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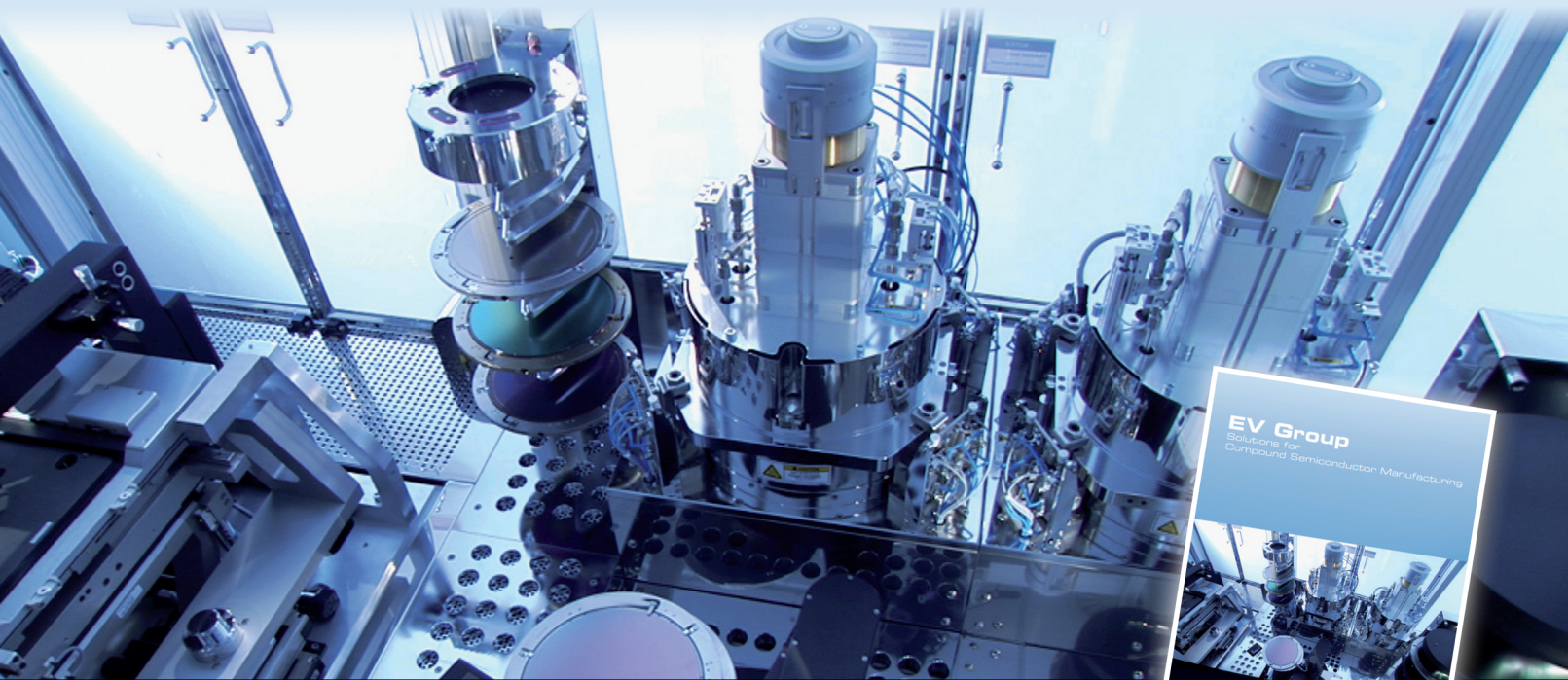

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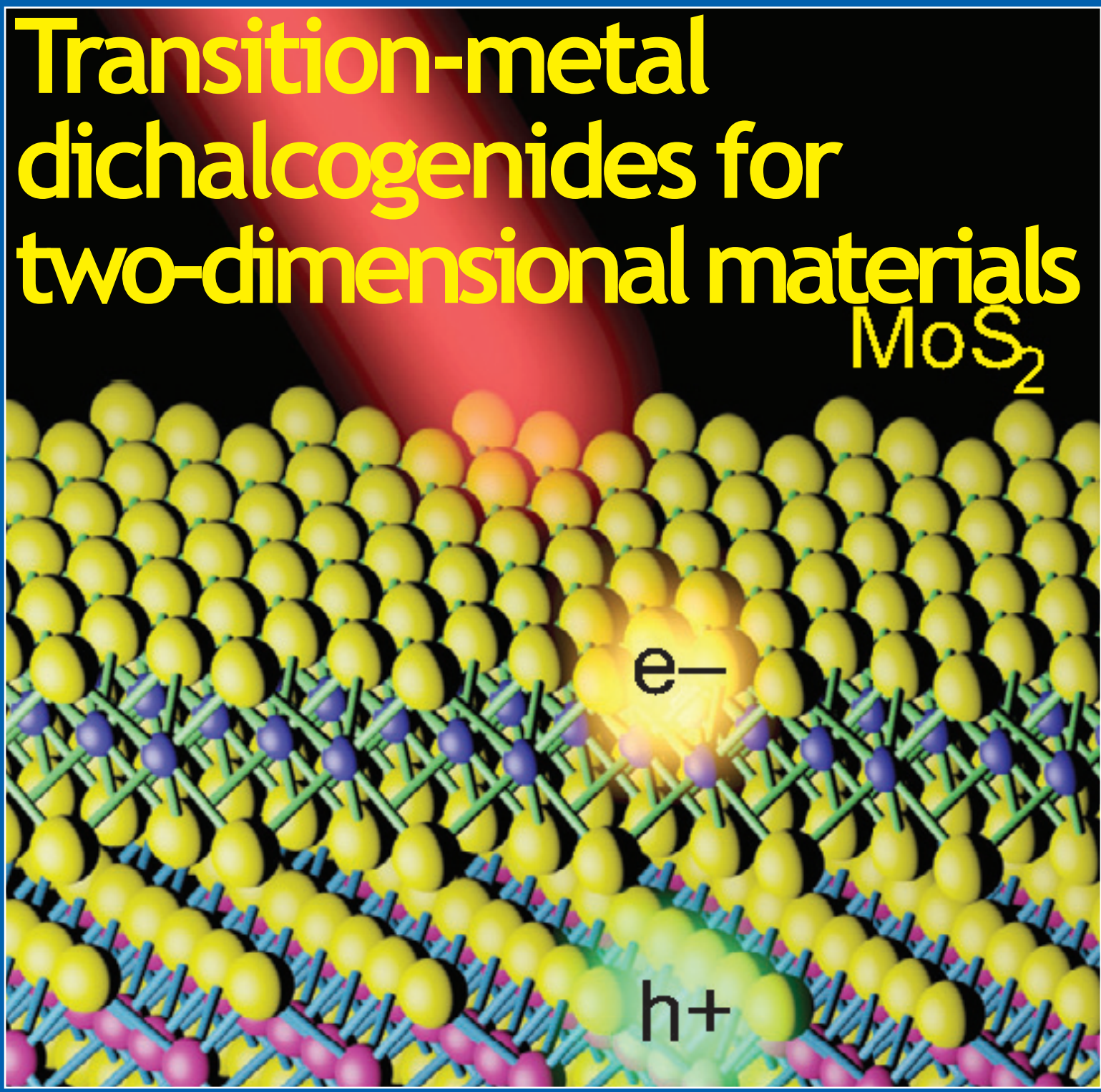
semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

Vol. 9 • Issue 7 • September 2014 www.semiconductor-today.com

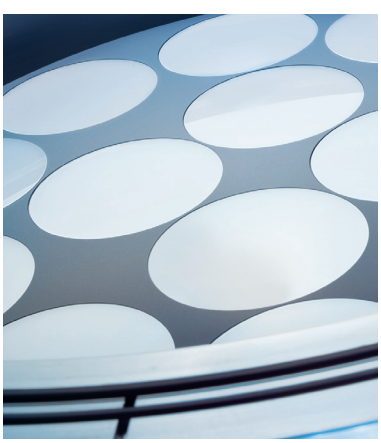
Transition-metal dichalcogenides for two-dimensional materials



RFMD and TriQuint to become Qorvo • JDSU splits in two
Emcore sells solar business • Thin-film PV efficiency hits 21.7%

Light Up a Brighter World

MaxBright MHP MOCVD System



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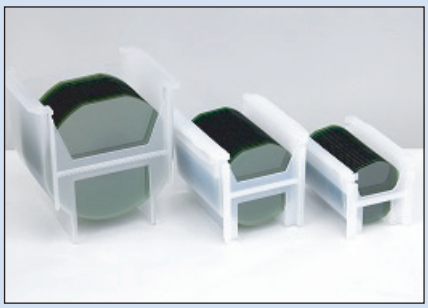
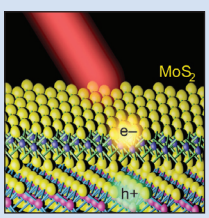


p23 Showa Denko's SiC epiwafers with (from left to right) diameters of 6-, 4- and 3-inches.

p34 Veeco's new TurboDisc EPIK700 GaN MOCVD system for high-volume LED production, which accommodates 31x4"-, 12x6"- or 6x8"-wafers.

p35 Riber's new Compact 21 Discover 3" substrate molecular beam epitaxy research system, launched at the MBE 2014 event.



Cover: Illumination of a MoS_2/WS_2 heterostructure with a MoS_2 monolayer lying on top of WS_2 monolayer creates an electron and hole in separate layers, opening up the prospects for using such ultrathin transition-metal dichalcogenides in efficient solar cells. **p76**

editorial

Adding & dropping businesses

In early September, the merger of RF Micro Devices and TriQuint Semiconductor was approved at meetings of the firms' respective shareholders, and should be finalized on schedule by the end of this year (subject to regulatory approval). In addition, the firms have also announced that the merged company will be called Qorvo (see page 12).

In contrast, the board of JDSU has just approved a 'de-merger' of its business, separating JDSU into two independent publicly traded companies: an optical components and commercial lasers company consisting of JDSU's Communications and Commercial Optical Products segments (CCOP); and a network and service enablement company (NSE) — see page 56. JDSU believes that the separation will allow CCOP to devote enhanced focus to its "leading position in optical components and subsystems for the telecoms market, expand its position in the high-growth datacom market (driven by cloud networking and data-center build-outs), and grow its commercial lasers and 3D sensing businesses". Separation is expected to be completed in third-quarter 2015. The de-merger is in contrast to the merger of JDS Fitel and Uniphase that first formed JDSU in 1999 followed by the binge of acquisitions (worth $45bn), including the likes of SDL, during the telecom boom of 1999–2000. More recently, in the last few years, several acquisitions in the area of network and service enablement — and the industry trend towards software-defined networks — have driven the separation of the increasingly disparate halves of the business.

Likewise, as a firm with two segments with even more disparate markets, Emcore has agreed to sell its Space Photovoltaics business (to private equity firm Veritas Capital for $150m) — see page 58. Of Emcore's remaining Fiber Optics business, the firm says that it has seen an improvement in the financial performance and in market conditions, while it aims to continue to implement various cost-reduction measures in the belief that it can achieve EBITDA break-even by September 2015.

Fellow optical communications component maker Finisar is similarly seeing increased demand, reporting an eighth consecutive quarter of revenue growth, up 7% sequentially and 23% year-on-year to a record $327m (see www.semiconductor-today.com/news_items/2014/SEP/FINISAR_080914.shtml). Finisar expects revenue to fall in the September quarter due to softness in telecom carrier spending, but growth should return in the December quarter, driven by a resumption in demand for transceivers for wireless applications (based on continued LTE deployment, especially in China) plus demand for bandwidth driving data-center build-out: the 23% growth comprised 31% growth in datacom products (compensating for soft growth of just 6% in telecoms). Regarding future prospects for new products, Finisar particularly cites its 100G CFP2 coherent transceiver modules (with the firm's vertically integrated structure exploiting its InP laser, modulator and receiver technology).

Many such new components were on display at September's European Conference on Optical Communications (ECOC) by the likes of Finisar, Emcore, Oclaro, II-VI, Civcom, GigOptix, NeoPhotonics, Source Photonics and TeraXion. In addition, the SCTE Cable-Tec Expo saw many product launches for CATV applications including optical devices from Emcore and GaAs- and GaN-based electronic devices from MACOM, RFMD and Anadigics. Both these events will be covered in the next issue.

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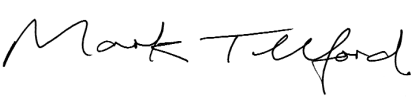

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***Semiconductor Today* covers the R&D and manufacturing of compound semiconductor and advanced silicon materials and devices** (e.g. GaAs, InP and SiGe wafers, chips and modules for microelectronic and optoelectronic devices such as RFICs, lasers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

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

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200mm GaN-on-Si Batch Reactor

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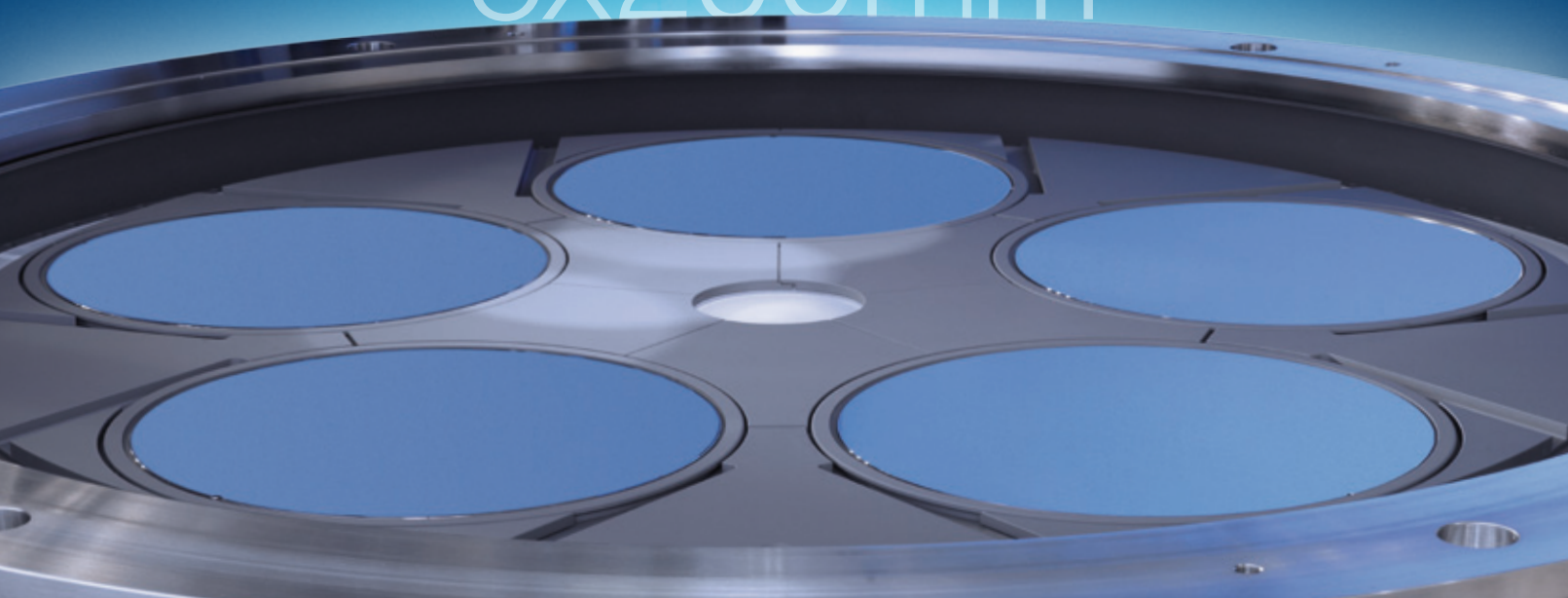

AIX G5+

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news

LED luminaire market for outdoor and parking applications to peak at $1.4bn in 2021

The global market for LED luminaires for outdoor and parking applications will grow from $921m in 2014 to $1.4bn in 2021, according to a report from Navigant Research.

Outdoor lighting systems are in the early stages of a transition from fluorescent, high-pressure sodium and metal halide lamps to LEDs. As LED prices continue to fall, the case for replacing today's most prevalent lighting technologies in outdoor systems is becoming increasingly compelling, says the report 'Outdoor and Parking Lighting Systems', which analyzes the market for outdoor luminaires, lamps, and lighting controls in end-use applications including city parks and public areas, sports parks and stadiums, commercial site lighting, open air parking lots, indoor parking garages, and university and college campuses.

"While the deployment of LED lighting in parking lots will dramatically cut energy bills and help politicians achieve environmental goals, better lighting quality is a significant additional benefit in itself," says senior research analyst Jesse Foote. "LED lighting can help drivers better identify objects, obstacles, and individuals; minimize glare and light pollution; and make spaces more visually appealing while enhancing safety for pedestrians and motorists."

Because the lifespan of LEDs is much longer than that of conventional lighting, direct revenue from lamp and luminaire sales will actually decline gradually after 2021, according to the report. This trend will drive the large lighting providers to move toward a 'lighting-as-a-service' model, in which LED lighting and energy management will be offered as an ongoing service rather than a one-time equipment sale.

www.navigantresearch.com/research/outdoor-and-parking-lighting-systems

LED display market to see a 1.4% annual decline to 2018

The analysts forecast that the global LED display market will decline at a compound annual rate of 1.4% over the period 2013-2018, according to a new market research report from .

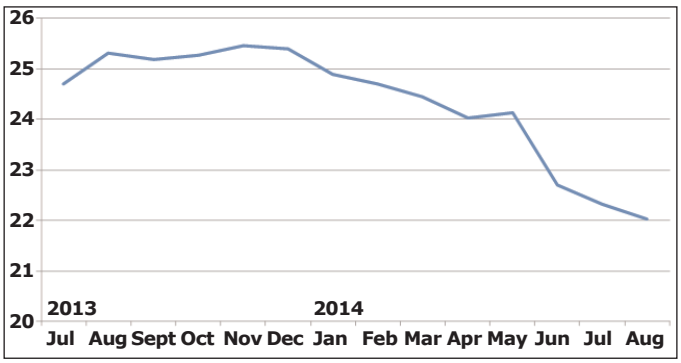
This report takes into account revenue generated from the sales of packaged LEDs used for displays and excludes revenue generated from the LEDs used for lighting. It also presents an analysis of the global LED Display market by application as well as end-user segmentation. The report explains the shift in LED application over the years from 2004 till 2013; it also includes the statistics of the Global LED market by application during the forecast period 2014–2018.

Key vendors include Cree, Nichia, Osram Opto Semiconductors, Philips Lumileds Lighting, and Seoul Semiconductor. Other prominent vendors are China Electric, Everlight, General Electric, LG Innotek, Panasonic, Samsung, Sharp, Tatung, Toshiba, and Toyota Gosei.

www.technavio.com/report/global-led-display-market-2014-2018

LED lamp retail pricing falls 10.49% year-on-year in August, as lumens per dollar rises over 24%

The global average retail price of LED lamps was $22.03 in August, down 1.26% on the prior month and 10.49% year-on-year, according to the August 2014 release of the IHS Technology LED lamp Retail Price Tracker.



Over the past 12 months, the lumens-per-dollar ratio of LED lamps has risen by 24.08% to 34.8 lumens per dollar, the report adds.

IHS has been tracking LED lamp retail pricing trends for more than two-and-a-half years. Each month analysts sample 2600 individual LED lamps sold in retailers across 15 countries globally. The change in statistics from previous months is due to a reclassification of some LED lamps and to the addition of about 100 new lamps being tracked.

https://technology.ihs.com/468917/led-lamp-retail-price-tracker-august-2014

Automotive industry playing increasing role in optoelectronics component market

Penetration of LEDs in headlamps rising from 2% in 2013 to 17% in 2019

In recent years, the optoelectronic component market has been dominated by a number of applications, namely LEDs, backlighting and the emergence of solid state lighting. In the optocoupler and photo-relay markets, the focus has been on the industrial sector, while the infrared component and sensor markets are dominated by the consumer and telecoms sectors. However, with car ownership increasing in less economically developed regions and vehicles becoming more technologically advanced, the automotive sector is playing an increasingly important role across all the major optoelectronic component product types, according to a Research Note from market analyst Stewart Shinkwin at IHS Inc.

Following a new European Union (EU) directive 2008/89/EC, which required all new models of car after 2011 to be fitted with daylight running lamps (DRLs), the adoption of LEDs in automotive exteriors has increased significantly. Due to the long lifetime and energy-efficient nature of LEDs, penetration in this market sector has been high and has helped to drive adoption of LEDs.

The penetration of LEDs in headlamp units is still relatively low, with only 2% of car headlamps using LEDs in 2013, according to figures from IHS Automotive. As their popularity, performance and efficiency grow, this is set to increase to 17% in 2019. This will bring significant growth to the LED market, with packaged LEDs for automotive exterior lighting set to rise at a compound annual growth rate (CAGR) of over 8%.

With the spread of technological advances in the automotive industry, the adoption of infrared components has increased, with a wide range of automotive applications including auto head-lamps, automatic windscreen wipers, gesture control, and night-vision displays. A number of manufacturers are putting an increasing emphasis on this sector, due to the relatively low competition compared with the consumer sector. Infrared revenue in this sector is forecast to grow from $118m in 2013 to $207m in 2019. It is unlikely these technologies will become standard features in lower-cost models, but their penetration in mid-tier models is increasing continuously, says IHS.

The increase in sales of hybrid electric vehicles (HEV) and full electric vehicles (EV) is also promoting growth in the market for optocoupler, which are used in HEVs to isolate the onboard chargers and other high-voltage systems. With HEV shipments growing at a CAGR of 18% through to 2019 and little price erosion due to the significant barriers to entry, this market is a lucrative one for those manufacturers that can operate here, says the market research firm. The market is forecast to nearly double from $74m in 2013 to $146m in 2019.

www.ihs.com

GaN driving microwave RF power semiconductor markets to over $300m by 2019

Availability of GaN devices for 4–18GHz becoming more pervasive

Spending on microwave RF power semiconductors will rise to more than $300m by 2019 as the availability of new gallium nitride (GaN) devices for 4–18GHz becomes more pervasive, according to the report 'Microwave RF Power Semiconductors' from market analyst firm ABI Research, which examines devices with power outputs of more than 3 watts operating at frequencies ranging from 4GHz to 18GHz.

Point-to-point communications, SatCom, radar of all types, and new industrial/medical applications will all benefit from the introduction of high-power GaN devices, adds the report (part of ABI Research's High-Power RF Active Devices Market Research), which contains analysis of the six main vertical segments (C-band GaAs, C-band GaN, X-band GaAs, X-band GaN, Ku-band GaAs, and Ku-band GaN) and is further expanded to 28 application sub-segments.

"While gallium arsenide (GaAs) devices are presently the backbone of microwave RF power, it is gallium nitride that will drive growth going forward," notes ABI Research director Lance Wilson. "GaN can operate at much higher voltages and at power levels that were difficult or impossible to reach using GaAs," he adds.

In addition to the above-mentioned application segments, microwave GaN is finally reaching the performance points that can start to seriously challenge travelling-wave tube applications for new designs that have historically used the latter.

www.abiresearch.com/market-research/service/high-power-rf-active-devices

LED market to grow at 13.5% CAGR to $42.7bn in 2020

LEDs to command 20% share of lighting market by 2020

The LED (chips and components) market is forecast to increase at a compound annual growth rate (CAGR) of 13.5% from 2014 to $42.7bn by 2020, according to a report 'Global Light Emitting Diode (LED) Market (Technology, Application and Geography), 2013–2020' from Allied Market Research (AMR, a market research and business-consulting wing of Allied Analytics).

The Asia Pacific dominates the LED market, commanding about three-quarters of the global electronics manufacturing industry. North America, due to its high-tech forensic and medical applications, leads the market for ultraviolet (UV) LEDs.

Due to the absence of hazardous mercury as well as their greater power efficiency, LEDs have penetrated the market and outdone compact fluorescent lamp (CFLs) in commercial lighting, says AMR. It is expected that LED lights will command about 20% share of the global lighting market by 2020, accounting for two-thirds of LED revenue. However, demand for basic LEDs in backlighting applications will decline as the organic LED (OLED) broadens its horizon of applications and eventually supersedes basic LED-based mobile displays, forecasts the market research firm.

UV LEDs primarily find application in medical treatment and forensic tests. The UV LED market is expected to develop further as companies rigorously work out acquisitions to expand their product portfolios and applications. In January 2013, Noblelight acquired UV LED maker Fusion UV in order to enhance its UV LED product features. Developed regions, though, are early adopters of UV LED technology, while the healthcare sector in developing regions such as Asia Pacific is also contributing to growth of the technology. The growing medical tourism sector and the lower cost of treatment should also strengthen the adoption of UV LED technology in developing regions, the report adds.

Government across the globe are implementing LED lighting in most public settings. The US government has already started replacing conventional street lights with LEDs, which is expected to be completed by the end of 2014. Such developments are instrumental to LED market growth.

"Growth in revenue will be slower than the rise in unit sales of LEDs due to the constantly declining price of LEDs; however, the overall market would grow at a constant pace due to growing demand for LEDs and expanding applications," notes AMR analyst Ranjan Singh.

"Continuous development in the technology suggests huge underlying potential for OLEDs during the forecast period," he adds, citing recent roll-outs of OLED mobile handsets by Samsung and Nokia. High-brightness (HB) LEDs hold nearly 60% market share, as they can provide much brighter light with lower voltages compared with other alternatives, says the firm. The rapid growth in the 4K TV segment suggests that HB-LED will continue to hold the key to LED market growth, it adds. Major companies such as Samsung SDI and RIT Display are making substantial investments in the development of advanced OLED display technologies.

The rising application of LEDs in general lighting has compelled manufacturers to concentrate on the launch of new LED lighting products and to expand their production. For example, Germany's Osram has opened its LED assembly plant in Wuxi, China, to expand its fully loaded LED capacities and also to strengthen its market position in the global LED market. The firm chose to locate the plant in China to capture the high potential of the Asian market.

Notable players in this space that are profiled in the report include American Bright Optoelectronics, Cree, International Light Technologies, Ledtronics, Philips Lumileds Lighting, Samsung Electronics, Seoul Semiconductor, Osram Licht, Nichia, LG Innotek, GE Lighting Solutions, and Toyoda Gosei. Of these firms, Nichia, Samsung and Osram held almost 35% share of global LED market revenue in 2013.

www.alliedmarketresearch.com/LED-light-emitting-diode-market

Over 2bn smartphones to ship in 2018, 1.25bn in 2014

ABI Research expects 1.25 billion smartphones to ship in 2014 and forecasts smartphone shipments to pass the 2 billion mark in 2018. The compound annual growth rate (CAGR) over the forecast period from 2014 to 2019 is 12%.

"While smartphone growth is beginning to fall, plenty of growth remains, with smartphone penetration of mobile subscribers under 30% worldwide," commented Nick Spencer, senior practice director, ABI Research. "Most advanced and affluent markets already have 60%+ penetration, so the growth is driven by developing markets and the reduction in smartphone ASPs."

Smartphones will consolidate their lead as the largest computing category, more than doubling that of its nearest rival in 2017. Growth is being driven by Chinese and Indian smartphone manufacturers, creating low-cost Android or AOSP devices for markets in Africa, Asia, the Middle East and Latin America.

These findings are part of ABI's Smartphones and Handsets Market Research, which includes Research Analyses, Market Data, Insights, and Competitive Assessments.

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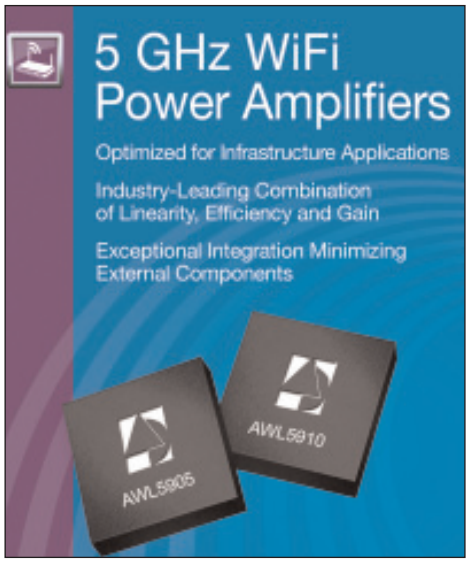
Anadigics' PAs enabling 802.11n and 802.11ac WiFi connectivity for North American infrastructure CPE maker

Broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA is shipping production volumes of its AWL5905 and AWL5910 power amplifiers (PAs) to a North American communications equipment maker. The power amplifiers are being leveraged for new 802.11n and 802.11ac WiFi infrastructure CPE (customer premises equipment).

"Adoption of the 802.11ac standard continues to accelerate as consumers and businesses increasingly turn to WiFi networks for data and multimedia connectivity," says Jerry Miller, senior VP of worldwide sales and applications. "As manufacturers develop the newest generation of WiFi infrastructure devices to support this trend, Anadigics' power amplifiers stand out as critical enablers. Our 802.11ac solutions deliver a world-class combination of linearity, efficiency and gain to enable infrastructure devices with higher data throughput at greater range, all while consuming less power," he claims. "These advantages are being validated by production shipments in support of multiple platforms at this top-tier WiFi



equipment manufacturer."

Anadigics' 802.11ac WiFi power amplifiers for infrastructure applications leverage the firm's patented InGaP-Plus technology and unique design architectures to offer performance and integration. The AWL5905 delivers high linear power gain of 30dB and ultra-low 2.0% EVM (error vector magnitude) at 19.5dBm, while the AWL5910 provides 31dB of linear power gain and 1.8% EVM at 22dBm output power. This combination of high gain and linearity ensures stable, reliable high-throughput WiFi connectivity in the toughest 802.11n and 802.11ac modulation formats, enabling extremely high transmission data rates, the firm claims.

Anadigics' 802.11ac WiFi power amplifiers integrate a digital PA enable interface that eliminates the need for costly external circuitry. The AWL5905 and AWL5910 also feature an integrated detector that facilitates accurate power control over varying load conditions and extended dynamic range.

The firm says that these performance and integration advantages, coupled with efficiency and thermal characteristics, enable multiple input multiple output (MIMO) designs that consume less power and are more thermally efficient. Due to lower current consumption, Anadigics' WiFi infrastructure power amplifiers also support the stringent power limitations of Power over Ethernet (PoE) equipment.

The compact 4mm x 4mm x 0.8mm QFN package also incorporates RF ports internally matched to 50Ω and DC blocked to reduce PCB space requirements.

www.anadigics.com

Anadigics' front-end ICs enable WiFi connectivity in LG G3 Beat

Anadigics is shipping production volumes of its AWL9280 and AWL9580S WiFi front-end ICs (FEICs) to LG Electronics in support of the global launch of the LG G3 Beat - known as the LG G3 s in Europe and the Commonwealth of Independent States (CIS). The feature-rich smartphone (a compact variant of the LG G3) offers a 5.0-inch HD IPS display, 1.2GHz quad-core processor, and 8 megapixel rear-facing camera with laser auto focus.

"We are very pleased to continue our long-term collaboration with LG Electronics and to be selected to enable wireless connectivity in the new LG G3 Beat," says Jerry Miller, senior VP of worldwide sales and applications. "Our FEICs have raised the bar in WiFi performance and integration, enabling faster throughput, longer battery life and more compact designs," he claims.

The AWL9280 2.4 GHz and AWL9580S 5GHz FEICs leverage Anadigics' patented InGaP-Plus technology and uniquely designed architectures to combine a high-performance power amplifier (PA), low-noise amplifier (LNA) with bypass option, and Tx/Rx RF switch on a single die. This level of integration greatly improves manufacturability and reliability, reduces the PCB area required, and simplifies RF front-end design to speed time-to-market, says Anadigics.

The compact 2.5mm x 2.5mm x 0.4mm QFN package also incorporates a high-accuracy integrated power detector and RF ports internally matched to 50Ω to reduce PCB space requirements.

The complete family of WiFi FEICs provides what is claimed to be outstanding noise figure performance and low error vector magnitude (EVM) to maintain high-modulation accuracy, enabling high data throughput.

www.anadigics.com

Taiwan GaAs foundry WIN Semiconductors reports highest monthly revenue in a year

For August, Taiwan's WIN Semiconductors Corp (the world's largest pure-play gallium arsenide foundry) has reported revenue of NT$1.04bn (US$34.5m) – its highest revenue in the past 12 months — up 7.41% on July and up 23.45% on a year ago. Growth is attributed to increased demand from branded handset vendors ahead of new product launches this quarter and next quarter, reports the Taipei Times.

WIN Semiconductors provides foundry services for GaAs components used in handsets, including smartphones. The company's major clients — Avago Technologies, Japan's Murata Manufacturing, China's RDA Microelectronics and US-based Skyworks Solutions — produce GaAs-based devices used by Apple, Samsung Electronics and Nokia in their products.

In August, power amplifier (PA) chips accounted for more than 50% of WIN Semiconductors' total sales. The rest included Wi-Fi-linked components and infrastructure-related applications, such as those for base-stations, optical fiber networks, satellite communications, and national defense businesses.

WIN's fellow local companies — Visual Photonics Epitaxy Co (VPEC) and Advanced Wireless Semiconductor Co (AWSC) — have also reported strong sales for August, reports Taipei Times.

VPEC, one of the world's top three GaAs epitaxial wafer manufacturers, reported revenue of NT$218m, up 5.3% on July and 30.45% on a year ago (and its highest since July 2013). GaAs foundry AWSC reported revenue of NT$275m, up 4.4% on July and 221% on a year ago.

WIN, VPEC and AWSC are expected to report strong sales for the September quarter, considering the launch of the Apple iPhone 6 as well as demand for PA chips for non-Apple handsets and other Wi-Fi-linked components.

However, analysts say that Taiwan's GaAs industry still faces potential challenges in the long term, such as price competition from power amplifiers based on CMOS silicon, the Taipei Times report concludes.

www.winfoundry.com
www.taipeitimes.com

Anadigics' small-cell power amplifiers selected for Nextivity's new smart signal boosters

Broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA is shipping production volumes of its AWB7122 and AWB7222 small-cell power amplifiers to Nextivity Inc of San Diego, CA, USA (a global provider of indoor coverage technology). Nextivity is using Anadigics' small-cell power amplifiers in the third generation of its Cel-Fi smart signal boosters, which are authorized by 146 global carriers (including AT&T and T-Mobile) in 74 countries for use on their networks.

"Poor cellular signal strength continues to be an issue for many mobile subscribers inside their homes and businesses," says Nextivity's chief technology officer Michiel Lotter. "As a result, we are seeing ongoing demand for our smart signal boosters, which improve voice coverage, data throughput, and battery life," he adds. "We chose the competitively priced, high-performance Anadigics family of amplifier products as they support the broadest range of UMTS/LTE frequency bands, offer scalable power levels within a single footprint, and enable rugged designs capable of withstanding electrical overstress conditions," Lotter notes.

"While carriers continue to expand and strengthen their wireless infrastructure, many users still experience limited signal strength indoors," says Tim Laverick, Anadigics' senior VP of Infrastructure Products. "Nextivity's newest signal boosters utilize our high-performance small-cell power amplifiers to address this challenge, delivering enhanced coverage."

Anadigics' complete family of small-cell wireless infrastructure power amplifiers leverages the firm's unique InGaP-Plus technology and uniquely design architectures to deliver performance that, combined with a high level of integration, enables manufacturers to develop compact wireless infrastructure solutions that consume less power and provide higher throughput with greater coverage.

The AWB7122 small-cell power amplifier delivers 24.5dBm linear output power for ¼-Watt applications, while the AWB7222 power amplifier offers 27dBm linear output power for ½-Watt applications. Both feature high linearity (supporting WCDMA, HSPA, LTE FDD and TD-LTE small-cell base-stations), enabling picocells, enterprise-class femtocells, and high-performance customer premises equipment (CPE) to achieve higher throughput (data rates) and greater coverage area, it is claimed. The AWB7122 and AWB7222 provide 16% and 13% efficiency, respectively, to minimize power consumption and offer greater flexibility in the choice of network power sources, the firm adds.

www.cel-fi.com
www.anadigics.com

RFMD and TriQuint shareholders approve merger

RF Micro Devices Inc of Greensboro, NC, USA and RF front-end component maker TriQuint Semiconductor Inc of Hillsboro, OR, USA have each announced preliminary results of their respective special meetings of shareholders held on 5 September to approve the agreement and plan of merger and reorganization involving RFMD, TriQuint and Rocky Holding Inc.

RFMD shareholders voted to approve the merger agreement and approve, by non-binding advisory vote, the compensation arrangements for RFMD's named executive officers in connection with the transaction.

"Today's shareholder vote is a significant endorsement of our vision to create the new leader in RF solutions," says RFMD's president & CEO Bob Bruggeworth. "With the closing of this transaction, we will bring under one roof the industry's broadest portfolio of critical enabling technologies, with expertise in mobile devices and complex infrastructure and global aerospace/defense applications."

TriQuint shareholders voted to approve the merger agreement, as well as the following:

- the absence of a provision in Rocky Holding's amended and restated certificate of incorporation that would provide for the election of directors of Rocky Holding by majority vote, which provision is instead located in Rocky Holding's amended and restated bylaws;
- the compensation arrangements, by non-binding advisory vote, for TriQuint's named executive officers in connection with the merger; and
- the amended TriQuint 2013 Incentive Plan.

"We are combining two industry pioneers and recognized innovators to create a diversified market leader with the scale to better serve the increasingly complex needs of our customers," believes TriQuint's president & CEO Ralph Quinsey.

TriQuint and RFMD anticipate that the closing of the transaction will occur in second-half 2014, subject to the receipt of required regulatory approval and other customary closing conditions.

www.triquint.com
www.rfmd.com

RFMD and TriQuint unveil new company name Qorvo

RFMD and TriQuint have revealed that the holding company under which the two firms will combine will be named Qorvo Inc.

Pronounced 'kor-vo', the name aims to convey the ability to deliver the core technologies and innovation to enable customers to launch next-generation designs more rapidly.

"Our new name reflects our company's commitment to keep customers at the center of all that we do," says RFMD's president & CEO Bob Bruggeworth, who will serve as Qorvo's CEO. "Qorvo will offer the agility, innovation and precision customers need for success in mobile, infrastructure, and defense markets," he adds.

It is reckoned that, by combining TriQuint's and RFMD's engineering creativity, product development expertise, complete product portfolios, and high-volume manufacturing, Qorvo will rapidly translate R&D advances into large-scale production.

"Our companies have been RF industry pioneers developing many of the core technologies our world now relies on," comments TriQuint's CEO Ralph Quinsey, who will be Qorvo's non-executive chairman.

Qorvo is expected to be traded on the NASDAQ Global Stock Market under the ticker symbol 'QRVO'.

TriQuint's TQP9059 MMPA wins China ACE Award

TriQuint Semiconductor says its TQP9059, a versatile multi-mode, multi-band power amplifier (MMPA) module with envelope tracking, has earned an award in the Outstanding RF/Wireless/Microwave Products of the Year category at the 2014 China Annual Creativity in Electronics (ACE) Awards.

The highly integrated module not only prolongs battery life with new envelope tracking technology but also simplifies complex RF design for multi-band smartphones with a new mobile chip interface used by multiple chipset partners, says TriQuint. The device is designed on the firm's GaAs HBT technology with CuFlip assembly offering what is claimed to be state-of-the-art reliability, temperature stability and ruggedness. Its RF performance meets the stringent linearity, noise and harmonics requirements for multi-mode operation while simultaneously offering a system current consumption lower by 50mA than the nearest competitor, it is reckoned, thus improving battery life.

"For a second year in a row, TriQuint has been recognized by China ACE for our continuing contributions to China's electronics industry," says Locker Jiang, TriQuint's China sales director for Mobile Products. "The TQP9059's designation as one of the top products in the semiconductor space is a direct reflection of TriQuint's ongoing commitment to drive innovation and simplify RF design."

The TQP9059 is one of the earliest envelope tracking MMPAs to be in mass production supporting a leading smartphone, TriQuint claims. The product is included on reference designs by multiple chipset manufacturers and is being designed into next-generation smartphones from multiple OEMs.

www.globalsources.com

Skyworks' David Aldrich named CEO of the Year by Massachusetts Technology Leadership Council

Analog semiconductor maker Skyworks Solutions Inc of Woburn, MA, USA says that its chairman & CEO David J. Aldrich was named CEO of the Year by the Massachusetts Technology Leadership Council (MassTLC) during the 2014 Technology Leadership Awards. "I humbly accept it on behalf of all Skyworks employees, as any award for Skyworks belongs to our wonderfully talented and hard-working team," comments Aldrich.

MassTLC is the region's leading technology association and network for tech executives, entrepreneurs, investors and policy leaders. The council announced the winners during its 17th annual awards gala attended by more than 750 executives, technologists, investors, media, analysts and other members of the Massachusetts innovation ecosystem, as well as Massachusetts Governor Deval Patrick (himself a recipient of the 2014 Commonwealth Award).

"The MassTLC Leadership Awards shine a spotlight on the vibrancy of the state's position as both a pioneer and leader in technologies that are fueling Massachusetts' economy," says MassTLC's president & CEO Tom Hopcroft. "Skyworks Solutions and David Aldrich are among the elite innovators from the Bay State's deep talent pool."

Technology Leadership Award Winners were selected in each category by an independent panel of judges consisting of executives, investors, analysts, media and thought leaders in each of the 16 respective categories including: CEO of the Year, CTO of the Year, Emerging Executive of the Year, Private Company of the Year, Public Company of the Year, Start-up to Watch, Innovative Technology of the Year — Big Data, Innovative Technology of the Year — Cloud, Innovative Technology of the Year — Education Technology, Innovative Technology of the Year — Healthcare and Life Sciences, Innovative Technology of the Year — Internet of Things, Innovative Technology of the Year — Mobile Applications, Innovative Technology of the Year — Mobile Technology, Innovative Technology of the Year — Robotics, Innovative Technology of the Year — Sales & Marketing; Innovative Technology of the Year — Security.

http://masstlcawards.org/2014/2014-winners
www.skyworksinc.com

Skyworks receives Diamond Supplier Award from Lenovo for outstanding service & support

Analog semiconductor maker Skyworks Solutions Inc of Woburn, MA, USA has received the Diamond Supplier Award from Lenovo for providing "outstanding service and support".

