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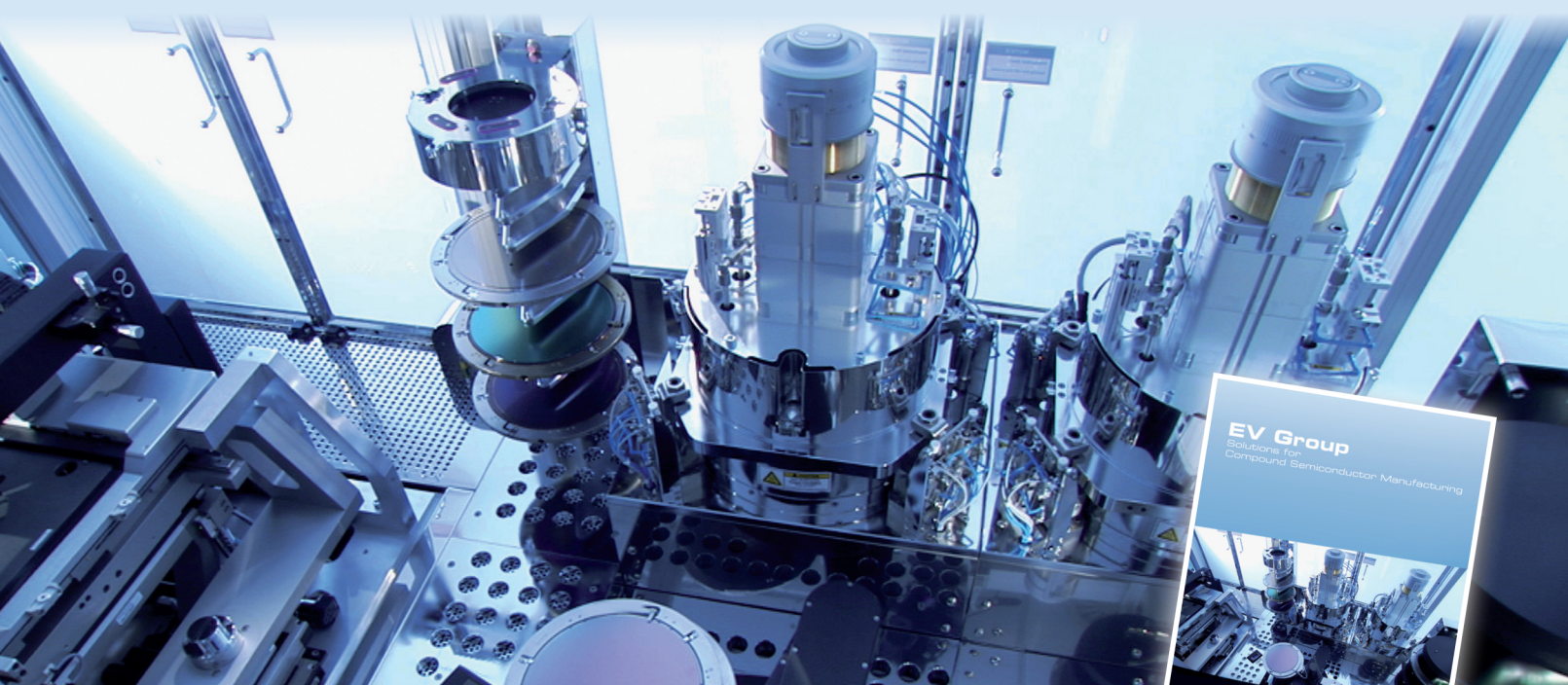
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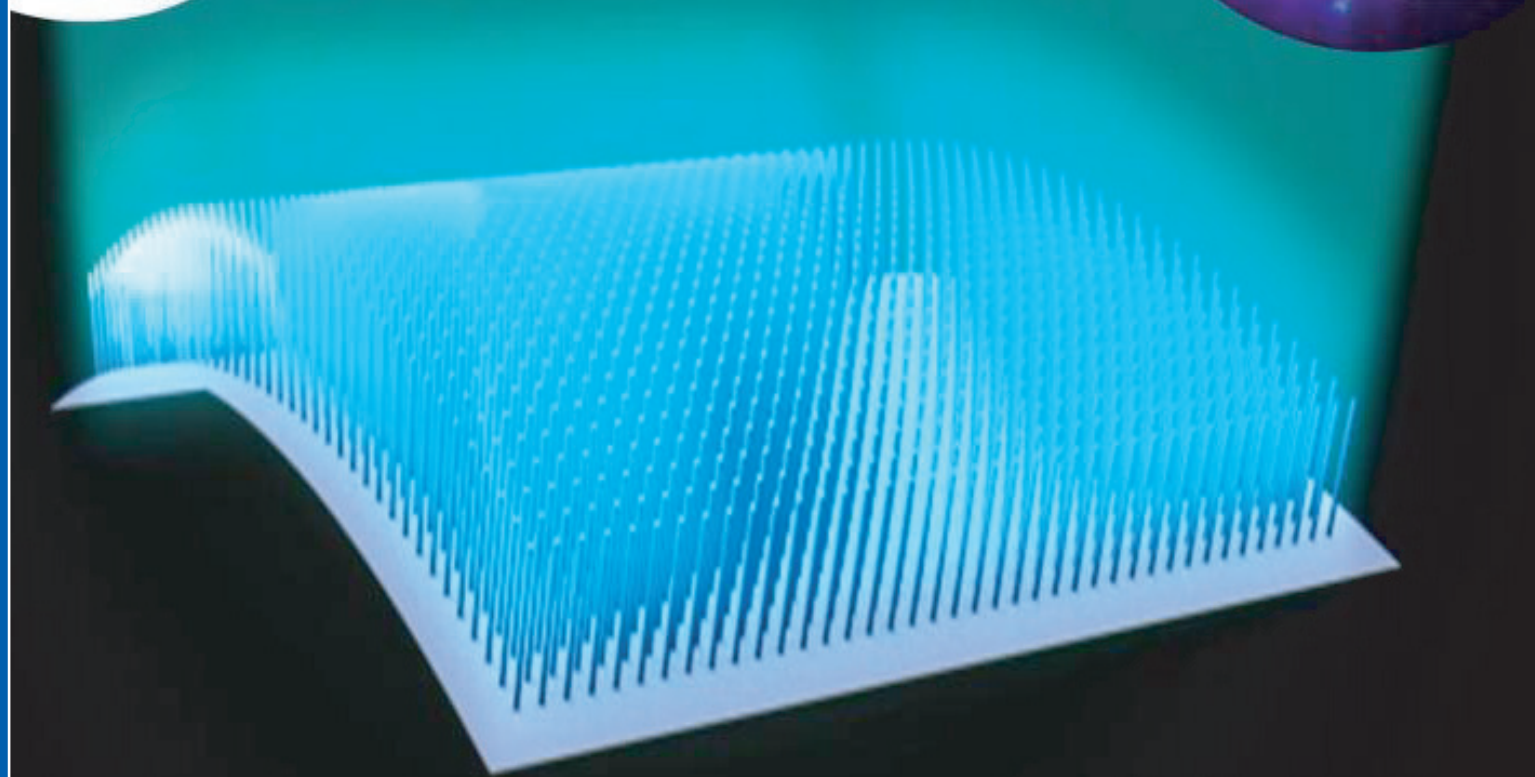
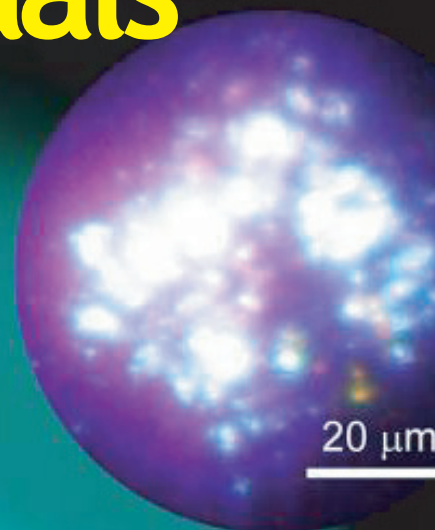
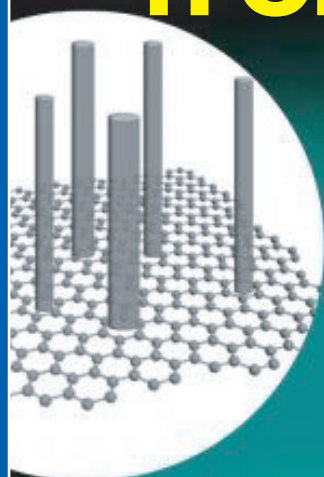
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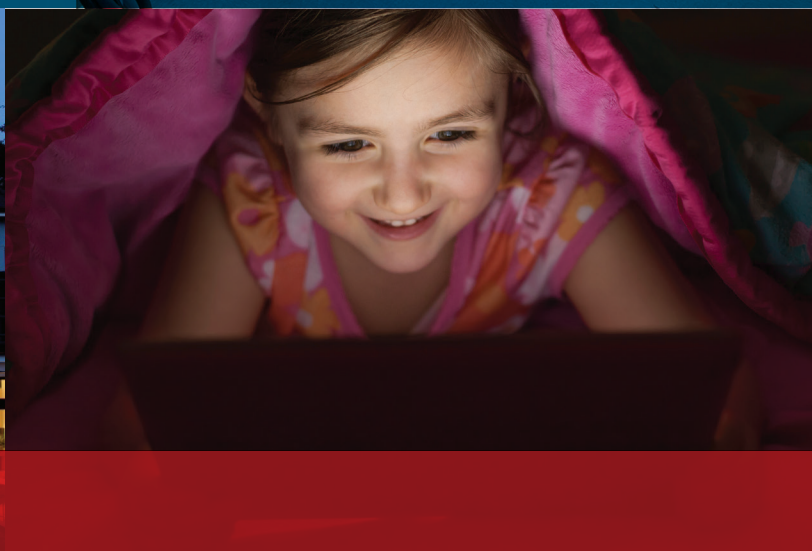
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III-V semiconductors from van der Waals epitaxy



IntelliEPI buys Soitec's GaAs epi business • GT goes bust
Nobel Prize for blue LED research • News from ECOC



Another breakthrough from Veeco. This time it's EPIK.

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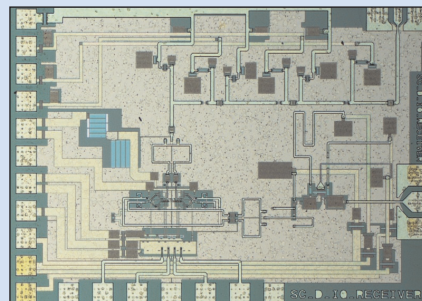
Veeco's New TurboDisc EPIK700 GaN MOCVD System

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semiconductor**TODAY** COMPOUNDS & ADVANCED SILICON

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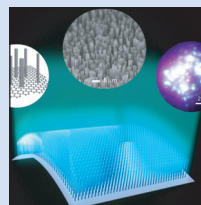
p16 Chalmers University's 1.6mm x 1.2mm 140GHz transmitter chip, which has achieved a 40Gb/s data transmission speed record.



p45 Shuji Nakamura who, together with Isamu Akasaki and Hiroshi Amano, has been awarded the Nobel Prize in Physics for blue LED research.



p71 Switzerland's Airlight Energy has partnered with IBM Research to commercialize high-concentration photovoltaic thermal systems.



GaN grown on graphene to enable easy release from an inorganic substrate and transfer to polymer as an alternative route to flexible devices.

Cover: A rendering of the growth process of Seoul National University, which has developed flexible micro-rod LEDs on polymer using

p94

Events topped by Nobel Prize

After last issue featured coverage of developments in ultrathin transition-metal dichalcogenide materials for applications in two-dimensional optoelectronics, in the feature article on pages 94–99 of this issue we cover research involving the related topic of van der Waals epitaxy. This technique has recently featured in several reports of work on growing III-V compound semiconductors on two-dimensional layered materials (such as graphene), since the weak van der Waals bonds between the layers (in contrast to the strong in-plane bonds within the two-dimensional thin film) offers the prospect of epitaxial growth of three-dimensional crystals on 2D layers with larger mismatches in lattice constant and thermal expansion. One potential application is the growth of blue LEDs directly on flexible polymer substrates.

Also in this issue we include news on device developments announced at recent events, including the IEEE Compound Semiconductor Integrated Circuits Symposium (CSICS, where Sweden's Chalmers University reported a microwave circuit that has set a record transmission rate of 40Gb/s for an operating frequency of 140GHz — see page 16), European Microwave Week (where Fujitsu reported a CMOS-based transceiver chip for automotive millimeter-wave radar operating at 76–81GHz, and Mitsubishi Electric/Tohoku University reported a 5GHz/60GHz dual-band receiver RF front-end CMOS IC for high-speed wireless communication — see pages 18–19), and the Cable-Tec Expo (where MACOM and RFMD showcased microelectronic components for the new DOCSIS 3.1 cable TV standard — see page 20 — and Emcore debuted a new DOCSIS 3.1 optical receiver and switch for CATV — see page 69). CATV products are among the broadband fiber-optics product lines retained by Emcore after agreeing to sell its tunable laser and transceiver product lines to photonic integrated circuit (PIC)-based module and subsystem maker NeoPhotonics for \$17.5m (see page 68). NeoPhotonics was also one of many optical communications component makers — including ClariPhy, Source Photonics, TeraXion, Finisar, Oclaro, II-VI Inc, GigOptix and even TI (with its first transimpedance amplifier for 100G optical networking) — to launch new products at the European Conference on Optical Communications (ECOC — see pages 59–67).

But by far the biggest event in the last month to garner more general attention was the award of the 2014 Nobel Prize for Physics to professors Isamu Akasaki, Hiroshi Amano and Shuji Nakamura for their respective work in developing the nitride-based blue LEDs that have subsequently opened up the field of white LEDs and energy-saving solid-state lighting (see page 45). While Shuji Nakamura has attracted most attention in recent years at Japan's Nichia for devising the nitride epitaxy growth technique and more recently at University of California Santa Barbara for progress in blue and green lasers, Akasaki and Amano have been recognized equally for earlier work on getting gallium nitride crystal to emit light. Indeed, whereas Nakamura and Amano are also to receive Japan's Order of Culture Award from Emperor Akihito in November, Akasaki is already a previous recipient of the Order of Culture Award, in 2011.

We can join in congratulating the Nobel Laureates for their achievements, while those building on their work can take pride in helping to transform the development of blue LEDs into the solid-state lighting technology that has caught the attention of the wider world.

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

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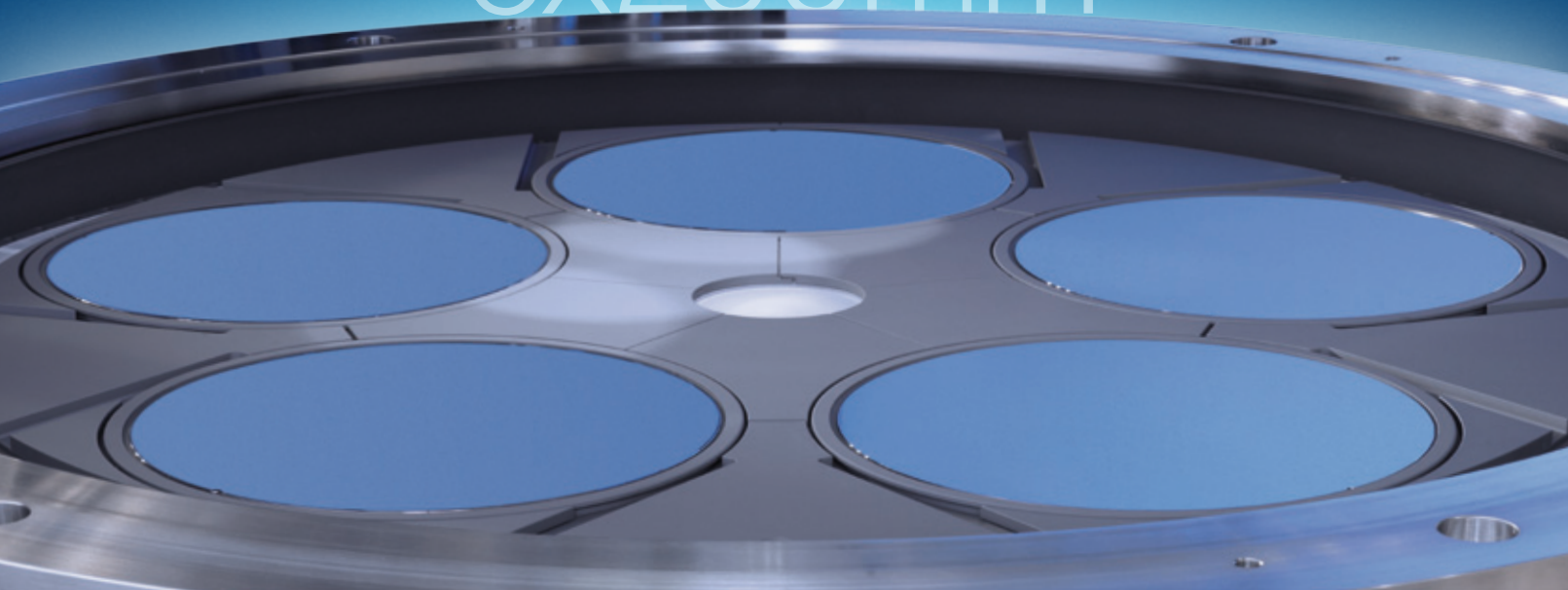
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Shipments of LEDs for residential applications to grow from 81 million in 2014 to 1.1bn units by 2023

Market for LED luminaires and lamps to explode in residential sector

Annual shipments of LEDs for residential applications are expected to grow from 81 million in 2014 to more than 1.1 billion by 2023, according to a report 'Residential Energy Efficient Lighting and Lighting Controls' from Navigant Research, which includes forecasts for LED, incandescent, halogen and fluorescent lighting.

Prices for LEDs have come down dramatically, and the market for LED luminaires and lamps is set to explode in the residential sector as prices continue to fall, efficacy improves, and new use cases for lighting develop, the report says.

Accompanying the spread of LEDs are advances in connected lighting that promise to dramatically alter the way people interact with the lighting in their homes.

"At the same time that many countries are phasing out or banning incandescent light bulbs, prices for LED bulbs are falling dramatically, especially for the popular A-type bulbs," says senior research analyst Jesse Foote. "While compact fluorescent bulbs (CFLs) are still less expensive than LEDs, they cannot offer the same performance, and their use of mercury is an ongoing concern. LED adoption is therefore

expected to increase rapidly in the coming years, as consumers choose to switch from incandescent to LEDs rather than to CFLs."

Some LEDs are being designed with an embedded radio that allows the home-owner to remotely control a bulb (or a group of bulbs) using a smartphone, rather than the traditional wall switch. For lamp manufacturers facing revenue pressure because of the longer replacement cycles of LED lamps, the connected lighting revolution is likely to provide a timely boost, according to the report.

www.navigantresearch.com

GaN LEDs in automotive to exceed \$1bn for first time

Exterior lighting driving growth to \$1.05bn in 2014 then \$1.3bn in 2018

The market for gallium nitride (GaN) packaged LEDs in automotive applications will reach \$1bn this year for the first time, rising by 11% from \$943m in 2013 to \$1.05bn in 2014, forecasts the LED Intelligence Service of IHS Technology in a Research Note by Jamie Fox, principal analyst for lighting & LEDs.

Growth is coming from exterior applications such as headlamps and daytime running lights (DRLs), where LED penetration is still low,

but the LED value per vehicle can be quite high. Osram, Nichia and Lumileds are ranked by IHS as the leading three suppliers to the market and are particularly dominant in exterior applications.

Audi has been a leader in the use of LEDs in its vehicles (especially in daytime running lights) since 2008, and many other manufacturers have followed the steady trend toward LEDs, says IHS. However, many vehicles that do not use LED lighting still remain, even at the

high end of the market. For example, the cutting-edge Tesla Model S (which retails for about \$100,000) does not yet have LED headlamps. Moreover, daytime running lights, cornering lights and indoor ambient lights are only available as an option rather than as standard.

IHS expects that LED lighting should increase in vehicles over the next several years, and that the market will grow further to \$1.3bn in 2018.

<https://technology.ihs.com>

LED lamp retail pricing falls 19.2% year-on-year in September, as lumens-per-dollar rises by 27%

The global average retail price of LED lamps was \$21 in September, down 4.9% on the prior month and 19.2% year-on-year, according to the September 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 27.1% to 35.44 lumens per dollar, the report adds.

IHS has been tracking LED lamp retail pricing trends for more than three years. Each month IHS analysts sample 2700 individual LED

lamps sold in retailers across 15 countries globally.

Research Note from IHS Technology, providing information on the latest data collected on average retail prices for light-emitting diode (LED) lamps.

<https://technology.ihs.com>

Wide-bandgap power semiconductor market to grow at 63% CAGR from \$150m to \$500m in 2017

The next-generation power semiconductor market will increase at a compound annual growth rate (CAGR) of 63% between 2011 and 2017 to over \$500m, says market research firm The Information Network in its report 'Next-Generation Power Semiconductors: Markets Materials, Technologies'.

"Traditional silicon-based power semiconductors are reaching their theoretical limitations," notes the report. "Fortunately because of their superior material properties, wide-bandgap power semiconductor devices such as silicon carbide (SiC) and gallium nitride (GaN) can offer performances orders-of-magnitude better than silicon devices. As a result, they are widely expected to be the next-generation power devices," he adds.

"The commercial battle for next-generation power semiconductors is evolving," continues the report. "As a result, many semiconductor

manufacturers are attempting to enter the market." Although small compared to the \$14bn silicon-based power semiconductor market, the next-generation power semiconductor market is already \$150m.

"We see insulated-gate bipolar transistor (IGBT) and power metal-oxide-semiconductor field-effect transistor (MOSFET) as the main growth drivers," the report says. "We look for strongest growth from IGBTs, although power MOSFETs had the largest market share in 2013 due to its fast switching speed, near-perfect gate impedance, fast switching speed, excellent stability, and a relatively low on-state resistance."

Because of their attractive performance, R&D on wide-bandgap power semiconductor devices has been intense. In development since the early 1990s, SiC material for power device applications has gone through the longest period and

come furthest in terms of maturity and reliability.

Benefiting from the growth of wide-bandgap devices will be processing equipment, reckons the report. Significant improvements in the technique of growing GaN material on silicon substrates have enabled high-quality, crack-free GaN epitaxial layers to be grown on silicon, overcoming the 17% crystal mismatch between the two materials' crystal lattices. For GaN epitaxy on Si or SiC, Veeco and Aixtron will benefit and grow strongly, utilizing their expertise in LED epitaxy, forecasts the market research firm.

Also, whereas silicon MOSFETs use wire bonding and traditional SO or TO packages, GaN-on-Si can be bonded using flip-chip technology. Companies benefiting would be equipment suppliers to the flip-chip industry, such as TEL NeXX Inc, concludes the report.

www.theinformationnet.com

Military GaAs device market to grow at CAGR of 13% to over \$0.5bn by 2018

Gallium arsenide (GaAs) device demand from the defense sector will grow at almost three times the growth rate for the commercial GaAs device market, as growing momentum behind the use of solid-state technologies in radar, electronic warfare, communications and other systems will drive increased demand for GaAs devices through 2018, forecasts a Strategy Analytics Advanced Defense Systems (ADS) service report.

Key findings from the report 'GaAs Industry Outlook 2013-2018', as related to GaAs demand from the defense sector, include the following:

- The military GaAs device market will grow at a compound annual growth rate (CAGR) of nearly 13%, exceeding over half a billion dollars by 2018 (compared with a CAGR of

under 5% for the overall GaAs device market).

- While GaAs devices are used in electronic warfare (EW) and smart munitions applications, the communications and radar applications will drive the bulk of demand.

- The largest usage of GaAs devices will continue to come from radar applications, which will account for over 60% of merchant GaAs military market revenue.

"Changing battlefield philosophies, including a shift toward more asymmetric conflicts, will place a premium on electronic capabilities," notes Asif Anwar, director of Strategy Analytics' ADS service. "GaAs devices have traditionally played an important role in defense applications, and future system requirements are driving increasing

demand for solid-state solutions which will propel demand for GaAs devices as well as other compound semiconductor technologies," he adds.

"GaAs will also continue to be an enabling technology for commercial markets, with increasingly sophisticated smartphones ramping up GaAs device content as well as growth in non-cellular markets," comments Eric Higham, North American director for ADS. "However, there will be serious challenges in the future as increasing competition from technologies like silicon and gallium nitride, along with new system and power amplifier (PA) architectures slow the future growth rate in the commercial GaAs device market to below historical averages."

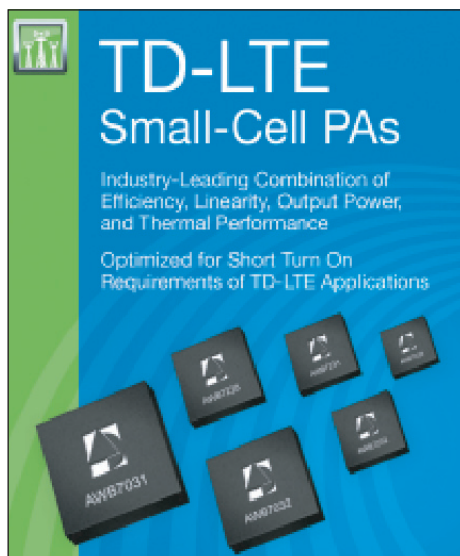
www.strategyanalytics.com

Anadigics launches TD-LTE small-cell power amplifiers

Broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has launched six new power amplifiers (PAs) optimized for TD-LTE (time-division long-term evolution) small-cell applications.

Like LTE FDD (long-term evolution frequency division duplex), TD-LTE is a 4G telecoms standard. While LTE FDD is the dominant global standard for LTE services today, TD-LTE networks are being rolled out by several major carriers, including China Mobile. According to a recent report by DIGITIMES Research, worldwide TD-LTE subscribers are forecasted to increase from 12.48 million at the end of first-quarter 2014 to 276.2 million at the end of 2016.

The AWB7031, AWB7032, AWB7228, AWB7231, AWB7232 and AWB7239 TD-LTE power amplifiers are optimized for small-cell applications, including picocells, enterprise-class femtocells, and high-performance customer premises equipment (CPE). The devices deliver what Anadigics' claims is an industry-leading combination of output power, linearity, power-added efficiency and thermal characteristics.



By combining this level of performance with integration and design choices that eliminate the need for complicated external bias circuitry, the small-cell power amplifiers enable manufacturers to easily develop compact wireless infrastructure solutions that are more thermally efficient, consume less power, enable higher throughput, and provide greater coverage and range, says the company.

"TD-LTE networks are quickly adding subscribers as a variety of providers adopt this high performance

standard," notes James Martin, senior director of business development for Infrastructure Products. "Our new TD-LTE solutions deliver optimal performance for the newest generation of small-cell devices," he adds. "Anadigics' TD-LTE small-cell power amplifiers offer an economical path for providers to expand broadband network coverage in support of more subscribers."

Anadigics' complete family of small-cell wireless infrastructure power amplifiers leverages the firm's patented InGaP-Plus technology and design architectures. The AWB7031 and AWB7032 power amplifiers are optimized for ¼-Watt linear output power applications and are housed in compact 5mm by 5mm packages. The AWB7228, AWB7231, AWB7232 and AWB7239 power amplifiers deliver +27dBm output power for ½-Watt linear output power applications. The new small-cell power amplifiers also support the short turn-on-time requirements of TD-LTE applications.

Samples of the new TD-LTE small-cell power amplifiers are available now for qualified programs.

ProEfficient-Plus PAs powering Samsung's Galaxy Note 4

Anadigics says that it is shipping production volumes of its ALT6735 ProEfficient-Plus power amplifier (PA) to Samsung Electronics for the new Galaxy Note 4.

Available through China Telecom, the GALAXY Note 4 features a 5.7" Quad HD Super AMOLED display, 16 megapixel camera with optical image stabilization and Android 4.4 KitKat operating system.

"We are pleased to continue playing a critical role in the Samsung Galaxy Note success story by enabling wireless connectivity in each of the past three generations of this award-winning product line," says Jerry Miller, senior VP of

worldwide sales & applications at Anadigics. "Our differentiated ProEfficient-Plus solutions offer the industry's highest combined efficiency. This performance advantage enables large-screen mobile devices to offer an unparalleled multimedia experience with maximum talk time and data use," he adds.

InGaP-based ProEfficient-Plus power amplifiers use the firm's patented InGaP-Plus technology and design architectures to deliver what is claimed to be the industry's highest efficiency across all power levels, enabling greater talk time and longer data application use.

This level of performance, combined with exceptionally low quiescent currents without the use of a DC/DC converter, maximizes battery life in mobile devices. In particular, the ALT6735 power amplifier delivers 44% power-added efficiency (PAE) at +28.8 dBm and 31% PAE at +16.5dBm. ProEfficient-Plus power amplifiers are also designed for use with an external switch-mode power supply (SMPS), in applications using average power tracking (APT), to further increase efficiency and reduce current consumption at low and medium operating powers.

www.anadigics.com

Anadigics launches high-output GaN line amplifier family optimized for DOCSIS 3.1 CATV networks

Broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has launched two high-power gallium nitride (GaN) line amplifiers for cable television infrastructure applications. The ACA2455 and ACA2456 support full DOCSIS 3.1 bandwidth, operating up to 1.2GHz, while supporting legacy bands down to 50MHz. Also, the output power of the line amplifiers enables use in Node+0 system architectures without active components downstream from the fiber node.

The new line amplifiers combine Anadigics' field-proven, highly linear gallium arsenide technology for the driver stage with a high-power GaN output stage, delivering what is claimed to be the industry's highest output power over the full DOCSIS 3.1 frequency band.

"Manufacturers are able to leverage these performance and reliability advantages to develop new solutions that enable MSOs [multi-system operators] to quickly deploy next-generation fiber-to-the-node networks," says Tim Laverick, senior VP of Infrastructure Products.



With Node+0 configurations, fiber is run deeper into the network, eliminating the need for downstream RF amplifiers. Node+0 is the natural evolution of node splitting and the shift to 'fiber deep' architectures as MSOs continue to seek new ways to increase system bandwidth by shrinking service groups to reduce the number of homes served by each node. This architecture also significantly simplifies network design, reduces maintenance costs, and decreases deployment time for

new build outs. As demand for faster data speeds accelerates, the total number of deployed nodes is expected to increase by up to 1000% according to some MSO estimates, increasing the total number of available sockets for these unique high-power line amplifiers, says Anadigics.

The ACA2455 and ACA2456 line amplifiers combine the firm's GaAs MESFET technology with a GaN output stage in a proven thermally enhanced 16-lead SOIC surface-mount package. The ACA2455 provides 28dB gain with +73dBmV composite output power and 625mA current consumption, while the ACA2456 offers 18dB gain with +76dBmV composite output power and 900mA current consumption. The firm's GaN surface-mount line amplifiers offer what is claimed to be exceptional composite triple beat (CTB), composite second-order (CSO), cross modulation, carrier-to-intermodulation noise (CIN), and modulation-error ratio and bit-error ratio (MER and BER) characteristics for optimal performance in a fully loaded spectrum.

DOCSIS 3.1 CATV infrastructure portfolio expanded with amplifier for 'high-split' return path

Anadigics has introduced a reverse-path amplifier optimized for data over cable service interface specification (DOCSIS) system standard version 3.1. The ARA2032 provides what is claimed to be industry-leading linearity, output power and noise performance over a wider 5–300MHz frequency range to enable advanced cable TV services, including higher upstream data speeds.

"Our new reverse-path amplifier delivers low harmonic distortion with high output power and gain to ensure exceptional signal integrity," says Tim Laverick, senior VP of Infrastructure Products.

"With a complete portfolio of 1.2GHz downstream and 'high-split' return solutions that leverage our rugged process technologies, advanced designs and proven packaging, Anadigics is helping to lead the industry transition to DOCSIS 3.1," he claims.

Anadigics continues to expand its CATV infrastructure product families in support of anticipated network buildouts and upgrades, including the adoption of DOCSIS 3.1. The firm's new infrastructure solutions complement its portfolio of surface-mount line amplifiers, line amplifier hybrid modules, reverse-path amplifiers, optical

receivers, and gain blocks.

Anadigics says that, by combining its proven high-linearity GaAs process with GaN HEMT technology, its new infrastructure solutions continue its tradition of delivering high-performance products with reliability. This is exemplified by the new ACA2455 and ACA2456 gallium nitride (GaN) line amplifiers that deliver what are claimed to be the industry's highest output power levels (featured in a proven, thermally enhanced 16-lead SOIC surface-mount package that maximize field reliability).

www.anadigics.com

Skyworks raises guidance for quarterly revenue growth to 51% year-on-year and 22% sequentially

Guidance for diluted earnings per share raised from \$1.00 to \$1.08

For its fiscal fourth-quarter 2014 (to end September), Skyworks Solutions Inc of Woburn, MA, USA (which manufactures analog and mixed-signal semiconductors) has raised its revenue guidance (given on 17 July) from \$680m (up 16% sequentially and 43% year-on-year) to \$718m (up 22% sequentially and 51% year-on-year) compared with \$587m for fiscal Q3/2014 and \$477m a year ago.

Skyworks has also raised its guidance for non-GAAP diluted earnings per share from \$1.00 (up 56%

year-on-year) to \$1.08 (up 69% year-on-year, and up 30% on fiscal Q3/2014's \$0.83 — the sixth consecutive quarter of above-20% year-on-year earnings growth).

"Skyworks upwardly revised outlook demonstrates the broad-based strength of our business and our ability to capitalize on positive underlying market trends to connect everyone and everything, all the time," says chairman & CEO David J. Aldrich. "These multi-year technology trends are setting the stage for us to outperform the

broader semiconductor industry in the December quarter and for the foreseeable future."

When Skyworks gave its original fiscal Q4 guidance on 17 July, it attributed expected growth to broad-based strength driven by new product ramps, content gains, growth across emerging markets, ongoing 802.11ac deployments, and the expanding set of opportunities within the Internet of Things

Skyworks will release its fiscal Q4/2014 results on 6 November.

www.skyworksinc.com

Skyworks launches single-control SOI SP2T switch for WLAN

Skyworks Solutions Inc of Woburn, MA, USA (which manufactures analog and mixed-signal semiconductors) has unveiled a single-control, silicon-on-insulator (SOI) single-pole double-throw (SP2T) switch.

Supplied in a 1mm x 1mm, 6-pin, quad-flat-no-lead package, the compact 0.01–6.0GHz SKY13453-385LF is intended for mode switching in pre-power amplifier cellular and dual-band WLAN transmit/receive applications.

Using advanced switching technologies, it is a reflective short switch that offers high linearity, maintains low insertion loss and achieves high isolation for both switching paths, says the firm.

www.skyworksinc.com

Diversity receive modules ramped for LTE smartphones

Skyworks Solutions Inc of Woburn, MA, USA (which manufactures analog and mixed-signal semiconductors) says that a family of diversity receive modules (DRx) for LTE smartphones is currently ramping with several tier-one manufacturers. The firm says that the new product category leverages its systems-level expertise and techniques developed for cellular base-stations to create a solution integrating multiple low-loss RF switches, receive SAW (surface acoustic wave) filters and low-noise amplifiers (LNAs) to dramatically enhance downlink data rates in LTE advanced MIMO systems. By amplifying the receive signal without increasing noise, receiver sensitivity is improved, depending on the band. As a result, carriers benefit from improved network efficiency while consumers experience considerably faster



download speeds, says Skyworks.

"Our new diversity receive modules create a performance differentiator for LTE applications and demonstrate Skyworks' device and systems level expertise, expanding product portfolio and integration capabilities," says David Stasey, VP & general

manager of analog solutions. "Further, we continue to capitalize on the need for highly specialized solutions that are driving significantly higher addressable content opportunities."

About 75% of network traffic on mobile devices is on the downlink or receive side. Skyworks says that its highly integrated DRx modules maximize data through-

put, minimize complexity and reduce overall footprint, helping mobile communication networks to deliver increasing amounts of data.

The new diversity receive solutions are now available for both sampling and production.

www.skyworksinc.com

Soitec receives Sony's Best Partnership award for support with RF-SOI substrates

Soitec of Bernin, France, which makes silicon-on-insulator (SOI) wafers, has received the Best Partnership Award from Sony Semiconductor for "outstanding support that has contributed to Sony's success in the radio-frequency (RF) semiconductor market".

Soitec's RF-SOI products include high-resistivity silicon-on-insulator (HR-SOI) and Enhanced Signal

Integrity (eSi) substrates, which are used for manufacturing switches in the latest generation of smart phones.

While Soitec's standard HR-SOI wafers are capable of meeting 2G and 3G wireless communication requirements, its eSi substrates achieve much higher linearity and isolation, helping designers to address some of the most

advanced LTE requirements at competitive costs, it is claimed.

As well as recognizing the long partnership between the two companies, the award demonstrates Soitec's commitment to deliver the enabling substrates that support Sony's RF devices business, says Bernard Aspar, senior VP & general manager of Soitec's Communication & Power business unit.

Ruckus chooses TriQuint's two new high-power WLAN modules for demanding fifth-generation 802.11ac

Ruckus Wireless Inc of Sunnyvale, CA, USA, which supplies wireless systems for the mobile Internet infrastructure market, has selected two new 5GHz WLAN power amplifiers (PAs) from RF front-end component maker TriQuint Semiconductor Inc of Hillsboro, OR, USA for its top-performing fifth-generation 802.11ac Wi-Fi platforms.

"TriQuint's high-power WLAN solutions help us deliver best-in-class Wi-Fi systems that give our carrier and enterprise customers unparalleled Wi-Fi performance," says Ruckus' co-founder & chief wireless architect Victor Shtrom.

TriQuint says that several other leading Wi-Fi infrastructure OEMs are evaluating its new PAs.

The TQP5525 and the TQP5523 deliver what is claimed to be best-in-class linearity to support the technically challenging features of the new 802.11ac Wi-Fi standard, such as multiple-use MIMO with minimal co-channel interference. The new PAs are also designed to support the power and voltage requirements of Power over Ethernet (PoE) applications. The TQP5525 provides 0.5W of output power, while the TQP5523 supports 0.25W to achieve lower power consumption at a lower cost.

"TriQuint continues to deliver advanced 802.11ac Wi-Fi products that enable OEMs to support the users' increasing demand for faster data throughput," says James Klein, TriQuint's VP of Infrastructure and Defense Products. "Our new WLAN power amplifiers are optimized for high data rates and range," he adds. "According to customer feedback, our TQP5525 delivers up to 3dB higher power output over our closest competition, which would double the operating range of access points delivering 802.11ac throughput," he claims.

As consumers and businesses increasingly turn to Wi-Fi networks for data and multimedia connectivity, adoption of the 802.11ac standard continues to accelerate

As consumers and businesses increasingly turn to Wi-Fi networks for data and multimedia connectivity, adoption of the 802.11ac standard continues to accelerate, says TriQuint. Wi-Fi devices with the new standard are expected to represent 45% of consumer Wi-Fi equipment shipments by year-end, according to ABI Research. Significant growth

in Wi-Fi network deployments is also being fueled by service providers' plans to off-load and complement data traffic from strained LTE networks, especially in congested urban areas.

The broadband performance of the TriQuint power amplifiers supports the global expansion of available Wi-Fi spectrum as well as the emerging intelligent transportation systems planned in the dedicated short-range communications (DSRC) bands, also known as the intelligent transportation system (ITS) band. Adhering to the strict regulatory emissions required in the automotive industry, these PAs are being implemented on a new generation of intelligent driving systems with consumer-friendly, vehicle-to-vehicle (V2V) communications that will enhance safety on the road, optimize traffic patterns to reduce congestion, and improve the environment by reducing emission and gas consumption.

The PAs operate over what is claimed to be the broadest frequency range (4.9–5.925GHz) available on the market, providing a single solution that supports the expansion of the Wi-Fi spectrum as well as V2V deployments.

www.triquint.com/applications/networks/wlan-bluetooth
www.ruckuswireless.com

MACOM launches 4-stage E-band driver amplifier and low-noise active mixer

At European Microwave Week (EuMW 2014) in Rome, Italy, M/A-COM Technology Solutions Inc of Lowell, MA, USA announced several new products.

The MAAM-011167 4-stage E-band driver amplifier builds on the previous MAAP-011106 E-band power amplifier launched in March. Delivering typical Psat of 24dBm for the 71–76GHz and 81–86GHz frequency ranges in a single product, the device is suitable for high-capacity macro cell and small-cell backhaul point-to-point radios.

The MAAM-011167 features variable gain with adjustable bias and an integrated power detector, allowing users to avoid extra loss and extra cost associated with a discrete power detector.

MACOM's bare-die power amplifier supports 18dB of small-signal gain with variable gain control for flexible performance tuning. Depending on the application and required power output, it can be used either as a final-stage power amplifier or as a driver amplifier for applications requiring higher power. Each device is RF tested to ensure performance compliance, and is fabricated using a pHEMT process.

"With the introduction of our latest E-band power amplifier, we're making it easier for transceiver designers to achieve high linear power and

gain control over the full E-band spectrum, while including the convenience and performance of an integrated output power detector," says Wireless Backhaul product manager Stuart Cornelius. "The addition of the MAAM-011167 to our market leading E-Band portfolio gives radio designers further options to optimize the output power level to their end-application requirements," he adds.

Production quantities and samples of MAAM-011167 are available from stock.

MACOM also introduced its MAMX-011023 4–23GHz discrete low-noise active mixer, which gives system designers flexibility to target a wide range of applications with a single mixer component. Offering what is claimed to be the widest frequency bandwidth coverage of any product in this category, the mixer provides a versatile and cost-effective platform for a wide range of applications spanning test and measurement, electronic warfare, point-to-point wireless, video satellite and more.

Housed in a lead-free, ultra-compact 1.5mm x 1.2mm TDFN surface-mount plastic package, the MAMX-011023 mixer maximizes space savings and manufacturing efficiencies. Designed for down frequency conversion and supporting

very low noise of 7dB typical, the mixer covers the 4–23GHz RF frequency range, has an ultrawide band IF of 8GHz, and supports conversion gain of 9dB typical at 12GHz and low power consumption at 3V/15mA. The mixer can be biased from a single positive supply.

The MAMX-011023 is fabricated using a GaAs process that features full passivation for increased performance and reliability, and can be used for either lower-sideband (LSB) or upper-sideband (USB) mixing. It integrates a FET gain element with LO and RF driving the same pin. The transconductance mixing allows a very low noise figure for an active mixer, enabling a high-performing solution for real-estate-constrained customers.

"The MAMX-011023 mixer delivers excellent performance over the widest frequency bandwidth supported today in this product category," claims product manager Tom Galluccio. "This wide bandwidth equips system designers to target a diverse range of products and applications with one easy-to-use device, enabling significant cost, design and component procurement efficiencies."

The MAMX-011023 is available now for sampling.

www.macom.com

Fully monolithic broadband surface-mount bias network for 2–18GHz

MACOM has launched a fully monolithic broadband surface-mount bias network utilizing the firm's patented HMIC process.

The MABT-011000 is designed for customers who need a rugged HMIC device with low loss and high performance with exceptional repeatability through millimeter-wave frequencies. The large vias reduce inductance and allow customers to easily solder down the part, while the gold backside

metallization provides the RF and DC grounding, says the firm.

MABT-011000 is suitable for the DC biasing of PIN diode control circuits. It functions as an RF–DC de-coupling network as well as the DC return and contains a series DC blocking capacitor. DC currents up to 60mA and DC voltages up to 50V may be used.

"The MABT-011000 greatly simplifies bias networks while delivering low loss and high performance,

making this a reliable and efficient fully monolithic broadband surface mount bias network for 2–18GHz," says product manager Paul Wade. "Utilizing MACOM's patented HMIC process ruggedizes the bias network, which is ideal for the DC biasing of PIN diode control circuits," he adds.

At 12GHz, insertion loss is 0.15dB, RF–DC isolation is 60dB, input return loss is 34dB, and output return loss is 37dB.

Pasternack receives 4-Star Supplier Excellence Award from Raytheon Integrated Defense Systems

RF, microwave and millimeter-wave product maker Pasternack Enterprises Inc of Irvine, CA, USA has been awarded the 4-Star Supplier Excellence Award by Raytheon's Integrated Defense Systems (IDS) business. This is the second consecutive year that Pasternack has been honored with a Supplier Excellence Award from Raytheon IDS.

Raytheon's Integrated Defense Systems business instituted the annual Supplier Excellence Awards program to recognize suppliers that have provided outstanding service and partnership in exceeding



customer requirements. Award candidates are judged on criteria including overall quality, on-time delivery and demonstrated commitment to continuous improvement. Pasternack was one of 87 companies recognized for 4-Star honors.

"Our commitment and contribution to the overall success of Raytheon's programs over the past 30+ years has been mutually beneficial and we look forward to years of success to come," comments Pasternack's CEO Terry Jarnigan.

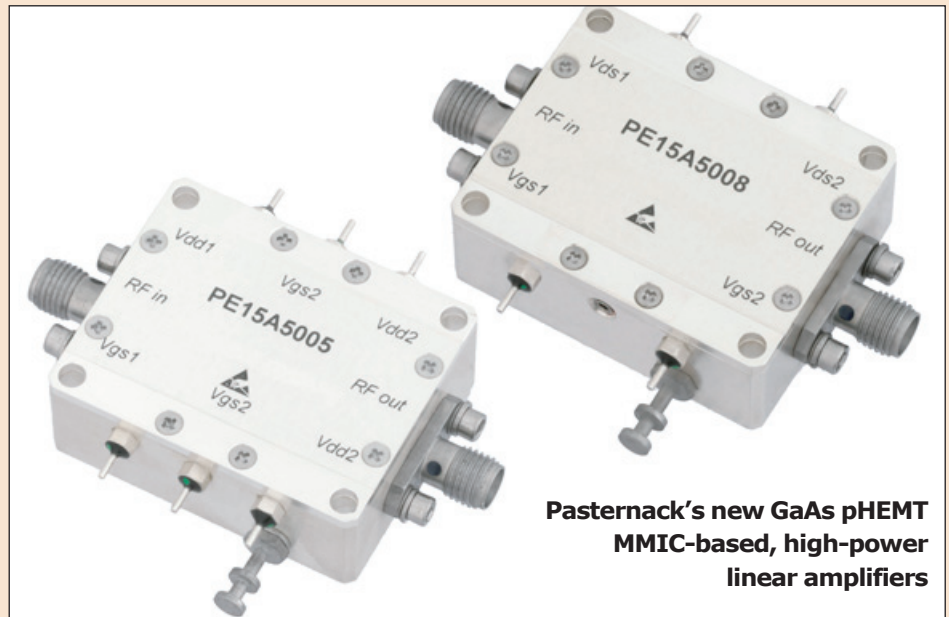
www.pasternack.com

Coaxial GaAs MMIC-based high-power linear RF amplifiers

Pasternack Enterprises has released eight new GaAs pHEMT MMIC-based, high-power linear amplifiers that provide accurate signal amplification across a multitude of commercial and defense applications such as communications, radar and sensors, test instrumentation, telecom infrastructure, fixed microwave backhaul, and commercial two-way radio, says the firm. The amplifiers operate from 0.8GHz to 9.5GHz and can be used as high-power-output amplifiers or driver amplifiers, depending on system architecture.

The new high-power RF amplifiers provide a choice of gain levels, frequency ranges, power outputs, and exhibit gain performance ranging from 19dB to 32.5dB.

They also offer competitive gain flatness from ± 0.5 dB to ± 2 dB and third-order intercept levels (IP3) from 38.5dBm to 47dBm. The linear RF amplifiers are offered in various frequency ranges with optimized performance over the pertinent range and are specially designed to ensure the robustness of the modules and ease of use through features such as mounting holes in the body of the aluminum enclosure,



Pasternack's new GaAs pHEMT MMIC-based, high-power linear amplifiers

which assures a more effective heat dissipation path.

The amplifiers are fully matched internally for input and output at 50 ohms, eliminating the need for any sensitive external RF tuning components. All of the new amplifiers are rated for operation over a -55°C to $+85^{\circ}\text{C}$ temperature range.

The new family of GaAs MMIC-based broadband high power amplifier modules brings additional diversity and versatility to Pasternack's growing RF amplifier offering, says

Michael Rachlin, director of product management. "Providing our industry with a comprehensive selection of market-leading amplifier solutions available for immediate shipment is a key strategic objective for Pasternack because it eliminates our customers' burden of extended lead times, which is common throughout the industry."

Pasternack's new GaAs MMIC-based high power linear amplifiers are available now from stock.

www.pasternack.com

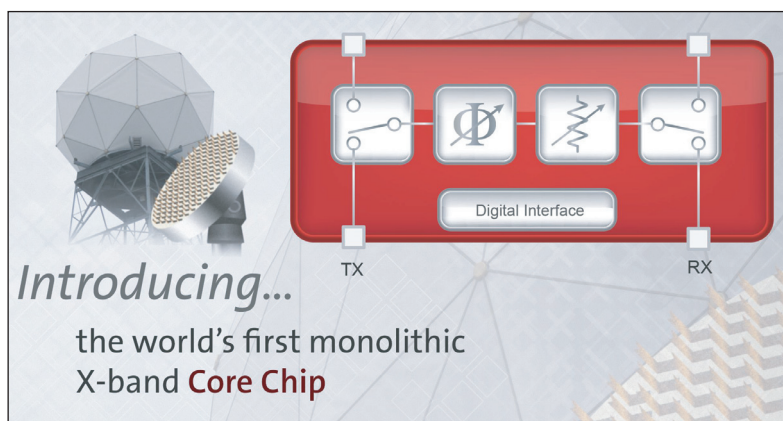
Peregrine expands integrated product portfolio into both ends of frequency spectrum

Peregrine Semiconductor Corp of San Diego, CA, USA has expanded its integrated product portfolio into DC and X-band frequencies, by introducing two integrated products: a True DC switch and an X-band core chip. Built on Peregrine's UltraCMOS technology, both products integrate RF, digital and analog components onto a single chip.

"From integrated switches to Global 1, Peregrine has introduced a broad range of industry-leading integrated products and technologies over our more than 25-year history," says Duncan Pilgrim, VP of marketing. "Today, we continue that legacy of innovative integration with two new ground-breaking products that include RF, digital and analog components on a single die. Only Peregrine's UltraCMOS technology enables this level of integration. Utilizing our integrated solutions, our customers are now able to maximize their resources, simplify their designs and focus on delivering high-quality and high-performance products to their customers."

Low-frequency intelligent integration: a true DC switch

At the lower end of the frequency spectrum, Peregrine claims that it has set a new standard with the industry's first RF integrated switch to achieve true DC capability. With a wide frequency range of 0 Hz to 8000MHz, the UltraCMOS True DC switch (PE42020) effectively operates in a previously unattainable portion of the frequency spectrum. This frequency expansion is paramount to markets that rely on accuracy and precision, such as test & measurement, says the firm. The True DC SPDT switch features high power handling, 30dBm at 0Hz and 36dBm at 8GHz, and maintains excellent RF performance and linearity from DC through 8000MHz. It can also switch DC and AC peak voltages in the range +10V to -10V at currents of up to 80mA.



On a single chip, the True DC switch integrates multiple functions: RF high-performance switching; analog: DC tracking; and digital control logic and impedance control (50Ω absorptive or open reflective).

Also, while low-frequency operation typically requires a slow switching time, the True DC switch uses advanced circuitry to remove this dependence, resulting in a 10μs switching time, and a 15μs settling time which is critical for test & measurement applications.

Peregrine's PE42020 features high-linearity (IIP3) performance of 63 dBm, and high port-to-port isolation of 37 dB @ 6 GHz. It supports standard +1.8V and +3.3V control logic and operates over a temperature range of -40°C to +85°C. The True DC switch also supports 1000V HBM ESD tolerance and is supplied in a compact 20-lead 4mm x 4mm QFN plastic package.

The PE42020 is sampling now and due for shipping early in 2015.

High-frequency intelligent integration

At the higher end of the frequency spectrum, Peregrine has introduced what it claims is the first integrated X-band, CMOS core chip to utilize MMIC (monolithic microwave integrated circuit) design techniques, enabling highly accurate signal control with minimal power loss. MMIC design techniques, such as Lange couplers, have only been used by III-V technologies. The use of these passive techniques on silicon

has always presented a challenge due to silicon's lossy nature at higher frequencies. Peregrine solves this by using an UltraCMOS sapphire

substrate, a near-perfect insulating substrate that naturally lends itself to integration.

This high-performance, X-band core chip integrates the following on a single die:

- a seven-bit digital phase shifter;
- a seven-bit digital step attenuator;
- high isolation signal-path switching;
- a compact digital serial interface control with true CMOS compatibility.

The X-band segment of the frequency spectrum is used by many modern satellite and radar systems, including synthetic aperture radar (SAR) and phased-array radar. Applications also include weather monitoring, air traffic control, defense tracking and earth observation. Peregrine says that its integrated chips offer a significantly reduced form factor delivering a distinct advantage within these systems that are tightly packaged within a small physical area. Additionally, Peregrine's UltraCMOS technology provides the high degree of reliability demanded by these critical applications, adds the firm.

Sampling in early 2015, the chip offers a maximum power handling of +18dBm from 9–10.1GHz and covers 31.75dB attenuation range in 0.25dB steps. The phase shifter offers 358° of phase range with a resolution of 7°. It maintains high attenuation and phase accuracy over frequency and temperature and exhibits low power consumption.

www.psemi.com/intelligentintegration

Peregrine launches high-linearity SPDT switch enabling dual-band architecture for DOCSIS 3.1 cable CPE devices

Peregrine Semiconductor Corp of San Diego, CA, USA — a fabless provider of radio-frequency integrated circuits (RFICs) based on silicon-on-insulator (SOI) — has launched the UltraCMOS PE42722, a high-linearity RF switch that enables a dual upstream/downstream band architecture in cable customer premises equipment (CPE) devices.

By using a dual-band architecture, multi-service operators (MSOs) have the flexibility to offer their customers new and expanded services while CPEs can comply with the new DOCSIS 3.1 cable industry standard. MSOs also benefit from the switch supporting both DOCSIS 3.0 and 3.1, allowing a simple and cost-effective transition to DOCSIS 3.1, says the firm.

CPE devices, such as set-top boxes, cable modems and home gateways, have previously supported only one upstream and downstream band at a time. Until now, no switch has met the linearity requirements necessary to support a dual-band architecture, says Peregrine. When upgrading to a different high-speed service plan, the customer is currently faced with the inconvenience of physically changing the CPE device to get the hardware necessary to support the higher upstream and downstream band requirements. The introduction of the PE42722 high-linearity switch marks the first time that dual upstream/downstream bands can

reside in the same CPE device, claims the firm. Once CPE devices are equipped with the PE42722 switch, the exchanging of hardware will no longer be necessary.

"By enabling a dual-band architecture, customers will be able to make a simple phone call to their cable service provider, who can then, 'with the flip of a switch', upgrade their customer's high-speed data service plan," says senior marketing manager Kinana Hussain. "The added bonus of also complying with the DOCSIS 3.1 standard makes this switch a must-have for all next-generation CPE devices."

