-x}\text{N}$ wells, buffer and barrier layers and multi-quantum barrier (MQB), along with maximum external quantum efficiency (EQE) and output power for LEDs with MQB.

Wavelength nm	Well x	Barrier/buffer x	MQB x	Max. EQE %	Max. power mW
250	0.62	0.77	0.95	1.18	4.8
262	0.55	0.72	0.94	1.54	10.4

described by the researchers as 'the highest values ever reported' (Table 3).

Multi-quantum barriers use interference effects from the wave-like behavior of electrons to enhance the barrier. The theoretical proposal for MQBs dates back to 1986 and the idea was applied in the early 1990s to aluminum gallium indium phosphide (GaInP/AlInP) red laser diodes (LDs). AlGaIn devices were produced with single and multi-layer EBLs to show the effect of using MQBs (Figure 10).

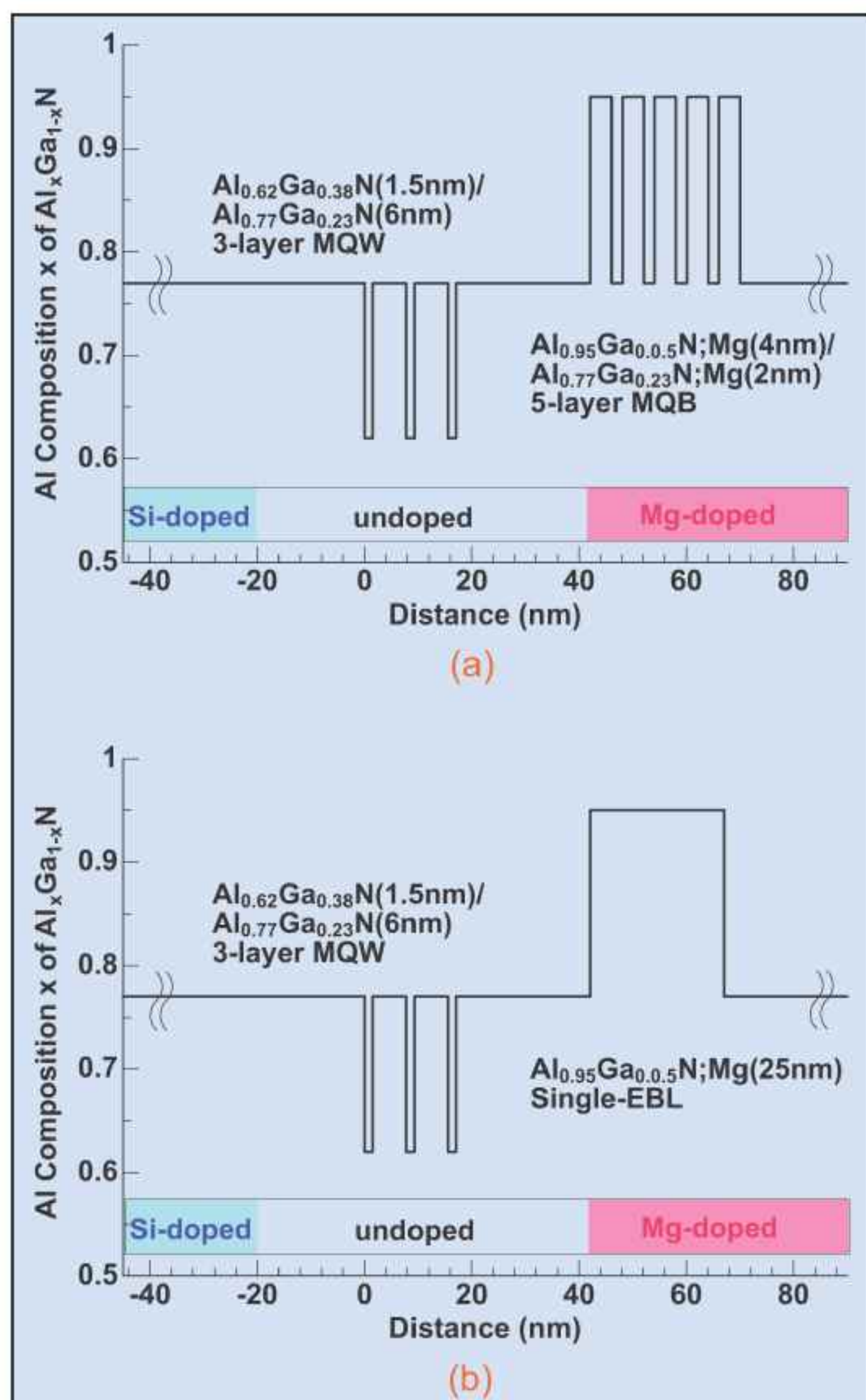


Figure 10. Compositions and doping profiles of AlGaIn layers used for 250nm AlGaIn QW LEDs produced by Saitama et al with MQB (a) and single-barrier EBLs (b).