The award, which is the highest recognition Lenovo provides to suppliers, specifically recognizes Skyworks for being a strategic partner and playing an instrumental role in delivering low-cost, customized solutions supporting the company's recent product launches. Lenovo uses a variety of Skyworks front-end solutions including multi-mode, multi-band power amplifiers (MMPAs), antenna switches, diodes and global positioning system (GPS) devices.

"Over the past 10 years Skyworks has been a valuable partner, particularly as Lenovo has continued to diversify beyond the personal computer into smartphones, tablets and smart televisions," says Lenovo's VP of procurement David Wang.

The award is Skyworks' second from Lenovo in two consecutive years. "We look forward to strengthening our partnership with Lenovo and supporting their continued growth in China and abroad," says Bradley C. Byk, Skyworks' senior VP of worldwide sales.

As the world's fourth-largest smartphone provider, Lenovo plans to expand its sales of smartphones beyond China, adding 20 new markets in the Middle East, Africa and Latin America. According to a market report from International Data Corp, Lenovo shipped 15.8 million smartphones in second-quarter 2014 and grew its market share to 5.4%, up from just 4.7% a year ago.

www.skyworksinc.com

IN BRIEF

Custom MMIC launches 50GHz distributed LNA

Custom MMIC of Westford, MA, USA has launched the CMD206, a DC–50GHz distributed low-noise amplifier (LNA) in die form.

The noise figure is under 3.5dB, gain is greater than 11dB, and P1dB (output power at 1dB compression point) is +12dBm at 30GHz. The amplifier requires an all-positive bias of only 4V @ 32mA (drain), 3V (gate).

An external drain bias network and input blocking capacitor are required for proper operation. The die offers full passivation for increased reliability and moisture protection.

Applications for the CMD206 include microwave radio and VSAT, telecom infrastructure, test instrumentation, military and space, and fiber optics.

www.CustomMMIC.com

GSI rejects proposed acquisition by GigOptix

GSI Technology Inc of Sunnyvale, CA, USA — a provider of static random access memory (SRAM) products primarily incorporated in networking and telecoms equipment — says that its board of directors has unanimously rejected the unsolicited, non-binding and conditional proposal to acquire the firm, announced on 19 August by GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical communications components for fiber-optic and wireless networks).

GigOptix proposed to acquire all of GSI's outstanding common stock for $6.50 per share, consisting of a combination of GigOptix common stock and cash (including $3.17 per share of GSI's own cash paid as a special dividend).

GSI communicated its response in a letter from chairman, CEO & president Lee-Lean Shu to GigOptix's co-founder, chairman, CEO & president Avi Katz. "After carefully and thoroughly reviewing your proposal, in consultation with its financial advisors Robert W. Baird & Co Inc and legal advisors DLA Piper LLP (US), our board has unanimously concluded that pursuing your unsolicited proposal would be contrary to the best interests of our stockholders," said Shu. "The board strongly believes that GSI Technology's prospects as a strong independent company are excellent and that our goal of continuing to build long-term stockholder value will be best served by remaining focused on the execution of our business plan," he adds.

"We are disappointed that GSI Technology's board of directors, without even engaging in a discussion with us, has rejected our acquisition proposal and chosen to deny its stockholders the opportunity to achieve a substantial premium and immediate liquidity for their shares," states Katz in a letter responding to GSI's board. "We are confident that moving forward promptly to consummate a transaction is in the best interests of all parties," he adds. "We are offering GSI Technology's stockholders superior value and the opportunity to participate in the upside of the combined company, which we believe is a better outcome than GSI Technology remaining an independent company," Katz continues. The combination should offer "an increasingly exciting set of solutions for customers", comprising both GSI's high-performance memory products for networking and telecoms equipment and GigOptix's high-speed communications components. "Together, this would allow us to strengthen the value proposition that we collectively provide to our customers through a wider range of companion and complementary products and more effectively challenge our respective competitors in the marketplace," Katz believes.

"In light of the value which we believe this combination brings, we continue to seek a negotiated agreement with GSI Technology, and will continue to explore all necessary steps to ensure that GSI Technology's stockholders are provided with the opportunity to realize the value inherent in our proposal," Katz states. "We therefore urge the GSI Technology board of directors to do the right thing and immediately engage in meaningful discussions with us so that we may deliver significant value to each of our stockholders."

www.gsitechnology.com
www.gigoptix.com

API Technologies launches high-reliability customizable 2–20GHz broadband amplifier

API Technologies Corp of Orlando, FL, USA, a designer and manufacturer of systems, subsystems, modules and components for RF, microwave, millimeter-wave, electromagnetic, power and security applications, has added the model BXHF1084 multi-octave broadband amplifier to its growing family of standard and configurable RF/microwave products. With its high-frequency capabilities and what is reckoned to be one of the industry's smallest footprints, the amplifier offers OEMs competitive advantage and faster time to market, it is claimed.

Providing S-, C-, X- and Ku-band operation in a single amplifier module, the BXHF1084's compact size, laser-welded housing and high-gain design (26dB typical) make it suitable for commercial and military applications including VSAT, SATCOM, point-to-point, multi-point, radar, and communications.

The broadband amplifier has an internal voltage regulator (allowing use with a wide range of available power supplies) and a small form factor (minimizing volume, allowing improved design flexibility in next-level assembly). Additionally, the amplifier offers a single positive bias, eliminating the need for negative rail or special power-up sequencing.

The BXHF1084 is configurable without additional engineering charges. The product is RoHS-compliant and available worldwide.

"This new broadband amplifier fills an industry need for rugged, high-performance amplifiers designed specifically for high-frequency applications," says Walter Witt, API's product line manager, RF/Microwave & Microelectronics (RF2M US).

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Peregrine boosts power handling by 60%, shrinks footprint by 75% and speeds switching by 350% in upgraded carrier-grade Wi-Fi switch

Peregrine Semiconductor Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-sapphire (SOS) and silicon-on-insulator (SOI) — has launched the UltraCMOS PE42424 high-isolation single-pole double-throw (SPDT) Wi-Fi RF switch, which is optimized for 802.11ac carrier and enterprise Wi-Fi access points.

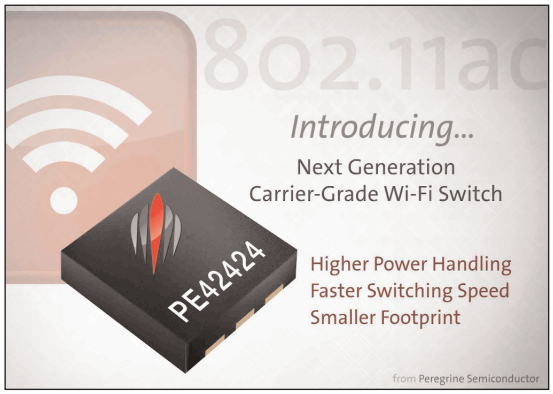
As a successor to last year's PE42423, the upgraded switch is 75% smaller and features a 60% increase in power handling and a 350% faster switching speed. The PE42424 is suited to transmit/receive switching applications for outdoor Wi-Fi access points that require high power handling and rugged, high-temperature performance. Peregrine says its RF switch enables these WLAN products to realize the promise of 802.11ac, which is offering high data throughput in increasingly dense, bring-your-own-device (BYOD) environments.

"Wi-Fi is by far the cheapest way to deliver mobile data so, at a worldwide level, the deployment of Wi-Fi access points is accelerating," says Joe Madden, founder & principal analyst at market research firm Mobile Experts. "More than 1.8 million 802.11ac access points will be deployed next year, including both indoor and outdoor applications. In addition, most indoor small cells will also include Wi-Fi access-point hardware for seamless integration of Wi-Fi with mobile services," he adds. "The wide bandwidth, high power and demanding linearity requirements of these access points drives a strong need for higher RF component performance."

Carriers have been experiencing an exponential increase in mobile data traffic, says Peregrine. To provide consistent quality of service, they are offloading this traffic to Wi-Fi networks, which are increasingly integrating 802.11ac into their small cells. Indoor units (IDUs) were the first Wi-Fi access points to adopt the 802.11ac standard, and Peregrine's inaugural Wi-Fi switch, the PE42423, was optimized for high performance within those devices. Now, outdoor unit (ODU) Wi-Fi access points are quickly adopting the 802.11ac standard, and their performance and environmental requirements are much more intensive. Peregrine developed the PE42424 to meet these specific 802.11ac-based ODU access point needs:

- high power handling of 8W (to accommodate the higher transmit power of the access-point radios);
- fast switching speed of 145ns (to enable higher throughput and data rates in high-density, BYOD environments);
- high port-to-port isolation (to reduce signal leakage between transmit and receive paths);
- temperature support up to 105°C (to withstand harsh environments and to reduce thermal constraints); and
- small 1.5mm x 1.5mm footprint (to reduce board area and offer engineers more design options for other functions).

"Peregrine is extending its Wi-Fi RF switch line to address the tough challenges faced by designers of next-generation 802.11ac access points," says senior marketing manager Kinana Hussain. "Our UltraCMOS technology and patented design techniques preserve the unmatched isolation performance of PE42424's predecessor while increasing the power-handling capability, improving switching speeds and reducing the form factor."



Peregrine's new PE42424 Wi-Fi switch.

The PE42424 supports the latest carrier-grade Wi-Fi device demands with additional features, including:

- high linearity over the entire power-supply range (with IIP3 of 61dBm and IIP2 of 125dBm), enabling system designs with lower supply rails and preventing linearity degradation through maximum power levels;
- high ESD rating of 2500V HBM on RF pins to ground (1000V CDM on all pins), increasing product reliability and easing manufacturing flow;
- smaller switch footprint that eliminates the need for external components (such as DC blocking capacitors); and
- control logic support for 1.8V and 3.3V and wide power supply range from 2.3V to 5.5V that provides design flexibility.

The PE42424 SPDT RF switch features fast switching time (145ns with a 125kHz switching rate) and high isolation (48dB at 2.4GHz and 35dB at 6GHz). The 50Ω absorptive switch supports +1.8V standard logic control and provides stable RF performance over a power supply range of 2.3–5.5V.

Samples, evaluation kits and volume-production parts are available now. Offered in a RoHS-compliant, 6-lead, 1.5mm x 1.5mm QFN package, the PE42424 costs $0.49 each for 10,000-quantity orders and $0.44 for 25,000-quantity orders.

www.psemi.com

Peregrine extends RF SOI switches from 13GHz to 18GHz

Peregrine Semiconductor has launched the UltraCMOS PE42542 and PE42543 18GHz single-pole four-throw (SP4T) broadband RF switches.

Expansion of the high-frequency portfolio — launched in 2013 with the PE42520 and PE42521 SPDT 13GHz switches — represents the first RF SOI switches to deliver a high-performance alternative to incumbent GaAs technology, it is claimed. The new switches uniquely offer test & measurement, wireless backhaul and military systems designers additional features such as broad bandwidth, low-frequency power handling, high ESD protection and a fast settling time, the firm adds.

"Peregrine is reaching high-frequency performance levels previously considered unachievable in RF SOI," says senior marketing manager Kinana Hussain. "Our in-house, high-frequency design expertise, coupled with our UltraCMOS technology, has enabled Peregrine to break the 13GHz RF SOI barrier last year and expand our high-frequency portfolio to 18GHz today, with a roadmap to many more high-frequency components."

Peregrine's high-frequency portfolio features high linearity that meets or exceeds GaAs switch performance across the entire frequency band, the firm claims. Since they are based on UltraCMOS technology, the components have attributes that GaAs technology cannot match, it adds:

- broad bandwidth that maintains performance across the frequency range;
- low-frequency power handling that maintains signal fidelity as the power passes through;
- fast settling time that avoids the gate-lag phenomenon;
- high linearity of 58dBm (IIP3) that ensures minimal signal compression;
- high ESD rating that offers four times more protection; and
- low power consumption that uses less than 5% power.

In addition, the PE42542 and PE42543 18GHz RF switches offer standard 1.8V and 3.3V input logic control and consistent performance across a wide 2.3–5.5V supply range. For special RF requirements, the PE42543 has a fast switching time of 500ns.

The PE42542 and PE42543 SP4T RF switches accommodate a frequency range from 9kHz to 18GHz and offer low-frequency power handling of 10dBm at 9kHz. They also offer consistent performance across a wide supply range with no drift in insertion loss and phase. Both switches feature 120µA power-supply-current consumption (a fraction of that required by competing GaAs switches, it is claimed).

Samples, evaluation kits and volume-production parts are available now. Offered in a RoHS-compliant, 29-lead 4mm x 4mm LGA package, the PE42542 and PE42543 are $18.15 each in 10,000-unit orders.

www.psemi.com

RFaxis offers bare die versions of entire portfolio of pure-CMOS single-chip, single-die RFeICs

Fabless semiconductor firm RFaxis Inc of Irvine, CA, USA, which designs RF semiconductors and embedded antenna solutions for wireless connectivity and cellular mobility, is to offer its entire product line of pure-CMOS, single-chip/ single-die RF front-end ICs (RFeICs) in bare die form, enabling customers to further reduce the size and bill of materials (BOM) cost of wireless products for both the Wi-Fi and Internet of Things (IoT) markets.

RFaxis has been in mass production of its RFeICs mostly in industry-standard quad flat no-lead (QFN) packages that range from 3mm x 3mm to 1.6mm x 1.6mm in size, serving a wide spectrum of the fast-growing wireless industry, including IEEE 802.11b/g/a/n/ac WLAN, 802.15.4/ZigBee, Bluetooth/ Bluetooth Low Energy, wireless audio/video, home automation, smart energy, and many emerging applications for the IoT.

"By offering customers a complete RF front-end in bare die form, we have set the stage to redefine the landscape of RF for the wireless industry," claims chairman & CEO Mike Neshat. "By gaining access to bare die, our ODM/OEM customers, specifically our module partners, will be able to offer more compact solutions at much lower costs to their end customers," he adds.

"The target markets for our RFeICs continue to grow explosively, with Wi-Fi shipments projected to exceed 3 billion units annually by 2017 and the IoT market to reach at least 50 billion units annually by 2020," Neshat continues. "Some industry experts forecast that the unit cost of IoT sensor nodes will be nearing the $1 range in order to make them ubiquitous, leaving little room for costly semiconductor components such as GaAs or SiGe," he adds. "With our pure-CMOS bare die solutions, we offer the industry the much sought-after ultimate solution in terms of size, performance and cost."

Traditionally, the RF front-end — which typically includes the power amplifier (PA) to increase transmission distance, the low-noise amplifier (LNA) to optimize receive sensitivity, and the antenna switch — has been implemented by stitching together several discrete ICs onto a dielectric substrate or package lead-frame, forming the RF front-end module (FEM). In contrast, using its patented technology, RFaxis provides the same functionality and performance of traditional FEMs but with one single-chip/single-die device, fabricated in an industry-standard CMOS process.

RFaxis says that the extremely rugged designs of its RFeICs (including robust ESD and high yield rate) aid the integration of its bare die with other RF transceivers/ SoCs into SiP (system-in-package) or other forms of wireless modules. As an example, the RFX1010 — a sub-GHz ZigBee/ISM RFeIC that integrates a half-watt PA, LNA and antenna switch on a single die in standard 0.18 micron CMOS process — is an integral part of a multi-chip module (MCM) offered by one of RFaxis' transceiver partners which has enabled what is claimed to be the industry's highest-performance sub-GHz solution with +27dBm transmit power. The RFX1010 has passed the most rigorous qualification process required for industrial-grade applications such as water and gas meters.

www.rfaxis.com

MACOM launches 200W cw power- L-band SMT limiter

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which manufactures analog semiconductors, components and subassemblies for analog, RF, microwave and millimeter-wave applications) has launched a 200W continuous-wave (cw) power L-band limiter with what is reckoned to be four times the power handling of its nearest competitor.

The MADL-011014 is a high-power limiter that is suited to the most demanding applications requiring high peak and cw power receive protection in air-traffic management and radar systems. The passive, fully matched limiter operates over the 1–2GHz bandwidth and integrates the equivalent of 19 discrete diode and passive components into a single packaged solution.

The device features 200W cw power handling and up to 1000W of peak power handling under 300μs and 10% duty-cycle pulse conditions.

The MADL-011014 has 0.35dB insertion loss, 19dB return loss, 53dBm CW incident power ,and 19dBm flat leakage power at +55dBm and is offered in a low-RGA fully hermetic package with a compact 10.1mm x 6.2mm x 3.2mm outline.

"The high power limiter is designed to provide a complete solution for the most demanding applications in the smallest possible size," says product manager Paul Beasly. "The MADL-011014 provides industry-leading power and small-signal performance in a SMT package which allows our customers to complete designs more rapidly, exceed system requirements, and protect critical systems with superior reliability under the harshest environmental conditions," he claims.

Samples of the MADL-011014 are available from stock.

www.macom.com

NRL team receives Outstanding Paper Award for large-area GaN-on-graphene

An interdisciplinary team at the US Naval Research Laboratory (NRL) has received the Japan Society of Applied Physics' 2014 Outstanding Paper Award.

The award is only given to a select group of papers that present excellent achievement in applied physics and are published in the last 24 months in Japan Society of Applied Physics journals, with fewer than 10 papers selected out of about 6300.

The paper describes NRL research that resulted in the first-time synthesis of large-area, high-quality gallium nitride (GaN) on graphene, the latter being previously formed on a wafer of semiconducting silicon carbide (SiC).

"This is the first-ever demonstration of epitaxy of a conventional semiconductor on an 'inert' two-dimensional material," claims NRL's Dr Charles Eddy, a materials engineer who heads the research team. "Inert 2D materials, such as graphene, do not have out-of-plane bonds to permit epitaxial growth of materials. Here, we've combined a gentle, but temperature-sensitive modification to the surface of the 2D material and a recently developed low-temperature epitaxial growth process to overcome this limitation," he adds. "The ability to combine new 2D materials and conventional semiconductors with high-quality interfaces opens up many opportunities for new electronic devices."

Eddy describes that the initial vision for the structures they have created is for use in transistors that could operate in the terahertz frequency range for various RF applications including communications and sensing.

This is the first-ever demonstration of epitaxy of a conventional semiconductor on an 'inert' 2D material

Looking ahead, the research team continues to develop both 2D materials and the low-temperature epitaxial growth process (atomic layer epitaxy) to explore more advanced device structures for electronic and optoelectronic applications.

The members of the interdisciplinary team are: Drs Neeraj Nepal (first author), Virginia D. Wheeler, Travis J. Anderson, Michael A. Mastro, Rachael L. Myers-Ward, Jaime A. Freitas Jr, D. Kurt Gaskill and Francis J. Kub from the Electronics Science and Technology Division (ESTD); Dr Syed B Qadri from the Materials Science and Technology Division; Drs Sandra C. (Hernandez) Hangarter and Scott G. Walton from the Plasma Physics Division; and Dr Luke O. Nyakiti (ex-postdoc in ESTD, now faculty at Texas A&M University).

www.nrl.navy.mil

Anvil transfers 3C-SiC on Si wafer production to Norstel

Anvil Semiconductors Ltd of Coventry, UK has secured a production source for its proprietary 3C-SiC on silicon epitaxial wafers through commercial silicon carbide (SiC) wafer and epitaxy supplier Norstel AB of Norrköping, Sweden.

Spun off from Finnish silicon wafer manufacturer Okmetic in 2005, Norstel makes n-type conductive and semi-insulating SiC substrates and single-crystal epitaxial layers by chemical vapor deposition (CVD). As well as epitaxy, Norstel also offers services for characterization and polishing of semiconductors used in power and high-frequency electronics.

Anvil was spun off in August 2010 from the University of Warwick's School of Engineering by its technology commercialization subsidiary Warwick Ventures Ltd in order to exploit patented developments in SiC power semiconductor technology. The firm's technology enables the growth of device-quality 3C-SiC epi on 100mm silicon wafers to thicknesses that allow the fabrication of vertical power devices. The proprietary process is said to overcome mismatches in lattice parameter and thermal coefficient of expansion and can be migrated onto 150mm wafers and potentially beyond. The material has applications ranging from power devices and LEDs to medical devices and MEMS.

Anvil's process for the growth of device-quality 3C-SiC epilayers on silicon wafers has been transferred onto production reactors at Norstel's facilities. Layers grown using Anvil's patented stress control techniques permit both 650V and 1200V devices to be realised.

Anvil is developing vertical Schottky barrier diodes (SBDs) and metal-oxide-semiconductor field-effect transistors (MOSFETs) on its 3C-SiC on silicon wafers for supply and license to the multi-billion dollar power electronics market. The use of silicon substrates and epitaxial growth of cubic SiC enables the fabrication of devices with the performance and efficiency benefits of SiC but at significantly lower material and manufacturing costs, a key target for the power electronics industry, says Anvil.

"Getting the process onto production equipment at Norstel underlines the capabilities of our technology," says Anvil's CEO Jill Shaw. "It opens the way for the use of multi-wafer reactors for our future production needs and a move to 150mm-diameter wafers," she adds.

"Our proven high-quality production expertise and capabilities in SiC epitaxy have helped Anvil to demonstrate the viability of their 3C-SiC solution," comments Norstel's chief commercial officer Ronald Vogel. "Norstel's manufacturing capacity will pave the way for Anvil's volume production," he adds.

www.anvil-semi.co.uk

Norstel and Ascatron ally to offer SiC epitaxy

Ascatron AB of Kista (Stockholm) and Norrköping-based Norstel AB in Sweden have entered into a cooperation agreement to jointly address the market for silicon carbide (SiC) epitaxy.

Spun off in 2011 from microelectronics and optics research institute Acreo AB in Kista, Ascatron specializes in silicon carbide (SiC) epitaxial material and device design. Using 3DSiC technology, the firm provides the complete doping structure based on epitaxy, enabling material quality and device performance unattainable through current methods, it is claimed. With 10 staff in Sweden currently, Ascatron focuses on fast delivery of custom-designed epi-wafers in small series for market verification and ramp up to large volume production. To support customer product development, it offers complete fabrication of device wafers and technology licensing.

Both Norstel and Ascatron are already providing SiC epi to the power electronic industry. But, by utilizing and sharing their respective expertise, equipment and capabilities, the firms expect to leverage their businesses. Another reason for the cooperation is sharpened demand for high-performance epi in terms of layer thickness, advanced structures and higher quality, driven by semiconductor device makers targeting higher voltages, new device types and better yield in device fabrication.

While Norstel's core offering is SiC crystal growth and wafers including epitaxy for volume production, Ascatron specialty is customized SiC epi and device design. "By combining the proven epitaxy production capacity of Norstel with our experience of advanced material, we will be able to serve all type of SiC epitaxy needs, from serial production of low-defect epi for Schottkys and MOSFETs, to R&D prototyping of thick epi with our unique buffer technology for future bipolar devices like IGBTs," says Ascatron's CEO Christian Vieider.

"We see the cooperation with Ascatron as a natural step to further utilize our capabilities in SiC epitaxy and to increase our market reach," says Norstel's president & acting CEO Per Zellman, underlining the strengths of a complete offering. "The companies have complementary capabilities and we are already cooperating successfully in projects like the EU project SPEED [Silicon Carbide Power Electronics Technology for Energy Efficient Devices] for new generations of high-power semiconductor devices."

The new constellation is able now to provide SiC epilayers with both n- and p-doping up to 250mm thick on wafers up to 100mm diameter (with 150mm wafers to follow soon).

www.ascatron.com
www.norstel.com

Japan's Sanix chooses Cree's 1200V silicon carbide MOSFETs for 9.9kW solar inverters

Cree Inc of Durham, NC, USA says that its C2M, 1200V, 80mΩ silicon carbide (SiC) MOSFETs have been selected by Japan's Sanix Inc, to be designed into their new 9.9kW three-phase solar inverters for use in the construction of commercial photovoltaic systems in the fast-growing Japanese solar energy market.

"Through this partnership with Cree and their SiC technology, Sanix is able to capture more market share in the competitive Japan solar market," says Sanix's general manager Hiroshi Soga. "Cree's silicon carbide MOSFETs were critical for Sanix to meet our efficiency and thermal design targets. SiC switches reduced losses in our inverter electronics by more than 30% versus the silicon super-junction MOSFETs we were considering," he adds. "In addition to providing a large efficiency gain, Cree's latest generation C2M SiC MOSFETs were priced competitively, making it possible to replace lower-voltage, less rugged, and less efficient silicon MOSFETs."

Utilized in the primary power conversion stage of the solar inverter, Cree's 1200V C2M0080120D MOSFETs feature faster switching characteristics and up to one-third the switching losses of comparably rated 900V silicon super-junction MOSFETs, it is claimed. By significantly reducing switching losses, the SiC MOSFETs enable lower total system energy losses, higher frequency switching, and cooler operating temperatures, Cree adds. These benefits improve conversion efficiency and reduce the system's size, weight, complexity, and thermal management requirements. At the system level, performance is improved, cost is decreased, and lifetime of the inverter is extended, it is reckoned.

A Cree SiC MOSFET, as selected for Sanix's new solar inverters.

"Cree SiC power devices can provide significant advantages with regard to PV inverter efficiency, reliability, and cost, and will provide Sanix with a critical competitive advantage as they continue to expand their share of the Japanese solar market," says Cengiz Balkas, general manager & VP, Cree Power and RF.

Demonstrated to achieve up to three times the power density of typical silicon technology, Cree's C2M family of SiC MOSFETs is available in 1200V and 1700V, ranging from 1Ωmω to 25mΩ. C2M MOSFETs have been designed into a range of industrial power applications since their launch in March 2013 and continue to experience increasing demand. Cree is currently delivering production volumes of SiC MOSFETs to Sanix and other PV inverter manufacturers, as well as to makers of industrial power supplies, auxiliary power converters, battery chargers, and motor drives.

https://sanix.jp/index_e.htm
www.cree.com/Power/Products/MOSFETs

Cree participates in roundtable on SiC-based power converters at Darnell Power Forum

Cree participated in the 11th annual Darnell Power Forum (DPF 2014) in Richmond, VI (23–25 September). As part of Darnell's Energy Summit 2014 (a solutions-oriented conference and exhibition event that also hosts the Green Building Power Forum and the Smart Grid Electronics Forum), the international three-day forum focused on advanced power conversion technologies enabling the development of next-generation power systems.

On 23 September, in the roundtable discussion 'Where Does SiC Fit?' a panel of experts highlighted SiC as the 'most mature' of new semiconductor materials vying for a place in next-generation power converters, and address topics such as the applications in which SiC brings the most value and how SiC compares to other new materials. Dr Jeffrey Casady, business development & programs manager at Cree, joined fellow panellists Dr Daniel Fernández (chief technology officer of INAEL Electrical Systems and Coordinator of Project SPEED), Baxter Moody (director of device development at HexaTech Inc, Alex Lidow (CEO of Efficient Power Conversion Corp), and Carl Blake (vice president at Transphorm Inc).

The moderator was Alex Huang, Progress Energy Distinguished Professor at North Carolina State University.

http://dpf.darnell.com
www.cree.com/Power

Dow Corning expands Prime Grade SiC wafer portfolio from 100mm to 150mm diameter

Prime Grade portfolio on show at ECSCRM 2014 in Grenoble

Dow Corning Corp of Midland, MI, USA, which provides silicon and wide-bandgap semiconductor technology, is now offering 150mm-diameter silicon carbide (SiC) wafers as part of its Prime Grade portfolio.

Launched in May with 100mm SiC wafers, the Prime Grade portfolio now also includes three tiers of manufacturing-quality 150mm SiC substrates — labeled Prime Standard, Prime Select and Prime Ultra. Each tier offers increasingly tighter tolerances on critical defect types that adversely impact device performance, such as micropipe density (MPD), threading screw dislocations (TSD) and basal plane dislocations (BPD).

"SiC wide-bandgap power semiconductors have rapidly evolved from a cutting-edge niche into an established technology sector that is increasingly focused on the manufacturing economies afforded by SiC crystal quality, wafer size and other critical factors," says Tang Yong Ang, vice president, Compound Semiconductor Solutions, at Dow Corning. "Dow Corning's decision to expand its Prime Grade portfolio to include 150mm-diameter SiC wafers aims to meet this very competitive demand," he adds. "As we rapidly scale production of these high-quality wafers, our customers will be able to more confidently pinpoint the SiC substrate that optimizes the performance and cost of their next-generation device design while leveraging the improved economies of scale offered by larger wafer diameters."

While many SiC wafer manufacturers promise low micropipe densities for their 150mm substrates, Dow Corning claims to be among the first to specify low tolerances of other defect types, such as TSD and BPD. Such defects reduce device yields and inhibit the cost-efficient manufacturing of large-area, next-generation power electronic devices with higher current ratings.

All Prime Grade SiC wafers offer consistent mechanical characteristics to ensure compatibility with existing and developing device fabrication processes, the firm says. The newly expanded Prime Grade portfolio of 150mm SiC substrates includes:

- Prime Standard SiC wafers that guarantee MPD of ≤1cm^{-2}, offering an option for balancing performance and cost when designing simpler SiC power electronic components, such as Schottky or junction barrier Schottky diodes, with low to medium current ratings.
- Prime Select SiC wafers that deliver more stringent tolerances for MPD (≤1cm^{-2}) and TSD (≤300cm^{-2}), making them suitable for more demanding SiC devices such as pin diodes or switches.
- Prime Ultra SiC wafers enable the design of high-power devices that require the highest crystal quality. SiC substrates in this tier deliver extremely low MPD (≤1cm^{-2}), TSD (≤200cm^{-2}), BPD (≤3000cm^{-2}) and a tightened wafer resistivity distribution for the design of the most advanced SiC power electronic devices, including next-generation switching devices such as metal-oxide-semiconductor field-effect transistors (MOSFETs), junction-gate field-effect transistors (JFETs), insulated-gate bipolar transistors (IGBTs) and bipolar junction transistors (BJTs) or pin diodes. The substrate quality in this tier can also benefit high-voltage (3.3kV and higher) and high-current device designs.

SiC wide-bandgap power semiconductors have rapidly evolved from a cutting-edge niche into an established technology sector that is increasingly focused on the manufacturing economies afforded by SiC

"Dow Corning's close customer collaboration in both silicon and wide-bandgap semiconductor technologies has given us a clear understanding of the competitive demands and opportunities in these markets," says chief technology officer Gregg Zank. "Combined with our unique expertise and market position, our growing reputation for outstanding SiC crystal quality, expanding epitaxy services and competitive pricing structures, Dow Corning is enabling our customers worldwide to compete and succeed in the fast-growing power electronics industry," he adds.

Prime Standard, Prime Select and Prime Ultra grades of both 100mm and 150mm SiC wafers are available globally from Dow Corning for development and sampling in standard production.

Dow Corning highlighted its Prime Grade portfolio of both 100mm and 150mm SiC wafers at the European Conference on Silicon Carbide and Related Materials (ECSCRM 2014) in Grenoble, France (21–25 September).

Also, in Session 'TU1 – Bulk', the firm gave an industrial talk on 'New 100mm and 150mm SiC wafer prime grade scheme for optimized device designs'.

In addition, in the poster sessions, Dow Corning presented three posters:

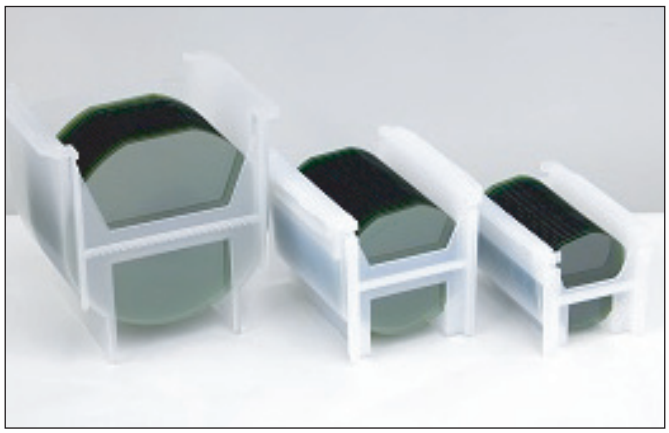
- (MO-P-02) 'Advanced Large Area 4H SiC Wafer Technology for Power Device Production' by Jeff Quast;
- (TU-P-15) 'Progress of SiC epitaxy on 150mm substrates' by Jie Zhang; and
- (WE-P-07) 'Effect of Surface Damage on SiC Wafer Shape' by Kevin Moeggenborg.

http://ecscrm2014.org
www.dowcorning.com

SDK boosts 6" SiC epi production capacity for power devices from 400 to 1100 wafers per month

Shipment of new-grade SiC epi with fewer defects and higher uniformity to start in October

Tokyo-based Showa Denko K.K. (SDK) has increased its capacity for producing 6" (150mm)-diameter silicon carbide (SiC) epitaxial wafers for use in power devices from 400 to 1100 wafers per month. SDK has hence increased its total SiC epiwafer production capacity in terms of 4" (100mm) wafer equivalents by about 60% from 1500 to 2500 wafers per month. Also, in October, SDK will start shipping a new grade of SiC epiwafer with fewer defects and higher uniformity.



SiC epiwafers with (from left to right) diameters of 6-, 4- and 3-inches.

Compared with mainstream silicon-based semiconductors, SiC power devices using SiC epiwafers can operate under relatively high-temperature, high-voltage and heavy-current conditions while substantially reducing energy loss, notes SDK. SiC power devices are hence regarded as next-generation power devices that enable the production of smaller, lighter and more efficient power control modules. Inverters based on SiC power devices are already used in applications such as power sources for servers in data centers, decentralized power generation systems utilizing new energy sources, and subway railcars. Moreover, some car makers and their suppliers have recently announced that they will use inverters based on SiC power devices in electric vehicles and hybrid electric vehicles (EVs/HEVs). Demand for SiC power devices is hence expected to rise.

SDK produces and sells 3", 4" and 6" SiC epiwafers. To increase the supply of 6" wafers, which can help to increase power device manufacturing productivity, the firm has added chemical vapor deposition (CVD) equipment that can be applied to the production of all sizes of SiC epiwafers in its range. The new equipment improves epiwafer productivity by about 30%, further reducing power-device production costs.

SiC-based power control modules for use in automobiles, power generation facilities, power transmission facilities and high-speed trains are now required to have heavier withstanding currents, while market demand for the SiC power control modules is expected to grow in the near future. To meet these requirements, the enlargement of SiC chip size is necessary.

To prevent a deterioration of yield rates in producing large-sized SiC chips from epiwafers, in October SDK will begin selling a new grade of SiC epiwafer with fewer surface defects (0.25 defects/cm^2 versus 0.5 defects/cm^2 for current-grade wafers). The new-grade products should enable users to expect an improvement in yield rate of more than 10% in the production of large SiC chips for the above applications (as estimated for chips of 7–10mm^2).

www.sdk.co.jp

Custom MMIC launches Ku- and Ka-band GaN PAs

Custom MMIC of Westford, MA, USA, a developer of performance-driven monolithic microwave integrated circuits (MMICs), has added to its expanding product line with the CMD216, a 14–18GHz gallium nitride (GaN) power amplifier in die form suitable for Ku-band communications systems.

The CMD216 delivers 16dB of flat gain across the entire 14–18GHz bandwidth, a P1dB (output power at 1dB compression point) of +37dBm, and a saturated output power of +38dBm. The device requires a bias of V_{dd} = 28V, 550mA, and V_{gg} = –3.4V. The amplifier also has a power-added efficiency (PAE) of 32% or more.

Custom MMIC has also added the CMD217, a 28–32GHz GaN power amplifier in die form, suitable for applications including Ka-band communication systems where high power and high linearity are required.

The CMD217 has more than 20dB of gain across its operating frequency range, with a corresponding P1dB of +36.7dBm and saturated output power of +39.3dBm (8.5W). PAE is 28–35% across the band.

The CMD216 and CMD217 have a fully matched 50Ω design and only requires external bypass capacitors to complete the bias circuitry. The die are passivated for increased reliability and moisture protection.

www.custommmic.com

Raytheon UK and Newcastle University team to investigate SiC interface defects

Raytheon UK's semiconductor business unit in Glenrothes, Scotland, UK has embarked on a Knowledge Transfer Partnership (KTP) project, in conjunction with researchers at Newcastle University, to enhance the performance of silicon carbide (SiC) electronic devices, specifically for Raytheon's own SiC CMOS process.

KTPs are supported by Innovate UK (formerly the Technology Strategy Board), the UK's innovation agency. Raytheon UK's KTP with Newcastle University is studying the characteristics of the interface between SiC and silicon dioxide (SiO_2), which critically impacts on the performance of a metal-oxide-semiconductor field-effect transistor (MOSFET).

'Trap' defects in the interface between the two materials affect the threshold voltage and maximum current that a MOSFET can handle. "Interface defects represent a significant obstacle in the mass adoption of silicon carbide technology in a wide range of sectors, such as aerospace, automotive, rail and energy, in which increasingly high-performance devices are required," says John Kennedy, head of Raytheon UK's Integrated Power Solutions.

Raytheon UK says that a detailed understanding of the interface behavior will enable it to optimize its manufacturing processes to minimize the occurrence of traps, resulting in not only higher-performance devices for its own power modules, products and systems but also for those customers using the firm's foundry services.

Interim findings of the KTP project, and other high-temperature SiC CMOS integrated circuit studies, will be presented at the European Conference on Silicon Carbide and Related Materials (ECSCRM 2014) in Grenoble, France (21–25 September).

In the long-term, the project aims to publish results on the development of characterization metrics for the SiC/SiO_2 interface, modelling of the impacts of defects on the observed MOSFET characterizations, short-loop trials of novel oxide structures and processing, full CMOS wafer integration of the optimized oxide structures and evolutionary repetition of the process optimization and characterization to continue the development process.

"Our foundry remains open to support silicon carbide power device development programs across the globe," notes Kennedy. "Customers at any part of the product development cycle can benefit from our experience and proven ability to take SiC device designs and processes through development stages to full production."

www.raytheon.co.uk/semiconductors
www.ncl.ac.uk/eee/research/groups/etm/etm-sic.htm

MACOM showcasing live GaN-on-Si demo at EuMW

At European Microwave Week (EuMW 2014) in Rome, Italy (5–10 October), M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for analog, RF, microwave and millimeter-wave applications) is showcasing its gallium nitride (GaN) product portfolio along with a live GaN-on-silicon demonstration. MACOM will also feature a suite of new products targeted at applications spanning industrial, scientific, medical, E-band point-to-point wireless and X-band radar.

At EuMW, MACOM is presenting:

- GaN portfolio — featuring what is claimed to be the industry's broadest portfolio of GaN power products, ranging from 100W GaN in plastic to 1000W ceramic GaN devices.
- Live demonstration of MACOM's GaN-on-Si integrated amplifier family, featuring matched, broadband, integrated amplifiers operating over a 30–2500MHz band, showcasing the ease of use of the products for a variety of applications.
- A new family of high-performance, ultra-compact broadband mixers, suitable for multi-market customers.
- X-band multi-function module — a fully integrated MMIC packaged in a 7x7 QFN, enabling dual path-transmit/receive operation over the X-band for weather and commercial radar applications.

MACOM staff are also presenting the following papers and posters:

- 'Improving GaN on Si Power Amplifiers Through Reduction of Parasitic Conduction Layer' by Lydon Pattinson, Tim Boles, Gary Lopes;
- 'A Novel 10MHz to 70GHz Surface Mount Amplifier for Broadband Applications' by Henrik Morkner, Alfy Riddle;
- '28Watt X-band Silicon P-I-N Diode RFIC Switches' by Jim Brogle, Andrey Rozbicki, Tim Boles;
- 'A 25W X-band GaN PA in SMT Package' by Johnathan Lecky;
- 'A High Linearity Amplifier Using an Optimized Transconductance Process' by A. Noll, D. Pal A. E. Parker, S. J. Mahon; and
- 'A Single-Chip, Low-Noise Video Amplifier with Variable Gain in a 0.5µm GaAs pHEMT Technology' by I. Bisby.