An additional benefit of the PE42722 high-linearity switch is its compliance with the DOCSIS 3.0 and 3.1 cable standards. The cable industry faces the challenge of supporting the customer's increasing demand for more high-speed home data, says Peregrine. To meet this rise in data consumption, the industry announced the DOCSIS 3.1 standard in October 2013. These new DOCSIS 3.1 requirements put enormous pressure on the entire cable industry eco system, from CPE devices to the infrastructure, the firm adds. To ease the infrastructure transition to the higher speeds and eliminate the need to replace the CPE, these devices must incorporate the flexibility to accommodate multiple upstream/downstream frequency band definitions. To create a dual-

band architecture, a switch must be placed directly at the cable modem (CM) connector before the filters and needs to comply with the stringent DOCSIS 3.1 CM spurious emissions requirements of -50dBmV . Such a low spurious level requires the switch harmonic performance to be better than -115dBc . The PE42722 is claimed to be the only RF switch available that can achieve these high harmonic requirements (with $2f_0 = -117\text{dBc}$ @ 170MHz and $3f_0 = -134\text{dBc}$ @ 170MHz).

Covering a frequency range of 5–1794MHz, the PE42722 readily supports an average input power greater than 65dBmV (with PIN,CW = 80dBmV and PIN,Peak = 85dBmV). The switch's low insertion loss (0.2dB @ 204MHz, 0.3dB @ 1218MHz, 0.7dB @ 1700MHz and 0.85dB @ 1794MHz) preserves noise figure and receiver sensitivity and achieves superior signal quality, says Peregrine, along with providing high isolation (50dB @ 204MHz, 40dB @ 612MHz, 33dB @ 1218MHz and 29dB @ 1794MHz). The PE42722 also features low current consumption of 130µA, standard +1.8V and +3.3V logic support, a wide voltage supply range of 2.3–5.5V, and 1.5kV ESD protection on all pins.

Offered in a 32-lead 5mm x 5mm QFN package, volume-production parts, samples and evaluation kits are available now. For 10,000-unit orders, each PE42722 switch is \$3.38.

www.psemi.com

Japan Fair Trade Commission clears Murata acquisition of Peregrine

In August, Murata Electronics North America Inc, a subsidiary of Murata Manufacturing Co Ltd of Kyoto, Japan, agreed to acquire all outstanding shares of Peregrine Semiconductor Corp of San Diego, CA, USA that are not already owned by Murata, for \$12.50 per share in cash (a total transaction value of \$471m, or \$465m excluding

Murata's existing holding).

The Japan Fair Trade Commission has now granted clearance for the proposed acquisition.

A special meeting of shareholders to consider and vote on the proposed merger is scheduled for 19 November. Peregrine is filing with the US Securities and Exchange Commission (SEC) definitive

proxy materials related to the proposed merger.

Completion of the merger remains subject to approval by Peregrine's shareholders and remaining regulatory approvals, but is expected during fourth-quarter 2014.

www.murata.com
www.psemi.com

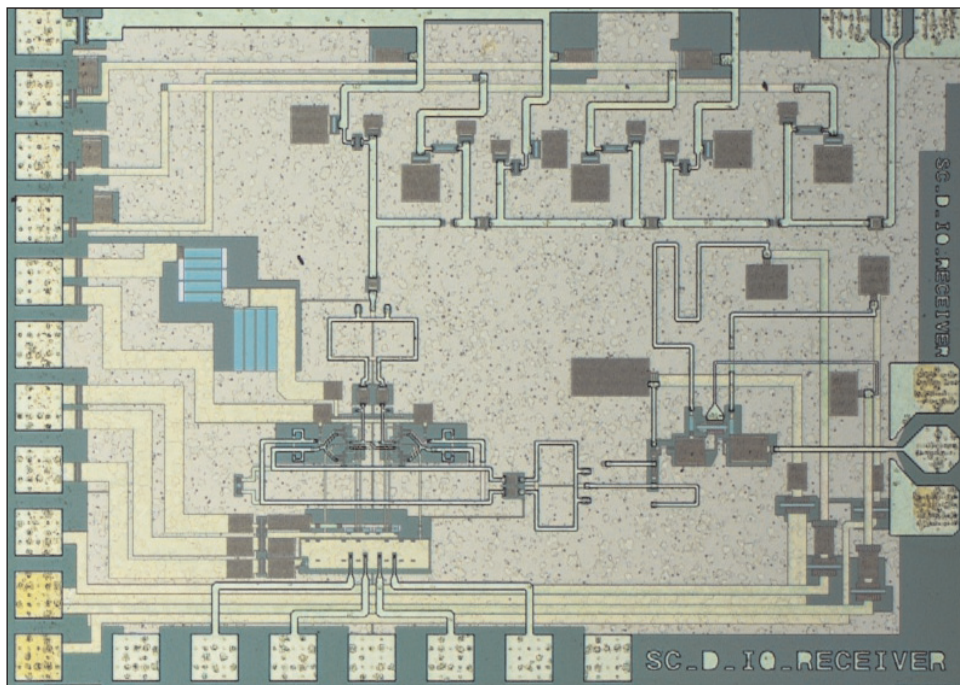
University of Chalmers achieves 40Gb/s data transmission speed record for 140GHz chip

Indium phosphide circuits targeted by Ericsson at transmission between base-stations and cellular towers

Researchers at Chalmers University of Technology in Gothenburg, Sweden have designed a microwave circuit that has set a record transmission rate of 40Gb/s for an operating frequency of 140GHz (presented in the session 'Breaking News Papers' at the 2014 IEEE Compound Semiconductor Integrated Circuits Symposium (CSICS) in San Diego, CA, USA (19-22 October).

With an increasing number of consumers, higher demands on image quality and more wireless systems, producing methods for transmitting the enormous amounts of data through the air with the right speed poses a major challenge. Using higher frequencies than are used currently, from 100GHz and higher, would give access to a larger band of empty frequencies, enabling a higher data rate. Researchers worldwide are working to produce data circuits that can transmit and receive signals that are strong enough at higher frequencies.

Semiconductor materials development has enabled manufacture of circuits that can now transmit high-frequency signals with sufficiently high power. "We have designed circuits for signals at 140GHz, where we have a large bandwidth," says professor Herbert Zirath, head of the Microwave Electronics Laboratory at Chalmers' Department of Microtechnology and Nanoscience, who is also employed part-time by Ericsson Research. Designed by Sona Carpenter, Herbert Zirath and Mingquan Bao and fabricated on a 1.6mm x 1.2mm indium phosphide (InP) chip, the 140GHz transmitter circuits incorporate an I-Q modulator, a three-stage amplifier, and a x3 frequency multiplier for the local oscillator. Data-transmission measurements were performed by Simon He. "In laboratory testing, we have achieved a transmission



Chalmers' 1.6mm x 1.2mm 140GHz transmitter chip. (Photographer/source Sona Carpenter).

rate of 40Gb/s, which is twice as fast as the previous world record at a comparable frequency," Zirath adds.

Some of the applications for quicker wireless data transmission that Zirath envisions include major cultural and sports events where high-resolution live films need to be transmitted to screens without any delay or long cables, and communication within and between the large computer rooms where our digital files end up when we place them in 'the cloud'. Improved wireless transmission can

The heavily increasing amount of data demands new solutions all the time. The increasing number of people watching films wirelessly is the primary reason underlying the need for quicker transmission

also mean fewer cords in our homes and at our workplaces.

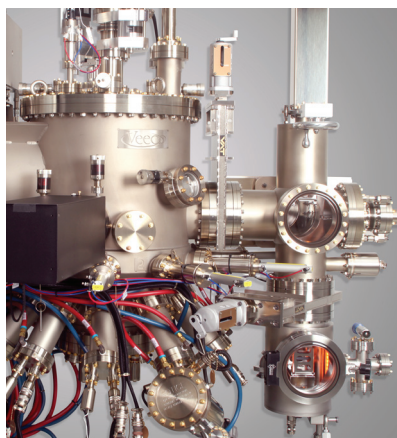
The circuits are of interest to Ericsson in terms of transmitting signals to and from base stations and cellular towers. "The heavily increasing amount of data demands new solutions all the time," says Zirath. "The fact that an increasing number of people are watching films wirelessly is the primary reason underlying the need for quicker transmission today," he adds. "It is only a matter of a couple of years before our circuits will be used in practical applications."

The project is being funded by the Swedish Foundation for Strategic Research, and the next step for the project involves moving from the laboratory to the outdoors to test the circuits under real circumstances. Within a few years, the goal within the project is to demonstrate wireless data transfer of 100Gb/s.

www.chalmers.se/en
<http://csics.org>

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Fujitsu develops lower-cost CMOS-based transceiver chips for automotive millimeter-wave radar

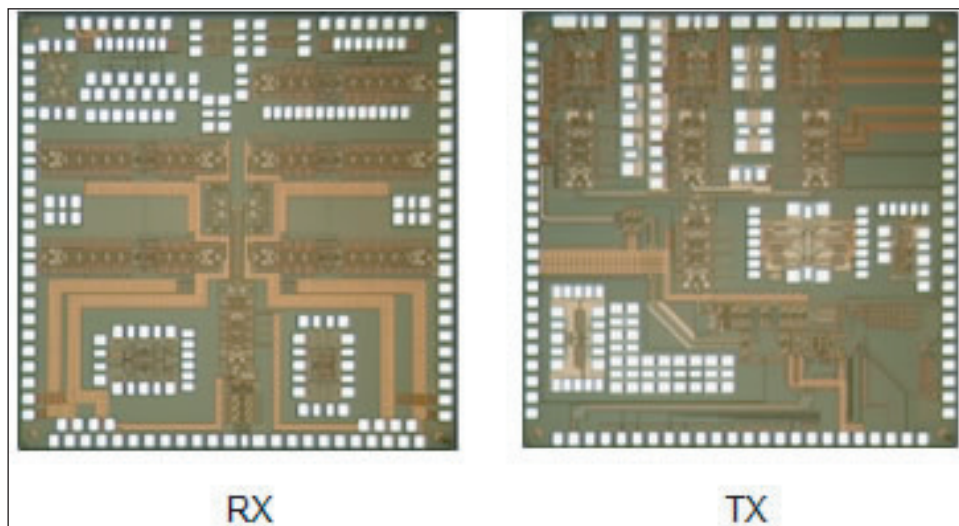
Prototype CMOS transceiver chip suppresses oscillator noise on receiver circuit by configuring frequency-conversion circuit for 76–81GHz band; power consumption halved versus SiGe

At the 44th European Microwave Conference (EuMC 2014) in Rome, Italy (6–9 October), Fujitsu Laboratories of Kawasaki, Japan reported that it has produced a transceiver chip for millimeter-wave radar in a complementary metal-oxide-semiconductor (CMOS) implementation, enabling costs to be reduced while boosting the short-range detection performance of the transceiver.

Existing millimeter-wave radar uses silicon-germanium (SiGe) transceiver chips. Using CMOS silicon would allow for lower costs and lower power consumption than SiGe, but it is more susceptible to noise, particularly in lower frequency ranges, which has made the use of CMOS for millimeter-wave radar impractical to date.

Fujitsu Laboratories says that it has succeeded in producing a prototype CMOS transceiver chip that suppresses oscillator noise on the receiver circuit by configuring a frequency-conversion circuit so that it is compatible with the 76–81GHz band used in automotive millimeter-wave radar. This greatly reduces noise levels found in previously attempted CMOS transceivers, resulting in performance equivalent to or better than current SiGe chips, it is claimed. The technology enables power consumption of CMOS-based millimeter-wave radar to be approximately halved compared SiGe chips, and at lower costs.

To make driving safer, cars are increasingly being equipped with technologies that can detect obstacles nearby and even control the brakes or accelerator in response. Technologies used for obstacle-detection include millimeter-wave radar, LiDAR and stereoscopic cameras. Compared to LiDAR and stereoscopic cameras (which both use visible wavelengths of light), millimeter-



Fujitsu's CMOS receiver chip (RX) and transmitter chip (TX).

wave radar is relatively unaffected by rain, fog and reflections, giving it an important role as an onboard sensor. The value that such sensors bring to cars creates an impetus to develop technologies for implementing these sensors at lower costs, says Fujitsu.

Millimeter-wave radar operates using high frequencies in the 76–81GHz range, and hence has required special SiGe bipolar transistors. However, advances in semiconductor technology have begun to make it possible to implement millimeter-wave circuits in inexpensive CMOS technology (most commonly used for digital circuits). Compared to conventional bipolar SiGe transistors, CMOS can run on lower-voltage power supplies, so it consumes less power and, although it performs roughly the same in the millimeter-wave range, it had been more adversely affected by noise in the low-frequency range. In millimeter-wave radar, a signal from an oscillator is transmitted, the signal is reflected back from obstacles and is received, and the two are compared to determine the distance, speed and direction of the

obstacle. Detection of nearby pedestrians and objects that have weak reflectance is especially problematic. To improve detection of nearby pedestrians, it was therefore essential to reduce low-frequency noise.

To ensure good detection performance at short distances with CMOS-based millimeter-wave radar requires a solution to the low-frequency noise problem. The technology developed by Fujitsu Laboratories hence has the following two key features:

- ensuring good high-frequency performance in the receiver chip while reducing low-frequency noise;
- consuming half the power of existing bipolar SiGe transistors.

Fujitsu Laboratories used a double-balanced resistive mixer in the receiver's frequency-conversion circuit, which takes the frequency difference (IF signal) that occurs from signals reflecting from objects (RF signals) and local oscillator signals (LO signals). A resistive mixer is a circuit format that can recover IF signals through electricity from LO signals without having to apply power supply voltage so the flow of

DC current to a mixer transistor can be kept to a minimum, which avoids the increase in low-frequency noise.

Also, using a double-balanced construction which synthesizes the differential motion of the resistive mixer, noise increase from DC offset that occurs via LO signals input to the mixer can be reduced. It also has the effect of reducing noise below 10kHz while maintaining high-frequency characteristics.

Fujitsu Laboratories produced a prototype 4-channel receiver chip using this circuit, with functionality equivalent to current SiGe products, along with a prototype transmitter chip that used a phase-locked loop (PLL) synthesizer with low phase noise that the firm announced last year (see Figure).

All told, this allowed for a millimeter-wave radar where all of the principal high-frequency circuits were produced using a 65nm CMOS process.

The SSB noise index (an indicator of the receiver chip's low-frequency

noise) was 12dB for the prototype — at the same level as existing SiGe products — representing an 18dB improvement over the figure of 30dB for CMOS units previously announced at academic meetings and other sources. This improvement represents a significant reduction in noise, equivalent to approximately one-sixtieth of previous levels, says Fujitsu. Furthermore, compared with SiGe chips that run on voltages of 3–5V, the CMOS technology used here achieves equivalent performance with a 1.2V power source, approximately halving power con-

Compared with SiGe chips that run on voltages of 3–5V, the CMOS technology used here achieves equivalent performance with a 1.2V power source, approximately halving power consumption

sumption, it is reckoned.

By reducing noise in the low-frequency range, the performance of millimeter-wave radar detecting nearby objects is improved, says Fujitsu. Performance in detecting pedestrians and nearby objects is hence improved. Adapting the widely used 65nm CMOS process technology to this application promises easier, low-cost mass production, says Fujitsu. Also, with half the power requirements of SiGe bipolar transistors, the power-supply circuitry for the radar sensor can also be less expensive. Furthermore, this makes it easy to combine multiple digital circuits, for more functional millimeter-wave radar in the future, the firm concludes.

Fujitsu Laboratories currently anticipates practical applications around 2018, and plans to continue working on more functional millimeter-wave radar.

<http://jp.fujitsu.com/labs/en>
www.eumweek.com/conferences/eumc.html

Mitsubishi Electric and Tohoku University develop 5GHz/60GHz dual-band receiver front-end CMOS IC

During European Microwave Week (EuMW 2014) in Rome, Italy (5–10 October), Tokyo-based Mitsubishi Electric Corp and Tohoku University presented technical details of a newly developed 5GHz/60GHz dual-band receiver RF front-end silicon-CMOS IC for a highly dependable and high-speed wireless communication system that Tohoku University has proposed, called the 'Dependable Air'.

Wireless communication is greatly dependent on high dependability and high speed. But, since high-speed wireless communication normally uses millimeter-scale radio waves, communication can be established only in line of sight. However, in the 5GHz band used for wireless LANs, communication is possible over the horizon. Tohoku University is proposing its

Dependable Air system for wireless handsets that use multiple standards (heterogeneous) to conduct seamless handovers according to the environment.

Mitsubishi Electric's new RF front-end IC is a miniaturized multi-band model that uses the 5GHz and 60GHz bands. Gain is 32dB in both bands. Noise figure is 5dB in the 5GHz band and 8dB in the 60GHz band. The input power at 1dB gain compression point (IP1dB) is –42.2dBm in the 5GHz band and –43.5dBm in the 60GHz band. In addition, the size of the IC has been reduced by about 30% by sharing parts of the 5GHz and 60GHz RF front-ends.

The firm has also reduced the extent of trial IC manufacturing by introducing electro-magnetic simulation of performance effects

in millimeter-wave bands for assembled ICs.

Going forward, Mitsubishi Electric aims to pursue standardization of this form of wireless communications (including IEEE802.11 and other standards) as well as to develop RFIC business for millimeter-wave communication devices.

Tohoku University's development of the Dependable Air system has been supported by the CREST funding program of the Japan Science and Technology Agency (JST). Under the CREST project titled 'Fundamental Technologies for Dependable VLSI System', research on the 'Development of Dependable Wireless Systems and Devices' is currently being carried out.

www.tohoku.ac.jp/en
www.MitsubishiElectric.com

MACOM showcases cable TV and broadband devices for high-speed cable networks

At the SCTE Cable-Tec Expo'14 in Denver (23–25 September), 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) showcased its portfolio of CATV and broadband devices enabling the evolution of modern cable networks.

To keep pace with the exponential growth in data demand while leveraging previously deployed fiber and copper, cable networks are working toward deployment of DOCSIS 3.1 equipment, says MACOM. This needs changes to the active and passive components within the infrastructure and customer premise equipment, such as higher power, linearity and bandwidth amplifiers, improved rejection filters, and a full new suite of power dividers and couplers —

essentially a full refresh of the equipment toolkit, the firm adds.

MACOM's suite of new product families includes the following:

- DOCSIS3.1 push-pull and power doubler GaAs infrastructure amplifiers in SMT plastic format, offering multiple system operators higher linearity and output power with extended 1.2GHz bandwidth.
- Diplex filters that deliver high isolation and return loss while simultaneously maintaining the lowest possible insertion loss. The higher power levels combined with extended frequency requirements of DOCSIS3.1 place much greater demands on the passive components in the system amplifier. Passives need to exhibit multi-octave flat response and not contribute to system distortion.
- A platform of surface-mount triplex filters covering the 42/54,

65/85, 85/105 and 204/258MHz bands that are MoCA 2.0-compliant and fully footprint compatible, allowing for simplified front-end designs and quicker design cycles. Extremely high-performance filter technology is needed to simultaneously support next-generation MoCA systems and new DOCSIS 3.1 interfaces to the core network.

- 300MHz reverse path single-ended, differential and variable-gain amplifiers, which meet the challenges of next-generation architectures because DOCSIS3.1 extends frequency bands in both the forward and reverse paths.
- FTTx amplifiers that have been developed specifically to meet radio frequency over glass (RfOG) and passive optical network (PON) system requirements.

www.macom.com

<http://expo.scte.org>

RFMD expands gallium nitride portfolio to support DOCSIS 3.1 cable networking

RF Micro Devices Inc of Greensboro, NC, USA has unveiled 11 new amplifiers, of which six are gallium nitride (GaN)-based products to support the requirements of the new data over cable service interface specification (DOCSIS) 3.1. RFMD showcased its portfolio of CATV components at the Society of Cable Television's (SCTE) Cable-Tec Expo in Denver (22–25 September).

RFMD's DOCSIS 3.1 family includes 1.2GHz power amplifiers as both hybrids and multi-chip modules (MCMs) that use GaN HEMT process technology and offer optimal linearity and output power while providing robust reliability. The newest addition to the product portfolio for DOCSIS 3.1 includes power doubler amplifiers, push-pull amplifiers, optical receivers, a reverse path amplifier, and a family of digital step attenuators. With the addition

of these new products, RFMD now offers more than 25 products tailored for DOCSIS 3.1 applications.

RFMD's downstream amplifiers operate at frequencies from 40MHz to 1.218GHz with extremely low distortion levels and typical input and output return loss of 20dB. The reverse path amplifiers work at up to 300MHz with high gain and highly integrated functions. RFMD says that its GaN technology offers the power density required to meet high-power CATV requirements. The firm has been shipping high-volume CATV GaN-based amplifiers for the past five years.

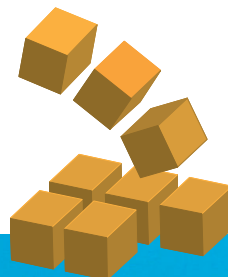
RFMD says that its GaN family allows cable operators and multi-system operators (MSOs) to easily upgrade existing CATV infrastructure to meet the power amplifier requirements of the new DOCSIS 3.1 standard, increasing effective

downstream data rates from 160Mb/s to 10Gb/s and upstream data rates from 120Mb/s to 1Gb/s compared to DOCSIS 3.0. The firm adds that, due to the high output and gain benefits derived from its GaN amplifiers, cable operators can upgrade their existing equipment within current locations, saving both installation time and cost.

"We continue to expand our family of GaN products, providing cable operators and MSOs an easy, cost-effective upgrade path to DOCSIS 3.1 to extend the life of their existing networks," says Gordon Cook, general manager of RFMD's Power Broadband business unit. "RFMD remains the only company shipping GaN amplifiers for CATV in high volumes and in the device and MCM packages customers need today," he adds.

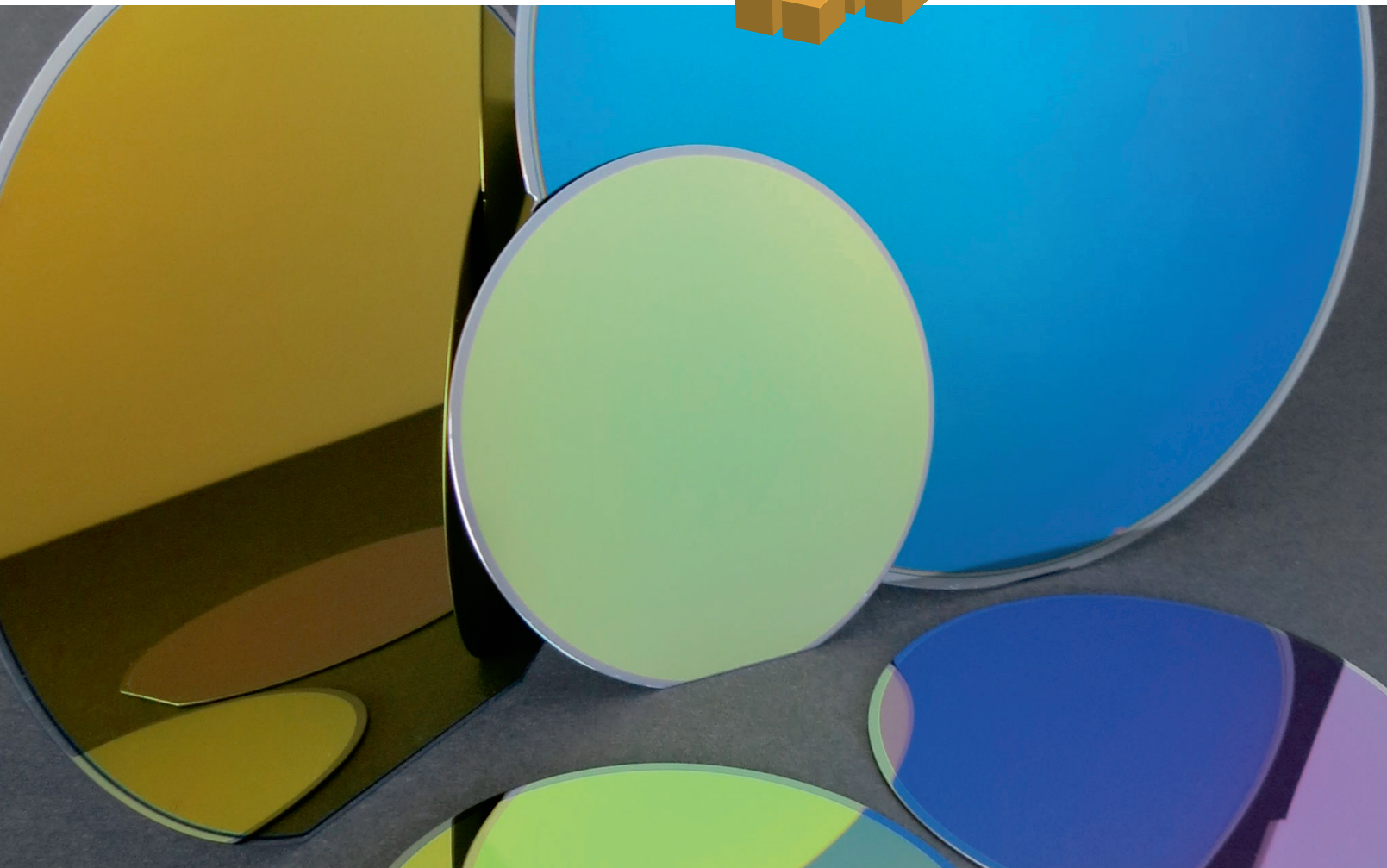
www.rfmd.com

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GeneSiC launches improved, lower on-resistance 1700V and 1200V SiC junction transistors

Silicon carbide (SiC) power semiconductor supplier GeneSiC Semiconductor Inc of Dulles, VA, USA has announced the availability of a family of low on-resistance 1700V and 1200V SiC junction transistors in TO halogen-free, RoHS-compliant TO-247 packages.

The 1700V SiC junction transistors comprise the 25mΩ GA50JT17-247, 65mΩ GA16JT17-247 and 220mΩ GA04JT17-247. The 1200V SiC junction transistors comprise the 25mΩ GA50JT12-247, 120mΩ GA10JT12-247 and 210mΩ GA05JT12-247. For both, current gain (h_{FE}) is >90 , maximum junction temperature (T_{jmax}) is 175°C, and the turn on/off; rise/fall times are <30 ns (typical). All devices are 100% tested to full voltage/current ratings.

The use of high-voltage, high-frequency, high-temperature and low on-resistance capable SiC junction transistors can increase conversion efficiency and reduce the size/weight/volume of power electronics applications requiring higher bus voltages, says GeneSiC. The devices are targeted at a wide variety of applications including DC



GA50JT17-247 junction transistor.

micro-grids, Vehicle Fast chargers, server, telecom and networking power supplies, uninterruptable power supplies (UPS), solar inverters, wind power systems, and industrial motor control systems.

GeneSiC says that its SiC junction transistors (SJT) exhibit ultra-fast

switching capability (similar to that of SiC MOSFETs), a square reverse-biased safe operation area (RBSOA), as well as temperature-independent transient energy losses and switching times. The switches are gate-oxide free, normally-off, exhibit positive temperature coefficient of on-resistance, and can be driven by commercial gate drivers (unlike other SiC switches it is claimed). In contrast to other SiC switches, unique advantages of the SJTs are claimed to be higher long-term reliability, greater than 10 microsecond short-circuit capability, and superior avalanche capability.

"These improved SJTs offer much higher current gains (>100), highly stable and robust performance as compared to other SiC switches," says president Dr Ranbir Singh. "GeneSiC's SJTs offer extremely low conduction losses at rated currents as superior turn-off losses in power circuits," he claims. "Utilizing the unique device and fabrication innovations, GeneSiC's transistor products help designers achieve a more robust solution."

www.genesicsemi.com/commercial-sic/sic-junction-transistors

EPC introduces wide-input, 20A GaN-based buck power conversion demonstration board

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 introduced the EPC9118, a fully functional buck power conversion demonstration circuit.

Featuring the EPC2001 and EPC2015 eGaN FETs as well as the LTC3891 buck controller, the board is a 30-60V input to 5V, 20A maximum output current, 400kHz buck converter. The design is suitable for distributed power solutions in tele-

com, industrial, and medical applications, says the firm.

The EPC9118 board contains the complete power stage (including eGaN FETs, driver, inductor and input/output caps) in a compact 1" x 1.3" layout to showcase the performance that can be achieved using the eGaN FETs and a traditional MOSFET controller together. The demo board is 2.5" square and contains a fully closed-loop buck converter with optimized control loop.

Despite its small size, the board has peak power efficiency greater than 93% capable of delivering 20A

at 5V with a 36V input. To assist the design engineer, the EPC9118 is easy to set up, says the firm, and contains various probe points to facilitate simple waveform measurement and efficiency calculation.

EPC9118 demo boards are priced at \$237.19 each and are available from Digi-Key. A Quick Start Guide containing set up procedures, circuit diagram, performance curves and a bill of material is also available.

<http://digikey.com/Suppliers/us/Efficient-Power-Conversion.page>
<http://epc-co.com/epc/Products/DemoBoards/EPC9118.aspx>

GaN-ready LLC transformer and PFC inductor magnetics

Magnetic components and assembly designer and manufacturer Precision Inc of Minneapolis, MN, USA has launched its GaN-ready magnetic capabilities. GaN-ready LLC transformers and PFC inductors are now available for applications spanning power factor correction (PFC), server, solar, automotive/HEV, industrial motor drives, and power supplies/UPS.

GaN switches provide key benefits to design engineers including:

- significant reductions in system volume, weight and size;
- higher operating temperatures/reduced heat sink requirements;
- lower switching losses/increased power output (up to 95% peak efficiency); and
- high breakdown strength, high maximum current and high oscillation frequency.

"GaN switching technology is fast becoming a very popular option in a wide number of applications,"

says design engineering manager Welly Chou. "Precision is proud to have joined forces with industry-leading GaN switch producers to create and now introduce high-performance GaN technology with demonstrated results."

Precision has partnered with GaN experts including International Rectifier (IR) and Transphorm to create ultra-compact power supplies with LLC transformer and PFC inductor technologies designed for optimum performance at high switching frequencies. Precision says that it has brought unique expertise in core material selection and the management of parasitics (i.e. leakage inductance and capacitance), together with an extensive Litz wire selection, to GaN technologies that are now available worldwide.

Precision provides other custom GaN-ready magnetics in both PFC and LLC formats directly to design

engineers and has partnered with both Transphorm and International Rectifier on large circuits with integrated GaN-ready magnetics.

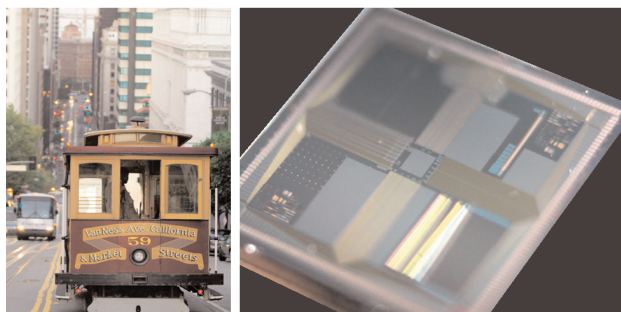
The EZ-GaN Evaluation Board All-in-One Power Supply from Transphorm is a complete high-density 250W computer power supply using 600V GaN HEMTs switching at 200kHz. The system is said to provide a reduction in size of up to a 45% (compared with a silicon-based equivalent) with a highly efficient design (greater than 95% peak efficiency). This solution was demonstrated in the booths of both Transphorm and OnSemi at March's Applied Power Electronics Conference & Exposition (APEC 2014) in Texas.

IR demonstrated its GaN technologies at APEC via a bridgeless Totem-Pole PFC circuit, achieving 99% efficiency with Precision's PFC-01200-00 inductor.

www.precision-inc.com

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Cree earns US DoD manufacturing readiness level 8 designation after completing Title III GaN-on-SiC Production Capacity Program

Cree Inc of Durham, NC, USA has earned the US Department of Defense (DoD) manufacturing readiness level eight (MRL 8) designation.

Awarded for its production of gallium nitride (GaN) monolithic microwave integrated circuits (MMICs), the designation verifies Cree's ability to provide assured, affordable and commercially viable production capabilities and capacities for items essential to national defense. The designation was granted upon Cree's completion of the DoD's Defense Production Act (DPA) Title III Gallium Nitride on Silicon Carbide Production Capacity Program.

"Cree exemplifies the mission-ready capability of a company that the DPA Title III office seeks," comments Mark Buffler, director, Defense Production Act Title III Program within the Office of the Secretary of Defense. "The key objective of these public-private partnerships is the creation of assured, affordable and commercially viable production capabilities and capacities for products and materials essential for our national

defense while strengthening the economic and technological competitiveness of the US defense industrial base," he adds.

Led by an integrated program team (IPT) and jointly funded through a public-private partnership effort, the three-year, multi-phase GaN on Silicon Carbide Radar/Electronic Warfare MMIC Production Capacity Project was structured to assess and refine manufacturing processes necessary to support a full-rate MMIC production capability. The IPT consisted of Air Force Research Laboratory Materials and Manufacturing Directorate (AFRL/RX) personnel, Cree engineers and manufacturing experts, and select government consultants. The program was managed by the Deputy Assistant Secretary of Defense, Manufacturing and Industrial Base Policy (MIBP) and administered by the US Air Force, the executive agent within the DoD.

Cree exemplifies the mission-ready capability of a company that the DPA Title III office seeks

Funded with \$18m in direct government funds and \$3.5m in Cree funds, the national defense program accounted for a total public-private partnership effort of \$21.5m.

Cree says that, since 2010, it has shipped more than 5 million MMICs and devices, making it one of the largest US suppliers of GaN technology for both the DoD and commercial markets. During this time, about 4 billion device hours in the field have been accumulated with an associated industry-leading FIT (failure-in-time) rate of less than 10 failures per 1 billion device hours, validating the robustness of Cree's manufacturing process and resultant devices under fielded conditions.

"This achievement clearly demonstrates the level of production-readiness that Cree's GaN manufacturing processes are capable of," says Dr John Palmour, Cree's co-founder & chief technology officer, Power and RF.

Cree offers foundry services for development and production using GaN HEMT MMIC processes, providing design and test services on a case-by-case basis.

DoD Category 1A Trusted Foundry status for 100mm RF GaN facility

Gallium nitride (GaN) RF device maker Cree USA has achieved a production milestone with its recent accreditation as a US Department of Defense (DoD) Category 1A Trusted Foundry for its 100mm RF GaN facility.

Granted through the Trusted Access Program Office (TAPO) and the Defense Microelectronics Activity (DMEA), accreditation is the highest designation awarded by the DoD, and differentiates Cree as a trusted supplier of GaN technology in support of national defense applications, adds the firm.

Category 1A Trusted Foundry accreditation validates that policies and procedures designed to ensure the trustworthiness, integrity and confidentiality of the manufacturing process — including chain of custody, supply continuity and anti-tampering — are securely in place.

"The DoD Trusted Foundry accreditation puts Cree into a select group of trusted manufacturers in the USA that are certified to produce both unclassified and classified hardware for DoD programs critical to national defense,"

says Jim Milligan, Cree's director of RF and microwave products. "This designation ensures that products manufactured at Cree meet the highest standards of secure handling and production control throughout the entire manufacturing process."

Since 2010, Cree has shipped more than 5 million MMICs and devices, and during this time about 4 billion device hours in the field have been accumulated with an associated FIT rate of less than 10 failures per billion device hours.

www.cree.com/foundry

Cree launches first 1.7kV, all-SiC power module

Cree Inc of Durham, NC, USA has released what it claims is the first all-SiC (silicon carbide) 1.7kV power module in an industry-standard 62mm housing.

Powered by Cree's C2M large-area SiC chip technology, the new half-bridge module exhibits 8mΩ on-resistance and 10-times higher switching efficiency than existing silicon module technology, it is claimed, making it capable of replacing silicon insulated-gate bipolar transistor (IGBT) modules rated at 400A or more.

The performance of the new 1.7kV all-SiC power module allows design engineers to simultaneously reduce the size and cost of magnetic and cooling elements while achieving superior system efficiency and reliability, Cree says. Unlike existing silicon-based systems in motor-drive, grid-tie and utility-scale solar-inverter applications, the new power module also enables lower

production costs and the development of smaller, lighter products with a lower overall total cost of ownership, the firm adds.

"The introduction of Cree's all-SiC, 1700V power module opens the door for SiC devices to become the switching device of choice for high-power motor drives," comments Devin Dilley, director of medium-voltage R&D for Vacon, a supplier of AC drives. "The application of these modules in SiC-based motor drives will enable a reduction in the size and cost of filter components by up to 40% while simultaneously increasing system efficiency," he adds.

The switching efficiency and voltage capability of the new module enables simplified, two-level topologies that are feasible at higher frequencies, eliminating the need to invest in complex, multi-level silicon-based solutions, Cree says. The high power density that can be achieved with the latest half-bridge module

further simplifies the implementation of modular system designs and enables extremely low mean time to repair for high overall system availability, it adds.

"Cree's power-module portfolio enables higher efficiency, improved reliability and lower total cost of ownership," says Cengiz Balkas, VP & general manager Cree Power & RF.

The new all-SiC, 1.7kV, 8mΩ half-bridge module is available as part number CAS300M17BM2 at preferred distributors including Mouser, Digi-Key and Richardson RFPD/Arrow RF & Power. Companion gate-driver boards have been developed in cooperation with Netherlands-based power-systems designer and manufacturer Prodrive. The boards are available through Cree sales channels or directly from ProDrive.

www.cree.com/Power/Products/SiC-Power-Modules/SiC-Modules/CAS300M17BM2

Cree launches all-SiC 1.2kV six-pack power module

Cree has expanded its SiC 1.2kV six-pack power module family with a new 20A all-SiC module suited for 5–15kW three-phase applications. Based on Cree's C2M SiC MOSFET and Z-Rec SiC Schottky diode technology, the module enables designers to unlock the traditional constraints of power density, efficiency and cost associated with Si-based inverters used in industrial power conversion systems, says the firm.

Electrical power generation systems provider Cummins Inc has tested and confirmed the capabilities of Cree's all-SiC 1.2kV six-pack power module family in its inverter platform. Furthermore, Cummins is working to integrate and exploit these capabilities with its next-generation, high-efficiency products.

"Cree's new 1.2kV all-SiC six-pack module family will allow us to increase the power rating of our class-leading inverter by 40%

while reducing power losses by 50% to increase efficiency by 5%," says Brad Palmer, power electronics product line architect at Cummins. "This new power module is a significant technological advancement, capable of outperforming Si IGBT modules with four times the current rating. We are delighted to have had the opportunity to be an early tester of this technology and look forward to incorporating it in our products."

The new all-SiC 1.2kV, 20A six-pack features what is claimed to be the industry's lowest switching losses due to the zero turn-off tail current in the MOSFET and the zero reverse recovery current in the Schottky diode. Compared with similar silicon IGBT modules, the new Cree 20A six-pack module operates at a much lower junction temperature allowing designers to aggressively pursue new paradigms in high frequency and

power density without compromising on efficiency.

"Cree SiC power products consistently allow our customers to overcome age-old design challenges and achieve superior system level performance that is simply not possible with Si-based systems," says Cengiz Balkas, general manager & vice president, Cree Power and RF. "The results achieved by Cummins with our new all-SiC six-pack modules enable the high performance required to develop efficient and cost-effective next-generation power conversion products."

The CCS020M12CM2 all-SiC 1.2kV, 20A six-pack power module and companion CGD15FB45P gate driver evaluation board are available now at authorized distributors, including Mouser, Digi-Key, and Richardson RFPD/Arrow RF & Power.

www.cree.com/Power/Products/SiC-Power-Modules/SiC-Modules/CCS020M12CM2

Advantech Wireless increases production capacity

Advantech Wireless of Montreal, Canada (which makes satellite, RF equipment and microwave systems) has increased its production capacity of GaN-based solid-state power amplifiers (SSPAs) and block up-converters (BUCs) in order to meet high market demand.

The firm says that, due to the success of its GaN-based SSPAs and BUCs and the market response, it has made its most popular GaN-based products available to be supplied with short delivery time.

"Market response to our innovative GaN-based SSPA offering in the last

several years has exceeded the production capabilities," says Cristi Damian, VP business development. "As a result, we have added additional manufacturing capacity to be in line with the demand," he adds.

Awarded 'Teleport Technology of the Year 2014' by the World Teleport Association and 'Vision Award' as Most Innovative Product of the Year 2013, the firm's SapphireBlu Series of UltraLinear GaN-based high-power amplifier (HPA) systems offers the highest linear power available on the market, claims the firm.

With what is claimed to be the

greatest variety of field-proven GaN-based SSPAs on the market, the firm also offers a complete line of compact, lightweight BUCs suitable for mobile applications (with units that are up to 50% smaller, offering up to 70% less power consumption and 30% less heat generation).

All GaN-based products can be fitted with Ethernet, SNMP, Telnet, Web GUI and/or CLI interfaces. The new systems are redundant ready, with no external controller required, suiting single-carrier, multi-carrier and multi-transponder uplinking.

www.advantechwireless.com

Advantech Wireless' GaN devices win North American Frost & Sullivan Award for New Product Innovation Leadership

Based on its recent analysis of the gallium nitride (GaN)-based devices market, Frost & Sullivan has recognized Advantech Wireless with the 2014 North American Frost & Sullivan Award for New Product Innovation Leadership.

Frost & Sullivan presents the award annually to the firm that has developed an innovative element in a product by leveraging leading-edge technologies. The award recognizes the value-added features/benefits of the product and the increased return on investment (ROI) that it offers customers which, in turn, increases customer acquisition and overall market penetration potential.

Frost & Sullivan says the firm's new series of GaN-based solid-state power amplifiers (SSPAs), together with other telecom devices, have revolutionized the GaN device market with their small form factor, reduced power consumption and heat generation, as well as capital and operating cost-efficiency.

Until recently, GaN's linearity, processing, biasing and cost characteristics appeared to limit the semiconductor's use to devices in low-frequency commercial applications and defense communications, where price was not much of

an issue. Aiming to bring the material into higher-power commercial markets, Advantech Wireless was convinced of GaN's potential in radio-frequency power amplification and other telecom applications.

Advantech Wireless says it hence dedicated significant resources to developing technologies such as its high-power amplifier, which can simultaneously transmit to all satellite transponders from a single antenna. This capability facilitates cost-efficient, energy-saving communications connectivity by enabling the replacement of multiple antennas and up to hundreds of travelling-wave tubes (TWTs)/klystrons, the firm adds.

"Advantech Wireless noted that the introduction of GaN HEMTs in early 2000 left an undeniable mark on the satellite communication landscape," says Frost & Sullivan research analyst Mike Valenti. "The company launched its ambitious R&D program in 2006 to design and manufacture a complete line of C-, X- and Ku-band SSPAs that could meet the most demanding satellite communication applications."

An outcome of the intense R&D efforts is the SapphireBlu Series of UltraLinear GaN technology-based high-power amplifiers. Their greater

ground power, linearity and cost-savings, along with Advantech Wireless' 13m A-line antenna in a major direct-to-home (DTH) uplink system in Latin America, allowed viewers in Latin America and Brazil to watch the World Cup 2014 soccer tournament played in Brazil

The firm says its products can enable key reductions in the size, weight and power of telecoms equipment from the ultra-high frequency (UHF) band to the Ka-band in satellite communications.

"Advantech Wireless develops solutions that balance satellite spectral efficiency to provide the smallest occupied bandwidth at enhanced link availability," says Valenti. "This results in capital and operating cost-savings that can be passed along to the customer."

Regarding device efficiency, the firm's GaN-based SSPA provides a 65% boost in mean time between failure (MTBF) compared with its similar GaAs-based SSPA product due to component reliability, number of components, and electrical efficiency. The SapphireBlu Series can reach 6kW in RF power, proving its reliability in the most environmentally stringent and demanding work conditions, it is claimed.

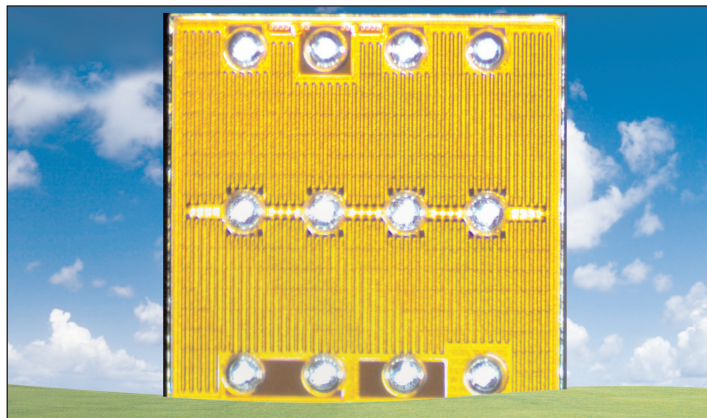
www.awards.frost.com

EPC launches 300V GaN power transistors for high-frequency applications

Efficient Power Conversion Corp (EPC) has launched the EPC2025, a 300V enhancement-mode gallium nitride on silicon (eGaN) power field-effect transistor (FET) for use in applications requiring high-frequency switching in order to achieve higher efficiency and power density. Applications enhanced by higher switching speeds include ultra-high-frequency DC-DC converters, medical diagnostic equipment, power inverters, and LED lighting.

The EPC2025 has a voltage rating of 300V and maximum on-resistance ($R_{DS(on)}$) of 150m Ω with a 4A output. It is available in passivated die form with solder bars for efficient heat dissipation and ease of assembly. The EPC2025's size measures 1.95mm x 1.95mm for increased power density.

"As end-systems increasingly require smaller-size DC-DC power converters, especially those used in



portable equipment, the demand for corresponding higher-speed switching power converters is increasing," says EPC's co-founder & CEO Alex Lidow. "The EPC2025 allows power designers to increase the switching frequency of their power conversion systems for increased efficiency and smaller footprint," he adds.

The EPC9042 development board is a 300V maximum-device-voltage half-bridge with onboard gate

driver, featuring the EPC2025, onboard gate drive supply and bypass capacitors. The 2" x 1.5" board has been laid out for optimal switching performance and contains all critical components for easy evaluation of

the 300V EPC2025 eGaN FET.

The EPC2025 eGaN FETs are priced at \$5.29 each in for 1000-unit quantities. EPC9042 development boards are priced at \$137.75 each. Both are available for immediate delivery from Digi-Key.

<http://epc-co.com/epc/Products/eGaNfets/EPC2025.aspx>

<http://epc-co.com/epc/Products/DemoBoards/EPC9042.aspx>

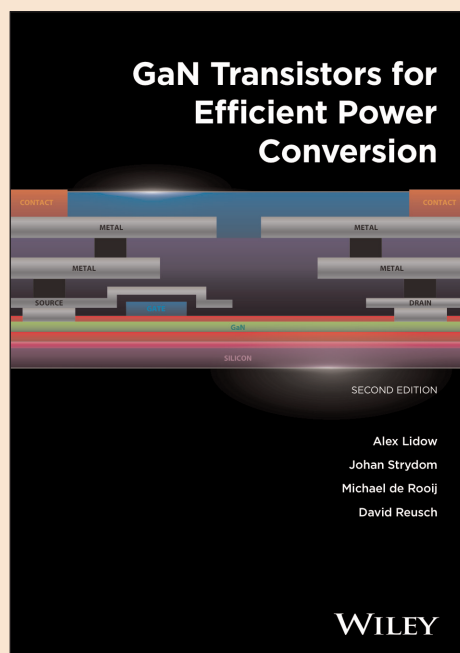
<http://digikey.com/Suppliers/us/Efficient-Power-Conversion.page>

Second edition of 'GaN Transistors for Efficient Power Conversion'

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 announced the publication of the second edition of 'GaN Transistors for Efficient Power Conversion', a textbook written by power conversion industry experts and published by John Wiley and Sons.

The book provides power system design engineering students, as well as practicing engineers, basic technical and application-focused information on how to design more efficient power conversion systems using GaN-based transistors.

The second edition has been substantially expanded to reflect the latest in GaN technology advances. It serves as a practical guide for



understanding basic GaN transistor construction, characteristics, and applications. Included are:

- Discussions on the fundamental

physics of these power semiconductors;

- Layout and other circuit design considerations;
- Application examples employing GaN including RF envelope tracking, wireless power transfer class-D audio and harsh radiation environments;
- Specific design techniques when employing GaN devices.

Collectively, the authors have over 90 years of experience working in power transistor design and applications. All four have doctorates in scientific disciplines and are widely recognized published authors. They are pioneers in the emerging GaN transistor technology, with Dr Alex Lidow concentrating on transistor process design and Drs Johan Strydom, Michael DeRooij, and David Reusch focusing on power transistor applications.

MACOM adds S-band high-power pallet and hybrid amplifiers to GaN portfolio

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 a portfolio of surface-mount S-band GaN power products optimized for commercial air traffic control, weather radar and military radar applications. The new products are available in a range of packaging options and power levels.

The 30Wpk and 85Wpk hybrid GaN amplifiers (MAMG-002735-030L0L and MAMG-002735-085L0L, respectively) are complemented by a 350Wpk aluminum-based pallet option, all of which deliver GaN high-power performance while enabling significant design and manufacturing efficiencies, the firm says. The new S-band GaN power products provide integrated solutions that enable users to accelerate time to market by leveraging commercial best practices for high-volume manufacturing, ensuring additional benefits including improved assembly yield, lower component count, and reduced touch labor, MACOM says.

The firm says that its GaN-on-SiC S-band power products are suited to applications with exacting size, weight and power (SWaP) requirements. The 30W_{pk} and 85W_{pk} hybrid amplifiers measure 7mm x 7mm and 14mm x 24mm, respectively, and the 350Wpk pallet measures just 51mm x 23mm.

The components support wide bandwidths to enable multi-function system capabilities and broad, dynamic frequency operation for complex waveforms, while maximizing power and cooling efficiency and providing robust performance over a wide range of input voltages. Flexible voltage operation equips system operators to meet targeted power requirements and dynamically manage their total system power budget while still maintaining high levels of efficiency and RF performance, says the firm.

"MACOM's portfolio of surface-mount GaN power products affords system designers a common platform that they can leverage across a growing range of frequency bands, while the pallet offers an even higher-power

rugged, balanced solution," says product manager Paul Beasley. "Our avionics, L-band and new S-band GaN power products deliver breakthrough power performance while minimizing design and manufacturing complexity to help customers accelerate time to market," he claims. "These new products, complemented by our portfolio of GaN-on-Si components, position MACOM to shatter the barriers to mainstream GaN adoption," he adds.

The GaN power products are designed to ensure high-reliability operation under a wide range of environmental conditions — the calculated mean-time-to-failure (MTTF) at 200°C is about 600 years. MACOM says that it manufactures its GaN power products via tightly controlled processes in accordance with IPC standards to ensure the highest levels of product integrity, reliability and consistency.

MACOM's new 85Wpk and 30Wpk hybrid power amplifier modules and 350Wpk pallet are now sampling to customers.

www.macom.com/gan

Presto rolls out E-band wafer-level RF testing service

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 introduced a wafer-level E-band RF testing service for semiconductor products. The production-scale testing service delivers a high-throughput, cost-competitive, end-to-end solution and is the first such service to be offered by a non-captive provider, claims the firm.

"The testing needs of the industry are simply now too large in volume, and aggressive in cost, to rely only on functional application testing," says Cédric Mayor, VP marketing.

"We have developed a production-ready wafer sorting pilot line that enables us to scale test cell productivity to production-worthy throughput on 4–8" wafers, while reducing test cost and maintaining test quality," he adds. "We designed this line to specifically address the advanced testing needs of E-band power amplifier manufacturers, and we are now ready to roll out capacity."

Demand for testing in the 71–86GHz band is being driven by rapid growth in the telecom backhaul segment, which transports data from cell sites in the peripheral radio access network (RAN) to the wireless packet core, adds Presto.

"We are currently capable of testing more than 300 wafers per year

per test cell," Mayor continues.

"The full waveguide design avoids potential problems of connectors and cables and delivers repeatability of less than 0.2dB wafer-to-wafer between insertions, despite an output power of 25dBm per site," he adds.

"The service is completely turn-key, including state-of-the-art incoming and outgoing inspection and conditioning processes for ultrathin 50µm-thick GaAs wafers. In fact, we have achieved near-zero breakage rates on GaAs wafers, and we are currently developing similar test capability for GaN, which we expect to be ready to be rolled out in 2015, pushed by the RF power amplifier market demand."

www.presto-eng.com



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www.rel-test.com

Keithley provides full wafer-level support including high-voltage CV testing for parametric curve tracer configurations

Electrical test instrument and system provider Keithley Instruments Inc of Cleveland, OH, USA has introduced new enhancements to its parametric curve tracer (PTC) configurations that incorporate high-power SourceMeter source measure unit (SMU) instruments.

For test engineers responsible for configuring high-power semiconductor test systems, the new Model 8020 High Power Interface Panel improves connectivity and simplifies complex measurements like high-voltage capacitance-voltage (C-V) measurements. The Model 8020 reduces set-up times, minimizes opportunities for connection errors, improves operator and test hardware protection, and increases users' confidence in the accuracy of their results, says the firm.

Characterizing high-power devices such as power MOSFETs, IGBTs and diodes involves several different types of measurements: on-state (high-current current-voltage), off-state (high-voltage current-voltage) and capacitance-voltage (C-V) at high bias voltages. However, each measurement requires the use of different instrumentation, cabling, connectors, and probes (for wafer-level testing) or test fixtures (for packaged device testing).

In the past, no standardized solutions for combining high-power instruments, interconnects and probers/test fixtures suitable for all three test types in the same test station were commercially available, says Keithley. When changing from one measurement type to another, high-power test system users once had to change the type of cables used manually, as well as critical hardware in the signal path between the device-under-test and the test instrumentation. High-voltage C-V testing was particularly complicated because no standard or reliable measurement setups and methods



Keithley's Model 8020 High Power Interface Panel.

were established. Test engineers often had to develop their own connection solutions through trial and error, which is not only expensive and time-consuming but can create an unsafe work environment, given the high outputs involved in testing power devices.

Keithley says that the configurable Model 8020 High Power Interface Panel allows test engineers to select the options that match their system's probe station, positioners or fixture. It also improves safety for both users and any low-power SMU instruments in the system, simplifies incorporating different combinations of instruments, as well as taking the confusion out of adding elements like series resistors and bias tees to the signal path, claims the firm.

The Model 8020 simplifies changing from one measurement type to the next by allowing test engineers to connect all measurement instruments to it at once, making further connection changes unnecessary, Keithley adds. When configured with optional C-V bias tees on the system's 3kV and 200V channels,

the Model 8020 acts as a high-performance I-V/C-V switch, allowing users to perform both I-V and C-V testing without re-cabling.

The Model 8020 provides input connections for Model 2657A (3kV) and 2651A (50A) high-power SourceMeter SMU instruments, Model 2636B and 2612B SourceMeter SMU instruments, and the Model PCT-CVU multi-frequency C-V meter. Various user-configurable output connec-

tors are available to accommodate almost any probe station.

The Model PCT-CVU, which supports C-V measurements from 10kHz to 2MHz, can be used to upgrade any Keithley PCT configuration to include 2- and 3-terminal capacitance measurements. It is designed for use with the new Model CVU-200-KIT bias tee kit to extend the voltage bias to 200V or the Model CVU-3K-KIT bias tee kit to extend it to 3kV to support both AC and DC testing in the Model 8010 or other high-power test fixtures.

The latest version (V 2.1) of Keithley's ACS Basic Edition Component Test Software expands the package's support for I-V and C-V measurements on devices like power MOSFETs, IGBTs and diodes. It complements the CV measurements that the Model 8020 and new bias tee kits make possible.