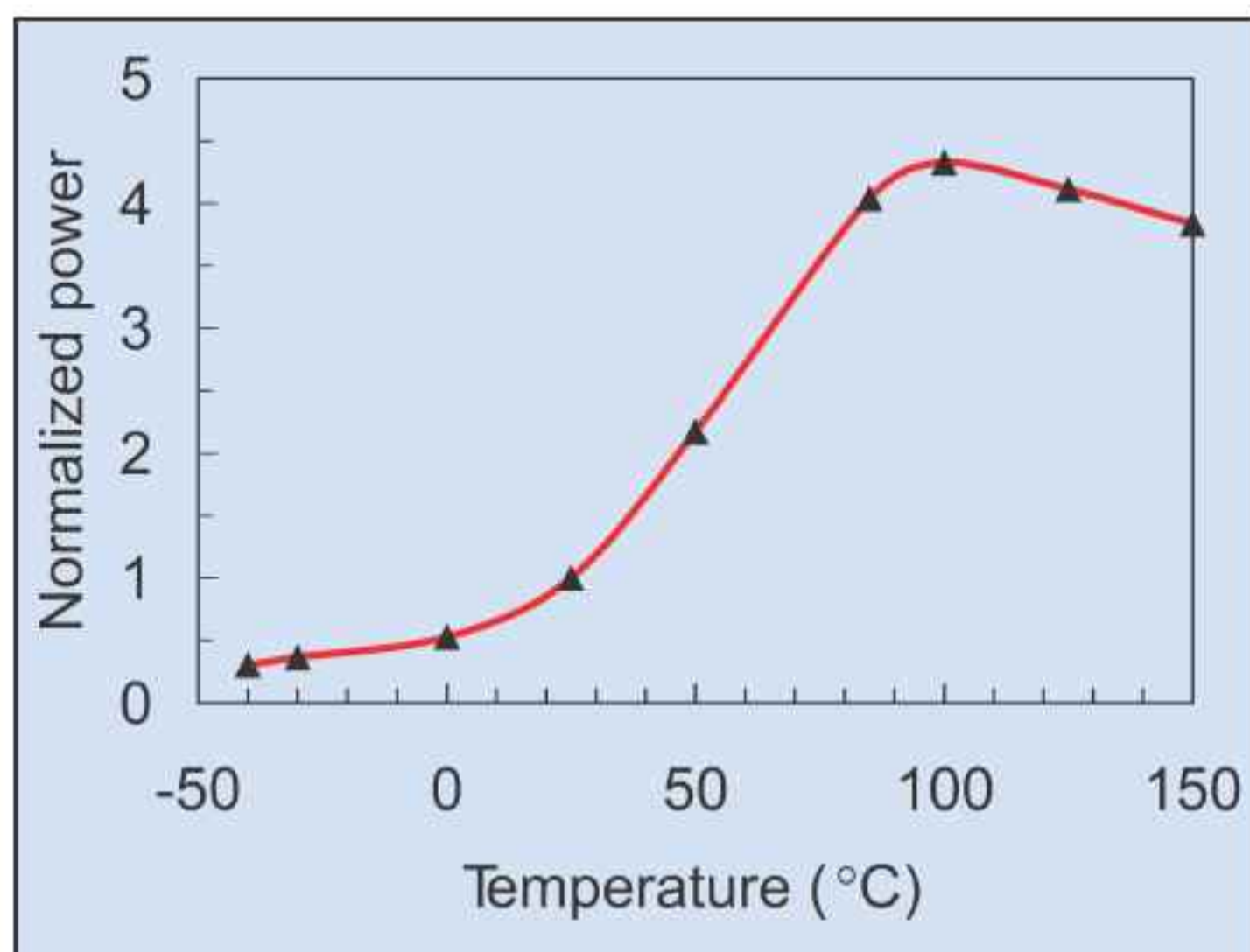


Figure 11. Temperature dependence of normalized output power of Nichia UV LED from -40 to 150°C .

Packaging and modules

Packaging is also a key component for developing UV LED sources. While much of the academic research on DUV LEDs has centered on increasing the quantum efficiency of the chip, commercial producers also have to consider the problem of extraction of the precious photons into the external world. In addition, thermal control is a particular problem for UV LEDs since the emissions depend on band-to-band transitions, rather than the less temperature-dependent localized states used in blue InGaN LEDs.

In fact, Nichia has found that in DC operation, where self-heating can occur, some devices actually produced more output power, achieving maximum power after about a minute [7]. This effect was probably due to the self-heating ionizing the acceptor doping in the p-type region, releasing holes (thermally enhanced p-type activation). Indeed, studies of the temperature dependence of the device (Figure 11) suggest that it is most efficient around 100°C . Using pulsed currents ($50\mu\text{s}$ width, 2kHz repetition), the output power was 0.69mW , 28% that achieved with DC operation.

It is estimated that deep ultraviolet devices have extraction efficiencies less than 10% due to light absorption in GaN contact layers and low reflection ratio from p-type layers. Thus, some of the tricks used for increasing extraction in longer wavelength LEDs are not available (as yet). For example, putting the LED in a reflecting cup to redirect photons emerging from the bottom of the chip is not of much use where the p-contact layers of the chip heavily absorb the ultraviolet radiation passing through. While using p-AlGaIn might allow greater extraction efficiency of ultraviolet radiation, it would severely reduce hole concentrations and hence injection efficiency, since the Mg acceptor levels become deeper with increasing aluminum content [12].