MACOM staff are also presenting in the following Microapp sessions:

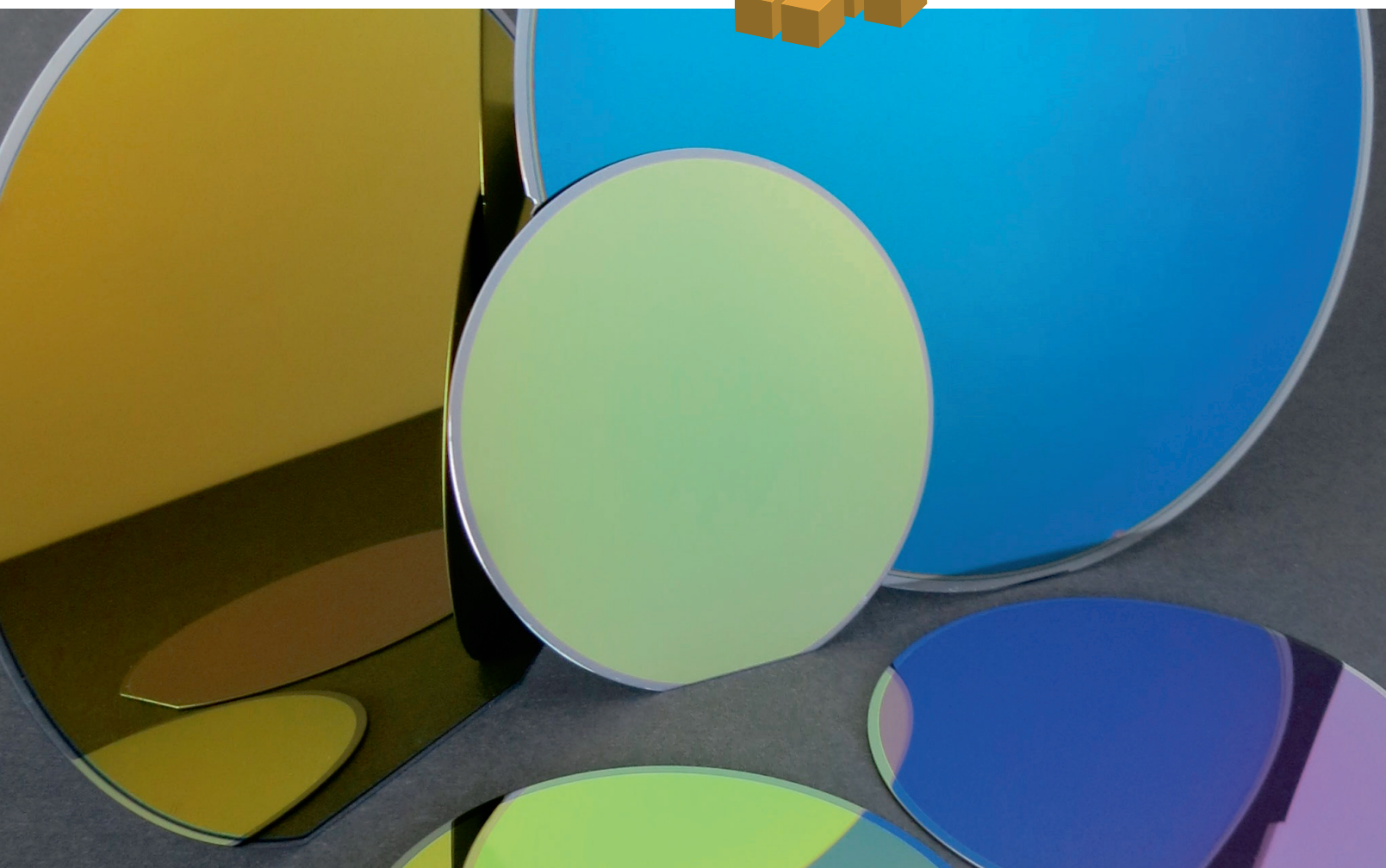
- 'GaN-on-silicon RF & Microwave HEMTs' by Douglas Carlson;
- 'GaN-on-silicon carbide Pallet Amplifier Advantages' by Gary Lopes; and
- 'Pulsed Power Thermal Considerations' by Timothy Boles.

www.macomtech.com
www.eumweek.com

THE FUTURE OF SEMICONDUCTORS HAS ARRIVED...

Translucent

www.translucentinc.com



III-N MOCVD HEMT

Rare Earth Oxide (REO)

Silicon

GaN-on-Si Epiwafers

Translucent's revolutionary GaN-on-Si technology employs a patented Rare Earth Oxide (REO) layer that electrically isolates the device layers from the substrate and also provides a physical barrier to stop silicon diffusion.

- Insulating REO buffer isolates GaN from silicon
- REO enables superior high voltage device performance at a competitive price

Germanium

Silicon

Ge-on-Si Epiwafers

Translucent's germanium-on-silicon technology forms the foundation for our photonics materials and multi-junction solar cells for Concentrated Photovoltaic (CPV) applications.

- Germanium directly on silicon
- Tailored bandgap via Group IV alloys

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ON Semiconductor and Transphorm to co-develop and co-market GaN-based power systems

ON Semiconductor of Phoenix, AZ, USA, which supplies silicon-based power and signal management, logic, discrete and custom devices for energy-efficient electronics, and Transphorm Inc of Goleta, near Santa Barbara, CA, USA, which designs and provides gallium nitride (GaN)-based power conversion devices and modules for power supplies and adapters, motor drives, solar inverters and electric vehicles, have partnered to co-develop and co-market GaN-based products and power system solutions for high-voltage applications in the industrial, computing, telecom and networking sectors.

The strategic partnership aims to leverage strengths inherent in both companies. Transphorm claims to be the first firm to bring to market production-qualified 600V GaN-on-Si transistors. As a supplier of energy-efficient power solutions, ON Semiconductor has expertise in system design and a portfolio ranging from power discretes, high-performance AC/DC controllers and integrated switchers to full custom ASIC power management solutions.

For power applications, GaN has been shown to deliver significant performance advantages compared to silicon-based devices. ON Semiconductor and Transphorm say that the new generations of packaged products they are co-developing will provide reliable, qualified solutions that aim to enable designers to achieve previously unobtainable levels of efficiency and power density.

"ON Semiconductor clearly recognizes the inherent benefits that GaN technology can bring to the power electronics market and we are excited about partnering with a recognized and proven leader in this area in addition to pursuing our own GaN development work," says Bill Hall, executive VP & general manager of the firm's Standard Products Group. "Together we can bolster customer confidence in this new technology and accelerate broad market adoption," he reckons.

Partnering with a leading power semiconductor company like ON Semiconductor will provide Transphorm's customers with a broader set of GaN-based products and solutions, notes Transphorm's CEO Fumihide Esaka. "This relationship is not only significant for faster penetration of GaN in the marketplace but also meaningful for the entire power conversion industry," he claims.

The first co-developed solutions based on 600V GaN transistors (addressing high-power-density applications in the 200–1000W range for compact power supplies and adapters for telecom and server markets) are expected to be available for sampling before the end of 2014. The packaged transistors will include low-voltage MOSFET silicon from ON Semiconductor for the cascoded switch plus proven GaN high-voltage high-electron-mobility transistors (HEMTs) from Transphorm. Co-packaging, assembly and test of the devices will be performed at ON Semiconductor production facilities.

Power system reference designs will be provided to customers, enabling implementation of new solutions with GaN-based transistors and the high-performance AC/DC controllers required to take full advantage of the technical benefits of GaN devices.

www.transphormusa.com
www.onsemi.com

Mouser to be GaN Systems' worldwide distributor

GaN Systems Inc of Ottawa, Ontario, Canada, a fabless developer of gallium nitride (GaN)-based power switching semiconductors for power conversion and control applications, has signed an exclusive worldwide distribution agreement with Mouser Electronics Inc (an engineering resource and global authorized distributor of semiconductors and electronic components).

Based on proprietary Island Technology, the firm says that its GaN power transistors offer advantages over traditional silicon MOSFETs and IGBTs to bring smaller, lighter and more efficient power electronics to applications including consumer appliances, data-center server racks, heavy-duty battery-operated power tools, and notebook travel adaptors.

GaN Systems says that its Island Technology IP incorporates the wide bandgap and superior switching speed, temperature, voltage and current performance of GaN into a unique structure that maximizes wafer yields and produces highly efficient transistors up to four times smaller and at lower cost than tradition design approaches.

To take advantage of the Island Technology devices' intrinsic fast switching and dense current-carrying capability, GaN Systems has also designed GaNPX packaging, which has no wire bonds, minimizing inductance and thermal resistance and increasing reliability.

With current ratings of 8A to 200A, GaN Systems claims to be the first company to offer a comprehensive product range of gallium nitride devices to the global market. Initial products distributed by Mouser will include the GS61008P, 80A/5mΩ normally-off 100V GaN transistor, and the GS66508P, a low-inductance, thermally efficient 650V transistor, with reverse current capability, zero reverse recovery charge and source-sense for optimal high-speed design.

www.mouser.com/gan-systems

Transphorm awarded patents for GaN power conversion

Transphorm Inc of Goleta, near Santa Barbara, CA, USA, which designs and provides gallium nitride (GaN)-based power conversion devices and modules for power supplies and adapters, motor drives, solar inverters and electric vehicles, has secured fundamental patents in the area of GaN power conversion.

The United States Patent and Trademark Office (USPTO) patent number 8,816,751 ('Inductive Load Power Switching Circuits') was granted on 26 August and patent application number 13/887,204 ('Bridge Circuits and Their Components') was allowed by the USPTO on 27 August. Both are directed towards the operation and use of GaN transistors in a multitude of applications including half bridges (the basic building blocks of a variety of power conversion circuits). Counterparts of these patents have also been issued in China and Taiwan and are pending in several other countries.

The patents belong to a bridge circuit patent family based on the TRANSPHORM DIODE-FREE GaN solution, where a GaN transistor also serves the function of the conventional anti-parallel or fly-back diode required in traditional approaches. This not only helps eliminate diode components but also eliminates the cost, space and energy loss associated with them, resulting in compact, higher-efficiency systems, says Transphorm. Bridge circuits are used in virtually all power converters/inverters, including photovoltaic (PV) inverters, motor drives, DC–DC blocks of power supplies, and many power factor correction (PFC) circuits such as ultra-high-efficiency Totem-Pole PFCs. These bridge circuits cover more than 60% of the total market.

Over the last several years, GaN semiconductors have emerged as a leading technology enabler for the next wave of compact, energy-efficient power conversion systems, ranging from ultra-small adapters, high-power-density PCs, server and telecom power supplies to highly efficient PV inverters and motion control systems, says Transphorm. A strong IP position is essential to ramping any commercial GaN business, it believes.

Transphorm has established a power conversion platform that, enabled by its EZ-GaN technology, has allowed it to introduce what is claimed to be the first 600V GaN products. The firm's products are backed by a broad intellectual property portfolio comprising over 450 independent patents/patent applications and more than 1100 worldwide patents/patent applications — claimed to be the most extensive IP portfolio in the GaN power arena. "Based on my years of experience with patent portfolios of emerging semiconductor companies, Transphorm's is the best and most complete I have ever encountered," remarks Roger Borovoy, Transphorm's IP counsel from Fish & Richardson.

"Transphorm's patent portfolio comprises fundamental IP in all key areas, ranging from material growth of GaN-on-silicon, device structures and fabrication, and packaging and circuits, with a particularly far-reaching impact on the use of GaN in applications," reckons Transphorm co-founder & president Primit Parikh. "No matter how other GaN providers manufacture their products, they will have to consider Transphorm's GaN bridge circuit patent family for bridge applications, by far the largest market segment for high-voltage GaN."

Transphorm's easy-to-embed power conversion modules are claimed to reduce energy loss by over 50% and simplify the design and manufacturing of a wide variety of electrical systems and devices, including motor drives, power supplies and inverters for solar panels and electric vehicles. The firm adds that its access to high-scale foundry manufacturing through its relationship with Fujitsu enables it to meet growing demand from global customers needing energy-saving GaN power conversion products.

www.transphormusa.com

GaN Systems shows new gallium nitride high-power transistors at Energy Conversion Congress & Expo

At the IEEE Energy Conversion Congress & Expo (ECCE 2014) in Pittsburgh (14–18 September), GaN Systems Inc of Ottawa, Ontario, Canada, a fabless developer of gallium nitride (GaN)-based power switching semiconductors for power conversion and control applications, showcased its latest products among its range of GaN power transistors. Based on its proprietary Island Technology, the firm produces highly efficient, smaller transistors at lower cost than traditional silicon MOSFETs and IGBTs, it is claimed.

GaN Systems says that its devices feature intrinsic fast switching and dense current-carrying capability. This is further enhanced by the firm's GaNPX packaging, which has no wire bonds, minimizing inductance and thermal resistance and increasing reliability.

The new devices from GaN Systems bring smaller, lighter and more efficient power electronics to applications including consumer appliances, data-center server racks, heavy-duty battery-operated power tools, and notebook travel adaptors. With current ratings of 8A to 200A, GaN Systems claims that, through an exclusive worldwide distribution agreement with Mouser Electronics, it is the first company to offer a comprehensive product range of GaN devices to the global market.

www.gansystems.com

http://2014.ecceconferences.org

EPC launches first commercially available monolithic enhancement-mode GaN transistor half-bridge

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) for power management applications, has launched the EPC2100, the first commercially available enhancement-mode monolithic GaN transistor half-bridge. By integrating two eGaN power FETs into a single device, interconnect inductances and the interstitial space needed on the PCB are eliminated. This increases both efficiency (especially at higher frequencies) and power density, while reducing assembly costs to the end-user's power conversion system, says EPC.

Specifically, the EPC2100 GaN power transistor offers power systems designers a solution that increases efficiency and power density for complete buck converter systems by nearly 93% at 10A and more than 90.5% at 25A when switching at 500kHz and converting from 12V to 1.2V.

Each device within the EPC2100 half-bridge component has a voltage rating of 30V. The upper FET has a typical $R_{DS(on)}$ of 6mΩ, and the lower FET has a typical $R_{DS(on)}$ of 1.5mΩ. The high-side FET is about a quarter the size of the low-side device to optimize efficient DC–DC conversion in buck converters with a high V_{IN}/V_{OUT} ratio. The EPC2100 comes in a chip-scale package for improved switching speed and thermal performance, and is only 6mm x 2.3mm for increased power density.

"Now designers have the first example of what's to come with eGaN technology — a family of monolithic eGaN half-bridge devices that save space, improve efficiency and lower system costs," says EPC's co-founder & CEO Alex Lidow. "As power conversion systems stretch into the multi-megahertz domain, the integration of discrete devices becomes increasingly important for high system efficiency and power density," he adds.

Now designers have the first example of what's to come with eGaN technology — a family of monolithic eGaN half-bridge devices that save space, improve efficiency and lower system costs

The EPC9036 development board is 2" x 2" and contains one EPC2100 integrated half-bridge component using the Texas Instruments LM5113 gate driver, supply and bypass capacitors. The board has been laid out for optimal switching performance and there are various probe points to facilitate simple waveform measurement and efficiency calculation.

The EPC2100 monolithic half-bridge price for 1000 units is $5.81 each. The EPC9036 development boards are priced at $137.75 each. Both are available from distributor Digi-Key.

http://digikey.com/Suppliers/us/Efficient-Power-Conversion.page

EPC gives seminar and technical presentations on GaN at Darnell's Energy Summit

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA, which makes enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistors (FETs) for power management applications, gave a half-day educational seminar and several application-focused technical presentations at Darnell's Energy Summit 2014 in Richmond, Virginia (23–25 September).

The summit combined efficient power conversion, green building design and smart grid electronics into a single conference. As a solutions-oriented event, with a strong emphasis on practical advances in power electronics and energy efficiency, presentations focused on advanced power conversion technologies needed for the successful development of next-generation power systems.

Expanding on the GaN FET technology textbook written by EPC, the 'Educational Seminar: GaN Transistors for Efficient Power Conversion' explained how GaN technology works. The session discussed fundamental GaN technology and how to use these devices. To showcase their real-world value, several applications including efficient DC–DC conversion, high-frequency envelope tracking and wireless power transfer were presented. The seminar concluded with a look at the future of gallium nitride as an emerging displacement technology for MOSFETs.

In addition, technical presentations given by EPC featuring GaN FETs included the following:

- Plenary session:

'GaN Transistors – Giving New Life to Moore's Law' by Alex Lidow.

- Technical sessions:

'Pushing the State of the Art in High Frequency Hard-Switching Converters Using eGaN FETs' by Johan Strydom;

'Performance Comparison Using eGaN FETs in 6.78 MHz Class-E and ZVS Class-D Wireless Power Transfer' by Michael de Rooij' and 'Advances in DC-DC Converters With eGaN FETs' by David Reusch.

www.epc-co.com

TF Semi completes spin-off from TSI Semiconductors, focusing on high-voltage power management including enhancement-mode GaN drivers

TF Semiconductor Solutions Inc of Roseville, CA, USA has completed its spin-off as an independent company after being the Products Division of TSI Semiconductors Inc (formerly Telefunken Semiconductors America), a specialty analog and mixed-signal foundry with ISO, Automotive and Industrial Class Certifications. TF Semi is partnering with TSI Semiconductors Inc and its parent company Telefunken Semiconductor GmbH & Co KG of Heilbronn, Germany.

With design centers in Torrance, CA and Dover, NH, USA, TF Semi is capitalizing on many years of investment in product, IP research & development work from its original high-voltage integrated circuit (HVIC) efforts at Telefunken.

TF Semi is focusing on designing and manufacturing devices for the high-voltage power management market — where its HVIC devices have already won designs with motor and power supply manufacturers — as well as LED drivers, LVDS interface devices, and JTAG system testing solutions. In particular, as well as high-side & low-side drivers, half-bridge drivers and 3-phase drivers, the portfolio includes what is claimed to be the industry's first 200V enhancement-mode gallium nitride (eGaN) driver, the TFG1200. TF Semi also offers a Specialty Products portfolio with devices targeting the LVDS interface, JTAG system test and power management for high-reliability applications.

The new company is led by Roger Lee, who over the past 25+ years has held senior executive management positions with Micron, SMIC, Founder Microelectronics. Most recently he was chief operating officer and interim president & CEO at TSI Semiconductors, where he continues to serve on the board of directors. "This is a great opportunity to capture a share of the fast-growing international green-power market," says Lee. "TSI Semiconductor Solutions, as a fabless semiconductor company, is well positioned to participate in the fast-growing HV power management and driver IC market."

TF Semi has sales and customer service offices in San Jose, CA, Sacramento, CA, Torrance, CA and Dover, NH, USA, in Taipei in Taiwan, and in Shenzhen and Beijing in China. The firm distributes its products through a network of global and regional distributors.

www.tfsemi.com

Transphorm partners with Tata on GaN-based solar inverters for India

Transphorm Inc of Goleta, near Santa Barbara, CA, USA, which designs and provides gallium nitride (GaN)-based power conversion devices and modules for power supplies and adapters, motor drives, solar inverters and electric vehicles, is partnering with Tata Power Solar (TPS) of Bangalore, India to introduce an efficient solar inverter based on Transphorm's GaN-based power switching platform using its patented EZ-GaN technology. With its TPH Series portfolio of GaN products (backed by its GaN power IP portfolio), Transphorm claims to have established the industry's only qualified 600V GaN device platform.

Under the partnership, Transphorm will supply GaN transistors, while Tata Power Solar will locally manufacture and market the GaN-powered solar inverters. The first product is scheduled to be released in early 2015.

"The inverter technology being developed has broad applications beyond solar conversion, and we anticipate these energy-efficient applications will find usage across various Tata companies," says Tata Power Solar's CEO Ajay Goel.

"By designing our solar inverter product family with Transphorm's industry-leading and qualified EZ-GaN platform, Tata Power Solar will provide the Indian energy sector with a compact and higher-efficiency PV inverter as well as a roadmap of higher-performance and smaller-form-factor solar PV power," says Dr Arul Shanmugasundram, executive VP Projects & chief technology officer for Tata Power Solar. "This world-leading product family will accelerate India's adoption of solar energy, enabling the goal of using renewables to power 20% of India's energy needs by 2020," he believes.

Transphorm says that its efficient, compact and easy-to-embed solutions can simplify the design and manufacturing of a variety of electrical systems and devices, including power supplies and adapters, PV inverters for solar panels, motor drives and power conversion for electric vehicles. The firm adds that its access to automotive-class-quality, high-volume foundry manufacturing through its business partnership with Fujitsu enables it to meet growing global demand from firms adopting energy-saving GaN power conversion products.

www.transphormusa.com

IQE increases underlying profit in first-half 2014 despite 17% year-on-year drop in revenue

Further benefits of restructuring expected from second half onwards

After giving a trading update for first-half 2014 in late July, epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has confirmed revenue of about £52m, down 17% on first-half 2013's £63m. This primarily reflects an industry-wide inventory de-stocking of about £8.5m plus the impact of a strong sterling-to-US dollar exchange rate (the latter accounting for £4.2m, or 8% of the 17% decline).

Despite this, adjusted gross margin has risen from 20.5% to 24.5%, attributed to cost reductions, efficiency gains, economies of scale and product mix.

EBITDA (earnings before interest, taxes, depreciation and amortization) was up 6% year-on-year (more than the expected 5%) from £10.5m to £11.1m. Despite the lower revenue, adjusted profit before tax (PBT) rose by 11% from £5.1m to £5.6m, which includes the benefit of cost reductions realised from the firm's restructuring program (which is on track to deliver annual recurring synergies in excess of £7m per annum). However, after £4.8m in non-cash exceptional charges and £3.1m in cash costs of restructuring (which included redundancy costs, requalification costs and the duplication of overheads to support the transition of customers between production facilities), the loss before tax (LBT) was £2.3m (compared with a profit of £2.5m a year ago).

Despite being up from £34.4m at the end of December 2013, net debt of £35.5m is still down from £37.7m at the end of first-half 2013 (and better than the targeted £36m).

"The group has again demonstrated the resilience of its business model through the delivery of continued growth in profitability despite the lower-than-expected revenues resulting from adverse effects of a significant inventory correction in the wireless industry and the translational effect of a strengthening of the sterling exchange rate against the US dollar," says IQE's chief executive Dr Drew Nelson.

In constant currency (dollars), Wireless revenue has fallen by 17% from $82.8m (85% of total revenue) a year ago to $69m (79.5% of total revenue). "IQE is unquestionably the global leader in the manufacture and supply of the industry's broadest portfolio of advanced semiconductor wafer products for the wireless sector [with market share of about 55%]," says Nelson. Wireless demand recovered during Q2/2014 from the customer inventory de-stocking. "Wireless will continue to be a long-term growth driver for our business as increasing connectivity continues to drive increasing demand for compound semiconductor devices," he adds.

Photonics revenue has risen by 22% (more than the expected 20%), from $13.8m (14.2% of total revenue) a year ago to $16.8m (19.4% of total revenue). Growth is largely from the increasing adoption of vertical-cavity surface-emitting lasers (VCSELs), as well as indium phosphide (InP)-based devices. "Our technology leadership and credibility in photonics are translating into contract wins," says Nelson. "This is being driven by a range of end-market applications including optical communications for backhaul, fiber-to-the-home [particularly in China], and data centres, gesture recognition and sensing, and industrials applications," he adds. "This growth will be further supported with the transition from the development phase into commercial production for high-efficiency solar power (CPV), anticipated for the second half of 2014." With reliability testing finished by the end of July and cell qualification completed, supply chain qualifications are at an advanced stage, and the first production orders are expected to yield revenue in second-quarter 2014, prior to an expected strong production ramp-up in 2015.

IQE has again demonstrated the resilience of its business model through the delivery of continued growth in profitability despite the lower-than-expected revenues resulting from adverse effects of a significant inventory correction in the wireless industry

"All of our lead indicators are pointing in the right direction," notes Nelson. "The destocking was concluded during Q2 and customers are forecasting an upbeat second half. Our investment in photonics technology is delivering tangible benefits, and has resulted in multiple contract wins. Our CPV [concentrated photovoltaic] business is in the final stages of end-customer qualification and remains on track to move from final development and customer qualification to production in second-half 2014," he adds.

The firm's restructuring is now largely complete and should deliver further recurring savings from second-half 2014 onwards. "Despite anticipating lower full-year revenues due to the inventory corrections during the first half, coupled with changes in product mix, the board remains confident in the group being on track to deliver full-year earnings in line with expectations," comments Nelson.

"Having established a world-leading position in the wireless communications market, IQE is beginning to replicate this across our other markets including photonics,

IQE agrees memorandum of understanding with WIN and Nanyang for Singapore centre of excellence

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has entered into a memorandum of understanding (MOU) with Taiwan's WIN Semiconductors Inc (the world's largest pure-play gallium arsenide foundry) and Singapore's Nanyang Technological University (NTU) to form a centre of excellence for the development of compound semiconductor technology in Singapore. The Compound Semiconductor Development Centre (CSDC) will be jointly owned by IQE, WIN, NTU, local management and key academics.

The three partners reckon that compound semiconductor technology will play a significant role in the future of the overall semiconductor industry, and that the initiative will provide a focal point for effective collaboration between industry and academia in developing next-generation technologies. Recognizing the significant investment that is already been made globally into the many emerging markets for compound semiconductors, its aim is to accelerate the development of compound semiconductor technology in Singapore and to provide an effective incubator for bringing new innovations to market.

The Economic Development Board of Singapore has played a key role in pulling the initiative together, complementing other compound semiconductor development activities being undertaken in Singapore such as SMART-LEES (Singapore-MIT Alliance for Research and Technology Center's Low Energy Electronic Systems). Such initiatives are creating next-generation IP that aims to support continued economic growth in Singapore.

The new project forms part of IQE's global reorganization plan, which in total is on track to deliver annual recurring synergies in excess of £7m per annum. As part of its contribution to the Singapore joint venture, IQE will provide facilities, equipment and IP on favourable terms to the CSDC. As a consequence, IQE is creating provisions of £4.2m for asset impairment comprising the transfer of tools to the CSDC and £7.7m for the lease of existing buildings and facilities. The parties expect that the CSDC will commence operation during fourth-quarter 2014.

The CSDC represents a very innovative approach to making the most of the skills and talent that exist in Singapore, reckons IQE's chief executive Dr Drew Nelson. "This will provide an effective route to overcoming the barriers that prevent new ideas and innovations being successfully brought to market and advancing and commercializing new compound semiconductor technologies," he believes. "

"We have built an exciting compound semiconductor capability within NTU," reckons NTU's professor Yoon Soon Fatt. "The CSDC provides a meaningful collaboration for us with two key industrials within the compound semiconductor industry," he adds.

"Singapore is committed to develop the compound semiconductor industry," says Terence Gan, director of Electronics at the Singapore Economic Development Board. "Compound semiconductors make energy-efficient LED lighting and fiber-optic communications possible, and will enable the creation of ultra-fast and ultra-energy-efficient semiconductor integrated circuits," he adds. "CSDC is an important partner to grow our pipeline of compound semiconductor R&D talent."

www.iqep.com
www.winfoundry.com
www.eee.ntu.edu.sg
http://smart.mit.edu/research/lees/lees.html

infrared, power, solar and CMOS++, the last of which is focussing on advanced technologies combining the simplicity of CMOS with the power of compound semiconductors," says Nelson. IQE's CMOS++ development comprises III-V materials such as gallium arsenide, gallium nitride or antimonides (e.g. InSb) on silicon wafers. "We have also made significant technical and commercial progress in areas such as gallium nitride (GaN) development and we are well positioned to enjoy a transition to volume production in the next 2–3 years," Nelson says.

IQE expects the silicon industry to transition to III-Vs-on-silicon in 2017–2020.

In addition, in mid-September, IQE entered into a memorandum of understanding (MOU) with Taiwan's WIN Semiconductors Inc (the world's largest pure-play gallium arsenide foundry) and Singapore's Nanyang Technological University (NTU) to form the Compound Semiconductor Development Centre (CSDC) at IQE's facility in Singapore, to be jointly owned by IQE, WIN, NTU, local management and key academics.

The project forms part of IQE's reorganization plan and rationalization of its global facilities, which is on track to deliver recurring savings of more than £7m per annum. However, as part of its contribution to the joint venture, IQE will provide facilities, equipment and IP on favourable terms to CSDC. The firm has hence booked provisions of £5.7m for asset impairment, comprising the transfer of tools to CSDC and £6.2m for the lease of existing buildings and facilities.

www.iqep.com

Presto expands capacity for RF test

US engineering hub tripled in capacity; Euro hub gains mm-wave test

Turnkey back-end production services firm Presto Engineering Inc of San Jose, CA, USA, which provides semiconductor product engineering & test services to both integrated device manufacturer (IDM), fabless and electronics companies, has tripled the capacity of its San Jose engineering hub, and has added new radio-frequency device testing equipment to its hub in Caen, France.

"The RF market is booming as a result of rapidly increasing consumer demand for smart-phones and other mobile devices, and the massive expansion of backhaul and data centers worldwide," says CEO Michel Villemain. "As a result, we are in full-expansion mode as we move to support this growth with aggressive investments in additional capacity," he adds. "Many of our North American and European customers need to have testing and back-end support services close to them, rather than in Asia for example, so that they can stay intimately involved with the development and ramp of these very complex, high-frequency devices."

Presto Engineering's hub in Caen, France will support all aspects of RF, as well as analog and mixed-signal devices. The Caen hub is the only back-end service house in Europe with 12-inch wafer probe capabilities coupled with the most advanced RF automated test equipment (ATE) in the market, says the firm. Presto Engineering's San Jose hub will focus on high-frequency RF testing at milli-meter wavelengths. Both operations will leverage Presto Engineering's RF, high-speed analog and mixed-signal test expertise developed over the past five years.

"We are unique in our ability to serve the RF space from both Europe and North America," claims Villemain. "Many of our customers develop RF devices for very specialized and critical applications, such as the high-speed communications, medical or defense industries. They prefer to keep production nearby, where they can keep a close watch on the fabrication process and avoid the risks and delays of off-shore production," he adds. "We see growing demand for RF capabilities from our customers, many of whom are leaders in their target markets, and believe our capacity expansion uniquely positions us to grow and deepen our relationship with them."

www.presto-eng.com

Sweden's Epiluvac launches as SiC CVD equipment maker

Start-up also targeting hot-wall reactors at deposition of GaN, AlN and graphene wide-bandgap materials

Epiluvac AB of Lund, Sweden says that it is now offering silicon carbide (SiC) chemical vapor deposition (CVD) epitaxy reactors in various configurations.

As one of the most interesting semiconductor materials in electrical power components for energy savings, silicon carbide components are already in use in hybrid cars and solar power inverters, says the firm. The high efficiency of such components minimizes energy loss and makes green power economically feasible, it adds. Epiluvac has now entered the scene as a new company aiming to supply the required deposition equipment.

Much of the pioneering research around silicon carbide was done at Sweden's Linköping University, where the hot-wall CVD reactor was developed. This reactor type has been used successfully worldwide by the most prestigious labs, says Epiluvac. With a team that has many years of experience developing hot-wall systems, Epiluvac aims to continue development of this type of reactor.

Sweden has a unique cluster of companies and universities in the forefront of silicon carbide technology. The hot-wall CVD reactor has been the workhorse in R&D labs all over the world, and many scientific papers have been published concerning material grown in them, says Epiluvac. "The system design during three decades has proven to meet the high expectations of the best researchers around the world," states managing director Bo Hammarlund.

"It is also our ambition to stay in close contact with our customers in order to customize the tools for their specific needs. We have a lot of experience in doing this," says Hammarlund. "With the unique cluster of silicon carbide companies we have in Sweden, we are also able to pick up new demands at an early stage for not only SiC but also GaN, AlN, and graphene." The hot-wall reactors have already proven to be successful for producing grapheme, with Epiluvac being a partner in the Strategic Innovation graphene program led by Chalmers University, Gothenburg.

Epiluvac's offices and manufacturing facilities are located in the Ideon Science Park, close to Lund University and the multi-disciplinary research centers ESS (the European Spallation Source particle accelerator) and the MAX IV Laboratory (a national synchrotron radiation facility for x-ray analysis).

www.epiluvac.com
www.maxlab.lu.se

Aixtron partners with Fraunhofer IISB to enhance silicon carbide production technology

New 8x150mm G5WW VPE system to develop 150mm epi processes

Deposition equipment maker Aixtron SE of Aachen, Germany has teamed up with Fraunhofer IISB (Institute for Integrated Systems and Device Technology) in Erlangen, Germany, to develop 150mm SiC (silicon carbide) epitaxy processes using Aixtron's new 8x150mm G5WW vapor phase epitaxy (VPE) system. The Planetary Reactor tool will be installed at the IISB cleanroom laboratory in fourth-quarter 2014.

"Through this partnership we expect to further accelerate the implementation of 150mm SiC technology in the industry by pairing our process know-how in manufacturing SiC epitaxial layers with Aixtron's SiC equipment expertise," comments Dr Jochen Friedrich, head of the Crystal Growth Department at Fraunhofer IISB. "We will use the G5WW production system for process optimization and demonstration purposes at the IISB facilities in Erlangen."

Fraunhofer IISB has developed fundamental understanding in low-defect-density SiC epitaxial processes which are elementary for the manufacturing of high-voltage SiC devices. Special characterization techniques such as room-temperature photoluminescence imaging and selective defect etching have been developed and adapted to the SiC material properties. Also in Fraunhofer IISB's laboratories complete SiC prototype devices can be processed and characterized.

Aixtron's new 8x150mm G5WW system.

"Based on the worldwide recognized experience of Fraunhofer IISB in SiC epitaxy technology and characterization, we will jointly enable the optimization of epitaxial production processes for 150mm SiC wafers using our state-of-the-art G5WW production tool," says Dr Frank Wischmeyer, Aixtron's vice president Power Electronics. "The goal of the collaboration is the demonstration of high-volume manufacturing processes addressing the SiC material requirements of SiC power devices," he adds. "With this joint effort we support Aixtron customers worldwide moving from 100mm to 150mm SiC processing technology from the year 2015 to achieve efficient and economic manufacturing processes for future SiC power devices."

Today, a variety of SiC devices like Schottky diodes and metal-oxide-semiconductor field-effect transistors (MOSFETs) are commercially available and put into practical use in switch mode power supplies (SMPS) for computer servers and TVs, in solar power inverters and efficient power converters in uninterruptible power supplies (UPS), medical equipment or commuter trains. To facilitate the widespread adoption of SiC in power electronics, cost reductions in SiC semiconductor material manufacturing and device processing are targeted through the implementation of 150mm SiC, says Aixtron.

www.aixtron.com
www.iisb.fraunhofer.de/en/departments/crystal_growth.html

MELCO begins using Aixtron MOCVD system for production of GaN-on-silicon power amplifiers

Deposition equipment maker Aixtron SE of Aachen, Germany says that Mitsubishi Electric Corp (MELCO) of Tokyo, Japan has begun operations with an AIX 2800G4 HT Planetary Reactor system. The 11x4"-wafer configuration metal-organic chemical vapor deposition (MOCVD) system will be used mainly for the development and volume production of high-efficiency gallium nitride on silicon (GaN-on-Si) power amplifiers for mobile communication base-stations.

Aixtron says that MELCO's decision to buy the G4 for production of high-efficiency power amplifiers is based on its experience with the previous G3 MOCVD tool generation. As the Planetary Reactor provides system flexibility and maximum production yield through material uniformity combined with low wafer bow, MELCO aims to use the new system in volume production.

"Gallium nitride-on-silicon technology is becoming the technology of choice for manufacturers of power electronics as it offers high performance and cost-effective manufacturing processes on 4", 6" and 200mm silicon," says Dr Frank Wischmeyer, Aixtron's VP of Power Electronics. "We are very pleased to enable MELCO to produce devices like monolithic high-efficiency power amplifiers or discrete HEMTs."

GaN-based components enable higher power densities at higher frequencies with potential applications that include satellite communication and radar, in addition to mobile phone network base stations.

www.aixtron.com

Veeco launches 31x4”/12x6”/6x8”-wafer EPIK700 gallium nitride MOCVD system

Throughput boosted by 2.5x and cost per wafer cut by 20% over previous-generation systems

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA has launched the TurboDisc EPIK700 gallium nitride (GaN) metal-organic chemical vapor deposition (MOCVD) system, which combines what are reckoned to be the industry’s highest productivity and best-in-class yields with low cost of operation, further enabling lower manufacturing costs for LEDs for general lighting applications.

Since the introduction of the TurboDisc K465i GaN MOCVD system in 2010, Veeco has steadily improved the cost of ownership. In 2011, it launched the first multi-reactor MOCVD system, the TurboDisc MaxBright. Veeco says that its MOCVD TurboDisc technology has been recognized as best in the industry by LED trade associations in each year from 2011 to 2013.

Based on Veeco’s proven TurboDisc technology, the new EPIK700 MOCVD system enables users to achieve a cost per wafer saving of up to 20% compared to previous generations through improved wafer uniformity, reduced operating expenses, and increased productivity, says the firm. The system’s reactor has more than twice the capacity of current-generation reactors. This increased volume, combined with productivity advancements within the reactor, results in a 2.5x throughput advantage over previous-generation MOCVD systems.

“In addition to higher capacity and throughput, the system contains proprietary technologies within the reactor that improve wavelength uniformity and drive higher yields in a tighter bin,” notes Jim Jenson, senior VP & general manager, Veeco MOCVD. “By combining the advanced TurboDisc reactor design with excellent uniformity, higher productivity, proven automation, low consumable costs and improved footprint efficiency, we have significantly improved the cost per wafer,” he adds.

Veeco’s TurboDisc EPIK700 GaN MOCVD system for high-volume LED manufacturing.

Available in one-and two-reactor configurations and said to be the LED industry’s highest-productivity MOCVD system, the EPIK700 features technologies including the new IsoFlange center injection flow and TruHeat wafer coil, providing homogeneous laminar flow and uniform temperature profile across the entire wafer carrier. These innovations produce wavelength uniformity to drive higher yields in a tighter bin. Designed for mass production, EPIK700 accommodates 31x4”, 12x6” and 6x8” wafer carrier sizes. Users can easily transfer processes from existing TurboDisc systems to the new EPIK700 MOCVD platform for quick-start production of LEDs, says Veeco.

Because of the flexible EPIK700 MOCVD platform, more upgrades, added benefits and future enhancements will continue to differentiate the system, the firm adds.

“One of the world’s top LED manufacturers has thoroughly evaluated and accepted the EPIK700 due to its production worthiness, stable process and reproducible results,” says executive VP William J. Miller Ph.D. “This new product will help our customers further succeed in the solid-state lighting market, by driving down LED manufacturing costs and increasing productivity,” he expects.

According to a recent IHS Research report, LED unit penetration is expected to reach 15% in such key markets as China, Japan, North America and Europe by 2016 and to more than double to 40% by 2020.

www.veeco.com

Riber launches Compact 21 Discover 3" substrate molecular beam epitaxy research system

At the 18th International Conference on Molecular Beam Epitaxy (MBE 2014) in Flagstaff, AZ, USA (7–12 September), Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, launched the Compact 21 Discover 3-inch substrate MBE research system.

Riber claims that the new model revolutionizes MBE-based research by suspending all vacuum sections of the reactor inside an ergonomic open-bottom frame (enabling 360° access to the system's components) and incorporating the transfer rod (traditionally a fragile, long part of the system) into the electronics cabinet. This not only protects the transfer device but decreases the system's length by more than 1.5m, halving the Discover's footprint in costly cleanroom space compared

with others products, it is reckoned. The result is what is claimed to be the most compact and ergonomic 3" MBE system on the market.

Compared with previous systems, the new open-frame design offers full access to the most important parts on an MBE system: the effusion cells (where the materials are evaporated and reloaded), easing use for the scientist and giving easy components access for maintenance engineers and technicians.

Based on the recent Compact 21DZ system, the Discover is also said to be the only 3" MBE system on the market to combine 12 symmetric cell ports with a 10" central port, offering flexible performance.

Riber says that the launch of the new model illustrates the firm's strategy to develop and create value through its range of MBE systems. The Compact 21 Discover delivers low footprint, ergonomic design and flexible use, and will drive Riber's development in new markets and buoyant geographical segments, the firm reckons.

www.riber.com

Oxford Instruments launches third annual Indian nanotechnology seminars

In Kolkata (24–25 November) and Delhi (27–28 November), Oxford Instruments is hosting its third series of annual seminars for the nanotechnology industry in India. 'Bringing the Nanoworld Together 2014' will showcase nanotechnology tools and their use in multiple fields.

The first day at each venue comprises Plenary Sessions focusing on 'Emerging Materials for Nanoscale Devices - Fabrication & Characterization'. Day 2 will focus on thin-film processing, materials characterization, surface science and cryogenic environments. A wide range of topics will be covered within each technical area. This will also present an opportunity for networking between all participants, including guest speakers from Indian and international institutes, speakers from the host institutes, and technical experts from Oxford Instruments.

Thin-film processing sessions will review the latest technical advances in etch and deposition, including: atomic layer deposition (ALD), magnetron sputtering, inductively coupled plasma (ICP) plasma-enhanced chemical vapour deposition (PECVD), nanoscale etch, MEMS (micro-electro-mechanical system), and molecular beam epitaxy (MBE).

The materials characterization, surface science and cryogenic environment sessions will cover multiple topics and technologies including: ultra-high-vacuum scanning probe microscopy (SPM), cryo-free low-temperature solutions, x-ray photoelectron spectroscopy (XPS)/electron spectroscopy for chemical analysis (ESCA), an introduction to atomic force microscopy (AFM) and applications such as nanomechanics, in-situ heating and tensile characterization using electron backscatter diffraction (EBSD), measuring layer thicknesses and compositions using energy-dispersive spectroscopy (EDS), nanomanipulation and fabrication within the SEM/FIB. The recently acquired business Andor Technology will also be showcasing its high-performance optical cameras and software, which are used in both the physical and bio sciences.

"We are demonstrating our commitment to our customers through providing these learning events, encouraging discussion and cross dissemination of ideas that is of benefit to all those attending," says Mark Sefton of Oxford Instruments Nanotechnology Tools. "We want our customers to be empowered to use these systems to the best of their abilities, with the maximum information possible behind them."

The seminar is free to attend but prior booking is essential.

www.oxford-instruments.com/btnt

Cambridge Nanotherm appoints CEO and business development director; receives ISO 9000 accreditation

Cambridge Nanotherm Ltd of Haverhill, Suffolk UK, a producer of semiconductor heat-sink technology, has appointed semiconductor industry veteran Ralph Weir as CEO. This comes just a few months after its first production line, allowing the firm to roll out its nano-ceramic heat dissipation technology at high volumes to meet the growing needs of LED makers. Cambridge Nanotherm has also announced ISO 9000 accreditation of its production line.

Weir has experience leading advanced technology teams in companies including Polar OLED, Actiri, Phase Vision, Mirics and Elixent. He has been appointed to ensure a smooth transition to mass production and to drive the next phase of Cambridge Nanotherm's global growth. Dr Pavel Shashkov (CEO since the firm was founded) becomes chief technology officer.

Established in 2010, Cambridge Nanotherm was supported by grants from the UK's Technology Strategy Board (TSB), East of England Development Agency (EEDA) and European Regional Development Fund (ERDF) and was a member of the Carbon Trust Fast-track Entrepreneur Programme. Since 2011 it has been financially backed by Enso Ventures.

Cambridge Nanotherm's products are based on its patented high-thermal-conductivity dielectric nano-ceramic coating. The firm embeds its technology in aluminium-backed PCBs using standard processes, or places it over or around semiconductors. The unique material currently wicks away heat at 2–3 times the rate of competing solutions, it is claimed, while still being 4–10 times thinner. This allows manufacturers of various semiconductor devices to produce radically cooler and more efficient devices, or to increase the density of their products, allowing for example brighter LEDs or more computational power within a given space.