The Model 8020 High Power Interface Panel and other parametric curve tracer system enhancements are configurable products. Pricing depends on the specific configuration selected.

www.keithley.com

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IntelliEPI acquires GaAs epitaxy business from Soitec's Specialty Electronics subsidiary

IntelliEPI to widen customer base including automotive radar market, as Soitec focuses on key products

Soitec of Bernin, France, which makes engineered substrates including silicon-on-insulator (SOI) wafers and III-V epitaxial wafers, has announced the sale of the gallium arsenide (GaAs) epitaxy business of the company's Soitec Specialty Electronics subsidiary (based at Villejust in Essonne, France) to Intelligent Epitaxy Technology Inc (IntelliEPI) of Richardson, TX, USA.

Founded in 1999, IntelliEPI uses proprietary real-time in-situ growth monitoring technology on molecular beam epitaxy (MBE) to manufacture indium phosphide (InP), gallium arsenide (GaAs) and

gallium antimonide (GaSb) epi-wafers for microelectronics and optoelectronics applications.

The deal follows a collaborative agreement between Soitec and IntelliEPI in December 2013 to serve the GaAs market, which involved a technology license granted by Soitec to IntelliEPI (including the prospect of a future equipment transfer).

"The transaction will enable IntelliEPI to widen its customer base and penetrate to several critical GaAs application markets such as automotive radar technology," says IntelliEPI's president & CEO

Yung-Chung Kao. "It will also enable IntelliEPI to provide best-valued products and services to all its customers with expanded manufacturing capacities from its Texas, USA location," he adds.

"The sale of our GaAs epitaxy business to IntelliEPI reflects our drive to refocus Soitec's electronics division on its key products under its five-year Soitec 2015 program," explains Bernard Aspar, senior VP and general manager of Soitec's Communication & Power business unit.

www.intelliepi.com

www.soitec.com

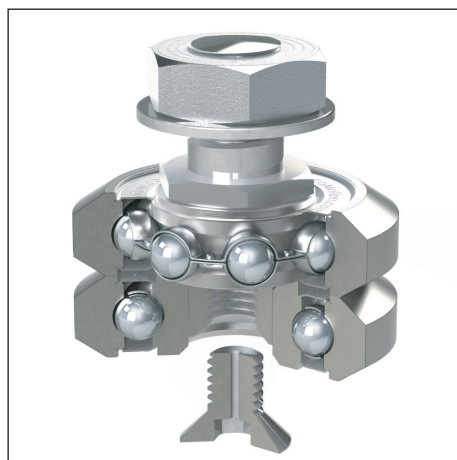
HepcoMotion's vacuum-grade bearings and vee slides used for Riber's latest MBE systems

HepcoMotion says that its vacuum-grade bearings and slides are being used by Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, in its latest systems.

Replacing an in-house unit, HepcoMotion's solution allows Riber to set the system pre-load without any play in the mechanism, ultimately providing much improved repeatability with a level of reliability not previously seen, it is claimed.

The MBE process requires wafers to be positioned accurately within a high-vacuum chamber. This highlights challenges with respect to accuracy and smoothness of motion, with the added complication of the need to work at a pressure of 10^{-9} mbar. Standard vacuum-compatible systems often only work under conditions reaching 10^{-6} mbar, says HepcoMotion.

When Riber needed to source a replacement positioning system, it turned to HepcoMotion and its size



HepcoMotion's vacuum bearing.

34 vacuum bearings. These complete stainless-steel products were already proving successful in vacuum applications up to 10^{-6} mbar, says HepcoMotion. To achieve the higher-vacuum suitability demanded, the firm used a special vacuum grease within the sealed bearings, allowing the product to operate at higher vacuum for extended process periods without fear of breakdown.

In wafer transfer operations, the

length of travel can vary, however Riber's standard solution calls upon flat SL2 slides (SSM44 x 1000mm long) with two VACSS SJ34C bearings and two VAC SSSJ34E bearings fitted into a special carriage, with the rack/pinion providing the drive solution. The configuration has been optimized to furnish Riber with an easy-to-install package.

HepcoMotion says that Riber now has a highly reliable solution with the opportunity to vary the frictional resistance to suit the application load and to maintain a high level of accuracy. A low-friction system is vital if fretting corrosion is to be avoided where stainless steels are running together effectively dry. Any contamination within the chamber would compromise the process, leading to a loss of wafers. HepcoMotion says that its vee guide has been able to provide the level of confidence needed by Riber to satisfy this specialist application.

www.hepcotion.com

www.riber.com

Riber sees 44% revenue growth in third-quarter 2014, driven by research MBE systems

Orders rising for Cells & Sources and Services & Accessories

For the first nine months of 2014 (to end-September), Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported a 10% drop in revenue year-on-year from €10.2m to €9.2m (50% from Asia, 44% from Europe and 6% from North America).

Of this, Systems revenue was €5.3m, down 11% year-on-year from €6m. Revenue from Services & Accessories was €3.3m, down 5% year-on-year from €3.1m. Revenue from Cells & Sources was €0.7m, down 28% year-on-year from €1m.

However, the total revenue for the first nine months of 2014 includes revenue for third-quarter 2014 of €4.3m, up 44% on €3m last quarter and up 79% on €2.4m a year ago. Of this, Systems revenue was €3.2m, up 55% on €2.1m last quarter. Revenue from Services & Accessories was €0.8m, level with last quarter. Revenue from Cells & Sources was €0.3m, up 112% on €0.1m last quarter.

The improved invoicing figures in Q3 reflect the seasonal trends for the production plan, which are focused on the end of the year. Over the first nine months of the year, five MBE machines were invoiced, compared with seven during the same period in 2013.

At the end of September, the order book amounted to €8m

(down 33% on €12m a year ago, but level with end-June 2014). This included eight systems worth €4.9m (down 50% on Systems orders of €9.7m a year ago but also down 11% on €5.5m at end-June). Nevertheless, with demand contracting on the industrial market, sales of Services & Accessories and Cells & Sources have shown a good level of resilience, due to the dynamic commercial development in the research market. In Q3/2014, Riber received orders for four MBE research systems in Poland, Russia and Taiwan. Orders for Services & Accessories plus Cells & Sources were collectively €3.2m (up 28% on €2.5m at end-June and 34% on €2.4m a year ago). Of this, Services & Accessories orders were €2.4m (up 10% on €2.1m at end-June and 13% on just under €2.1m a year ago), while Cells & Sources orders were €0.8m (double the €0.4m at end-June and nearly triple the €0.3m a year ago).

Riber is moving forward with the implementation of its diversification strategy, signing distribution agreements for thin-film deposition products with complementary technologies to supplement MBE [with CVD, ALD and PVD]

"In a still challenging environment, the third quarter of 2014 showed signs of improvements, including a stronger level of orders placed thanks to Riber's proactive commercial approach on the research market," says chairman Frédéric Goutard.

Riber is focusing its sales & marketing on the research market and developing its new range of organic light-emitting diodes (OLED) cells. "We are moving forward with our OLED roadmap, with the development of a new range of cells," says Goutard. "Our objectives in this buoyant market are being consolidated with the pilot materials sold this quarter," he adds.

Alongside this, Riber is moving forward with the implementation of its diversification strategy, signing distribution agreements for thin-film deposition products with complementary technologies to supplement MBE (e.g. with France-based CVD and ALD system supplier AnnealSys in July and Mexico-based PVD system supplier Intercovamex in October).

In view of its industrial production schedule for fourth-quarter 2014, Riber has confirmed its full-year 2014 target for revenue of €15–19m (down about 28% on €23.5m in 2013), with a loss of over €3m (compared with net income of €0.2m in 2013).

www.riber.com

Riber to distribute Intercovamex PVD systems

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has signed a distribution agreement with Intercovamex of Mexico, a supplier of physical vapor deposition (PVD) systems.

Riber says it is moving forward with its diversification strategy into other thin-film deposition techniques, and will be the exclusive distributor of Intercovamex PVD systems in the USA, Russia, India, China, UK, France and the French-speaking part of Switzerland.

Formed in 1991 by ex Riber engineer Jean Marc Zisa, Intercovamex is the largest high-vacuum PVD system manufacturer in Latin America. Intercovamex has represented Riber as a distributor in Latin America for 22 years.

www.intercovamex.com/en-research/sistemas-depositos.html

Epistar qualifies Veeco's new EPIK700 MOCVD system for high-volume LED production

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA says that Taiwan's largest LED chip-maker Epistar Corp has evaluated and accepted its new TurboDisc EPIK700 gallium nitride (GaN) metal-organic chemical vapor deposition (MOCVD) system for the production of light-emitting diodes.

"It is vital that we continue to push our roadmap to reduce solid-state lighting costs with the most innovative and efficient production solutions available," comments Epistar's president Dr MJ Jou. "EPIK's performance, reliability and production readiness, as well as the support we received from Veeco during the beta-testing phase, fully met our high manufacturing standards," he adds. "The seamless recipe transfer from our installed base of Veeco K465i and MaxBright systems to the EPIK700 is allowing us to quickly produce production-quality LED devices. In addition, the EPIK700's cost of ownership advantage will help reduce our cost per wafer, making it a highly attractive platform for our future capacity expansions."

Based on Veeco's proven TurboDisc technology, the EPIK700 MOCVD system (launched in September)



enables users to achieve cost per wafer savings of up to 20%, it is reckoned (compared to previous-generation MOCVD systems), through improved wafer uniformity, reduced operating expenses and increased productivity.

"Given Epistar's position as one of the world's top LED manufacturers... we look forward to supporting future Epistar expansions in Taiwan and China," says Jim Jenson, senior vice president, Veeco MOCVD Operations. "Our goal at Veeco is to help customers further accelerate the solid-state lighting market by driving down LED manufacturing costs and increasing productivity," he adds.

Veeco's new EPIK700 is reckoned to be the LED industry's highest-

productivity MOCVD system. Available in one-and two-reactor configurations, it 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, due to its large reactor size (accommodating 31x4", 12x6" and 6x8" wafer carrier sizes), the EPIK700 offers a 2.5x throughput advantage over other systems. Users can easily transfer processes from existing TurboDisc systems to the new EPIK700 MOCVD platform for quick-start production of high-quality LEDs, says Veeco. Also, because of the flexibility of the platform, more upgrades, added benefits and future enhancements will continue to differentiate the system, the firm adds.

www.epistar.com.tw

www.veeco.com/mocvd

Nanojoin chooses Veeco MaxBright M systems for production ramp

In Q3/2014, China's Suzhou Nanojoin Photonics Co Ltd ordered multiple TurboDisc MaxBright M MOCVD systems for high-volume production of LEDs to be used for general lighting applications.

Nanojoin was jointly founded in 2008 by Suzhou New Sea Union Telecom Technology Co Ltd, Suzhou Institute of Nano-tech and Nano-bionics (SINANO) and the Chinese Academy of Sciences (CAS). Covering an area of 150,000m², along with a clean production workshop of 24,000m² and production and testing lines,

Nanojoin specializes in the development and production of LED wafers, chips and solid-state lighting (SSL) products. It currently uses both single- and multi-reactor Veeco MOCVD systems in its production fab.

"After careful evaluation of all platforms, we have determined that Veeco's MOCVD technology provides the unique advantages needed to successfully ramp LED production," comments Nanojoin's general manager Wang Huaibing. "As we look to capitalize on growing adoption of energy-efficient lighting,

we required an MOCVD system that is both stable and productive."

The MaxBright M offers a modular, compact design for improved serviceability and up to 15% improved footprint efficiency compared with the standard MaxBright MOCVD system, says Veeco. The system features numerous layout configuration options to fit various fab spacing requirements, including sub-floor storage, which enables more wafer starts per square foot and a reduced cost of ownership.

www.nanojoin.com

www.veeco.com/mocvd

Sandia orders Taiyo Nippon Sanso commercial-grade GaN MOCVD tool

Matheson of Basking Ridge, NJ, USA, a subsidiary of Taiyo Nippon Sanso Corporation (TNSC), has been selected by Sandia National Laboratories to provide a commercial-grade gallium nitride (GaN) metal-organic chemical vapor deposition (MOCVD) system for its compound semiconductor device development work with aluminum gallium nitride (AlGaIn) and aluminum nitride (AlN). The fully integrated SR-4000HT tool is scheduled for delivery in Q1/2015. TNSC will build the tool at its production facilities in Japan, and Matheson will be the US provider of the system to Sandia.

"We evaluated several different supplier systems and platforms for our needs through our rigorous competitive bidding process and, in the end, we found that the SR-4000HT best met our technical specifications," says Jeffrey Fiegel, a member of

the Sandia technical staff who participated in the selection process. "Its capability to grow atmospheric AlGaIn layers with a high growth rate will improve the efficiency of our device development efforts, as well as, we believe, produce higher quality materials," he adds.

"The unique design of the SR-4000HT is largely based on Sandia's research in early 2000 and the joint research between TNSC and Kyoto University in the late '90s," says TNSC's executive corporate officer Koh Matsumoto. "Growing high-aluminum-content devices at high growth rates, while operating at higher than 40kPa pressures and elevated temperatures, will afford Sandia shorter fabrication turnaround times, better electrical properties, and unmatched reproducibility."

www.mathesongas.com

www.sandia.gov

IN BRIEF

President & CEO for Intermolecular

Intermolecular Inc of San Jose, CA, USA has appointed Dr Bruce McWilliams as president & CEO, replacing David Lazovsky, who has resigned as president & CEO and from the board of directors.

"We are grateful to Dave for his many years of service in leading Intermolecular from its inception," says McWilliams. "

McWilliams has served on the Intermolecular board since 2005 (chairman since June 2014). He was most recently CEO of SuVolta from June 2009, and CEO of Tessera from 1999 to 2008.

"I am looking forward to working with our customers to realize the value of our unique R&D platform and capabilities," says McWilliams.

www.intermolecular.com

www.laytec.de

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CVD Equipment adds chief operating officer

CVD Equipment Corp of Central Islip, NY, USA (a designer and maker of equipment for developing and manufacturing electronic components, materials and coatings for research and industrial applications) has appointed Dr Steven Aragon to the newly created position of chief operating officer.

CVD offers a range of chemical vapor deposition, gas control, and other equipment for the research, design and manufacture of semiconductors, solar cells, graphene, carbon nanotubes, nanowires, LEDs, MEMS, smart glass coatings, battery, ultra-capacitors, medical coatings, industrial coatings and equipment for surface mounting of components onto printed circuit boards. CVD's application laboratory focuses on higher-efficiency

nano and nano-to-macro material manufacturing for a variety of growth markets, marketed through subsidiary CVD Materials Corp.

Aragon has over 25 years of thin-film process, materials, and system expertise applied to photovoltaic, optical, electronic, and magnetic device fabrication. He received his Ph.D. in Physical Chemistry from the University of California, Santa Cruz, in 1990 and his MBA from Santa Clara University in 1996. Aragon is the holder of five process equipment design patents. He was a co-founder of Optimus Energy Systems International Inc and served as its chief technical officer & senior VP – engineering. Previously, he was VP – engineering at Stion Corp of San Jose, CA, USA, which makes nanostructure-based

CIGSS (copper indium gallium sulphur-diselenide) thin-film photovoltaic panels. His prior experience also included serving as VP – engineering at CIGS PV maker Day Star Technologies Inc.

"I have known Steve for about 10 years and worked with him as a customer of CVD," says president & CEO Leonard Rosenbaum, who adds that Aragon will help CVD continue to expand its production capabilities.

"As a former customer, I can attest to the excellence of R&D and manufacturing products offered by CVD," comments Aragon.

"The continued investment in the Operational area of our business will provide the expertise to support growth in key strategic markets."

www.cvdequipment.com

Cardiff University planning Research Institute for Compound Semiconductor Technology

At the Cardiff University's first Innovation Fast Forward Festival in Wales, UK, vice-chancellor professor Colin Riordan has outlined plans to invest £300m to transform a site from a disused, former industrial space into a new campus comprising four new buildings.

As well as what is claimed to be the world's first Social Science Research Park (SPARK), an Innovation Centre and a Translational Research Facility, this includes a Research Institute for Compound Semiconductor Technology.

As a unique facility in the UK, the proposed institute would demonstrate and test compound semiconductor technology in realistic environments, providing facilities that allow for R&D but also greater engagement with industry, aiming to position Cardiff to become the UK and European leader in translational research in this area.

"Cardiff Innovation System matches a multi-million pound investment with a vision to put innovation and



entrepreneurship at the heart of our strategy," said Riordan.

"Working with the Welsh and UK governments, local authorities such as Cardiff Council, the NHS in Wales, business partners and civic society, Cardiff Innovation System can establish the university, the city and Wales as international leaders in innovation," he believes. "Cardiff Innovation system will help us demonstrate the relevance of our work to the communities we serve, better connect industry,

business, government and charities with our academics, and nurture student entrepreneurship and grass-roots business development."

Riordan also outlined how it is intended to develop and embed an ethos of innovation across the university. Plans include a

practitioners/innovators-in-residence program, high-level training and skills development for postgraduate students, and the development of existing enterprise education and opportunities to strengthen the culture of entrepreneurial and innovative thinking among students.

Business cases are being developed for the proposed new buildings, to be subjected to approval of the university's Council (its governing body).

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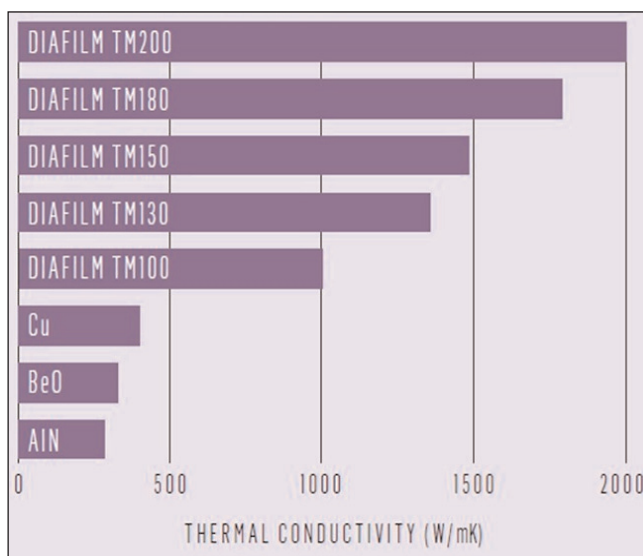
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Element Six launches thermal grade of CVD diamond for heat management

Luxembourg-registered synthetic diamond materials firm Element Six (a member of the De Beers Family of Companies) has developed a new thermal grade of diamond grown by chemical vapor deposition (CVD). DIAFILM TM130 has a thermal conductivity in excess of 1300W/mK and is available in both metallized and unmetallized wafers form.

Similar to Element Six's material grades in its DIAFILM TM range, TM130 offers full isotropic heat spreading in both planar and through-plane directions. Enhancing its portfolio to offer more options addressing unique thermal management needs, Element Six now provides five material grades spanning five levels of performance (1000–2000W/mK).

"CVD diamond is the most thermally conductive material at room temperature, far surpassing the thermal conductivity of copper," says Adrian Wilson, director of Element Six Technologies. "With this new offering, we're continuing to build our extensive portfolio of thermal grade materials to meet the needs of those in the microelectronics and electronics packaging industry," he adds. "Recognizing a 'one-size fits all' approach is not effective, we are committed to providing a full range of options and specifications to effectively address



TM130 joins Element Six's family of CVD diamond heat spreaders, which thermally outperform traditionally used materials such as copper.

thermal management challenges, including specific requirements for surface flatness, low roughness and metallization."

Element Six says that, due to its combination of properties including high thermal conductivity, mechanical strength, electrical insulation, low weight and chemical inertness, CVD diamond is uniquely suited to thermal management in applications such as advanced packaging. In this role, CVD diamond enables system size reductions, improved reliability and the opportunity to design higher-power systems within an existing module footprint.

With a focus on customizability, Element Six's solid thermal products are available up to 3mm thick and in diameters up to 140mm that can be laser cut to any required size.

Metallization solutions also enable die bonding with low thermal barrier resistance, consistent with industry-standard soldering and brazing.

At the International Microelectronics Assembly and Packaging Society's 47th International Symposium on Microelectronics (IMAPS) in San Diego, CA, USA,

on 15 October Element Six gave the presentation 'Advanced Thermal Dissipation in GaN-on-Diamond Transistors' (developed in conjunction with the University of Notre Dame), discussing the thermal barriers that stand in the way of achieving the intrinsic performance potential of gallium nitride (GaN) semiconductors, including details of a recent solution that replaces GaN's entire host substrate — such as silicon or silicon carbide (SiC) — with a synthetic diamond substrate (resulting in a more than 40% reduction in peak device temperature).

www.e6.com/thermal

Thermco recruits sales & marketing director

Thermco Systems, a division of Tetreon Technologies Ltd of Washington, West Sussex, UK, says that Dr Amir R. Mirza is joining its leadership team as sales & marketing director.

As a designer and manufacturer of capital equipment for the semiconductor, MEMS, LED, photovoltaic and nanotechnology industries, Thermco Systems makes horizontal diffusion furnaces, and has sold



more than 30,000 furnaces since the company was founded in 1962.

Mirza has over 20 years' experience in the semiconductor industry in a variety of engineering and management roles at Honeywell, GE and Motorola. In addition,

in the semiconductor capital equipment arena, he has served as international product manager with SUSS MicroTec and as technology manager with EV Group.

"His product marketing and broad international business development experience will help drive our continued growth in the emerging markets sector," comments Thermco Systems' CEO Gerry Thurgood.

www.thermosystems.com

OEM Group signs Sciencetech as exclusive distributor in China

OEM Group of Phoenix, AZ, USA, which supplies legacy semiconductor capital equipment, has signed an agreement with Sciencetech Corp as an exclusive representative/distributor for China. Specifically, Sciencetech will be the authorized distributor for OEM's LEGENDS product lines.

OEM Group provides new and re-manufactured systems, specialized upgrades, genuine parts, certified service, software licensing, and process application development. Its LEGENDS technology portfolio is based on exclusive intellectual property acquired from semiconductor brands including: P5000, Tegal Etch, Sputtered Films Endeavor, Equinox, MRC Eclipse, AGHeatpulse, Varian Sunset, Lam AutoEtch and Applied Materials-Semitool manual batch, automated batch and single-wafer Equinox. OEM Group also offers applications development labs for

wet processing and foundry services for piezoelectric AlN films.

Established in Taipei in 1979 and with offices throughout China and Taiwan, Sciencetech is a service and equipment representative firm serving the semiconductor (front-end, back-end and GaAs), flat-panel display, LED, data storage, scientific instrument and high-tech sectors.

"Together, we will bring customers throughout China our proprietary LEGENDS solutions, and help those markets accelerate," says OEM Group's CEO Wayne Jeveli. "By partnering with Sciencetech, we are leveraging their local presence, strong service infrastructure and extensive expertise in our target markets," he adds. "This continues the expansion of our capabilities in Asia and is key to serving our customers quickly and efficiently."

www.oemgroupinc.com

IN BRIEF

'Manufacturer of the Year' for IQE at Made in Wales awards

At a ceremony on 23 October at in Cardiff (organized by UK-based business publisher Insider Media Ltd, and attended by Julie James, the Welsh Government's deputy minister for skills and technology), epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK was announced as winner of the 'Manufacturer of the Year' title at the Made in Wales Awards.

The award is in recognition of IQE's manufacturing development during the last 12 months. The firm was cited as being the market leader in providing wafers to the wireless chip industry, having a global market share of 50-60%.

www.iqep.com

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EVG unveils covalent bonder for engineered substrate and power device production

Targeted applications include compound semiconductors and engineered substrates for 'beyond CMOS'

EV Group of St Florian, Austria (a supplier of wafer bonding and lithography equipment for MEMS, nanotechnology and semiconductor applications) has launched the EVG580 ComBond high-vacuum wafer bonding system, which enables electrically conductive and oxide-free covalent bonds at room temperature. Built on a modular platform to support high-volume manufacturing (HVM) requirements, the new system is suited to bonding different substrate materials together in order to enable higher-performing devices and new applications, including multi-junction solar cells; silicon photonics; high-vacuum MEMS packaging; power devices; and compound semiconductor and other advanced engineered substrates for 'beyond CMOS' applications such as high-mobility transistors, high-performance/low-power logic and radio frequency (RF) devices.

Several EVG580 ComBond systems have already been shipped to device makers and R&D centers. Customer demonstrations are available at EVG's corporate headquarters.

"During the recent installation and acceptance test phase our new EVG580 ComBond has demonstrated its capacity to create excellent covalent bonds at room temperature," says Fabrice Geiger, VP Silicon Technologies Division at micro/nanotechnology R&D center CEA-Leti of Grenoble, France. "CEA-Leti is looking forward to working with EVG within our Common Lab on implementing the EVG580 ComBond to further development activities in several key areas," he adds.

"The EVG580 ComBond system masters the crucial surface preparation steps that are needed to ensure contamination- and oxide-

free bonds at room temperature," says EVG's executive technology director Paul Lindner. "We can bond nearly anything on anything — creating many different material combinations in wafer form," he adds. "This supports our customers' efforts to develop and ramp new devices into mass production to enable a variety of emerging and high-growth applications — from the development of silicon photonics for next-generation telecommunications to more advanced power devices that can enable electric vehicles to drive longer distances between charges."

Challenges combining compound semiconductors and silicon

Combining materials with different properties to produce electronic devices, such as III-V compound semiconductor materials like gallium nitride (GaN), gallium arsenide (GaAs) and indium phosphide (InP) with silicon substrates, can lead to enhanced device performance due to higher carrier mobility as well as open up new capabilities such as the emission of light through silicon, which can enable optical interconnects and routers, says EVG. However, combining these materials through traditional epitaxial growth processes leads to crystal dislocation defects due to differences in lattice constant and coefficient of thermal expansion (CTE), which in turn degrade performance.

Benefits of wafer bonding

These manufacturing issues can be mitigated by growing each semiconductor material separately on optimized growth substrates and then combining them through wafer bonding, says EVG.

Room-temperature covalent bonding, in particular, is a suitable choice since it eliminates the need for annealing processes, which gener-

ate high temperatures that can add additional stress due to CTE mismatch. However, a key limitation of room-temperature covalent bonding has been the inability to maintain tight control of the thickness and uniformity of the bond interface layer, including effective removal of particle contaminants and the native oxide layers, which is necessary to achieve an interface that has both sufficient bond strength and electrical conductivity between the bonded materials. The EVG580 ComBond addresses these limitations, says the firm.

Key features

Key features of the EVG580 ComBond include the following:

- a dedicated ComBond Activation Module (CAM) seamlessly integrated into the platform, which provides advanced surface preparation by directing energized particles to the substrate surface instead of wet chemical etching to achieve a contamination-free and oxide-free bond interface;
- operation in a high-vacuum process environment, preventing re-oxidation of the treated wafers prior to the bonding step;
- configurable with up to five modules that can process in parallel to support both R&D and HVM applications; and
- processing of wafer sizes up to 8-inches (200mm).

EVG at SEMICON Europa

EVG exhibited at SEMICON Europa 2014 in the ALPEXPO, Grenoble, France (7–9 October). Also, the firm's representatives presented 'Future of MEMS: Market and technologies perspective' at the International MEMS Industry Forum, 'Hybrid wafer bonding for 3D IC' at the 3D Integration Session and 'Nanoimprint status for HVM' at the Lithography Session.

www.evgroup.com

EVG introduces SmartNIL large-area nanoimprint lithography process, targeting photonics, LED and bioengineered device production

EV Group of St Florian, Austria (a supplier of wafer bonding and lithography equipment for MEMS, nanotechnology and semiconductor applications) has introduced its SmartNIL large-area nanoimprint lithography (NIL) process. Available on all EVG NIL platforms, including mask aligners as well as the EVG720 and the new EVG7200 UV-NIL systems, SmartNIL provides a low-cost, large-area and high-volume manufacturing solution for a variety of advanced devices, including:

- photonic-based devices such as LEDs, lasers and photovoltaics;
- micro arrays and nano-devices for medical devices and bioengineered applications; and
- advanced storage media, including emerging forms of non-volatile memory (NVM).

"SmartNIL is built on more than 15 years of NIL experience at EVG that includes the largest installed base of NIL systems worldwide, and is the only NIL technology currently used in high-volume manufacturing on substrates up to 200mm today," says executive technology director Paul Lindner. "With our new EVG7200 UV-NIL system, which has industry-leading resolution down to 20nm in volume production, EVG brings the advanced soft stamp and imprint capability of SmartNIL to larger substrates and smaller geometries," he adds. "This enables our customers to achieve even greater cost-of-ownership (CoO) benefits and realize the full manufacturing potential of nanoimprint lithography."

The benefits of SmartNIL include:

- Photonic devices (such as photovoltaics, LEDs, laser diodes and optical sensors) rely on the nano-scale manipulation of light to achieve optimal performance. This can be tailored by using nano-scale structures such as photonic crystals, gratings, phase-shift structures and



EVG's SmartNIL large-area soft nanoimprint lithography process for high-volume manufacturing is available on the new EVG7200 automated UV-NIL system.

wave guides.

- In bioengineered applications, nano-scale manufacturing processes are a requirement, since most biologic events begin at the nanometer scale.
- For both applications, traditional writing methods for producing nano-scale features either have extremely low throughput and hence cannot be easily scaled up



The EVG720 NIL system.

for cost-efficient production (such as electron-beam writing) or have sufficient throughput but are too cost-prohibitive, such as stepper systems for optical lithography.

- Certain photonic and bioengineered applications can also realize greater throughput and CoO benefits from the ability to pattern 3D structures or different height levels in a single step, which can best be accomplished with a soft-stamp UV-NIL approach.

- SmartNIL coupled with the EVG720 system (for 150mm substrates), which is in use at multiple device manufacturers' fabs, and the new EVG7200 system (for 200mm substrates) provides the optimal combination of high resolution, high alignment accuracy and high throughput in a cost-effective platform required for volume production for photonic and bioengineered device applications.

Key features of SmartNIL technology include the following:

- A large full-field imprint area (up to 200mm).
- The fastest full-substrate UV-NIL solution for high-volume-manufacturing applications (>40 substrates per hour for 200mm substrates).
- Integrated soft-stamp fabrication technology reduces tool footprint and provides fast replication (less than 10 minutes versus 24 hours or more with competing technologies).
- Enables patterning on highly topographical structures; less sensitive to bowed and warped wafers.
- Optimized releasing properties extend the lifetime of the stamp.
- Self-cleaning properties reduce particle contamination and improve overall processing yields.
- A room-temperature process avoids thermal mismatch and long-range structure distortion for improved alignment accuracy.

www.evgroup.com/en/products/lithography/nanoimprint_systems

GT files for bankruptcy court protection under chapter 11

GT Advanced Technologies Inc of Merrimack, NH, USA (a provider of polysilicon production technology as well as sapphire and silicon crystalline growth systems and materials for the solar, LED and power electronics markets) has, along with certain of its subsidiaries, commenced voluntary cases under chapter 11 of the Bankruptcy Code in the US Bankruptcy Court for the District of New Hampshire. The firm expects that the court will authorize it to continue to conduct business as usual while it seeks to resolve its current issues and develops a reorganization plan.

As of 29 September, GT had about \$85m in cash. Now, it is seeking debtor-in-possession financing, which would provide an immediate source of additional funds enabling the firm to satisfy the obligations associated with the daily operation of its business, including the timely payment of employee wages.

As a result of the filing, NASDAQ may temporarily halt trading in the GT's stock pending the receipt of additional information on the firm's financial condition.

"GT has a strong and fundamentally sound underlying business," says president & CEO Tom Gutierrez. "Today's filing does not mean we are going out of business; rather, it provides us with the opportunity to continue to execute our business plan on a stronger footing, maintain operations of our diversified business, and improve our balance sheet," he adds. "We are convinced that the rehabilitative process of chapter 11 is the best way to reorganize, protect our company and provide a path to our future success. We remain committed to our roots in innovation and our diversification strategy. We plan to continue to operate as a technology leader across our core set of businesses."

Market analysts say that the bankruptcy stems from a breakdown in the firm's relationship with Apple. GT manufactures sapphire glass used in some Apple products. In November 2013, GT signed a multi-year, \$578m contract with Apple to supply advanced sapphire material for iPhone. The deal covers items such as the camera-lens cover window, the fingerprint-ID button, and (potentially) a full-screen sapphire touchscreen. GT is to produce the sapphire at Apple's facility in Arizona with around 700 GT staff. It was anticipated that Apple business would account for more than 80% of GT's 2014 revenues. According to financial services firm Raymond James, Apple loaned GT \$350m to build a sapphire manufacturing facility, and some have speculated that Apple may have requested early repayment.

www.gtat.com

Trading in stock switched from NASDAQ to OTC Pink Marketplace

GT Advanced Technologies says that it will not pursue an appeal of the determination by The NASDAQ Stock Market LLC to suspend trading in its common stock (from the

opening of the market on 16 October) based on the firm's voluntary petition for reorganization relief under Chapter 11 of the US Bankruptcy Code.

GT indicated that its common stock will be eligible to trade on the OTC Markets Group Inc's OTC Pink Marketplace (under the symbol GTATQ), effective 16 October.

Class action lawsuit filed against GT Advanced executives

Glancy Binkow & Goldberg LLP has filed a class action lawsuit 'Deerhaven Capital LLC vs Gutierrez et al' (docketed as 14-cv-00463) in the United States District Court for the District of New Hampshire on behalf of a class comprising purchasers (between 5 November 2013 and 9:40am on 6 October 2014 inclusive) of securities of GT Advanced Technologies Inc of Merrimack, NH, USA (a provider of polysilicon production technology as well as sapphire and silicon crystalline growth systems and materials for the solar, LED and power electronics markets).

The complaint alleges that defen-

dants made false and/or misleading statements and failed to disclose material adverse facts about the company's operations and financial prospects. Specifically, it is claimed, defendants misled investors that there were significant risks that the firm would be unable to fulfill the requirements of an agreement with Apple Inc to supply sapphire material and that, as a result, the firm was facing a liquidity crisis.

On 9 September, Apple revealed that its new iPhone 6 and iPhone 6 Plus smartphones utilized Corning's Gorilla Glass for the display instead of GT Advanced's sapphire material, as investors were expecting.

GT Advanced's share price subsequently fell by nearly 13% (\$2.29 per share) to close on 9 September at \$14.94 per share.

As of 29 September, GT Advanced had about \$85m of cash remaining. On 6 October, the firm said that it was filing for bankruptcy protection under Chapter 11. The firm's shares subsequently fell by nearly 93% (\$10.25 per share) to close on 6 October at \$0.80 per share.

Members of the class described above may move the court no later than 8 December to serve as lead plaintiff.

www.glancylaw.com/case/gt-advanced-technologies-inc-0

Bridgelux launches chip-on-board LED arrays using full Class A Color specification

At the Hong Kong International Lighting Fair 2014 (27–30 October), Bridgelux Inc of Livermore, CA, USA (a vertically integrated manufacturer of solid-state light sources for lighting applications) has debuted its new Vero Decor Series Class A chip-on-board (CoB) LED array products. The launch marks Bridgelux's new 'human-centric' approach to product development and color targeting by using gamut area index (GAI) to measure how light and color appeal to and are perceived by the human brain.

Lighting has become a critical design feature for high-end retail and commercial spaces, with solid-state LED technologies playing a vital role in helping businesses differentiate and stand out to their customers, says Bridgelux. "Light has the power to influence how people behave, what they purchase, their productivity and their mood," adds CEO Brad Bullington.

Traditionally, the lighting industry uses color rendering index (CRI) as a primary measure of light quality. However, CRI only measures color distortion. Gamut area index (GAI) measures color saturation and strength to more accurately reflect the holistic effect of light and how a

person will perceive color. The Decor Series Class A is engineered at the optimal GAI and CRI combination based on human perception of light.

Available through global channels in mid-November, the Decor Series Class A arrays are said to be the first products to use the full Class A Color specification from the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute and the Alliance for Solid-State Illumination Systems and Technologies (ASSIST).

In research and development since 2002, Class A Color – which redefines high color quality of light – was created at the LRC with funding by ASSIST. The long-term study examined how people perceive white light sources and what they prefer in terms of color rendering and the white hue or tint of a light source. Bridgelux specifiers and engineers developed prototype lamps based on the Class A Color spectral requirements for the LRC to use in field evaluations.

"Class A Color has been broadly tested and 'tuned' to ensure the most pleasing blend of naturalness and vividness based on subjective human perceptions," says Jean Paul Freyssinier, senior research scien-

tist at the Lighting Research Center. "A majority (75%) of those tested from around the world agree that Class A Color light sources provide the best color rendering and optimum saturation levels," he adds.

Distinguished by its human appeal, brightness and natural rendering, Class A colors are inherently more vivid and whites are their whitest due to a broader spectrum of colors and saturation, says Bridgelux. The firm says that, by achieving a balance of color properties that match how people perceive color, the Decor Series Class A LED arrays not only deliver superior color quality but also provide a better return on investment compared with traditional halogen and ceramic metal halide bulbs. Decor Series Class A LEDs consume 30% less energy, generate 70% less heat, and last 20 times longer than halogen or metal halide light sources, it is reckoned.

Vero Decor Series Class A arrays will be available with correlated color temperatures (CCTs) of 4000K and 3000K, designed for applications including high-end retail, hospitality, museums and commercial spaces.

www.bridgelux.com

Intelligent LED Solutions launches industrial UV LEDs

UK-based LED specialist Intelligent LED Solutions (ILS) – a division of display and optoelectronics provider Intelligent Group Solutions Ltd (IGS) – has launched a range of high-power UV LEDs suited to demanding industrial applications such as polymer curing, ink curing, counterfeit detection, aquarium lighting, medical and DNA sequencing.

The UV power LED has been designed to have higher thermal endurance (ensuring better reliability at higher temperatures) and comes in a range of output powers, package formats and wavelength options

(ranging from 365nm to 420nm). Radiometric power ranges from 320 to 7000mW.

The high-power UV LEDs feature a vertical chip structure on a patented metal alloy substrate, offering advances in optical output and high thermal conductivity.

"UV LED technology is playing an increasing role in industrial design," says ILS director Adrian Amor.

"The high-power LED offers a more efficient and more robust solution for engineers working to develop demanding applications that require a UV light source," he adds.

"For those exploring UV LED technology for the first time, our team at ILS is able to provide design support and prototyping within the European market place," continues Amor.

"We also have the capability to deliver production LEDs and assemblies to wherever in the world that the customer's manufacturing or assembly is being undertaken."

For those wishing to evaluate and prototype with the new high-power UV LED range, star boards with wires, strips and component LEDs will be available through RS Components.

www.i-led.co.uk

Lumileds adds smaller, 6.5mm 1202s to LUXEON CoB arrays for spotlights and directional lamps

In an expansion of its LUXEON CoB line, Philips Lumileds of San Jose, CA, USA has introduced the LUXEON CoB 1202s array, with a more compact size than the existing CoB 1202 that makes it a suitable for designers of PAR lamps and other compact directional lamps and spotlights. The CoB 1202s is also available with CrispWhite Technology, which highlights the richest whites, vibrant reds and colors for retail settings.

"The 1202s lifts the bar even higher by producing light output in a smaller, 6.5mm LES [light-emitting surface] that was only possible previously in 9mm LES arrays," says Ahmed Eweida, product manager for the LUXEON CoB line. "In addition,



Lumileds' new LUXEON CoB 1202s LED array.

the 1202s does so with a superior CBCP [center-beam candle power], delivering 65,000 candelas at a 10° beam angle," he adds.

Lumileds first introduced CrispWhite Technology for the retail lighting community across its chip-on-board line in July. "Shop owners and their customers clearly prefer LED lighting with CrispWhite over CDM and halogen," says product line director Eric Senders. Also, the LUXEON CoB range (including the 1202s) is available in a very warm version — with a correlated color temperature (CCT) of 2200K — for applications requiring a candlelight-like glow.

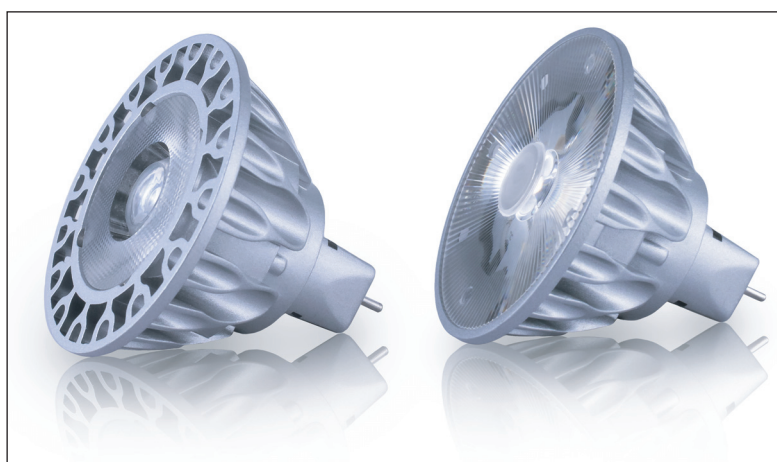
Lighting designers are using the CoB 1202s to produce highly reliable directional lamps. A full list of compatible drivers, optics and holders helps speed time-to-market of all downlights and spotlights as well.

www.philipslumileds.com/LUXEONCoB

Soraa launches MR16 lamps with third-generation GaN-on-GaN LED, boosting efficiency by 30%

Soraa Inc of Fremont, CA, USA, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates, has launched a complete line of MR16 LED lamps powered by its third-generation GaN-on-GaN LED. Featuring full-visible-spectrum light, the new MR16 LED lamps feature a 30% improvement in efficiency, suiting applications in restaurants, retail, high-end residential and office environments where light quality and smooth dimming are essential.

The new lamps feature the firm's point-source optics for high-intensity and uniform beams; and unique Violet-Emission 3-Phosphor (VP3) LED technology for rendering colors and whiteness. Utilizing every color, especially deep red emission, VP3 Vivid Color renders warm tones accurately, and achieves a color rendering index (CRI) of 95 and deep red (R9) rendering of 95, says the firm. Also, unlike blue-based white LEDs without any



Soraa's new MR16 LED lamps.

violet/ultra-violet emission, the VP3 Natural White is achieved by engineering the violet emission to properly excite fluorescing agents including natural objects like human eyes and teeth, as well as manufactured white materials such as clothing, paper and cosmetics.

As a replacement for halogen lamps, Soraa says that its true retrofit-sized MR16 LED lamps are fully dimmable and suitable for

enclosed, non-ventilated indoor and outdoor fixtures — where other LED lamps struggle to perform, the company claims.

The LED lamps are available in 50W to 75W halogen

equivalent light output; beam angles of 10°, 25°, 36° and 60°; 2700K, 3000K, 4000K and 5000K correlated color temperatures; and 95CRI and 85CRI.

Also, Soraa's 10° lamps work with its magnetic accessory SNAP System. With a simple magnetic accessory attachment, beam shapes can be altered and color temperature can be modified.

www.soraa.com

Isamu Akasaki, Hiroshi Amano and Shuji Nakamura awarded Nobel Prize for Physics

Professors Isamu Akasaki, Hiroshi Amano and Shuji Nakamura have been jointly awarded the 2014 Nobel Prize for Physics for their development of the first blue LEDs. Each will share prize money of 8 million kronor (\$1.1m/£0.7m).

"A lot of big companies really tried to do this and they failed," commented committee chair Per Delsing, a professor at Chalmers University of Technology in Gothenburg, Sweden. "But these guys persisted and they

tried and tried again, and eventually they actually succeeded."

By the start of the 1990s, red and green LEDs had been in production for several decades, but the creation of blue LEDs remained an important challenge. It would take blue LEDs to enable the mixing of all three colours to create white light.

In 1986, Akasaki and Amano, at Japan's Nagoya University, developed a technique to grow larger crystals than had previously been achieved

of the compound semiconductor gallium nitride.

In 1990, working at Tokushima-based Nichia Chemicals, Nakamura developed a technique that manipulated crystal growth temperature, which resulted in the production of gallium nitride crystals capable of being processed into blue LEDs. From here it was a short step to creating white LED light.

www.nobelprize.org/nobel_prizes/physics/laureates/

Nakamura receives Japan's Order of Culture Award

In a ceremony at the Imperial Palace on 3 November (Japan's Day of Culture), Emperor Akihito is presenting Shuji Nakamura with the 2014 Order of Culture Award, which recognizes contributions to the nation's culture.

Nakamura, a professor of materials at University of California Santa Barbara, is among several award candidates selected by Japan's Ministry of Education, Culture, Sports, Science and Technology. Chosen from a list of people designated as Persons of Cultural Merit, recipients are decided by the Cabinet of Japan.

"By making white LED lighting a reality, he has opened the door to affordable, energy-efficient lighting," says UCSB chancellor Henry T. Yang. "He also has advanced the frontiers of science with his unparalleled breakthroughs in physics, materials science and technology."

The Order of Culture award comes in the wake of Nakamura winning the 2014 Nobel Prize for Physics (shared with professors Isamu Akasaki and Hiroshi Amano) in recognition of the development of the blue LED which, in turn, paved the way for the white LED. Amano has also been selected for the 2014 Order of Culture medal. Akasaki was awarded the Order of Culture in 2011.



Nakamura at the press conference for his Nobel Prize in Physics. (Photo Credit: Sonia Fernandez.)

Nakamura received his bachelor's, master's and doctoral degrees in electrical engineering from the University of Tokushima, Japan. He spent the early years of his career in research at Japan's Nichia Chemical Industries Ltd, followed by a year at the University of Florida as a visiting research associate. In 1989, he initiated research into blue LEDs using group-III nitride materials. In 1993 and 1995, respectively, he developed the first group-III nitride-based blue/green LEDs then the first group-III nitride-based violet laser diodes (LDs). Nakamura is currently co-director at UCSB's Solid State Lighting & Energy Electronics Center (SSLEEC), where he continues to develop GaN thin-film technology.

Nakamura joined the faculty at UCSB in 2000 as professor of materials and of electrical and computer engineering. In 2001, he was appointed to the Cree Chair in Solid State Lighting and Display. Six years later he and his team of researchers at what was then known as the Solid State Lighting and Energy Center at UCSB achieved lasing operation in non-polar GaN semiconductors. Their demonstration of the first non-polar blue-violet laser diodes represented a breakthrough in laser diode development.

Nakamura's previous honors include the Nishina Memorial Award (1996), the Materials Research Society Medal (1997), the Institute of Electrical and Electronics Engineers' Jack A. Morton Award, the British Rank Prize (1998), the Benjamin Franklin Medal (2002), the Millennium Technology Prize (2006), the Czochralski Award (2007), the Prince of Asturias Award for Technical Scientific Research (2008), the Harvey Award (2009), the Technology and the Engineering Emmy Award (2011) and the LED Pioneer Award (2012). Also, in 2003 he was elected a member of the US National Academy of Engineering.

www.materials.ucsb.edu/recruitment/Faculty/nakamura/nakamura.php

US DOE announces \$10m funding opportunity for solid-state lighting research and development

As part of the Obama Administration's effort to cut energy waste and double energy productivity by 2030, the US Department of Energy (DOE) has announced solid-state lighting (SSL) research & development funding opportunity (DE-FOA-0001171, 'Solid-State Lighting Advanced Technology R&D - 2015'), under which a total of up to \$10m in funding will be directed toward all three existing DOE SSL R&D program areas:

- Core Technology Research — the application of fundamental scientific concepts to SSL technology;
- Product Development — using the knowledge gained from basic or applied research to develop or improve commercially viable SSL materials, devices, or systems;
- US Manufacturing — accelerating

SSL technology adoption through manufacturing innovations and improvements that reduce costs and enhance quality and consistency.

The funding aims to accelerate the development of high-quality light-emitting diode (LED) and organic light-emitting diode (OLED) products with potential to reduce lighting energy use for American families and businesses by half and enhance US global competitiveness.

During the past 10 years, the DOE has helped to accelerate SSL technology deployment, yielding estimated energy savings of \$1.8bn in 2013. The DOE's Office of Energy Efficiency and Renewable Energy (EERE) aims to accelerate development and facilitates deployment of energy efficiency and renewable energy technologies and market-

based solutions that strengthen US energy security, environmental quality, and economic vitality.

Solid-state lighting technologies, which include both LED and OLED technologies, have the potential to save \$26bn a year in energy costs in the USA by 2030, it is reckoned.

Currently available LED technology has luminous efficacy of about 150lm/W. The DOE targets a 75% rise to 250lm/W. Higher-performing LEDs will help to reduce overall costs and increase lighting efficiency.

The DOE will select up to 10 projects from industry, academia, and national laboratories. Concept papers are due by 14 November, and applications are due by 15 January.

<https://eere-exchange.energy.gov/#FoaIde4195533-28bf-4481-959b-597792fd4784>

Seoul Semiconductor announces mass production of Acrich MJT 3030 LED

South Korean LED maker Seoul Semiconductor has announced availability of its Acrich MJT 3030 LED. Using Seoul Semiconductor's high-reliability Acrich MJT technology, the MJT 3030 offers improved performance and high lm/\$ in a mid-power package, says the firm.

Measuring 3.0mm x 3.0mm, the Acrich MJT 3030 delivers a typical luminous flux of 103 lumens at 40mA at 22V, 25°C, 3000K and can be driven to a maximum current of 60mA, delivering up to 155 lumens to address high-lumen applications that require low-cost and high-reliability solutions. To improve time-to-market, lighting manufacturers seeking ENERGY STAR qualification can take advantage of the completed 6000 hours LM-80 data of the MJT 3030.

Utilizing Seoul Semiconductor's high-voltage architecture Acrich MJT 'Multi-Junction chip Technology', the Acrich LED eliminates the



Seoul Semiconductor's new Acrich MJT3030 packaged LED.

trade-off between size and efficacy, it is claimed. The Acrich MJT 3030 can be operated in either AC or DC modes. AC mode, which uses

The new Acrich MJT 3030 LED combines the improved performance and high lumens per dollar with the reliability of the MJT technology

the Acrich IC instead of an AC/DC converter, improves reliability and simplifies integration when making lighting fixtures.

The 0.97 power factor and the low total harmonic distortion (THD) of Acrich IC-based modules helps save energy and optimize designs. In DC-mode, the low-current operation can lower the number of components and reduce the cost of the power supply. The inherent flexibility of the Acrich MJT 3030 LED enables optimized performance in both AC and DC configurations, says the firm.

"The new Acrich MJT 3030 LED combines the improved performance and high lm/\$ with the reliability of the MJT technology, enabling lighting manufacturers to create new innovative solutions to address a wide range of lighting applications," says Jay Kim, executive VP of lighting sales.

www.seoulsemicon.com

Illuminating Engineering Society recognizes Lattice Power for first high-output GaN-on-silicon LED PAR38 lamp

Lattice Power Corp of Nanchang, China, which claims to be the first company to commercialize gallium nitride (GaN)-on-silicon LEDs, says that its new PAR38 LED lamp has been recognized by the Illuminating Engineering Society (IES) Progress Committee as providing an important advancement in lighting. The firm's new proprietary GaN-on-Si LED PAR38 LED lamp delivers what is claimed to be outstanding efficacy, superior brightness and excellent color rendering.

Growing GaN material on a silicon substrate has been a vexing problem for the industry as a result of the material lattice mismatch and thermal expansion mismatch between GaN thin film and silicon substrate, says Lattice Power.

These mismatches contribute to defects in the material, cracking on the wafer and poor quantum efficiency of the epi-layer.

By developing a series of proprietary technologies to overcome the mismatch problems, Lattice Power says that it is able to manufacture consistent quality and reliable LEDs, adding that its GaN-based LEDs on silicon substrate offers high light density and better thermal dissipation.



Lattice Power's 2000lm PAR38 LED lamp, recognized by the IES Progress Committee.

The firm's GaN-on-Si LED PAR38 lamp has what is claimed to be the industry's highest lumen output without active cooling — 2000 lumens at 27W. A thermal pipe heat-sink provides efficient heat dissipation and eliminates the need for active cooling. The lamp is also claimed to have the highest power and lumen density from a single-emitter LED and the lowest thermal resistance from an integrated package (at 0.25C/W). The 27W PAR38 LED

lamp is available in various color temperature.

As a vertically integrated company, LatticePower designs, engineers and manufactures all the components in its lighting products, optimizing performance for commercial applications and reducing time to market at scale, says the firm. All products are certified to international standards for the general lighting market, including indoor and outdoor applications.

The IES Progress Report submittals, which consist of new products, applications, research, design tools and publications, are reviewed by

the IES Progress Committee, which is responsible for monitoring developments in the art and science of lighting worldwide. The committee consists of lighting industry professionals with expertise in various areas in the field. Each submittal goes through a comprehensive judging process and is evaluated for uniqueness, innovation and significance to the lighting industry.

www.lpglighting.com

www.ies.org/progress

Luminus announces 5-year warranty on XNOVA COB LED arrays & completion of 6000-hour LM-80 test

Luminus Devices Inc of Billerica, MA, USA has announced a five-year limited warranty for the XNOVA family of chip-on-board (COB) arrays designed for both indoor and outdoor directional lighting applications.

This follows the recent completion of the firm's 6000 hour LM-80 testing, which demonstrated long-term color stability and robust lumen maintenance under extreme conditions, including high temperature and high drive current.

"Our XNOVA COB arrays have already been recognized by customers as having industry-leading efficacy, value, and quality of light, and now we have long term data and the 5-year warranty to give customers peace of mind knowing that their fixtures and bulbs will comply with Energy Star and deliver consistent performance for many years to come," says Jim Miller, Luminus' executive, VP of sales & marketing. "Our mission is to help our customers achieve

new levels of performance in their end products, so that they can gain advantages over their competitors, and this 5 year warranty helps our customers confidently position themselves as providers of robust, long lasting bulbs and luminaires," he adds.

Luminus Devices showcased its XNOVA illumination product line at the Hong Kong International Lighting Fair (27-30 October).

www.luminus.com

[/products/xnova.html](http://products/xnova.html)

GaN micro-rods grown on graphene yield flexible LEDs

Catalyst-free MOCVD process promises bendable and stretchable electronic and optoelectronic devices

Currently, most flexible electronic and optoelectronic devices are fabricated using organic materials. However, for these devices inorganic compound semiconductors such as gallium nitride (GaN) can provide advantages over organic materials — including superior optical, electrical and mechanical properties — but they are difficult to grow on flexible substrates.

Now, researchers at Seoul National University (SNU) led by professor Gyu-Chul Yi have grown GaN micro-rods on graphene to create transferrable LEDs and enable the fabrication of bendable and stretchable devices (Kunook Chung et al, *APL Materials*, 2, 092512 (2014)).

"GaN microstructures and nanostructures are garnering attention within the research community as light-emitting devices because of their variable-color light emission and high-density integration properties," says Yi. "When combined with graphene substrates, these microstructures also show excellent tolerance for mechanical deformation."

Ultrathin graphene films consist of weakly bonded layers of hexagonally arranged carbon atoms bound together by strong covalent bonds. This makes graphene an ideal substrate "because it provides the desired flexibility with excellent mechanical strength — and it's also chemically and physically stable at temperatures in excess of 1000°C," says Yi.