A leading example of a commercial producer is Sensor Electronic Technology (SET). This US company carries out its own packaging R&D and has both device fabrication and packaging facilities at its site in Columbia, South Carolina. The firm finds that the majority of its more than 1000 customers have no experience in the use of semiconductors, so it has to be a solutions provider.

SET also extracts UV light that is 'waveguided' along the active layers, emerging from the edges of the chip (Figure 5). The company would also like to extract light emitted through the p-type contact. The researchers at SET are working on a new device structure that has the potential to more than double the extracted light.

For thermal control, SET's ultraviolet LEDs use a heatsink. Further strategies being developed include improving the doping to reduce the resistance of the injection layers. Larger-area devices to reduce the current densities are another strategy for reducing self-heating.

With US National Science Foundation (NSF) funding, the firm has developed a phase I prototype portable all-LED 273nm water sterilization unit with capability of 5-log (99.999%) virus inactivation/removal with a 0.5 liter/min flows and 4-log (EPA Ground Water Rule, www.epa.gov/safewater/disinfection/gwr/index.html) with 1 liter/min. UV radiation can also be used for surface sterilization.

Nichia has also tested a multi-LED arrangement consisting of 26 devices (2×13), which produced an output of 223mW with pulse injection (5ms, 10Hz repetition) at 1.85A. Measurements were carried out with water cooling. The maximum current was limited by the ability to remove heat across the bonding interface between the LED chip and sub-mount. The maximum current in DC operation was 460mA ($\sim 35\text{mA}/\text{die}$), giving a UV output of 60mW . ■