Joining alongside Weir as business development director is Andrew Duncan, who has a history with a variety of specialized ceramics companies including Morgan Advanced Ceramics (as technical manager for Metallised Products) and CeramTec (as technical sales manager). Duncan is tasked with expanding Cambridge Nanotherm's customer base and capitalizing on the its early momentum.

www.camnano.com

5N Plus gains $17.5m in financing from EDC

Export Development Canada (EDC) has announced $17.5m in financing for Montreal-based 5N Plus.

5N Plus provides specialty purified metals such as bismuth, gallium, germanium, indium, antimony, cadmium, selenium and tellurium, and also produces related semiconducting compounds such as cadmium telluride (CdTe), cadmium sulphide (CdS) and indium antimonide (InSb) as precursors for the growth of crystals for solar, LED and eco-friendly materials applications. The firm also has fully integrated closed-loop recycling facilities.

As Canada's export credit agency, EDC provides financing, insurance and bonding to help Canadian firms with international business prospects. As a profitable Crown corporation operating on commercial principles, EDC works with private- and public-sector financial institutions to boost capacity for Canadian companies to engage in trade and investment.

EDC's financing is part of a $125m credit facility for 5N announced in August, which will be used to help it grow its international operations. Six other financial institutions were included in the facility, with HSBC Bank Canada acting as lead arranger. EDC says that it was chosen as a commercial partner because its extensive market knowledge aligns well with 5N's growth strategy.

"As our revenues have shown in the last five years, our company has been focused on growth," says 5N's president & CEO Jacques L'Écuyer. "This financing will be used to support our continued growth, and we feel that EDC is a great partner to have moving forward because they understand our international vision, and are well positioned to help us along our new strategic path."

To date, 5N has grown largely via acquisitions, but its strategy now is to increase value-added activities, expand recycling operations, broaden its presence in Asia, and capitalize on the international platform that it has built.

About 99% of 5N's Canadian sales are exports, showing the strong global demand for its materials. Many of the purified metals that it produces (e.g. bismuth, gallium, germanium and tellurium) are critical precursors in growing markets for solar panels, LEDs etc.

"5N's potential for international growth is tremendous, and EDC has the resources to help support that growth," says Carl Burlock, senior VP, financing and investments, at EDC. "We can provide financing, market intelligence, and advice to help 5N, and other companies like 5N, establish and grow their presence in different parts of the world," he adds. "Opening doors to new markets means more customers, and increased export sales."

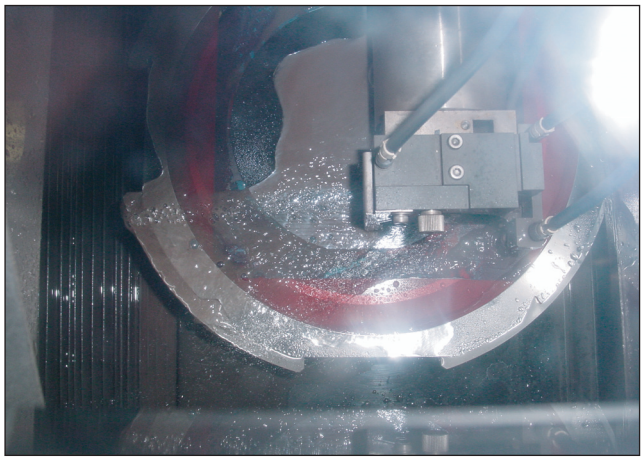
www.5nplus.com
www.edc.ca

AIT develops temporary bonding wax for precision wafer and substrate back-grinding and thinning

As devices such as cell phones, cameras, and tablets continue to shrink, there is also a big push to shrink the thickness of these devices, and hence the thickness of the dies and wafers, says AI Technology Inc (AIT) of Princeton Junction, NJ, USA (which provides materials and adhesive solutions for electronic interconnection and packaging). Wafers and substrates are thinned down from as much as 750μm down to 25–50μm to improve the performance and/or provide a thinner and lighter electronic device.

While back-grinding tapes are used in many applications in place of traditional wax solutions, a temporary bonding wax that can be applied to the thickness of 10μm still provides many advantages over the thicker back-grinding tapes, particularly for more aggressive processes and more fragile wafers, says the firm.

Responding to this need for thinner wafers and substrates, AIT has developed a series of temporary wax-like media that has been proven to be useful in many of these thinning applications. Unlike traditional wax, AIT's wax-like media provides well-defined melting points of 80ºC and 160ºC for different processing requirements and easy removal. The bonding medium can be dissolved cleanly with IPA or acetone. AIT says that its temporary bonding media have been proven useful in all of the four primary methods for wafer thinning: mechanical grinding, chemical mechanical polishing (CMP), wet etching and atmospheric downstream plasma (ADP), and dry chemical etching (DCE).



AIT's back-grinding liquid wax (BGL) can be spun to form 10μm film for precision bonding with a die-shear bond strength of over 500psi for temperatures 15ºC below the melting point. The firm provides the temporary bonding/protective wax in pre-dissolved isopropyl alcohol (IPA). The thickness of this wax film can be adjusted in the spin coating process or by diluting the wax liquid further with IPA.

One of AIT's feature Temporary Bonding IPA-Soluble Wax Solutions, BGL7080, can be heated to 60ºC and still maintain a stable bond. Other high-temperature waxes, such as BGL70160-HV and BGL7080-HV7, can maintain a relatively stable bond up to 135ºC and 150ºC, respectively. These waxes can withstand exposure to high temperatures up to 225ºC for shorter time periods without degradation.

Release or dismount is achieved by melting the wax at a high temperature to lower the viscosity of the wax layer significantly, allowing the release of the wafer or device mechanically by lifting or gentle sliding.

For high-temperature waxes, IPA or other solvents must be used to swell, penetrate, soften, and dissolve the waxes. This can be done by dipping and soaking the wafer/substrate into an IPA bath. Warm IPA at 40–60ºC will accelerate this dismount mechanism.

AIT says that it has developed its temporary bonding/protective wax solutions by working with customers to meet their specific needs. The firm can also formulate a solution that will work for a customer's stringent requirements.

www.aitechnology.com

Rubicon appoints CFO as interim CEO after Parvez steps down; initiates search for new CEO

Raja Parvez has stepped down as CEO and member of the board of directors of Rubicon Technology Inc of Bensenville, IL, USA (which makes monocrystalline sapphire substrates and products for the LED, semiconductor and optical industries).

To ensure a smooth transition, the board has appointed chief financial officer William Weissman as interim CEO to lead Rubicon's executive team. Chairman Don Aquilano will lead a board search for a permanent CEO with the assistance of a leading executive search firm.

Rubicon says that Parvez has played a leadership role at the firm since 2006 and has been key to its vertical integration strategy as well as product innovation.

"On behalf of the entire Rubicon board, I want to thank Raja for his leadership, passion and the many important strategic initiatives he has driven for the company," says Aquilano. "Raja has worked diligently to lead the company through challenging cycles and transitions in our industry," he adds.

www.rubicontechnology.com

MEI reports uniformity results for Cu & TiW metal etch in compound semiconductor production

MEI Wet Processing Systems and Services LLC (a subsidiary of MEI LLC) of Albany, OR, USA has revealed performance data on its new Cu & TiW Critical Etch System for compound semiconductor manufacturing.

MEI says that its Critical Etch batch wet processing systems achieve comparable etch uniformity, providing superior results compared with single-wafer spray tools for Cu and TiW etch. Also, its critical etch solution enables consistent etching even within dense patterned areas. The immersion etch uniformity enables process engineers to minimize over etch times, the firm claims, enabling the use of lower-cost immersion technology to produce high-end products. The critical etch system also saves manufacturing floor space by reducing the wet process footprint requirement by at least 60% over comparable-throughput single-wafer spray tools, it is reckoned.

"MEI's Critical Etch solution for Au, Ag, Cu and TiW will allow semiconductor manufacturers to lower costs, reclaim valuable cleanroom space and increase yield while producing high-quality results," claims Dan Cappello, president & CEO of MEI LLC. "Our immersion system etch uniformity far surpasses many alternative solutions," he adds. "Side by side 'split lot' comparison data demonstrates superior performance with <2% etch uniformity, compared to >15% for other immersion and spray tool designs."

MEI says that it has leveraged its immersion experience so that, unlike conventional metal etch systems, its Critical Etch System is a low-cost, small-footprint, high-performance package. Systems can be configured for single or combination metal etch steps over a wide variety of needs. Whereas conventional etch solutions rely on dry tool or complex deplating processes that are very expensive to operate, MEI's immersion solution enables a new generation of mobile devices to be produced in a cost-effective manner, the firm claims. MEI's batch immersion systems are field proven on 1–5μm features which were consistently etched with exceptional uniformity and high throughput.

The firm's Critical Etch solution targets semiconductor and MEMS processing applications where metal pattern etches are required to create sophisticated mobile communication devices.

www.meillc.com

CRAIC adds Raman to flagship UV–visible–NIR and fluorescence microspectroscopy system

UV–visible–NIR microscope and microspectrometer manufacturer CRAIC Technologies of San Dimas, CA, USA has added Raman microspectroscopy to its flagship product: the 20/30 Perfect Vision microspectrophotometer.

The firm says that users of the 20/30 PV now have the ability to acquire Raman spectra, with multiple laser wavelengths — in addition to UV–visible–NIR absorbance, reflectance, fluorescence and emission microspectra – rapidly and easily from micron-scale samples.

The 20/30 PV can acquire all these spectra from the same area because it features CRAIC's proprietary optical aperturing technology. It also has the ability to acquire images of these same microscopic samples in the UV, visible and NIR regions.

Applications for such a multi-purpose instrument include developing the latest advanced materials (such as graphene and carbon nanotubes) and measuring thin-film thickness in semiconductors.

"The 20/30 PV is now able to acquire vibrational spectra in addition to UV–visible–NIR spectra and images," says president Dr Paul Martin. "Using CRAIC Technologies' proprietary optical technology, the Raman, UV–visible–NIR and luminescence spectra are all from the same area. The ability to acquire spectra using multiple techniques and of the same microscopic target area represents a strong advantage for the 20/30 PV microspectrophotometer," Martin adds.

The 20/30 PV microspectrophotometer is a self-contained unit that features advanced UV–visible–NIR light sources, solid state lasers, true UV–visible–NIR microscopy, sensitive Lightblades spectrometers and Lambdafire spectral and imaging software. Raman microspectroscopy is added with the Apollo Raman microspectroscopy packages. Each Apollo is a self-contained package including laser, spectrometer and hardware.

All these capabilities can be integrated into the 20/30 PV microspectrophotometer, providing multiple methods for rapidly and easily analyzing microscopic samples. With its Raman, UV–visible–NIR spectroscopic and imaging capabilities, durable design, ease-of-use and CRAIC's experience in microanalysis, the 20/30 provides a solution to the most challenging analysis, says the firm.

www.microspectra.com/products/2030-microspectrophotometer

Changelight raising $130m to expand InGaN LED epiwafer production

New factory to boost annual InGaN chip production to 62.87bn units

LED maker Changelight Co Ltd of Xiamen, China plans to issue 6.07 million stocks to raise a total of RMB800m ($130.39m) in financing in order to expand its production of indium gallium nitride (InGaN) LED epitaxial wafers, according to LEDinside (a division of market research firm TrendForce). One of the firm's stockholders in particular, Wang Weiyong, will be purchasing RMB80m worth of stocks.

Changelight's InGaN LED epiwafer expansion project, which involves establishing a new factory, is expected to cost a total of RMB1.34bn. The new factory's production capabilities will span all GaN LED model products, and increase the firm's InGaN LED chip production to 5.239 billion unitsper month (62.87 billion units per year). Retail revenue from the project is expected to reach RMB1.21bn. The firm also expects that, during the factory's period of operation, net profit will be RMB123m, gross profit margin will be 29.23% and net profit margin will be 11.6%.

InGaN LED epiwafers tend to have the classical features of a capital-intensive and technology-intensive industry, according to sources cited by LEDinside. The recent financing would support Changelight's advances in the LED chip manufacturing industry, it adds.

www.changelight.com.cn/en

SemiLEDs launches chip-scale ReadyMount Enhanced CSP white LEDs combining flip-chip and ReadyWhite technologies

SemiLEDs Corp of Hsinchu, Taiwan has announced sampling and mass-production availability of its newest line of white chip-scale packages, the ReadyMount Enhanced CSP (EC) series.

By combining SemiLEDs' Enhanced Flip-chip (EF) approach with the firm's ReadyWhite phosphor technology, the EC delivers what is claimed to be unprecedented flexibility, reliability and manufacturability in a single 1.4mm x 1.4mm low-profile device. Rated for input power of up to 3W, the EC is a fully packaged white emitter SMD component, ready for surface mounting on any board-level module or chip-on-board (COB) application, lowering capital costs and enabling extremely high-lumen-density configurations, it is claimed.

"Our unique chip-scale package (CSP) brings all the benefits of SemiLEDs' rugged EF Series FlipChip architecture to an extremely compact emitter, which is simple to integrate using standard tape & reel surface-mount manufacturing," says Mark Tuttle, general manager for SemiLEDs Optoelectronics Co Ltd. "This innovation reduces final component cost up to 50%, with a packaging cost reduction of up to 80% over conventional packaging," he reckons. "EC Series products, such as the EC-W1414, enable system integrators and luminaire manufacturers a direct path to a highly cost-effective solution on a per-lumen basis now, with additional viewing angles and die sizes under development."

While useful for creating compact multi-die white packaged LEDs, the ReadyMount products can benefit light-engine and luminaire manufacturers who have previously had to rely exclusively on packaged die solutions, says SemiLEDs. Incorporating the firm's EF Series FlipChip, the electrical contacts are moved to the bottom of the chip, leaving an emitting surface that is uninterrupted by wire bonds or top-side electrodes. The result is a compact chip-scale package, just 0.4mm high, with output of up to 300lm at 1A.

The EC series is available in standard ReadyWhite correlated color temperatures (CCTs) ranging from 2700K to 10,000K with color rendering indices (CRIs) up to 90 minimum.

In addition to the manufacturing benefits of the chip-scale package, elimination of the wire bonds also improves the optical integration characteristics by taking advantage of the unobstructed and nearly edge-to-edge emitting chip surface that enables the die to be mounted very close together. This simplifies the optics by eliminating the need for complex mixing lenses that are used to control ghosting and shadows in narrow-beam applications. The glass top surface is also very mechanically robust, and is not prone to the handling damage or stresses faced by wire-bond or flip chips with a silicone covering. The typical 145º field of view also demonstrates good color-over-angle characteristics as a result of the ReadyWhite technology, says SemiLEDs.

By enabling densely packed mounting with simplified optics, the EC series is suitable for general lighting applications including indoor and outdoor lighting, architectural lighting, and torches/flashlights. The rugged architecture and compact size of the single white die are also suited to mobile device flashes and LCD backlighting applications, says the firm.

www.semileds.com

Excelitas unveils OmniCure AC8 Series UV LED curing systems for commercial, industrial & medical applications

Excelitas Technologies Corp of Waltham, MA, USA, which provides customized optoelectronics to OEMs, has launched its OmniCure AC8 Series of UV LED curing systems. The latest addition to the AC Series of UV LED curing solutions features superior optical uniformity, enhanced process control and ease of integration to support diverse applications in the curing of inks, adhesives and coatings.

The scalability of the AC8 Series allows for adjoining of multiple LED heads in order to achieve larger curing areas, supporting customization and flexibility without compromising output uniformity. The new high-power, air-cooled UV curing systems have also been especially designed with a small form factor to meet the needs of demanding applications in medical, industrial and electronics manufacturing including touch panel/display, solar panels, conformal coatings and print.

OmniCure AC8 UV LED curing system.

The OmniCure AC8150/AC8150P, AC8225/AC8225P and AC83000 systems are designed with custom front-end optics to provide high power, high peak irradiance and exceptional uniformity at different working distances. The AC8 Series also utilizes a patented process for addressing individual UV LED module outputs, providing exceptional uniformity over the entire curing area. Precise control of the UV irradiance level ensures that the correct amount of UV light is provided on every exposure for consistent and reliable results, says Excelitas. Also, the compact, air-cooled design allows seamless integration into new or existing production lines, enabling system upgrades with minimal disruption.

"Excelitas strives to develop products to help customers be more productive and cost efficient. The OmniCure AC8 Series helps do just that by increasing throughput for a wide range of applications in the curing of inks, adhesive and coatings," says Oliver Scheuss, VP, solid-state lighting and UV/microscopy.

www.excelitas.com/OmniCureAC8Series

Penn State research shows whiteness and color rendering has strong effect on LED lamp preference, says Soraa

Soraa Inc of Fremont, CA, USA, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates, has announced new psychophysical research proving that whiteness and color rendering have a strong effect on the perception of energy-efficient LED lighting. The study was approved by an Institutional Review Board and led by Kevin Houser at Penn State University.

Compared with conventional blue-based LEDs, study participants overwhelmingly preferred the whiteness and color rendering of Soraa's full-visible-spectrum lamps with Violet-Emission 3-Phosphor (VP_3) technology, it is reported. Soraa says that, like conventional electric light sources such as incandescent and halogen lamps, its lamps emit full-visible-spectrum light that renders warm, saturated color s — including important colors like reds and bright greens.

Furthermore, the lamps excite optical brightening agents (OBAs) in white objects like clothing, paper and plastics, making them look intentionally whiter. However, in their race to create maximally efficient, cheap products, most LED makers skipped parts of the spectrum, says Soraa. This has resulted in blue-LED based lighting products that cannot truly render whiteness or colors.

Uniquely, it is claimed, Soraa's full-visible-spectrum lamps with VP_3 Natural White are engineered to emit all colors of the rainbow, including violet, which excites OBAs and perfectly renders whites. The research study at Penn State showed that the vast majority of participants preferred objects rendered under Soraa's full-visible-spectrum light over standard LED light that lacked the short wavelength range of the spectrum.

Study participants also commented that colors were more saturated, vibrant and attractive under Soraa's full-visible-spectrum LED lamps with VP_3 Vivid Color — with a color rendering index (CRI) of 95 and R9 of 95 — versus blue-based LED lamps with a standard CRI of 85 and R9 of 0. The research showed that the firm's VP_3 technology rendered colors with high fidelity and no change in saturation; and the colors accurately matched the reference halogen lamp. This was true not only for colored objects, but also for participants' skin complexions.

"There are those who've asked: does color and whiteness rendering really matter? Well, it does, and we now have the data to prove it," says chief technology officer Mike Krames. "Because all of our lamps render the entire visible spectrum, white fabrics and paper goods pop, plastics are brilliant and people's smiles are whiter, and colors are more natural and beautiful," he adds. "That's good news for consumers and retailers, who want and deserve the enormous economic and environmental benefits of LED lighting, but are unwilling to sacrifice the sales benefits of excellent light quality in return."

www.soraa.com

Soraa adds SaveMoneyOutCarbon.com as UK distributor

UK full-service energy-efficiency firm SaveMoneyCutCarbon.com has announced a new partnership as Master Distributor for Soraa Inc of Fremont, CA, USA and its GaN-on-GaN (gallium nitride on gallium nitride) technology, which provides an alternative to halogen MR16 lamps.

Soraa's LED lamps are suitable for high-end retail, jewellers, art galleries, museums and the hospitality industry. For spotlighting over products, the firm's 95-CRI (colour render index) GaN-on-GaN technology is said to show a true representation of colors with crisp shadows and detail.

Soraa's LED lamps use GaN epitaxial layers on a native GaN substrate, rather than the standard GaN on sapphire or silicon carbide (SiC) substrates. GaN-on-GaN LEDs are claimed to produce more light per area of LED and are more cost-effective than technology based on other, non-native substrates.

Soraa's full-visible-spectrum light delivers colour rendering that is reckoned to surpass halogen sources. The firm's LED lamps are also claimed to run cooler and have no IR or UV radiation, reducing heat and emissions that can compromise sensitive materials.

"With an expanding range, we will be providing a portfolio of larger form factors essential for retail, hospitality and residential applications," says SaveMoneyCutCarbon.com's managing director Mark Sait.

"In the much-needed drive for energy-efficiency, we lost sight of a fundamental point: colour is just as important as light," notes Nick Farraway, Soraa's senior VP – International. "Only Soraa creates GaN-on-GaN lighting products for tomorrow's general illumination market," he adds. "All Soraa lamps feature 3-phosphor LEDs with violet pump that enable benefits such as point-source optics for beautiful, uniform beams of high-intensity Violet 3-Phosphor (VP_3) Natural White and VP_3 Full-spectrum Vivid Colour."

www.soraa.com
www.savemoneycutcarbon.com/2014/08/savemoneycutcarbon-com-agrees-master-distributor-

Plessey adds in-house GaN-on-Si LED assembly line

to provide engineering samples & pilot builds ahead of full production

UK-based Plessey has announced a further move to aligning operations to its expanding facility in Plymouth by adding an LED assembly line. The line should enable the firm to focus on its high-brightness LED growth plans based around its solid-state lighting and sensing business, taking new products from concept to production in less time while also functioning as an innovation center for the next generation of LED packages.

The assembly line uses a laser saw process and finishes with an automatic test for industry-standard PLCC (plastic, leadless chip carrier) packages. It includes die attach, wire bonding, phosphor mixing, encapsulation and singulation, in addition to all the other industry-standard, supporting equipment and processes. Designed specifically around speed and flexibility, the line will provide engineering samples for customer evaluation and pilot builds ahead of full production.

"The industrialization of GaN-on-silicon LED technology does not end at producing wafers — it also requires as much attention to the back-end processing to ensure that all the benefits we make at wafer level are fully realized in the final product," says Plessey's operations director Mike Snaith. "This is the best way to provide customers with the LED products they need."

Plessey says that its Plymouth facility is already demonstrating returns for this transition, enabling it to build working samples of complete in-house filament prototypes for the new market of LED filament replacement bulbs. The filament prototypes use dedicated die and assembly, all of which is designed and manufactured within the facility.

"The fact that we are recruiting recognized industry shapers from the world of solid-state lighting is a tangible endorsement that the Plessey value proposition is both exciting and credible," reckons chief technology officer Dr Keith Strickland.

The firm says that the facility brings additional benefits with wafer sawing and, going forward, new LED packaging standards will be established to match benefits made at the wafer level. Plessey adds that the assembly line investment is the start of this cycle of innovation where a revision of the value chain for LEDs and solid-state lighting is taking place.

Plessey's range of products for lighting applications will be showcased at the LuxLive event at ExCel London, UK (19–20 November).

www.plesseysemiconductors.com/led-plessey-semiconductors.php

San'an expands by ordering 50 Aixtron MOCVD systems

China's largest LED maker San'an Optoelectronics Co Ltd has ordered 50 next-generation Showerhead metal-organic chemical vapor deposition (MOCVD) systems from Aixtron SE of Aachen, Germany.

Aixtron says that this is one of the largest orders that it has ever received, and is growing evidence that LED manufacturers are beginning to expand production capacity to meet the constantly increasing demand for LEDs.

The systems will be delivered starting in fourth-quarter 2014, and will be installed in San'an's Chinese production facility by an Aixtron service team.

The tools will be used to expand San'an's production capacity for ultra-high-brightness LED chips based on gallium nitride.

www.sanan-e.com/en
www.aixtron.com

Seoul launches 30W Acrich LED Light Engine

South Korea's Seoul Semiconductor has launched an LED light engine with Acrich3 technology, consisting of a module with Acrich MJT 5050 series LED, Acrich3 IC technology and a heat-sink and secondary optics.

The Acrich light engine does not require a complex AC/DC converter and can be operated directly from the AC mains, simplifying designs, reducing component count and improving on the reliability of the luminaire, the firm says. The new 30W Acrich light engine delivers a typical luminous flux of 3000lm at $120V_{AC}$ operation at 5000K corresponding to a typical efficiency of 100lm/W. When operated in a power compensation mode, the Acrich3 technology can adapt to variations in the line-voltage as great as 20% and still deliver power-level regulation within 5% to ensure uniformity of the light output.

The new LED light engine also enables smart lighting control systems, where the Acrich3 technology can interface through a wide variety of wireless networks such as IEEE 802.15.4, WiFi and Bluetooth to control dimming, further optimizing energy savings. The IP67 light engine is available in various color temperatures and beam patterns.

"The payback period for streetlights can be significantly reduced with this new Acrich light engine," reckons Jay Kim, executive VP of the Lighting sales division. "By eliminating AC/DC converters in streetlights, maintenance costs can be lowered and reliability can be improved without compromising on price, quality and energy savings," he adds.

www.SeoulSemicon.com

Shareholders approve Epistar's acquisition of FOREPI

At a special general meeting on 1 September, shareholders of Epistar Corp (Taiwan's largest LED epiwafer and chip maker) have approved the acquisition of fellow Taiwanese LED epiwafer and chip maker Formosa Epitaxy Inc (FOREPI). FOREPI's shareholders have also approved the deal in a separate shareholder meeting. Taiwan's Fair Trade Commission has also issued its approval of the acquisition.

As announced in late June, Epistar is to issue 174.612 million new shares (worth NT$10 each, totalling NT$1746.12m) to acquire FOREPI through a stock swap of 1 Epistar share for 3.448 FOREPI shares (to be completed by end-December 2014).

Epistar is currently the world's largest manufacturer of aluminium gallium indium phosphide (AlGaInP) epiwafers and chips and the second largest of indium gallium nitride (InGaN) epiwafers and chips.

According to a report by Taiwan's Central News Agency, at Epistar's special general meeting chairman Lee Biing-jye said that the firm is keen to raise its economy of scale, as a larger-sized supplier in the global LED industry could grasp a larger market share. Lee said a larger Epistar is expected to meet rising demand in 2015, in particular in the second quarter of the year, when peak season effects could boost shipments.

After the acquisition, Epistar will become the biggest vendor of both AlGaInP and InGaN LED products and will have a 30–40% share of the global LED epiwafer and chip market, it is reckoned.

Lee also said that, as the global LED industry is on the road to recovery, Epistar has to position itself well to take advantage of the upward trend by raising production capacity, and the acquisition is part of its efforts to launch new products and boost Epistar's capacity.

In the production expansion stage, Epistar will need a larger workforce, said Lee, and the acquisition will allow the firm to make better use of FOREPI's experienced staff. Epistar is unlikely to make massive layoffs after completion of the acquisition, he adds.

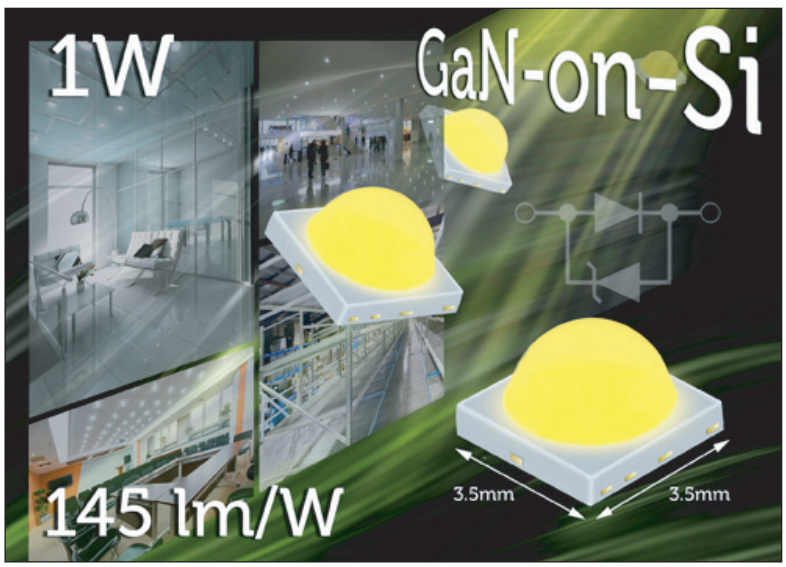
www.forepi.com.tw
www.epistar.com.tw

Toshiba launches ultra-compact 1W GaN-on-silicon white LEDs in 3535 lens type package

Toshiba Electronics Europe of Düsseldorf, Germany (TEE, the European electronic components business of Tokyo-based Toshiba Corp) has extended its LETERAS family of white LEDs with a new series of ultra-compact devices that combine cost-effective gallium nitride-on-silicon (GaN-on-Si) chips with an industrial-standard 3535 lens type package.

High-performance white LEDs have typically been fabricated on expensive sapphire substrates using relatively small 100mm or 150mm wafers, notes Toshiba. However, LETERAS LEDs use a cost-effective GaN-on-Si process technology that allows GaN LEDs to be produced on 200mm silicon wafers.

Devices in the TL1L3 series of 1.0W LEDs are supplied in a package with a footprint of 3.5mm x 3.5mm and a height (including lens) of just 2.42mm. Despite their small size, the LEDs deliver typical luminous flux ratings of 112–145 lumens, depending on the correlated color temperature (CCT).



Toshiba says that its latest LEDs with integrated lens are suitable for implementation in tube lights, light bulbs, down lights and ceiling lights, as well as street light and floodlight designs.

The new TL1L3 LED series comprises seven devices offering colour temperatures ranging from 2700K to 6500K. Minimum colour rendering index (Ra) ratings of up to 80 contribute to natural-looking lighting across all target applications, it is claimed. A low typical forward voltage (V_F) of just 2.85V (at a forward current of 350mA) helps to keep power consumption to a minimum, the firm adds.

TL1L3 LEDs are rated for operating temperatures between –40°C and 100°C and have a maximum power dissipation of 3.4W. They also offer a very low typical thermal resistance $R_{th(j-s)}$ from LED junction to solderpoint of only 5°C/W, adds the firm.

www.toshiba-components.com/LEDS

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www.evatecnet.com

Lumileds launch Matrix Platform, delivering infinitely configurable LED boards, linear flex and modules using application-optimized LEDs

Philips Lumileds of San Jose, CA, USA has expanded beyond its LED product offerings to include the Matrix Platform, consisting of turnkey LED solutions using components, optics and LUXEON LEDs assembled on a wide selection of board types. The platform launches with two product lines — the LUXEON XR and LUXEON XF — on rigid and flexible substrates, respectively.

"More than ever, luminaire manufacturers need robust solutions that meet their specific design requirements," says Viral Hazari, product line director for the Matrix Platform. "That need, together with today's time-to-market pressures, inspired our Matrix Platform," he adds. Based on customer requirements, Lumileds can provide LUXEON XR and LUXEON XF solutions designed with any LUXEON LEDs. Additionally, there are both 'off-the-shelf' and 'built-to-spec' options.

Lumileds' LUXEON XF-3535L LEDs on flexible substrate.

With Matrix Platform solutions, luminaire makers/designers benefit from faster time-to-market, simplified supply chain and access to proven illumination-grade LUXEON LED performance, the firm says. "Lumileds sees manufacturers quickly moving toward boards and modules to meet their time-to-market goals, and indeed we have been working with select customers for some time to understand and enhance the value we could provide with these solutions," says Hazari.

The firm's production line in Penang, Malaysia is dedicating 12,000ft^2 of capacity to Matrix Platform solutions. "We can rapidly turn around new designs — in many cases within two weeks of design approval."

Lumileds first rigid substrate module product, the LUXEON XR-3535L for troffer applications, provides uniform, distributed light. Specified at correlated color temperatures (CCTs) of 3000K, 3500K or 4000K and a color rendering index (CRI) of 80, the LUXEON XR-3535L achieves an output of 1320–1515lm and an efficacy as high as 160lm/W. For applications requiring a greater degree of design freedom and a flexible substrate (including accent lighting and cabinet lighting), the LUXEON XF-3535L produces 1100–5070lm with an efficacy as high as 160lm/W.

www.philipslumileds.com

Lumileds' LUXEON CoB with CrispWhite wins LFI Innovation Award

Philips Lumileds of San Jose, CA, USA says that its proprietary CrispWhite Technology, which was on display at June's LightFair International 2014 trade fair in Las Vegas, has been awarded the LFI Innovation Award in the category of LED/OLED Chips and Modules.

The LFI Innovation Awards are judged by an independent panel of lighting professionals — recognizing products that exemplify the best in innovative design and thinking. In 2014, there were 261 entries spanning 14 categories.

LUXEON CoB with CrispWhite Technology was developed specifically for retail applications including downlights and spotlights where the truest color representation is desired by store owners and retail customers. CrispWhite is offered throughout the LUXEON chip-on-board (CoB) line of arrays, which feature what is claimed to be he industry's highest combination of efficacy and lumen density (with a lumen range of 1000–10,000lm and typical efficacy of 100lm/W).

LUXEON CoB LEDs with CrispWhite Technology.

Lumileds says that thousands of show attendees (including lighting professionals and designers) got a preview of CrispWhite's light spectrum at both LightFair International and the Guangzhou International Lighting Exhibition in June. "We displayed saturated red, blue and white fabrics lit by CrispWhite next to the same fabrics lit by halogen and CDM sources," says product line director Eric Senders. "Overwhelmingly, attendees preferred CrispWhite's rendition."

www.philipslumileds.com/CrispWhite

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Cree files lawsuits to protect LED component IP

Cree Inc of Durham, NC, USA has filed patent infringement lawsuits in the United States District Court for the Western District of Wisconsin to prevent Taiwan-based LED makers Harvatek Corp and Kingbright Corp from infringing its patented intellectual property. The patents protect, among other things, Cree's LED component portfolio, including the firm's white light LEDs.

The US patents included in these cases are:

- 6,600,175 — solid-state white light emitter and display using same;
- 7,943,945 — solid-state white light emitter and display using same;
- 8,659,034 — solid-state white light emitter and display using same;
- 7,910,938 — encapsulant profile for light-emitting diodes;
- 8,766,298 — encapsulant profile for light-emitting diodes; and
- 8,362,605 — apparatus and method for use in mounting electronic elements.

"Cree continues to invest significant resources in developing industry-leading technologies, and it is paramount that we protect the investment of our current licensees, shareholders and customers," says general counsel Brad Kohn. "These cases demonstrate that Cree will continue to take the necessary measures worldwide to protect our patents and other intellectual property rights against any company that infringes our patents."

www.cree.com/About-Cree/Licensing

Cree wins Lighting for Tomorrow Award in Solid-State Lighting

On 16 September at the American Lighting Association (ALA) Annual Conference, Cree received the 2014 Lighting for Tomorrow Award for Solid State Lighting design in the directional lighting category with the Mini CXA HD Punch, a concept design with 100W PAR38 performance in an MR11 lamp size.

Cree designed the Mini CXA HD Punch to demonstrate innovations using its XLamp CXA 1310 high-density LED array, emitting a smooth beam with what is claimed to be exceptional color rendering. Currently in review for ENERGY STAR qualification, the Mini CXA HD Punch concept design delivers a correlated color temperature (CCT) of 3000K with a 40º beam angle and is designed to support a wide range of decorative colors. Cree claims its high-density (HD) LEDs deliver the industry's highest optical control factor (OCF), enabling new lighting solutions that were not previously possible.

"With unmatched lumen density and small light-emitting surface (LES), Cree high-density LEDs made it possible to deliver the performance of a 100W PAR38 in a 75% smaller form factor, something that has never been done before," claims David Cox, Cree director of alliance development.

The Lighting for Tomorrow panel consisted of eight judges drawn from the residential lighting community and experts in lighting technology, lighting sales, standards and safety, energy efficiency, lighting design and communications. Submissions were evaluated considering the following criteria: color appearance, color rendering, illuminance, application efficiency, value and aesthetics. The Mini CXA HD was described by judges as an innovative design that provides quality performance and beam smoothness for its size, setting it apart from its competition and pushing the boundaries of the category.

Sponsored by the ALA, the CCE (Consortium for Energy Efficiency) and Underwriters Laboratories (UL), the Lighting for Tomorrow Awards honored a broad range of residential LED products such as fixtures, retrofit kits and replacement lamps, focusing on high-demand LED product categories such as high-lumen replacement A-lamps, replacement A-lamps under $10, and fixtures under $50.

www.cree.com/xlamp/lightingfortomorrow

Toyoda Gosei grants white LED device license to Harvatek

Toyoda Gosei Co Ltd of Kiyosu, Aichi Prefecture, Japan has entered into a license agreement relating to silicate-based white LEDs with Taiwan-based surface-mount device LED maker Harvatek Corp.

Toyoda Gosei, together with Tridonic Jennersdorf GmbH in Austria and Leuchtstoffwerk Breitungen GmbH and Litec GbR in Germany — the four members of the B.O.S.E. (Barium Ortho-Silicate Europium) Consortium — owns basic patents for a technology that generates white light with blue LEDs and novel yellow silicate phosphors. The technology enables the manufacture of white LEDs with high accuracy and high brightness, the primary applications of which include cell phones, laptops, GPS and other small displays, accounting for a large share of the LED market.

To make the white LED technology available to the LED industry, the B.O.S.E. Consortium offers two different licensing schemes: a Device License for using the white LED technology, and a Material License for manufacturing and marketing the phosphors.

Toyoda Gosei has granted the Device License to Harvatek for it to join the pool of white LED makers with the B.O.S.E. Consortium's silicate-based LED patents.

http://toyodagosei-led.jp/pdf/licensees.pdf
www.harvatek.com

Cree launches MH-B high-power LEDs to boost performance and lower system cost

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has introduced the XLamp MH-B LED, a new generation of high-power LEDs that delivers better performance and a more effective way to achieve low-cost systems than mid-power (MP) LEDs.

Using Cree's high-reliability ceramic package technology, the MH-B LED is able to operate at higher temperatures than MP LEDs with no reduction in rated lifetime, enabling a 60% reduction in heat-sink size and cost. Using up to 26 times fewer LEDs than MP LEDs to achieve the same level of performance, the MH-B is optimized to simplify LED system designs for applications where multiple MP LEDs are currently used.

"Cree has once again invented a lighting-optimized solution that can lower my costs and decrease manufacturing times," comments Frank Chen, technical director at Zhejiang Shenghui Lighting Co Ltd and Sengled Optoelectronics Co Ltd. "While chip-on-board (CoB) LEDs are an attractive alternative to MP LEDs in terms of reliability and cost, they aren't compatible with my automated manufacturing processes," he adds. "The new XLamp MH-B LED finally gives me a more reliable alternative to mid-power LEDs."

Cree's XLamp MH-B LED chip.

Featuring Cree's EasyWhite technology and a small 5mm light-emitting surface, the MH-B provides many system benefits over arrays of MP LEDs, including tighter beam angles, simpler optics, a more traditional appearance and easier color consistency, claims Cree. As a single LED, the MH-B LED delivers up to 830 lumens at 175mA and can also be used in arrays to address higher-lumen applications that require low cost and high reliability, such as high-bay, outdoor area and downlights.

"The new XLamp MH-B LED combines the reliability and manufacturability of Cree's high-power LEDs with the simplicity and performance of our CXA LED arrays," says Paul Thieken, Cree's director of marketing, LED components. "MH-B introduces a new technology platform that gives customers the best of both technologies, while avoiding the limitations of mid-power LEDs," he adds.

The MH-B LED is available in correlated color temperatures (CCTs) of 2700–6500K with high color rendering index (CRI) options. Product samples are available now and production quantities are available with standard lead times.

www.cree.com/xlamp/mhb

Cree launches TrueWhite LED replacement for halogen MR16 lamps

Cree has launched MR16 Series LED lamps with TrueWhite Technology, delivering the soft, diffused light of a traditional 50-watt halogen MR16 lamp and designed for global compatibility with virtually all existing sockets. With a suggested retail price of $25, the MR16 TrueWhite LED lamps consume up to 83% less energy, it is reckoned, and are designed to meet ENERGY STAR qualification to deliver a rapid payback of less than one year (compared with a 50-watt halogen MR16 lamp and based on usage of 12 hours per day and the national average of $0.13 per kWh electric costs).

Featuring a design that delivers output of more than 580 lumens in conjunction with a proprietary lens, the MR16 Series TrueWhite LED lamps eliminate the glare commonly associated with 50-watt halogen MR16 lamps to deliver a soft, diffused light with what is claimed to be a category-leading color rendering index (CRI) of 92. The lamps are dimmable and available in 15º spot, 25º flood and 40º wide flood beam angles in a 1.97", ANSI-compliant form factor, allowing them to easily fit into existing tracks for a one-for-one replacement, says Cree.

Cree's MR16 Series TrueWhite LED lamps.

The MR16 Series TrueWhite LED lamp is available via distributors throughout the USA and Canada.

www.cree.com/lighting/MR16serie

Synopsys to develop advanced model and first PDK of POET's planar electronic technology

PET/PDK to be available by end 2014

POET Technologies Inc of Toronto, Canada — which, through subsidiary OPEL Defense Integrated Systems (ODIS Inc) of Storrs, CT, USA, has developed the proprietary planar-optoelectronic technology (POET) platform for monolithic fabrication of integrated III-V-based electronic and optical devices on a single semiconductor wafer — is collaborating with Synopsys Inc (which provides software, IP and services used to accelerate innovation in chips and electronic systems) to develop an advanced model and first process design kit (PDK) of POET's planar electronic technology (PET) targeting the 40nm technology node widely used for highly integrated systems-on-chip (SoC).

POET will use Synopsys' TCAD (technology computer-aided design) toolset and services to continue to develop the PET and POET PDKs. The PET PDK milestone (MS-12) focuses on devices requiring only the electronic subset of the POET devices and processes. "Synopsys will provide expertise and services to the POET team, enabling us to expedite the design process," says POET's chief technology officer Daniel DeSimone. "The Synopsys TCAD software toolset is well positioned for the POET PDK requirements."

The Synopsys toolset will be used for process technology development and design of nano-scale devices in POET's III-V compound semiconductor process. Devices include complementary HFET and HBT transistors with high-electron-mobility performance, including a thyristor with both optical and electrical operation. These devices will form the foundation of POET's technology, which is able to integrate active optical circuitry, lasers, modulators, filters, detectors and electrical circuitry on a single die.