For the GaN micro-rod growth, the very stable and inactive surface of

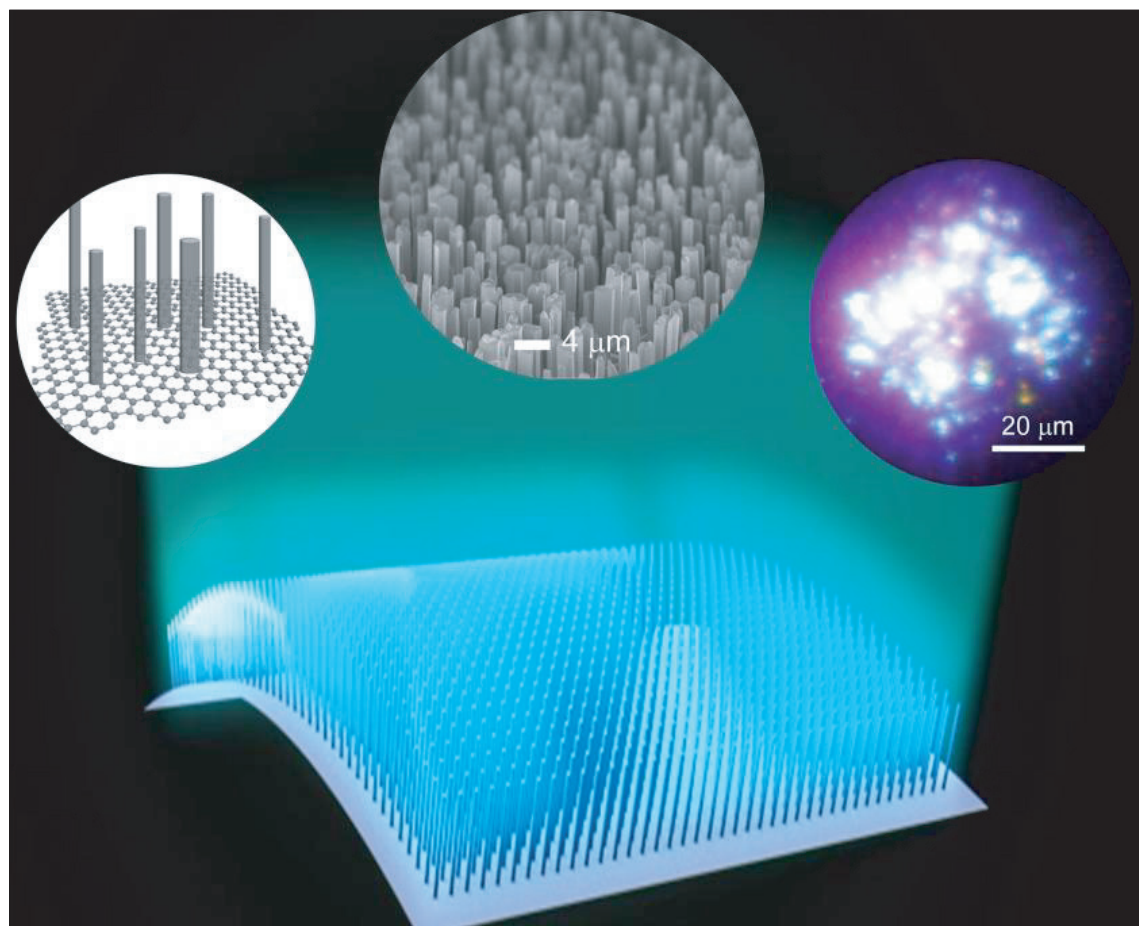
graphene offers a small number of nucleation sites for GaN growth, which would enhance three-dimensional island growth of GaN micro-rods on graphene. To create the actual GaN microstructure LEDs on the graphene substrates, the team uses a catalyst-free metal-organic chemical vapor deposition (MOCVD) process that they developed in 2002. "Among the technique's key criteria, it is necessary to maintain high crystallinity, control over doping, formation of heterostructures and quantum structures, and vertically aligned growth onto underlying substrates," Yi says.

When the team put the bendability and reliability of the GaN micro-rod LEDs fabricated on graphene to the test, they found that the resulting flexible LEDs

showed intense electroluminescence (EL) and were reliable. "There was no significant degradation in optical performance after 1000 bending cycles," notes Kunook Chung, lead author of the paper and a graduate student in SNU's Physics Department. The researchers reckon that this represents a breakthrough for next-generation electronic and optoelectronic devices, enabling the use of large-scale and low-cost manufacturing processes.

"By taking advantage of larger-sized graphene films, hybrid heterostructures can be used to fabricate various electronics and optoelectronics devices such as flexible and wearable LED displays for commercial use," concludes Yi.

<http://scitation.aip.org/content/aip/journal/aplmaterial/2/9/10.1063/1.4894780>



A rendering of the micro-rod growth process. Credit: Seoul National University.



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Cree's quarterly revenue falls 2% to \$428m, as lower LED sales outweigh Lighting and Power & RF growth

Lighting margins fall, driven by more LED bulbs and fewer fixtures, plus factory growth pains

For fiscal first-quarter 2015 (ended 28 September 2014), Cree Inc of Durham, NC, USA has reported revenue of \$427.7m, up 9% on \$391m a year ago but down 2% on the record \$436.3m last quarter (and below the \$440–465m forecasted in mid-August).

"We have good momentum in our Lighting and Power & RF segments, although fiscal Q1 results were below our targeted levels [\$440–465m, forecasted in mid-August] due primarily to lower-than-expected LED demand [down 13% sequentially]," says chairman & CEO Chuck Swoboda.

Power & RF Product revenue was \$31m, up 8% on \$28.6m last quarter and 24% on \$25.1m a year ago (remaining 6–7% of total revenue), and at the higher end of the previously announced target.

Lighting Product revenue was \$223.1m (the upper end of the target range), up 7% on \$208.2m last quarter and 51% on \$147.9m a year ago (rising from 38% of total revenue through 48% to 52% of total revenue). Growth was driven by stronger-than-expected demand in both LED fixtures and LED bulbs (as Cree's retail partner shipped some orders from fiscal Q2 into Q1 to support its stocking requirements for the fall lighting season).

However, revenue for LED Products (LED components, LED chips, and silicon carbide materials) was \$173.6m, down 13% on \$199.5m last quarter and 20% on \$218m a year ago (falling from 56% of total revenue through 46% to 41% of total revenue). This is due primarily to lower global LED demand from both direct and distribution customers (with China business declining the most).

Power & RF Products gross margin has risen further, from 53.7% a year ago and 56.9% last quarter to

57.6%, due to a more favorable product mix. However, LED Products gross margin has fallen from 46.6% a year ago and 45.1% last quarter to 39%, driven by weaker LED demand which resulted in higher revenue reserves (to reflect the more aggressive LED pricing environment) and higher inventory reserves (related to the factory over-build). Also, despite rising from 26.9% a year ago to 29.1% last quarter, Lighting Products gross margin has fallen to 24.9%, driven by a higher mix of LED bulb products, a less favorable mix within LED fixtures, and Lighting factory execution challenges related to the firm's growth.

Overall gross margin has fallen further, from 39.2% a year ago and 37.9% last quarter to 32.4% (below the targeted 37.5%), due primarily to a lower mix of LED sales, a higher mix of Lighting sales (bulbs) and the lower gross margin within these two segments.

Operating expenses were cut sequentially from \$108m to \$103.5m (\$4m lower than targeted, due to lower LED sales commissions and lower discretionary spending). However, this was not enough to offset the drop in gross margin. Operating margin has hence fallen further, 15%

Despite rising from 26.9% a year ago to 29.1% last quarter, Lighting Products gross margin has fallen to 24.9%, driven by a higher mix of LED bulb products, a less favorable mix within LED fixtures, and Lighting factory execution challenges related to the firm's growth

a year ago and 13.1% last quarter to just 8.2%.

On a non-GAAP basis, net income was \$29.6m (\$0.24 per diluted share), down on \$51.3m (\$0.42 per diluted share) and \$47.3m (\$0.39 per diluted share) a year ago and below the expected \$48–55m (\$0.40–0.45 per diluted share).

During the quarter, operating cash flow was \$13.3m (down from \$91.1m last quarter). Spending on property, plant & equipment (PP&E) has risen further, from \$58.9m last quarter to \$63.4m (almost doubling from \$33.7m a year ago), related primarily to capacity-expansion projects begun in fiscal 2014. Meanwhile, patent spending was roughly level at \$4.8m. So, total capital expenditure was \$68.2m (up from \$64.3m last quarter). Free cash flow has hence fallen further, from \$30.8m a year ago and \$26.8m last quarter to –\$55m. Cash and investments therefore fell by \$57.6m from last quarter from \$1.162bn to \$1.105bn.

During the quarter, inventory rose by \$26m to \$310.8m (from 94 days worth to 96 days, on the high side of the 90-day target), due primarily to the factory over-build in LED products compared with the weaker-than-forecasted LED demand.

Order backlog for fiscal Q2 is similar to last quarter, as higher Lighting backlog is being offset by the continued weakness in LEDs (with component customers and distributors continuing to operate on short lead-times).

For its fiscal second-quarter 2015 (ending 28 December 2014), Cree expects revenue to fall to \$400–420m. Lighting Product revenue will see single-digit growth (with strong LED fixture growth partially offset by a 12% drop in LED bulb revenue since Cree's retail partner is reducing inventory to normal levels towards

the end of the calendar year as the lighting season slows down). However, this growth will be offset by LED Products revenue falling by about 12% sequentially due to lower overall demand plus channel inventory reductions. Power & RF Product revenue should be level.

Despite the lower LED Product revenue, gross margin is expected to rebound slightly to 33.5%, as Lighting Products mix is targeted to shift more favorably back from bulbs to fixtures in fiscal Q2 while Lighting factory productivity is forecast to improve over the next several quarters. Operating expenses are expected to rise by about \$2m, due primarily to higher sales expense from fixtures sales plus higher legal spending (as Cree funds its IP licensing strategy). Operating margin should hence fall. Net income is targeted at \$24–29m (\$0.20–0.24 per diluted share).

"We target positive free cash flow for Q2 due primarily to reducing our working capital balances and lower capital spending," says chief financial officer Mike McDevitt. "Our targeted working capital improvement will be primarily driven by reducing our LED factory production to reduce our inventory levels to a line with near-term LED demand," he adds.

"With our revised LED Products outlook, we are reducing our LED factory capacity investments. However, we target continued

investment for infrastructure projects to support our longer-term forecasted growth for fiscal 2016 and 2017," says McDevitt. "As a result, we target property, plant & equipment spending to be \$200m plus or minus for fiscal 2015 [up 10–12% on fiscal 2014]," he adds.

"The LED competitive environment is currently very challenging, especially in lighting applications where mid-power and high-power LEDs compete for designs," notes Swoboda. "There is a lot of available mid-power LED capacity chasing customer designs at very low LED margins. We believe this market will rationalize over time as

The LED competitive environment is currently very challenging, especially in lighting applications where mid-power and high-power LEDs compete for designs. There is a lot of available mid-power LED capacity chasing customer designs at very low LED margins. This market will rationalize over time as the LED semi-cycle matures and capacity is more fully utilized

the LED semi-cycle matures and capacity is more fully utilized," he adds. "When that will happen is difficult to forecast, however we believe that our LED technology delivers fundamentally more lumens per wafer, which positions Cree for long-term success."

In particular, recent developments include:

- introducing the ZR high-efficacy (HE) LED troffer (the first commercially available 150 lumens-per-watt LED troffer on the market);
- launching 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 LEDs);
- announcing a cooperation agreement with Taiwan's Lextar Electronics Corp (whereby Cree is investing \$83m to take a 13% stake in Lextar, in exchange for the supply of sapphire-based LED chips, targeting the mid-power market segment).

"While the LED industry conditions are challenging, we're confident that innovation is still the key to leading the market and driving growth in all of our businesses," says Swoboda. "Given our technology leadership, new product pipeline and strong balance sheet, we remain uniquely positioned to capitalize as the industry transitions to LED lighting," he believes.

www.cree.com

Cree increases stock repurchase program to \$550m for fiscal 2015

The board of directors of LED chip, lamp and lighting maker Cree Inc of Durham, NC, USA has approved an increase in the firm's stock repurchase program, such that is now authorized to repurchase shares of its common stock worth up to \$550m in fiscal 2015 (from 30 June 2014 to 28 June 2015).

Previously, in May, Cree's board approved an increase in its stock repurchase program to \$300m (spanning from 20 June 2013 to a revised expiration date for the pro-

gram of 28 June 2015.

So far in fiscal 2015, Cree has repurchased 2.65 million shares under the program at an average price of \$36.54 per share (an aggregate value of \$97m). There is hence \$453m remaining in the firm's stock repurchase program through 28 June 2015.

The repurchase program can be implemented through open market or privately negotiated transactions at the discretion of management. Cree will continue to

determine the time and extent of any repurchases based on its evaluation of market conditions and other factors.

The board has also authorized the firm to secure an increase in its working capital line of credit facility (instigated in May at \$150m) to \$500m. The line of credit will provide Cree with the flexibility to fund strategic opportunities and its general business needs.

www.cree.com

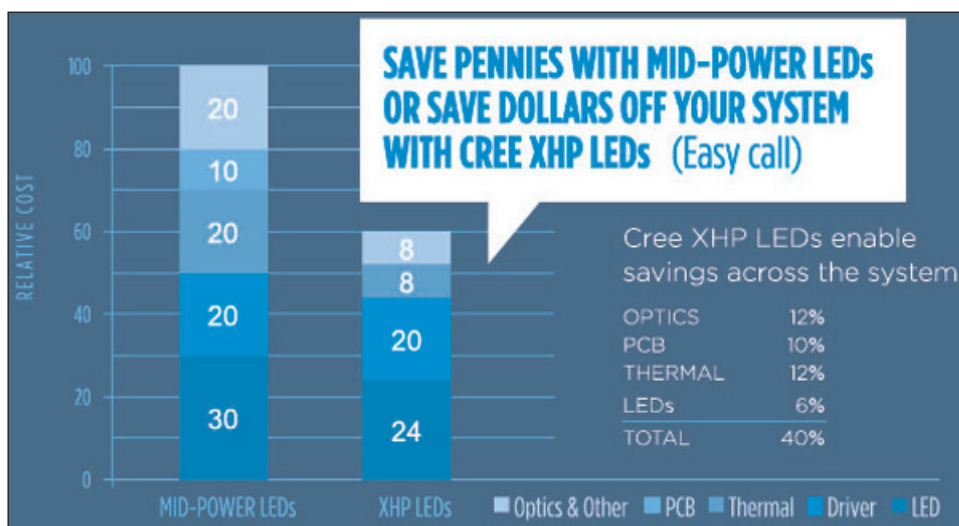
Cree introduces new SC5 Technology Platform with launch of Extreme High Power LEDs

Single-LED light output doubled, cutting system cost by up to 40%

Cree Inc of Durham, NC, USA has introduced its SC5 Technology Platform, targeted at powering the next generation of lighting with the introduction of the firm's new Extreme High Power (XHP) LEDs. The new class of LEDs can reduce system costs by up to 40% in most lighting applications, it is reckoned.

"The SC5 Technology Platform redefines what is possible in high-power LEDs by doubling the lumens out of a single LED, giving lighting manufacturers the flexibility to innovate significantly lower cost systems," claims chairman & CEO Chuck Swoboda. "This new platform establishes a new benchmark for LED lumens per wafer," he adds. "This also validates our belief that high-power LED technology enables the best lighting system designs."

The SC5 Technology Platform is built on Cree's silicon carbide (SiC) technology and features advances in epitaxial structure, chip architecture and a light conversion system optimized for best thermal and optical performance. The SC5 Technology Platform can hence achieve greater lumen density and longer lifetime at higher operating temperatures than previous LED technology, which can significantly reduce thermal, mechanical and



optical costs at the system level, says Cree.

"LEDs are no longer the most expensive portion of an LED lighting system, but they fundamentally determine the overall system performance and cost," says Dave Emerson, VP & general manager for Cree LEDs. "While other LED manufacturers only promise incrementally lower LED cost, our new Extreme High Power (XHP) LEDs leveraging the SC5 Technology Platform directly address the increased burden that thermal, mechanical and optical elements now place on total system cost," he adds.

The first available family of XHP LEDs is the XLamp XHP50 LED,

delivering up to 2250 lumens at 19 watts from a 5.0mm x 5.0mm package. At its maximum current, the XHP50 provides twice the light output of what is claimed to be the industry's brightest single-die LED (the XLamp XM-L2 LED) at a similar lumens per watt and without increasing the package footprint. By leveraging Cree's latest reliability innovations, the XHP50 is designed to maintain L90 lifetimes above 50,000 hours even at high temperature and current.

Limited samples of the XHP50 product family are available now, with commercial availability by the end of 2014.

www.cree.com/SC5

Cree launches 150 lumen per watt LED troffer

Cree has introduced the ZR High Efficacy (HE) LED troffer, a commercial-specification-grade troffer with luminous efficacy of 150 lumens-per-watt designed to reduce energy consumption by 70% compared with traditional fluorescent troffers, enabling greater design freedom for users looking to achieve LEED certification.

With a 100,000-hour lifetime (twice as long as comparable LED troffers) and a 10-year limited

warranty, the ZRHE LED troffer is a suitable replacement for health-care, petroleum, commercial building and other applications demanding extreme reliability and long product lifetime.

The troffer features Cree True-White Technology and delivers 4000lm in both 2 x 2 and 2 x 4 configurations. With 0-10V dimming capabilities as standard, the ZRHE Series LED troffer can deliver greater energy savings and help to meet emerging energy

codes for new and retrofit installations that require 24/7 operation, says Cree.

"The ZRHE LED troffer pushes the limits of LED technology, redefining the standard for the commercial-specification-grade market by delivering the breakthrough combination of energy savings, superior color quality and reduced maintenance costs," claims Norbert Hiller, Cree's executive VP, lighting.

www.cree.com/lighting/ZRSeries

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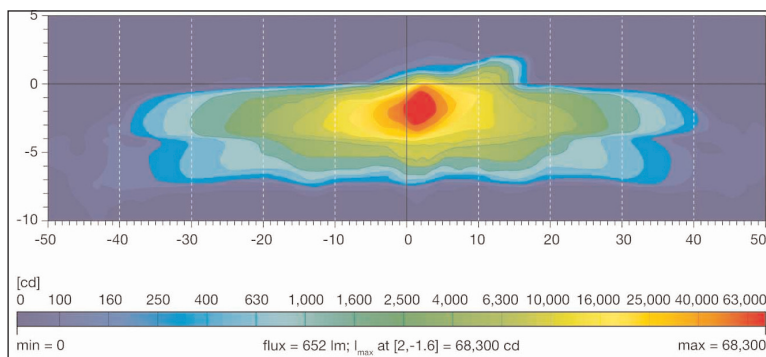
Osram triples luminance of car headlight LED to 1400lm,

At the Vision Congress in Paris (14–15 October), Osram Opto Semiconductors GmbH of Regensburg, Germany showcased an LED for car headlights with luminance three times that of existing versions, so that a single LED can be used to provide a complete low beam. Previously, several LED chips have been needed, depending on the design and the type of LEDs used.

The high brightness is the result of the firm's UX:3 chip technology, ceramic conversion technology and high-current technology used in projection applications. In future it will be possible to design much smaller headlights, with every lighting function smaller than a box of matches, says Osram Opto.

A low-beam unit measuring only 30mm x 50mm generating 1400lm from a single LED chip as its light source could be a reality in only a few years time, Osram reckons. At 200 megacandelas per m², the latest LED has three times the luminance of existing LEDs for these applications and loses less than 10% of its intensity even at high operating temperatures of 85°C.

"In developing the LED we applied our extensive experience in projection applications to combine the high-current technology used in



Distribution of light under laboratory conditions.

such applications with UX:3 chip technology and ceramic conversion technology which is standard practice for white headlight LEDs," says Stefan Grötsch, senior key expert at Osram Opto. Even the special mounting technology based on the Osram Ostar platform was transferred from projection to this automotive application, involving soldering the chip directly to the copper. The large amounts of heat produced as a result of the high output can be dissipated much more easily, which in turn greatly improves the thermal connection, says the firm.

Path to series production

The high brightness values were measured in the lab but should be achieved soon by series-production LEDs, reckons Osram Opto. The R&D results will gradually flow into

product development next year, adds the firm.

Together with the use of laser technology which produces very high luminance, a series LED

could lead to extremely compact headlight solutions, says Osram, expanding its product portfolio in this sector. It is conceivable, for example, that headlights will become ultra-compact, comprising a laser high beam and LED low beam, and that other automotive applications such as interior lighting and new types of head-up display will follow. These displays will project key information directly onto the windshield, such as video of the area directly in front of the car or navigation instructions, and will be much more vivid and graphic than is the case with existing systems, says Osram. They will therefore be classed as 'augmented reality' displays because they enrich the viewing experience with additional information.

www.osram-os.com

Nanoco signs follow-on agreement with Osram to use cadmium-free quantum dots in LED lighting

Nanoco Group plc of Manchester, UK (which produces cadmium-free quantum dots and other nanomaterials for applications including lighting, LCD displays, solar cells and bio-imaging) has signed a follow-on joint development agreement with Germany's Osram (one of the world's biggest lighting firms) for the use of Nanoco cadmium-free quantum dots in general lighting.

Founded in 2001, Nanoco has been working with Osram since 2011 to deliver LED lighting with superior performance characteristics. Much

technical progress has been made to date in optimizing the method for incorporating Nanoco's Cd-free quantum dots with blue LEDs.

Quantum dots are said to open up new potential for LED lighting (which currently lacks the warmth and color performance of an incandescent bulb) and have the capacity to appeal to a new set of buyers who want the efficiency and economy of the LED together with the 'effect' of natural light. Use of quantum dots in lighting has been hindered by containing the highly regulated and

toxic heavy metal cadmium.

Nanoco's technology involves no cadmium or heavy metal, offering a sustainable solution.

"Since signing our initial development agreement with Osram, we've made technical progress towards the development of an LED incorporating cadmium-free quantum dots and offering substantially improved color performance," says Nanoco's CEO Michael Edelman. The latest, 12-month agreement with Osram aims to further product development.

www.nanocogroup.com

Osram and Toyoda Gosei extend 2007 patent agreement

Osram Opto Semiconductors GmbH of Regensburg, Germany and Toyoda Gosei Co Ltd of Kiyosu, Aichi Prefecture, Japan have extended an agreement (from 2007) which allows the firms to use each other's patents for specific technologies, including white LEDs, and lasers.

The initial agreement allowed the two firms more freedom to develop, manufacture and market new products without fear of unintentional violations of patents. By facilitating research at both companies, new developments in LED technology have been enabled, including an

acceleration of research to improve the luminosity of LEDs, the firms say.

The new agreement extends the scope of the patents covered by the original 2007 agreement, to include patents filed after the execution of the original agreement.

www.osram-os.com

Versatilis awarded US patent for processing semiconductor fines/powders

The US Patent Office has issued US Patent No. 8,859,310 to Versatilis LLC of Winooski, VT, USA (a technology and business development firm that focuses on novel materials and processes for electro-optical devices as well as extending its Versulite brand of 2D layered materials). Versatilis commercializes technology by licensing and partnering with others, or by setting up separate focused subsidiaries (e.g. VerLASE Technologies, launched in 2013 with an investment by Wakley Ltd, to focus on laser-based light sources in the visible).

The new patent shows how fine semiconductor particles (powders or fines, which are widely available either readily synthesized or often a waste byproduct of processes such as dicing wafers into ever smaller chips) can be processed into low-cost solar cells or micro-LEDs.

A principal challenge in making such devices has always been forming the active layer (the light absorbing layer in a solar cell or the light-emitting layer in an LED). This has also been the most costly and capital-intensive part of the manufacturing process, as it must be made to high standards of crystal quality and uniformity, e.g. leading solar cells use mono- or polycrystalline silicon wafers while LEDs use variants of gallium nitride on expensive sapphire, silicon carbide or even GaN wafers. In many cases, these materials are thicker than needed — the added thickness lends structural support to the end device

without adding to efficiency, but contributes to overall cost and weight of the structure.

Versatilis says that, instead, it has shown that the active layer can be made from semiconductor fines or powders of single-crystal particles by rapid deposition as a closely packed monolayer, and then further processed into functional active diode structures (solar cells or LEDs). Such particles are readily available, often as a byproduct of other processes or made inexpensively off-line, or sometimes chemically synthesized. For example, silicon fines are widely available (screened for a desired size distribution), as are copper indium gallium diselenide (CIGS) and GaN particles (the latter chemically synthesized). Also, a small amount of such 'dust' can go a long way (e.g. a kilogram of 1µm single-crystal CIGS particles used as micro-solar cells can cover an area over 300m², resulting in very low costs per unit area).

"By leveraging cheap, ex-situ produced and optimized, single- or polycrystalline powders and fines for Si, Ge, CIGS, GaN, ZnO as the starting raw material and wrapping unique processing techniques around that, we can produce highly functional optoelectronic devices with reduced infrastructure, processing, and material utilization cost," says chief technology officer Ajay Jain (inventor of the now patented technology).

Versatilis says that the potential cost savings have led others to try using semiconductor particles in

various ways, but none have proven commercially practical. A major challenge has been to deposit the particles quickly enough and as a monolayer. Similarly, researchers have shown basic functional devices with nanorods, nanowires and other semiconductor nanostructures in the lab, only to be stopped by a general lack of production-ready manufacturing technology for the nanoscale, including suitable tools for in-line process metrology and characterization, says the firm.

In addition to processing semiconductor particles into useful devices, Versatilis says it has unique fluidics technology for rapidly depositing such particles as a monolayer (from nano- to micro-scale) on wafers or in a continuous, high-speed web. The firm has licensed the technology to Versuflex Technologies LLC, which is now selling benchtop process tools to R&D labs. The process can tolerate reasonable variation in particle size and shape, and various methods are possible for orienting particles floating on the surface of a fluid medium.

"This technology will not set performance records for efficiency in PV cells nor in lumens/watt for LEDs, but we believe there is no cheaper, more practical way to realize semiconductor diode based functionality over a large, flexible area," says CEO George Powch, "It can enable low-cost building-integrated photovoltaics or rival OLEDs with a wholly inorganic large-area micro-LED solution," he believes.

www.versatilis.com

Shimadzu adds 10W blue direct diode laser for materials processing and measuring applications

Japan's Shimadzu Corp has expanded its product line of high-output high-brightness short-wavelength laser products by releasing the HK-5650 fiber-coupled blue direct diode laser, on show at the International Exhibition for Advanced Optical Technology (InterOpto 2014) at Pacifico Yokohama, Japan (15–17 October). Anticipating the expected rapid expansion in the market for materials processing lasers, Shimadzu has been focusing on establishing a business supplying lasers with next-generation functionality used for processing materials. The firm has hence developed the HK-5650 10W-output fiber-coupled blue direct diode laser as a strategic product.

The direct diode laser offers the advantages of small size, high electrical-to-optical conversion efficiency, and potentially low costs from mass production. However, increasing the output requires a

large light-emitting surface, which reduces brightness. Also, due to the infrared light it produces, conventionally its applications have been limited to the heating or welding plastics.

In contrast, the latest product offers 16 times higher brightness than previous models at the short 450nm wavelength (where absorption by metals is high) and has an especially small spot size. It is hence suitable for applications such as the microfabrication of highly reflective and thermally conductive materials (such as gold and copper), which has been increasing in demand due to the diversification of processed materials and the miniaturization of smart phones and other electronic devices. It is also suitable for 3D printers, which have drawn much interest in recent years. Also, research is being conducted on using it for next-generation lighting applications, where it is suitable as

a laser excitation source for white phosphors. The fiber-coupled design allows transmission flexibility for a high degree of freedom and greater general applicability.

Shimadzu aims to continue increasing output and brightness levels in the future, and to take advantage of the technology developed with this product to develop high-brightness red and green laser modules as well, which could be used in RGB (red-green-blue) light sources for large projectors.

Shimadzu plans to expand its laser business by expanding the product line to meet the diverse needs of users in the laser processing field (which accounts for 30% of the light source market), in the analytical and measuring instrument fields (where the firm expects to reap synergistic benefits via its core business), and in other new application fields.

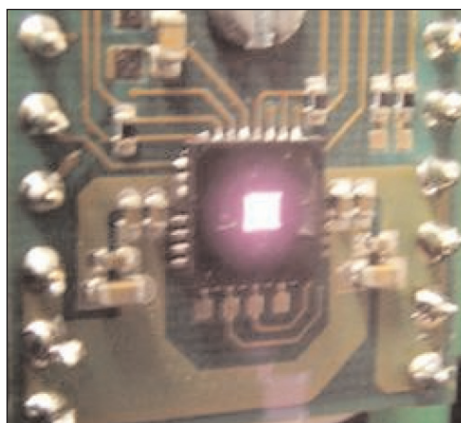
www.shimadzu.com

Princeton Optronics launches ultra-high-reliability 8W VCSEL arrays for 3D sensing, imaging & gesture recognition

Princeton Optronics Inc of Mercerville, NJ, USA, which manufactures high-power single- and multi-mode vertical-cavity surface-emitting lasers (VCSELs) and VCSEL arrays, has announced the availability of an ultra-high-reliability, high-power (8W) VCSEL array product with an efficiency of >40% at 60°C and a MTTF (mean time to failure) of >100 years at an operating temperature of 70°C.

The reliability is achieved through improved device processing and a new chip-on-submount mounting technology. The device is directly surface-mountable on printed circuit boards (PCB) and suitable for high-volume manufacturing.

A key application is as an illumination source for 3D sensing or imaging in computers, tablets and cell



The new 8W VCSEL array mounted on a submount and on a PC board.

phones. The VCSEL array can be used for either structured light or time-of-flight (ToF) applications. The high efficiency and high reliability of the firm's VCSEL arrays make them suitable illumination

devices for 3D sensing applications. In addition, surface mounting makes them suited to low-cost, high-volume consumer electronics use.

The arrays can be packaged in a variety of configurations for high-volume applications, similar to LEDs. They do not require a hermetically sealed housing, which reduces the packaging cost. Also, optics can be added to the package, creating greater options for beam handling in the customer's illumination system.

Princeton Optronics recently won approval for two patents (US Patent 8,675,706B2 and 8,783,893B1) for surface-mounted VCSELs for illumination applications, making them uniquely positioned for this market, it is claimed.

www.princetonoptronics.com

JDSU and Amada launch 2kW direct diode laser

JDSU of Milpitas, CA, USA has collaborated with UK-based Amada (a manufacturer of machine tools for metal fabrication) to develop a new direct diode laser (DDL) that provides up to 2kW of output power. The DDL has been integrated into a new sheet metal cutting system from Amada called ExC, demonstrated at the 23rd International Sheet Metal Working Technology Exhibition (EuroBLECH) in Hanover Germany (21–25 October).

Direct diode lasers have predominantly been used for welding or treating the surface of metals during manufacturing processes. The DDL design created by JDSU and Amada is claimed to be one of the first solutions that leverages this technology to cut metal.

Direct diode lasers are gaining momentum over CO₂-based cutting systems for metal processing because of advantages they provide that include higher cutting speeds, improved cutting quality, increased energy efficiency, and lower maintenance requirements. Such benefits in turn result in lower overall costs for metal processing manufacturers.

As one of the solutions to replace traditional CO₂ lasers for metal processing, the market for direct diode lasers is projected to rise at a compound annual growth rate (CAGR) of 15.3% over 2012–2017, to \$237m, according to industry analyst firm Strategies Unlimited.

"For more than seven years, JDSU and Amada have collaborated on the industry's most innovative laser solutions," says Alan Lowe, president of Communications and Commercial Optical Products (CCOP) at JDSU. "The new ExC platform complements the fiber-laser engine portfolio we've developed with Amada to provide manufacturers with a diverse range of solutions that meet their various metal processing needs."

The new system's benefits include:

● **Increased energy efficiency.** The new DDL engine significantly increases the efficiency (percentage of electrical power converted into

usable light) during the metal cutting process.

● **Faster cutting capability & improved cutting quality.** ExC cuts mild steel sheets 30% faster and cuts aluminum sheets 75% faster compared to traditional CO₂ systems, Amada reckons. It also improves smoothness of the cut surface by an order of magnitude.

● **Compact size and reduced costs.** Maintenance and power costs are reduced due to the DDL's compact and integrated structure and ability to use less power. According to Amada, this translates into a reduction in power costs of about 50% during sheet metal processing.

www.amada.co.uk

www.jdsu.com

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GigOptix's revenue rises 6% in Q3, driven by telecoms growth of 49%

ASIC revenue up 46% and datacom revenue up 80% year-on-year

For third-quarter 2014, GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical communications components for fiber-optic and wireless networks) has reported its third consecutive quarter of revenue growth, to \$8.5m. This is up 6% on \$8m last quarter and up 16% on \$7.3m a year ago (and above the \$8.2–8.4m guidance given on 28 July).

Of total revenue, 36% came from the Industrial (ASIC) product line and 64% came from the High-Speed Communications product line.

Industrial revenue grew by 27% on last quarter to \$3.1m, driven by demand for larger-geometry ASIC products (ahead of an expected shift by customers towards smaller-geometry products starting in 2015).

High-Speed Communications revenue fell by 4% due to a drop in wireless business (to just 5% of High-Speed Communications revenue), nearly offset by strong demand in telecom business (rising to 56% of High-Speed Communications revenue) while datacom business remained robust (at 39%).

Specifically, wireless revenue fell from an exceptionally strong \$1.3m last quarter to just \$0.3m. In addition to a seasonal decline, GigOptix temporarily held major device shipment to a specific European contract manufacturer for one key customer as they worked through some internal financial issues. "We took a conscious decision to hold more than \$400,000 of already booked shipments in order to mitigate any potential financial collision risk and allow for time to negotiate a reasonable payment plan for this contract manufacturer," says chairman & CEO Avi Katz. "This event did not occur till very late in the third quarter and accounted for most of the sequential quarterly revenue decline," he adds.

Optics-related revenue (telecom and datacom collectively) grew by

almost 20% on last quarter. In particular, telecom-related revenue grew by 49%, driven by successful product introduction and acceptance of the firm's 100Gb/s coherent linear multi-chip driver modules for multiple telecom applications. In addition, shipments of the 40Gbps datacom product have grown about 80% year-on-year.

"For the last two years we have shipped more of the current-generation 100Gb/s coherent drivers, namely the limiting drivers, than all our competitors combined," reckons Katz. "With the current successful introduction of our new 100Gb/s coherent linear driver, we will maintain this lead position in the industry in the years to come," he believes.

Strong demand for the new 100G linear driver product made Alcatel GigOptix's sole greater-than-10% customer in Q3 (at 32%).

On a non-GAAP basis, gross margin returned to above the 60% threshold, at 61%, compared with 59% last quarter and 62% a year ago. This was driven by a decrease in overhead-related costs coupled with a favorable product mix in Industrial business.

Despite adding the 10 engineering staff of Tahoe RF Semiconductor Inc (acquired at end-June by assuming \$450,000 in liabilities, of which \$350,000 was paid out during Q3), R&D expense remained at \$3m, as the increased headcount-related expense was offset by a decrease in project-related expenses and a small restructuring of GigOptix's San Jose engineering team. Selling, general & administrative (SG&A) expenses remained about \$1.5m.

Net income was a record \$0.73m (\$0.02 per diluted share), compared with \$0.27m (\$0.01 per diluted share) last quarter and a net loss of \$0.68m (\$0.03 per diluted share) a year ago. Adjusted EBITDA has risen further, from \$1m last quarter and \$0.1m a year ago to a record \$1.4m (the

firm's 13th consecutive quarter of EBITDA profitability). During the quarter, cash and cash equivalents fell from \$18.5m to \$18.1m. The firm has no debt outstanding.

"Our record non-GAAP net income and adjusted EBITDA as well as improved GAAP results in the third quarter validate the positive impact of the actions we've taken over the last 24 months in driving revenue growth through restructuring of our worldwide global sales & marketing organization and improving efficiencies by restructuring our back-end operations in the engineering organization," says Katz.

Driven by continued solid demand for key products, for fourth quarter 2014 GigOptix expects revenue to rise to \$8.5–8.8m (up 8–12% year-on-year). Gross margin should be about 60%, despite R&D expenses rising to about \$3.2m due to project spending, with SG&A expenses remaining about \$1.5m. Capital expenditure (CapEx) should fall from \$330,000 in Q3 to about \$300,000. Cash reserves should be maintained, as cash generated by operations should be offset by normal working capital purposes.

Driven by the capacity ramp-up for 100Gbps coherent linear telecom products and 40Gb/s datacom products over the coming year, full-year revenue should be 12% up on 2013 (with datacom revenue roughly doubling to more than \$8m).

Regarding wireless business, Katz comments: "Now that we have put in place the contractual payment agreement with this contract manufacturer, we believe that if we begin to see a recovery of the wireless device revenue in the fourth quarter, we will end the year with revenue that will almost double what we have generated out of this line in 2013". He adds that wireless business should continue to present good growth through 2015.

www.gigoptix.com

GigOptix and partners showcase 100G live demos at ECOC

At the European Conference on Optical Communications (ECOC) in Cannes, France in September, GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical communications components for fiber-optic and wireless networks) showcased its 100Gbps networking with live demonstrations of its 4-channel 28Gbps VCSEL driver/TIA chipset together with low-power-consumption clock data recovery (CDR) from Santa Clara-based fabless semiconductor firm MoSys Inc and GigOptix' linear quad driver inside BrPhotonics' Thin Film Polymer on Silicon (TFPS) DP-QPSK modulator-based integrated 100Gbps TOSA for CFP2 transceivers.

GigOptix and MoSys have agreed to jointly market the 4-channel 28Gbps VCSEL driver/TIA chipset together with MoSys' low power-consumption CDR for 100Gbps datacom market. This partnership allows fast market penetration with what is claimed to be the best combination of performance, cost and form-factor chipset on the market.

At ECOC, GigOptix, MoSys and BrPhotonics — a joint venture between GigOptix and CPqD (an independent Brazil-based research center) — showcased the following products:

- GigOptix HXT6204: a 28Gbps 4-channel vertical-cavity surface-emitting laser (VCSEL) driver for

compact, low-power optical transmitter pluggable modules and active optical cables (AOCs);

- GigOptix HXR6204: a 28Gbps 4-channel trans-impedance amplifier (TIA) receiver array designed for high-capacity datacom pluggable modules and AOCs;

- MoSys MSH110: a 28Gbps 4-channel LineSpeed Low Power Retimer IC;

- a fully bundled solution comprising MoSys' LineSpeed Low Power Retimer (MSH110) IC and the GigOptix HXT/R6204 laser driver and TIA ICs; and

- BrPhotonics' 100Gbps integrated TOSA (transmitter optical sub-assembly) reference platform for CFP2 transceivers: a 100Gbps DP-QPSK TOSA reference platform with GigOptix' GX62472 linear driver and 100Gbps DP-QPSK polymer modulator chip, example coherent receiver, and biasing circuitry.

At GigOptix's booth, interoperability was demonstrated between the MoSys' LineSpeed Low Power Retimer (MSH110) IC and the GigOptix HXT/R6204 laser driver and TIA ICs. The 100G demonstration showed the devices combined to deliver a complete loopback of 4 lanes of 25.78Gbps over more than 100m of multimode fiber. The performance between the devices has been optimized to deliver error-free performance with PRBS-31 traffic across the fiber and

highlights the ability of the MoSys' full duplex re-timer and GigOptix's TIA and laser driver (LD) to form a solution for VCSEL-based applications such as 100GBASE-SR4. The low-power 700mW Retimer and laser driver and TIA devices support multiple module form factors including the stringent size and power envelope requirements of the QSFP28 MSA form factor. Future product combinations resulting from the partnership between GigOptix and MoSys will make further improvements in power and address additional optical applications.

BrPhotonics demonstrated a coherent optical link design for 100Gbps long-haul communication with a complete CFP2 TOSA and separate receive path circuitry. The integrated CFP2 TOSA and reference platform use a GigOptix GX62472 linear quad MZM (Mach-Zehnder modulator) driver, a BrPhotonics 100Gbps DP-QPSK (TFPS) modulator, and an independent tunable laser. Discrete coherent receiver devices are located on the reference PCB as well as the GigOptix bias boards. The demonstration setup provides eye-diagram display on a real-time sampling scope, and X and Y polarization observation via optical constellation analyzer.

www.gigoptix.com

www.mosys.com

JDSU creates chief marketing and strategy officer

JDSU of Milpitas, CA, USA has named Paul McNab to the newly created position of executive VP & chief marketing and strategy officer, reporting to president & CEO Tom Waechter and responsible for corporate marketing, strategy and business development.

"Dynamic, exciting change is taking place in our markets, creating new opportunities for JDSU and making it a great time to add a strategist of Paul's caliber to our team," says

Waechter. "Paul brings a depth of networking background and extensive experience identifying and developing solutions for the software-defined network architectures of the future."

McNab will continue to serve in this role for the new NSE [Network and Service Enablement] company following the planned spin-off of the CCOP [Communications and Commercial Optical Products] company announced by JDSU.

During a 16-year career with Cisco, McNab held executive marketing, strategy and engineering positions.

"Increased network connectivity and extension of the network edge beyond the access switch, all the way to the application adds enormous complexity," says McNab. "JDSU brings unique expertise addressing the need for increased capacity and deeper visibility into network and application performance."

www.jdsu.com

Oclaro expanding manufacturing capacity for 100G client-side pluggable optics

Oclaro Inc of San Jose, CA, USA (which provides components, modules and subsystems for optical communications) is increasing investment in 100G manufacturing capacity to support the growing demand for 100G client-side pluggable optics.

The increased investment has been driven by the firm's introduction of 100G client-side interfaces in the CFP/CFP2 form factors, and will enable Oclaro to support the existing 100G form factors along with higher-density form factors that will be shipping in 2015 and beyond.

Complementing this, Oclaro has also launched its second-generation CFP2 transceiver, which has been sampling to key customers and is expected to enter volume production in fourth-quarter 2014.

"By continuing to make key investments in manufacturing capacity and new product develop-

ment, Oclaro is well positioned to lead the transition from CFP to CFP2 as more customers demand the higher density, lower cost and lower power consumption enabled by CFP2 designs," reckons chief commercial officer Adam Carter.

"Our customers benefit greatly from Oclaro's long history of delivering CFP/CFP2 solutions, which enables us to provide industry-leading quality, continued cost competitiveness and product improvements for data-center 100G and service provider dual-rate applications," he claims.

Oclaro showcased its complete line-up of LR4 CFP and CFP2 solutions at the European Conference on Optical Communications (ECOC) in Cannes, France in September.

The new second-generation CFP2 features very high performance at OTU4 rates as a result of the firm's in-house expertise in electro-absorption modulated laser (EML)

technology. Oclaro says that EML has emerged as a critical requirement for its customers because of its superior dual-rate performance, and the firm has included this feature in its new designs to meet this demand.

Oclaro says that the new CFP2 transceiver highlights its commitment to continually improve the features and functionality of its CFP2 designs with next-generation solutions. These innovations are helping Oclaro to drive the adoption of 100G client interfaces in core applications such as switching, routing and aggregation in data centers, internet exchanges and service provider peering points, where longer-reach and high-density 100G connections are required to meet the growing bandwidth demands.

www.oclaro.com

www.ecoc2014.org

II-VI showcases new compact optical amplifier array product platform

At the European Conference on Optical Communications (ECOC) in Cannes, France in September, II-VI Inc of Saxonburg, PA, USA showcased a compact optical amplifier array product platform that is now generally available following qualification and customer verification.

Arrayed amplifiers are critical to emerging optical network architectures including colorless, directionless and contentionless (CDC) networks, says the firm, as they overcome signal losses in the optical switching equipment. Accordingly, compact, high-density solutions with reduced power consumption are essential requirements for these applications, where optical amplifiers are employed at each add and drop port of optical transmission systems.

"These requirements drive the need for creative packaging technologies and differentiated optical components," says Dr Richard Smart, chief scientist & general manager of the II-VI Network Solutions Division. "Our unique dual-chip pump laser technology and advanced hybrid passives are key enablers of these highly compact arrayed amplifiers," he adds. "We have unmatched levels of vertical integration in our amplifiers — from materials to sub-components to key enabling components, all from within the II-VI product portfolio, demonstrating the value of being a highly vertically integrated manufacturer," Smart claims.

"Widespread deployment of CDC networks will require compact, cost-efficient amplifier solutions," says Dr Sanjai Parthasarathi, director of product line management. "Our

arrayed amplifier platform seeks to enable the acceleration of such deployments," he adds. "Our unique dual-chip 980nm pump lasers provide the performance and individual control of discrete lasers, within a package footprint approaching 25% of alternative solutions. Our advanced hybrid passives perform multiple optical functions in a single optical component. This minimizes optical fiber management and splicing as well as reduces signal attenuation."

II-VI says it is currently engaged with multiple Tier-1 customers to provide arrayed amplifier solutions. With qualification of the first-generation products now completed, developments are underway to enable reduced packaging dimensions and to provide higher levels of functionality and integration.

www.ii-vi.com

First demo of 200G coherent CFP2 pluggable transceiver

Oclaro Inc of San Jose, CA, USA says that, at September's European Conference on Optical Communications (ECOC) in Cannes, France, it was the first company to demonstrate a 200G coherent transceiver.

The next-generation coherent module features power dissipation of only 12W, and Oclaro claims that the small CFP2 form factor enables users to be first to market with 400G line-cards (using 2x 200G with 16-QAM) that deliver optimum density and performance for applications such as data-center interconnects and metro/regional packet optical transport networks.

Featuring 100G and 200G flexible modulation, the analog coherent CFP2 pluggable transceiver has been shipping to customers since May, and was shown at ECOC operating in 100G PM-QPSK or 200G 16-QAM mode. The transceiver leverages Oclaro's proven indium phosphide (InP) photonic integration circuit (PIC) technology to deliver what is claimed to be industry-leading performance, increased density and low cost in a pluggable format. The firm says that these critical requirements are being demanded by new Web 2.0 customers, router companies and long-haul network equipment manufacturers that are

struggling to meet the explosive bandwidth demands and are looking to deploy faster 100G and 200G optical networks while keeping costs down.

"Oclaro is on track to be the first company to bring a high-density coherent CFP2 pluggable transceiver to market," says chief commercial officer Adam Carter. "This important 200G milestone validates our strategy to focus on delivering differentiated products that leverage Oclaro's core competencies and continually raise the bar on density, performance, and power efficiency to help our customers meet their growing bandwidth requirements," he adds.

"CFP2-ACO [analog coherent optics] technology is the most important catalyst for cutting the cost of coherent equipment and accelerating the rollout of 100G metro networks," comments Andrew Schmitt, principal analyst, Carrier Transport Networking, at Infonetics Research. "Oclaro took a leadership role in developing a coherent CFP2-ACO transceiver, and our aggressive 2016 forecast is based on the wide availability of this technology," he adds.

The analog coherent CFP2 transceiver incorporates Oclaro's InP PIC

technology for both transmit and receive elements of the module. The transmitter utilizes Oclaro's narrow-linewidth tunable laser and nested Mach-Zehnder modulators and can be used in 100G PM-QPSK or 200G 16-QAM with the appropriate external DSP on the line-card. Key features of the CFP2 coherent transceiver include its small size, power dissipation of only 12W, and high optical output power of 0dBm with 16-QAM modulation format. All relevant circuitry, such as laser and modulator control and drivers and receiver TIAs, are included inside the analog CFP2.

Coherent DSP solution provider ClariPhy of Irvine, CA, USA is working with Oclaro to demonstrate the coherent 200G CFP2 pluggable transceiver. "We see strong market demand for solutions that can deliver cost-effective, high-density 100G and 200G connections," says ClariPhy's senior VP sales Reza Norouzian. "Our customers have validated the technology in Tier-1 networks and are very excited by this combined solution of Oclaro's coherent CFP2 and ClariPhy's LightSpeed-II CL20010 coherent SoC [system-on-a-chip]," he adds.

www.oclaro.com

TI launches its first 100G transimpedance amplifier

Texas Instruments Inc (TI), which develops analog ICs and embedded processors, has introduced its first transimpedance amplifier (TIA) for the 100G optical networking market.

TI says that, as a key component of the system, the ONET2804T brings high levels of sensitivity with negligible cross-talk penalty between channels and low input-referred noise (IRN < 2µA) to provide high signal integrity for stable and robust communication in hot-pluggable transceivers. The newest member of TI's broad optical networking portfolio, the

100G TIA serves parallel optical interconnects in applications with data rates of up to 28Gbps, such as optical line-cards, point-to-point microwave backhuls and video over fiber.

The ONET2804T is available as a bare die with a 750µm channel pitch, enabling designers to wire bond directly to a photodiode (easing system integration and reducing system complexity). Also, using a two-wire I2C interface, designers can optimize their systems to drive high performance at low power consumption, aiding design flexibility says TI. Suggested retail

pricing in 1000-unit quantities starts at \$45.

Support is available on the High-Speed Interface Forum in the TI E2E Community, where engineers can search for solutions, get help, share knowledge and solve problems with fellow engineers and TI experts.

The firm says that the ONET2804T four-channel 28Gbps TIA adds a new dimension to its portfolio of optical networking products, which includes various types of laser drivers and limiting amplifiers for building optical networking systems.

www.ti.com/onet2804t-pr-eu

Finisar demonstrates complete end-to-end 50Gb/s optical interface using silicon photonics

At the European Conference on Optical Communications (ECOC) in Cannes, France in September, fiber-optic communications component and subsystem maker Finisar of Sunnyvale, CA, USA gave what it claims was the first demonstration of a 50Gb/s optical interface using silicon photonics technology.

The technology concept shows both 40G and 50G NRZ-based transceiver modules running error-free on a single wavelength over single-mode fiber (SMF), complementing Finisar's previously demonstrated 40Gb/s and 50Gb/s vertical-cavity surface-emitting laser (VCSEL) technology over multi-mode fiber (MMF).

This live demonstration showcases Finisar's development of next-generation optical interfaces and offers technology building blocks necessary for emerging optical standards, such as Serial 40G Ethernet, Serial 50G Ethernet, Next-generation 100G Ethernet, and 400G Ethernet.

"Finisar's demonstrations of various 40G and 50G serial optical technologies are important for the industry in order to gain consensus about which technologies to adopt for the next generation of Ethernet that will lower costs and drive rapid adoption," says Finisar's senior director of strategic marketing Craig Thompson. "Regardless of the data rate and technology used, the

biggest challenge in bringing 50G to market is the engineering of the total system — the optics, ICs, packaging and firmware control — and designing it for high-volume manufacturing," he adds.

"Cisco has made a significant investment in silicon photonics and we are excited to see Finisar advancing the development of this important technology," comments Luca Cafiero, senior VP & general manager of the Insieme business unit at Cisco Systems. "Silicon photonics technology has the potential to close the gap between switch ASIC and optical transceiver development cycles."

www.ecoc2014.org

Finisar demonstrates next-generation ROADM technology

At ECOC, Finisar demonstrated new products for high-speed optical networking, including a low-profile dual wavelength-selective switch (WSS) and high-resolution optical channel monitor (OCM) that enable the design of next-generation reconfigurable optical add-drop multiplexer (ROADM) line-cards.

Low-profile dual WSS and high-resolution OCM ROADM technology

Finisar is demonstrating how the combination of its low-profile dual WSS and high-resolution OCM provides the foundation for next-generation ROADM subsystem design. With the flexibility of the WSS coupled with the resolution and accuracy of the OCM, systems equipment OEMs can create high-performance, single-slot, route-and-select ROADM line-card designs.

The dual WSS is the newest addition to what is claimed to be the industry's broadest portfolio of wavelength-selective switches, built on Finisar's Flexgrid and LCoS technology. It offers dynamic deployment of bandwidth at

6.25GHz channel width and intra-channel attenuation control. The dual WSS is available in three low-profile configurations (2x1x20, 2x1x9 or 2x8x12) to support ROADM line-card and colorless, directionless add/drop applications.

The high-resolution OCM features power accuracy to 0.5dB when monitoring signal power at 6.25GHz resolution. This improvement enables optimization of signal power and center frequency of densely packed super-channel carriers, which not only heightens system performance but also assures future compatibility as new innovations increase spectral utilization, says Finisar.

The live demonstration connects optical sources through the dual WSS, generating a spectrum with various channel widths, locations, and attenuation profiles. Through the high-resolution OCM, the performance of the dual WSS as well as the OCM's ability to resolve intra-channel features and super-channel carriers can be observed by comparing the OCM output to

an optical spectrum analyzer (OSA). Both the low-profile dual WSS and high-resolution OCM are sampling now.

UltraSpan amplifier coherent link demonstration

Finisar is also showcasing ultra-long (400km) repeater-less fiber-optic link technology that extends beyond the reach and capabilities of traditional telecom transmission systems. Based on its UltraSpan amplifiers, Finisar is showing a 100G ultra-long repeater-less coherent link over an ultra-long span. These links offer Class 1M operation over a secure platform, are network interfaced, and can be controlled remotely. Ultra-long links are used in applications such as oil, gas, mining, energy and transportation. UltraSpan amplifiers are currently shipping in production.

At ECOC, Finisar also displayed equipment from its portfolio of products including its latest optical transceivers, active cables, WSS devices, advanced optical components, optical amplifiers, and passive devices.

www.finisar.com

CWDM4 MSA releases detailed specification for low-cost 100G optical interfaces targeting data centers

The CWDM4 MSA consortium has released the first detailed specification (revision 1.0) for low-cost 100G interfaces targeting data-center applications. Formed in March, the CWDM4 MSA (multi-source agreement) targets a common specification for 100G optical interfaces that addresses data communication links up to 2km in the data center.

The CWDM4 architecture employs 4 lanes of 25Gb/s using coarse wavelength division multiplexing (CWDM) technology to transport 100G optical traffic across duplex single-mode fiber (SMF). The specification is designed to take advantage of forward error correction (FEC) on the host port, in accordance

with IEEE 802.3bj KR4 RS FEC. The specification was developed through a broad review process, soliciting detailed feedback from a large group of industry experts from more than 40 companies that include system OEMs, optical component vendors, chip vendors, and fiber cabling manufacturers.

From the five founding members Avago Technologies, Fin-

The CWDM4 architecture employs 4 lanes of 25Gb/s using CWDM technology to transport 100G optical traffic across duplex single-mode fiber

isar, JDSU, Oclaro and Sumitomo Electric, the CWDM4 MSA has now substantially expanded its membership to also include Brocade, ColorChip, Hitachi Metals, Juniper Networks, Kaia, Mitsubishi Electric, Neophotonics, Oplink, Skorpions Technologies and SiFotonics.

"The CWDM4 MSA has achieved a key milestone in the push towards mass adoption of 100G interfaces in datacenter applications," comments Vladimir Kozlov, founder & CEO of Lightcounting Market Research. "Achieving revision 1.0 allows the industry to move forward in developing a common, ubiquitous optics platform for next-generation data-center applications."

www.cwdm4-msa.org

TeraXion launches packaged InP I-Q modulator

TeraXion Inc of Quebec City, Canada (which designs and manufactures optoelectronic components and modules for high-speed fiber-optic transmission networks, fiber lasers and optical sensing applications) has launched its first-generation indium phosphide dual-polarization I-Q modulator for 100 and 400Gb/s long-haul and metro networks.

Based on a nested Mach-Zehnder

configuration that enables 100G DP-QPSK and 200/400G QAM optical transmission, the I-Q modulator has a typical V_{pi} of 1.5V with a bandwidth of 35GHz and 9dB insertion loss. The device includes monitoring photodiodes and a polarization beam combiner in a small (41mm x 19mm) package, which allows for direct line-card integration. It is claimed to be the

first InP modulator that offers equivalent performance to the lithium niobate legacy counterpart with a smaller footprint and with much lower V_{pi}.

The dual-polarization I-Q modulator was exhibited at the European Conference on Optical Communications (ECOC 2014) in Cannes, France (22–24 September).

www.teraxion.com/en/igm

Finisar announces redemption of all \$40m of its 5.0% convertible senior notes due 2029

Fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has announced the redemption of all its the outstanding 5.0% convertible senior notes due 2029 on 29 October.

As of 9 October, there was about \$40,015,000 worth of the convertible notes outstanding.

Finisar subsequently said that the holders of all the notes had voluntarily converted their notes into

Finisar shares prior to the scheduled redemption date of 29 October (announced on 10 October).