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

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Index

- | | |
|--|-------------------------------------|
| 1 Bulk crystal source materials p90 | 14 Chip test equipment p94 |
| 2 Bulk crystal growth equipment p90 | 15 Assembly/packaging materials p94 |
| 3 Substrates p90 | 16 Assembly/packaging equipment p94 |
| 4 Epiwafer foundry p91 | 17 Assembly/packaging foundry p95 |
| 5 Deposition materials p91 | 18 Chip foundry p95 |
| 6 Deposition equipment p92 | 19 Facility equipment p95 |
| 7 Wafer processing materials p93 | 20 Facility consumables p95 |
| 8 Wafer processing equipment p93 | 21 Computer hardware & software p95 |
| 9 Materials and metals p93 | 22 Used equipment p95 |
| 10 Gas & liquid handling equipment p93 | 23 Services p95 |
| 11 Process monitoring and control p94 | 24 Consulting p95 |
| 12 Inspection equipment p94 | 25 Resources p95 |
| 13 Characterization equipment p94 | |

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www.sicrystal.de

sp3 Diamond Technologies

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www.sesmi.com

TECDIA Inc

(see section 16 for full contact details)

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5 Deposition materials

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6 Deposition equipment


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9 Materials & metals

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Las Vegas Convention Center, NV, USA

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www.lightfair.com

16–21 May 2010

8th International Symposium on Semiconductor Light Emitting Devices (ISSLED2010)

Peking University, Beijing, China

E-mail: issled2010@pku.edu.cn

www.issled2010.com.cn

17–20 May 2010

2010 CS MANTECH (International Conference on Compound Semiconductor Manufacturing Technology) including 25th Annual Reliability Of Compound Semiconductors (ROCS) Workshop

Portland Marriott Downtown Waterfront, OR, USA

E-mail: csmantech@csmantech.org

www.csmantech.org

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SEMICON Singapore 2010

Suntec, Singapore

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www.semiconsingapore.org

21 May 2010

LED Lighting 2010

University of Naples 'Federico II', Naples, Italy

E-mail: info@led-lighting.it

www.led-lighting.it/english

23–28 May 2010

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Hyatt Regency, Lake Tahoe, NV, USA

www.tms.org/Meetings/Specialty/icmovpe-xv

23–28 May 2010

IEEE Microwave Theory and Techniques Society (MTT-S) International Microwave Symposium (IMS 2010)

Anaheim Convention Center, CA, USA

E-mail: aw@ee.ucr.edu

www.ims2010.org

31 May – 4 June 2010

Compound Semiconductor Week 2010: IPRM 2010 (22nd International Conference on Indium Phosphide and Related Materials) ISCS 2010 (37th International Symposium on Compound Semiconductors)

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AXT	68	Oxford Instruments-TDI	41
CS MANTECH	89	Plasma-Therm	34
EV Group	47	Pridgen	43
Evatec	39	Riber	31
III/V-Reclaim	27	Tecdia	15
Insaco	29	Veeco Instruments — MBE	7
IQE	19	Veeco Instruments — MOCVD	IFC
k-Space	57	Wafer Technology	23
LayTec	33		

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www.ispsd2010.com

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E-mail: e.koot@solarplaza.com

www.thesolarfuture.com

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E-mail: eveg@bsp-a.com

www.euroled.org.uk

9–11 June 2010

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New Munich Trade Fair Center, Germany

E-mail: dsartiaux@semi.org

www.pvgroup.org/intersolareu

9–11 June 2010

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E-mail: exhibit@mail.pida.org.tw

www.optotaiwan.com/en

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Moscow — Expo Center, Russia

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www.semiconrussia.org

16–17 June 2010

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and Opportunity**

Network Meeting Center, Santa Clara, CA, USA

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<http://oida.org/events/green10>

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Conference (PVSC)**

Oahu, HI, USA

E-mail: wendy_larsen@nrel.gov

<http://pv-solar.org>

21–24 June 2010

Solid State and Organic Lighting (SOLED)

Karlsruhe-Messe und Kongress (Conference Center),
Germany

E-mail: cust.serv@osa.org

www.osa.org/meetings/topicalmeetings/SOLED

22–25 June 2010

LED Expo and OLED Expo 2010

KINTEX, Seoul, South Korea

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<http://isgn3.org>

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12–16 July 2010

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