"POET Technologies' III-V process and devices IP represent a significant innovation for our industry," comments Terry Ma, Synopsys' VP of engineering for TCAD. "This collaboration with POET will combine the strengths of our TCAD modeling expertise and POET's innovative technologies to provide leading-edge semiconductor companies significant benefits for next-generation semiconductor designs."

The PET PDK and process offers lower cost and simpler process fab options for applications that do not require the full POET optical feature set, says the firm. Due to the high mobility inherent in III-V materials, PET technology is predicted to deliver performance that could be equivalent to 3–4 nodes ahead of mainstream technologies, it is reckoned. Further performance and capabilities will be enabled by incorporating in-plane optical intra- and inter-chip signaling capabilities within the electrical technology.

The PET/PDK is scheduled to be available at the end of fourth-quarter 2014 and will allow POET to provide detailed design information to industry fab partners and customers. This will enable pre-semiconductor design evaluation to integrate optical, analog and digital functions together, says POET. PET-based electronic devices represent a breakthrough in performance and power efficiency, the firm claims.

"This [the 40nm technology node] is an aggressive target for our POET devices and process IP," says Copetti. "This will demonstrate to the industry the significance and the strengths of POET compared to the performance and power efficiency of today's widely used technologies."

www.synopsys.com
www.poet-technologies.com

DILAS launches 2.5kW fiber-coupled diode laser system for materials processing

Diode laser maker DILAS of Mainz, Germany has launched a higher-power fiber-coupled diode laser system for materials processing applications with output power of 2.5kW at 980nm.

The SF2500/10 fiber-coupled system is based on micro-channel-cooled diode laser bars featuring a compact footprint and convenient aiming beam. With a beam parameter product of 110mm mrad, the system delivers 2.5kW through a cladding-mode-free QBH high-power

1000µm-core-diameter fiber, 0.22NA at single wavelength of 980nm.

The stand-alone fiber-coupled diode laser system includes a water-water heat exchanger and diode laser driver inside a compact chassis. DILAS' standardized diode laser control unit (DLC) provides standardized external interfaces.

With this new high-power diode laser system, DILAS is expanding into new market applications such as surface treatment (e.g. selective hardening), cladding or high-power brazing. In addition, the 2.5kW system is suitable for scientific research applications that require large spot sizes and uniform intensity profile.

www.dilas.com

POET collaborating with foundry to reproduce and enhance repeatability at 100nm

POET Technologies has announced an agreement with a third-party foundry to reproduce and enhance repeatability of the 100nm scale results obtained at the POET labs at University of Connecticut (UCONN). The third-party foundry will also help POET to shrink the 100nm PET (Planar Electrical Technology) devices and process to a 40nm feature size.

Having developed a structure suitable for scaling its transistors to 100nm, POET has engaged a third-party foundry to replicate the results with greater precision and larger scale using electron-beam writing tools. Definition and repeatability of 100nm has been difficult in the POET labs due to the limitations of available lithography tools and other equipment. The collaboration gives the team access to superior capability and diagnostics, allowing the POET approach to start to scale to both 3" and 6" wafers with much larger device count and across-wafer alignment. The fine features will then be merged with optical lithography and other procedures necessary to transition to a manufacturing environment. In addition, the effort will target linewidth reductions from 100nm down to 40nm which should enable POET performance parameters to compete with present state-of-the-art processes. The reduction will be parallel to the firm's efforts with its Synopsys TCAD collaboration.

"Developing the 100nm feature size technology in the current POET labs has proven to be challenging," notes chief scientist & board member Dr Geoff Taylor. "With the collaboration of our third-party foundry, we now have access to state-of-the-art equipment. This will help us make the process more stable and predictable and help prove our process in a true manufacturing environment."

The results of the physical devices at 40nm developed at the third-party foundry can then be correlated to models of the PET technology developed using TCAD tools from Synopsys and vice-versa.

"We have the right collaboration in place with Synopsys and our third-party foundry to model our technology down to 40nm and correlate our process to real physical device measurements," says executive chairman & CEO Peter Copetti. "This should provide us with results needed to showcase our technology to potential customers at the optimum node for our platform. We expect synergistic benefits from having parallel operations with the same end target."

www.poet-technologies.com

IN BRIEF

BinOptics unveils 4x25G lasers for 100G data-centers

BinOptics Corp of Ithaca, NY, USA,which provides lasers for data centers, mobile backhaul, access and silicon photonics, has announced the availability of 25G lasers at four wavelengths (1270, 1290, 1310 and 1330nm), allowing 100G solutions for data centers through course wavelength division multiplexing (CWDM).

Trends such as cloud computing and streaming video have fueled a rapid increase in bandwidth demands from data centers, notes the firm. Compared to 10G and 40G, 100G solutions provide an increase in data transfer with lower power consumption per bit of transferred data.

Earlier this year, an analyst at Infonetics Research said: "40G alone will easily pass $1bn in revenue this year as it becomes the technology of choice in the data center." Infonetics also expects the 100G market to gain critical mass in 2015.

"Our team has been focused on 100G needs of data centers for some time," says BinOptics' CEO & co-founder Alex Behfar. "Our 25G CWDM lasers can meet the demand for lower power consumption in data transfer, allowing increased bandwidth and density in data centers."

BinOptics' 25G distributed feedback (DFB) laser diodes are designed to operate at temperatures from 0°C to 70°C with low power consumption. The products utilize BinOptics' proprietary Etched Facet Technology for what is claimed to be exceptional reliability and performance while offering a cost-effective solution.

The 127, 129, 131, and 133 D-25x-Lxx11 products are now sampling and are expected to be in full production by the end of 2014.

www.binoptics.com

Advanced Photonix awarded $1.6m contract for US Navy's Guided Missile Weapons System program

Advanced Photonix Inc (API) of Ann Arbor, MI, USA (which designs and makes APD, PIN, and FILTRODE photodetectors, HSOR high-speed optical receivers, and T-Ray terahertz instrumentation) has received a contract worth about $1.6m from a leading military contractor that acts as a prime supplier for the US Navy's Guided Missile Weapon System. The contract is for a custom photodiode and is expected to be completed within the next 18 months, and payment is due upon shipment.

The Navy's Guided Missile Weapon System is reckoned to be the world's most modern ship self-defense weapon and has been designed to provide protection for ships of all sizes. The specific guided missile is a supersonic, light-weight, quick-reaction, fire-and-forget missile designed to destroy anti-ship missiles. Its autonomous dual-mode passive RF-to-infrared guidance design requires no shipboard support after the missile is launched, providing uniquely high-firepower capability for engaging multiple threats simultaneously.

"This vital missile program has been one of the Navy's most reliable missile guided systems," says API's president & CEO Richard Kurtz. "This is an ongoing program which we have been fortunate to have for the past 15 years and expect this program to continue into the future."

The photodiode serves as a detector on the missile's proximity sensor. Because the missile's airframe rotates like a rifle bullet for greater accuracy, the system requires four detectors mounted 90 degrees away from each other. So, as the airframe rolls, there is always a detector sensing for proximity.

Ideally, the ship's missile will strike the enemy's incoming missile, but the proximity sensors are there to ensure that, if there is not a direct heads-on hit, the Navy's missile will detonate as it passes by the incoming missile, protecting the fleet below.

The RIM-116 rolling airframe missile (RAM) is designed to destroy anti-ship cruise missiles and asymmetric air and surface threats. It was developed as a cooperative program between the USA and German governments and continues to be cooperatively produced and supported. Currently, there are two RIM-116 configurations. Block 1A (RIM-116B) is nearing completion of full-rate production. Block 2 (RIM-116C), for which API is supplying its photodiodes, is currently in low-rate initial production and undergoing developmental and operational testing.

In addition to missile guidance, API's technology serves the military by providing components for heads-up displays, satellite positioning, laser range finders, and navigation.

In fiscal 2014, military and aerospace contracts generated $2.7m of API's total revenue of $29m. The firm anticipates that this contract, along with the absence of government sequestration this fiscal year, will result in greater revenue from these customers.

The new project is part of API's Optosolutions line of business that serves not only the military/aerospace industry but also customers in testing and measuring (T&M) as well as the medical market. In the T&M market, API technology is used in such diverse areas as water quality monitoring, the control of seed planting, safety monitoring, currency validation, counterfeit detection, and pyrometry (heat measurement at a distance). Among applications in the medical field are immunoassay testing, retina eye diagnostics, pulse oximetry and flow cytometry. The firm estimates that the total addressable market for its optoelectronics is about $150m annually.

www.advancedphotonix.com

Luceda Photonics receives growth finance for development and marketing of PIC design framework

Fidimec (the investment arm of nanoelectronics research center imec of Leuven, Belgium, supporting the creation and growth of its spin-off companies) and the €20m fund SOFI I (a Spin-Off Financing Instrument that provides venture capital to new companies originating from the Flemish Strategic Research Centers) are investing €340,000 in Luceda Photonics of Dendermonde, Belgium. Luceda will use the new financing to start commercialization of its photonic integrated circuit (PIC) design software and to continue to invest in R&D for new product features.

Luceda was founded in June as a joint spin-off from Ghent University (UGent), Vrije Universiteit Brussel (VUB) and imec, combining experience in PIC design including expertise in developing process design kits (PDKs). The core of the firm's product offering is the IPKISS design framework. Launched in 2012 as an open-source software platform for the integrated photonics design community, IPKISS covers the complete photonic IC design flow from component design and simulation through circuit definition and layout, all the way to tape-out and testing. Its component library builds on years of design experience gathered over more than 300 validated designs. The IPKISS environment also includes CAPHE (a circuit simulation tool for complex optical circuits) and B-CALM (a GPU accelerated FDTD simulator).

The IPKISS framework was originally developed by UGent's Photonics Research Group (which has a research staff of about 70, active in photonic integration on silicon IC platforms and applications in information & communication technology, sensing and life sciences) together with imec's associated lab at UGent. The B-CALM software was developed by the VUB's Brussels Photonics Team (B-PHOT), which is active in micro-miniaturized photonics. With its micro-optical design platform, its wafer-scale polymer optics prototyping line and its large-scale micro-optical measurement centre in cleanroom conditions, B-PHOT is involved in optical modelling, optical characterization, low-cost rapid prototyping, and proof-of-concept demonstration of micro-optical modules and micro-photonic systems.

"We want photonic IC designers to enjoy the same first-time-right design experience as electronics IC designers," says Luceda's CEO Erwin De Baetselier. "IPKISS is a state of the art environment that makes the design flow for photonic ICs robust and will save our customers considerable design time," he adds. "The open nature of the IPKISS toolset permits the seamless integration of various third-party or even in-house tools and measurement capabilities. The photonics designers will gain insight, repeatability and accuracy of their entire design process," Baetselier continues.

"Photonic ICs are on their way to become a mainstream industrial reality in the datacom, telecom and sensor markets," says professor Roel Baets, photonics professor at UGent and head of imec's associated photonics lab at UGent. "Together, UGent's Photonics Research Group and imec's associated photonics lab at UGent have invested many years to develop a unique design framework for photonics ICs. It is the right time now to bring this to the market. We are convinced that Luceda Photonics will have a substantial and lasting impact in this emerging industry," he adds.

"By adding B-CALM to its product portfolio, Luceda Photonics offers its customers the unique possibility to efficiently design coupling structures to sub-wavelength plasmonic optoelectronic components," notes professor Hugo Thienpont, head of VUB's B-PHOT team. "This puts Luceda Photonics in pole position for the design of ultra-high-speed photonic ICs as used in data-centers and supercomputers."

www.lucedaphotonics.com

Finisar receives Technology Achievement Award from Brocade

Fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has received the 2014 Technology Achievement Award from network provider Brocade Communications Systems Inc of San Jose, CA.

The technology award recognizes the supplier who is both innovative and proactive in providing technology solutions that ensure Brocade's competitive advantage. The selection criteria included excellence in roadmap alignment, partnership in product design, technology leadership, and proactive engineering support. A few examples of Finisar's achievements were highlighted during the event, including:

- the broadest portfolio offering from any supplier;
- a commitment to aligning to Brocade's roadmap;
- a dedication to emerging technologies such as 32G SFP+, 100G CFP2, CFP4 and QSFP28;
- unwavering commitment to supporting Brocade's customer requirements; and,
- a leadership position in vertical-cavity surface-emitting laser (VCSEL) technology that surpasses industry performance.

"Finisar will continue to provide customers with innovative optics technology solutions to drive the industry forward," says Todd Swanson, executive VP, sales & marketing.

www.finisar.com

MACOM launches first four-channel CDR with integrated high-output-voltage EML driver for 100G modules

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes analog semiconductors, components and subassemblies for analog, RF, microwave and millimeter-wave applications) has launched the newest addition to its portfolio of clock & data recovery (CDR) devices and modulator drivers for 100Gbps optical module applications.

The MAOM-37051A is a four-channel 28Gbps CDR with integrated electro-absorption modulated laser (EML) driver that can deliver up to $2.5V_{pp}$ single-ended output. The device integrates MACOM's CDR technology with its EML drivers in a small-form-factor surface-mount package to provide what is claimed to be the lowest-power solution available for CFP4 and QSFP28 transceivers. MACOM gave a live demonstration of the product at the China International Optoelectronic Exposition (CIOE 2014) in Shenzhen (2–5 September).

The next generation of pluggable modules for 100G in CFP4 and QSPF28 form factors requires drastic reductions in the size and power consumption of components. MACOM says that its MAOM-37051A meets these stringent performance requirements for the transmitter and, when combined with its M37046 Receiver CDR and M03100 TIA devices, provides the lowest-power complete chip-set solution for 100G modules.

"Working very closely with our customers and understanding their needs, this product — along with our receiver chip-set — enables the lowest-power solution for the next generation of pluggable 100G modules," claims Stefano D'Agostino, Distinguished Fellow of Technology at MACOM.

Samples of the MAOM-37051A are available now.

Optical portfolio for PON, 10G and 100G showcased at CIOE

At CIOE 2014 in Shenzhen , MACOM showcased its portfolio of clock & data recovery (CDR) ICs, transimpedance amplifiers (TIAs) and laser drivers for 10–100G applications and beyond.

Leveraging a suite of semiconductor technologies, MACOM creates solutions covering data-center, client access, metro and long-haul applications, including:

- 100G chipset solutions for CFP2/4 and QSFP28 form factors;
- modulator drivers for coherent applications at 100G and beyond;
- a 10G complete chipset for SFP+/XFP MSA modules;
- Gigabit passive optical networks (GPON) ONU/OLT (optical networking unit/optical line terminal) complete chipset solutions; and
- the next generation of 10G-EPON (10 Gigabit Ethernet PON) and XG-PON1 (next-generation GPON) ONU/OLT chipset solutions.

www.cioe.cn/eindex.html
www.macom.com/cioe2014

Most integrated 10G SFP+ optical module chipset

MACOM has launched what is said to be the most integrated 10G chipset, suitable for 10G/12G SFP+ and XFP optical module designs. The chipset consists of a transimpedance amplifier (TIA) along with an integrated laser driver and a limiting amplifier, with the option of an integrated clock & data recovery (CDR).

The chipset will enable SFP+ form-factor modules with less than 800mW maximum power across operating conditions. MACOM offers a complete proven SFP+ reference design for quick seamless module designs.

The M02193 is a laser driver integrated with a limiting amplifier that supports data rates from 1Gbps to 12.5Gbps, while the M02190 is a laser driver integrated with reference-free CDR supporting data rates from 9.95Gbps to 11.7Gbps. Both laser drivers are designed to DC-couple to the laser diode in order to reduce overall power dissipation, eliminating external biasing circuits.

The laser drivers offer what is claimed to be the first 10G closed-loop extinction ratio (ER) control that eliminates the cumbersome laser look-up table calibration in production. Users only need to set the target ER and the laser drivers will automatically maintain this ER across operating conditions.

The M02190 and M02193 devices offer what is claimed to be the highest integration in the industry with on-chip controller, EEPROM memory and an APD DC–DC controller, providing a complete solution reducing overall system costs. Completing the chipset is the M02131 low-power, high-sensitivity TIA, which consumes less than 100mW typical power with better than –20dBm sensitivity.

"Our latest 10G chipset offers the industry's highest integration, lowering overall bill of material costs," says Angus Lai, MACOM's product marketing director, High Performance Analog. "With its best-in-class power consumption and link margin, it is the ideal solution for new 10G SFP+ module designs," he claims.

MACOM highlighted the new 10G chipset alongside established physical media device (PMD) solutions at CIOE 2014.

www.macom.com

CIVCOM launches 2nd-gen 100G coherent transponders

Two years after launching its first-generation 100G coherent transponder, CIVCOM of Petach Tikva, Israel (which provides high-end DWDM tunable transponders) claims to be first to release a line of second-generation 100G coherent transponders based on the LightSpeed-II family of DSPs from ClariPhy Communications Inc of Irvine, CA, USA, which develops high-speed mixed-signal digital signal processing (MXSP) systems-on-chip (SoC) for coherent optical networks. The new transponders offers what is claimed to be best-in-class cost per bit by delivering the highest performance available with reduced cost, foot print and power consumption.

CIVCOM says that it is committed to expanding the acceptance and deployment of 100G coherent technology by offering a product line of transponders optimized to fit different market segments:

- Metro 100G-OIF coherent transponder — Optimized for metro networks, this module enables vendors that deployed first-generation 100G OIF modules to seamlessly provide a competitive solution for the metro.
- Regional 100G-OIF coherent transponder — Designed for regional and inter-city applications, the module has what are claimed to be the best optical signal-to-noise ratio (OSNR) results on the market, reduced power consumption and size, and offers significant saving compared to Gen I transponders.
- Long-haul OIF transponder — Targeting long-haul (LH) and ultra-long-haul (ULH) networks, this transponder offers what are claimed to be the highest chromatic dispersion (CD) compensation and best OSNR tolerance on the market.

Advantages include: drop-in replacement to existing Gen I line-cards; significant savings — what is claimed to be the best cost-per-bit available; optimization to different market segments; and low risk — utilizing field-proven optical components.

"CIVCOM and ClariPhy worked closely together to bring this line of products to the market," says CIVCOM's CEO Gabby Shpirer. "The test results surpassed our high expectations, especially with respect to the best-in-class performance of the modules," he adds.

"These new industry-leading coherent products will significantly accelerate 100G deployments into applications spanning regional, metro, long-haul and ultra-long-haul networks, while addressing the ever-increasing demand for cost-effective, high-performance coherent technology," believes ClariPhy's CEO Nariman Yousefi.

www.clariphy.com

Microsemi acquires Centellax

MMIC design technologies & communications product range boosted

Microsemi Corp of Aliso Viejo, CA, USA (which designs and makes analog and RF devices, mixed-signal integrated circuits and subsystems for communications, defense & security, aerospace and industrial markets) has acquired Centellax of Santa Rosa, CA, USA, a supplier of high-speed analog and RF devices for the optical communications and Ethernet datacom markets.

With a design team combining capabilities in millimeter-wave engineering and high-speed digital design, Centellax makes next-generation products designed specifically for high-speed communications markets, with higher levels of integration enabling better performance and more cost effective products. Microsemi says that the acquired product lines and technology will expand its existing communications product portfolio while allowing it to leverage Centellax's optical and Ethernet data-center capabilities.

"The high-speed design and packaging capabilities of Centellax are at the very edge," comments Microsemi's chairman & CEO James J. Peterson. "We look forward to incorporating its leading-edge designs into our ever expanding communications product portfolio."

The transaction is not expected to have a material effect on Microsemi's revenues or expenses. Microsemi also reaffirms its revenue guidance for its fiscal fourth-quarter 2014.

Microsemi announces $100m stock repurchase program

Microsemi's board of directors has authorized the repurchase of up to $100m of the firm's common stock. The timing and amount of repurchase transactions under this program will depend on market conditions and corporate and regulatory decisions. The purchases will be funded from available working capital.

Microsemi says that the share repurchase program is an efficient method for returning excess cash to its shareholders. The firm has consistently reduced debt and strengthened its cash flow generation over the last five years, and continues to execute on its business plan to grow shareholder value.

The authorization permits the firm to repurchase up to $100m of stock before end-September 2016. The program does not obligate Microsemi to acquire any particular amount of common stock, and may be modified or suspended at any time at the firm's discretion.

www.microsemi.com

JDSU separates into optical components and commercial lasers firm and network and service enablement firm

Split expected to be completed by third-quarter 2015

JDSU of Milpitas, CA, USA says that its board of directors has unanimously approved a plan to separate JDSU into two independent publicly traded companies:

- An optical components and commercial lasers company (CCOP), consisting of JDSU's Communications and Commercial Optical Products segments (serving a $7.4bn optical communications market, expected to grow at a compounded rate of 11% over the next four years) and a $2.5bn commercial lasers market (growing at a forecasted 7% annually). CCOP's fiscal 2014 revenues were $794.1m.
- A network and service enablement company (NSE), consisting of JDSU's Network Enablement, Service Enablement and Optical Security & Performance (OSP) Products segments (addressing a $7bn network and service enablement market, expected to grow at 6–8% annually) focusing its investments primarily on higher-growth markets (particularly software supporting virtualized and software-defined networks), plus the $1.1bn optical security market (growing at an expected 6–8%, with the OSP business operating as a separate segment inside NSE). Combined fiscal 2014 revenue for NSE and OSP was $949.5m.

"Over the past five years, JDSU has invested heavily in innovation that is well aligned with the industry's best growth opportunities, including cloud networking, data-center expansion and software-defined networks," says president & CEO Tom Waechter. "These opportunities extend beyond the traditional telecom ecosystem and now include web services, over-the-top, enterprise and other customers… Two fundamentally focused companies best position us to stay ahead of the accelerating pace of technology change and to compete even more effectively across the unique markets we serve today," he believes. "Now is the time to make this transition, giving these businesses the opportunity to maximize their success while providing shareholders with distinct investment opportunities in two growth markets."

As well as creating clearer investment profiles for both companies and enhancing shareholder value, JDSU believes that the separation will allow CCOP to: devote enhanced focus to what it claims is its leading position in optical components and subsystems for the telecoms market, expand its position in the high-growth datacom market (driven by cloud networking and data-center build-outs), and grow its commercial lasers and 3D sensing businesses; and enable NSE to continue its leadership in network enablement, while continuing to transition to a more software-centric company aligned with the industry's rapid shift to software-defined networks.

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Alan Lowe, CCOP's president since 2008 and executive VP of JDSU, is the CEO-designate of the CCOP stand-alone company. "He has built a strong team and has a solid track record of execution during his seven years at JDSU," comments Waechter. "Alan has a deep understanding of and familiarity with CCOP's markets and customers."

JDSU's president & CEO Tom Waechter will continue in this role with the stand-alone NSE company.

The separation of the two companies is expected to occur through a tax-free pro rata spin-off of CCOP through distribution of the new CCOP company's shares to JDSU shareholders. Separation is expected to be completed in calendar third-quarter 2015, subject to the satisfaction of closing conditions including obtaining final approval from JDSU's board of directors, receipt of tax opinions, the effectiveness of an applicable registration statement with the US Securities and Exchange Commission (SEC) and satisfaction of foreign regulatory requirements. Separate corporate brand identities for each business are expected to be announced at a later date.

During the periods preceding the separation, JDSU expects to incur significant one-time charges related to the separation and to achieving related expense savings. Cash expenditures to obtain anticipated combined cost savings of about $50m are expected to be $75–100m.

For the firm's fiscal first quarter of 2015 (ending 27 September 2014), JDSU is reaffirming its guidance of net revenue of $405–425m and non-GAAP earnings per share of $0.08–0.12.

www.jdsu.com

Emcore selling space solar business to Veritas Capital

Further savings target break-even of Fiber business by September 2015

Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and solar power markets, has entered into a definitive agreement for an affiliate of private equity firm Veritas Capital to purchase its Space Photovoltaics business for $150m in cash (subject to working capital adjustments) and the assumption of certain liabilities. Subject to approval by Emcore's shareholders and other customary closing conditions, the transaction (which is not subject to a financing condition) is expected to close in December or January.

In connection, an affiliate of Veritas has entered into a voting agreement with certain shareholders of Emcore (including certain directors and officers of the company) that control about 11% of the voting power of the firm, under which they have agreed to vote their shares in favor of the transaction.

Founded in 1998 and based in Albuquerque, Emcore's Space Photovoltaics business provides products for space power applications including high-efficiency multi-junction solar cells, coverglass interconnected cells (CICs) and complete satellite solar panels, along with terrestrial applications including high-efficiency multi-junction solar cells for concentrating photovoltaic (CPV) power systems.

The assets to be sold comprise substantially all of Emcore's Photovoltaics reporting segment, as well as all rights to the buildings owned, and includes about 275 staff in Albuquerque. The Space Photovoltaics business fiscal 2013 revenue was $70.5m.

"The management and employees at Emcore have an established history of providing leading technology and reliable products to the worldwide satellite industry," comments Veritas Capital partner Benjamin Polk. "We look forward to continuing this excellent track record under our ownership and to working with the Space Photovoltaics team to expand the business," he adds.

Veritas invests in companies that provide critical products and services to government and commercial customers worldwide including those operating in aerospace & defense, healthcare, technology, national security, communications, energy and education.

"Veritas' proven track record of fostering growth in high-technology and defense industry companies makes it an excellent fit for Emcore's Space Photovoltaics business," says Emcore's Dr Hong Hou president & CEO. "Emcore's board of directors and management team believe this transaction will benefit our satellite customers while providing considerable value to our shareholders," he adds. "Veritas' industry expertise and financial resources will enable the business to continue to provide its customers with the reliable, high-performance products and best-in-class customer service that they have come to expect, while also representing a platform from which to grow the business," continues Hou.

Tax benefits preservation plan

Emcore's board of directors has adopted a Tax Benefits Preservation Plan (rights plan) to help preserve the value of net operating losses by reducing the risk of limitation of net operating loss carryforwards and certain other tax benefits under Section 382 of the Internal Revenue Code. The value of the tax benefits could be reduced if Emcore experiences an 'ownership change' under US federal income tax rules, which occurs if one or more '5% shareholders' (as defined under US federal income tax laws) have aggregate increases of 50% in their Emcore ownership over a three year historic period. The rights plan reduces the likelihood that Emcore will experience such an ownership change by discouraging any person or group from becoming a 5% shareholder or increasing their Emcore ownership if they already are a 5% shareholder. In connection with the rights plan, Emcore has declared a dividend of one right for each share of common stock outstanding as of the close of business on 3 October.

Strategic alternatives

In December 2013, Emcore's board of directors formed a Strategy and Alternatives Committee consisting of Steven Becker (chairman), Stephen Domenik and James Tegnelia. The committee retained Raymond James as advisor. Over the past nine months, the committee has been working diligently to review a broad spectrum of alternatives. The sale of the Space Photovoltaics business to Veritas is the first major action resulting from the review of strategic alternatives. The committee and the entire board continue to work closely with Raymond James in reviewing a wide variety of alternatives to increase shareholder value. In addition, the board views the tax benefits as a significant asset, and the announcement of the rights plan indicates the board's intention to take steps to preserve that asset.

The management team has undertaken a thorough review of the remaining operations and has implemented significant cost-reduction measures. The firm says that it has seen an improvement in the financial performance and the market conditions in its Fiber Optics business. In conjunction with the divestiture of the Space Photovoltaics business, Emcore will continue to review and implement various initiatives to further reduce the cost structure. The board believes that the remaining business can achieve EBITDA break-even, excluding stock compensation, amortization, accretion and other items, by September 2015.

www.veritascapital.com
www.emcore.com

Emcore's CEO to step down on sale of Solar business

Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and space solar power markets, has announced a transition plan of its CEO position in connection with the sale of its Space Photovoltaics business. In light of Emcore's more narrowly focused business operations following the completion of this transaction, president & CEO Dr Hong Q. Hou will be stepping down from his position.

Hou will continue to serve in his current role until his successor is appointed. After serving as president & CEO since March 2008 and as a member of the board of directors since 2006, he will work with the board to ensure a smooth transition to the next CEO for the remaining fiber-optics business. Hou will resign from the board after a successor has been appointed.

The board has formed a search committee consisting of current board members Dr Gerald Fine, Dr James Tegnelia and Stephen Domenik. The committee has been granted the authority to identify, consider, assess, evaluate, research and recommend to the entire board the candidates for the post of CEO.

After joining Emcore as director of technology in 1998, Hou co-founded the Photovoltaics division and led the commercialization of high-efficiency multi-junction solar cell technology for space power applications, which was based on his research work and patents licensed from Sandia National Laboratories. Hou was instrumental in taking concepts from the drawing board to the production of space-qualified products. From 2000 to 2006, he served as VP & general manager of several fiber-optics divisions (leading many initiatives to grow the fiber-optics businesses) and was instrumental in sourcing, negotiating, acquiring and integrating several companies into Emcore's business portfolio. Hou was promoted to chief operating officer in December 2006, then to president & CEO in March 2008.

"Hong has provided tremendous technical and business leadership to Emcore over the past 16 years and has helped navigate the company through a very dynamic and complex marketplace," comments co-chairman Dr Gerald Fine. "I applaud his contributions to the space photovoltaics and fiber-optics industries," he adds. "It was with his vision and passion for success that Emcore became a leader in this innovative and competitive industry. He has helped to both lead the company in the development of new technologies and business opportunities, as well as manage people through extreme challenges."

www.emcore.com

Emcore demonstrates end-to-end DOCSIS 3.1 CATV transmission link capabilities at Cable-Tec

At the Society of Cable Television's (SCTE) Cable-Tec Expo in Denver (23–25 September), Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and space solar power markets, hosted a demonstration of its end-to-end DOCSIS 3.1 CATV transmission link capabilities.

A DOCSIS 3.1-compliant prototype of Emcore's Medallion 6000 Series 1550nm CATV transmitter was featured, along with the new Medallion 2100 optical A/B switch and Medallion 7100 CATV fiber amplifier transmitting over a 40km fiber link to Emcore's RFoG (radio frequency over glass) transceiver.

Based on Emcore's proprietary continuous-wave laser technology, the Medallion 6000 externally modulated transmitter couples high optical output power up to 11.0dBm with low optical linewidth.

The transmitter leverages proprietary pre-distortion circuitry to provide what is claimed to be superior composite triple beat (CTB) and composite second-order (CSO) performance with stimulated Brillouin scattering (SBS) suppression levels of greater than 21dBm through 40km of fiber.

The Medallion 2100 optical A/B switch is a high-performance solution for network protection and optical redundancy in CATV/FTTx networks. Its automatic switching protects the network from inadvertent service outages due to up-stream optical signal degradation.

The Medallion 7100 fiber amplifier provides stable optical outputs over a wide operating temperature range, as well as the high power and low noise figures demanded by CATV applications.

Emcore's RFoG transceiver is passive optical network (PON)-compatible and supports 1310/1590/1610nm burst mode analog return-path, and digital or QAM upstream.

"Our end-to-end DOCSIS 3.1 demonstration at the Cable-Tec Expo will show Emcore's capabilities to deliver the highest-quality video and audio, along with high-speed data transmission in a DOCSIS 3.1 compatible system," says Gyo Shinozaki, director of marketing for CATV products. "Emcore's line of CATV components and systems will support cable operators as they move to this latest DOCSIS standard for higher-speed data transfer over their existing CATV networks," he adds.

http://expo.scte.org

Construction begins on 250MW Silver State South Solar Project in Nevada

On 3 September, federal, state and local leaders joined executives from NextEra Energy Resources LLC (one of the largest wholesale generators of electric power in the USA, and a subsidiary of NextEra Energy Inc of Juno Beach, FL, USA), Edison International company Southern California Edison (SCE) of Rosemead, CA, USA and cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA to break ground on the 250MW Silver State South Solar Project being constructed in Primm, NV, on the California/Nevada border 40 miles south of Las Vegas. The project is strategically located near a major transmission hub and is adjacent to an existing power plant and transmission line corridor.

First Solar is building Silver State South, which will provide 300 construction jobs. As the firm's fifth utility-scale solar power plant in development, construction or operation in southern Nevada, it also positions First Solar as the largest solar developer in the state, with about 750MW of projects in various stages of development, construction and operation.

A subsidiary of NextEra Energy Resources will own and operate the project. All of the power output will be provided to Southern California Edison under a long-term contract.

When fully operational by early 2016, the project is expected to generate enough energy to serve the needs of about 80,000 homes, displacing about 150,000 metric tons of CO_2 annually(equivalent to taking nearly 30,000 cars off the road).

www.NextEraEnergyResources.com
www.firstsolar.com

Sofradir launches ready-to-deploy large-format 1024x1024 visible-to-SWIR detector for space missions

Sofradir of Palaiseau near Paris, France, which makes cooled infrared (IR) detectors based on mercury cadmium telluride (MCT/HgCdTe), indium antimonide (InSb), quantum-well infrared photodetector (QWIP) and indium gallium arsenide (InGaAs) technology for military, space and industrial applications, has introduced Next-Generation Panchromatic (NGP) 1k2, a new ready-to-deploy 1024x1024 visible-to-SWIR (short-wavelength infrared) detector.

NGP's large format provides increased space resolution or spectral resolution for image spectrometers and other observation instruments used in space, enhancing the ability of scientists to correctly identify and characterize chemical phenomena. Equally importantly, NGP's ready-to-deploy design allows space agency customers to quickly tailor it to fit any spectral waveband, offering system integrators more flexibility and shortening mission preparation time.

Sofradir developed the large-format NGP as part of an R&D contract with the European Space Agency (ESA). Its 1k x 1k format is four times larger than Sofradir's existing SATURN staring array IR product currently deployed on observation satellites or spacecrafts.

As initially planned, it took 24 months to design and validate NGP. The bigger the format, the better the image resolution, making it well suited to future hyperspectral or spectrometry applications but also to Earth observation or deep-space science applications, says the firm.

"The product's ready-to-deploy feature responds to demands to shorten space mission delivery times or to minimize the risks in delays," says Sofradir's space department manager Philippe Chorier. "Based on its added performance and time saving benefits, we anticipate a lot of interest in NGP 1k2 in future space missions," he adds.

NGP's large format provides increased space resolution or spectral resolution for image spectrometers and other observation instruments used in space

Due to its 1024x1024 15μm-pitch-format HgCdTe array — sensitive from visible to SWIR (0.35–2.5μm), hybridized on a capacitive feedback transimpedance amplifier (CTIA) read-out integrated circuit demonstrating low noise (<150 electrons), low consumption and high linearity (>99% of the dynamic range) — the focal plane assembly met all expectations (e.g. ROIC design first-pass success) and provides the imaging performances (low PRNU photoresponse nonuniformity, low dark current, high MTF modulation transfer function) required by future space-based payloads.

NGP is claimed to be the first European-made space-oriented megapixel array that space agencies can now consider for deep space science (planets and asteroids studies), Earth observation and Earth monitoring (meteorology, global warming studies, agriculture surveillance) applications. This year the NGP detector was selected for the SENTINEL-5 mission, which is planned for launch by 2021 on-board the METOP-SG satellite in order to monitor the Earth's atmosphere from a polar orbit.

www.sofradir.com

Iridium qualifies Spectrolab-powered solar panel system for NEXT constellation of satellites

New, larger triple-junction solar cells manufactured from 6" wafers

Iridium Communications Inc of McLean, VA, USA has completed an extensive testing program for qualification of its new solar panel design for the Iridium NEXT constellation of satellites.

The array that powers the satellites contains four solar panels and will span 9.4m when fully extended, developing more than 2kW of power over a demanding charging cycle in Iridium's low earth orbit. The panel was developed by Boeing subsidiary Spectrolab Inc of Sylmar, CA, USA, which manufactures multi-junction space solar cells and panels, and Mitsubishi Electric Corp (MELCO), which supplies lightweight solar panel substrates. These companies are part of the Iridium NEXT Mission Team, led by Iridium's prime contractor and European satellite maker Thales Alenia Space.

The solar arrays are powered by new, larger triple-junction (XTJ) solar cells manufactured from 6" wafers, which yield 50% more solar cell surface area than cells used in Iridium's existing constellation and deliver higher performance while reducing costs.

"The successful completion of qualification testing for the solar panel design marks yet another important milestone on our journey to launching Iridium NEXT," says Iridium's chief operating officer Scott Smith. "The innovation at the heart of the solar panels demonstrates how we are fundamentally re-thinking the design of every aspect of our constellation with improved efficiency, performance and longevity in mind."

Larger triple-junction solar cells made from 6" wafers yield 50% more surface area than cells used in Iridium's existing constellation

Working closely with Spectrolab, the new design was put through a grueling life test and qualification program to ensure that it works to specification using representative sections of the actual panels. The design verification test represented every mechanical and electrical configuration and was tested with a simulation of the rigorous low-earth-orbit charging environment into which the arrays will be deployed.

The solar array was tested to 1.5 times its planned lifespan in space to ensure it can meet and exceed the expected lifetime of the satellite. The solar cells were put through 75,000 thermal cycles, each representing the Iridium NEXT satellite's movements in and out of the sun's radiating heat as it orbits the Earth.

The Iridium NEXT satellite network will consist of 66 in-orbit satellites and a number of in-orbit spares. The constellation is expected to begin launching in 2015 and will offer continued service for Iridium customers as well as greater bandwidth and data speeds when fully operational in 2017.

www.spectrolab.com

First Solar completes Phase 1 of Barilla Solar Project

Cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA has announced completion of Phase 1 of the Barilla Solar Project in Pecos County, Texas, bringing about 18MW$_{AC}$ of generating capacity to the Texas competitive wholesale market.

First Solar will offer electricity generated by the Barilla plant on a competitive open contract basis, making it the first such solar asset in Texas. The firm developed, constructed and will operate the power plant, which incorporates a suite of controls and capabilities essential to supporting grid stability and reliability within the ERCOT (Electric Reliability Council of Texas) region. The project is in the final stages of the commissioning process.

"First Solar is a pioneer in bringing West Texas solar into the diverse energy portfolio of Texas," says Pecos County judge Joe Shuster. "In West Texas we've got plenty of land, some with a lot of oil under it, and all of it with sunshine which makes it perfect for solar plants like this. I'm excited to see Barilla as the first project in what I hope will soon be the 'Texas solar patch'," he adds.

"This project demonstrates First Solar's capability to rapidly develop, construct and commission a solar asset offering clean, renewable energy at competitive rates to the grid when and where it is needed," says Tim Rebhorn, First Solar's senior VP of business development. The Barilla power plant will contribute to lower electricity prices for Texas consumers, while providing a reliable resource to power providers, he adds.

According to the US National Renewable Energy Laboratory (NREL), Texas has the greatest technical potential for solar development in the USA. The Barilla Solar Project takes advantage of one of the best solar resource geographies in the state, with the added benefit of tying into nearby existing power transmission infrastructure in the West Texas region. The solar power plant uses no water for electricity generation, an important additional benefit in an area where scarce water resources must be preserved.

www.firstsolar.com

ZSW raises thin-film PV efficiency record from 21% to 21.7%

Using a solar cell made of copper indium gallium diselenide (CIGS), ZSW (Zentrum für Sonnenenergie- und Wasserstoff-Forschung — or Center for Solar Energy and Hydrogen Research — Baden-Württemberg) of Stuttgart, Germany has regained the thin-film photovoltaic efficiency record, raising it from 21% (set by researchers in Sweden in June) to 21.7%, as confirmed by Fraunhofer Institute for Solar Energy Systems ISE. ZSW had previously raised the record from 20.3% (set in August 2010) to 20.8% (set in November 2013).

The record extends the CIGS PV cell's lead in solar energy conversion efficiency over multicrystalline cells (which still dominate the market) to 1.3%. "Our advances once again confirm the tremendous technological potential of CIGS thin-film photovoltaics," says professor Michael Powalla, ZSW board member and head of its Photovoltaics division. "The lab data show that further efficiency improvements will be possible in the years ahead. This could drive down the cost of CIGS technology even more sharply."

Covering 0.5cm^2 in area (standard for such tests), the record cell was manufactured in a laboratory coating system using the co-evaporation process, which is highly reproducible in the lab(more than 40 cells were made with efficiency ratings exceeding 21%), indicating that the method lends itself to industrial manufacturing and could readily be scaled up to mass production.

"It will probably take some time for this efficiency increase to make its way into module manufacturing, but 17–19% is very much possible in the next few years," reckons Powalla. CIGS modules currently on the market are rated at about 15% efficiency. However, the physical area of modules is larger, so they are less efficient than solar cells.

ZSW reckons that its latest results boost the chances of CIGS thin-film technology gaining a large share of the market. This is good news for Reutlingen-based Manz AG. ZSW licensed the technology to Manz and developed it jointly with this industry partner. The firm exclusively markets a turnkey manufacturing line for producing CIGS thin-film solar panels and now aims to transition this increase in efficiency out of the lab and into the factory. The aim is to make CIGS solar systems economical and affordable practically anywhere in the world.

The coating of thin-film cells is measured in microns, so they consume far less material and energy in their manufacturing than standard solar cells and can hence have a major impact on cutting future production costs, says ZSW. This is why the Germany Federal Ministries for the Environment and for Economic Affairs and Energy as well as the state of Baden-Württemberg have provided funding for the technology. "The roughly 4m euros in basic funding flowing to the ZSW every year from the state is money well spent," comments Baden-Württemberg's Minister of Finance and Economics Dr Nils Schmid.

www.zsw-bw.de

China's CNBM completes acquisition of Germany's Avancis

Chinese building materials and glass maker CNBM (China National Building Materials Group Corp) has completed its acquisition (announced on 22 April) of Avancis GmbH of Torgau, Germany, which makes copper indium gallium diselenide (CIGS) thin-film solar modules.

The firm continues as Avancis, but now as a subsidiary of CNBM headed by Dr Franz Karg (CEO) and Oliver Just (CFO), producing and distributing modules under the PowerMax brand.