The notes were converted at the rate of 93.6768 shares of Finisar's common stock for each \$1000 principal amount of convertible notes (a conversion price of about \$10.68 per share), in accordance with the existing terms of the notes. As of 8 October, the closing sale price of the stock, as reported on the NASDAQ Global Select Market,

was \$15.83 per share. A total of about 3.75 million shares of Finisar common stock were issued upon conversion.

The issuance will not increase the number of Finisar fully diluted shares outstanding for financial reporting purposes, as such shares were included in the number of Finisar fully diluted shares outstanding in the firm's most recent quarterly report on Form 10-Q.

www.finisar.com

Source Photonics launches first integrated, pluggable GPON SFP ONU with network clock synchronization

Optical communication product maker Source Photonics Inc of Chatsworth, CA, USA has announced what it claims is the first integrated, pluggable Gigabit passive optical networks (GPON) SFP optical networking unit (ONU) with 1 Pulse-Per-Second (1PPS) and Time-of-Day (ToD) support for network clock synchronization.

The family of GPON ONU SFP transceiver products is based on the ITU-G.984.2, G.988 and the Broadband Forum TR-156 standards, and offers full GPON OMCI stack, an SGMII interface operating at 1Gb/s or 2.5Gb/s, and full digital diagnostics monitoring capability.

Available in industrial-temperature grade, and with low typical power dissipation of 1.5W, the integrated GPON SFP ONU is suitable for mobile small-cell backhaul applications.

In the same product family of integrated pluggable GPON ONUs, Source Photonics offers a version with fully implemented IEEE 1588v2 capability for network clock synchronization, in an SFP package with standard pin-out.

Both versions with network clock features are available in standard GPON wavelength configuration, as well as options for CWDM multi-wavelength versions to support wavelength overlay on existing

installations to maximize the fiber utilization of the PON optical distribution networks (ODN) plant.

The product family of pluggable GPON ONUs complements Source Photonics' broad product portfolio of optical interfaces for mobile infrastructure applications. With a comprehensive range of CPRI- and OBSAI-based optical transceivers from 1Gb/s to 10Gb/s data rates shipping in volume to major infrastructure equipment manufacturers for major deployments globally, Source Photonics offers optical components for C-RAN, antenna front-haul, and small-cell back-haul.

www.sourcephotonics.com

100G-LR4 interoperability between QSFP28 module & new CFP4

At the European Conference on Optical Communications (ECOC) in Cannes, France in September, Source Photonics gave a live demonstration of interoperability between its 100G-LR4 QSFP28 and 100G-LR4 CFP4 products, which represent the latest additions to its portfolio of small-form-factor high-data-rate products operating at 40G and 100G.

As part of the interoperability demonstration, Source Photonics has announced availability of its 100G CFP4 product, supporting both the IEEE 100GBase-LR4 standard as well as ITU-T OTU4 over

10km of standard single-mode fiber. The module is fully compliant to the CFP4 multi-source agreement (MSA), with power consumption below 6W, and performance features that makes it suitable for routing applications.

First demonstrated at March's Optical Fiber Communication conference (OFC 2014) in San Francisco, Source Photonics' 100G QSFP28 is claimed to be the first QSFP28 module to support the 100G-LR4 standard. Featuring a typical power consumption of 3.5W and supporting 10km transmission over single-mode fiber, the

QSFP28 module enables high-density and low-latency applications in data centers and in carrier routing equipment. In addition to the standard LR4 interface, Source Photonics offers an 'LR4-Lite' version of the QSFP28 with reduced link budget and power dissipation, supporting 100G links up to 2km without the need for FEC. The Lite version is fully interoperable with standard 100GBase-LR4 interfaces for links up to 2km, presenting a highly flexible and cost-effective option for data-center and IP routing applications.

www.ecoc2014.org

Infinera appoints general counsel

Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has appointed James Laufman as senior VP, general counsel & corporate secretary.

Laufman most recently served as VP & general counsel of fabless

semiconductor company Marvell Semiconductor Inc, which he joined in 2008. Previously, he was VP, general counsel & secretary of semiconductor company Integrated Device Technology Inc from 1999 to 2008. Prior to that, he was VP & general counsel of Rohm Corp from 1994 to 1998. From 1990 to 1994, he worked as an associate attorney at the Berliner Cohen and Popelka

Allard law firms, specializing in the litigation and resolution of commercial transaction matters.

Laufman has a Bachelor of Science degree in Business Administration, Finance (cum laude) from California State University, Chico and a Juris Doctorate degree from Santa Clara University School of Law.

www.infinera.com

OIF demos 100G multi-vendor interoperability at ECOC

The Optical Internetworking Forum, operating with the theme of 'OIF Interoperability 2014 — Accelerating Momentum on the Road to Next-Generation Architectures', completed a multi-vendor interoperability demonstration highlighting the expansion of 100G component availability to smaller form factors by testing live traffic over media including optical fiber, copper cables and backplanes. The event marks the OIF's fifth demonstration of 4 x 25Gb/s (100Gb/s) channels and includes nine different demo scenarios featuring 11 participating firms. The demonstrations were on display at September's European Conference on Optical Communications (ECOC) in Cannes, France.

OIF members participating in the demos included Amphenol, Finisar, Fujitsu Optical Components, Inphi,

JDSU, Molex, MoSys, Semtech, TE Connectivity, Xilinx and Yamaichi Electronics, with Agilent and Tektronix providing testing equipment.

"OIF members continue to lead the industry in developing agreements that enable an interoperable ecosystem of hardware based on 25–28Gb/s electrical and optical channels," says Semtech's Ed Frlan, the OIF PLL Interoperability Working Group chair. "The demonstrations at ECOC validate the work that has been completed within the OIF and the next-generation work that is in process."

Interoperable demonstrations at ECOC included:

- CFP4 optical modules from multiple suppliers with CEI-28G-VSR electrical channels interoperating over a range of single-mode fiber lengths;
- a CFP4 active copper cable assembly

operating with CEI-28G-VSR links with multiple ASIC suppliers;

- testing and validation of chip to module "VSR channels" with compliance boards per CEI-28G-VSR,
- interoperation of various QSFP28 direct attach copper cables (DAC) from multiple vendors over CEI-25G-LR channels;
- three different connector supplier's electrical backplane connectors showing CEI-25G-LR operation with multiple SerDes suppliers; and
- a demonstration of the effects of variations in surface condition on thermal performance with the 400G CDFP Style 2 pluggable module, per the on-going OIF thermal interface development project.

A white paper regarding the demonstration is available at:

www.oiforum.com/public/OIF_Interoperability_2014.html

OIF PLL demonstrations featuring Molex solutions

High-speed fiber-optic interconnect firm Molex Inc of Lisle, IL, USA took part in 'Optical Internetworking Forum (OIF) Interoperability 2014 — Accelerating Momentum on the Road to Next-Generation Architectures' demonstrations at September's European Conference on Optical Communication (ECOC) in Cannes, France. The OIF stand featured Molex and other OIF member firms in live Physical and Link Layer demonstrations showcasing advanced 100G technologies for 400G data transmission over various media including optical fiber, copper cables and backplanes.

"Designed for high-speed multi-channel systems, Molex solutions deliver the interoperability needed in today's resource-intensive data centers," says Scott Sommers, global group product manager at Molex.

Molex solutions were spotlighted in four OIF demonstrations:

Demo #4: CEI-28G-VSR QSFP29 Module Compliance Output Test
Molex's zQSFP+ (zQuad Small

Form-factor Pluggable Plus) connectors on a module control board supported 28G operating data rates in a multi-test demonstration. zQSFP+ connectors supported CEI-28G-VSR requirements over a QSFP28-based chip-to-module channel at 28G operating rate.

Demo #5: CEI-25G-LR Passive Copper Cable

Highlighting four vendor cables operating at the same data rate, the demonstration featured a scalable Molex zQSFP+ four-lane cable design operating at up to 25.78G per lane with optimized electrical performance, signal integrity, and EMI protection.

Demo #7: CEI-25G-LR Backplane Channel Connector

Molex's Impel 25G LR backplane and daughter cards provided signal integrity and mechanical isolation in a demonstration running four lanes of bi-directional traffic at 25.78G. Offering scalable price-for-performance, the high-density Impel backplane system enables data rates from 25G up to 56G data

rates (56G obtained using PAM 4 encoding).

Demo #9: OIF CEI-25G VSR Thermal Pluggable Module

Utilizing eight zCD (style 2) connectors, cages, modules and heat-sinks mounted in a side-to-side airflow line-card emulator, the demonstration featured Molex's high-speed zCD connectors and thermal resistant modules to show the effects of heat-sink pin geometry in a simulated real-world environment transmitting 400G (25G over 16 lanes). The demonstration probed and recorded heat levels to assess thermal dissipation properties of connector and cage thermal technologies.

"Interoperability translates into more choices for customers," says Sommers. "OIF multi-vendor demonstrations blend advanced technologies and highlight important industry progress toward the goal of achieving total interoperability in fiber-optic technologies."

www.molex.com
www.ecoc2014.org

ClariPhy accelerates 400G networks by shipping 28nm 200G coherent optical system-on-a-chip

ClariPhy of Irvine, CA, USA has announced production shipments of its LightSpeed-II CL20010. The industry's first 28nm coherent system-on-a-chip (SoC), the CL20010 accelerates Internet bandwidth for data centers, transport infrastructure and cloud-based networks. It is the only solution that delivers a multi-rate and multi-modulation architecture enabling true Software Defined Networking (SDN) at the physical layer. The CL20010's configurable bandwidth supports data rates from 40G to 200G per wavelength, enabling the performance and scalability demanded by the rapidly changing network infrastructure marketplace.

"Widespread adoption of coherent technology in the metro and for data-center applications is held back due to the cost of the solutions," says Andrew Schmitt, principal analyst, Carrier Transport Networking at Infonetics Research. "Flexible modulations to increase the capacity of coherent links over short interfaces is a crucial competitive advantage and I believe ClariPhy is the first component supplier to ship this."

Major telcos and data center operators worldwide are upgrading their optical transport infrastructure to address the global capacity crunch. Carriers worldwide are looking for scalable coherent transmission solutions at the lowest cost per bit. According to the Cisco Visual Networking Index in June, global Internet traffic in 2018 will be equivalent to 64 times the volume of the entire global Internet in 2005, with metro traffic surpassing long-haul traffic by 2015. 200G single-chip solutions, such as ClariPhy's CL20010, that are agile, scalable, programmable and significantly reduce upgrade costs, are the 'Holy Grail' for data centers, transport infrastructure and cloud-based networks – underscoring the huge opportunity for companies that can successfully deliver such devices.

"We see strong market demand for 200G coherent solutions for applications in optical transport networks, new data centers and cloud-based networks, where advanced performance, network flexibility, and a rich feature set are required," says Richard Craig, president of

Oclaro's Integrated Photonics business. "We are very excited that ClariPhy's latest 200G coherent SoC exhibits excellent performance with Oclaro's analog coherent CFP2 module. Several of our customers have expressed strong interest in solutions based on this combination since it provides them with the speed, efficiency, and scalability needed to meet their increasing bandwidth demands."

"400G is a top priority for network operators as they look to deploy and scale their Internet infrastructure," said

Widespread adoption of coherent technology in the metro and for datacenter applications is held back due to the cost of the solutions. Flexible modulations to increase the capacity of coherent links over short interfaces is a crucial competitive advantage

We see strong market demand for 200G coherent solutions for applications in optical transport networks, new data centers and cloud-based networks, where advanced performance, network flexibility, and a rich feature set are required

Nariman Yousefi, CEO of ClariPhy. "Achieving production shipments of the CL20010 represents an important milestone and demonstrates ClariPhy's unique ability to engineer advanced 200G and beyond coherent optical transport solutions that address stringent carrier requirements for increased performance, bandwidth, speed and reach, while interoperating with today's transport infrastructure. We have generated a considerable amount of design momentum with OEMs and carrier networks worldwide."

Key features of the ClariPhy LightSpeed-II CL20010 SoC

ClariPhy's LightSpeed-II CL20010 28nm multimode SoC offers what are claimed to be unprecedented levels of integration, performance and SDN capabilities that allow the network to adapt in changes in traffic growth automatically. Its innovative design includes:

- The industry's first standard product SoC that supports 200G 16QAM modulation on a single wavelength, and that enables 400G dual-carrier super channels in 75GHz of DWDM spectrum.
- An increase of 170% in fiber capacity and a reduction of 50% in cost per bit versus today's 100G coherent systems.
- Support for standard 100G QPSK modulation with the industry's best OSNR performance, providing carriers the flexibility of using a single, software programmable line-card for 200G and 400G transmission at distances exceeding 3500km.
- A 'one stop shop' approach, with all significant intellectual property developed by ClariPhy, providing ICs to customers with superior feature sets and accelerated time-to-market.

The CL20010 is shipping in production to multiple OEM customers, and has undergone successful trials at several Tier-1 carriers.

www.clariphy.com

NeoPhotonics announces general availability of dual-rate 100G CFP2 LR4 transceiver

NeoPhotonics Corp of San Jose, CA, a vertically integrated designer and manufacturer of both indium phosphide (InP) and silica-on-silicon photonic integrated circuit (PIC)-based modules and subsystems for high-speed communications networks, has announced the general availability of low-power, dual-rate 100G CFP2 LR4 transceivers for telecom and datacom applications.

The 100G CFP2 LR4 requires less than half of the power as well as half of the size compared to 100G CFP form-factor transceivers, making it an attractive next-generation 100G module solution for bandwidth-hungry data-center applications where both port density and lower power are desired, says NeoPhotonics.

The 100G CFP2 LR4 transceiver is designed to fully comply with the IEEE 802.3 100GBASE-LR4 and CAUI-4 Electrical Interface as well as OTN OTU4 standards for link distances up to 10km. It also complies with CFP2 MSA (multi-source agreement) and MDIO functionality. The 4-channel PIC-based integrated transmitter is based on NeoPhotonics' proven performance and high-volume manufacturing platform of 28G EML lasers and

This new form factor, based on our industry-leading 28G EML laser technology, will provide additional value to the rapidly expanding 100G market

drivers, which enable best-in-class module performance, interoperability and ease of deployment, claims the firm.

"After serving the 100G market with our CFP product, we are pleased to add this second-generation form factor into our 100G portfolio," comments NeoPhotonics' chairman & CEO Tim Jenks. "CFP2 is the first 100G interface that provides face-plate density advantages over 10G SFP+," he adds. "Therefore we believe this new form factor, based on our industry-leading 28G EML laser technology, will provide additional value to the rapidly expanding 100G market in which maximum bandwidth management is a necessity," concludes Jenks.

www.neophotonics.com

NeoPhotonics launches low-power-consumption 28G EML laser and driver for dual-rate 100G LR4/ER4 CFP2 pluggable transceivers

NeoPhotonics has announced general availability of its low-power-consumption 28G electro-absorption modulated laser (EML) and driver for dual-rate 100G LR4/ER4 CFP2 client-side transceivers. Low-power EML lasers and drivers are especially critical for 100G CFP2 power class 3 transceivers, which require a total power consumption of less than 9W.

The CFP2 EML laser and driver for 100G LR4/ER4 CFP2 transceivers is fully compliant with the 25G IEEE 802.3ba 100GBASE-LR4/ER4 standard and the stringent 28G OTU-4 standards. The designs are optimized between the driver and the EML laser to shorten the design cycle time for CFP2 transceivers and provide the best matched solution.

The available form factors for the matched laser and driver are as a 100G Quad TOSA (transmitter optical sub-assembly) integrating 4-channel EML lasers into a

PIC-based TOSA and also as a matched chip-on-carrier laser and driver. The maximum power consumption for the Quad TOSA is 2W over the operating temperature range, while the typical maximum power consumption for the driver over the temperature range is 0.3W.

Along with the already available high-volume CFP version of the EML laser and driver, NeoPhotonics provides 25/28G dual-rate high-volume EML laser and driver sets for all current 100G client interface applications.

"The introduction of high-performance components such as our CFP2 EML laser and driver underlines our commitment to continue supporting the ultra-high-speed segment of the transceiver market through NeoPhotonics Semiconductor [formerly the Optical Component Unit of LAPIS Semiconductor]," says chairman & CEO Tim Jenks.

"We are pleased to support our customers with a growing portfolio of high-performance components based on our proven InP EML and GaAs pHEMT technologies and to facilitate the rapidly expanding 100G market with high-performance yet low-power-consumption and cost-effective components," he adds.

At September's European Conference on Optical Communications (ECOC 2014) in Cannes, France, NeoPhotonics exhibited its suite of standard and small-form-factor PIC-based components for 100G coherent line-side applications, along with its 100G client-side CFP2 transceivers and its next-generation transceivers for access networks. In addition, chief system architect Dr Winston Way gave a talk 'CDC ROADMs: Exploring Modular and Expandable Approaches' in the 'Optical Network Agility' session of the Market Focus forum.

www.neophotonics.com

Emcore selling tunable laser and transceiver product lines to NeoPhotonics for \$17.5m

Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and space solar power markets, has entered into a definitive purchase agreement for NeoPhotonics Corp of San Jose, CA — a vertically integrated designer and manufacturer of both indium phosphide (InP) and silica-on-silicon photonic integrated circuit (PIC)-based modules and subsystems for high-speed communications networks — to purchase its tunable laser and transceiver product lines for \$17.5m (\$15m plus a working capital and inventory adjustment of \$2.5m). This consists of \$1.5m in cash at closing and a \$16m promissory note from NeoPhotonics.

The purchase price is subject to certain adjustments for inventory, net accounts receivable and pre-closing revenue levels, which will amend the principal amount under the promissory note. The promissory note will mature two years from the closing date (subject to prepayments under certain circumstances) and will be secured by certain assets being sold to NeoPhotonics. The transaction is expected to close by early January.

Assets to be sold include production and development fixed assets and intellectual property for the external-cavity laser (ECL)-based integrable tunable laser assembly (ITLA), micro-ITLA, tunable XFP transceiver, tunable optical sub-assemblies and integrated coherent transmitter (ICT) products for 10, 40, 100 and 400Gb/s telecoms networks. Emcore will retain its broadband fiber-optics product lines including cable TV transmitters and modules, fiber-to-the-premise (FTTP) transceivers, InP-based lasers, photodiodes and modulators, RF over fiber satellite communications products, video transport equipment, and microwave and specialty photonics products (i.e. the firm's

broadband business).

In fiscal 2014, the tunable laser and transceiver product lines represented about 25% of Emcore's overall revenue. However, the profitability levels from these product lines have not been positive historically. The sale of the ECL-based telecom products allows Emcore to eliminate losses and continued investments in these product lines, and to focus on its core broadband fiber-optics product portfolio. Emcore says that its core competencies in compound semiconductor-based products will remain the cornerstone of its Fiber Optics business, addressing high-speed fiber-optic broadband transmission for CATV, satellite and microwave communications, broadcast and professional video, and defense & homeland security applications.

"The sale of our tunable laser and transceiver product lines is an important step in transforming the company and paving our path to generating consistent positive cash flow," says president & CEO Dr Hong Hou. "Following the closing of the previously announced sale of the company's space photovoltaics business and the sale of the tunable laser and transceiver product lines, we expect improved operating results going forward with renewed focus on our broadband business," adds Hou.

In December 2013, Emcore's board of directors formed a Strategy and Alternatives Committee, and the committee retained Raymond James as financial advisor. Over the past ten months, the committee has been working to review a broad spectrum of alternatives. The sale of the tunable laser and transceiver product lines is a result of such strategic review process. Emcore says that the Strategy and Alternatives Committee and the board continue to work closely with Raymond James in

reviewing alternatives to increase shareholder value.

Meanwhile, Emcore's management team has undertaken a review of the remaining operations and has implemented cost-cutting measures. The firm has seen an improvement in the financial performance and the market conditions of its broadband Fiber Optics business. Management believes the remaining business can achieve EBITDA break-even by September 2015 with some realignment of corporate infrastructure.

"Emcore's narrow-linewidth tunable laser product line is highly complementary to our broad existing portfolio of optical components for 100Gb/s coherent transport systems, and this acquisition significantly expands our footprint in this rapidly growing segment," says NeoPhotonics' chairman & CEO Tim Jenks.

"Emcore's external-cavity laser tunable laser has the narrowest linewidth in the industry, which we believe will become increasingly important for advanced modulation schemes at 400G and beyond. Combining this business into NeoPhotonics will allow us to provide customers with a full product suite that serves the entire coherent market."

NeoPhotonics intends to add the Emcore tunable lasers to its current product line and to continue to serve Emcore's current customers without interruption. Emcore has supported these products from its facility in Newark, CA and NeoPhotonics expects to integrate this business into its existing Silicon Valley facilities. Emcore's revenue for this product line has been about \$9m per quarter. The acquisition is expected to be accretive to NeoPhotonics by second-quarter 2015.

For Q3/2014 (to end-September), NeoPhotonics expects revenue of \$80–82m, gross margin of 25–27% and between net loss of \$0.04 and earnings of \$0.06 per diluted share.

www.neophotonics.com

www.emcore.com

Emcore launches 7840 DOCSIS 3.1 low-noise CATV optical receiver and Medallion 2100 optical A/B switch

Emcore has launched the 7840 DOCSIS 3.1 low-noise CATV optical receiver and the Medallion 2100 optical A/B switch for cable TV.

The 7840 is the latest model in Emcore's family of high-speed optical receivers and is fully compliant with the new DOCSIS 3.1 standard, supporting operational bandwidth up to 1.2GHz. The Medallion 2100 optical A/B switch is a high-performance solution for network protection and optical redundancy in CATV/FTTx networks.

DOCSIS is the standard that facilitates the addition of high-speed data transfer over existing CATV systems for internet access through cable TV services. DOCSIS 3.1 is the latest version being adopted by cable companies to deliver greater capacity and speed. It allows for up to 50% more data throughput over the same spectrum to deliver up to 10Gbps downstream and 1 to 2Gbps upstream. It also decreases the cost-per-bit for data delivery by improving the efficiency of spectrum

use and increasing the energy efficiency of cable modems.

The 7840 DOCSIS 3.1 low-noise optical receiver is a single-mode fiber-pigtailed module featuring a low-noise, impedance-matched broadband photodiode and RF amplification. The device receives optical analog and/or digital signals for a range of video broadcast options and delivers the corresponding RF electrical output. The wide bandwidth supports the delivery of any combination of analog and digital channels up to 1.2GHz of spectrum.

The Medallion 2100 A optical A/B switch is the latest addition to the Medallion family of rack-mountable CATV optical transmission elements. It is packaged in a convenient 1 RU rack-mountable housing and provides an automatic or manual fiber-switching function to protect the network from inadvertent service outages due to up-stream optical signal degradation. Each fiber's optical signal power level is continuously monitored, as is an

adjustable optical trip threshold for each channel. Derived from the feature-rich Medallion series software and hardware base platform, the Medallion 2100 series is a low-power, cost-effective, high-performance switching solution for applications that demand reliable and rapid response to changing network conditions. Multiple standard configurations are available, including up to four independent optical switches in a single housing. Custom configurations are available.

"The 7840 DOCSIS 3.1 CATV optical receiver can be used in both 1310nm and 1550nm applications at different points of a given network and expands our line of DOCSIS 3.1 components, which also includes the 1616A and 1752A lasers," says Gyo Shinozaki, director of marketing for Emcore's CATV products. "The Medallion 2100 is capable of manual switching or can be switched remotely via SNMP, adding optical protection to many system applications "

<http://expo.scte.org>

Dual micro-ITLA tunable laser for coherent optical networking

Emcore has launched the Dual micro-ITLA (integrable tunable laser assembly) for the coherent market, which has begun customer sampling for qualification (with commercial availability expected in Q1/2015).

The Dual micro-ITLA integrates proprietary cooled external-cavity laser (ECL) technology in a smaller package that offers all the micro-ITLA's benefits in a form-factor that needs 25% less space than two micro-ITLAs combined, while delivering the same performance. Emcore claims that, due to its narrow linewidth, low noise and frequency accuracy, its ECL ITLA technology has been the most widely used tunable laser source for high-speed 100 and 400G coherent transmission systems. The smaller form-factor and reduced power consumption

of the Dual micro-ITLA enables users to design even higher densities into their coherent systems.

The addition to Emcore's tunable laser product family follows the ITLA and micro-ITLA, which have dominant market positions in coherent optical networking, reckons Dr LC Chiu, executive VP & general manager of the Fiber Optics Division. "Over 300,000 ITLAs and micro-ITLAs combined have been deployed in the field, carrying live traffic over the most advanced high-speed coherent networks in the world. The new Dual micro-ITLA continues our leadership in tunable laser technology for demanding high-performance telecom applications," he adds.

"The Dual micro-ITLA leverages the advanced performance capabilities of the micro-ITLA and enables even

higher integration levels, while continuing to provide our customers a highly differentiated tunable laser platform," says Emcore's VP of business development Jaime Reloj. "Emcore is the industry leader in tunable lasers for the coherent market," he claims. "The new Dual micro-ITLA will extend that leadership in 100 and 400Gbps transmission systems, and to future networks needs as well."

The Dual micro-ITLA is configurable for specific customer applications and comes with a standard ITLA RS-232 digital user interface for convenient technology-independent control. Other standard features include a grid-agnostic channel plan, off-grid tuning, and in-operation power and frequency adjustment.

www.ecoc2014.org

Houston wins \$1.5m SunShot grant for GaAs thin-film PV on metal foil

DOE grant to fund work to boost efficiency and lower costs

Professor Venkat Selvamanickam at the University of Houston has received a \$1,499,994 grant from the US Department of Energy (DOE) SunShot Initiative to produce high-efficiency, inexpensive thin-film photovoltaics.

The SunShot Initiative was created in 2011 to make solar energy cost-competitive with other forms of electricity by the end of the decade. Since then, it has funded more than 350 projects, with a goal of reducing the cost of solar electricity to about \$0.06 per kilowatt-hour.

Selvamanickam (the M.D. Anderson Chair professor of mechanical engineering and director of the Applied Research Hub at the Texas Center for Superconductivity) began thinking several years ago about developing a technique to produce solar cells using a technique similar to the one he uses for coating semiconductors as thin films on low-cost metal substrates, based on a similar roll-to-roll manufacturing technology.

The most efficient solar cells are composed of a germanium wafer topped with gallium arsenide. But GaAs-on-Ge solar cells are expensive, Selvamanickam says, both because of the high costs of the germanium wafer and the manufacturing process. Also, the germanium wafers are small, requiring a large number to cover much area, so they are used mainly for space applications.

Selvamanickam's process involves using a metal foil tape with a germanium thin film (although another substance could be used as a base) and moving it at high speed with the roll-to-roll technology, coating it in a vacuum chamber with gallium and arsine vapor.

The work is being performed in Selvamanickam's Energy Devices Fabrication Laboratory at the University of Houston's Energy Research Park (established in 2010 to conduct translational research to rapidly develop and transfer new

technologies to industry). The new project with SunShot will be conducted in collaboration with the South Dakota School of Mines and Technology.

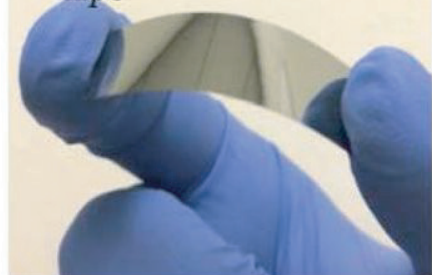
Selvamanickam's team presented a proof-of-concept with his application to the DOE, showing high-quality GaAs thin films on metal foils (P. Dutta et al, Appl. Phys. Lett., vol105, p092104, 2014).

Other researchers have used roll-to-roll manufacturing technology for solar cells, but not with the germanium-GaAs materials so they had much lower efficiency, Selvamanickam says. Single-junction solar cells on germanium wafers produced with GaAs can operate at an efficiency of 28.5%, with a cost of several dollars per watt. Selvamanickam's goal is to produce a solar cell that operates at 24% efficiency at a cost of 20 cents per watt.

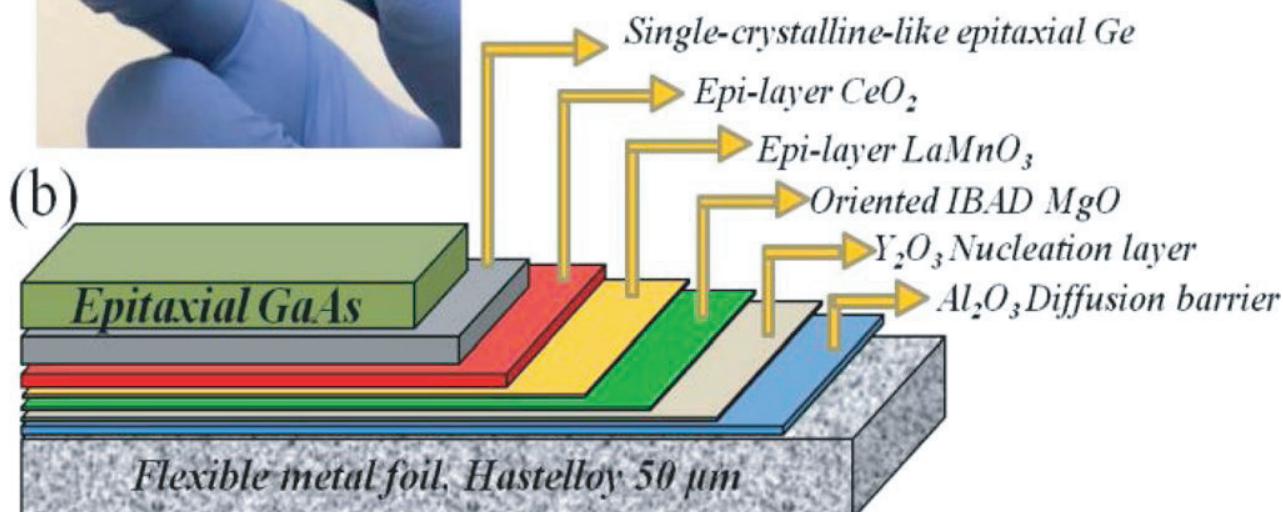
www2.egr.uh.edu/~vselvama

www1.eere.energy.gov/solar/sunshot

(a) Epitaxial GaAs on metal tape



(a) Photo of epitaxial GaAs thin film on flexible metal foil, and (b) schematic of the multilayer architecture developed to grow epitaxial GaAs thin films on metal foil.



Airlight & IBM partner to commercialize HCPVT system

Airlight Energy of Biasca, Switzerland, which supplies proprietary technology for large-scale production of electricity using solar power and for energy storage, has partnered with IBM Research, aiming to bring affordable solar technology to market by 2017. The high-concentration photovoltaic thermal (HCPVT) system can concentrate the sun's radiation 2000 times and convert 80% of it into useful energy to generate 12kW of electrical power and 20kW of heat on a sunny day (enough to power several average homes).

The 10m-high system uses a 40m² parabolic dish made of patented fiber-based concrete, which can be molded into nearly any shape in less than 4 hours and has mechanical characteristics similar to those of aluminium but at one-fifth the cost.

The inside of the parabolic dish is covered with 36 elliptic mirrors made of 0.2mm-thick recyclable plastic foil with a silver coating, which are then curved using a slight vacuum. The mirrored surface area concentrates the sun's radiation by reflecting it onto several micro-channel liquid-cooled receivers, each of which is populated with a dense array of multi-junction photovoltaic chips. Each 1cm x 1cm chip produces up to 57W on a typical sunny day. To protect them from rain or dust, the mirrors and the receiver are encased with a large inflated transparent plastic enclosure, which also prevents birds and other animals from getting in harm's way.

The chips, similar to those used on orbiting satellites, are mounted on micro-structured layers that pipe treated water within fractions of millimeters of the chip to absorb the heat and draw it away 10 times more effectively than with passive air cooling. The 85–90°C hot water maintains the chips at safe operating temperatures of 105°C, which otherwise would reach over 1500°C. The entire system sits on a tracker. The direct hot-water cooling design has already been made commercially available in IBM's high-performance



computers, including SuperMUC (Europe's fastest supercomputer) in 2012. "The direct cooling technology with very small pumping power used to cool the photovoltaic chips with water is inspired by the hierarchical branched blood supply system of the human body," says Dr Bruno Michel, manager, advanced thermal packaging at IBM Research.

An initial demonstrator of the multi-chip solar receiver was developed in a previous collaboration by IBM and the Egypt Nanotechnology Research Center. With such a high concentration and based on its radical design, researchers believe that with high-volume production they can achieve a cost of 2–3 times lower than comparable systems.

To market, license and sell the HCPVT system globally, Airlight Energy has spun off the new firm Dsolar (dish solar), which has licensed several patents from IBM in the area of hot-water chip cooling. "Not only is the system affordable, but it will create jobs where it is installed because many of the materials will be sourced locally," says Dr Gianluca Ambrosetti, Airlight's head of research, responsible for building the new spinoff. "We expect to partner with firms around the world to bring a commercial version to market by 2017," he adds.

Based on its current design, scientists estimate that the operating lifetime for the HCPVT structure is up to 60 years with proper maintenance. The protective foil and the plastic elliptic mirrors will need to be replaced every 10–15 years depending on the environment, and

the PV cells need replacing every 25 years. Throughout its lifetime the system will benefit from design and manufacturing improvements, allowing even greater system efficiency, the firm reckons.

The HCPVT system can also be customized with further equipment to provide drinkable water and air conditioning from its hot water output (e.g. salt water can pass through a porous membrane distillation system, where it is vaporized and desalinated).

Airlight and the IBM Corporate Service Corps (CSC) aim to team up to donate an HCPVT system to two deserving communities. Each winning community will receive a prototype HCPVT system from Airlight, and be eligible for pro bono enablement and transformation support from IBM CSC. Applications from communities will be open in 2015 and the winners will be announced in December 2015, with installations beginning in late 2016.

Airlight and IBM see the HCPVT system providing energy to locations worldwide such as southern Europe, Africa, the Arabian peninsula, the southwestern part of North America, South America, Japan and Australia. As well as residences, applications include remote hospitals, medical facilities, hotels and resorts, shopping centers and locations where available land is at a premium.

Some of the initial funding for the development of the HCPVT system was provided to IBM Research, Airlight Energy, ETH Zurich and the Interstate University of Applied Sciences Buchs NTB (Institute for Micro- and Nanotechnology MNT) in a three-year \$2.4m (CHF2.25m) grant from the Swiss Commission for Technology and Innovation.

www.airlightenergy.com

www.research.ibm.com/labs/zurich/dsolar

Alta Devices cooperating with Airware to integrate solar power into small unmanned aerial vehicles

Four-fold increased flight endurance critical for precision agriculture, search & rescue, land surveying and commercial applications

Alta Devices of Sunnyvale, CA, USA (a Hanergy Holdings company) has announced a cooperation with Airware to enable manufacturers of small unmanned aerial vehicles (UAV) to integrate solar power into their aircraft.

Founded in 2007, Alta is focused on improving the production economics of high-efficiency solar photovoltaics. The firm fabricates gallium arsenide PV cells in a micron-thick thin-film that it then lifts off the growth GaAs substrate (which can then be reused multiple times to amortize its high cost). The thin-film cell can then be placed on a flexible substrate. The firm's use of GaAs has allowed its single- and dual-junction solar cells

to produce record conversion efficiencies of 28.8% and 30.8% respectively. The single-junction GaAs thin-film solar cells are already in production.

Alta has shown that, by integrating its thin, lightweight solar material onto the wings of a small UAV, flight endurance can be increased by more than four-fold. On certain designs, a solar-enabled UAV can fly all day long under sunny conditions, without landing to swap or recharge batteries.

Airware offers hardware, software and cloud services for the rapid development and safe operation of commercial drones. Alta says that, by partnering with Airware, it will be able to bring its AnyLight solar

cell technology to a wide range of commercial vehicles operating around the world. Moreover, through the relationship, UAV manufacturers employing Airware services can dramatically increase their flight endurance with ease, it is claimed.

"This fundamentally changes the utility of small unmanned systems in a number of end markets," reckons Alta's VP of sales & marketing Rich Kapusta. "For precision agriculture, search and rescue, or land surveying, UAVs need to fly longer and farther than today's systems provide," he adds. "The most effective way to increase endurance is by adding solar."

www.altadevices.com

Soitec and partners inaugurate 1.29MWp CPV solar power plant in southern Portugal

Concentrating photovoltaic (CPV) solar module maker Soitec of Bernin, France says that, in an opening ceremony on 7 October, the Alcoutim CPV power plant was inaugurated by the Portuguese government's Secretary of State for Energy, Artur Trindade, in the presence of Luxembourg-based energy supplier Enovos and the three Portuguese project partners: the Calouste Gulbenkian private foundation, electrical contracting firm EIP (Electricidade Industrial Portuguesa) and project developer Luz.On.

Located at a site in Alcoutim near the Vale do Guadiana National Park in southern Portugal, the plant consists of 82 CPV systems supplied by Soitec with combined capacity of 1.29MWp. Construction of the facility was announced in December 2013. Operation began in spring 2014.



The Alcoutim CPV power plant in Portugal.

Soitec says that, in the sun-rich region of Portugal, its CPV technology has demonstrated the full extent of its efficiency, with modules delivering a yield of over 30%. With annual generation of 1900MWh, the plant provides sufficient electricity to meet the needs of several hundred homes in Portugal.

Despite being one of the major European energy suppliers (already

well established in Germany, Belgium, France and Italy), the project is Enovos' first in Portugal, comments José Bériot, head of project development for Soitec's Solar Energy Division in southern Europe and Africa. "This power plant demonstrates the full potential of CPV, and has opened the way for other similar projects in southern Europe," he adds.

"This success also was made possible by the involvement of EIP and Luz.On," continues Bériot, who also thanks the Calouste Gulbenkian foundation (whose philanthropic commitment supports the arts, education and science). "Since 2003, it has expanded its activities to include the environment and sustainable development," he adds.

www.soitec.com

Soitec to sell 150MW of power purchase agreements to large North America solar services provider

Concentrator photovoltaic (CPV) solar system maker Soitec of Bernin (Grenoble), France says that subsidiary Soitec Solar Development LLC has entered into a sales agreement with one of the largest providers of solar energy services in North America to sell 150MW_{AC} of power purchase agreements (PPAs) with San Diego Gas & Electric (SDG&E) for a solar project under development in California.

In 2011, SDG&E entered into five PPAs with Soitec for 155MW_{AC} requiring the use of Soitec's CPV systems.

Construction of the project is subject to certain conditions pertaining to the transaction and, once the conditions have been fulfilled,

Soitec expects to receive a CPV systems order from the designated engineering, procurement & construction (EPC) contractor. Upon completion, the project will deploy up to 83,400 CPV modules manufactured at Soitec's San Diego factory.

This is also an important milestone in executing Soitec's strategic plan, as this agreement will provide significant demand to our US solar manufacturing operation

The latest sales agreement demonstrates the interest generated by Soitec's CPV technology in the US market, says the firm's CEO André-Jacques Auberton-Hervé. Soitec notes that the ability of CPV technology to operate without cooling water and to withstand hot ambient temperatures with minimal environmental impact makes it suited to use in the desert areas of California.

"This is also an important milestone in executing Soitec's strategic plan, as this agreement will provide significant demand to our US solar manufacturing operation," adds Auberton-Hervé.

www.sdge.com
www.soitec.com

First Solar sells 150MW Solar Gen 2 project to Southern Power

US wholesale energy provider Southern Power, a subsidiary of Atlanta-based Southern Company, has acquired the 150MW Solar Gen 2 project in California from cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA.

The Solar Gen 2 facility is being built and will be operated and maintained by First Solar. Construction of the project began in 2013. Completion is expected later in fourth-quarter 2014. Southern Power will initially own 100% of the project, with First Solar agreeing to acquire a minority interest subject to certain terms and upon fulfillment of certain conditions. "We look forward to further opportunities to work together," says First Solar's CEO Jim Hughes.

The Solar Gen 2 project spans three sites — each of which is approximately a 50MW grid-connected solar photovoltaic (PV) system — comprising a combined 1451 acres of land in Imperial

County, California. The project will consist of more than 1 million thin-film PV solar modules mounted on single-axis tracking tables manufactured by First Solar.

As the largest solar facility in the Southern Power portfolio, Solar Gen 2 is expected to generate enough electricity to power more than 60,000 average California homes. Electricity generated by the plant is contracted to serve a 25-year power purchase agreement (PPA) with San Diego Gas & Electric Company (SDG&E), a subsidiary of Sempra Energy that provides energy to 3.4 million people through 1.4 million electric meters and 850,000 natural gas meters in San Diego and southern Orange counties.

"Expanding our partnership with First Solar — a global renewable leader — will help us continue to develop a more diverse energy mix for America," says Southern Company's chairman, president & CEO Thomas A. Fanning.

Southern Power has previously acquired seven solar facilities with Turner Renewable Energy, with Southern Power's ownership of the facilities totaling 262MW. The acquisition of Solar Gen 2 is expected to increase the total Southern Power-owned solar capacity to 338MW. Total generation capacity of the eight projects is expected to be 441MW.

The acquisition fits Southern Power's business strategy of growing the wholesale business in targeted markets through acquiring generating assets and building new units, the output of which is significantly covered by long-term contracts. California's Renewables Portfolio Standard (RPS) program requires investor-owned utilities, publicly owned utilities, electric service providers and community choice aggregators to increase procurement from eligible renewable energy resources to 33% of retail sales by the end of 2020.

www.southerncompany.com
www.firstsolar.com

Inaugural panel installed at South America's largest plant

In the presence of the Republic of Chile's President Michelle Bachelet, the Chilean Senate's President Isabel Allende and Minister of Energy Máximo Pacheco, cadmium telluride (CdTe) thin-film photovoltaic module maker First Solar Inc of Tempe, AZ, USA has ceremonially installed the first solar panel for the 141MW_{ac} Luz del Norte Solar Power Plant. Located 58km north of the city of Copiapó, the project should be complete by December 2015 and will become the largest solar plant in Latin America as well as the biggest in the world to sell electricity on an open contract basis (not necessarily only to regulated clients).

"This year alone, we are incorporating more than 1000MW of new energy to our system through different non-conventional renewable energies," said Bachelet, speaking to a group gathered at the construction site. "This is an important step towards our 2025 target of having 20% of our energy coming from non-conventional renewable

energies," she added. "Chile is in a position to be a leader in renewable energy in the Southern Cone, and in the Atacama region we are doing so," Bachelet continued.

"Northern Chile is one of the places with the highest solar radiation in the world, and therefore is the place to develop alternative renewable energy projects such as First Solar's here in the Atacama region," said Pacheco. "With the implementation of this technology, we will achieve the goal set in our Energy Agenda that, by 2025, 20% of the country's energy will come from such sources," he added.

The project will generate power using 1.7 million of First Solar modules, and will produce enough energy to provide electricity to over 173,962 homes, avoiding over 185,000 metric tons of CO₂ emissions per year.

The 141MW generated by Luz del Norte will directly benefit the end consumer, since its generation entails low variable costs, which are expected to decrease the electricity

system's total cost of electricity.

Luz del Norte will positively impact the regional economy, creating up to 370 construction jobs. First Solar also places a priority on working with regional suppliers, while investing in training them to raise their standards to internationally required levels.

At the event, authorities recognized First Solar's sponsored educational program with Jose Antonio Carvajal Polytechnic School in Copiapó, where a PV system was installed to educate and train the student community.

In conjunction with Solar Energy International (SEI), First Solar is completing its second year of renewable energy training with students from this educational establishment in the installation of PV panels, contributing to expanding their career opportunities as well as nurturing the nascent solar industry. The first 20 students to complete the program graduated this year, and another 23 are currently in their first year.

www.firstsolar.com

Soitec and Focusic begin phase 2 of 20MW Hami project

Renewable-energy power plant developer Focusic New Energy Holding Co Ltd of Zhengzhou, China and concentrator photovoltaic (CPV) solar system maker Soitec of Bernin (Grenoble), France, have said that the second phase of the Hami CPV power plant project has started. It will be completed by the end of 2014, while the third and last phase of the project will be installed in 2015.

Hami is located on the edge of the Gobi desert in the Xinjiang province, a region where Soitec's CPV technology can operate without cooling water, can withstand hot ambient temperatures and has minimal environmental impact (being suited to use in such environmentally sensitive desert areas).

With a final capacity of 20.5MWp, the plant will be one of Asia's biggest CPV power plants. As announced in November 2013, the Hami project

is already fully financed by a loan of 200m yuan (about \$32.7m) from the China Development Bank.

"We started our cooperation with Soitec in 2011," says Focusic's managing director Ma Wenxing. The firm first built a 2.7MWp pilot plant based on Soitec's CPV technology, which was inaugurated last July. "This first phase has confirmed the high efficiency and power output of Soitec's CPV technology. We therefore decided to use Soitec's modules for the two remaining phases of our project," he adds. "At the end of this year, 5.8 new megawatts will be erected in Hami. Finally, we will reach a 20.5MWp total capacity in 2015, with 12 additional megawatts to be installed during the third and last phase of the project."

"The first phase of this project has already demonstrated the excellent

results of our products and we are very pleased Focusic decided to pursue their collaboration with us for the remaining parts of this CPV power plant," says Fabio Mondini de Focatiis, VP of Middle East, Asia Pacific and LATAM of Soitec's Solar Energy Division. "Modules ordered for the second phase have all been shipped and we have already started to produce the ones needed for the third phase," he adds. Soitec CPV systems are already installed in more than 20 countries worldwide. "Regarding this new major project, we strongly believe that the combination of Focusic's local expertise and our CPV technology can effectively address China's renewable-energy needs with a competitive energy solution."

www.focusic.hk/English
www.soitec.com

VDE and Fraunhofer ISE awards First Solar thin-film PV industry's first Quality Tested certification

Germany's VDE Testing and Certification Institute, in conjunction with partner Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany, has issued VDE Quality Tested (QT) Certification to cadmium telluride (CdTe) thin-film PV module maker First Solar Inc of Tempe, AZ, USA for its design, engineering & construction of the Macho Springs 50MW_{AC} power plant in Luna County, NM, USA.

The plant, which began commercial operation in May, uses First Solar's thin-film module and balance of system technology. In a first for the industry, the QT certification of the complete PV plant marks the implementation of a strategic alliance to enhance technical bankability.

"They have now passed the most rigorous quality assurance requirements at the PV plant/system level, thereby assuring a significant reduction of technical risk for the financial performance of First Solar systems," says John Sedgwick, president of VDE Testing and Certification Institute's US subsidiary VDE Americas. "Certification of the Macho Springs facility documents that First Solar leads the industry in technical bankability at the PV power plant/system level," he adds.

"We have implemented rigorous, world-class quality assurance processes throughout our operations," says Azmat Siddiqi, First Solar's senior VP Quality & Reliability.

For years, certification of PV plant sub-components according to

international standards (such as IEC standards for PV modules and inverters) has been the basis for establishing technical bankability of PV plants. VDE QT Certification of Macho Springs verifies the plant as a bankable solar asset and affirms that independent experts have validated every step from initial design through to installation and operation.

"VDE and Fraunhofer ISE strive to set a new benchmark in the global industry for PV power plant quality and reliability assurance, leading to greater risk reduction," says Burkhard Holder, head of Energy and Smart Technologies at VDE Institute Germany. "We verify not only the quality of individual plant components, but also the safety and performance of the overall system," he adds. "Such a comprehensive approach, including both field and lab testing, leads to a significantly higher level of technical bankability and risk reduction for PV power plant investors and financial entities."

Highlighting its stringent, comprehensive level of quality assurance, VDE QT Certification was designed to deliver advantages in four key areas: electrical and mechanical safety of the system; system performance (through a highly accurate energy yield report); proper system operation; and independent verification for investors, lenders, insurance companies and other stakeholders. Certification comprises comprehensive design review, modelling, and over 300 testing points that must be

passed in order to achieve the VDE Quality Tested Mark of certification.

"Independent quality assurance for PV systems has played an important role ever since the earliest days of PV deployment," says Klaus Kiefer, head of quality assurance PV Modules and Power Plants at Fraunhofer ISE. "We are very pleased to add our long-term expertise in precise performance evaluation as an integral part of the VDE QT certification. Our team worked closely with both VDE and First Solar staff to apply our experience and knowledge to assure the maximum quality and performance at the Macho Springs facility," he adds.

"This certification brings more than 30 years and 38GW of German PV experience to the US for the highest level of quality and superior confidence that the asset will provide long-term financial returns," says Sedgwick. "The awarding of VDE QT Certification to the Macho Springs facility highlights the importance of professional certification procedures to ensure the highest plant quality and technical bankability," he adds. "The Macho Springs plant represents the caliber of asset that the industry has been working towards — an independently verified high-quality PV plant that is providing power at prices competitive with traditional non-renewable base load power."

www.ise.fraunhofer.de

www.vde.com/en/institute

www.firstsolar.com

Solar Frontier supplies 21.3MW project in Ube, Japan

Tokyo-based Showa Shell Sekiyu subsidiary Solar Frontier — the largest manufacturer of CIS (copper indium selenium) thin-film photovoltaic modules — has supplied 21.3MW of modules for one of the largest megasolar (utility-scale) power plants, on a 30ha site in Ube City, Yamaguchi Prefecture, Japan.

The plant, which began construction in March 2013 and came on stream in July, is owned and managed by US Power Co Ltd, a joint operating company set up by Showa Shell Sekiyu and Ube Group.

The plant is expected to generate about 25,010,000kWh annually (sufficient for about 6900 house-

holds in Japan) and will reduce CO₂ output by about 8300 tons. Electricity generated at the facility will be sold to Chugoku Electric Power Company and has been approved for Japan's solar energy feed-in tariff program.

www.ube.co.jp

www.solar-frontier.com

Ascent Solar gains China JV business license, allowing \$32.5m cash injection by Suqian

Transfer of manufacturing to cut costs, boosting margins

Ascent Solar Technologies Inc of Thornton, CO, USA, which makes lightweight, flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic modules integrated into off-grid applications and its EnerPlex series of consumer products, says that it has attained a key milestone for its China joint venture.

In December 2013, Ascent and the Suqian Municipality of Jiangsu Province agreed to create a joint venture to build a manufacturing facility in China, in which Suqian would provide a cash injection of \$32.5m, as well as 5-years' free usage of the newly built manufacturing facility along with a 5-year tax holiday and significant trade incentives. Ascent would provide proprietary technology, equipment and expertise to operate the plant as well as a nominal amount of

cash. Ascent's ownership in the JV would progressively grow up to 80% of the JV after all of these items are completed.

Ascent has now officially been granted the Business License as well as the Certificate of Approval for Establishment of Enterprises with Foreign Investment in the People's Republic of China. These documents were the main gating factors for starting the operations of the JV. Now, several activities will start concurrently, including the cash injection by Suqian into the JV and the transfer of proprietary technology and under-utilized equipment by Ascent. As announced on 23 June, Suqian has ascribed a value of RMB400m (\$77m) to Ascent's proprietary technology, representing 48% of Ascent's required contribution to the JV. Ascent expects that certain

components of the JV factory will be in operation by the end of first-quarter 2015.

"We are pleased to have this approval from the appropriate government agencies, which has gone through a stringent process including lengthy feasibility studies and environmental impact assessments," says Ascent's president & CEO Victor Lee. "As we build and transfer much of our manufacturing operations to Suqian, we expect to dramatically reduce our production costs, logistics costs, and overhead costs among others, enabling meaningful improvements in margin as we ramp up the production capacity," he adds. "The factory also provides close proximity to the region exhibiting tremendous growth for consumer electronic products like EnerPlex."

www.AscentSolar.com

Modules selected by Vanguard for arrays in space and UAV missions

Ascent Solar Technologies is to provide its lightweight, flexible CIGS thin-film PV modules to Vanguard Space Technologies for two additional Small Business Innovative Research (SBIR) programs.

Founded in 1994, Vanguard specializes in the engineering, tooling, manufacturing, assembly and testing of lightweight and precision aerospace structures. Its main product lines include antenna reflectors, spacecraft structures, instrument structures and solar power systems for commercial, defense, military and research satellites. Vanguard has extensive experience in composite and advanced, hybrid technologies for spaceborne applications. It also has a growing business in space power and optical and thermal products including modular solar panels, flexible solar panels, shielded, electromagnetically clean

solar panels, solar concentrators, deployable solar arrays and deployable radiator arrays.

Vanguard will use proprietary space environment protection technology along with automated manufacturing approaches, combined with Ascent's flexible PV, to create a very thin, high power-to-weight ratio, large solar arrays for space, as well as for novel integration into the wings of unmanned aerial vehicles (UAVs). Ascent Solar says that it will leverage its experience with space-based and demonstrated UAV solar products to provide optimized variants of its production photovoltaics.

"Our existing flexible, monolithically integrated CIGS product represents an excellent starting point for a wide range of applications, including Vanguard's space and UAV-based products," says

Ascent's chief technology officer Dr Joseph Armstrong. "Our production CIGS represent an excellent option to futuristic solar cells where availability is as critical to mission success as our flexibility, light weight, and durability have been. Our growing relationship with Vanguard represents an exciting partnership for developing new products in these challenging markets," Armstrong adds.

"The advent of our extreme-environment thin-film coatings, automated manufacturing friendly array design, and Ascent's proven cell technology provides an excellent fit for our ongoing investigations into next-generation durable, affordable, large-area space solar arrays and also extended range UAV solar wing-skins," says Matt Wrosch, Vanguard's manager of Solar Power Systems.

<http://vst-inc.com>

Ascent Solar launches EnerPlex consumer products in Australia and South Pacific via distributor SeeChange and retail partner Anaconda

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 launched its consumer products in 25 of Anaconda's Adventure Superstores throughout Australia, New Zealand and the South Pacific region.

"Anaconda is proud to be partnered with off-grid consumer power solutions from EnerPlex; after looking for the best products to showcase in store, EnerPlex was the first-choice supplier for this unique offer," says Benjamin Rieson of Anaconda.

EnerPlex offers a complete portable power solution by uniting its lightweight and rugged solar with power storage solutions for consumers. With ruggedized products, which can withstand the

harshest environments, EnerPlex provides a charging solution for consumers who want to get off the grid, says Ascent Solar.

"Australasia and the South Pacific is a rich target market for the EnerPlex brand, with many citizens living off the grid and away from traditional power sources," says John Masanik, EnerPlex's manager of business development. "Our partnership with both [distributor] SeeChange and Anaconda will allow us to immediately penetrate these markets with 25 physical retail locations," he adds.

"When we researched who was buying our mobile power products we were surprised how many were camping, tramping, hunting, fishing, hiking and biking enthusiasts," says SeeChange's managing director Joe Caccioppoli. "These customers have unique requirements as their

technology must be able to handle the rigors of being used outdoors and they also have the opportunity to leverage Mother Nature to provide power," he adds. "To support this large consumer group we needed to add to our portfolio the very best suppliers of outdoors designed mobile power products. As EnerPlex has a wide range of quality, multi-award winning innovative products, they were an obvious choice for us. Their solar technology in particular is the best in the market, delivering better performance in variable light conditions and more power per kilogram than any other product we have found. SeeChange is very proud to be the exclusive distributor for EnerPlex in Australia, New Zealand and the Pacific Islands."

www.AscentSolar.com

www.goenerplex.com

Ascent Solar signs Peak Development as UK EnerPlex distributor

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 signed Peak Development Ltd (a specialist distributor of accessories, add-ons and enhancements for digital devices) as the preferred distributor to large retailers for EnerPlex products in the UK.

"Never have we seen such well-designed products that are flexible, robust and also work so well in the changeable British weather," comments Peak's managing director Robert Baseley.

EnerPlex offers a complete portable power solution by uniting its lightweight and rugged solar with power storage solutions for consumers. With ruggedized products, which can withstand the harshest environments, EnerPlex

provides a charging solution for consumers who want to get off the grid, says Ascent Solar.