Founded in 1984, CNBM is China's largest building materials firm, with 180,000 staff and €30.8bn revenue in 2013. In 2012 it bought Germany's CTFSolar GmbH, which provides production equipment and plants for manufacturing cadmium telluride (CdTe) thin-film solar modules. CNBM is now one of the largest manufacturers of highly transparent front glass for solar modules. It is also active in acquiring, planning and constructing large PV systems via engineering subsidiary CTIEC. The Chinese government is currently pursuing a program for the development of solar energy and CNBM aims to play a key role via Avancis.

Avancis and its predecessor firms (including Arco Solar) began developing its PV technology in the early 1990s. The production process has relied on second-generation technology, developed by its R&D lab in Munich and implemented in its production sites in Torgau. In January, Avancis raised its record for externally certified efficiency for encapsulated CIS thin-film modules from an aperture efficiency of 15.1% (set in 2011) to 16.6% (for a 30cm x 30cm module), as confirmed independently by the US Department of Energy's National Renewable Energy Laboratory (NREL). The firm's latest manufacturing process is based on its third-generation CIGS technology.

Preparations to restart the improved production process at Avancis' 100MW plant are beginning immediately, including new hires along the lines of the ramp-up plan.

Meanwhile, Avancis' Tech Center in Torgau and the R&D center in Munich will continue their research, development and small-series production. The firm says it is focusing on production and improving its PowerMax SMART modules to be used for ground-mounted systems and building-related applications.

Most Avancis' staff have accepted transfer to the new entity. Product guarantees remain unchanged for all current and new customers.

www.Avancis.de

Ascent Solar announces new investment of $8m led by largest shareholder TFG Radiant

On 29 August, Ascent Solar Technologies Inc of Thornton, CO, USA, which makes lightweight, flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic modules that it integrates into its EnerPlex series of consumer products, has entered into a stock purchase agreement (SPA) with existing stockholders TFG Radiant Investment Group and Series A investor Seng Wei Seow for about $8m of common stock.

In the first tranche of the transaction (which has closed), Ascent issued 845,309 common shares to Seow and 845,309 shares to TFG Radiant at a fixed per share price of $2.366 (representing a 30% premium to the closing price of $1.82 per share on 28 August), yielding in net proceeds of $4m.

In a second tranche, Ascent will issue 1,425,000 common shares to TFG Radiant at a fixed per share price of $2.80 (about 54% premium to the closing price on 28 August) to yield additional net proceeds of about $4m. The firm expects to hold a special stockholder meeting to approve the issuance of the second tranche shares in October. If stockholder approval is obtained, this second tranche will close shortly after the special stockholder meeting.

TFG Radiant's stake in Ascent has risen to about 18.3% of the outstanding common stock subsequent to the closing of the first tranche and would further increase to 26.2% after closing the second tranche.

"Our largest shareholder continues to demonstrate great confidence in us as our transition to consumer value-added products has yielded higher revenues," says chairman Dr Amit Kumar. "Our business model and strategy has undergone tremendous change, which has translated into growing interest in our new products resulting in strong revenue growth over last year. While the repositioning of the company is challenging, we now feel that we have completed much of the ground work necessary for us to create value going forward," he adds.

"We feel more upbeat now than ever before with regards to Ascent's future success. Ascent has demonstrated growing sales momentum quarter after quarter," comments TFG Radiant's chairman Winston Xu. "The company is at an inflection point of its development, and we believe the foundation has been built to enable increasing growth in sales," he adds. "As the largest shareholder of Ascent Solar, TFG Radiant strongly believes in Ascent's business plan, and is firmly committed to the company's strategy for growth. Ascent's game changing technology is truly unique in the industry and the broad array of products launched and soon to be launched will underscore this point."

Ascent Solar announces reverse stock split

Ascent Solar's board of directors approved a 1-for-10 reverse stock split of the firm's common stock (effective from 26 August) with the aim of increasing the per-share trading price in order to satisfy the $1 minimum bid price requirement for continued listing on the NASDAQ Capital Market.

As a result of the reverse stock split, every 10 shares of the firm's common stock issued and outstanding were automatically combined into one issued and outstanding share without any change in the par value of those shares. In lieu of issuing fractional shares, Ascent rounded fractions of shares up to the nearest whole share.

The firm has about 11.7 million post-split shares outstanding. The number of authorized shares of common stock remains at 250,000,000 shares.

The number of shares of Series A and Series C Convertible Preferred Stock outstanding were not affected by the reverse stock split. However, the numbers of shares of common stock into which each outstanding share of Series A and Series C Convertible Preferred Stock is convertible were adjusted proportionately. All outstanding RSUs (restricted stock units), stock options and warrants to purchase shares of common stock were adjusted proportionately. The maximum number of shares available for grant under the firm's stock option plan and restricted stock plan has also been adjusted proportionately.

www.AscentSolar.com

Ascent regains compliance with NASDAQ minimum bid price rule

Ascent Solar has received notification from the Listing Qualifications Department of The Nasdaq Stock Market that it has regained compliance with Nasdaq Listing Rule 5550(a)(2), the minimum bid price requirement for continued listing on The Nasdaq Capital Market.

Ascent had been notified by Nasdaq in September 2013 that its common stock did not satisfy the minimum bid price requirement. Now, on 11 September, Nasdaq provided confirmation to Ascent that the closing bid price of its common stock for the prior 10 business days had met the minimum bid price requirement and advised Ascent that this matter is now closed.

Low-cost non-toxic process for cadmium telluride solar cells

The University of Liverpool proposes the use of magnesium chloride in place on cadmium chloride in CdTe solar cell production.

University of Liverpool researchers propose replacing a toxic treatment step in cadmium telluride (CdTe) solar cell production with one that is benign, but apparently just as effective [J.D. Major et al, Nature, published online 25 June 2014].

Presently a cadmium chloride ($CdCl_2$) doping 'activation' treatment is used to form the photovoltaic junction with cadmium sulfide (CdS) and also to passivate grain boundaries. Both aspects are essential in providing high-efficiency devices. Without treatment, cells have efficiency of ~2%. The treatment increases this to over 10% and laboratory 'champions' have gone beyond 20% — the chart of the US National Renewable Energy Laboratory (NREL) currently gives a 20.4% record. Unfortunately, $CdCl_2$ is toxic and expensive (~30 cents/gram). Unlike CdTe and CdS, $CdCl_2$ is water soluble, releasing toxic Cd ions and posing risks to production workers and the wider environment.

The proposed replacement treatment involves magnesium chloride ($MgCl_2$). The Liverpool team estimates the cost of $MgCl_2$ at 0.1 cent/gram, since it can be obtained from sea water. The material is widely used for cold-weather road treatments, bath salts, and as a food additive (e.g. in tofu).

The researchers comment: "A process change from $CdCl_2$ to $MgCl_2$ has huge potential instantly to reduce the cost of power generation by CdTe photovoltaics and to minimize the risks in industrial production."

The Liverpool cells were deposited on TEC10 soda-lime glass that was coated with fluorine-doped tin oxide supplied by NSG Group. A 120nm layer of CdTe was deposited on a 100nm zinc oxide (ZnO) buffer using sputtering at 200°C and room temperature, respectively. The CdTe layer was extended by close space sublimation in nitrogen with the source at 620°C and substrate at 520°C. Before the chloride treatment the cells were etched using a nitric/phosphoric acid solution.

The standard chloride treatment consisted of evaporation of a 100nm layer of $CdCl_2$ onto the CdTe. Two alternative $MgCl_2$ treatments were tried: in one, the $MgCl_2$ was deposited in methanol solution; in the other, the $MgCl_2$ was applied to a glass slide that was placed next to the CdTe substrate during annealing in a tube furnace. In fact, all samples were annealed for durations of 10–60 minutes in the temperature range 390–450°C.

The optimum anneal for the standard $CdCl_2$ and the $MgCl_2$ solution treatments was found to be 20 minutes at 430°C. The $MgCl_2$ vapor treatment from the glass slide was found to be best at 430°C for 40 minutes.

The cells were completed with a further wet etch and deposition of gold back-contacts.

The performance of devices (Table 1) shows that the $MgCl_2$ vapor treated cells gave identical performance to the standard process within the margin of error. Alternative materials such as sodium chloride (NaCl, normal table salt), potassium chloride (KCl), and manganese chloride ($MnCl_2$) gave much inferior results with efficiencies less than 6.7%.

The researchers have also developed a more efficient CdTe cell with $MgCl_2$ activation that replaced the ZnO buffer with oxygen-doped CdTe and reduced the CdS layer thickness to 40nm. The $MgCl_2$ was applied in this case in a water solution via spray coating. Also, the back side of the structure was coated with 2nm copper to improve the back contact. The conversion efficiency reached 15.7%. A further notable feature was an open-circuit voltage of 0.857V, "equivalent to that of the current CdTe champion cell", says the team. ■

http://dx.doi.org/10.1038/nature13435

Author: Mike Cooke

Table 1. Peak solar-cell performance for all chlorides tested.

Treatment	Peak efficiency (%)	Peak fill factor (%)	Peak short-circuit current density (mA/cm^2)	Peak open-circuit voltage (V)
$CdCl_2$	13.02	70.01	22.13	0.831
$MgCl_2$ solution	12.71	69.08	22.41	0.821
$MgCl_2$ vapor	13.50	70.24	23.26	0.826
NaCl	6.75	53.34	19.78	0.603
$MnCl_2$	4.37	45.87	18.30	0.520
KCl	5.49	50.11	17.95	0.607

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Working toward lasers for on-chip global interconnects

Tokyo Institute of Technology has claimed the first RT-CW operation of a lateral-current-injection GaInAsP membrane FP laser on silicon.

Tokyo Institute of Technology has claimed the first room-temperature continuous-wave (RT-CW) operation of a lateral-current-injection (LCI) gallium indium arsenide phosphide (GaInAsP) membrane Fabry-Perot (FP) laser bonded to a silicon substrate [Daisuke Inoue et al, Appl. Phys. Express, vol7, p072701, 2014].

The researchers believe their work could lead to ultralow-power-consumption lasers for on-chip optical interconnections. The aim would be to use such a laser in conjunction with on-chip waveguides to replace copper global interconnects that suffer from signal delays and Joule heating effects.

The semiconductor heterostructure for the laser (Figure 1) was grown on n-type indium phosphide (InP) substrate using molecular beam epitaxy (MBE). The five quantum wells (QWs) in the active region consisted of 1% compressively strained 6nm $Ga_{0.22}In_{0.78}As_{0.81}P_{0.19}$ in 0.15% tensile-strained 10nm $Ga_{0.26}In_{0.74}As_{0.49}P_{0.51}$ barriers. The 15nm optical confinement layers (OCLs) were also of GaInAsP.

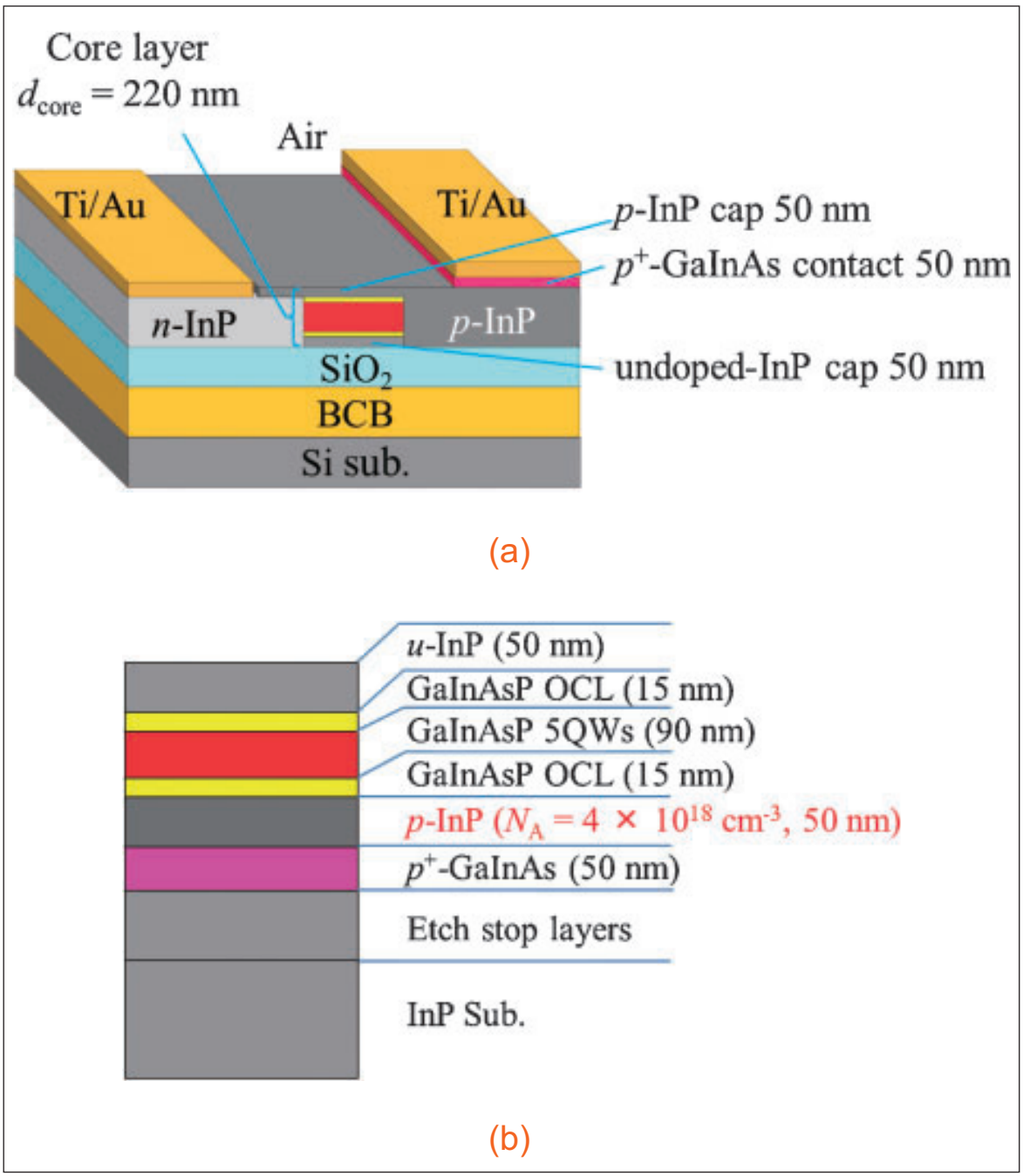

Figure 1. (a) Schematic structure of membrane laser on Si substrate and (b) initial heterostructure.

Before the laser was transferred to the silicon substrate, the lateral-current-injection structures were created using reactive ion etching and a two-step organometallic vapor phase epitaxy (OMPVE) of the

n-InP and p-InP contact regions on either side of the 0.7μm-wide device mesa stripe.

The top of the structure was covered in 1μm of silicon dioxide. The host silicon substrate was prepared with a 2μm layer of spin-coated benzocyclobutene (BCB) adhesive, pre-cured at 210°C in nitrogen. The laser wafer was flipped onto the host silicon and bonded at 25kPa pressure at 130°C, followed by hard-curing at 250°C for an hour in nitrogen.

Selective etching was used to removed the InP substrate and etch stop layer. The p^+-GaInAs was also removed except for the p-electrode region. The p-InP cap layer was etched away from the n-electrode region. Finally, the titanium/gold (Ti/Au) electrodes were applied.

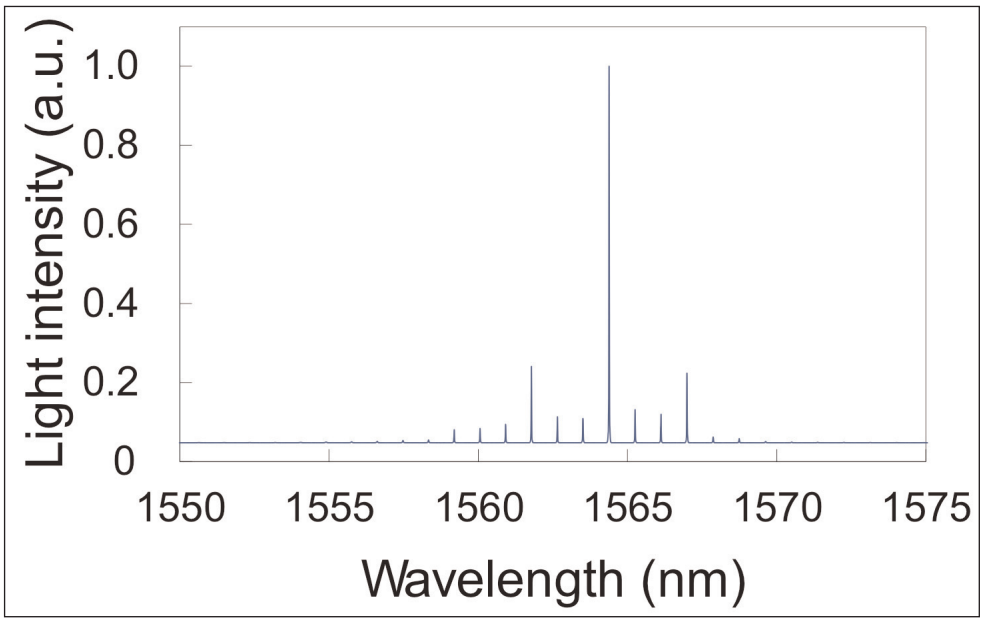

Figure 2. Spectrum of LCI membrane FP laser with 370μm cavity length and 0.7μm stripe width. Bias at twice threshold current of 2.5mA.

The structure was cleaved into Fabry–Perot lasers of various cavity lengths. A 350μm-long device had a threshold current of 2.5mA (1100A/cm^2 density) in room-temperature continuous-wave operation. The external differential quantum efficiency was 22% from each facet (44% in total). The output power was 1.1mW at 10mA.

By analyzing the performance of lasers with different cavity lengths, the researchers estimate an internal quantum efficiency (IQE) of 75% and a waveguide loss of 42/cm. The internal quantum efficiency is close other vertical lasers and LCI membrane lasers on semi-insulating InP produced previously by the researchers. The team comments: "This indicates that non-radiative carrier recombination at both the top and bottom surfaces of the membrane structure are almost negligible, which is attributed to 50nm-thick InP cap layers as well as high-quality buried heterostructure interfaces prepared by two-step OMVPE re-growth. In addition, this high internal quantum efficiency indicates that there is minimal leakage current through the p-InP cap layer to the n-InP layer."

The waveguide loss, however, is significantly higher than the 5.1/cm achieved for LCI lasers on semi-insulating InP at Tokyo Institute of Technology. The researchers suggest that scattering losses may have arisen from the side-wall roughness of the re-growth interface between the mesa stripe and the InP cladding layers.

The emission wavelength was around 1565nm (Figure 2). ■

http://iopscience.iop.org/1882-0786/7/7/072701/

Author: Mike Cooke

Toshiba red InGaN LED reaches 1.1mW at 20mA

Highest power output achieved so far for such devices.

Toshiba Corp has developed red light-emitting diodes (LEDs) with indium gallium nitride (InGaN) multiple quantum wells (MQWs), achieving light output power (LOP) of 1.1mW at 20mA injection current [Jong-Il Hwang, et al, Appl. Phys. Express, vol7, p071003, 2014]. The researchers comment: "To the best of our knowledge, this is the first demonstration of a nitride-based red LED with the LOP exceeding 1mW operating at 20mA." At 250mA, the output power was 7.8mW.

p^+-contact	Mg-doped GaN	
p-contact	Mg-doped GaN	
Multiple quantum well	4x(InGaN/AlGaN/InGaN)	4x(3nm/1nm/10nm)
n-contact	Si-doped GaN	3μm
Buffer	GaN	2μm
Substrate	c-plane sapphire	

Figure 1. Heterostructure for red LED.

The semiconductor material for the nitride-based red LED (Figure 1) was grown using metal-organic chemical vapor deposition (MOCVD) at atmospheric pressure (760Torr). The MQW active region included an aluminium gallium nitride (AlGaN) interlayer (IL) between the InGaN well and barrier. The growth temperatures of the InGaN well and AlGaN interlayer were 755°C, while the barrier was grown at 100°C higher.

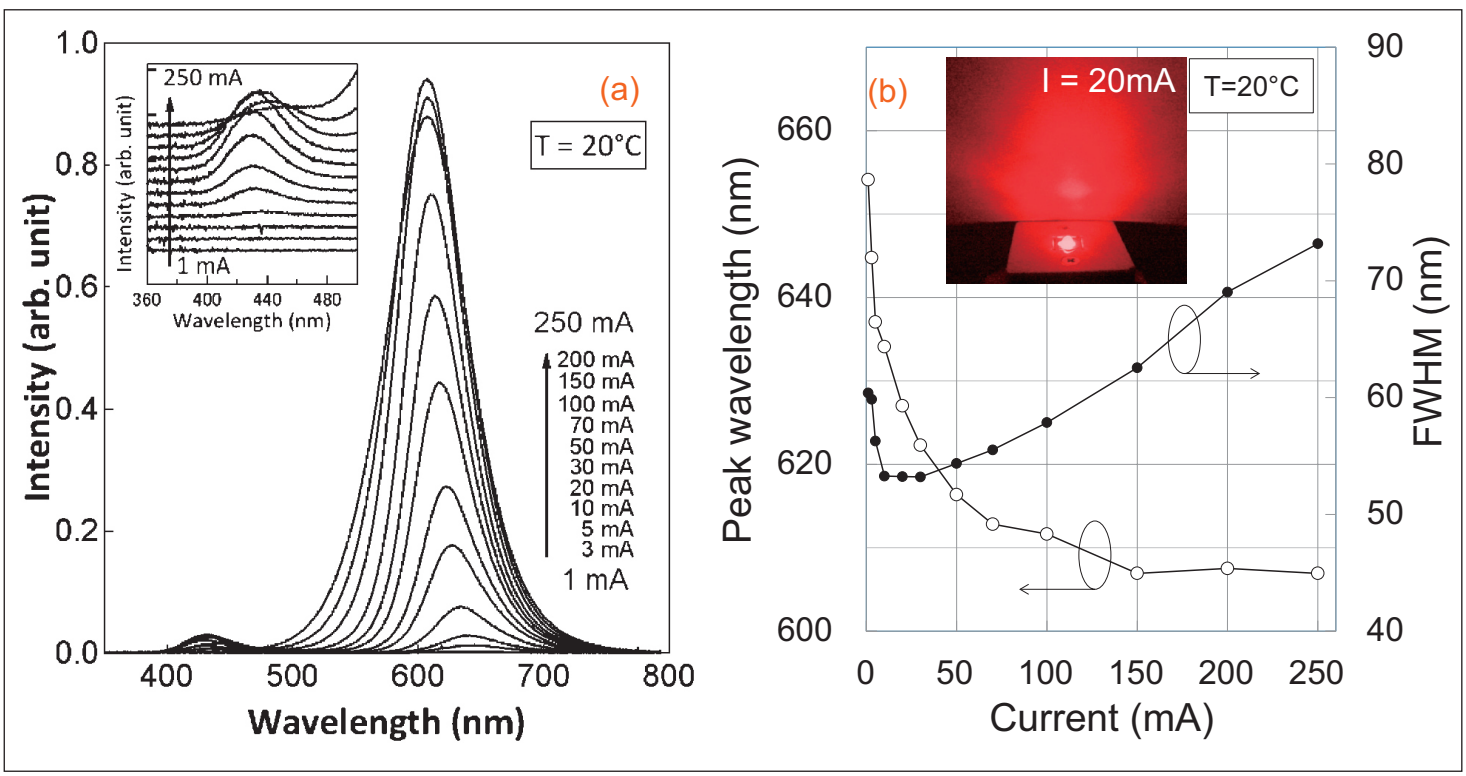

Figure 2. Electroluminescence (EL) properties of red LED with 90% aluminium content of AlGaN interlayer. (a) EL spectra measured at each injection current level. (b) Peak wavelength and FWHM of spectrum (inset: emission image of a red LED measured at 20mA).

The well's indium content was estimated at 35% and that of the barrier at less than 1%. Two LED material structure types were produced with interlayer aluminium contents of 30% or 90%. The higher-Al-content LED was found to result in lower defect densities in the active region. The researchers think that the improvement could be due to strain compensation, "although further study is needed". The LED devices were therefore fabricated from the material with a 90%-Al interlayer.

The LED structure consisted of p-type indium tin oxide (ITO) transparent contact and titanium/platinum/gold n-type electrode. The researchers estimated a 60% light extraction efficiency through ray tracing. The 460μmx460μm LED was encapsulated in a molded silicon resin and packaged.

Spectral analysis of the electroluminescence showed a main red-light peak at greater than 600nm wavelength and some weak emission at 430nm (Figure 2). The weak emission was attributed to phase separation effects where the InGaN well material does not have a uniform alloy composition. Fortunately, the weak emission was "negligibly small". The researchers comment: "This indicates that the phase separation in the InGaN QW was effectively suppressed in the present red LED".

At the usual low current injection value of 20mA, the peak wavelength was 629nm with a full-width at half-maximum (FWHM) of 53nm. At higher current the peak shifted towards the blue end of the spectrum with the FWHM narrowing up to 30mA. The blue shift was attributed to carrier screening of polarization fields and band-filling effects.

Above 150mA, the peak stopped shifting, remaining around 607nm. At high current the FWHM increased due to thermal effects. Thermal effects also have a red-shifting effect on the bandgap and could compensate the blue-shifting tendencies above 150mA.

Along with the light output power (LOP) at 1.1mW, the external quantum efficiency (EQE) of 2.9% was at 20mA injection (Figure 3). The forward voltage was 4.4V at 20mA and 1.9V at 0.1mA. The 1.9V value is comparable to the potential needed for the red emission at that current (~1.9eV for 0.65μm wavelength).

The researchers also made measurements with different ambient temperature conditions and found a thermal droop characteristic temperature (T_0) for light output power that varied with current injection. The larger T_0 at high current indicates weaker temperature dependence since the thermal degradation effect is self-generated.

The researchers believe that further performance improvement can be achieved through "suppression of defect generation in the active layer by optimizing the local structure as well as the growth condition". ■

http://dx.doi.org/10.7567/APEX.7.071003

Author: Mike Cooke

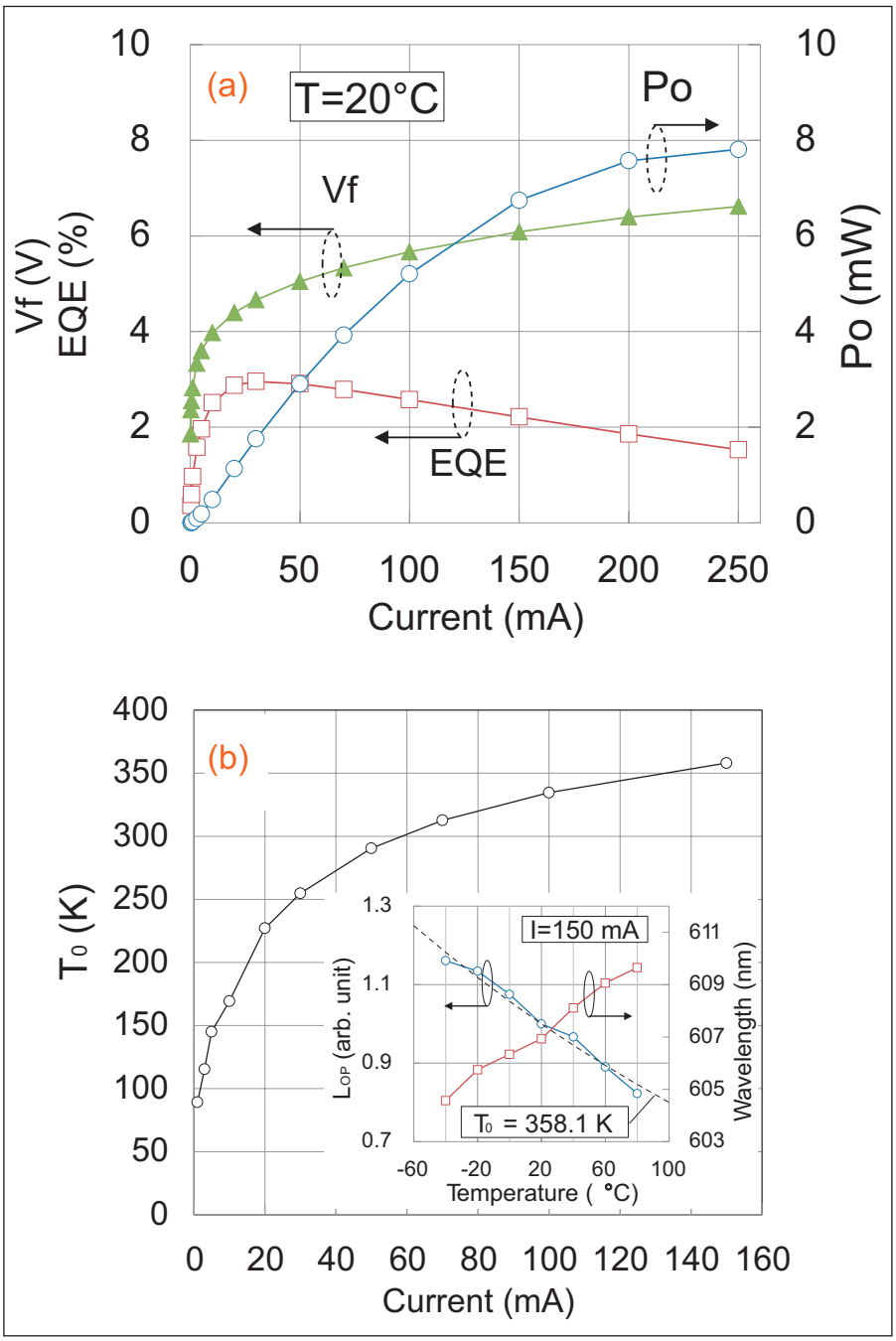

Figure 3. Light output power (LOP), external quantum efficiency (EQE), forward voltage (V_f), and characteristic temperature (T_0) properties as functions of injection current. (a) LOP (open circle), EQE (open square), and V_f (filled triangle). (b) T_0 values. Inset: temperature dependence of LOP and wavelength measured at 150mA. Dashed line indicates calculation based on intensity formula proportional to exp[T/T_0] relative to base measurement at 20°C and with T_0 358.1K.

Increasing light output from InGaN LEDs on silicon wafer

Substrate removal from under device reduces light absorption for six-fold increase in emission slope.

China's Nanjing University of Posts and Telecommunications has improved the performance of indium gallium nitride (InGaN) light-emitting diodes (LEDs) on silicon (Si) substrate by removing the substrate from the region under the device [Zheng Shi et al, Appl. Phys. Express, vol7, p082102, 2014].

InGaN LEDs produce light with relatively short wavelengths that are strongly absorbed

Contact	p-GaN	120nm
Multiple quantum well	InGaN/GaN	125nm
Contact	n-GaN	2.8μm
Buffer		4.29μm
Substrate	Silicon	

Figure 1. Epitaxial structure.

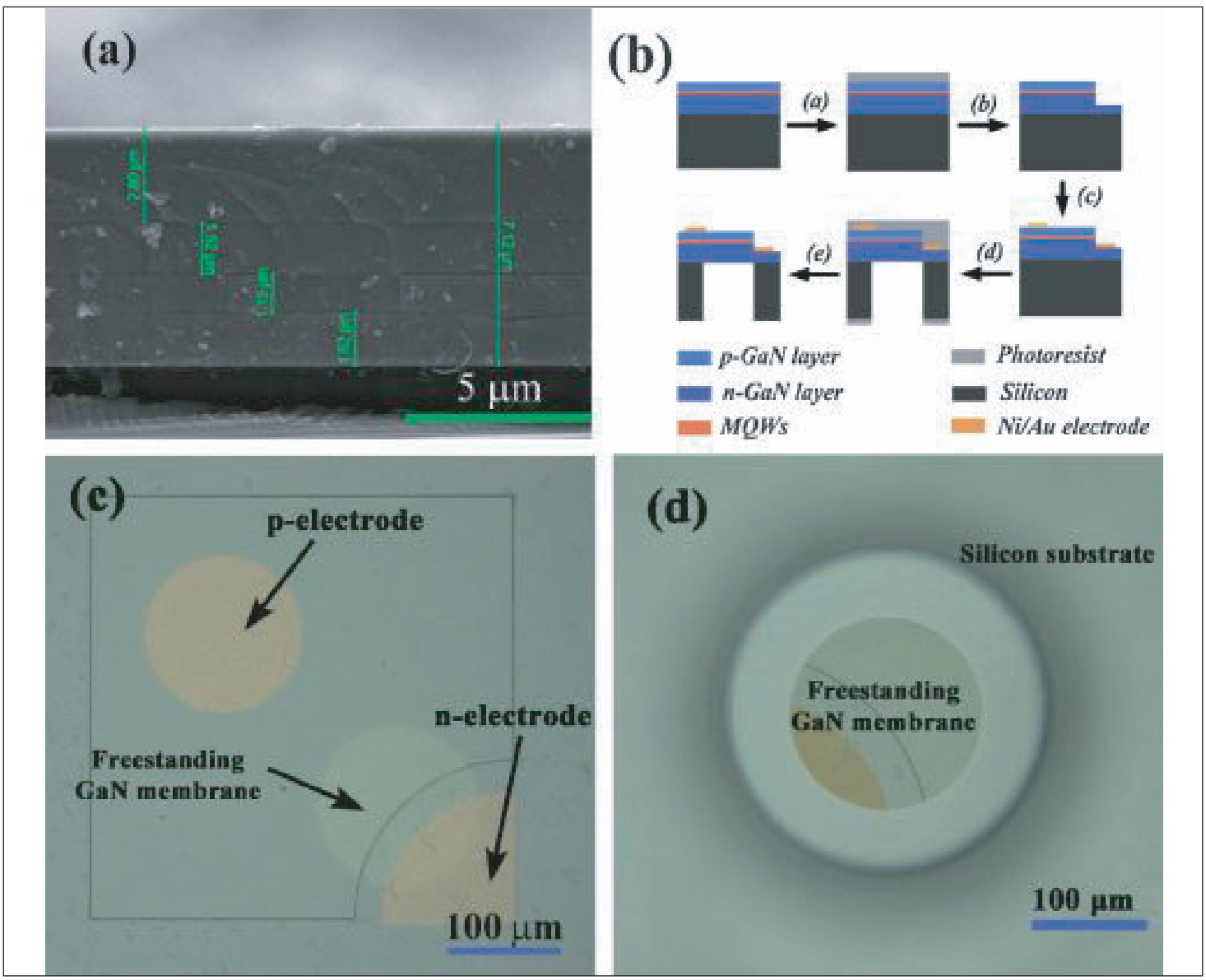

Figure 2. (a) Cross-sectional SEM image of LED; (b) schematic of fabrication of free-standing membrane LED; (c) optical microscopy image of free-standing LED; (d) optical microscopy image of silicon substrate.

by silicon since the photon energies exceed the latter material's bandgap. Removing the silicon substrate material from under the LED — giving a free-standing membrane of nitride semiconductor material — increases the ability of the light to escape the device.

The researchers believe that substrate removal could also allow wavelength tuning and integration with cooling systems to reduce thermal degradation at high-power operation.

The epitaxial nitride semiconductor structure (Figure 1) used thick buffer layers to bridge the lattice and thermal expansion mismatches between GaN and silicon.

Fabrication (Figure 2b) began with spin coating photoresist on the epitaxial structure (a), followed by patterned reactive ion etch down to the n-GaN layer to form a mesa (b). Then, the n- and p-contact regions were patterned and nickel/gold semi-transparent metal ohmic contacts were deposited and annealed (c).

More photoresist was applied to the top surface before deep reactive ion etch was used to remove the silicon substrate from the under-side of the LED, using the buffer as an etch-stop (d). The free-standing membrane device was finished with the removal of residual photoresist (e).

The LED chip area was 400μmx400μm, with the p-electrode diameter 100μm and n-electrode quarter circle radius 150μm. The designed hole diameter in the silicon was 200μm and the membrane diameter was 142μm. The researchers were concerned that a too wide free-standing region would not be able to sustain residual stresses in the structure. The sidewall angle of the hole was 81.5°.

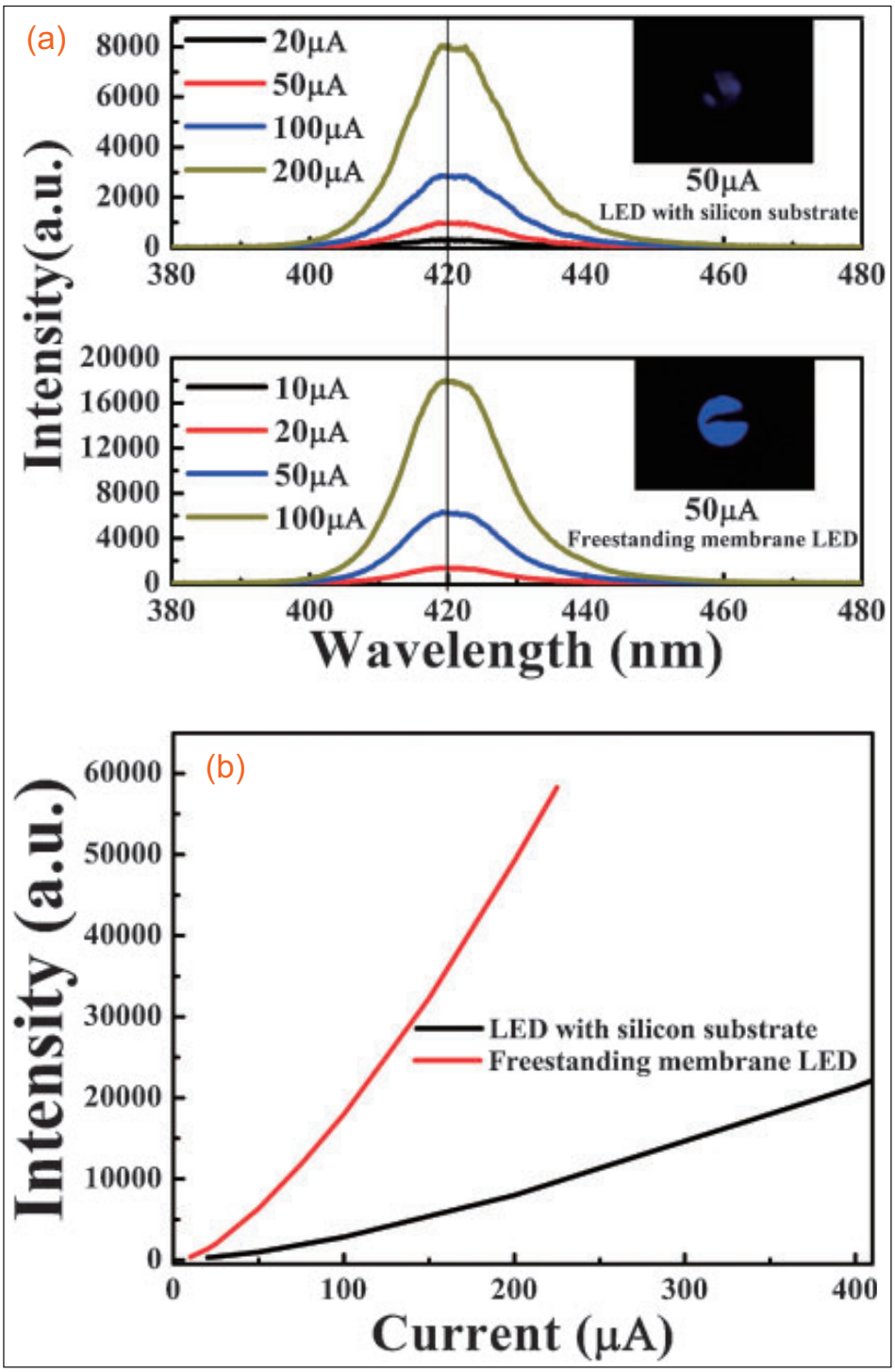

Figure 3. (a) Room-temperature electroluminescence spectra of LEDs under different continuous current injections. Inset: top view of fabricated LEDs under 50μA current; (b) peak emission intensity of fabricated LEDs as function of injection current.

Photoluminescence increased with the removal of the silicon substrate from under the LED region. Spectral analysis also showed a blue-shift in the emission peak. Multiple reflections gave interference fringes in the spectrum.

The researchers comment on the current-voltage (I–V) performance that "considerable improvement of the I–V characteristics for the free-standing membrane LED may be attributed to the reduction of the spreading resistance and the increase in the conductivity". The removal of silicon from underneath the device reduced the turn-on voltage by about 1V.

The membrane device had a strong electroluminescence at 420nm (Figure 3). The researchers say that the slope of increased emission with current injection was about six times larger for the free-standing membrane structure. ■

http://dx.doi.org/10.7567/APEX.7.082102

Author: Mike Cooke

MOCVD trends helping to drive down LED chip costs

Veeco's Sudhakar Raman explains how a new generation of processing equipment is cutting the cost of manufacturing high-brightness LEDs by improving the yield and productivity of the MOCVD process.

Driven by the growing adoption of LED lighting for retail, commercial, industrial, roadway and residential lighting, global LED manufacturers are preparing for another LED market transition. After past LED growth from mobile devices and television backlighting, manufacturers are facing stronger pressure from their lighting customers to deliver higher-quality and lower-cost LED bulbs.

To keep pace with this growing lighting demand, LED manufacturers need efficient and productive LED chips to keep bulb costs down. That's where Veeco comes in. A new generation of processing equipment made by Veeco is cutting the costs of producing high-brightness LEDs by improving the efficiency and yield of the metal-organic chemical vapor deposition (MOCVD) process — critical to LED formation (the critical first step in LED manufacturing, depositing light-emitting chemical layers on a substrate wafer that is processed into the LED chips).

Although it is evident that solid-state lighting is increasing rapidly, production costs still stand as a significant gating factor to the widespread adoption for energy-efficient LED lighting. To help improve costs and productivity there are three key technology factors that are vital for MOCVD manufacturing and cost-efficient LED production.

1. Uniformity advantage — better epitaxial performance

The growth of the epitaxial layer remains the most important technology for the manufacture of LEDs. Depositing gallium nitride (GaN) layers onto a sapphire wafer enables the conversion of an electric current into photons of light. Each layer in the GaN structure must be deposited while maintaining precise control over the thickness and composition of each layer. This is why LED manufacturers keep their deposition process and growth methodologies highly proprietary.

Deposition uniformity within the wafer, between wafers and in terms of run-to-run reproducibility is extremely important to the ultimate performance — and therefore value — of the LEDs. So, one of the most important factors for users is to operate MOCVD reactors that deliver excellent uniformity. This can be done, in part, by ensuring that tools are designed to run a consistently clean and efficient process.

One of the most import elements in process uniformity is stringent temperature control. For example, for several years, we consistently enabled an increased rate of GaN growth by using a heated inlet flange in our reactors. This is an example of how hardware or tool design improvements that increase the control of temperature can improve within-wafer and wafer-to-wafer uniformity. Controlling repeatability and thermal transitions ensures better uniformity and faster process times, which, in turn, drives faster throughput.

2. Flexibility advantage — ease of use; ease of adoption

The epitaxial processes used in the manufacturing of LEDs are largely well established. However, process revisions and innovations are essential for success. One example of this is the trend toward larger-diameter wafers.

The advantages of moving to larger substrates for manufacturing LEDs are similar to those that have driven the transitions to larger wafers for the fabrication of silicon integrated circuits. These include reduced overall manufacturing expenses, cost savings throughout the entire wafer processing cycle, and fewer steps per LED. To help shorten the time to transition to larger-wafer production, the coming MOCVD generation will incorporate capabilities that will facilitate next-generation MOCVD system adoption. These include seamless process transfer from previous generations, the ability to change wafer sizes instantly, easy service access and software upgrade capability, thereby quickly enhancing capacity for users.

3. Cost-of-ownership advantage — superior economic capability

It is incumbent upon MOCVD manufacturers such as Veeco to help customers improve throughput and reduce LED chip costs. It is clear that LED manufacturers want to reduce costs, increase throughput and improve performance through:

- increased reactor capacity — enabling more wafers to be processed in fewer runs;
- optimal wafer placement — improving uniformity and

leading to higher yields;
- one-touch operating capability — minimizing the need for constant operator supervision;
- enhanced thermal and planar uniformity of wafers — contributing to improved yields;
- improved process flow and temperature control — increasing throughput and producing more quality wafers per month;
- increased uptime — allowing more continuous runs between maintenance;
- lower maintenance costs and improved system efficiency — lowering consumable use; and
- better capital efficiency — leading to stronger profitability for customers.

Future-proofing customers

Technology is advancing rapidly and, to keep pace with steadily falling chip average selling prices (ASPs), MOCVD users need to adopt new technology and process improvements rapidly as well. To this end, Veeco is developing new technologies and capabilities with an eye toward our long-held strategy of future-proofing customers. That is, our goals ensure that customers can extend and enhance their MOCVD systems in the future by:
- continually improving performance to extend yield improvements and throughput;
- maximizing cost of ownership;
- transitioning easily to larger wafer sizes; and
- boosting their capacity while reducing tool/fab floor footprint.

These are exciting times for the LED industry. With end products from mobile devices, tablets and TVs to a wide array of lighting applications, demand for LEDs in a range of power and brightness levels will continue to escalate. To keep pace with this demand, LED makers will need to operate manufacturing equipment and processes that deliver optimal performance in terms of uniformity, thermal stability, repeatability and cost-effectiveness. The requirements are clear, and we look forward to helping write the next chapter in this evolving LED market. ■

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www.veeco.com

Band engineering for improved photo-electro-chemical etch

A band-engineering technique has been developed to improve photo-electro-chemical etch of nitride materials for optoelectronic and micro-electro-mechanical system applications.

Researchers from Ohio State University (OSU) and University of California–Irvine (UCI) have developed a band engineering technique to improve the results from photo-electro-chemical (PEC) etch of nitride semiconductors [Prashanth Ramesh et al, Appl. Phys. Lett., vol104, p243503, 2014]. Although the etch process was used to create micro-cantilever structures, the researchers also see potential for optoelectronic applications.

PEC etch uses the narrower bandgap of indium gallium nitride (InGaN), compared with gallium nitride (GaN), to selectively remove material. The technique uses excitation of electrons and holes in the sacrificial layers, and an electrochemical bias, to enhance the etching of InGaN.

The OSU/UCI researchers tested the inclusion of 10nm highly n-type layers that simulations suggested would reduce the band-bending effect at the top and bottom of a 200nm sacrificial layer of 5% InGaN. These band-bending effects concentrate the PEC etch in the middle of the sacrificial layer. The band bending also raises a barrier to the extraction of electrons through the substrate electrode. Both factors lead to incomplete etching of the sacrificial layer.

The highly doped 'guard' layers provide charge that compensates for polarization charges that are induced at the interfaces between the GaN and InGaN layers. The researchers comment: "This results in a flat energy band in the entire InGaN layer, allowing uniform distribution of holes, with the energy bands aligning with those in the undoped GaN region".

The guard layers also prevent holes from drifting out of the InGaN and allow efficient extraction of electrons through the InGaN/GaN template interface.

Materials for the OSU/UCI PEC etch (Figure 1) were produced on GaN/sapphire templates from Kyma Inc using a Veeco Gen930 molecular beam epitaxy (MBE) system. The deposition process was nitrogen plasma assisted.

The materials were patterned with a titanium/nickel etch mask to create a large array of micro-cantilever structures of width 5–40μm and length 100–400μm. The mask allowed mesa structures to be formed using a chlorine-based reactive ion etch down to the template layer. The mask was removed to allow better penetration of radiation from a xenon ultraviolet lamp. The radiation from the lamp was filtered by another GaN/sapphire template wafer from Saint Gobain Crystals so that the radiation energy was below that of GaN's bandgap. The substrate electrode for the electro-chemical part of the etch process consisted of titanium/gold. The counter electrode was platinum. A 1 molar (1mole/liter) solution of potassium hydroxide was used as electrolyte. The PEC etch was carried out for 30 minutes with a +1V bias between the substrate and counter electrodes.

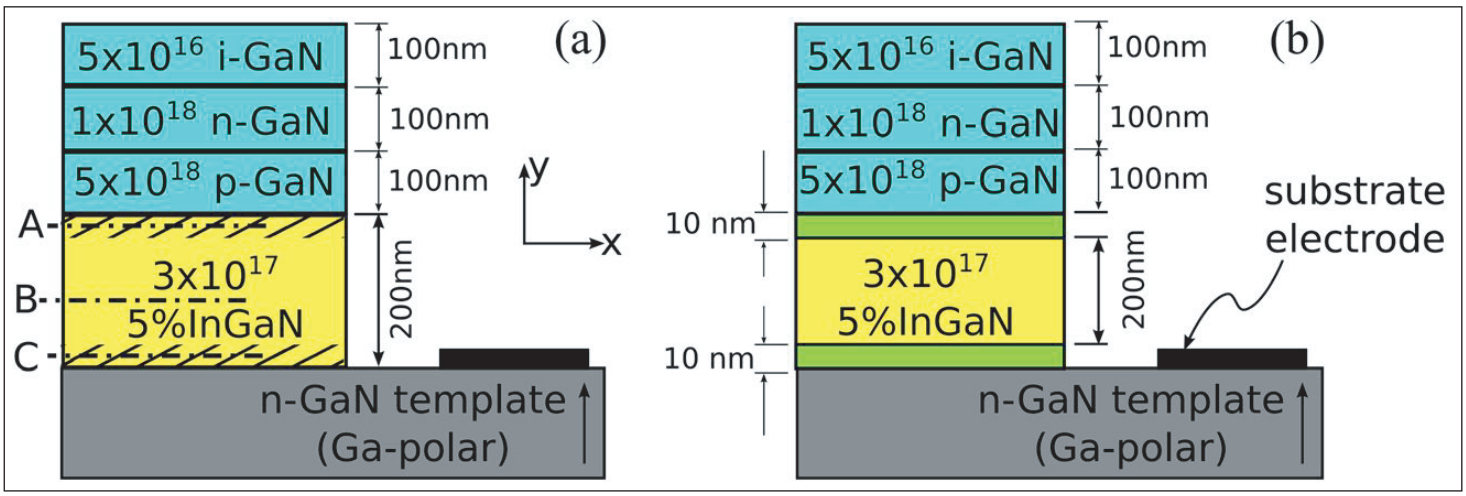

Figure 1. (a) Control stack and (b) test stack structures. Unlabeled 10nm layers in (b) are highly n-type ($4x10^{19}/cm^3$) GaN.

A 'control' stack without the highly doped 'guard' layers resulted in distorted micro-cantilevers with a radius of curvature of 40μm. The curving of the cantilevers is attributed to residual stress gradients from unetched InGaN sacrificial material. The control cantilevers also suffered from cracking and warping of the anchor regions.

The 'test' stack with 'guard' layers, by contrast, gave cantilevers with "relatively minor residual curvatures and no cracking or warping of the anchor areas" (Figure 2). The researchers comment: "The minor residual curvatures seen with the use of the test stack are comparable to those reported elsewhere and are attributed to linear stress gradients due to sapphire and the metallization. These results also strongly suggest that the sacrificial InGaN layer was almost completely removed, proving the effectiveness of the proposed guard layers." ■

http://dx.doi.org/10.1063/1.4883890

Author: Mike Cooke

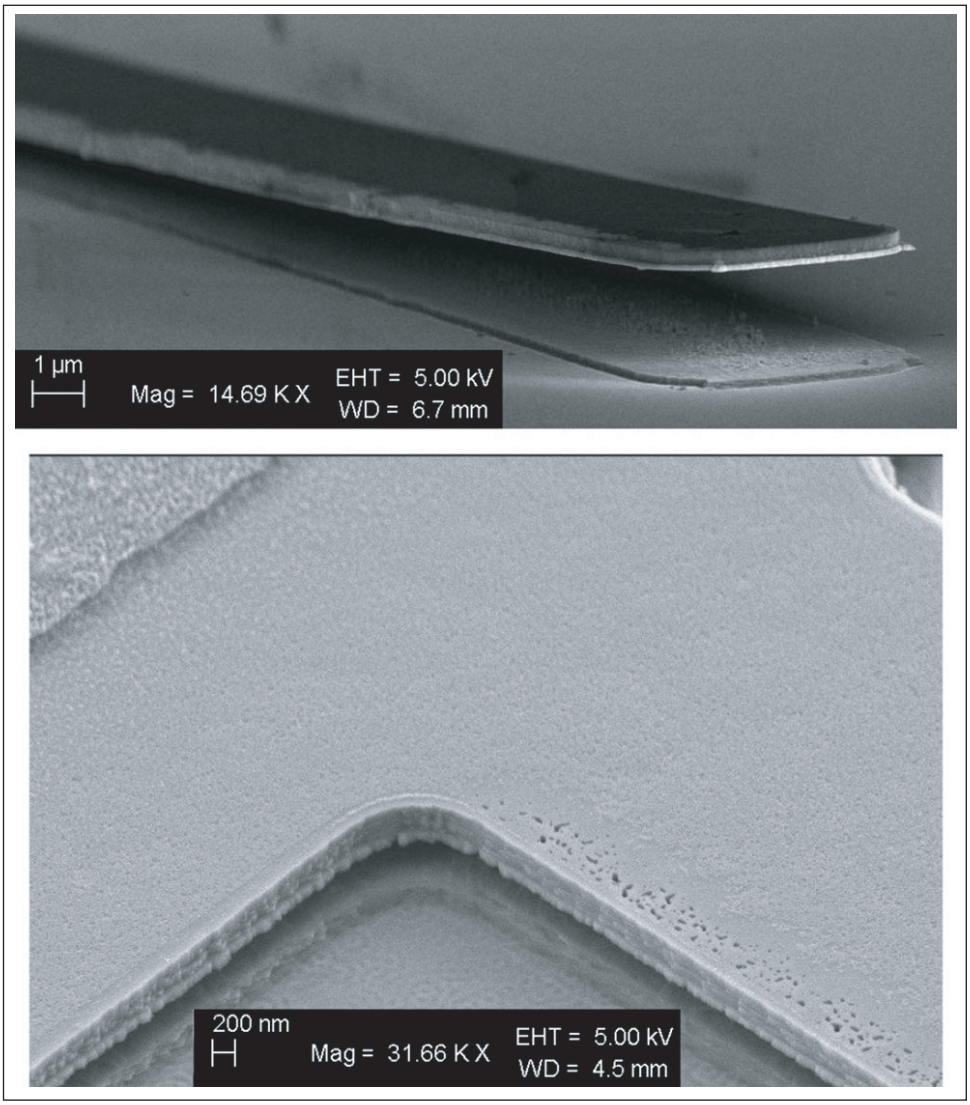

Figure 2. Scanning electron microscope (SEM) images of micro-cantilevers etched using test stack.

Ultrathin transition-metal dichalcogenides and 2D optoelectronics

A strong coupling of light and electrons and holes in ultrathin transition-metal dichalcogenides has opened prospects for efficient solar cells. Mike Cooke reports on developments in devices and structures consisting of compounds of the transition metals molybdenum (Mo) and tungsten (W) and the chalcogenides sulfur (S) and selenium (Se).

Transition-metal dichalcogenides (variously abbreviated as MX_2, TMD, TMDC) have become the trendy research vehicle for ultrathin two-dimensional (2D) electronics. With an eye to funding, researchers can often make exaggerated and/or misleading claims about their results and this is particularly true in new areas of study such as this. Similar claims were made in the early days of graphene research, and we can expect a sequence of optimism, pessimism and, finally, realism for both graphene and now TMDs. While we do our best here to find solid results and paths to real applications rather than wishful thinking, errors made in this respect are inevitable.

The crystal structure of TMD materials consists of strong bonds within a plane and weaker van der Waals bonds between layers. Like graphene, a 'facile' exfoliation technique to create flakes of a few layers, or even monolayers, of TMD materials is to use Scotch tape. By simply sticking the tape on bulk material and pealing it off, one can carry away flakes that are then removed from the tape and studied under a microscope or floated in solution onto a substrate. Although exfoliation is indeed 'facile', in the sense of being simple to implement, it is very labor intensive and could not lead to a robust mass-production process.

Much of the interest for TMD devices centers on the large optical coupling to direct-bandgap transitions leading to photovoltaic possibilities. Direct bandgaps are needed for efficient optoelectronics. The bandgap is around 2eV, a region of particular interest for solar cells. Although the bare efficiencies are small, it has to be remembered that these are responses for a few atomic layers (~0.3nm per TMD layer), whereas standard solar cells have micron-scale absorber layers. Another feature is that the electron–hole binding into excitons is large at around 0.5eV. Excitons appear in photoluminescence studies as resonance peaks and usually couple strongly to incoming photons.

Ultrafast charge separation

For solar cells one needs the electrons and holes generated by incoming photons to separate and thus produce a current, rather than recombining. Researchers in the USA and China have demonstrated "for the first time" efficient electron–hole separation through charge transfer in molybdenum/tungsten disulfide (MoS_2/WS_2) monolayer semiconductor heterostructures [Xiaoping Hong et al, Nature Nanotechnology, published online 24 August 2014].

The researchers from University of California at Berkeley, Lawrence Berkeley National Laboratory, Peking University, Arizona State University, and Kavli Energy NanoSciences Institute, say that the hole transfer time from the MoS_2 to WS_2 layer is ultrafast, at less than 50 femtoseconds ($50x10^{-15}$ seconds or, more correctly, $5x10^{-14}$ seconds). While the hole transfers to the WS_2 layer, the electron remains behind in the MoS_2.

Beyond solar cells, the researchers also see opportunities for photodetection, photovoltaics and photocatalysis arising from the combination of the demonstrated ultrafast charge transfer and strong optical absorption of MX_2 semiconductors.

The researchers chose to study the MoS_2/WS_2 combination because previous theoretical work suggested that these materials would form a 'type II' band profile, with the conduction band lowest in one material and the valence band highest in the other (Figure 1). With such an energy-level structure, the electrons would congregate in the material with the lowest conduction band and the holes in the material with the highest valence band (holes 'float' upwards in energy), hopefully enabling efficient separation for energy harvesting.

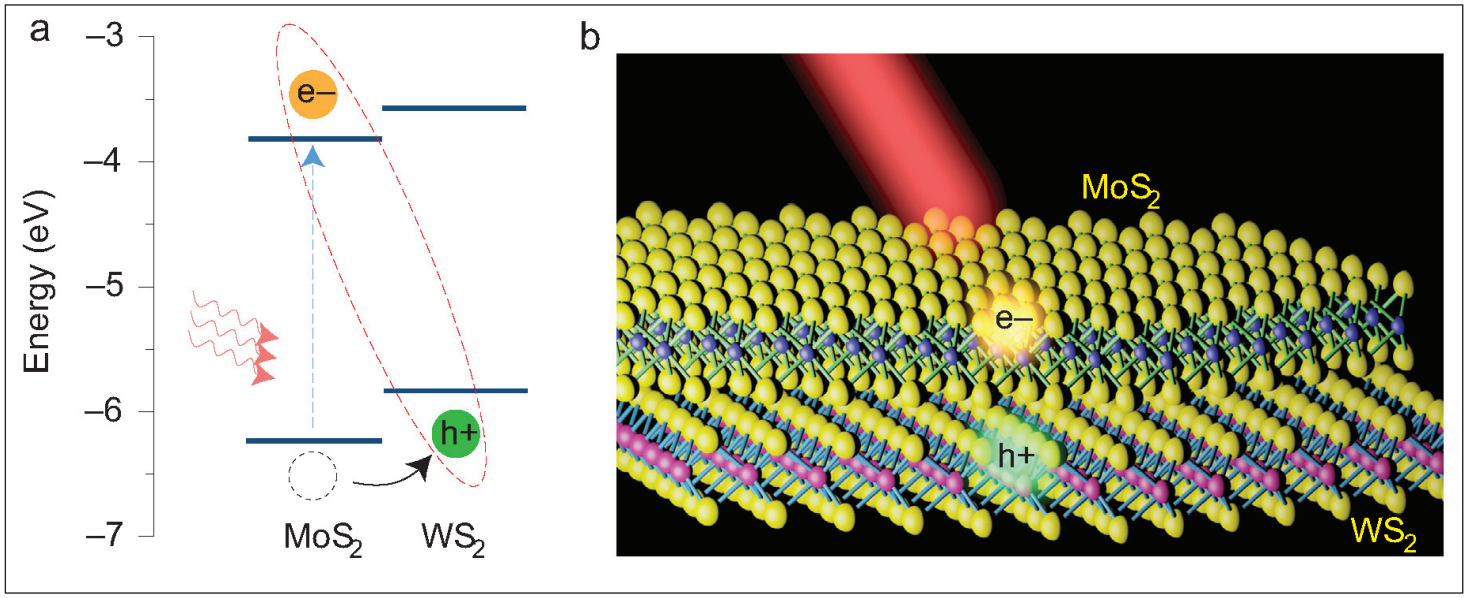

Figure 1. Band alignment and structure of MoS_2/WS_2 heterostructures. (a) Schematic of theoretically predicted band alignment of MoS_2/WS_2 heterostructure. (b) Illumination of MoS_2/WS_2 heterostructure with MoS_2 monolayer lying on top of WS_2 monolayer creates electron and hole in separate layers.

The MoS_2 monolayer was grown on 285nm silicon dioxide on silicon substrate, using chemical vapor deposition (CVD). The WS_2 monolayer was grown on sapphire, again with CVD. The WS_2 material appeared on the sapphire substrate as flakes.

The MoS_2 was transferred to the WS_2 on sapphire on polymethyl methacrylate (PMMA) film. The film was spin coated on the MoS_2 and released from the substrate by etching in potassium hydroxide solution. After transfer onto the WS_2, the PMMA was dissolved in acetone.

The MoS_2/WS_2/sapphire was annealed to create the heterostructure. Raman spectroscopy was used to confirm that the heterostructure consisted of monolayers of MoS_2 and WS_2.

Photoluminescence with 2.33eV radiation at 77K on regions with only MoS_2 or WS_2 gave

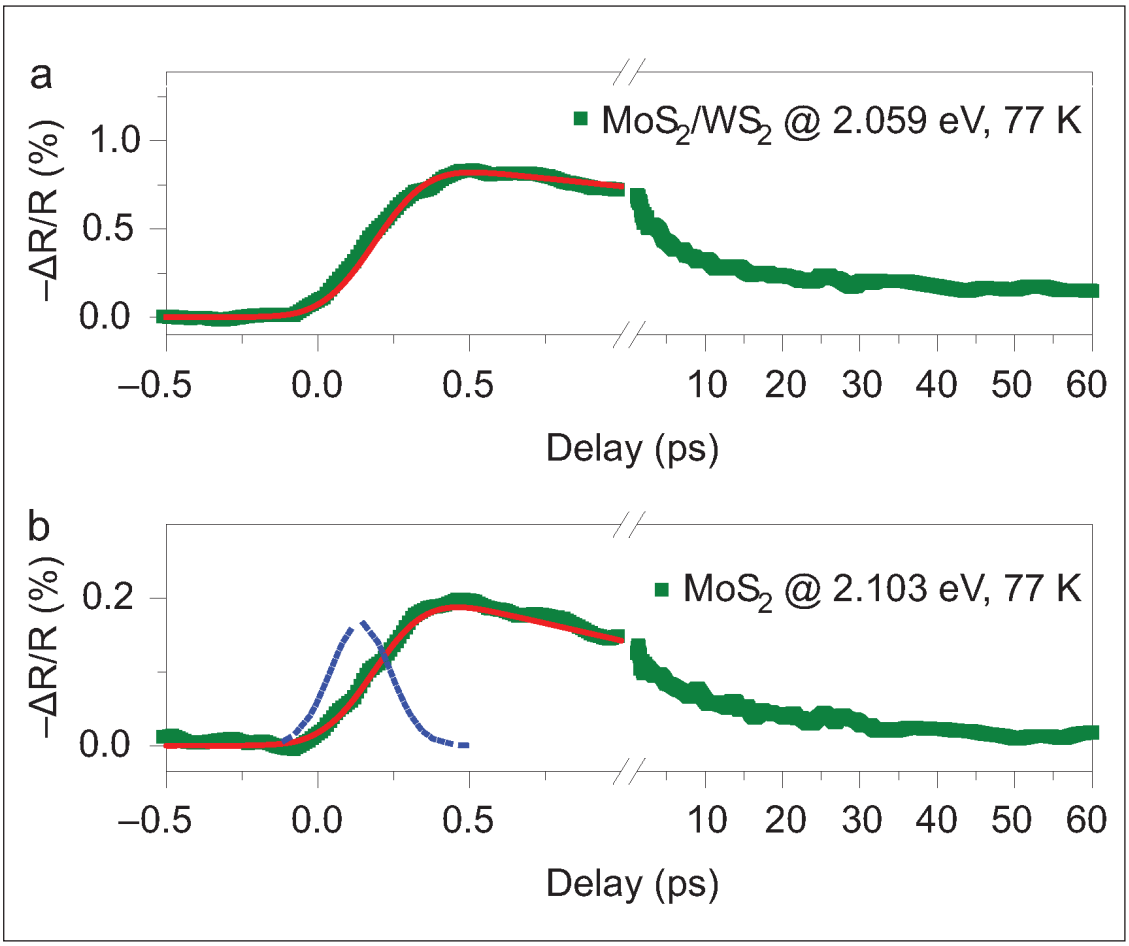

Figure 2. (a) Evolution of transient absorption signals at the WS_2 A-exciton resonance in MoS/WS_2 heterostructure. (b) Dynamic evolution of transient absorption signals at the MoS_2 B-exciton resonance in isolated MoS_2 monolayer. Both signals show almost identical ultrafast rise times, limited by laser pulse duration of ~250fsecs. Convoluting instrument response function (blue dashed line in b) and instantaneous response in MoS_2 reproduces ultrafast dynamics in MoS_2 monolayer (red trace in b). Similar convolution shows that rise time in the MoS_2/WS_2 monolayer is ~25fsecs (red trace in a) and has an upper limit of 50fsecs.

resonance peaks at 1.93eV or 2.06eV, respectively. The researchers attribute these resonances to 'A-excitons'. In regions where MoS_2 overlaid WS_2 to form a hetero-structure, these peaks were significantly 'quenched'. The researchers take this as evidence that charge transfer had taken place with the separation of the electrons and holes into the MoS_2 and WS_2 layers, respectively. An alternative quenching mechanism of energy transfer would by contrast reduce the high-energy peak and enhance the lower-energy peak, according to the researchers. The quenching effect was also seen in room-temperature measurements.

The researchers also carried out more detailed pump-probe experiments at 77K. The probe consisted of detecting changes in the reflection spectrum at various times after the pump pulse. By changing the energy of the pump photons the separate excitons could be generated. The researchers used a 1.86eV photon pump to generate MoS_2 excitons. The change in reflection spectrum was directly proportional to the absorption spectrum.

Resonant features at 2.06eV and 2.46eV were found in the absorption spectra of MoS_2/WS_2 heterostructures. The researchers attribute these, respectively, to the A- and B-exciton states in WS_2. Such features are not seen in WS_2-only samples since the pump energy is too low to excite them. The researchers comment: "This provides direct evidence of efficient charge separation in photoexcited MoS_2/WS_2 heterostructures (Figure 1a): electron–hole pairs are initially created in the MoS_2 layer, but holes quickly transfer to the WS_2 layer due to the type II band alignment, while electrons stay in the MoS_2 layer."

Using the rise time for the exciton resonance, the researchers estimate that the hole transfer occurs within 50fsecs of the pump pulse (Figure 2). "Similar ultrafast hole transfer also takes place at room temperature," the researchers say. Most processes in MX_2 materials, such as exciton lifetimes, are typically on the order of tens of picoseconds (10^{-12} seconds).

The researchers believe that the efficient charge separation is due in part to the formation of 'charge transfer excitons' with the electrons and holes binding across the interface between the different layers.

Vienna University of Technology has similarly created vertical type II structures using layers of MoS_2 and WSe_2 [Marco M. Furchi et al, Nano Lett., vol14, p4785, 2014]. The researchers were able to tune the junction with a gate potential applied to the substrate, achieving photovoltaic charge transfer.

The substrate was silicon dioxide on silicon. The TMD layers were achieved using exfoliation from bulk crystals. The first TMD layer was exfoliated directly onto the substrate and then annealed in vacuum at 380K for several hours. The second TMD layer was transferred using PMMA at 380K.

The sample was then cooled to room temperature and the PMMA removed. The structure was finished with focused-ion beams used to cut away chunks of bulk material that would make short-circuits and with further annealing at 380K. Palladium was used as the contact metal.

Photoluminescence measurements on MoS_2 and WSe_2 monolayers gave peaks for A-excitons at 1.85eV and 1.65eV, respectively. The researchers estimate the exciton binding energy to be ~0.5eV, which added to the energies of the exciton resonances should give the bandgap energy. The MoS_2 PL spectrum also showed a 2.0eV B-exciton.

The gate potential affected the carrier characteristic of the WSe_2, changing from n-type (> −11V) to p-type (<-47V). By contrast, the MoS_2 layer is n-type down to full depletion at −71V. The n-type behavior of the MoS_2 layer is attributed to thermally activated impurity states that contribute electrons to the conduction band.

By biasing the gate between −71V and −47V, a pn junction is formed between the materials, giving diode current rectification.

The photovoltaic performance was measured with the gate potential −50V and a halogen lamp giving incident optical power between 180W/m^2 and 6400W/m^2. The researchers believe that excitons generated in the separate layers relax into interlayer exciton states due to the type-II heterostructure. The carriers then diffuse laterally to the contacts. The dominant efficiency limiting factor is interlayer recombination, the researchers believe. The researchers estimate an external quantum efficiency of 1.5% at 590nm wavelength. The power conversion efficiency of 0.2% is comparable to values obtained for bulk WSe_2 (0.1–0.6%) and MoS_2 (1%).

The researchers believe that stacking or plasmonic enhancement could result in better efficiency. With plasmonic enhancement of 10% and sandwiching the dichalcogenide junction between electrodes for vertical carrier extraction could give 5x better efficiency, says the team.

The researchers believe that "Bringing together different 2D materials in a roll-to-roll process or direct heterostructure growth could lead to a new photovoltaic solar technology. Moreover, due to the plurality of 2D materials with different band gaps and electron affinities, low-cost multijunction solar cells could come within reach."

One-dimensional heterojunctions

Researchers based in USA, UK, and Hong Kong have developed a physical vapor transport process that creates one-dimensional (1D) heterojunctions between 2D semiconductor monolayers of $MoSe_2$ and WSe_2 [Chunming Huang et al, Nat. Mater., published online 24 August 2014]. The team consisted of members

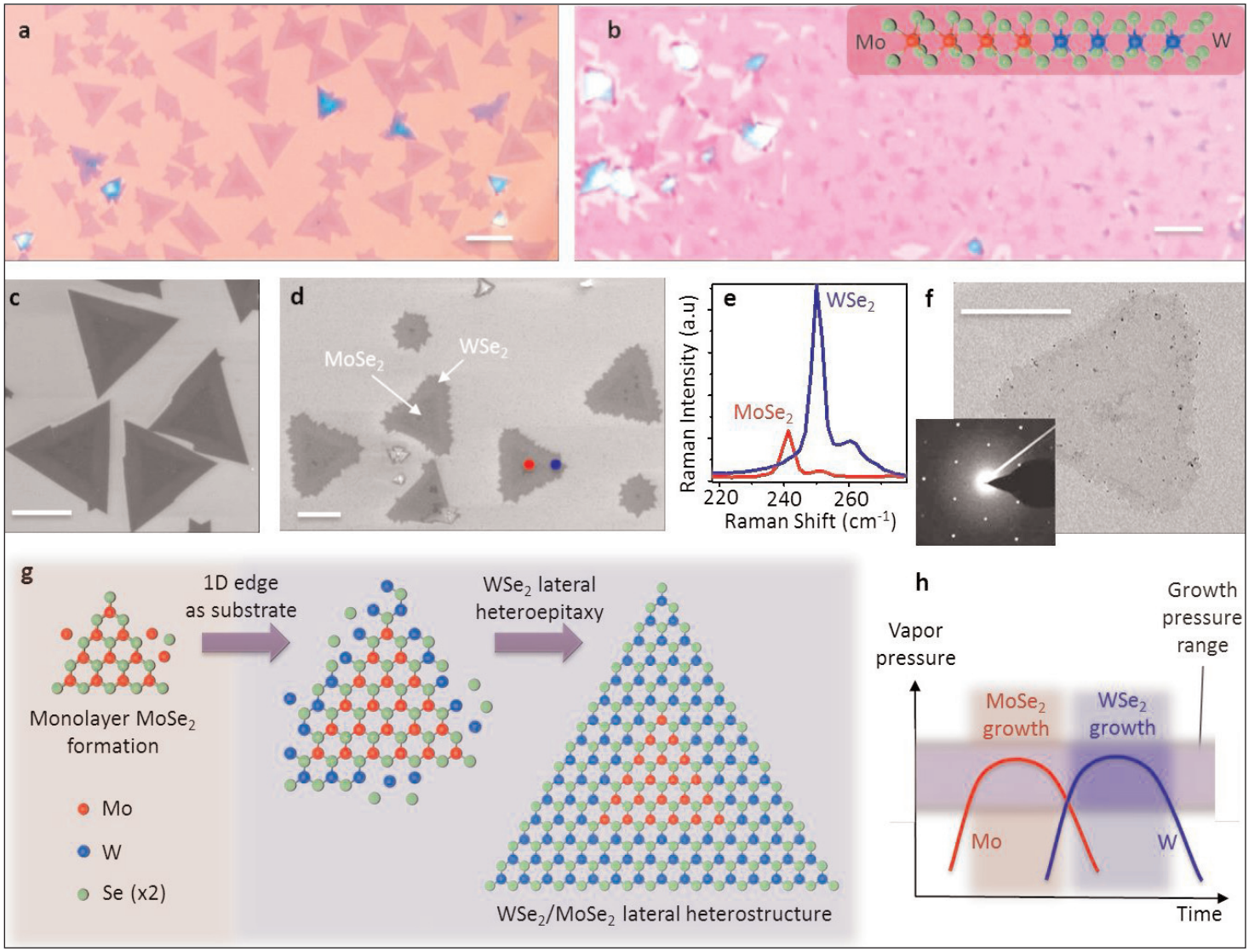

Figure 3. In-plane hetero-epitaxy of 2D $MoSe_2$/WSe_2 lateral heterostructures. a, Optical image of triangular heterostructure crystals. b, Optical image of semi-continuous film. Inset: side-view cartoon of in-plane heterojunction. c and d, SEM images of heterostructure crystals from two different growths. All scale bars 10μm. e, Raman spectra (514.5nm laser excitation) taken at points indicated in d. f, BF TEM image of isolated heterostructure. Inset shows electron diffraction pattern implying a single undistorted lattice. Scale bar: 5μm. g, Schematic illustration of process of in-plane epitaxial growth of lateral heterostructures. h, Schematic of atomic vapor pressure variation leading to growth of two materials in sequence.

from University of Washington, University of Warwick, and University of Hong Kong.

"Heterojunctions are fundamental elements of electronic and photonic devices," comments Xiaodong Xu, an assistant professor of materials science and engineering and of physics at University of Washington. "Our experimental demonstration of such junctions between two-dimensional materials should enable new kinds of transistors, LEDs, nanolasers, and solar cells to be developed for highly integrated electronic and optical circuits within a single atomic plane."

David Cobden, professor of physics at University of Washington adds: "In the future, combinations of two-dimensional materials may be integrated together in this way to form all kinds of interesting electronic structures such as in-plane quantum wells and quantum wires, superlattices, fully functioning transistors, and even complete electronic circuits."

The researchers quote the direct optical bandgaps of $MoSe_2$ and WSe_2 at 1.550eV and 1.653eV, respectively. The lattice constants of the two-dimensional materials are close to each other: 3.280Å for WSe_2 and 3.288Å for $MoSe_2$. The Washington/Warwick/Hong Kong team suggests that their horizontal $MoSe_2$/WSe_2 1D heterojunctions may also lead to type II behavior and thus efficient charge separation.

Growth of the lateral heterostructures was achieved through physical vapor transport from $MoSe_2$ and WSe_2 powders in hydrogen onto silica-on-silicon substrate in a 1-inch tube furnace. The sources were heated to 950ºC. The temperature in the substrate region of the tube was 650–750ºC.

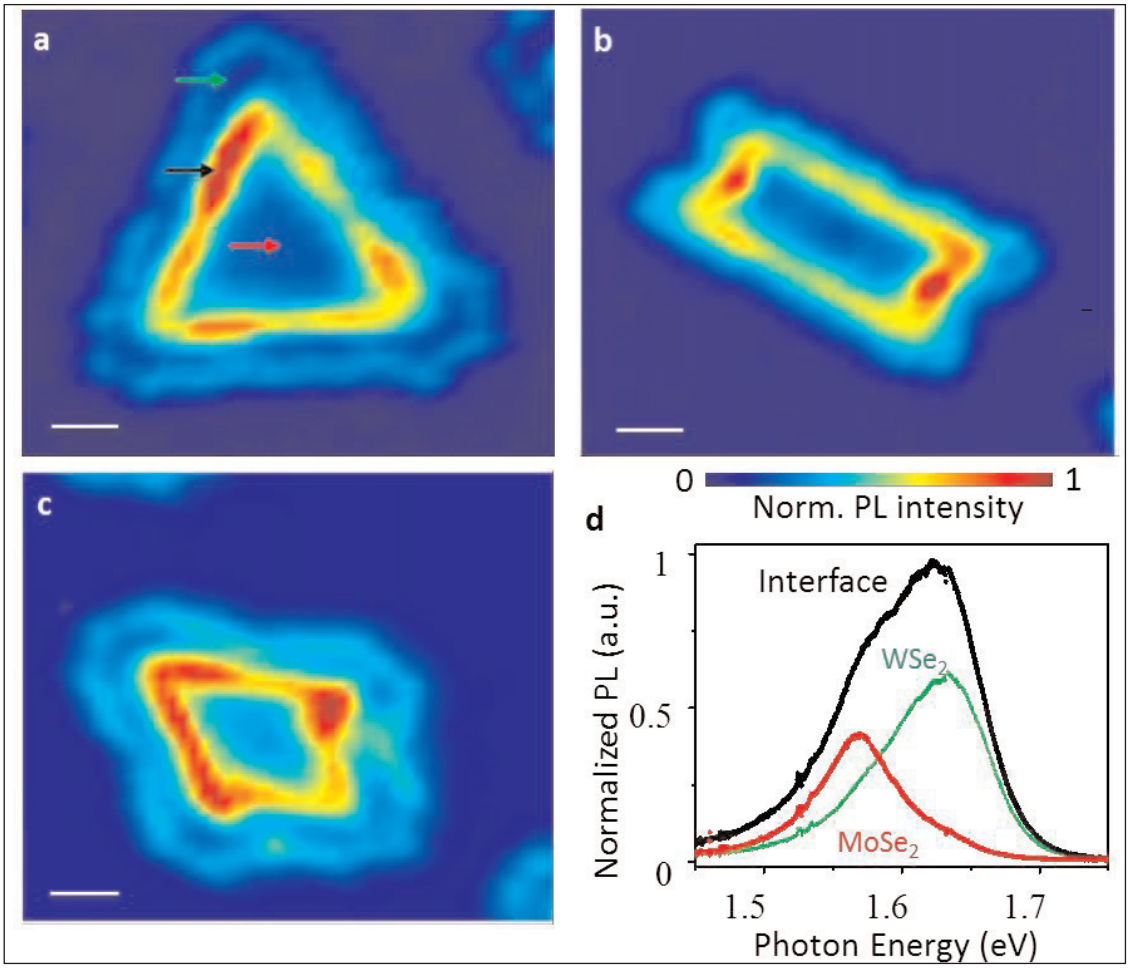

Figure 4. Photoluminescence from 1D heterointerfaces. a, 2D PL intensity map of triangular lateral heterostructure. Scanning micro-PL was performed with 532nm laser excitation at room temperature. b & c, Similar measurements for heterostructures with other shapes. Scale bars: 2μm. d, PL spectra taken at points indicated in a.

The researchers believe that a larger furnace would make it possible to mass-produce sheets of $MoSe_2/WSe_2$ semiconductor heterostructures. With the 1-inch tube furnace, it took about five minutes to grow the crystals. However, the heating and cooling took up to 2 hours.

The growth process often resulted in monolayer crystal patches of approximately equilateral triangles of side 15μm (Figure 3). Other shapes were also seen: strips, stars, arrows ... A wet process was used to transfer the monolayer material on PMMA to the analysis substrates (silicon dioxide, electron microscope grid, etc).

The triangular crystals tended to have darker inner regions and paler outer perimeters. Raman spectroscopy suggested that the inner regions tended to be $MoSe_2$ and the outer regions WSe_2. The researchers explain the structure as being due to $MoSe_2$ growth being favored early on but, as the vapor pressure shifts, the growth tips towards crystal WSe_2 monolayer coverage. The researchers add: "The similarity of the two materials permits the epitaxial growth of WSe_2 directly on existing $MoSe_2$ crystal edges."

The shift in growth from $MoSe_2$ to WSe_2 may also be due to the different evaporation properties of the source powders.

The researchers comment: "The reproducibility of our results suggests that a more sophisticated setup with independent control of the vapor components could be developed if necessary to create heterojunction sequences programmably for complex device applications."

Such sequences could be used to create one-dimensional quantum wells within the two-dimensional semiconductor monolayers.

Analysis with various techniques suggested that all the atoms lay on a single MX_2 honeycomb lattice with no dislocations or grain boundaries. The interface between the $MoSe_2$ and WSe_2 regions occurs on a scale of several lattice constants. In the interface region the material is an alloy of the two materials, i.e. $W_xMo_{1-x}Se_2$ with a steep x-composition gradient from 0 to 1. Away from the interface the researchers found some Mo substitutions on the WSe_2 side. Also, some Se vacancies were apparent.

Microscopic photoluminescence (PL) studies showed exciton peaks at 1.57eV and 1.63eV in the $MoSe_2$ and WSe_2 regions, respectively (Figure 4). These are 'identical' with the values found for homogeneous $MoSe_2$ and WSe_2 monolayers.

The peak for the heterojunction region was intermediate in energy and broader than for the pure $MoSe_2/WSe_2$ regions. Also, the emission was brighter — "possibly due to trapping of excitons by defects or enhanced radiative recombination at the interface".

As yet, no electron transport study has been made due to the lack of a suitable, reliable contact structure.