"The UK continues to be a high-value target market for EnerPlex, one which bears huge potential for growth," says John Maslanik, EnerPlex's manager of business development. "Through our new partnership with Peak Development we intend to push further into the consumer space to realize this opportunity."

Ascent signs TodoSolar as EnerPlex distributor in Mexico

Ascent Solar Technologies has signed TodoSolar as its new distributor of EnerPlex products in Mexico.

EnerPlex offers a complete portable power solution by uniting its lightweight and rugged solar with power storage solutions for

consumers. With ruggedized products, which can withstand the harshest environments, EnerPlex provides a charging solution for consumers who want to get off the grid, says Ascent Solar.

"Branching into the Mexican market is a great step forward for the

EnerPlex brand," John Maslanik, EnerPlex's manager of business development. "TodoSolar is a fantastic partner, whose connections in the Mexican retail market will help us quickly bring products to shelves throughout Mexico."

www.enerplexmex.com

Stion launches improved CIGS solar modules

Stion Corp of San Jose, CA, USA, which makes nanostructure-based CIGS (copper indium gallium sulphur-diselenide) thin-film photovoltaic panels, has announced the release and certification of its Elevation 4 module line, which delivers up to 10% more energy than conventional crystalline silicon modules with the same power rating, it is reckoned. The modules are available in variants ranging from 135W to 155W, in 5W increments. Elevation 4 modules are certified to the ANSI/UL 1703, IEC 61730 and

IEC 61646 standards.

Stion says that product enhancements enable the Elevation 4 module to provide high energy yield due to an anti-reflective coated glass and temperature coefficient of $-0.26\%/^{\circ}\text{C}$.

The Elevation 4 module uses Stion's proprietary Circuit Protection System (CPS), which provides significantly improved moisture resistance and lifetime durability over crystalline silicon modules, it is claimed. The modules are also resistant to potential-induced

degradation, light-induced degradation, and are engineered to survive in harsh environments and to out-perform in non-ideal situations, claims the firm.

Stion says that its proprietary, monolithically integrated CIGS thin-film solar modules use significantly less energy and raw materials than traditional PV modules and are fully compliant with the European Union Restriction of Hazardous Substances (RoHS) directive.

www.stion.com

Stion, Hannah Solar and Washington Gas Energy Systems partner to provide solar energy for water treatment plant

Stion Corp of San Jose, CA, USA, which makes nanostructure-based CIGS (copper indium gallium sulphur-diselenide) thin-film photovoltaic panels, has unveiled a 1MW solar array at the Vidalia Water Treatment Facility in Vidalia, GA, USA.

Washington Gas Energy Systems Inc (an affiliate of Washington Gas Light Company and a subsidiary of WGL Holdings) assembled a team of partners that leveraged Stion's solar modules and the development and engineering, procurement & construction (EPC) experience of full-service design/build solar integrator Hannah Solar of Atlanta, GA, USA. Stion's warm-temperature performance is said to provide a significant energy yield advantage over crystalline silicon solar modules, especially in the warm climate of Georgia. This is the first of several Washington Gas Energy Systems-owned projects using Stion's modules.

"We performed a full system analysis with Stion," notes says Hannah Solar's CEO & president Pete Marte. "The total system cost was lower and it produced more energy than the other options we considered."

Operating since February, the



The 1MW solar array at the Vidalia Water Treatment Facility.

project was made possible by the Georgia Power Advanced Solar Initiative (GPASI) and will be owned and operated by Washington Gas Energy Systems. The firm was awarded a contract with Georgia Power to buy 100% of the power produced by the solar array for the next 20 years. The design consists of more than 7000 of Stion's Elevation solar modules

connected to transformerless inverters. The plant provides energy for powering the treatment plant and the neighboring homes. The Vidalia project is part of Stion's growing portfolio of installations at water treatment facilities.

www.stion.com
www.hannahsolar.com
www.wgesystems.com

XsunX exceeds 146kW in total commercial solar systems sales incorporating new power management features

XsunX Inc of Aliso Viejo, CA, USA, which is developing hybrid copper indium gallium (di)selenide thin-film (CIGS) photovoltaic (TFPV) cell technologies and 'CIGSolar' manufacturing processes, says that its sales of solar power systems integrating new commercial power management features have now reached 146kW. Providing detailed on-site energy generation and facility-wide usage data, the power management capabilities are designed to help clients expose and eliminate inefficiencies while working towards net-zero energy consumption.

"The complexity of how utilities charge commercial clients for their power makes achieving net-zero energy consumption hard to attain by adding solar alone," says CEO Tom Djokovich. "Our goal at XsunX has been to deliver technology that could help achieve this goal without driving the cost for a solar power

system through the roof," he adds. "The cost for adding our new commercial power management 'CPM' capabilities adds only pennies to a typical commercial solar power system."

The firm's addition of CPM technologies to its solar power system designs was the first of two key planned system upgrades. The next goal is to integrate on-site power storage to

The firm's addition of CPM technologies to its solar power system designs was the first of two key planned system upgrades. The next goal is to integrate on-site power storage to decrease building dependency from utilities for incidental building load demands

decrease building dependency from utilities for incidental building load demands.

"Our goal is to provide clients with an economically balanced three-part solution delivering on-site power production to off-set 100% of their kilowatt hour needs, the ability to manage every aspect of how they use power to eliminate waste, and the delivery of on-demand stored power to offset costly incidental power hogging equipment loads," says Djokovich.

Similar to how hybrid vehicles blend the efficiencies of on-demand power from internal combustion with electric power, XsunX says that it is focused on delivering a hybrid commercial solar power solution to provide maximum cost-reducing benefits, while allowing clients to continue to rely on the benefits of power as needed from the local utilities to in-fill demand.

XsunX to deliver 117kW commercial solar system

XsunX says that it ended September with the sale of a 117kW commercial solar system, and is launching a marketing push for fourth-quarter 2014 offering its 'Zero Cost' system package to commercial clients.

The firm says that interest in its commercial solar system offerings has continued to build across multiple business sectors spanning from small and large commercial operations to industrial and cold storage facilities, to homeowners association (HOA) groups. Recent interest has also come from agricultural operations, where the energy costs for pumping, refrigeration and processing systems can make the difference between operating profits or losses, the firm adds.

XsunX says that it has developed a team of qualified engineering

and specialty contractors with extensive commercial solar experience necessary to service the diverse conditions that can be encountered in commercial buildings. The firm couples this design and delivery capability with factory direct pricing and zero down financing options.

"Through the combination of our system designs and effective pricing, installation incentives and financing options, we can present qualified clients with a 'Zero Cost' commercial solar system installation and ownership proposal," says XsunX's CEO Tom Djokovich. "For these clients, our installation packages can reduce up-front costs to zero, and net reductions to annual operating costs," he adds.

Up until now, the early adopters of commercial solar have included well-financed national brands

such as Walmart, Staples, FedEx, Toys 'R' Us etc. However, more banks are taking notice of the potential for commercial solar, and many new financing alternatives are creating profitable opportunities for the banks, the solar contractors, and the business owners, says XsunX.

"The bottom line is that we can offer clients the opportunity to trade a larger energy bill for a lower one, as well as the opportunity to own their systems," says Djokovich. "Our clients do not have to shell out tens or hundreds of thousands of dollars upfront to own and benefit from adding solar to their businesses," he adds. "This is the message that we deliver every day in the marketplace, and we are now beginning to see traction," concludes Djokovich.

www.xsunx.com

Highly conductive p^{++} -AlGaAs/ n^{++} -GaInP tunnel junctions for operation up to 15,000 suns in concentrator solar cells

In the last few decades there has been great interest in III-V multi-junction solar cells (MJSC) for concentrator applications due to their promise to significantly reduce the cost of electricity.

Being formed by series connection of several solar cells with different bandgaps, a key role in a MJSC structure is played by the tunnel junctions (TJ) aimed to implement

such series connection. Essentially, tunnel junctions (tunnel diodes or Esaki diodes) are thin, heavily doped p-n junctions where quantum tunneling plays a key role as a conduction mechanism. Such devices were discovered by Nobel laureate Leo Esaki at the end of 1950.

The key feature of tunnel junctions for their application in MJSC is that, as long as quantum tunneling is the dominant conduction mechanism, they exhibit a linear I-V dependence until the peak tunneling current (J_p) is reached. This initial ohmic region in the I-V curve is ideal for implementing low-loss interconnections between the subcells with different energy bandgaps that constitute a MJSC.

According to this brief introduction, two important requirements can be deduced for TJs.

- They should provide minimum electrical losses in the interconnection (i.e. low voltage drop) by exhibiting low equivalent resistance and high peak tunneling currents. This requirement is specially demanding in ultra-high concentrator applications where photo-generated currents are quite high ($\sim 10\text{A}/\text{cm}^2$ for 1000 suns up to $\sim 150\text{A}/\text{cm}^2$ for 15000 suns).

- They should be transparent (i.e. non-absorbing) for the light passing to underlying subcells.

In terms of materials to implement the TJ, these two requirements point to opposite directions. High transparency is obtained by choosing high-bandgap materials

while the highest peak tunneling currents are obtained by using low-bandgap materials, which suffer from higher light absorption. Hence, optimization of the bandgap materials used in order to get a trade-off between high peak tunneling current and high optical transmission is required when working at high concentrations.

In previous work by the III-V semiconductor group at IES-UPM (Solar Energy Institute of the Technical University of Madrid), a p^{++} -AlGaAs:C/ n^{++} -GaAs:Te design was presented with the highest J_p reported to date ($10,000\text{A}/\text{cm}^2$) for a TJ in the field of MJSCs. With the aim of improving the transparency of this TJ, a new design was implemented by substituting the GaAs cathode by a heavily Te-doped GaInP layer, in the quest for a p^{++} -AlGaAs:C/ n^{++} -GaInP:Te design. The goal of this TJ is to work as a connection between the GaInP top cell and the Ga(In)As middle cell in a lattice-matched GaInP/Ga(In)As/Ge triple-junction solar cell.

For electrical characterization of the TJ, a test structure was grown on a (100) GaAs wafer, mis-oriented 2° towards the nearest (111) A plane, by metal-organic vapor phase epitaxy (MOVPE). The heavily doped p-n junction was grown after 20nm of GaInP:Si, which is the material used for the window layer of the middle cell in a real MJSC structure (see Figure 1 left). After these layers, a GaAs cap layer was grown to facilitate the formation of ohmic contacts.

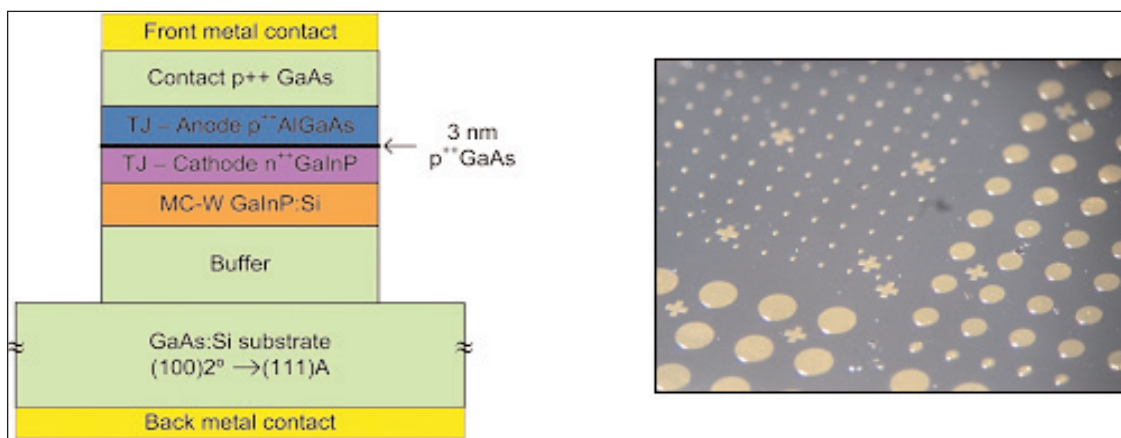


Figure 1 (left) Semiconductor structure of the p^{++} -AlGaAs:C/ n^{++} -GaInP:Te TJ and (right) photograph of the processed diodes.

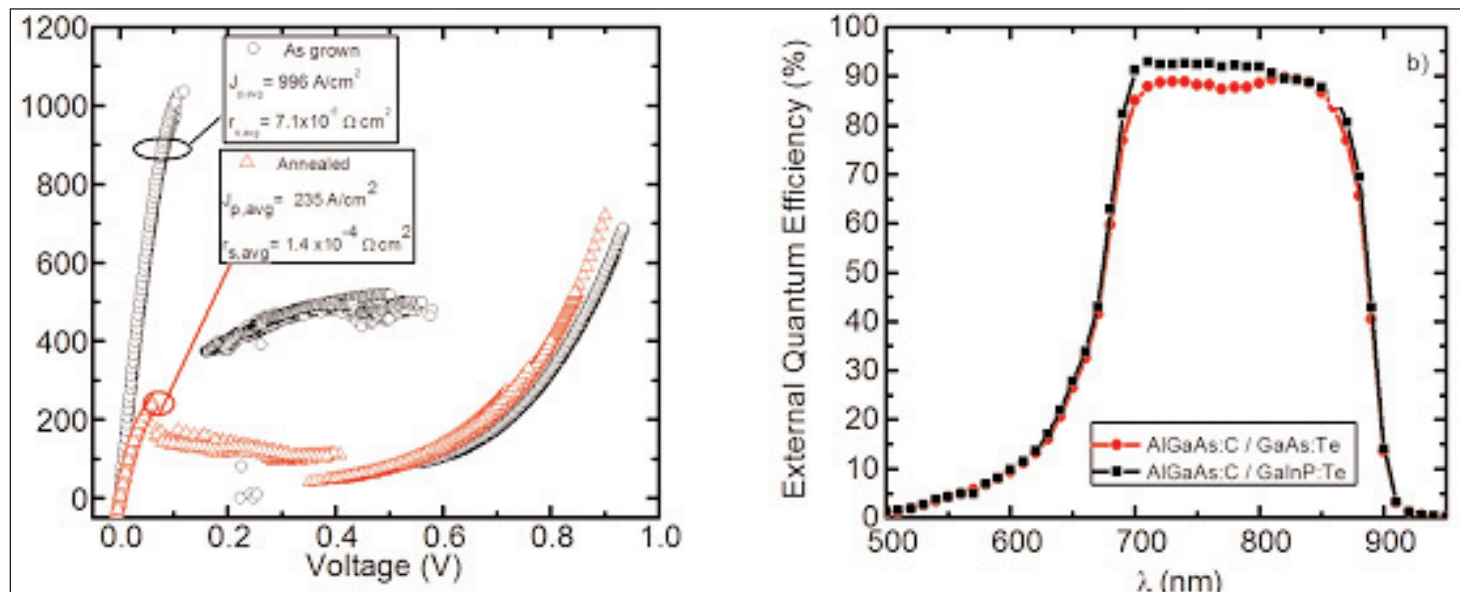


Figure 2 (left) J–V measurements of p^{++} -AlGaAs:C/ n^{++} -GaInP:Te TJs fabricated with the as-grown structures (black circles) and after thermal annealing at 675°C for 30 min (red triangles) and (right) EQE measurements of GaInAs SCs with a p^{++} -AlGaAs:C/ n^{++} -GaInP:Te (black squares) and a p^{++} -AlGaAs:C/ n^{++} -GaAs:Te (red circles) TJ on top. The results are plotted for devices with ARC.

It has been widely reported in the literature that TJs suffer from thermal degradation. So, when grown as individual test devices, they typically show much better characteristics than when grown in real structures where the thermal load is higher. To take this effect into account and simulate the thermal load that the TJ will suffer during growth of the rest of the layers of a complete MJSC structure, a second identical sample was grown and subsequently annealed at 675°C for 30 minutes to simulate the thermal load associated with growth of the MJSC's top cell. The front contact metallization of both samples was formed with AuZn, and AuGe/Ni/Au was used for the back contact (see Figure 1 right).

The J–V curves were measured for both samples with the 4-point probe technique. As can be seen from Figure 2, an average J_p of 996 A/cm² was obtained, together with a specific resistance of $7 \times 10^{-5} \Omega \text{ cm}^2$, for as-grown samples. The sample that suffered additional thermal load showed a reduced peak tunneling current of 235 A/cm², which is also high enough to allow the TJ to operate in the ohmic region up to ultra-high concentrations of 15,000 suns. In this second case, the specific resistance increased to $1.4 \times 10^{-4} \Omega \text{ cm}^2$, which is still a value low enough to guarantee a negligible voltage drop, even at ultra-high concentrations.

In relation to the optical properties of this new TJ structure, the external quantum efficiency (EQE) was measured to verify the current gain in the middle subcell because of a lower optical absorption. For that, two new samples were performed by using Ge (100) substrates. Two samples were grown. For one, after growth of the middle cell, a lower-bandgap TJ was grown (p^{++} -AlGaAs/ n^{++} -GaAs). The other one had a new high-bandgap design (p^{++} -AlGaAs:C/ n^{++} -GaInP:Te).

In both structures, after the TJ growth, a GaInP layer of 750 nm was grown, mimicking the top-cell absorption.

The same anti-reflection coating layer was deposited on both samples prior to EQE measurement. As can be seen (Figure 2 right), the EQE of the samples with a high-bandgap tunnel junction is improved due to the higher transparency of this design, allowing more light to reach the middle subcell. This EQE improvement results in a current gain around 0.56 A/cm² when considering the AM 1.5 D ASTM G 173-03 (1000 W/m²) spectrum.

All these characteristics indicate that this TJ structure can be integrated in a MJSC without being the limiting component of the device when working at even ultra-high concentrations (15,000 suns). All the work (simulation of structures, epitaxial growth by MOVPE and electrical and optical measurements) was carried out at IES-UPM.

These structures are being implemented in an optimized triple-junction solar cell that is intended to exceed efficiencies of 40% working at ultra-high concentrations. ■

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Photo-electro-chemical etch & vertical-cavity laser diodes

UCSB has used the photo-electro-chemical etch technique to give a smooth surface for the deposition of distributed Bragg reflectors.

University of California, Santa Barbara (UCSB) has used photo-electro-chemical etch (PEC) to create 405nm-wavelength vertical-cavity surface-emitting lasers (VCSELs) based on indium gallium nitride (InGaN) multiple quantum wells (MQWs) [C. O. Holder et al, Appl. Phys. Lett., vol105, p031111, 2014]

According to the researchers, VCSELs are attractive from a number of perspectives such as "circular output beam, single longitudinal mode operation, low output beam divergence, reduced threshold current, reduced device footprint, high modulation frequency, and characteristic vertical emission normal to the substrate, enabling the fabrication of high density 2D arrays."

However, short-wavelength VCSEL devices based on nitride semiconductors such as InGaN are difficult to make. In particular, deposition of dielectric distributed Bragg reflectors (DBRs) on the n-side of the device requires the removal of the substrate. Methods to remove the substrate generally result in an undesired rough surface. UCSB has used PEC to create a smooth surface after substrate removal.

The epitaxial structure (Figure 2) was grown on m-plane free-standing GaN from Mitsubishi Chemical using atmospheric-pressure metal-organic chemical vapor deposition (AP-MOCVD). The substrate was misoriented 1° in the $[000\bar{1}]$ direction to avoid the formation of pyramidal hillocks, as happens with on-axis growth.

The use of m-plane growth direction, rather than the more usual c-plane, was designed to avoid the problems of electric fields resulting from the spontaneous and piezoelectric (strain-dependent) polarization of nitride semiconductor alloys. Also, m-plane lasers have shown linear gain versus current characteristics, low transparency carrier and current densities, and high anisotropic gain.

The epi material was formed into VCSELs flip-chip bonded onto a sapphire submount (Figure 1). The p-side DBR consisted of 13-period silicon dioxide/ tantalum pentoxide ($\text{SiO}_2/\text{Ta}_2\text{O}_5$) dielectric pairs.

The 415nm MQW part of the epitaxial structure was used as the active region for a PEC undercut etch that removed the substrate. The illumination above the 415nm bandgap was provided by a continuous wave (CW) 405nm laser at 200mW ($65\text{W}/\text{cm}^2$).

The generated holes created the conditions for selective etch through oxidation of gallium atoms in the sacrificial MQW layer. The electrolyte was potassium hydroxide solution. Photo-generated electrons were removed through a reduction reaction at a titanium/gold (Ti/Au) cathode.

The aperture of the VCSEL was positioned to be closer to the Ga-face of the MQW sidewall, allowing more

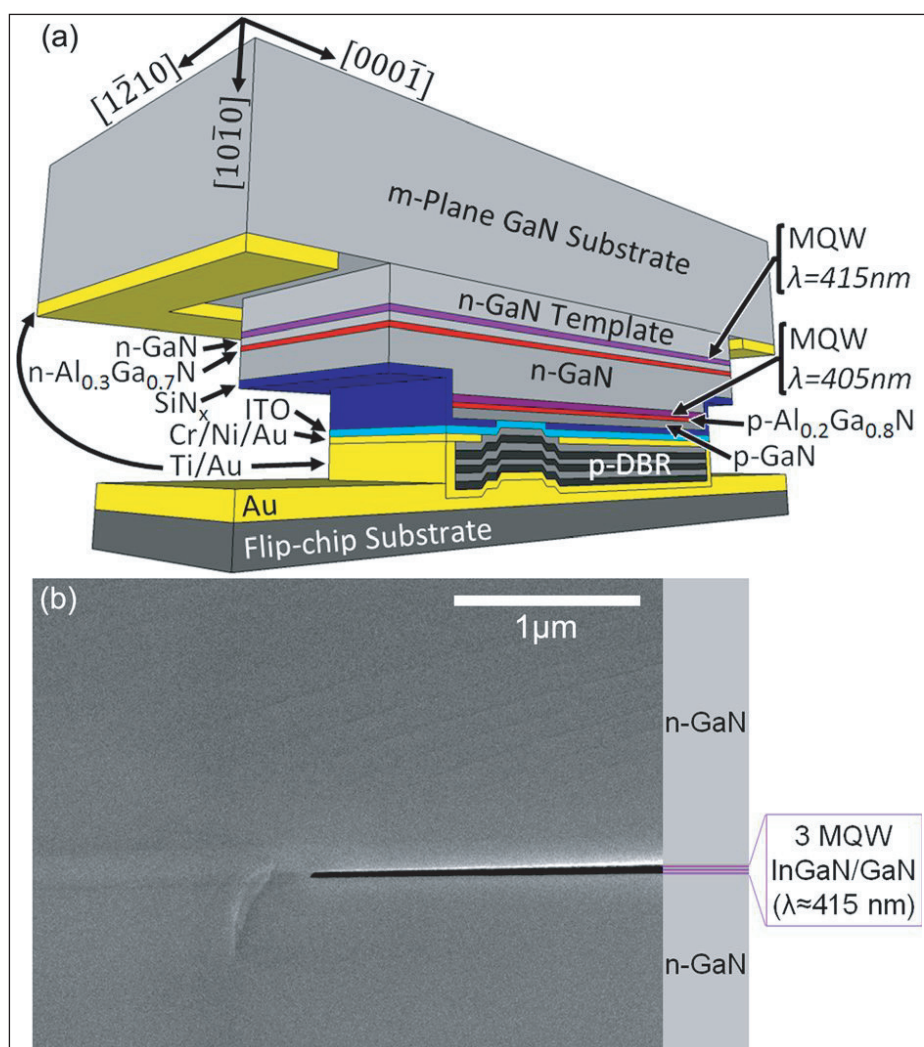


Figure 1. (a) Schematic cross-section of VCSEL following flip-chip bonding, but before native substrate removal. (b) SEM image of bandgap-selective PEC undercut etching for substrate removal.

rapid, complete etching of the aperture region. The PEC process was continued until the substrate could be removed.

The researchers comment: "Beyond the simplicity of this substrate removal technique, PEC undercut etching has the potential to enable the reuse of free-standing GaN substrates, as the substrates are essentially undamaged after removal. This capability could significantly reduce the cost of non-polar and semi-polar VCSELs as well as non-polar and semi-polar edge-emitting lasers and light-emitting diodes (LEDs)."

After the substrate removal, titanium/gold was deposited on the n-GaN surface as a device contact. The new n-contact was also used as a cathode for more PEC etching. The illumination was from an ultraviolet mercury-xenon lamp with a filter that removed light with wavelengths shorter than 320nm. The n-Al_{0.3}Ga_{0.7}N layer with 310nm bandgap acted as an etch-stop and hole-blocking layer that prevented holes participating in etching.

After the etch, the root mean square (rms) roughness of the n-Al_{0.3}Ga_{0.7}N surface was 0.53nm. The 10-period n-side DBR was deposited on this surface.

Light output (L) measurements were made at varying temperature with pulsed current injection (Figure 3). The duty cycle was 0.3% and the pulse width was 30ns. The threshold current rose with temperature between 34mA at 15°C and 48mA at 40°C. The T₀ characteristic temperature of the threshold is 75.19K.

The power output versus current (L-I) curves show a kink at lower temperature thought to be related to the onset of higher-order lasing modes. The wavelength of the laser emission rose with temperature at the rate 0.015nm/K.

The laser light was not centered in the 7μm-diameter aperture – possibly the result of "inhomogeneity in material composition, surface morphology, local cavity length, current spreading, or transverse optical confinement," according to the researchers.

The polarization of the emitted laser light at 20°C with 60mA injection was found to be 100% in [1̄210] a-direction. The researchers took care to filter out light from spontaneous emission from the polarization measurements.

With c-plane laser diodes, some devices have been reported with 80% polarization – however, in general, the light from c-plane devices should be randomly polarized across an array due

Contact	p ⁺⁺ -GaN	14nm
Spacer	p-GaN	113nm
Electron blocking	p-Al _{0.2} Ga _{0.8} N	15nm
Laser MQW	5x(In _{0.1} Ga _{0.9} N/GaN)	3x(7nm/5nm)
Spacer	n-GaN	902nm
Hole blocking/etch stop	n-Al _{0.3} Ga _{0.7} N	15nm
Contact	n-GaN	50nm
Sacrificial MQW	3x(In _{0.12} Ga _{0.88} N/GaN)	
Template	n-GaN	2μm
Substrate	m-plane GaN	

Figure 2. Epitaxial structure for m-plane VCSELs. Cavity length was designed at around 7.5 wavelengths.

to the circular symmetry of the band structure of c-plane devices. By contrast, m-plane MQW devices exhibit a splitting occurs in the top valence band levels due to unbalance biaxial stress. This leads to stronger coupling to electric fields polarized along the a-direction. ■

<http://dx.doi.org/10.1063/1.4890864>

Author: Mike Cooke

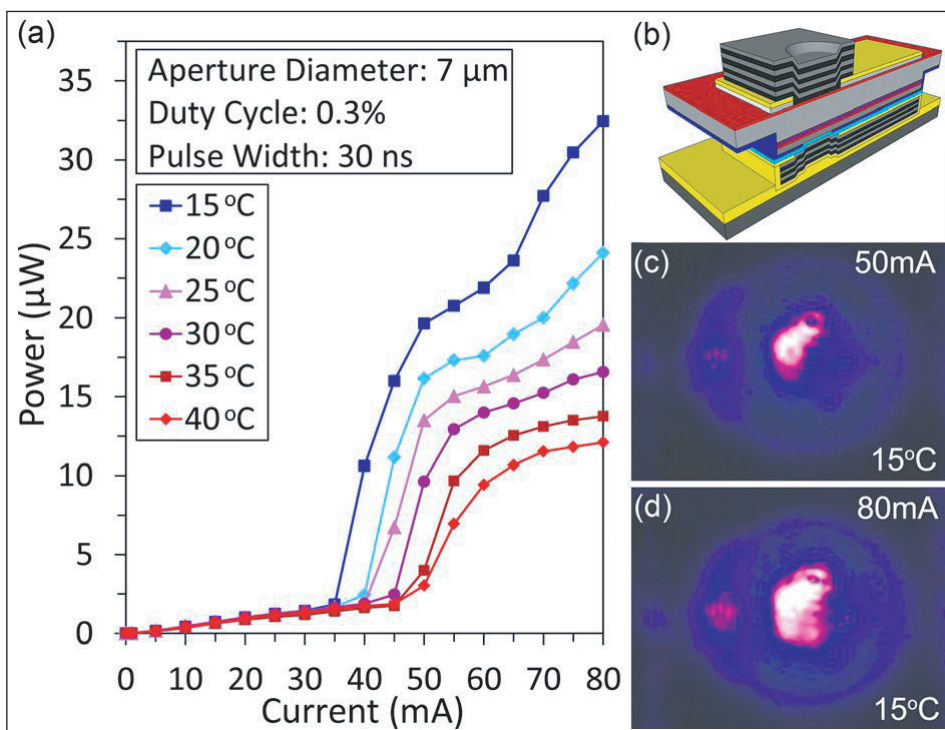


Figure 3. (a) Dependence of time-average output on current for VCSEL for range of stage temperatures. (b) Schematic of completed VCSEL. Near-field images of VCSEL at (c) 50mA and 15°C, (d) 80mA and 15°C.

Graded electron blocking improves III-nitride VCSELs

Varying the AlGa_N composition flattens the barrier to hole injection while raising the barrier to electron overflow.

Researchers in Taiwan have used graded electron-blocking layers (GEBLs) to improve the performance of III-nitride compound semiconductor vertical-cavity surface-emitting laser (VCSEL) diodes [B C Lin et al, Laser Phys. Lett., vol11, p085002, 2014]. The team was variously based at National Chiao Tung University, National Changhua University of Education, Advanced Optoelectronic Technology Inc, and Research center for Applied Science.

Most III-nitride light-emitting devices employ electron-blocking layers of aluminium gallium nitride (AlGa_N) to confine electrons to the active multiple quantum well (MQW) regions where it is desired they should recombine with holes in the valence band, producing photons. However, electron-blocking layers (EBLs) often have the undesired side-effect of inhibiting hole injection.

The epitaxial III-nitride structures (Figure 1) used by the Taiwan team were grown on c-plane sapphire using metal-organic chemical vapor deposition (MOCVD). The n-side distributed Bragg reflector (DBR) consisted of 25 pairs of AlN/GaN layers.

The EBL consisted of either ungraded p-Al_{0.25}Ga_{0.75}N or p-AlGa_N graded from 0% to 25% Al composition. The grading of the AlGa_N composition was achieved by varying the Al/Ga precursor ratio. The deposition temperature was 870°C in both ungraded and graded AlGa_N deposition. The alternative grading technique of growth temperature variation was not adopted, since it could damage the previously grown MQW structure.

Contact	p-GaN	100nm
EBL	p-AlGa _N	20nm
MQW	10x(In _{0.1} Ga _{0.9} N/GaN)	10x(2.5nm/10nm)
Contact	n-GaN	880nm
DBR	25x(AlN/GaN)	
Nucleation	GaN	30nm
Substrate	c-plane sapphire	

Figure 1. Epitaxial structure.

Transmission electron microscope (TEM) images of the interface between the last GaN barrier of the MQW and the ungraded EBL showed several abnormal dark regions. Such dark regions tend to be associated with degradation of crystal material quality. By contrast, dark regions were not apparent in the GEBL.

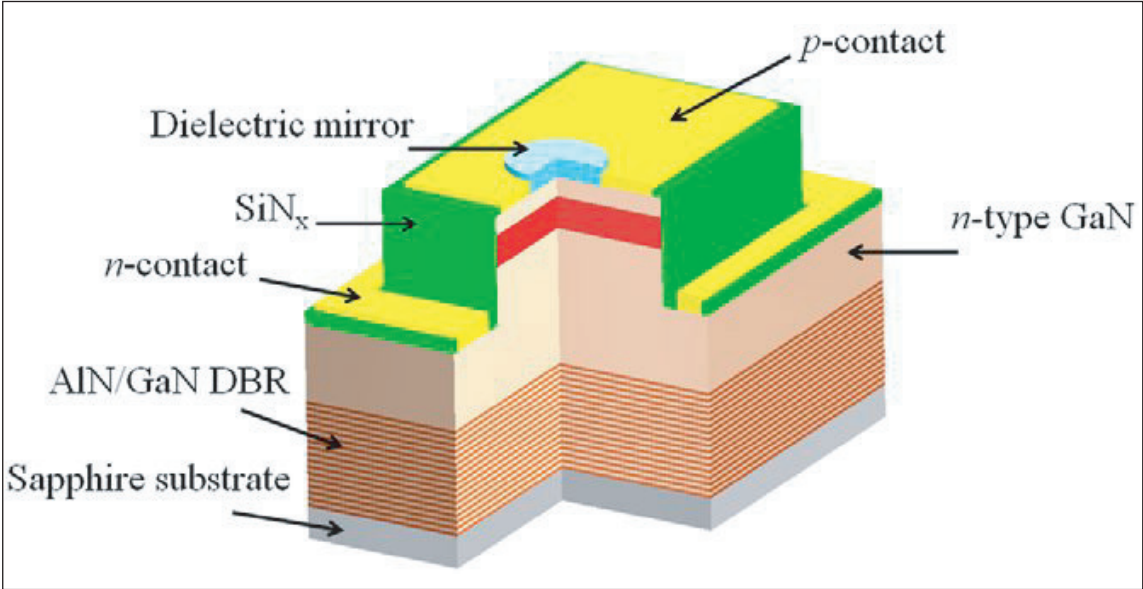


Figure 2. Schematic of InGa_N-based VCSEL structure.

Simulations suggested that the effect of the GEBL was to provide a flatter profile in the valence band, while increasing the effective barrier in the conduction band, in comparison with the ungraded EBL. The flatter valence profile reduces the barrier for hole injection. The higher conduction-band barrier makes the EBL more effective at confining the electrons to the MQW active region. The positive effects of the GEBL are thought to be due to the reduced polarization charge density at the interface with the last GaN barrier of the MQW, where the aluminium composition of the GEBL starts at 0%.

Fabrication of the VCSEL (Figure 2) involved plasma-enhanced CVD of silicon nitride (SiN_x) for current confinement, opening a $10\mu\text{m}$ -diameter current aperture, deposition and annealing of 40nm indium tin oxide (ITO) as a transparent current-spreading layer in the aperture, deposition of n- and p-contact electrodes (nickel/gold and titanium/aluminium/nickel/gold, respectively), and completion with the deposition of 10 pairs of tantalum pentoxide and silicon dioxide dielectrics to give the p-side DBR. Both DBRs give

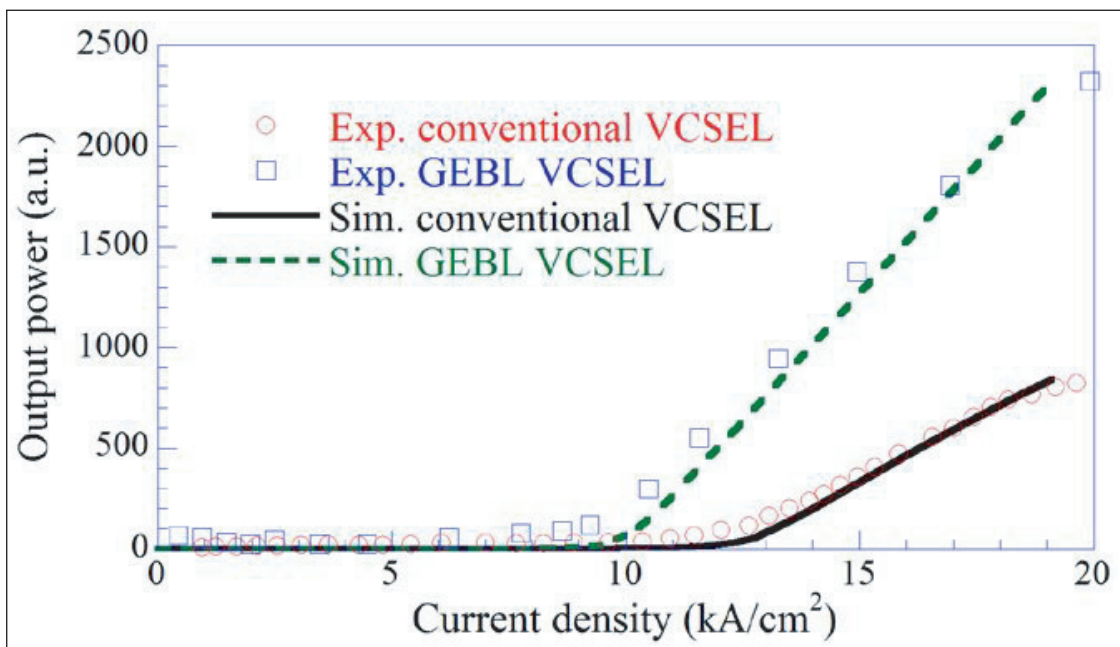


Figure 3. Laser performance of VCSELs with conventional rectangular EBL and GEBL obtained by experiment and numerical simulation.

about 99% reflectivity at the peak emission wavelength of 410nm.

The researchers compared their simulations with measurements made at 300K in continuous wave (CW) operation. The GEBL device shows a reduced threshold current density of 9.2kA/cm^2 , compared with 12.6kA/cm^2 for the ungraded EBL VCSEL. The GEBL device also shows higher slope efficiency. At 20kA/cm^2 , the laser output power is a factor of 3.8 times that of the ungraded EBL VCSEL. ■

<http://dx.doi.org/10.1088/1612-2011/11/8/085002>

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Visible laser light lift-off for UV-A LEDs on free-standing gallium nitride

Removal of substrate improves light output power at 380nm wavelength by a factor of 1.7x at 50mA injection current.

Meijo and Nagoya universities in Japan have developed a laser lift-off (LLO) technique for removing gallium nitride (GaN) substrates from ultraviolet (UV) light-emitting diodes (LEDs) to improve light extraction efficiency [Daisuke Iida et al, Appl. Phys. Lett., vol105, p072101, 2014].

GaN substrates absorb UV-A light due to impurities such as oxygen and carbon. Typical LLO techniques use UV laser light to separate GaN buffer layers from sapphire substrates. The UV light is strongly absorbed by the GaN layers but not by the sapphire. The absorbed light decomposes the GaN structure and droplets of Ga form, allowing separation of the GaN from sapphire.

However, UV LED devices cannot be separated in this

way since the UV laser light would also damage the UV active region. The Meijo/Nagoya team has instead developed an LLO technique for devices grown on free-standing GaN substrates which uses visible laser light absorbed by a superlattice with gallium indium nitride (GaInN) layers. The visible laser light does not damage the UV emitting layers. The use of free-standing GaN substrates reduces the density of performance-killing threading dislocations, also improving performance.

The heterostructures were produced by metal-organic vapor phase epitaxy in a face-down 2-inch x 3-wafer horizontal-flow reactor. The substrate was free-standing GaN, with a threading dislocation density less than $10^6/\text{cm}^2$. The researchers first developed the LLO technique involving $\text{Ga}_{0.85}\text{In}_{0.15}\text{N}/\text{GaN}$ superlattice (SL)

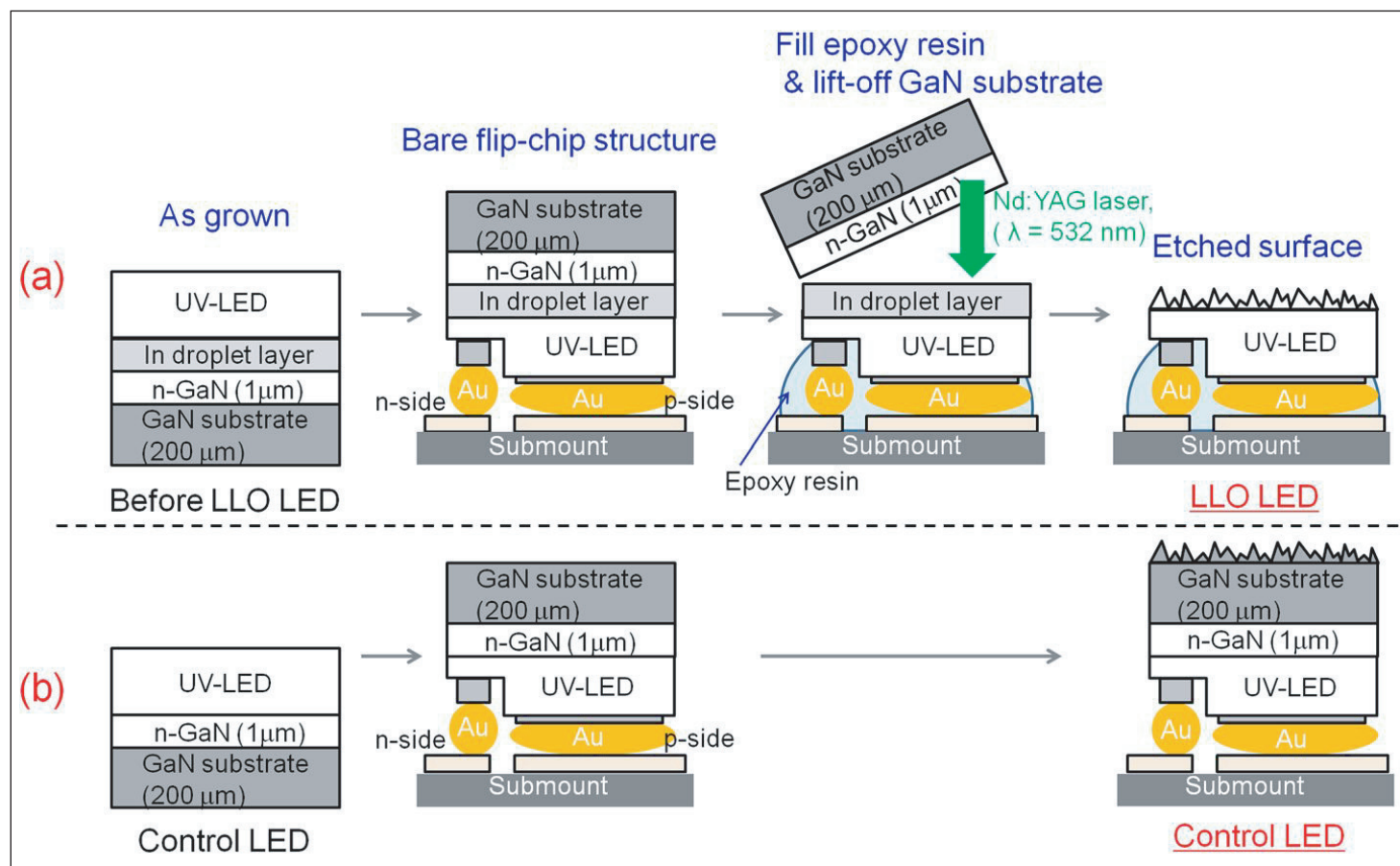


Figure 1. Schematic view of fabrication steps of (a) LLO and (b) control LEDs.

structures that would act as 'removing layer'.

Samples with and without the removing layer were grown. The removing layer, where present, was sandwiched by $1\mu\text{m}$ n-GaN layers ('Sample A'). In the comparison sample (B) without removing layer, a $1\mu\text{m}$ n-GaN layer was grown on the free-standing substrate. The samples were completed by $2\mu\text{m}$ of n- $\text{Al}_{0.03}\text{Ga}_{0.97}\text{N}$.

The GaInN material is unstable at high temperature and decomposes with indium droplets forming at high temperature, such as the 1040°C used to grow the n-GaN and n-AlGaIn layers. The threading dislocation density of sample A with removing layer increased to $5 \times 10^7/\text{cm}^2$,

while sample B without removing layer showed a smaller increase to $3 \times 10^6/\text{cm}^2$.

The researchers comment: "We consider that, after the decomposition of $\text{Ga}_{0.85}\text{In}_{0.15}\text{N}/\text{GaN}$ SLs during growth, the threading dislocations were induced via the generation of misfit dislocation in the interface between n-GaN and the In droplet layer."

This would lead to expectations of reduced LED performance for devices grown on sample A templates. However, the dislocation densities in both samples were still lower than the values that are typical in nitride semiconductors grown on sapphire ($2\text{--}5 \times 10^8/\text{cm}^2$).

Having developed the LLO method, the researchers produced 380nm UV-A LEDs to test its suitability (Figure 1). The removing layer consisted of an 8-period SL. Above the removing layer were $1\mu\text{m}$ of n-GaN, $2\mu\text{m}$ of n-AlGaIn, a 10-period 2nm/2nm $\text{Ga}_{0.97}\text{In}_{0.03}\text{N}/\text{GaN}$ SL, a 10-period 6nm/12.5nm $\text{Ga}_{0.95}\text{In}_{0.05}\text{N}/\text{GaN}$ multiple quantum well (MQW) active region, a 20nm p- $\text{Al}_{0.13}\text{Ga}_{0.87}\text{N}$ electron-blocking layer, and a 120nm p-GaN contact.

Fabrication consisted first of plasma etch down to the n-AlGaIn contact layer, deposition of silver/indium tin oxide (ITO) n- and p-contacts, singulation into $500\mu\text{m} \times 600\mu\text{m}$ chips, flipping onto submounts with gold bumps, and epoxy resin fill of the gap between chip and submount.

Next came the LLO step using a pulsed second-harmonic 532nm Nd:YAG laser with irradiation

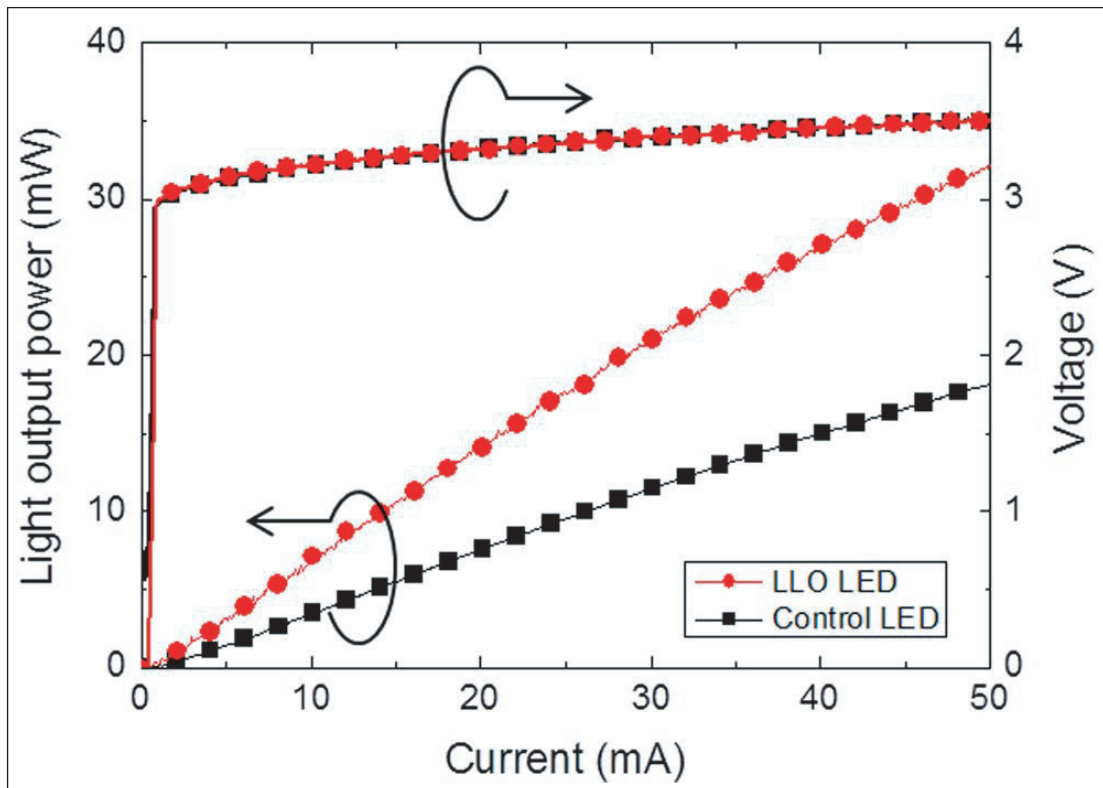


Figure 2. Light output and voltage versus current characteristics of LLO and control LEDs.

energy density of $125\text{mJ}/\text{cm}^2$. Tests suggested that the SL removing layer that had decomposed into indium droplets absorbs visible light through surface plasmon resonance. By contrast, the GaN substrate and UV LED layers do not absorb visible light. Therefore, the laser light is selectively absorbed by the removing layer, allowing lift-off. The device layers were thus not damaged by high-energy visible laser light, as often happens in other LLO processes.

Finally, the emission surface of the LED was roughened with an etch process in hot potassium hydroxide solution. Such roughening can increase light extraction efficiency.

Although the LLO device was expected to have reduced internal quantum efficiency (IQE) due to the higher threading dislocation density of the template, the higher light extraction efficiency results in brighter emission compared with a control device produced on a sample B template. Also, the peak wavelength of the LLO LED was slightly shorter at 380nm, compared with 383nm for the control. The thick GaN substrate absorbs shorter wavelengths more strongly, shifting the peak to longer wavelengths.

At 50mA, the output power of the LLO LED was 1.7x that of the control (Figure 2). At the same time, the current versus voltage performance of the two devices was very similar. The researchers attribute this to the extremely low resistance of the n-AlGaIn contact. ■

<http://dx.doi.org/10.1063/1.4893757>

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Grading InGaN wells to boost LED light output & efficiency

Varying indium composition has allowed wider quantum wells with reduced carrier density, reducing Auger recombination.

Singapore's Nanyang Technological University and Turkey's Bilkent University have developed a graded multiple quantum well (MQW) structure with the aim of increasing light output power and reducing efficiency droop in 450nm indium gallium nitride (InGaN) light emitting diodes (LEDs) [Zi-Hui Zhang et al, Appl. Phys. Lett., vol105, p033506, 2014].

The use of graded InGaN composition allowed wider wells to be created in the hope of reducing carrier densities so that, in turn, Auger recombination is reduced. Auger recombination is a non-radiative mechanism

where the energy from electron-hole transitions is transferred to another carrier (electron or hole) rather than being emitted as a photon. Such a mechanism becomes more significant as carrier densities increase.

Commercial InGaN LEDs use MQWs with abrupt wells of InGaN with GaN or low-indium-content InGaN barriers. The thickness of abrupt InGaN wells is limited to around 3nm due to crystal quality considerations. The grading technique allowed the Nanyang/Bilkent team to increase the thickness to 5nm.

The aim of the design was to increase the light output power while reducing efficiency droop effects. Often, changes aimed at reducing efficiency droop do so at the cost of peak efficiency.

The epitaxial structures (Figure 1) were grown on c-plane sapphire by metal-organic chemical vapor deposition (MOCVD). Two device structures with different MQW designs were produced — one without composition grading and the other with.

The standard non-graded three-period MQW ('sample A') consisted of 3nm $\text{In}_{0.15}\text{Ga}_{0.85}\text{N}$ wells in 12nm GaN barriers. The graded structure ('sample B') used composition grading between 8% and 15% indium to give the wider 5nm well. The barrier

thickness was kept at 12nm. The target peak emission wavelength of both structures was 450nm.

The researchers also believe that another effect of grading would be to reduce the polarization-induced interface charge density from around $0.54 \times 10^{17}/\text{m}^2$ to $0.3 \times 10^{17}/\text{m}^2$ (Figure 2). At the same time, the grading also introduces a bulk charge density in the well of $5.15 \times 10^{24}/\text{m}^3$. Therefore the electric field in the well is reduced and, along with it, the quantum-confined Stark effect that creates a tendency for the electrons and holes to be pulled apart, reducing light emission.

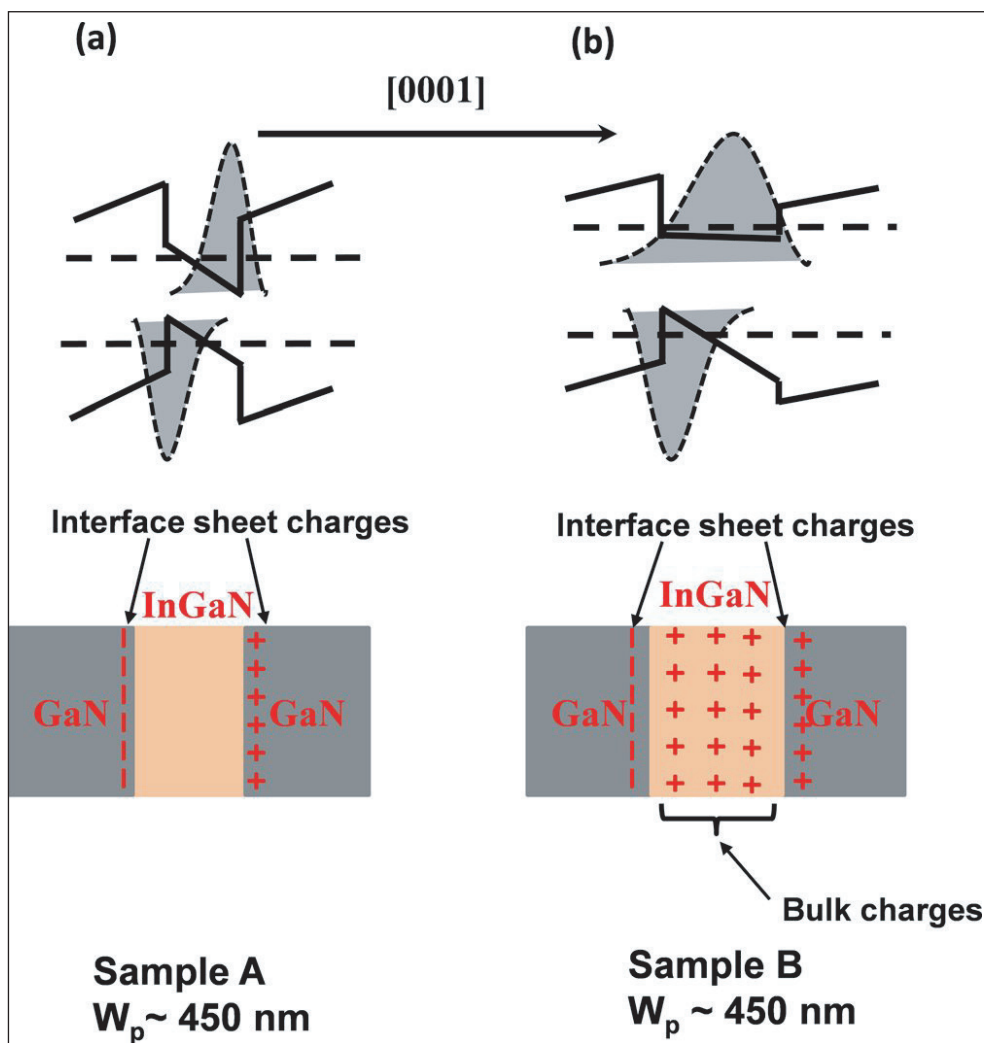


Figure 2. Schematic energy diagrams for quantum well region of (a) conventional LED sample A and (b) proposed LED sample B with wide quantum well and InN composition linearly decreasing along the [0001] growth orientation.

These changes are therefore expected to increase the overlap of the electron-hole wavefunctions and hence to increase recombination into photons. Also, by allowing wider wells, the grading reduces carrier concentration for a given current injection, decreasing the non-radiative Auger recombination route.