Contact technology

With the need for a better methodology in mind, Rutgers University and Los Alamos National Laboratory in the USA have developed a strategy for creating contacts in ultrathin MoS_2 nanosheets (2–3 layers) by

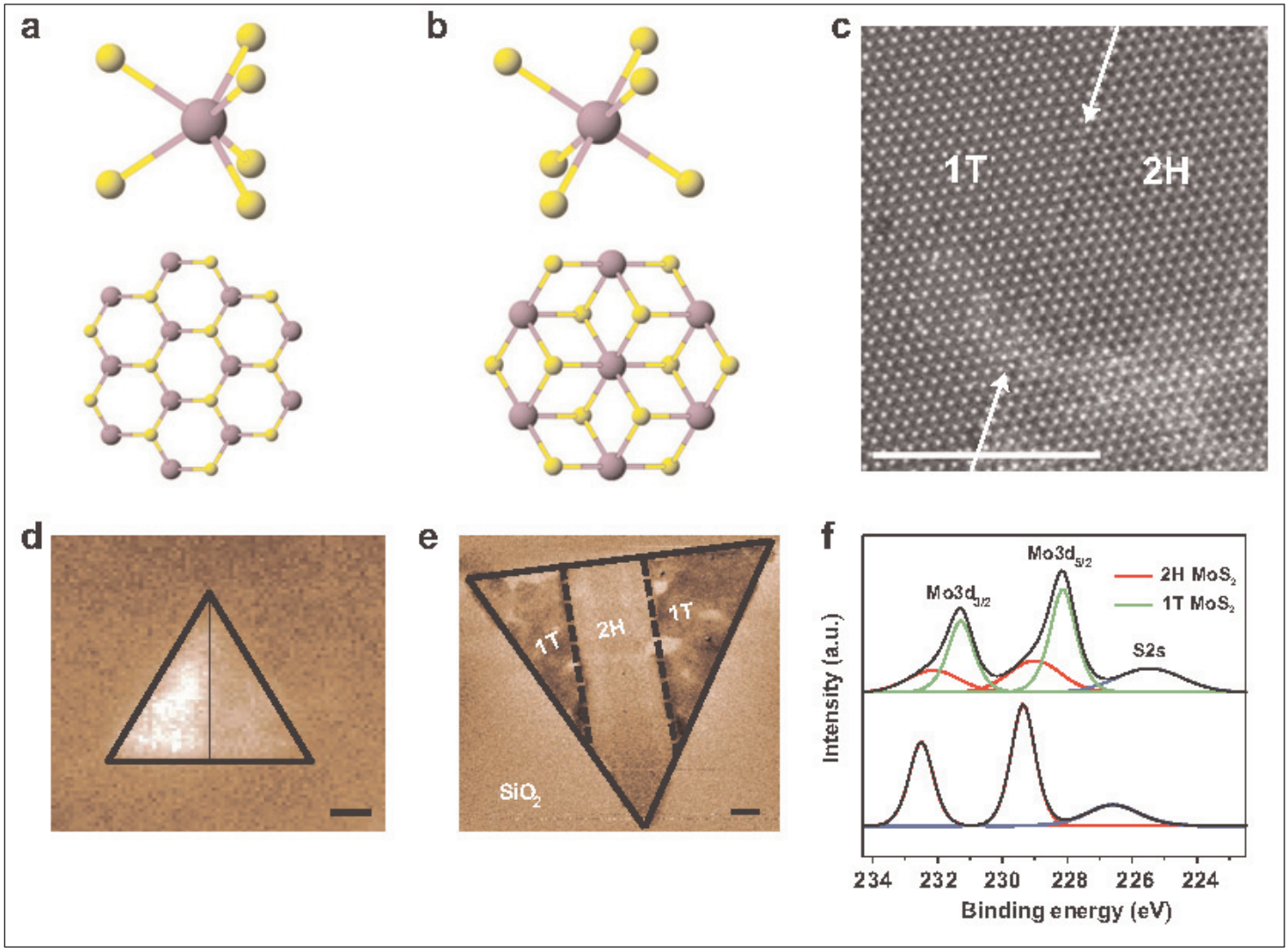

Figure 5. 1T and 2H phases of MoS_2. a,b, Crystal structures of 2H and 1T phases, respectively (purple, metal; yellow, chalcogen). c, High-resolution transmission electron microscope image of atomically thin phase boundary (indicated by arrows) between 1T and 2H phases in MoS_2 monolayer (scale bar 1nm). d, Photoluminescence map of triangular MoS_2 monolayer – left side 2H phase, right side converted to 1T. e, Electrostatic force microscopy phase image of MoS_2 monolayer (scale bars 1μm). f, X-ray photoelectron spectra (XPS) showing Mo3d and S2s peaks of 1T and 2H phases of MoS_2. Typical experimentally measured spectra are shown in black and fits are shown in red (for 2H phase) and green (for 1T phase). The lower curve is 100% 2H phase, whereas the top curve can be fitted with both 1T and 2H phase components.

locally transforming the phase from the semiconducting 2H to metal 1T crystal structure [Rajesh Kappera et al, Nature Materials, published online 31 August 2014]. A contact resistance of 200–300Ω-μm (0.2–0.3kΩ-μm) was achieved at zero gate bias in a field-effect transistor structure. The resistance was reduced a further factor of three with +30V gate potential.

These contact resistances represent a five-fold improvement over values for 2H MoS_2 contacts that are in the range ~1kΩ-μm. "The 1T contact resistance values are lower than the best values of ~0.6–0.7kΩ-μm reported thus far for MoS_2 devices," the researchers add. The 1T contact resistance is even comparable with state-of-the-art for metal/silicon (0.3–0.5kΩ-μm), as reported in the 2012 International Technology Roadmap for Semiconductors.

The researchers comment: "The low contact resistance is attributed to the atomically sharp interface between the phases and to the fact the work function of the 1T phase and the conduction band energy relative to vacuum level of the 2H phase are similar (~4.2eV)." The transistors demonstrated ~50cm^2/V-s effective mobility, 85μA/μm drive current, 90–100mV/decade subthreshold swing, and ~10^7 on/off current ratio. The researchers also found the device performance of 1T electrodes to be highly reproducible and independent of the contact metal (gold, calcium, palladium).

The MoS_2 was exfoliated onto SiO_2/Si substrates. The MoS_2 flakes were covered with PMMA and openings made for the contact regions by photolithography. The transformation to 1T polytype (Figure 1) was achieved by treatment with n-butyl lithium at room temperature

for 1 hour. After treatment, residues were washed away with hexane and de-ionized water. The 1T regions were found to have a phase concentration of 70%. The researchers expect even better transistor performance if this concentration were to be increased.

Device fabrication continued with application of metal pads to the contact areas. The gate structures were also produced at the same time in top and bottom configurations. High-k dielectrics for the top-gate configuration were deposited in atomic layer deposition (hafnium dioxide) or plasma-enhance chemical vapor deposition (silicon nitride) processes.

The team comments: "The 1T phase is metastable, but we have demonstrated that it is stable under environmental conditions and also as catalyst for hydrogen evolution — however, its stability under high-performance device operation remains to be elucidated."

Although we have focused on compounds with S/Se, another possibility for the chalcogenide is tellurium (Te). University of Geneva researchers have found a direct bandgap of 1.02eV and a narrower indirect bandgap of 0.88eV for 4nm-thick $MoTe_2$ crystals [Ignacio Gutiérrez Lezama et al, 2D Mater., vol1, p021002, 2014]. The researchers are hopeful that there will be a transition to a direct bandgap when thinner layers are studied.

Other researchers have studied the coupling with polarized light and have been able to generate and manipulate spin and valley currents [Tao Jiang et al, Nature Nanotechnology, published online 31 August 2014, Fudan University, Collaborative Innovation Center of Advanced Microstructures, University of California at Berkeley; Hongtao Yuan et al, Nature Nanotechnology, Published online 7 September 2014, Stanford University, SLAC National Accelerator Laboratory, Peking University, Collaborative Innovation Centre of Quantum Matter].

The spin current is related to the magnetic moment of the electron, while a valley current consists of electrons in a particular part of the band structure. The distinct valleys in the band structure can be theoretically treated as an index with a similar influence on electron dynamics as spin. While 'spintronics' has been researched for some time, the possibility of 'valleytronics' has only been discussed recently in the context of graphene and TMDs. ■

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Aspect ratio trapping to improve InGaAs quality on silicon substrates

ART technique eliminates GaAs anti-phase boundaries at a relatively low aspect ratio of 1.3.

Researchers based in France and USA have been working on ways to improve material quality for indium gallium arsenide (InGaAs) compound semiconductor quantum wells (QWs) on silicon (Si) [R. Cipro et al, Appl. Phys. Lett., vol104, p262103, 2014]. The researchers from Université Grenoble Alpes, Université de Lyon, and US-based Applied Materials are seeking ways to incorporate III-V high-mobility materials on silicon and thus boost transistor performance.

One of the main problems with growing InGaAs and related materials on silicon is lattice mismatch, with differences of 4% for pure GaAs and 11% for InAs, respectively, compared with silicon. Often, the materials are grown on indium phosphide (InP) substrates and transferred by complex direct wafer bonding techniques. Direct growth on silicon would be preferable.

Instead, the researchers used an 'aspect ratio trapping' (ART) method, where the compound semiconductor material was grown in trenches in silicon dioxide (SiO_2) on 300mm Si (100) in an Applied Materials metal-organic chemical vapor deposition (MOCVD) system. The trenches were aligned in the [110] direction. The growth of the compound semiconductors was preceded by cleaning using Applied's SiCoNi technology developed for cobalt/nickel physical vapor deposition (PVD).

A GaAs nucleation layer was grown directly on the exposed silicon surface at low temperature, followed by higher-temperature growth (less than 550°C) of GaAs/AlAs/InGaAs/AlAs/GaAs. The aluminium arsenide (AlAs) constituted the barrier parts of the QW system.

The researchers were particularly keen to remove anti-phase boundary (APB) defects. With just 180nm GaAs grown in the trenches, the APB density was found to decrease as the width of the trench decreased. The APB density estimated from micro-photoluminescence measurements was 3.9/μm with 1000nm trench width (0.18 aspect ratio). This reduced to 0.25/μm with 300nm trenches (0.6 AR).

The researchers add: "For narrower cavities, APBs are no longer observed. An aspect ratio of 1.3 is sufficient to completely annihilate the APBs."

Scanning transmission electron micrographs (STEM) of GaAs in 1.3 AR trenches suggested that misfit dislocations beginning at the Si/GaAs interface were blocked by the SiO2 sidewalls and did not proceed vertically through the GaAs layer. TEM study showed that the crystalline defects generated by the 4% GaAs/Si(100) lattice mismatch were confined to the first 20nm of GaAs.

Having developed a good-quality GaAs buffer, the researcher added a GaAs/AlAs/InGaAs/AlAs/GaAs stack to give the InGaAs QW. Secondary-ion mass spectroscopy (SIMS) was used to characterize the abruptness of the interfaces. The interface widths for AlAs/InGaAs, as measured by indium concentration varying from 14% to 86% of maximum, were 2.5nm and 2.9nm for

Results are promising for the development of InGaAs nMOSFETs on silicon. Also, due to the relatively low process temperatures, the technique could allow the development of co-integration of Ge-based pMOSFETs

Table 1. Characteristics of the samples studied in this work by micro-PL.

Sample	Targeted In content (%)	Measured InGaAs thickness (nm)	Micro-PL peak energy (eV)	FWHM (meV)	Extracted In content (%)
#1	10	15	1.37	68	7
#2	20	13	1.29	95	16
#3	30	10	1.10	60	35
#4	40	8	1.06	100	42

the upper and lower interfaces, respectively.

The InGaAs quantum wells were characterized using micro-PL with 623.8nm excitation from a helium-neon laser. The spot size was 0.5μm. Samples with low-AR trenches (<1.3) did not give any micro-PL signal. The researchers therefore studied only the 1.3 AR materials in depth (Figure 1). There was also a lesser signal from the GaAs layer for band-to-band emission at 1.43eV with a full-width at half maximum (FWHM) of 50meV. The QW emissions varied with indium content (Table 1). The FWHMs of the signals were around 60meV.

The researchers comment: "The ART strategy combined with an ultra-thin 150nm GaAs buffer layer seems efficient to block most of the defects such as dislocations and antiphase boundaries. It has been shown that an aspect ratio of 2 is required to effectively suppress the defects in selective epitaxy. But even in our below 1.5 aspect ratio patterns, defect densities are strongly decreased, leading to a room-temperature photoluminescence."

Cathodoluminescence from an electron beam showed bright and dark zones, suggesting the presence of the dislocations that form non-radiative recombination centers. "Further work is in progress to adapt the cavity aspect ratio and size, and the growth parameters, in order to block the remaining defects and to form defect free QWs," the researchers say.

The researchers believe that their results are promising for the development of InGaAs nMOSFETs on silicon. Also, due to the relatively low process temperatures, the technique could allow the development of co-integration of germanium-based pMOSFETs to give complementary metal-oxide semiconductor (CMOS) circuitry. ■

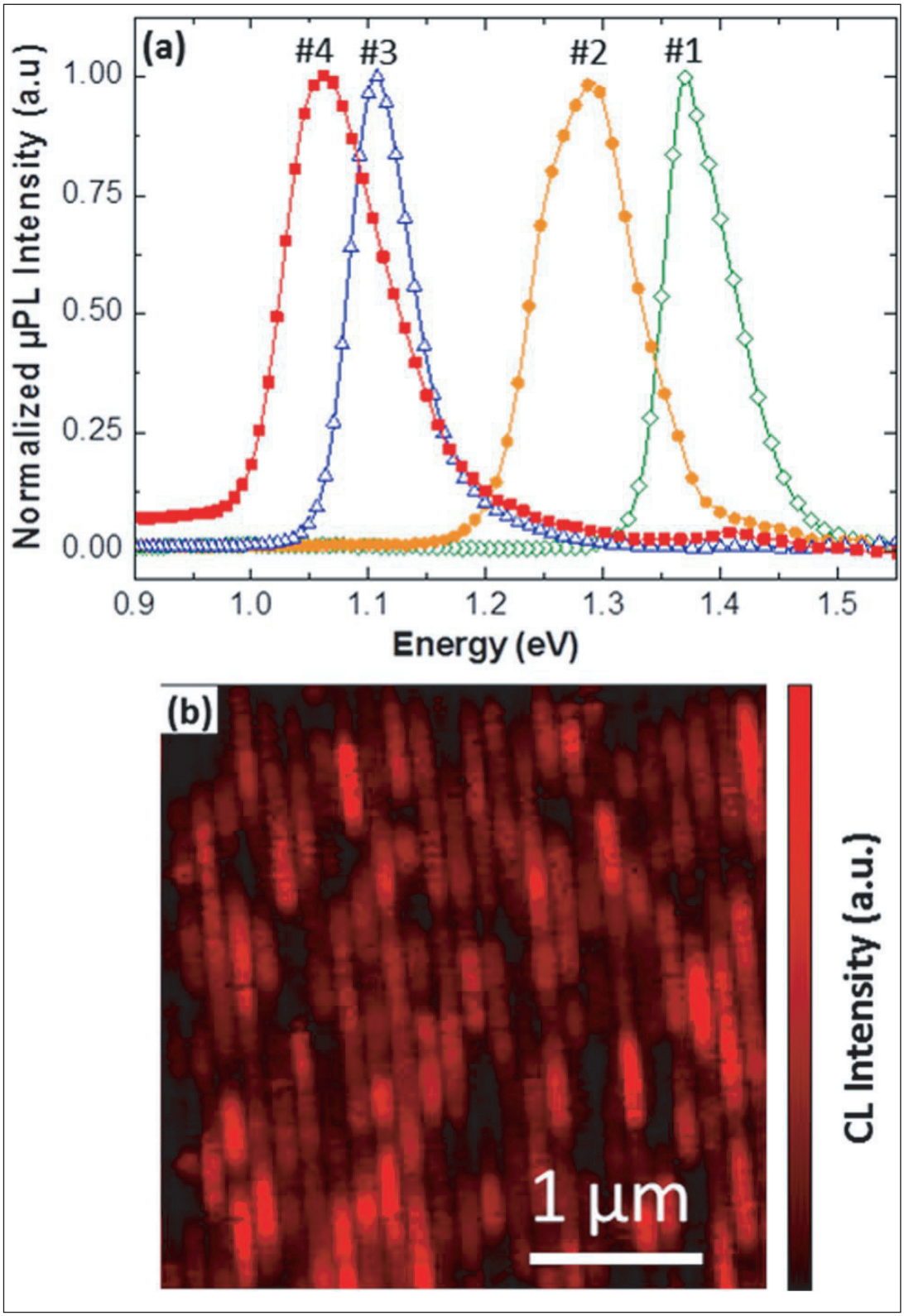

Figure 1. (a) Normalized room-temperature micro-PL spectra of different InGaAs QWs having different composition of indium of (#1) 10%, (#2) 20%, (#3) 30%, and (#4) 40%. (b) 5K panchromatic CL mapping of sample #1.

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Author: Mike Cooke

Passivating nitride transistors without vacuum processing

Research team claims first application of ultrasonic spray pyrolysis deposition of aluminium oxide in GaN HEMTs.

Researchers in Taiwan have applied a non-vacuum process to deposit aluminium oxide (Al_2O_3) passivation for nitride semiconductor high-electron-mobility transistors (HEMTs) [Bo-Yi Chou et al, IEEE Electron Device Letters, published online 11 July 2014].

Normally, Al_2O_3 is deposited on aluminium gallium nitride (AlGaN) or gallium nitride using vacuum processes such as atomic layer deposition (ALD), metal-organic chemical vapor deposition (MOCVD), or plasma-enhanced chemical vapor deposition (PECVD). The necessity to pump down to vacuum conditions increases process time.

To avoid vacuum processing, researchers at National Cheng Kung University, Feng Chia University, and Industrial Technology Research Institute (ITRI) used ultrasonic spray pyrolysis deposition (USPD) — a technique that has been used for silicon-based solar cell and humidity sensor fabrication, but not previously for GaN HEMTs. The team comments: "The USPD technique possesses advantages of cost-effectiveness, reduced processing time, and non-vacuum environment."

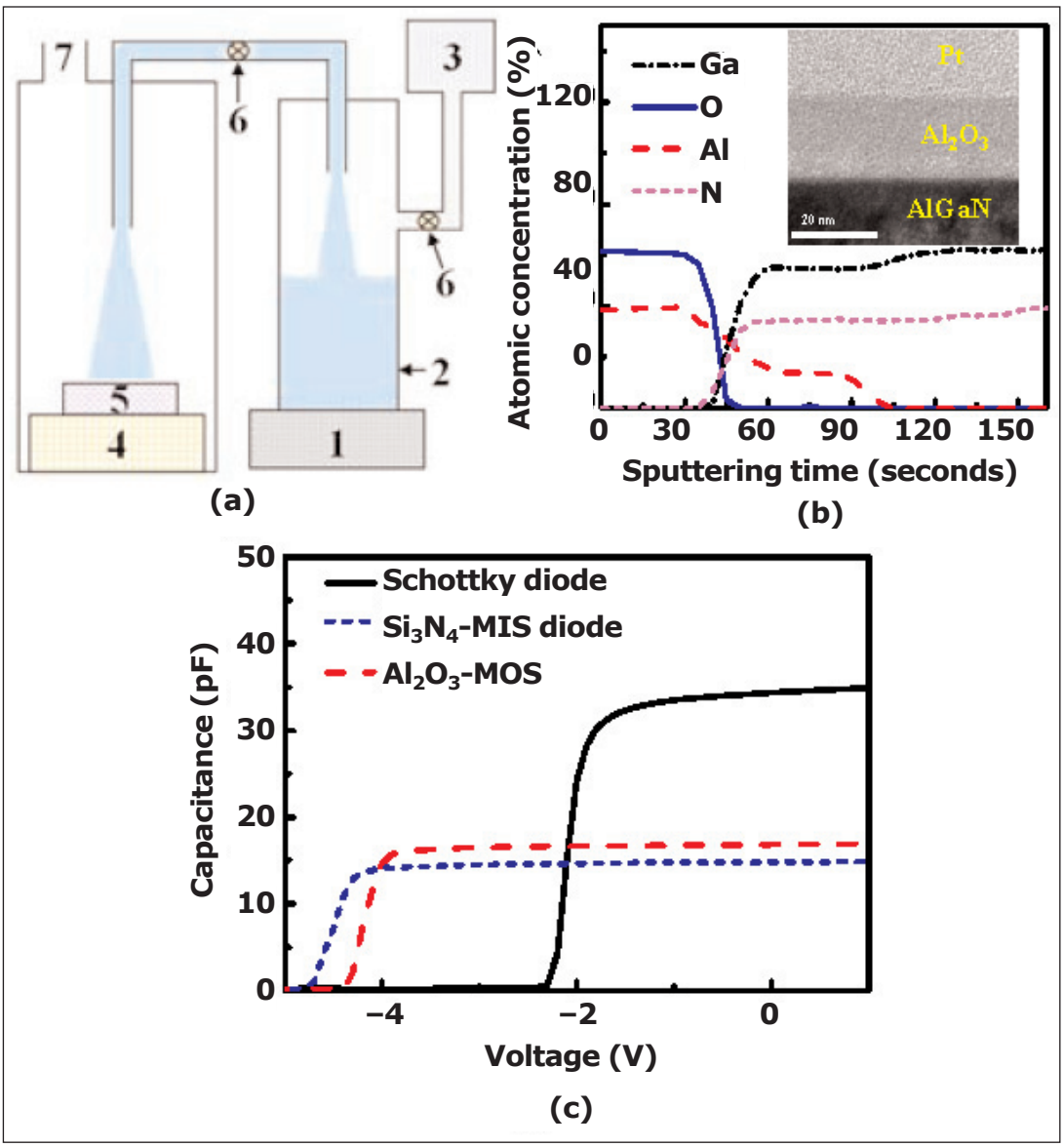

Figure 1. (a) Schematic of USPD system: (1) ultrasonic atomizer, (2) precursor solution, (3) carrier gas supply system, (4) heater, (5) sample holder, (6) controller and (7) exhaust. (b) Atomic concentration of the studied sample by using electron spectroscopy for chemical analysis (ESCA) and, inset, transmission electron microscope (TEM) photo of Al_2O_3/AlGaN. (c) C–V characteristics of diodes.

The researchers used epitaxial material grown on silicon carbide (SiC) using low-pressure MOCVD. The barrier layer was 25nm $Al0_{.25}Ga_{0.75}N$ and the buffer/channel was 2μm GaN.

The transistor fabrication involved cleaning, mesa isolation, source/drain contact (Ti/Al/Ni/Au) deposition and annealing, and gate formation and passivation. Three types of device were produced: unpassivated, and passivated with Al_2O_3 or Si_3N_4. The unpassivated device was annealed at 350°C for six minutes, mimick-

ing the growth condition for the Al_2O_3 passivation. The 100nm Si_3N_4 was applied using 300°C PECVD.

The USPD process (Figure 1) for Al_2O_3 deposition involved aluminium acetylacetonate dissolved in water/ethanol. The precursor was atomized using ultrasound and transported to the 350°C heated substrate in nitrogen carrier gas. At the substrate the aluminium acetylacetonate decomposes to give Al_2O_3. The resulting layer was 20nm, deposited at the rate 3.5nm/minute. On a 4-inch substrate the thickness uniformity was ±0.7nm.

Capacitance–voltage (C–V) measurements on metal-insulator-semiconductor diodes gave dielectric constants of 7.13 and 9.32, respectively, for Si_3N_4 and Al_2O_3 layers. The corresponding leakage currents under fields of 1MV/cm were $4.8x10^{-6}$A/cm^2 for Si_3N_4 and $2.2x10^{-8}$A/cm^2 for Al_2O_3. The unpassivated Schottky diode structure had a current leakage under reverse bias of $1.5x10^{-6}$A/cm^2. The areas of the test diodes were 8000μm^2. The interface trap densities (D_{it}) were estimated at $5.5x10^{11}$/cm^2-eV for Al_2O_3, compared with $9.7x10^{11}$/cm^2-eV for Si_3N_4.

Hall measurements (Table 1) showed reduced sheet resistance (RSH) with Al_2O_3 passivation. The improvement is attributed to increased carrier sheet density (n_s) that more than compensates for a slightly reduced electron mobility (μ_n) due to carrier-carrier scattering. The researchers comment: "The obtained higher n_s–μ_n product and lower RSH are advantageous to enhance the current drive ability for the present design."

The HEMTs were formed by etching the Al_2O_3 with phosphoric etch. The gate length was 1μm and the width was 100μm. The gate spacing from the source/drain contacts was 2μm.

A variety of DC, AC and pulsed measurements were made. The researchers comment: "In comparison with unpassivated and Si_3N_4-passivated devices, reduced D_{it}, decreased leakage current, enhanced drain current density, relieved RF drain current collapse, and improved power performance are achieved at the same time for the present Al_2O_3-passivated HEMT design."

According to the researchers, the reduced current collapse (Figure 2) "indicates that the surface traps in the gate-to-drain/source regions have been effectively suppressed by using the USPD-grown Al_2O_3 passivation layer." ■

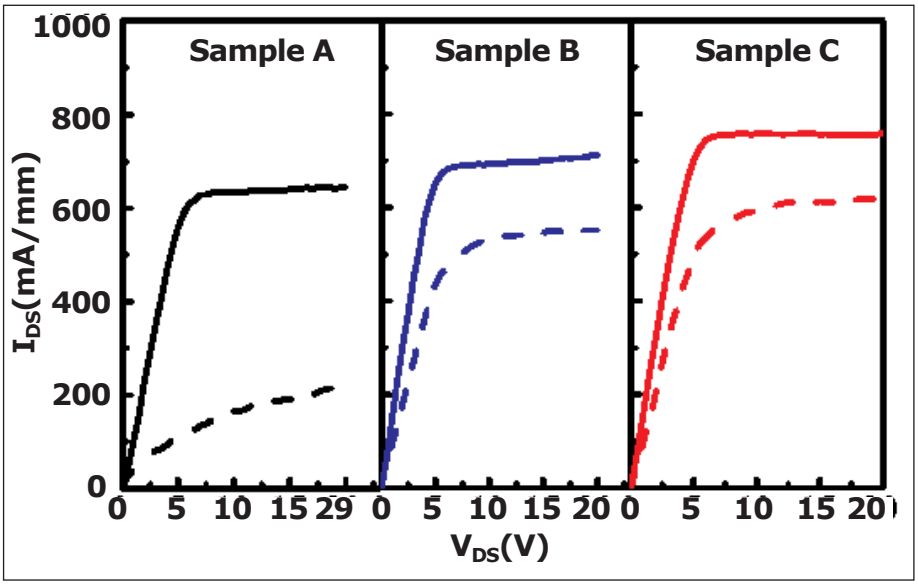

Figure 2. Pulsed drain current-bias (I_{DS}–V_{DS}) characteristics of samples A–C with quiescent-bias points of (V_{DS0}, V_{DS0}) = (0V, 0V) (solid lines) and (10V, –4V) (dash lines).

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6853327

Author: Mike Cooke

Table 1. Hall measurement parameters and DC and AC characteristics.

Sample	A	B	C
Passivation	None	Si_3N_4	Al_2O_3
Hall measurements			
Carrier density	$1.07x10^{13}$/cm^2	$1.15x10^{13}$/cm^2	$1.25x10^{13}$/cm^2
Electron mobility	1270cm^2/V-s	1250cm^2/V-s	1235cm^2/V-s
Sheet resistance	460Ω/square	434Ω/square	404Ω/square
DC measurements			
Maximum drain current	552.7mA/mm	629.2mA/mm	686.6mA/mm
Drain current at 0V gate	337.6mA/mm	384.2mA/mm	421.7mA/mm
On resistance	10.94Ω-mm	9.5Ω-mm	8.65Ω-mm
Source resistance	2.4Ω-mm	2.2Ω-mm	2Ω-mm
Drain resistance	7.3Ω-mm	6.3Ω-mm	5.9Ω-mm
Peak transconductance	114.1mS/mm	131.3mS/mm	152.4mS/mm
Off breakdown for 1mA/mm source–drain current and –6V gate	75V	70V	109V
Gate–drain breakdown for 1mA/mm gate–drain current	–103.8V	–94.5V	–152.4V
2.4GHz measurements at 15V drain bias and –2V gate potential			
Maximum output power	18.5dBm	19.3dBm	20.5dBm
Power added efficiency	25.1%	29.4%	33.6%

Gallium nitride thin-film transistors produced at less than 250°C

Low-temperature process suggests potential for flexible/transparent electronics application.

Turkey's Bilkent University has used hollow-cathode plasma-assisted atomic layer deposition (HCPA-ALD) to make gallium nitride (GaN) thin-film transistors (TFTs) at temperatures below 250°C [S. Bolat et al, Appl. Phys. Lett., vol104, p243505, 2014]. The researchers claim this as the lowest reported process temperature for GaN transistors.

Thin-film transistors are usually produced using amorphous silicon. While these devices are used as the driving element in liquid crystal displays, low carrier mobility, high fabrication thermal budget, and strong absorption of visible light limits applications and is not suitable for flexible and transparent electronics.

Zinc oxide and related materials have recently been developed as an alternative, with characteristics matching or even bettering silicon-based devices. However, ZnO TFTs suffer from stability issues.

GaN could be a stable base material, but the compound is usually processed at temperatures exceeding 1000°C. Such temperatures would generally destroy the other components for which the TFTs are the driving element.

Bilkent's very low process temperature results in polycrystalline material. Although the performance for these first

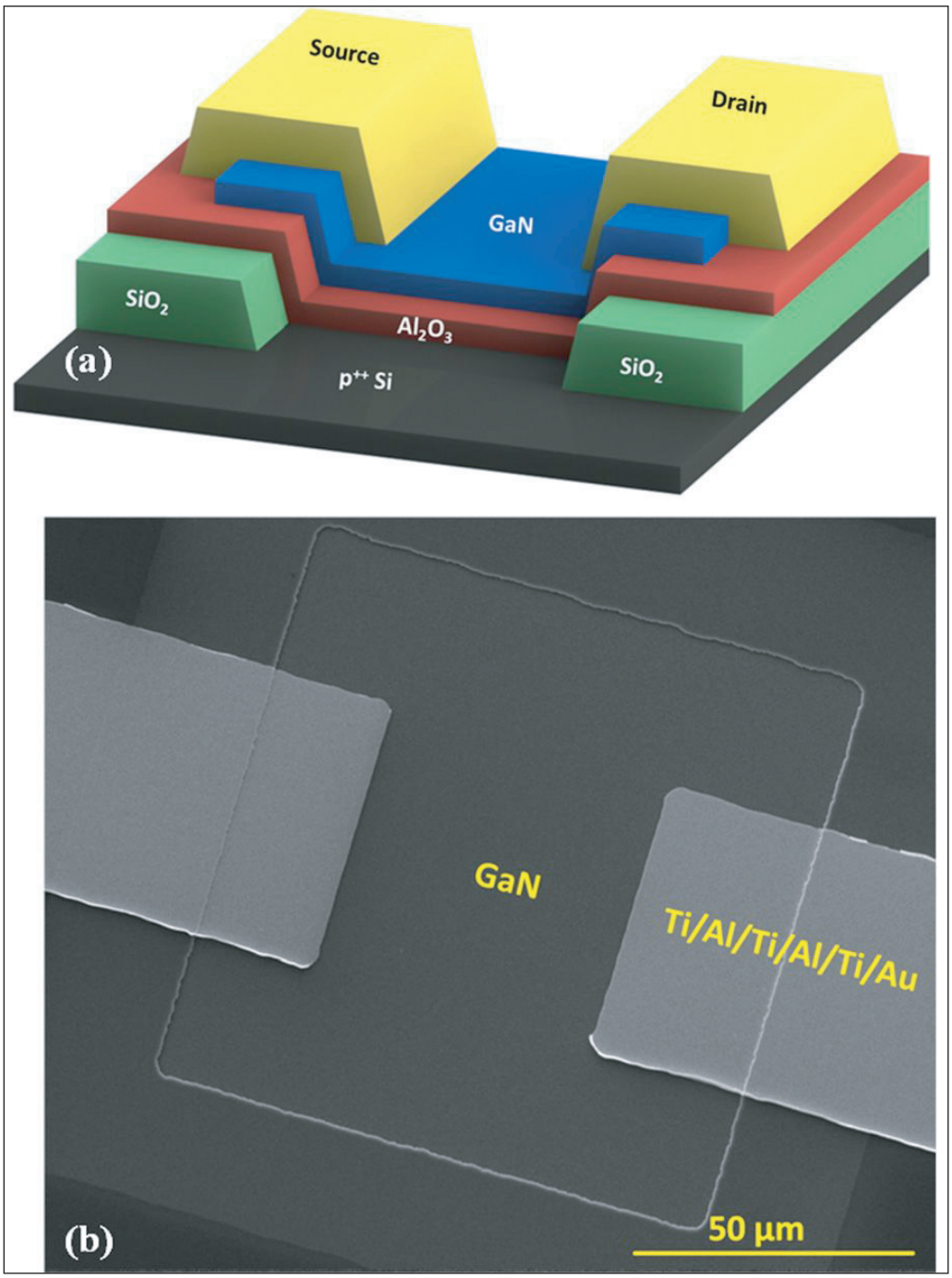

Figure 1. (a) 3D schematic of the HCPA-ALD-based GaN TFT; (b) SEM image of the fabricated device.

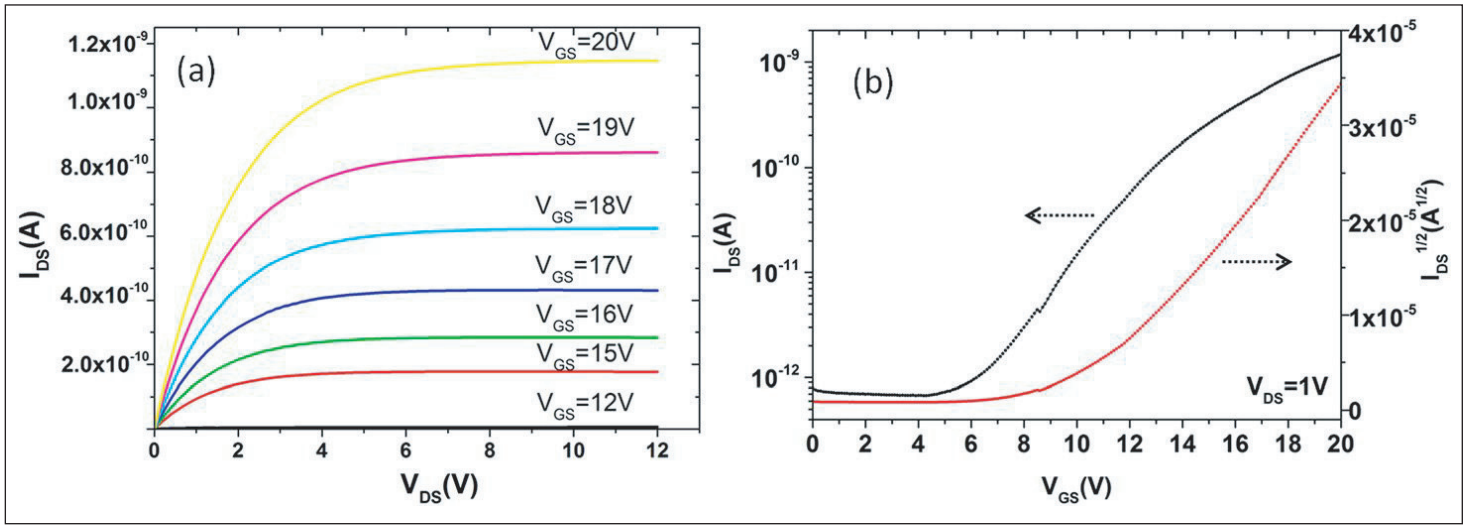

Figure 2. (a) Output and (b) transfer characteristics of HCPA-ALD-based GaN TFTs.

simple bottom-gate devices was not particularly impressive, the researchers see potential for the GaN-based devices as stable flexible/transparent TFT devices after further materials and process optimization.

The Ga precursor for the HCPA-ALD was trimethyl-gallium. The nitrogen was supplied as N_2 in a hydrogen carrier. The plasma power was 300W and the temperature was 200°C. The TFT structure (Figure 1) was defined using a 200nm 250°C plasma-enhanced chemical vapor deposition (PECVD) silicon dioxide mask.

Layers of 77nm aluminium oxide and 11nm GaN were deposited in a window in the SiO_2 at 200°C using a modified Fiji 200-LL ALD reactor from Ultratech/Cambridge NanoTech Inc. X-ray analysis showed the GaN film to be polycrystalline with average crystallite size of 9.3nm. The aluminium oxide provided the gate insulator and the GaN provided the channel; the bottom gate was the p++-silicon substrate itself.

The active region was isolated using an argon-based plasma etch. The source-drain electrodes consisted of titanium/aluminium/titanium/aluminium/titanium/gold . The metal stacks were not annealed to keep the thermal budget as low as possible. The length and width of the resulting device were both 50μm.

The devices had an on/off ratio of $2x10^3$ with a drain bias of 1V (Figure 2). Gate leakage was less than 0.5pA for all bias conditions. The threshold voltage was 11.8V, giving an n-type enhancement-mode (normally off) operation. The subthreshold swing was 3.3V/decade. The effective charge mobility was 0.025cm^2/V-s. The researchers comment: "This particularly low mobility can be attributed to the nanocrystalline structure of the HCPA-ALD based GaN thin films, and the surface states at the semiconductor insulator interface."

Positive bias stress testing was carried out with measurement of the threshold voltage after applying a field of 2.5MV/cm between the gate and grounded source–drain electrodes. A shift in threshold voltage indicates charge trap states at semiconductor/insulator interfaces or within the aluminium oxide. The shift increased with duration of the stress stage of the test. At 200 seconds, the shift was around 5.5V; this increased to 7.3V for 1000 seconds of stressing. The researchers point out that the 1000-second shift in high-performance zinc oxide-based TFT is larger. ■

http://scitation.aip.org/content/aip/journal/apl/104/24/10.1063/1.4884061

Author: Mike Cooke

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event calendar

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5–9 October 2014
Mid-IR Optoelectronics: Materials and Devices (MIOMD-XII)
CORUM convention center, Montpellier, France
E-mail: miomd2014@miomd2014.org
www.miomd2014.org

5–10 October 2014
226th Electrochemical Society (ECS) Meeting
Moon Palace Resort, Cancun, Mexico
E-mail: meetings@electrochem.org
www.electrochem.org/meetings/biannual/fut_mtgs.htm

7–9 October 2014
Solar Power International (SPI '14)
Las Vegas Convention Center
E-mail: plangdon@solarenergytradeshows.com
www.solarpowerinternational.com

7–9 October 2014
SEMICON Europa
Alpexpo, Grenoble, France
E-mail: eweller@semi.org
www.semiconeuropa.org

8–9 October 2014
Power Electronics Conference: the ultimate path to CO_2 reduction
ALPEXPO, Grenoble, France
E-mail: eweller@semi.org
www.semiconeuropa.org/node/2586

9 October 2014
SEMI International Standards Program: Compound Semiconductor Materials (TC), DGKK Arbeitskreis
TU Bergakademie Freiberg, Germany
E-mail: abusch@semi.org
www.semi.org/eu/node/8826

9–10 October 2014
Invest in Photonics
Bordeaux, France
E-mail: pitch@invest-in-photonics.com
www.invest-in-photonics.com

12–15 October 2014
23rd European Workshop on Heterostructure Technology (HeTech2014)
Justus Liebig University Giessen, Germany
E-mail: info@hetech2014.org
www.hetech2014.org

12–16 October 2014
27th IEEE Photonics Conference (IPC 2014)
Hyatt Regency La Jolla, San Diego, CA, USA
E-mail: i.donnelly@ieee.org
www.ipc-ieee.org

15–17 October 2014
LED Japan/Strategies in Light
Pacifico Yokohama, Japan
E-mail: registration@pennwell.com
www.sil-ledjapan.com

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21–23 October 2014
Strategies in Light Europe
M.O.C. Event Centre, Munich, Germany
E-mail: registration@pennwell.com
www.sileurope.com

6–8 November 2014
11th China International Forum on Solid State Lighting (SSL CHINA 2014)
The Westin, Pazhou, Guangzhou, China
E-mail: lih@china-led.net
www.sslchina.org/en

11–13 November 2014
Avionics Fiber-Optics and Photonics Conference 2014 (AVFOP)
Hyatt Regency Atlanta, Georgia, USA
E-mail: m.figueroa@ieee.org
www.avfop-ieee.org

11–14 November 2014
Asia Communications and Photonics Conference (ACP 2014)
Shanghai International Convention Center, China
E-mail: info@acp-conf.org
www.acp-conf.org

18–20 November 2014
Intersolar India 2014
Mumbai, India
E-mail: swapna.kulkarni@mmi-india.in
www.intersolar.in

3–5 December 2014
SEMICON Japan 2014
Tokyo Big Sight, Japan
E-mail: jeventinfo@semi.org
www.semiconjapan.org

15–17 December 2014
IEEE International Electron Devices Meeting (IEDM 2014)
Hilton San Francisco, CA, USA
E-mail: iedm@his.com
www.ieee-iedm.org

28–30 January 2015
Euro - TMCS I (Theory, Modelling and Computational Methods for Semiconductors, European Session)
University of Granada, Spain
E-mail: info@tmcsuk.org
www.tmcsuk.org/conferences/Euro-TMCSI

4–6 February 2015
SEMICON Korea 2015
COEX, Seoul, Korea
E-mail: semiconkorea@semi.org
www.semiconkorea.org

7–12 February 2015
SPIE Photonics West 2015
Moscone Center San Francisco, CA, USA
E-mail: customerservice@spie.org
http://spie.org/photonics-west.xml

24–26 February 2015
Strategies in Light
Sands Expo & Convention Center, Las Vegas, NV, USA
E-mail: registration@pennwell.com
www.strategiesinlight.com

2–5 March 2015
LED China 2015
Pazhou, Guangzhou, China
E-mail: led-trust@ubm.com
www.LEDChina-gz.com

17–19 March 2015
SEMICON China 2015
Shanghai New International Expo Centre, China
E-mail: semichina@semi.org
www.semiconchina.org

22–26 March 2015
Optical Fiber Communication Conference & Exposition (OFC 2015)
Los Angeles Convention Center, CA, USA
E-mail: info@ofcconference.org
www.ofcconference.org

31 March – 1 April 2015
Intersolar China 2015
China International Exhibition Center (CIEC), Beijing, China
E-mail:maas@intersolarchina.com
www.intersolarchina.com

13–15 April 2015
CPV-11 (11th International Conference on Concentrator Photovoltaics)
Aix-les-Bains, France
E-mail: info@cpv-11.org
www.cpv-11.org

13–16 April 2015
SPIE Optics + Optoelectronics 2015
Clarion Congress Hotel, Prague, Czech Republic
E-mail: info@spieeurope.org
http://spie.org/optics-optoelectronics.xml

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