Electroluminescence measurements in an integration sphere with 1mm-diameter indium metal contacts to the n- and p-type regions of the device showed increased output and efficiency for sample B, in line with the researchers' simulations (Figure 3). At 150 A/cm² injection current, the LED based on sample B showed a 29.39% rise in output power, compared with a sample A device. At the same injection, the devices' droop in external quantum efficiency (EQE) from the peak value was 39.23% for sample A and 31.83% for sample B. ■

<http://dx.doi.org/10.1063/1.4891334>

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Ohmic contact	p ⁺ -GaN	10nm
Contact	p-GaN	0.2μm
Electron blocking	p-Al _{0.2} Ga _{0.8} N	25nm
Multiple quantum well	3x(InGaN/GaN)	
Contact	n-GaN	2μm
Template	GaN	4μm
Nucleation	GaN	30nm
Substrate	c-plane sapphire	

Figure 1. Schematic epitaxial structure.

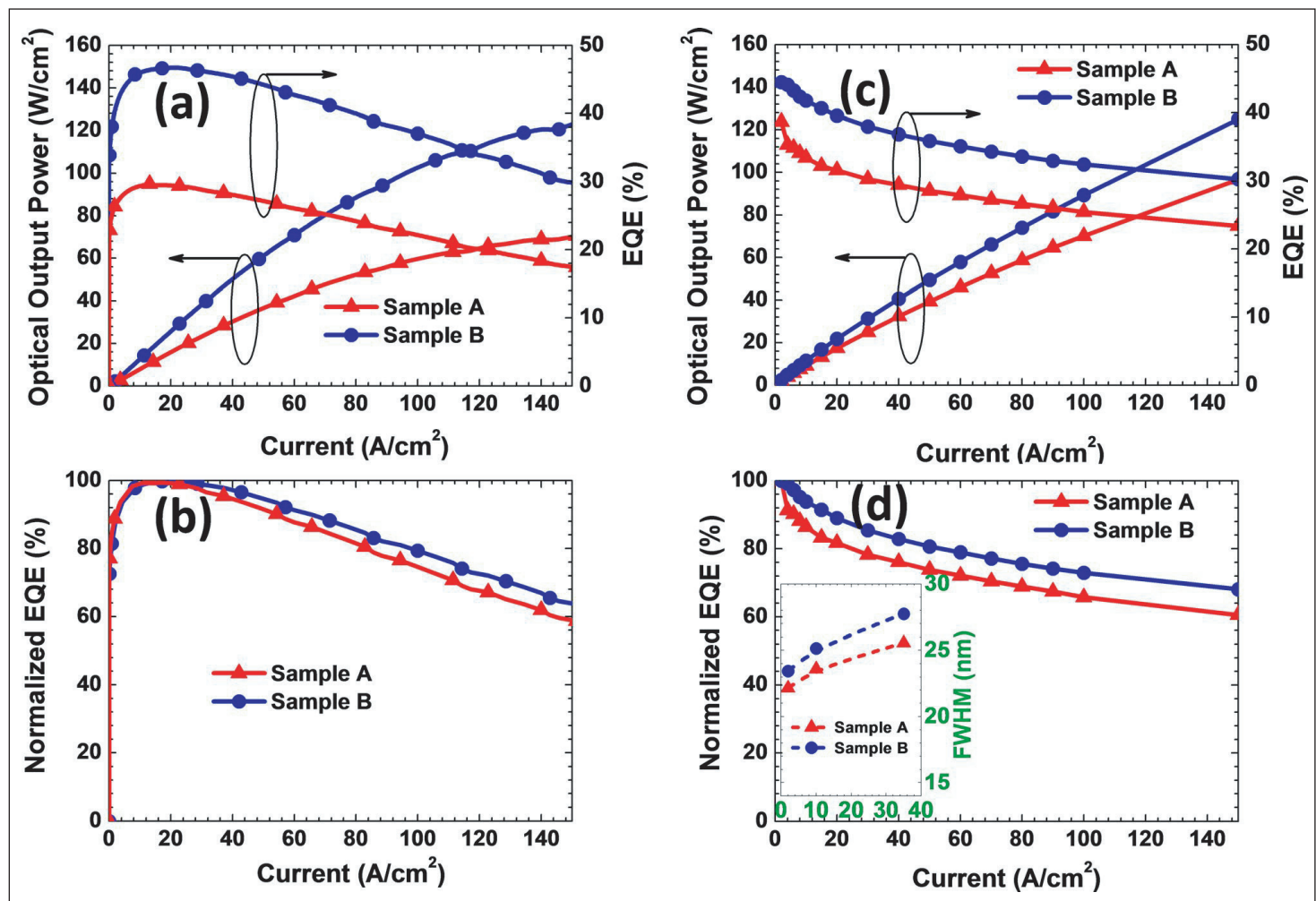


Figure 3. (a) Numerically computed optical output power and EQE, (b) calculated normalized EQE, (c) experimentally measured optical output power and EQE, and (d) measured normalized EQE, and (inset) full-width at half maximum (FWHM) versus current density.

High-electron-mobility light-emitting devices for optoelectronics

Nitride semiconductor transistor heterostructure have been used as the basis for light-emitting Schottky diodes and transistors.

Hong Kong University of Science and Technology (HKUST) has developed 365nm ultraviolet (UV) light-emitting diodes (LEDs) on undoped high-electron-mobility (HEM) aluminium gallium nitride (AlGa_{0.25}N) structures [Baikui Li et al, Appl. Phys. Lett., vol105, p032105, 2014].

UV LEDs are normally produced using variously doped layers of indium gallium nitride or aluminium gallium nitride. By contrast, GaN-based transistors use undoped AlGa_{0.25}N and GaN layers to create a two-dimensional electron gas (2DEG) channel through contrast in the polarization of the two materials. GaN-based transistors are being developed for radio frequency high-power amplification wireless transmission and switched power supply devices.

The HKUST light emitters used the AlGa_{0.25}N/GaN structure of HEM transistors (HEMTs) and Schottky diode contacts. The researchers see potential for compact optoelectronic systems, such as on-chip lighting control and opto-couplers for electrical power conversion. Another possible use

would be in microdisplays where the 2DEG channel would provide the back electrode and a Schottky contact would define the pixel.

The researchers produced both LEDs and light-emitting transistors (HEM-LETs) on heterostructures consisting of a 21nm Al_{0.25}Ga_{0.75}N barrier on 3.8μm GaN buffer. The substrate for the metal-organic chemical vapor deposition (MOCVD) was 4-inch p-type silicon (111). The heterostructure contained a 2DEG channel of density 10¹³/cm² and mobility 2080cm²/V-s.

Ohmic contacts consisted of annealed titanium/aluminium/nickel/gold. Atomic layer deposition (ALD) equipment was used to remove native oxide from the surface, nitridize the heterostructure surface, and deposit 4nm aluminium nitride (AlN). Plasma-enhanced chemical vapor deposition (PECVD) added a 50nm silicon nitride (Si₃N₄) layer. The AlN/Si₃N₄ layers provided passivation and surface protection.

The Schottky contact was fabricated by selectively removing the passivation/protection with a combi-

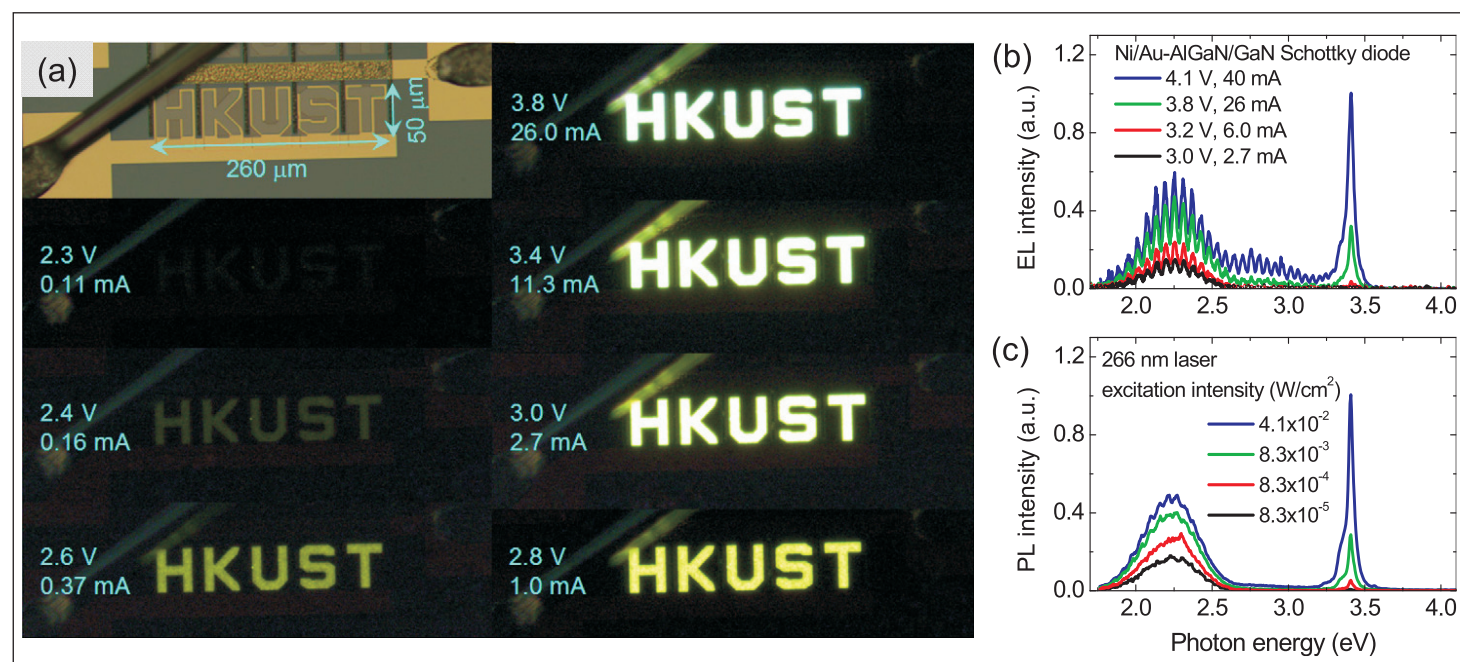


Figure 1. (a) Visible electroluminescence (EL) of Ni/Au-AlGa_{0.25}N/GaN Schottky diodes under different forward biases from 2.3V to 3.8V. (b) EL spectra of diode under different bias/current conditions. (c) Photoluminescence spectra of heterostructure excited by 266nm laser at various excitation powers.

nation of plasma and wet etch. The semi-transparent 5nm/6nm nickel/gold Schottky contact was deposited using electron-beam evaporation.

The transistor had an ohmic source and semi-transparent Schottky drain. The gate stack included 15nm/8nm silicon nitride/aluminium oxide (AlO) insulation and 20nm/200nm nickel/gold electrode. The transistor was annealed at 400°C for 10 minutes in nitrogen atmosphere.

The Schottky diode emitted electroluminescence when biased above 2.2V. The spectrum contained yellow, blue and UV emissions (Figure 1). The UV component consisted of a narrow peak at around the GaN bandgap of 3.4eV. The yellow and blue emissions were broad, associated with transitions from the conduction band or shallow donor level to deep acceptor levels. All the emissions were attributed to the GaN buffer and not the AlGaIn barrier layer. The balance between the UV and yellow/blue components shifted to the UV as the injection current increased. Similar spectra were obtained with photoluminescence.

The current-voltage behavior of the diode shows a current threshold at 1.1V and a further threshold at ~2V, associated presumably with the onset of electroluminescence.

The onset of electroluminescence at ~1.4V below the 3.4V expected from the bandgap energy indicates "an abnormal anti-Stokes light emission process". Anti-Stokes emission refers to an energy boost coming from thermal phonons (lattice vibrations). The researchers believe the hole injection results from de-pinning of the Fermi level of the Schottky metal contact under forward bias.

The researchers explain: "Under a forward bias, electrons are injected from the 2DEG and accelerated by the electric field in the AlGaIn barrier. Then, the electrons become 'hot' when arriving at the Ni-AlGaIn interface. These hot electrons will impact and ionize the upper surface-band states. As electrons in the upper surface-band are ionized, the metal Fermi level is de-pinned

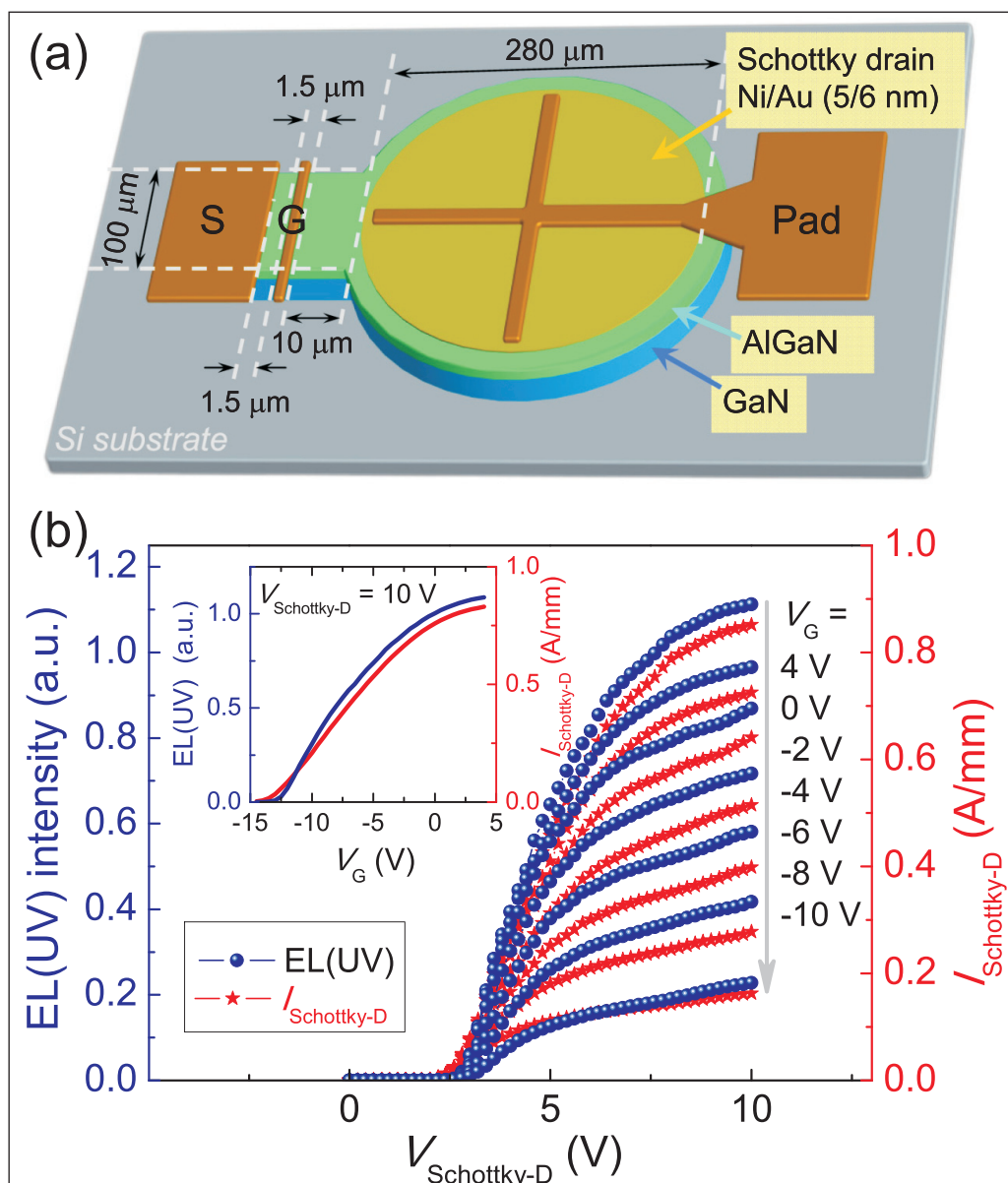


Figure 2. (a) Schematic device structure of AlGaIn/GaN HEM-LET. (b) Current (I) versus voltage (V) for Schottky drain (D) (red line) and EL(UV)-intensity (blue line) characteristics at various gate (G) biases. Inset provides EL(UV)-intensity and drain current versus gate voltage at 10V drain.

simultaneously from its original position, subsequently moving downward and getting re-pinned at the lower surface-band. Then, both the energy barrier height and effective barrier thickness become considerably smaller for hole injection via tunneling from the metal Fermi level into the valence band of AlGaIn."

The researchers estimate the room-temperature light output power from a 10⁻³cm² Schottky light-emitting diode area at 11.2μW at 4V bias, corresponding to 71mA current. The HEM-LET has a similar 2V threshold for electroluminescence from the drain electrode (Figure 2). HEMTs produced on the same heterostructure had an off-state leakage of 10-6mA/mm and an on/off current ratio of 10⁸. ■

<http://dx.doi.org/10.1063/1.4890238>

Author: Mike Cooke

Adoption of flip-chip LEDs & chip-scale packaging changing material/equipment market and supply chain

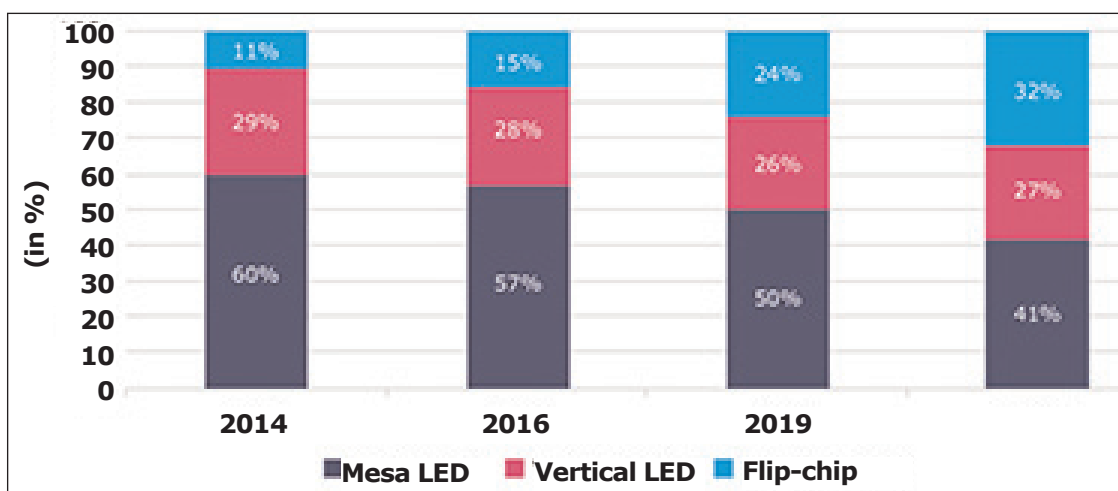
The LED packaging equipment market will return to growth for the next 3 years but then fall sharply, forecasts **Yole Développement**.

Following the LED TV crisis and with the entry of Chinese players, positioning has been reshuffled in the LED industry, according to the report 'LED Packaging Technology and Market Trends 2014' from Yole Développement. The quality of products from Chinese LED makers has increased to a level where they are now real competitors to all players, notes the market research firm.

In such a highly competitive environment, three major challenges lie ahead for the LED industry regarding the general lighting market: improving efficacy, reducing cost, and increasing color consistency.

To answer these challenges, several players have now turned to flip-chip (FC) LEDs, which present several advantages over traditional horizontal (mesa) and vertical LEDs. These are wire-bonding free, can be driven at higher current, and have a smaller package, notes Yole.

Also, although FC LED technology was launched quite a long time ago (by Lumileds), it was restricted from 'popularization' due to technical barriers (e.g. low yield regarding bumping/eutectic process). Additionally, the financial investment required (for packaging equip-

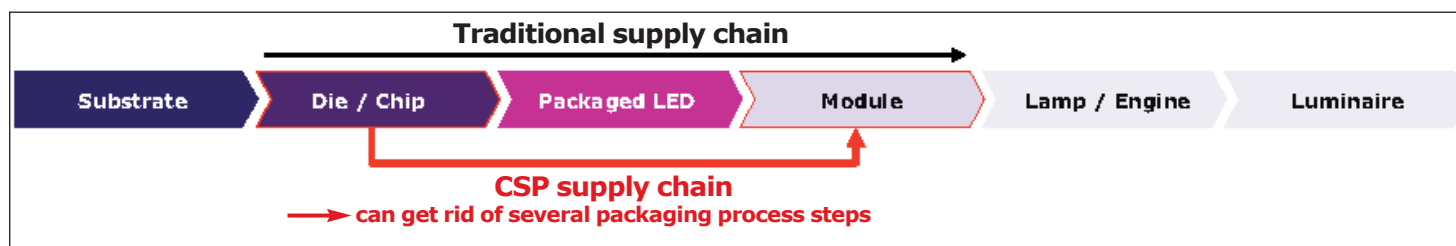


High-power LED — mesa versus vertical versus flip-chip.

ment) represented a strong barrier in an industry that was still recovering. However, the technology has gradually attracted attention from the lighting, backlighting and flash markets, becoming one the most important developing items in 2014.

Whereas flip-chip LED represented just 11% of overall high-power LED packaging in 2013, Yole expects this to rise to 34% by 2020. Flip-chip LEDs will take market share from vertical LED that will represent 27% of overall high power LED packages by 2020.

In addition to offering an increased 'performance/cost' ratio, flip-chip LEDs are also a key enabling technology for the development of chip-scale packages (CSP), which could allow further cost reduction.



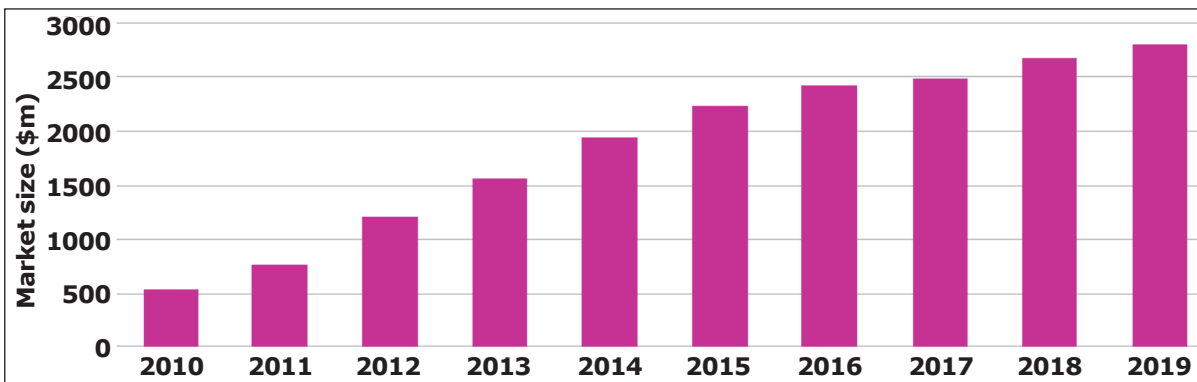
How CSP can modify the traditional supply chain.

CSPs are novel to the LED industry but they are the mainstay of the semiconductor industry. Development of CSPs for silicon ICs was driven by miniaturization, improved thermal management, higher reliability, and simply the need to connect to an ever increasing pin-count on an ever shrinking die. CSPs also enabled a reduction in device parasitics and allowed ease of integration into Level 2 packaging (e.g. module packaging for LEDs). It is therefore a natural evolution for this packaging innovation to proliferate into other industries (such as the LED industry).

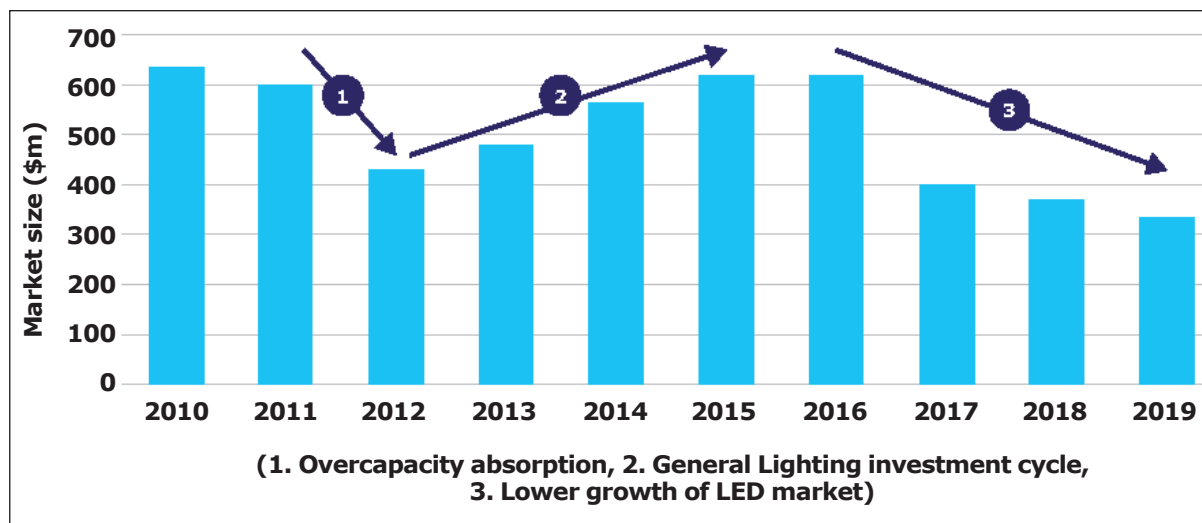
Basically, a CSP represents a single-chip direct-mountable package that is the same size as the chip. Regarding LED devices, CSPs are made of a blue FC LED die on which a phosphor layer is coated (the main application of such a package being general lighting). CSP presents several advantages (including miniaturized size and better thermal contact to substrates). However, eliminating several process steps of traditional LED packaging, CSPs are also having an impact on the industry structure, with some LED chip makers supplying their products directly to LED module makers. In the middle and long term, this technology could make chip makers supply directly to module makers.

LED packaging materials market to grow by 1.5x in 2014–2019, driven by package substrate, phosphor and encapsulant/optic material

With the general lighting market triggered, LED packaging needs materials that meet the requirements of the applications. Regarding packaging substrates, the high power density of devices induces the use of ceramic substrates, a market that will grow from nearly \$400m in 2013 to \$700m in 2019. Encapsulant/optic materials will follow the same trend (from nearly \$300m in 2013 to \$700m in 2019), driven mostly by



LED packaging materials revenue.



LED packaging equipment revenue.

the increased use of silicone material offering better reliability/lifetime than traditional epoxy material. At the phosphor level, the expiry of key 'yellow phosphor' patents in this area from 2017 will increase the adoption of YAG (yttrium aluminium garnet) and increase competition (ultimately leading to further price decreases). But, even with the decrease in average selling prices (ASPs), the market will grow from nearly \$600m in 2013 to \$900m in 2019.

LED packaging equipment market growth to return for next 3 years, then fall sharply

The LED packaging equipment market, which stagnated in 2012 due to industry oversupply, is growing again but will peak at nearly \$600m by 2015–2016, forecasts Yole. Indeed, the period 2013–2016 represents the main investment cycle for general lighting applications with the change of investment type due to flip-chip and chip-scale packages, adds the firm.

After 2016, the market will decline sharply for several reasons, two of which are the widely expected consolidation of the industry and the lower growth of the market.

After 2019, it is questionable whether new LED applications (medical lighting, smart lighting etc) will impact the equipment market, concludes Yole. ■

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III-V compound semiconductors from van der Waals epitaxy

Researchers have been exploring crystal growth on two-dimensional layered materials such as graphene. Mike Cooke reports.

Although van der Waals (vdW) bonds are weaker than other chemical bonds that are categorized as 'covalent' or 'ionic', large numbers can add up to give effective cohesion in materials in the manner of Velcro. For example, many protein molecules depend on vdW bonds for correct folding of the component polypeptide chains.

Van der Waals epitaxy involves growth on two-dimensional (2D) layered materials such as graphene. In 2D-layered materials there are strong in-plane bonds and weak vdW bonds between the layers. Other 2D layered materials include molybdenum/tungsten sulfide/selenide.

It is hoped that the more relaxed vdW bonding will allow epitaxial (vdWE) growth of 3D crystals on vdW-bonded 2D layers with larger mismatches in lattice constant and thermal expansion. Although the lattice mismatch between graphene and gallium nitride (GaN) is around 23%, a number of research teams have been developing the growth of III-V semiconductor (e.g. GaN) on graphene. However, there are challenges such as suppressed nucleation due to low adsorption and migration energies of adatoms leading to cluster growth rather than single-crystal films.

Bendy blue LEDs on polymer

Much of the research has centered on GaN on graphene. For example, Seoul National University, South Korea, has developed flexible micro-rod light-emitting diodes (LEDs) on polymer using GaN grown on graphene [Kunook Chung et al, APL Mater., vol2, p092512, 2014]. The LED layers consisted of indium gallium nitride (InGaN) multiple quantum wells (MQWs).

Although inorganic compound semiconductor materials have been grown directly on flexible polymer substrates, the thermal budget is very tight. III-nitride semiconductors generally need high temperature for high-quality crystal growth. The Seoul National University used growth on graphene to enable easy release from an inorganic substrate and transfer to polymer as an

alternative route to flexible devices.

The graphene was prepared on copper foil by chemical vapor deposition (CVD) and then transferred to silicon dioxide on silicon substrate. The GaN microrods were grown using metal-organic CVD (MOCVD) with trimethyl-gallium (TMGa), ditertiarybutyl-silane (DTBSi) and ammonia (NH₃) precursors in nitrogen carrier gas. Two-step GaN growth at 750–850°C (3mins) and then 950–1050°C (30mins) was followed by annealing at 1100°C (10mins).

The hexagonal micro-rods were grown on a 2µm GaN buffer. The density of rods was 10⁷/cm². With the 30 minute growth time, the rods were 1µm in diameter and 7.5µm high. The buffer improved vertical alignment of the rods, allowing fabrication of coaxial quantum wells on the top and sidewalls of the cylindrical rods.

The micro-rods exhibited near-bandedge photoluminescence at 3.4eV photon energy, and at higher pump powers stimulated emission. There was also some weak deep-level emission around 2.2eV. Detailed micro-photoluminescence of a single rod showed no shift in the peak position in spectra from the top, middle and base regions of the rod, suggesting negligible strain fields.

An 8-period quantum well structure of In_{0.07}Ga_{0.93}N in GaN barriers was MOCVD coated coaxially onto the top and sidewalls of the n-type GaN micro-rods. The LED device structure was completed with a coaxial p-GaN layer. The well thickness was estimated at 8nm on the sidewalls and 4nm on the top of the rods. The emission wavelength from cathodoluminescence (electron-beam excited) on the wells was 439nm from the top region and 414nm from the sidewalls, the difference arising from the varying well thickness, according to the researchers.

LEDs were fabricated with metal contact deposition and transfer to polyimide (Figure 1). The rods were insulated from each other by a polyimide fill. Oxygen plasma etch exposed the tips of the rods. The metal contact to the p-GaN consisted of nickel/gold. The

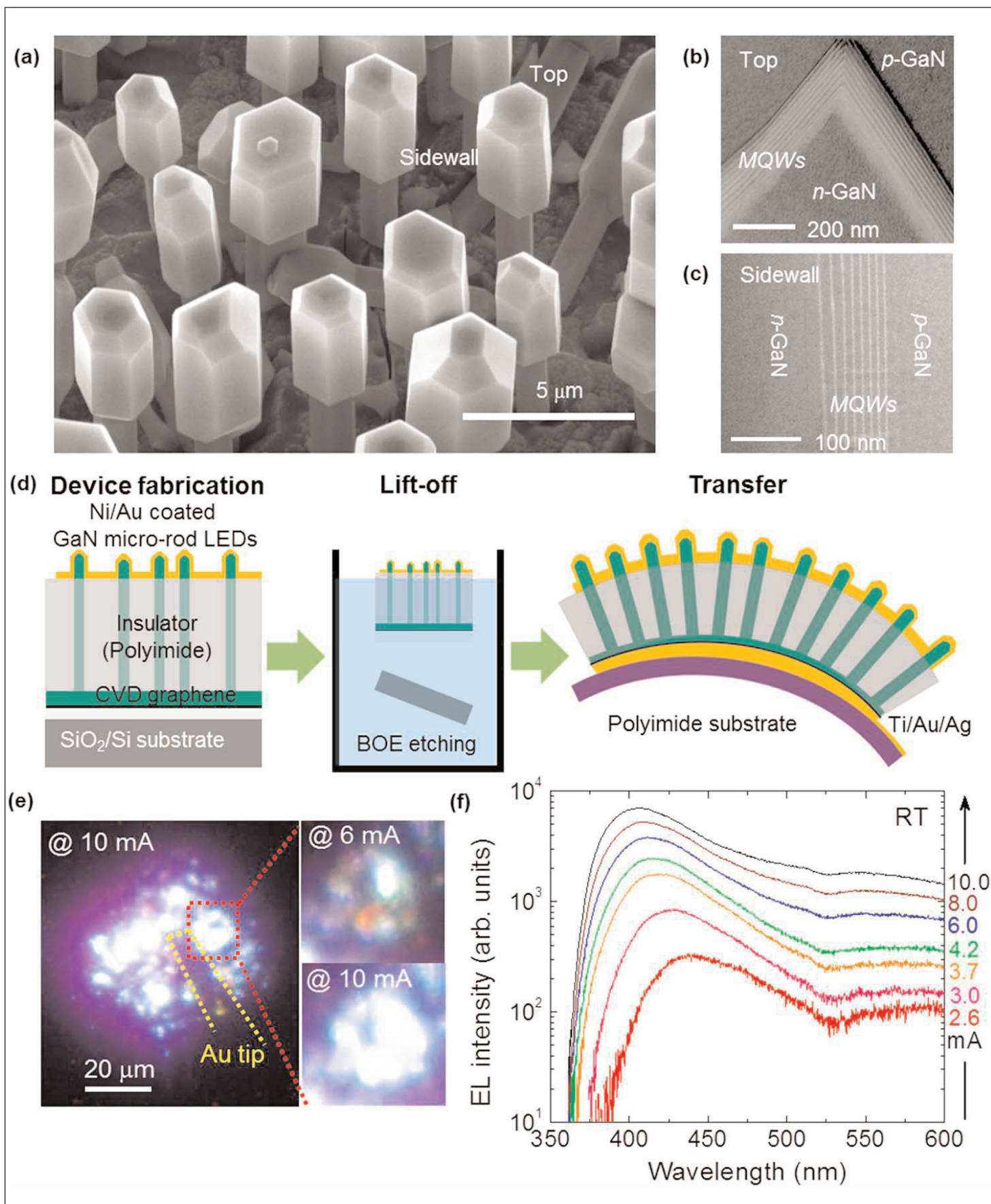


Figure 1. GaN micro-rod LEDs fabricated on graphene. (a) Field emission scanning electron microscope image of coaxial GaN micro-rod LEDs on graphene. Scanning transmission electron microscope images of (b) top and (c) sidewall of MQW layers. (d) Schematic fabrication process for vertical structure micro-rod LEDs. (e) Magnified optical images of LED emission. (f) Power-dependent electroluminescence spectra at room temperature.

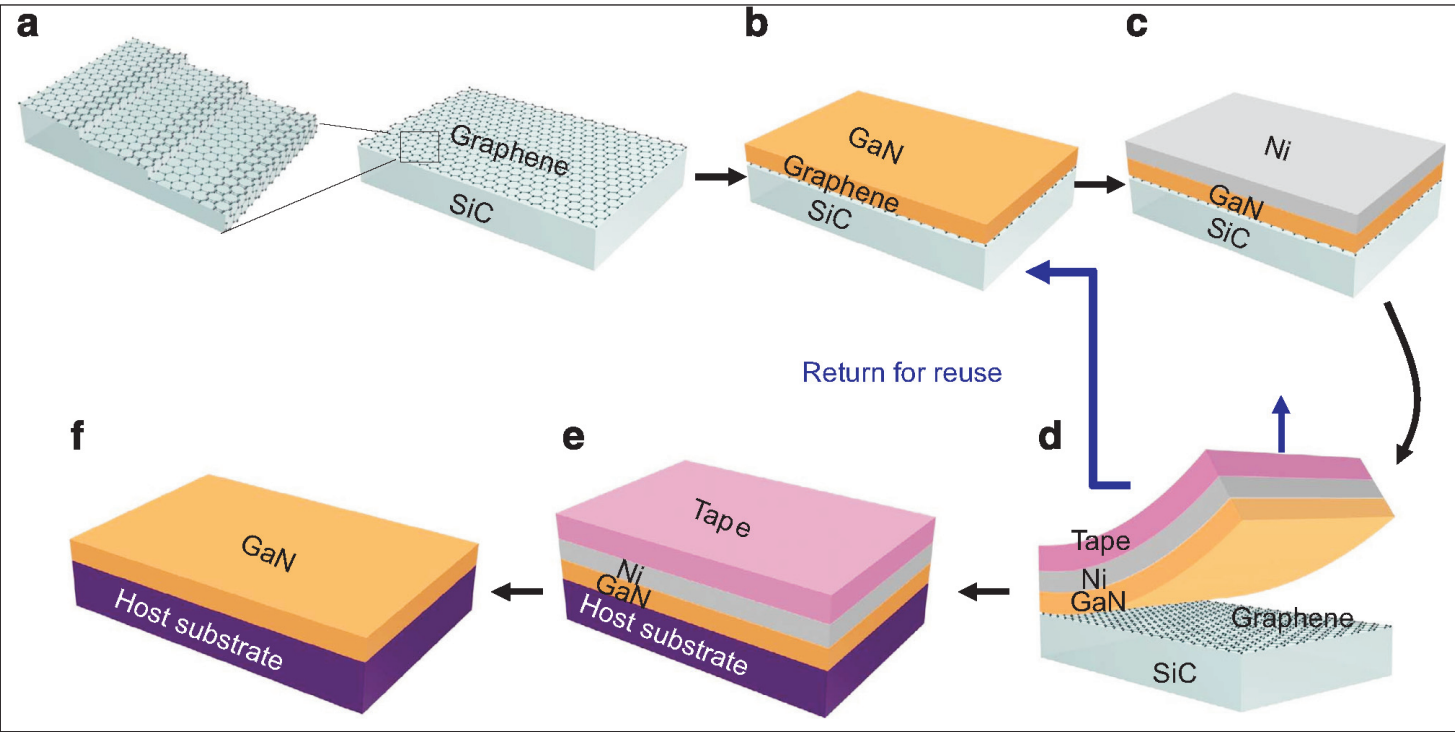


Figure 2. Schematic for growth/transfer of single-crystalline thin films on/from epitaxial graphene. (a) Graphitization of SiC substrate to form epitaxial graphene. (b) Epitaxial growth of GaN on graphene. (c) Deposition of stressor layer (Ni). (d) Release of GaN from substrate with handling tape. (e) Transfer of released GaN/Ni/tape stack to host substrate. (f) Removal of tape and Ni by thermal release and wet etch, leaving GaN film.

n-type titanium/gold contact was made to the base of the GaN buffer, after separation of the epitaxial material from the growth substrate by a wet buffered oxide etch (BOE). An additional thick silver layer was used to give reliable current injection.

The LEDs emitted strong blue light with orange and green from some rods at lower injection (6mA). The longer wavelength emissions turned blue as the current injection increased beyond 10mA. The researchers attribute the orange/green emission to yellow emission in the p-GaN layer. The team believes the yellow emission source could be reduced by optimizing the material growth process.

The devices were also subjected to bending and the electroluminescence suffered no degradation from bending with a 6mm curvature radius. However, bending with a 4mm radius resulted in markedly decreased electroluminescence, suggesting damage from the bending.

GaN and blue LEDs

IBM T. J. Watson Research Center, USA, has also developed vdWE for growth of GaN on graphene. The single-crystal quality of the resulting GaN was comparable to growth on traditional substrates such as sapphire or silicon carbide (SiC) [Jeewan Kim et al, Nature Communications, vol5, p4836, 2014].

Further, the researchers demonstrated transfer of the crystal material to other materials, allowing re-use of

the expensive graphene on SiC growth substrate. The team was able to reuse the substrate and create functioning blue LEDs.

The IBM method starts by forming a graphene layer through graphitizing the surface of the SiC substrate. The graphene growth is self-limiting and results in a layer with vicinal steps that the researchers used as nucleation sites for the subsequent GaN epitaxy (Figure 2). The steps were 5–10nm high and the step terrace width 5–10µm.

A variety of MOCVD processes were tried to create GaN on graphene. The GaN epilayer was limited to ~1cm² area due to the small MOCVD reactor used. The researchers found that a modified two-step process at 1100°C and 1250°C resulted in continuous and smooth GaN films.

This high-temperature two-step process contrasted with the usual low-temperature/high-temperature process (580°C/1150°C) two-step process typically used for deposition on SiC or sapphire. In the case of GaN/graphene growth, the traditional two-step process resulted in GaN clusters. A one-step 1100°C growth resulted in stripes of GaN on graphene that was attributed to nucleation at the vicinal step edges. A one-step process at 1250°C resulted in no GaN growth due to the reduced sticking coefficient at higher temperature.

Electron-microscope and diffraction analysis of the GaN film indicated planes of well aligned single-crystalline wurtzite. The researchers estimated the

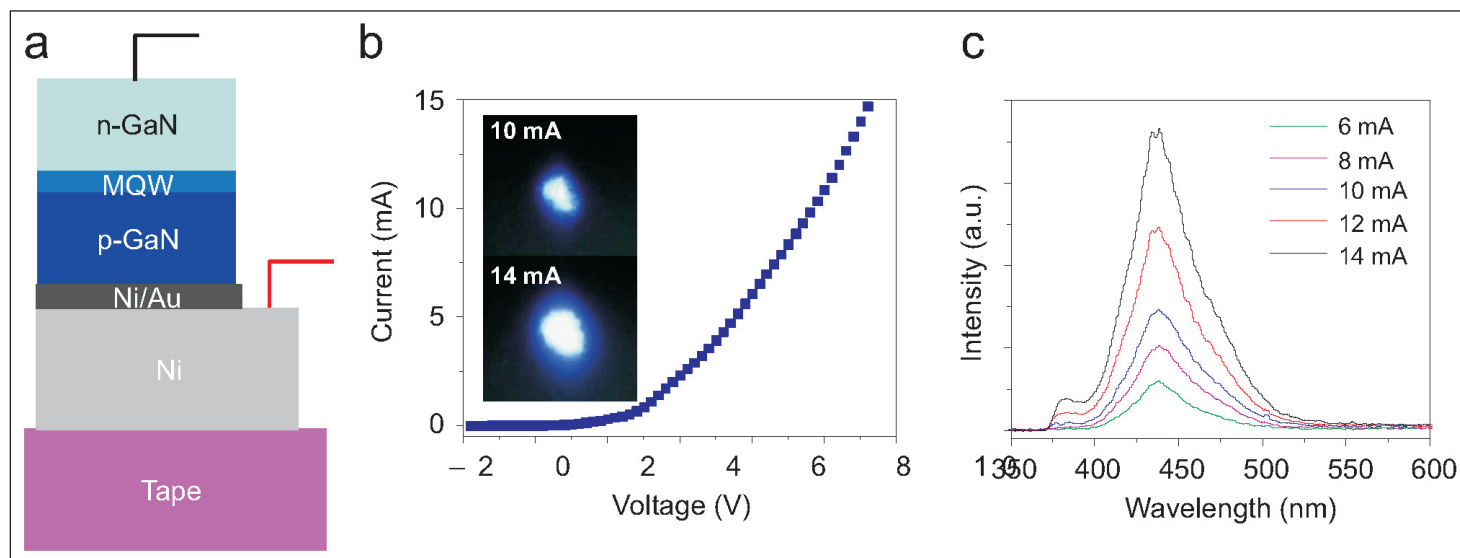


Figure 3. Fabrication of GaN blue LED transferred on tape. (a) Schematic of transferred visible LED device on tape. (b) Current versus voltage (I–V) characteristic of a transferred LED stack. Inset pictures of LED emitting blue light. (c) Electroluminescence (EL) spectra of transferred LED stack.

density of threading dislocations over a $30\mu\text{m}^2$ area at around $1 \times 10^9/\text{cm}^2$. "This density is in the comparable range with that of AlN-buffer-assisted GaN films grown on the conventional substrates, sapphire or SiC by using MOCVD ($5 \times 10^8/\text{cm}^2$ – $8 \times 10^9/\text{cm}^2$)," according to the team.

X-ray analysis gave a rocking curve full-width at half maximum (FWHM) value of 0.06° (216arcsec) for the (002) GaN peak. The researchers say this value is similar to that found for GaN on sapphire or SiC.

To release the GaN film, the researchers applied a $2\mu\text{m}$ nickel layer as stressor to create strain in the $2.5\mu\text{m}$ GaN film and release the GaN/graphene vdW bonds. Thermal release tape was applied to the nickel for handling and to allow transfer of the GaN layer to another host substrate. The release temperature of the tape was 90°C .

Atomic force microscopy (AFM) of the GaN surface that was attached to the graphene/SiC showed terrace structures. The researchers believe that this means the entire GaN layer was successfully removed from the growth substrate. Further, Raman spectroscopy could not detect any graphene residue on the released GaN film.

The low surface roughness of 5\AA root mean square (RMS) allowed the researchers to directly bond the GaN film to a 90nm silicon dioxide insulator layer on (001) silicon substrate. The researchers comment: "The transferred GaN on insulator shows perfect single-crystalline diffraction patterns indicating no degradation of crystalline quality during the transfer process."

The researchers contrast the low atomic-level surface roughness to the high roughness obtained using laser lift-off substrate separation. In particular, the atomic-scale roughness allows direct bonding without the

need for adhesive.

The graphene/SiC substrate was used repeatedly to grow GaN films, confirming the potential for reuse of expensive SiC substrates. Iron chloride (FeCl_3) solution was used to remove nickel residue from the previous release process.

The researchers grew an LED stack on a substrate that had previously been recycled three times. The stack consisted of three 3.5nm indium gallium nitride multiple quantum wells in GaN barriers, along with n- and p-type contact layers.

Nickel/gold was applied to the top p-contact and the structure was released using the nickel stressor/thermal release tape technique. Direct electrical probing showed diode behavior and 40nm wavelength blue electroluminescence (Figure 3).

Gallium arsenide

Researchers have also explored the growth of gallium arsenide (GaAs) on graphene (Figure 4) [Yazeed Alaskar et al, *Adv. Funct. Mater.*, published online 26 August 2014]. The team consisted of personnel from the universities of California at Los Angeles, Riverside and Irvine, and the Saudi Arabia National Nanotechnology Research Center.

The researchers used a Perkin Elmer 430 molecular beam epitaxy (MBE) system to deposit the GaAs on a multilayer graphene buffer on silicon (111) substrate. The graphene consisted of flakes exfoliated using Scotch tape and transferred to the silicon. The surface was cleaned using acetone and isopropanol both before and after the graphene application to avoid and remove traces of organic materials from the exfoliation process.

Raman spectroscopy showed a low response for the disorder-induced D-band peak, which had an intensity

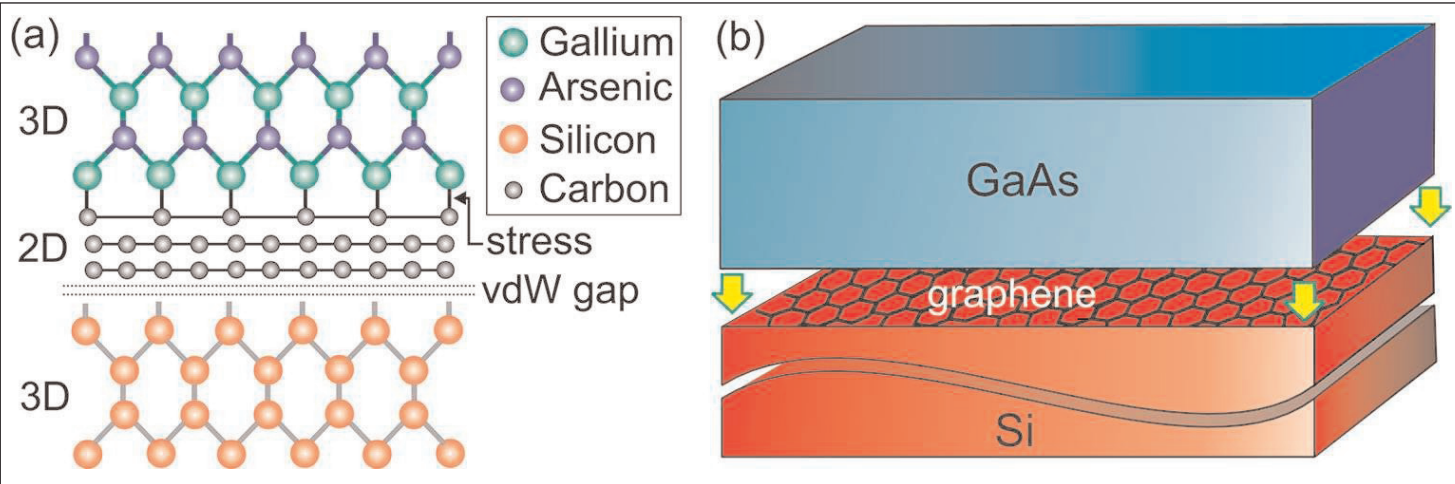


Figure 4. (a) Atomic geometry of GaAs/multi-layer graphene/Si interface showing only topmost graphene layer is strained by heteroepitaxial growth, (b) schematic for structure with GaAs grown on top of single-layer graphene buffer layer/Si substrate.

ratio of less than 0.1 compared with the G-band peak. The Raman result suggests high quality multi-layer graphene. Atomic force microscopy gave a RMS roughness of 0.2nm.

The researchers tried two nucleation techniques. In the first, an arsenic-terminated surface was produced on which GaAs was then grown. In the second, the initial surface termination was changed to gallium.

The As-termination technique resulted in clumping of the GaAs into islands, leading to poor-quality GaAs. For Ga-termination, the research got the best results from two monolayers of Ga. The Ga prelayer was deposited at room temperature. The first deposition of GaAs occurred at 350°C, avoiding islanding and enhancing nucleation. The surface roughness of the resulting material was found to be as low as 0.6nm RMS.

The researchers comment: "To our knowledge, this result is the first illustration of an ultrasmooth morphology for GaAs films on vdW material."

However, Raman spectroscopy suggested the presence of defects in, and incomplete crystallization of, the nucleation layer. X-ray diffraction rocking curves from the (111) plane had a FWHM of 245arcsec. The researchers say that this suggests that the crystal quality for this orientation requires further improvement.

On the other hand, the FWHM from the 25nm nucleation on graphene is comparable to values achieved in micron-scale GaAs layers grown directly on silicon. "The two-orders-of-magnitude improvement in the quality of our GaAs films can be attributed to the graphene buffer layer mitigating lattice and thermal

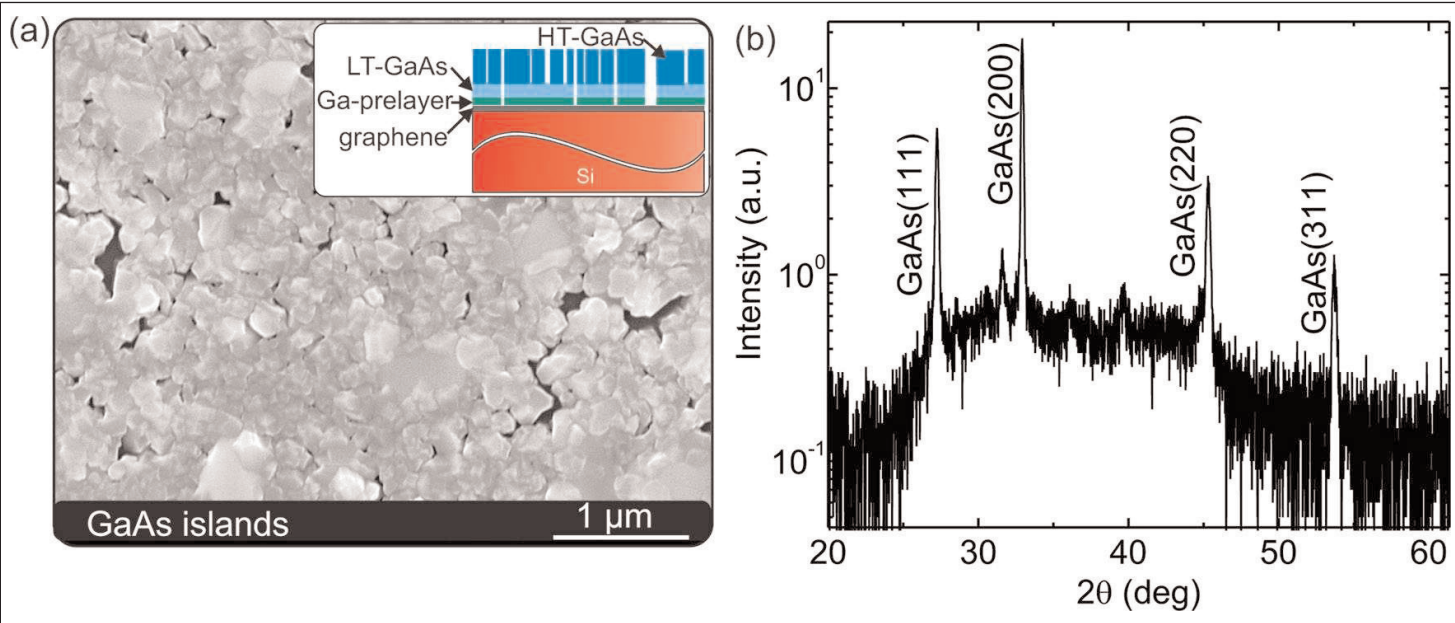


Figure 5. SEM plan-view image of (a) 200 nm high-temperature grown GaAs on top of 25nm thick nucleation layer, with Ga-prelayer and (b) x-ray diffraction scans for GaAs grown by two-step growth, showing polycrystallinity with presence of GaAs (111), (200), (220), and (311).

mismatch between GaAs and the underlying substrate," the researchers write.

Having developed a nucleation layer, the researchers sought to create a two-step process of nucleation followed by raising the temperature to 600°C to grow a further 200nm of GaAs. This resulted in a polycrystalline film with a faceted surface, due to thermal degradation of the nucleation layer (Figure 5). The researchers attempted to avoid island growth in the high-temperature epitaxy step by increasing the nucleation layer thickness to 100nm, but the problems continued to be apparent. "This suggests the GaAs/graphene interface is not stable at high temperatures," the researchers comment.

Unfortunately, high temperatures are needed to crystallize GaAs and to suppress the effects of defects and dislocations through migration. The researchers suggest

through theoretical considerations that the problem resides in low adsorption and migration energies of gallium and arsenic on multi-layer graphene that lead to cluster-growth at high temperature.

Based on their results, the researchers suggest that optimization of the growth parameters in terms of the prelayer or the use of an alternative van der Waals material could lead to single-crystal 2D GaAs on Si. The team is also looking for a low-temperature or modified deposition technique that would eliminate the occurrence of 3D island growth at high growth temperatures. ■

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Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

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Scaling III-V integration to 300mm silicon and beyond

A direct wafer bonding method could open the way to integrated high-mobility electronics and optoelectronics.

Researchers based in Japan and USA have reported further details of a direct wafer bonding (DWB) technique that could open the way to integration of indium gallium arsenide (InGaAs) high-mobility electronics and optoelectronics on the largest-diameter wafers available [SangHyeon Kim et al, Appl. Phys. Lett., vol105, p043504, 2014]. The team from University of Tokyo, JST-CREST funding program, and IntelliEPI has previously presented details of the process at the VLSI Symposium [Cooke, Semiconductor Today, p78, June/July 2014].

The researchers believe that their DWB process offers a combination of wafer scalability to more than 300mm, tight integration with silicon devices, and channel layer quality that is not matched by the competing integration methods (Table 1).

Generally, DWB and other epitaxial transfer techniques use a donor wafer where the InGaAs or other III-V semiconductor channel layer is grown on a III-V material

Table 1. Comparison among integration schemes of III-V MOSFETs on Si wafer.

Integration method	Wafer-level epitaxy	Epitaxial transfer	Aspect ratio trapping	Wafer bonding with Si donor
Structure	III-V channel/ thick buffer/Si	III-V-OI with trench	III-V/Si	III-V-OI
Short-channel-effect control	Finfet	Ultra-thin body	Finfet	Ultra-thin body
Water scalability to 300mm	+	—	+	+
Tight integration with Si device	—	+	—	+
Channel layer quality	+	+	—	+

such as indium phosphide (InP). However, this limits the ability to integrate with large-diameter silicon wafers. While III-V substrates are often limited to 2" and less, the maximum silicon wafer diameter is 300mm commercially, with 450mm in development.

The team has overcome the limitation by creating a donor wafer on 4" silicon wafers using molecular beam epitaxy (MBE). The technique is hence not constrained by the limitations of III-V crystal growing technology.

The buffer between substrate and InGaAs channel layer (Figure 1) consisted of gallium arsenide (GaAs) followed by graded indium aluminium arsenide (InAlAs).

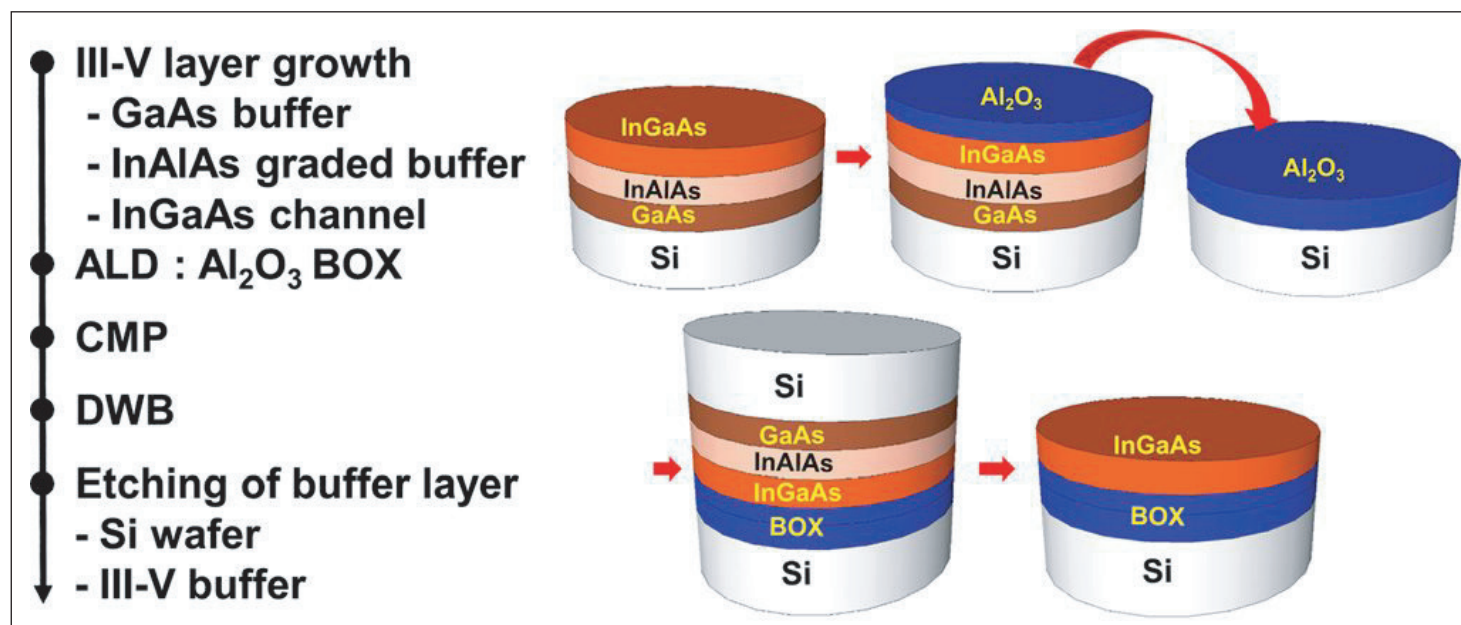


Figure 1. Fabrication of InGaAs-OI wafer by DWB technique using silicon donor wafer.

Various thicknesses up to 50nm for the $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ channel layer were produced. Room-temperature Hall measurements gave $6550\text{cm}^2/\text{V}\cdot\text{s}$ mobility and $1.5 \times 10^{17}/\text{cm}^3$ carrier concentration.

The wafer bonding was prepared by applying aluminium oxide (Al_2O_3) by atomic layer deposition (ALD) to both the donor and final wafers. Chemical mechanical polishing (CMP) was used to smooth the wafers. The bonding was performed after further ALD of hafnium dioxide (HfO_2).

The InGaAs channel layer on oxide insulator was finally revealed by etching away the silicon donor wafer and the GaAs and InAlAs buffer layers with tetramethylammonium hydroxide (TMAH), citric acid, and hydrochloric acid solutions, respectively.

The researchers believe that alternative methods of substrate removal could be

implemented, such as hydrogen-induced thermal wafer splitting. The researchers add that such wafer splitting processes would be expected to significantly reduce process costs through recycling of the donor wafer.

Infrared photography showed a good, uniform bond with no voids present. Raman and photoluminescence spectral analyses showed very similar performance of layers produced with silicon or InP donor substrates.

The root-mean-square surface roughness of the InGaAs layer was 1.4nm, according to atomic force microscopy (AFM). Transmission electron microscopy (TEM) gave images with no dislocations and fast Fourier transform analysis of the image suggested good crystal quality.

Metal oxide semiconductor field-effect transistors (MOSFETs) were fabricated with Al_2O_3 oxide and tantalum metal gate stack on 9nm InGaAs-on-insulator (InGaAs-OI) body. The source/drain contacts were nickel/InGaAs. With a $1\mu\text{m}$ gate length, the subthreshold swing was 100mV/decade and the on/off current

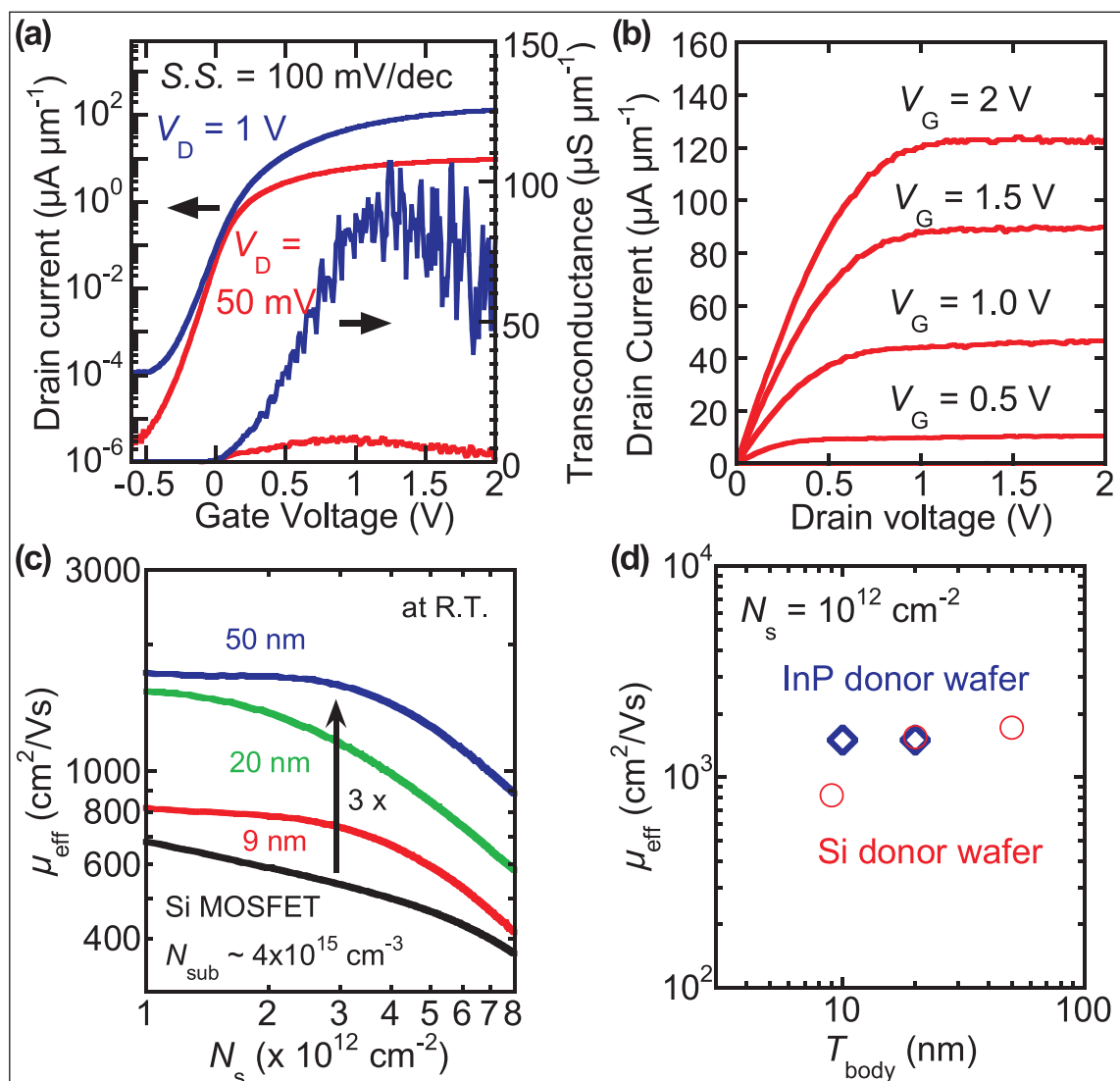


Figure 2. (a) Measured transfer and (b) output characteristics of InGaAs-OI MOSFETs. (c) Effective mobility characteristics of InGaAs-OI MOSFETs with 9nm, 20nm, and 50nm body thickness, and of reference Si MOSFET. (d) The effective mobilities of InGaAs-OI MOSFETs from InP and Si donor wafer versus body thickness.

ratio more than 10^6 . The peak transconductance was around $100\mu\text{S}/\mu\text{m}$.

The effective mobility of MOSFETs on varying body thickness increases to $1700\text{cm}^2/\text{V}\cdot\text{s}$ at 50nm (Figure 2). At 9nm body thickness, the effective mobility is still an improvement on Si MOSFETs. The 50nm mobility is 3x that of Si-based devices. The mobility for silicon donor wafer devices was comparable to that of MOSFETs produced using InP donor wafers. The researchers comment: "These results strongly suggest that high-quality InGaAs-OI can also be fabricated from Si donor wafers."

The drain current versus gate voltage performance at 50mV drain was very uniform across $35\mu\text{m}$ gate MOSFETs. The leakage current was also as low, if not lower, as for a similar sample of InP-donor-wafer MOSFETs. Both these indicators suggested that good, uniform-quality channel layers had been achieved. ■

<http://dx.doi.org/10.1063/1.4891493>

Author: Mike Cooke

First high-frequency noise report of InAlN barrier HEMTs on silicon

Singapore researchers present a good candidate for low-noise and high-linearity receiver circuit applications.

Researchers in Singapore have reported high-frequency performance of gallium nitride (GaN) indium aluminium nitride (InAlN) high-electron-mobility transistors (HEMTs) on silicon substrates, including the first noise measurements [S. Arulkumaran et al, IEEE Electron Device Letters, published online 13 August 2014]. The team from Nanyang Technological University and the A*STAR (Agency of Science, Technology and Research) organization believe such devices are good candidates for low-noise and high-linearity receiver circuit applications.

The product of the unilateral power gain cut-off and gate length is the "highest ever reported for InAlN/GaN HEMT on silicon substrate", according to the researchers. Alternative substrates for GaN HEMTs are silicon carbide (SiC) or sapphire.

The HEMT heterostructures were grown on high-resistivity silicon (111) substrates using metal-organic chemical vapor deposition (MOCVD). The nucleation layer of 100nm AlN was followed by a 1000nm GaN buffer, 1nm AlN spacer and 9nm $\text{In}_{0.17}\text{Al}_{0.83}\text{N}$ barrier. The InAlN composition gives a lattice match to that of GaN. The InAlN/AlN/GaN interface results in a two-dimensional electron gas (2DEG) channel in the GaN buffer with mobility of $759\text{cm}^2/\text{V}\cdot\text{s}$ and carrier concentration of $2.74 \times 10^{13}/\text{cm}^2$.

HEMT fabrication began with mesa isolation through a plasma etch process. The ohmic contacts consisted of annealed titanium/aluminium/nickel/gold. The T-gate of nickel/gold had a $0.17\mu\text{m}$ footprint/gate length (L_g) and $0.5\mu\text{m}$ head. The gate width was $2 \times 75\mu\text{m}$. The source-gate and gate-drain separations were $0.8\mu\text{m}$ and $1.7\mu\text{m}$, respectively. Passivation was provided by plasma-enhanced chemical vapor deposition (PECVD) of silicon nitride.

The maximum current density of the device was $1320\text{mA}/\text{mm}$ at 1V gate potential. The maximum extrinsic transconductance was $363\text{mS}/\text{mm}$. The

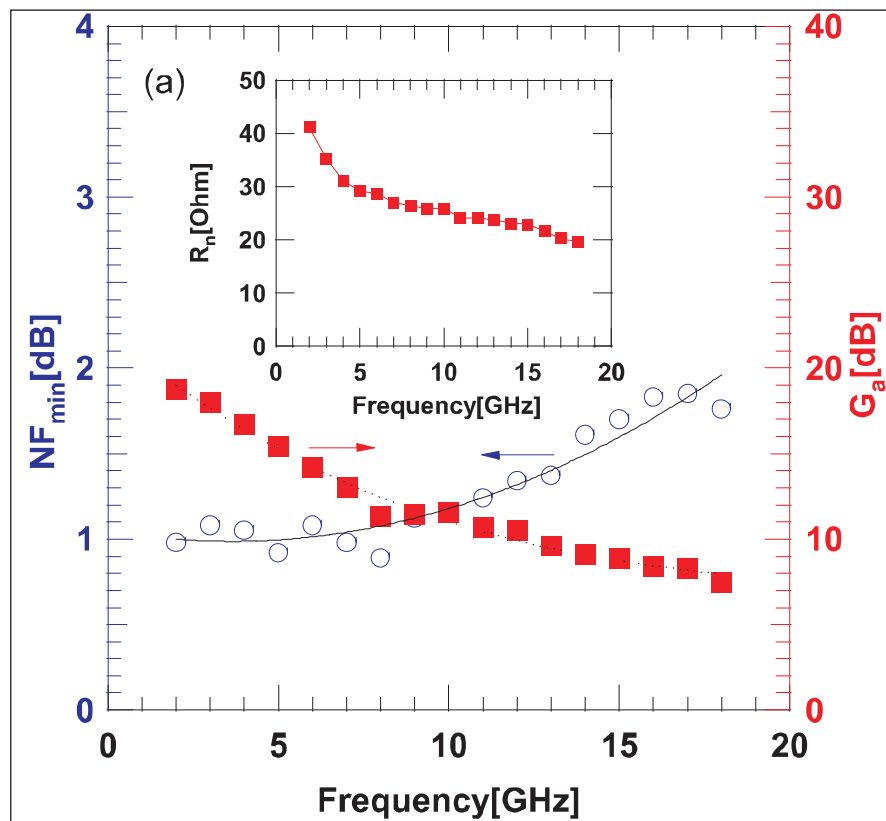


Figure 1. (a) NF_{min} and G_a versus frequencies (2–18 GHz).

researchers comment: "The observed current density is almost double than that of similar AlGaIn-barrier thick GaN HEMTs ($800\text{mA}/\text{mm}$)."

In frequency measurements, the cut-off (f_T) was found to be 64GHz at -2.4V gate and 6V drain biases. The unilateral power gain cut-off ($f_{max}(U)$) was 72GHz. The maximum stable gain $f_{max}(\text{MSG})$ was 106GHz. The researchers add: "The product $f_{max}(U) \times L_g = 12.24\text{GHz}\cdot\mu\text{m}$ is the highest ever reported for InAlN/GaN HEMT on Si substrate." In InAlN-barrier HEMTs on silicon carbide, a product of $25\text{GHz}\cdot\mu\text{m}$ has been achieved, possibly due to better 2DEG mobility or lower parasitic effects.

Noise performance was measured between 2GHz and 18GHz with a drain bias of 4V and gate potential of -2.25V (Figure 1). The minimum noise figure (NF_{min}) measurements at 10GHz and 18GHz were 1.16dB and 1.76dB, respectively. The corresponding associated

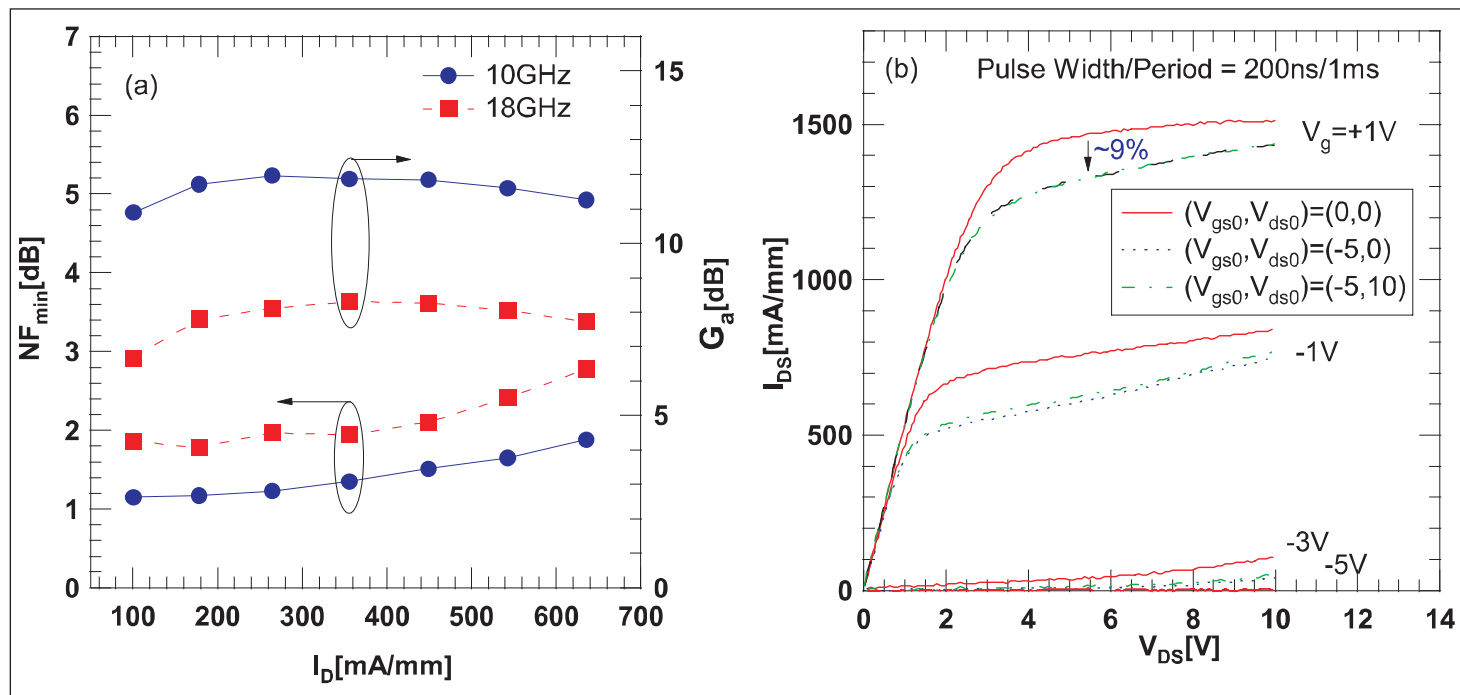


Figure 2. (a) Variation of NF_{min} and G_a over drain current (I_D) at 10GHz and 18GHz. (b) Pulsed drain-source current-voltage (I_{DS} - V_{DS}) characteristics for InAlN/GaN HEMTs on silicon substrate.

gain (G_a) readings were 11.54dB and 7.5dB. The researchers write: "The obtained NF_{min} at 10GHz and 18GHz are comparable to the reported values for AlGaIn/GaN on Si substrate with the same gate length. The measured NF_{min} of our devices at 18GHz is comparable to the NF_{min} of InAlN/GaN on SiC and AlN/GaN on Si substrate (see Table 1)."

In the lower-frequency 2-8GHz range the Singapore device demonstrated slightly high NF_{min} values and some variation in performance that could be attributed to shot-noise effects from the gate leakage currents associated with the Schottky-based gate structure. Metal-insulator-semiconductor gate stacks would reduce leakage, hopefully reducing the noise in this lower range.

The noise figure variation ($NF_{min(low)} - NF_{min(high)}) / (I_{DS(max)} - I_{DS(min)})$ of 1.36dB-mm/A at 10GHz and 1.67dB-mm/A at 18GHz over the drain current range 100mA/mm-636mA/mm was smaller than found by

other groups producing AlN/GaN HEMTs and AlGaIn/GaN HEMTs with similar gate lengths on silicon substrate (Figure 2). However, short-gate InAlN/GaN HEMTs on SiC show smaller variation, due presumably to the use of field plates and ohmic contact re-growth to reduce access resistance.

The researchers also assessed current collapse under gate-lag and drain-lag pulsed bias conditions. The collapse was 9% in both cases. The researchers say that the gate-lag current collapse is better and the drain-lag collapse is comparable to previously reported measurements on InAlN/GaN HEMTs on sapphire substrates. The reduced collapse effect is related to the lattice-matched InAlN barrier and optimized silicon nitride passivation, according to the team. ■

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6877666>

Author: Mike Cooke

Table 1.

Affiliation	HEMT structure	$L_g(\mu m)$	$NF_{min}(dB)$ @10(18)GHz	$(NF_{min(low)} - NF_{min(high)}) / (I_{DS(max)} - I_{DS(min)})$ @10GHz (dB-mm/A)
UIUC	AlGaIn/GaN on SiC	0.25	0.75 (0.98)	-1.25
IEMN	AlGaIn/GaN on Si	0.17	1.1 (1.8)	-14.4
Renesas	AlGaIn/GaN/AlGaIn on Si	0.16	0.78 (-1.2)	—
ETH-Z	InAlN/GaN on SiC	0.10	0.62 (1.5)	—
CNRS	InAlN/GaN on SiC	0.15	0.8 (1.8)	-1.18
Triquint	InAlN/GaN on SiC	0.05	0.3	-0.74
NTU	AlGaIn/GaN on Si	0.25	1.25	-8.49
IEMN	AlN/GaN on Si	0.16	1.0 (1.8)	-1.67
This work	InAlN/GaN on Si	0.17	1.16 (1.76)	1.36

New slant on field plates for gallium nitride HEMTs

An increase in breakdown voltage of 66% has been achieved over conventional field-plate designs.

Researchers in Japan and USA have claimed the first experimental demonstration of higher breakdown voltage for slant field-plate (FP) gallium nitride (GaN) high-electron-mobility transistors (HEMTs) over conventional field-plate designs [Kengo Kobayashi, et al, Appl. Phys. Express, vol7, p096501, 2014].

Field plates are used in GaN HEMTs to manipulate and reduce peak electric fields, allowing higher voltages to be achieved. Generally, field plates consist of layers of metal on insulating dielectric parallel to the underlying semiconductor materials. Higher voltage performance can be achieved with multiple layers of FPs and dielectric, but with increased complexity and cost.

Inspired by numerical simulations from a few years ago suggesting better breakdown performance, the team at Tohoku University and Massachusetts Institute of Technology (MIT) set out to create slant field plates on GaN HEMT structures. Metal-organic chemical vapor phase epitaxy was used to create semiconductor heterostructures with a gallium nitride buffer, aluminium nitride (AlN) spacer, and aluminium gallium nitride (AlGaN) barrier on semi-insulating sapphire.

The HEMT fabrication (Figure 1) consisted of titanium/aluminium/titanium/platinum/gold ohmic metal deposition, mesa isolation plasma etch, 780°C ohmic annealing, plasma-enhanced chemical vapor deposition (PECVD) of silicon carbon nitride (SiCN) surface passivation, gate and field-plate formation, and ohmic contact access etch and deposition of titanium/platinum/gold source/drain electrodes.

The test devices had a gate length of 230nm with gate separations from the source and drain of 4µm each.

The SiCN PECVD used hexamethyldisilazane (HMDS) vapor to create a 200nm film. The carrier gases were hydrogen and ammonia. The gas-balance allowed variation of the SiCN composition, resulting in different plasma-etch characteristics. SiCN produced with ammonia carrier is more easily etched, compared with SiCN from hydrogen carrier.

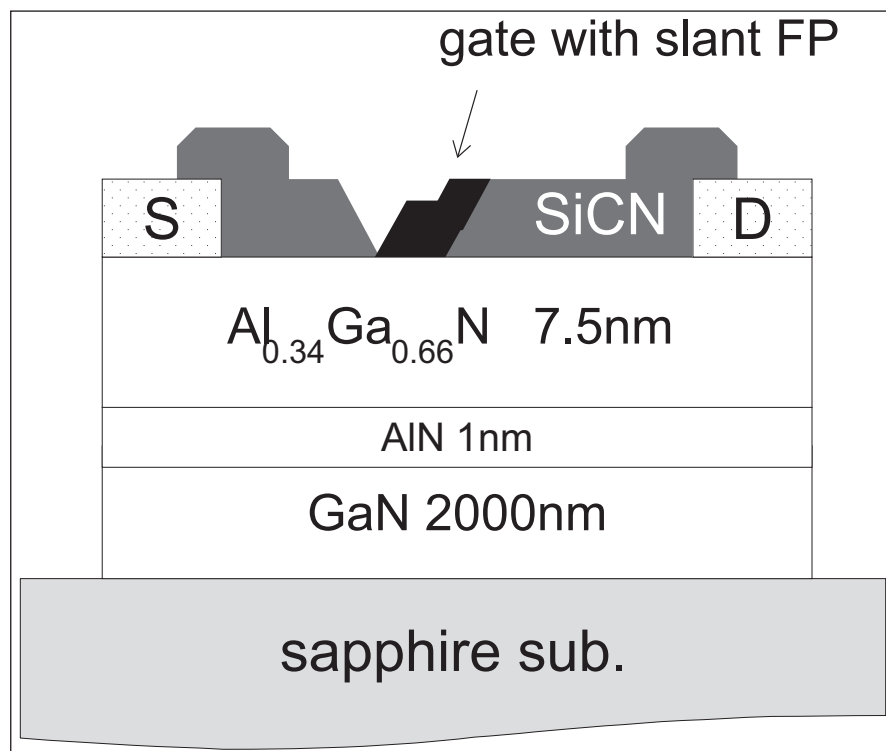


Figure 1. Cross-sectional view of AlGaIn/GaN HEMT with slant field plate.

Variation of the carrier from pure hydrogen to pure ammonia in ten steps allowed the researchers to create a slant surface for the field plate when the gate window was created with plasma etching. The etch was carried out in two parts: first a vertical reactive-ion etch with carbon hexafluoride (C₂F₆), followed by a lateral etch with sulfur hexafluoride (SF₆).

The gate metals were nickel/gold. The field-plate metal was evaporated onto the sample, which was tilted to ensure that the metal was deposited on the drain side slant of the SiCN passivation. Devices were also produced where the SiCN layer was produced in 3- and 4-steps, giving field plates with different characteristics. Having 10 steps gives a practically smooth slanted FP.

The DC characteristics of the three test devices were almost identical. In the off-state, the bulk of the drain current comes from gate leakage. All the devices were able to sustain voltage sweeps to 160V without hard breakdown. By contrast, a comparison device without a field plate suffered hard breakdown at 83V.

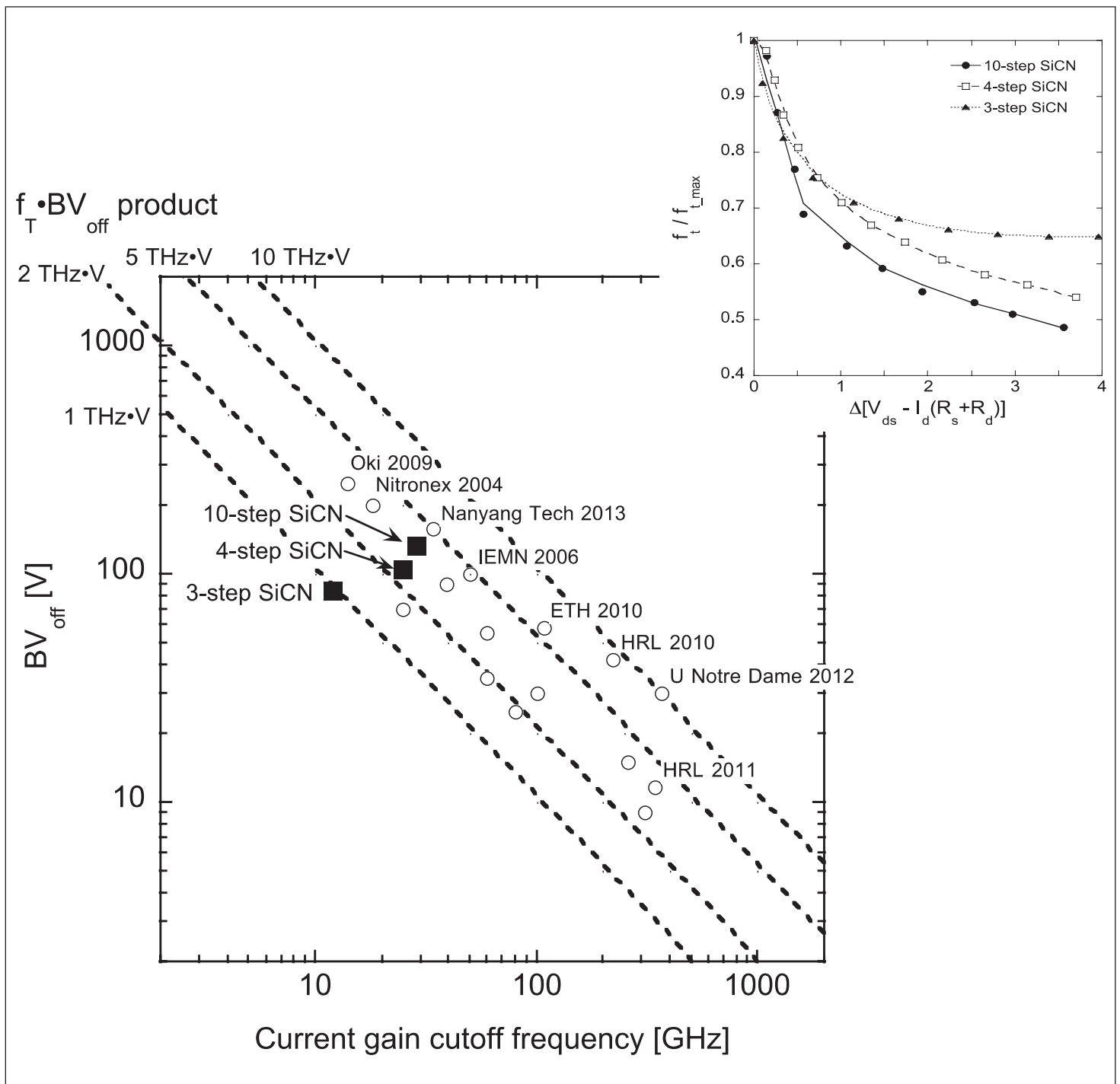


Figure 2. BV_{off} versus f_T for various GaN-based HEMTs, including Tohoku/MIT devices. Inset: change in f_T normalized with respect to maximum value (f_T/f_{Tmax}) as effective drain voltage, $V_{ds} - I_d(R_s + R_d)$, increases from value for f_{Tmax} .

The off-state breakdown (BV_{off}) increased with the number of steps used in depositing the SiCN passivation. Defining the breakdown voltage as that giving a drain current of 1mA/mm, the researchers found the 10-step device to have 66% greater BV_{off} over a HEMT with a conventional double field-plate design.

The frequency performance was also measured. The maximum current-gain cut-off frequencies (f_T) were 12GHz, 24.7GHz, and 28.8GHz for 3-, 4-, and 10-step field plates. The HEMT without a field plate also had an f_T of 12GHz, like the 3-step HEMT. However, the

maximum current density was halved in the device without a field plate.

Although the 10-step HEMT has the best frequency performance, the f_T decreases more rapidly with increased drain bias in comparison with the other devices. The maximum f_T and BV_{off} values give a 4-fold advantage for the $BV_{off} \cdot f_T$ product of the 10-step device over HEMTs with conventional field plates (Figure 2). ■

<http://dx.doi.org/10.7567/APEX.7.096501>

Author: Mike Cooke

Envelope tracking market to exceed 4 billion units by 2018

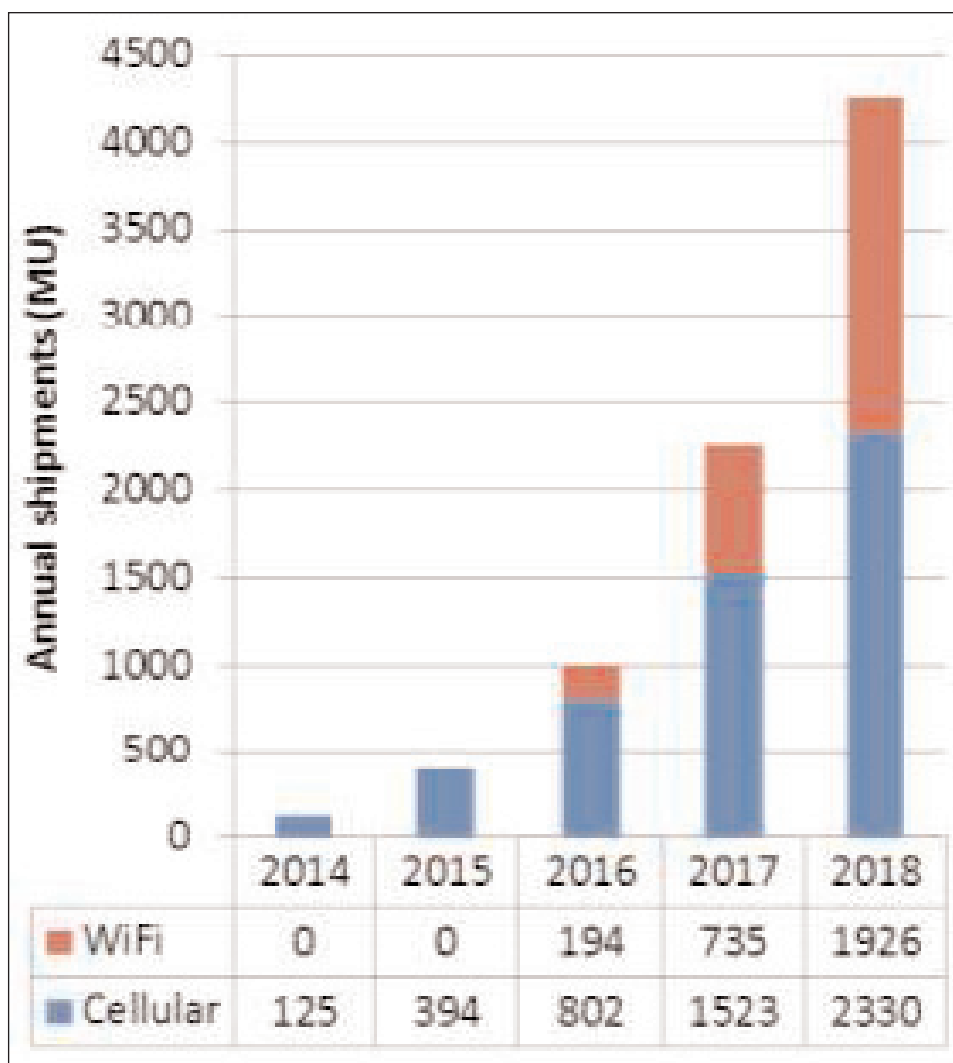
Nujira highlights a \$3bn market opportunity over five years as envelope tracking becomes ubiquitous for 4G smart-phones.

Envelope tracking (ET) adoption rates will soar, according to a new forecast analysis published by fabless envelope tracking (ET) semiconductor firm Nujira Ltd of Cambridge, UK. The firm's research predicts that the total market for ET power supply chips will exceed 4 billion units a year by 2018, representing a \$3bn market opportunity over the next five years as ET becomes ubiquitous across the 4G smart-phone market.

ET is a technique for improving the energy efficiency of RF power amplifiers (PAs). The traditional DC-DC converter supplying the PA is replaced by a highly agile ET power supply chip. This dynamically modulates the power supply pin of the RF PA with a high bandwidth, low noise waveform, synchronised to the instantaneous envelope (amplitude) of the signal being transmitted. At any instant in time, the PA is operating in a highly efficient compressed state, where the power supply voltage is just sufficient to enable the PA to transmit the instantaneous output power required.

Since the launch of the first ET-enabled phone in 2013 the market has expanded rapidly, with ET technology now featured in 15 flagship LTE phones from Apple, Samsung, LG/Google, HTC, Sony, ZTE and Amazon, with others in the pipeline. Nujira expects that those phones alone will account for about 125 million unit shipments of ET chips in 2014. In the next two years ET adoption is expected to cascade down from high-end smart-phones to the mid-tier sector, which together are forecast by market research firm Strategy Analytics to surpass 1 billion units by 2016.

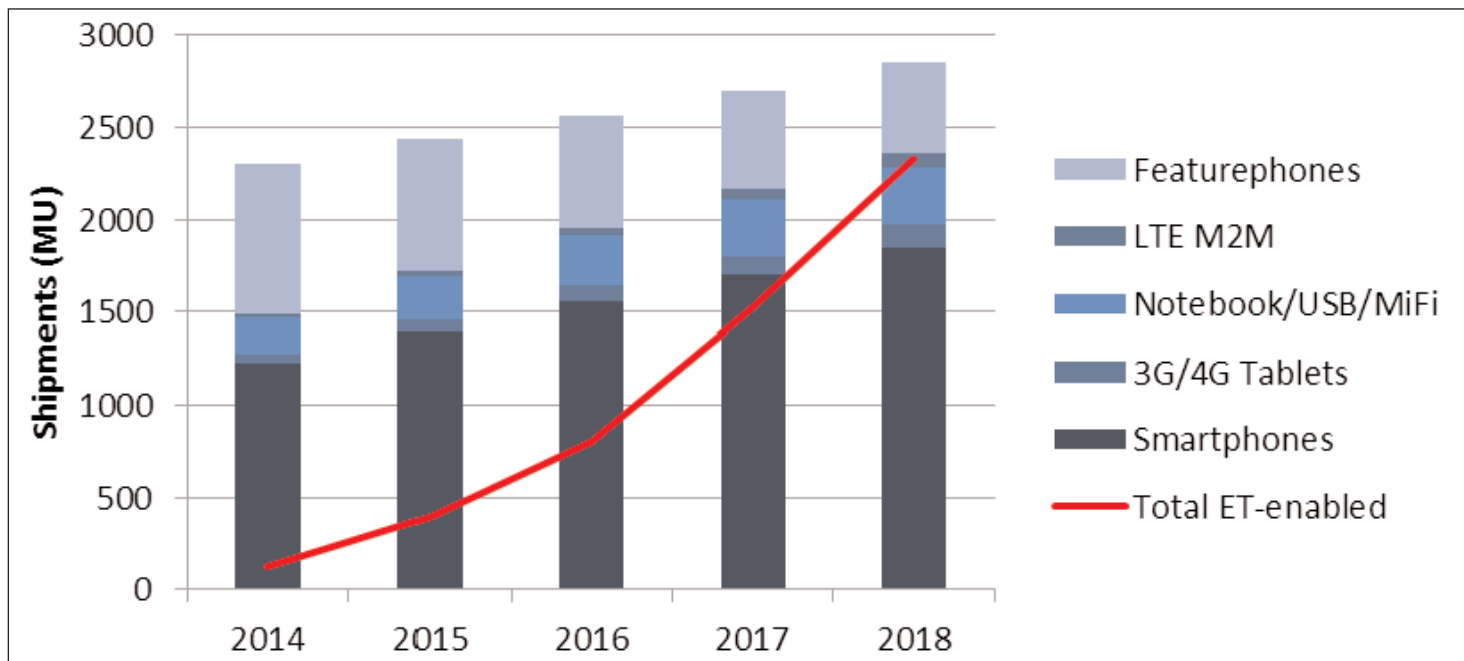
Nujira also expects that further opportunities will emerge for ET technology in WiFi, driven largely by the new high-data-rate 802.11ac standard. Existing WiFi PAs achieve less than 10% energy efficiency, and the market is ripe for high-bandwidth ET solutions that can



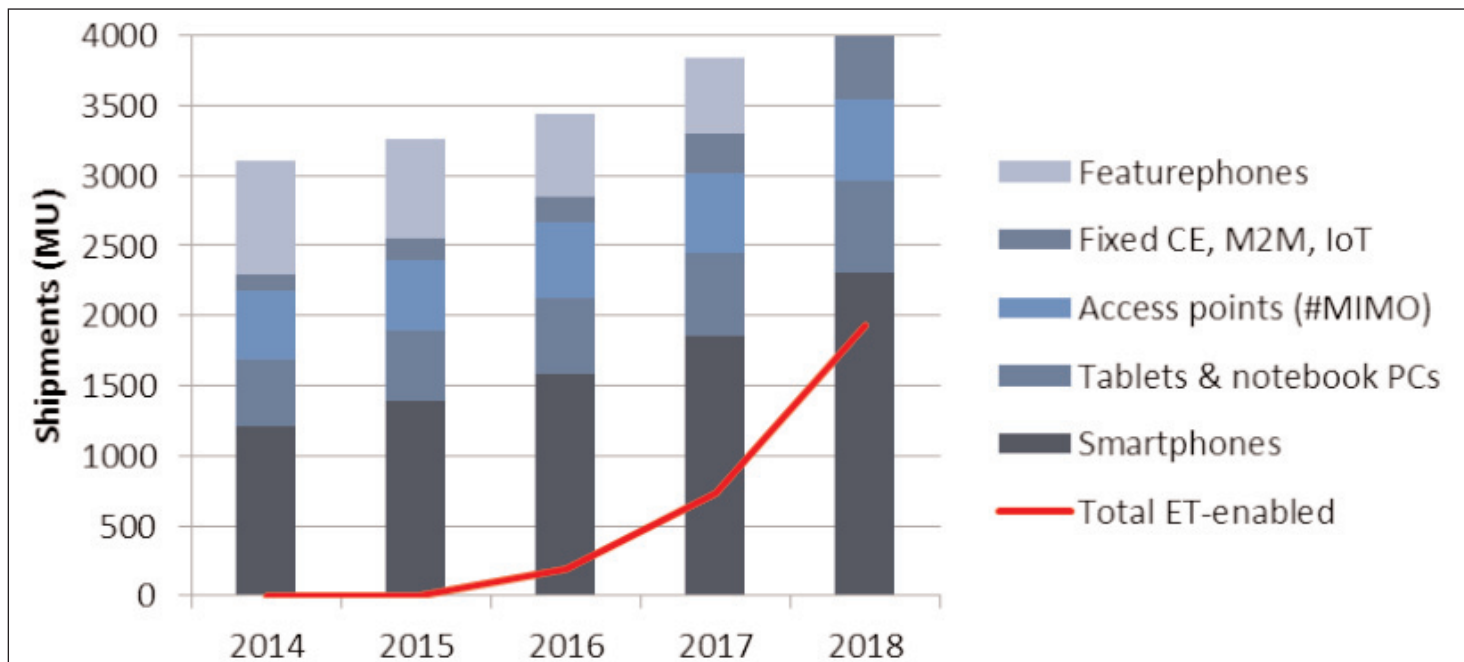
Envelope tracking shipment forecast.

cut current consumption by 75%, reckons the firm. Nujira expects that the first ET-enabled WiFi solutions will be shipping in 2016, with rapid adoption by 2018 across access points, smart-phones and 'Internet of Things' applications – a potential market of 2 billion units a year.

"The adoption of ET this year into all flagship smart-phones shows that key OEMs have recognized the value of integrating ET into their devices," says CEO Tim Haynes. "The continued roll-out of 4G LTE networks, including TD-LTE in China and the move to LTE-Advanced, will further reinforce the requirement for ET across the world," he adds.



Envelope tracking market opportunity in 3G/4G cellular.



Envelope tracking market opportunity in WiFi.

Alongside the product-level benefits of increased battery life, reduced heat dissipation and better signal coverage, ET is a vital enabling technology for CMOS PAs, allowing them to compete with incumbent gallium arsenide (GaAs) PAs, says the firm. Nujira believes that CMOS PAs will show significant growth over the next 5 years, driven by lower cost, higher front-end integration levels, and supply chain consolidation. By 2018, component-level integration of ET functionality with the CMOS ET PA will enable adoption in cost-driven 4G/LTE markets such as M2M/IoT and low-end smart-phones, as well as performance-driven applications such as 802.11ac WiFi, believes Nujira.

"With widespread adoption this year, mobile device manufacturers are waking up to the potential of ET," comments Christopher Taylor, director of the RF & Wireless Components advisory service at market research firm Strategy Analytics. "The report from Nujira paints an interesting picture of the changing landscape of the RF front-end market," he adds. "It is clear to see that, whether as a standalone chip, integrated with a CMOS PA, or ultimately into the cellular chipset, ET will rapidly become a critical enabling technology for the next generation of high-data-rate wireless communications." ■

www.nujira.com/market-projections-pa-810.php

PFC, PV inverter and now rail applications fueling silicon carbide market

Silicon carbide in electric and hybrid electric vehicles has been delayed beyond 2018, says **Yole Développement**, but 6'-inch wafers for power electronics will enter the market in 2016–2017.

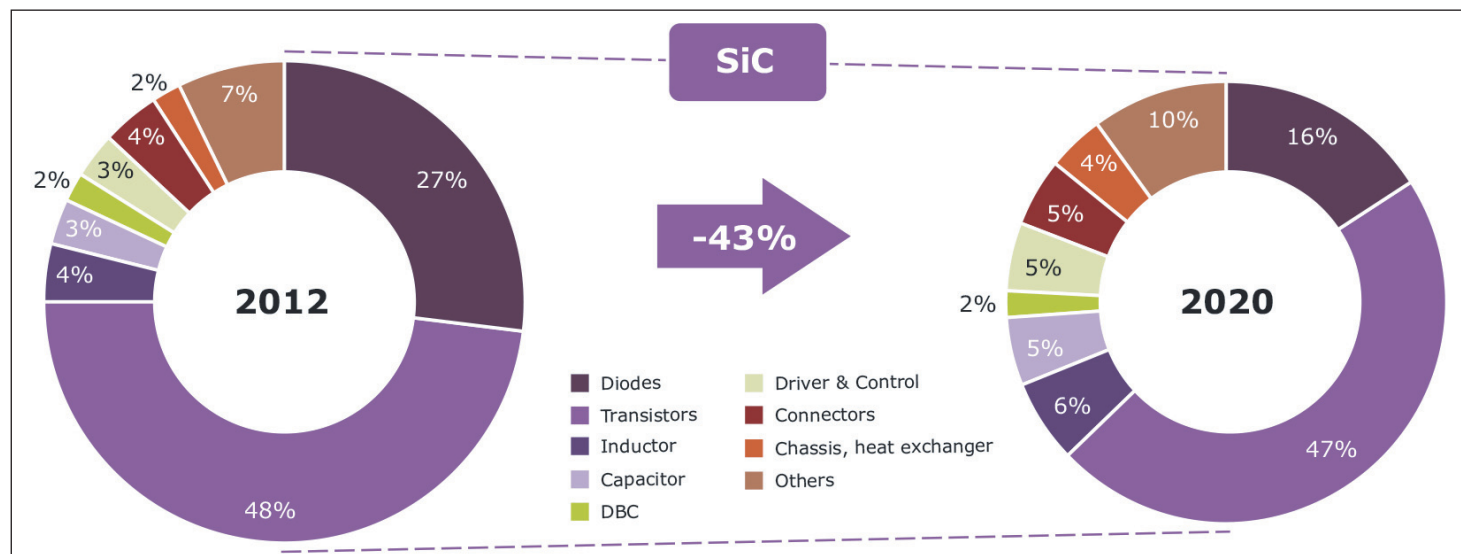
The market for silicon carbide (SiC) chips reached almost \$100m in 2013 due to already well-established power factor corrector (PFC) applications, which still demands large volumes of diodes, according to Yole Développement. Secondly, photovoltaic systems, despite a depressed market, are the beachhead for new SiC-powered inverter or micro-inverter line-ups, says the market research firm in its new report 'SiC Modules, Devices and Substrates for Power Electronics Market'. In addition, SiC is propagating over all industrial segments, it adds.

For example, rail applications such as train traction has surprisingly adopted SiC sooner than expected. This strategic choice has been made by industrials because of the availability of 1.7kV full and hybrid modules that have been demonstrated and installed by Mitsubishi Electric in Japan. Train applications could expand at a compound annual growth rate (CAGR) of more than 80% over 2015–2020. "Indeed, we expect other rolling-stock manufacturers will quickly adopt SiC, firstly in metro and then in the high-speed trains," says Dr Philippe Roussel, business unit manager at Yole. "We also forecast PV inverters to keep on imple-

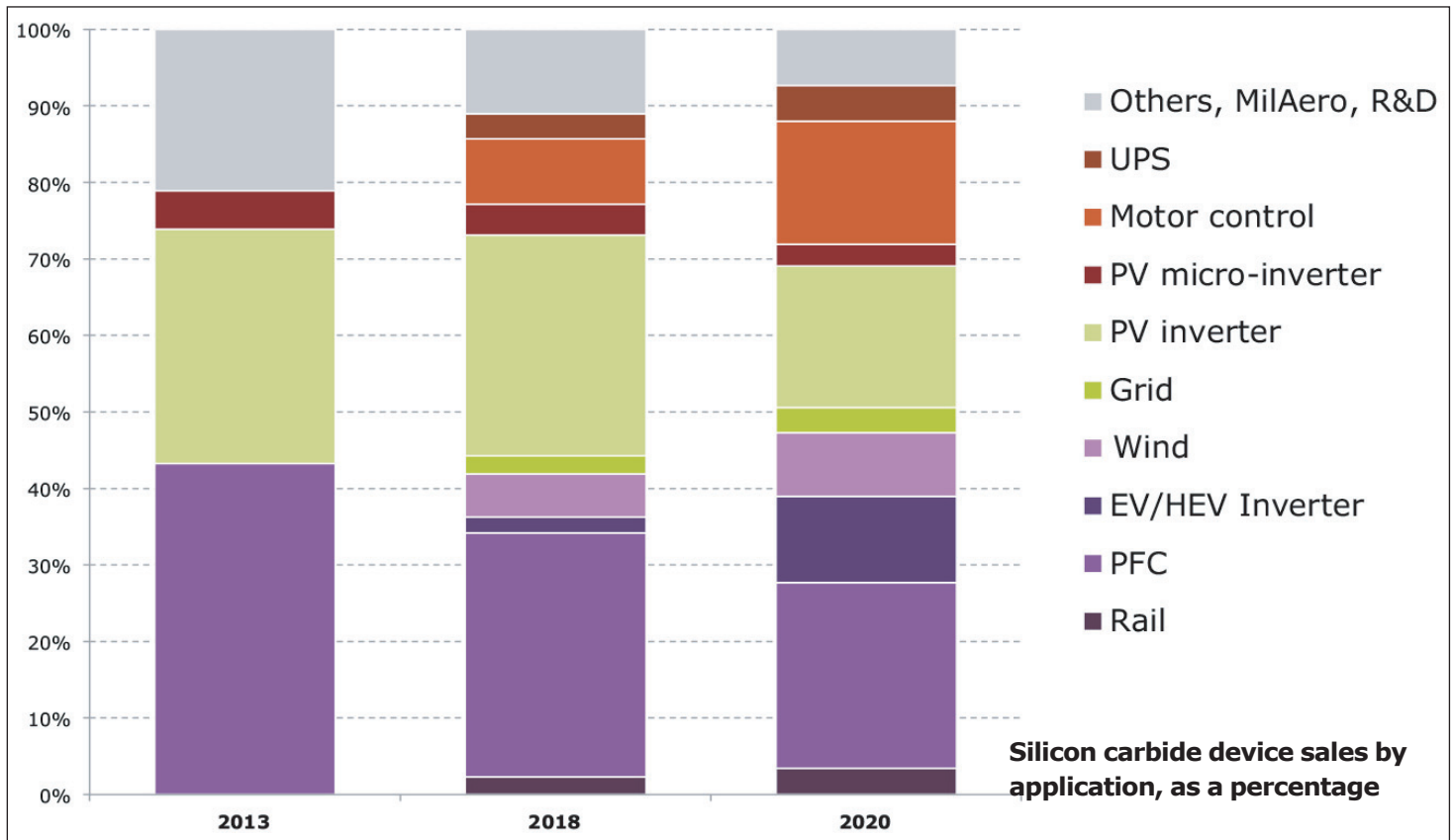
menting SiC at an annual growth rate of almost 12%," he adds.

The adoption of SiC in train applications is a major factor in the SiC industry. "It shows that SiC could play an important role in the high- and very high-voltage ranges, more than 1.7kV," says Dr Hong Lin, technology & market analyst, Compound Semiconductors & Power Electronics, who remains convinced that these voltage and related power ranges "are exactly the place-to-be for SiC technology... Such technology can bring real added-value, despite a price positioning that differs from silicon," he reckons. Here, savings are made at the system level, where passives and other cooling can be dramatically reduced when moving to SiC, Lin notes.

In its 2014 analysis of the SiC market, Yole also takes into account the competition with gallium nitride (GaN) devices in the PFC area. Now able to answer the needs of the 600V segment, GaN is becoming a serious competitor for SiC technology, the firm notes. Yole's analysts therefore remain quite conservative regarding this application, which could switch to nitrides in the coming years.



SiC-based EV/HEV inverter bill-of-material evolution for 2012–2020 with device and component price erosion.



SiC in EV/HEV delayed beyond 2018

It has always been said that SiC could play a major role in EV/HEV power electronics. Most car makers agree that there is a 10% fuel saving when moving from silicon to SiC in hybrid vehicles. For a pure electric car this metric (for a given battery pack) will translate into lower battery consumption or extended range. It is now obvious that EV/HEV could easily capture the biggest portion of the SiC business, says Yole.

However, even though all technical indicators are green, the car industry is reluctant to implement SiC, claiming that the economics are not yet fully compatible with their expectations. "Such conservatism heavily impacts our previous predictions," says Yole. According to key industrial voices (Toyota, Denso, Honda, Nissan etc), SiC will only be on the short list by 2018 for the most optimistic players and by 2020 for others. "By adding GaN 600V normally-off (Noff) devices (now in the starting blocks), we approach the most conservative scenario we developed in the past years, exhibiting a SiC device business in 2020 that will exceed \$400m," says Yole.

6-inch SiC wafers for power electronic applications to arise in 2016-2017

For n-type substrates, 4" wafers are the mainstream product on the market. The introduction of 6" n-type substrates in power electronic devices is slower than expected, says Yole. The quality of 6" wafers seems to still be an issue and the price is highly dependent on the quality, varying from \$1300 to \$2000. Additionally, the supply of 6" wafers is still limited.

The ratio between the price of 6" and 4" n-type substrates is about 2.5x, which is still too high and does not make 6" wafers appealing to device makers, despite their intention to transition to 6" in order to reduce device cost. The price of 6" n-type wafers is expected to drop quickly in the next two years and fall below the \$1000 threshold. The large-scale transition to 6" is expected to take place in 2016-2017.

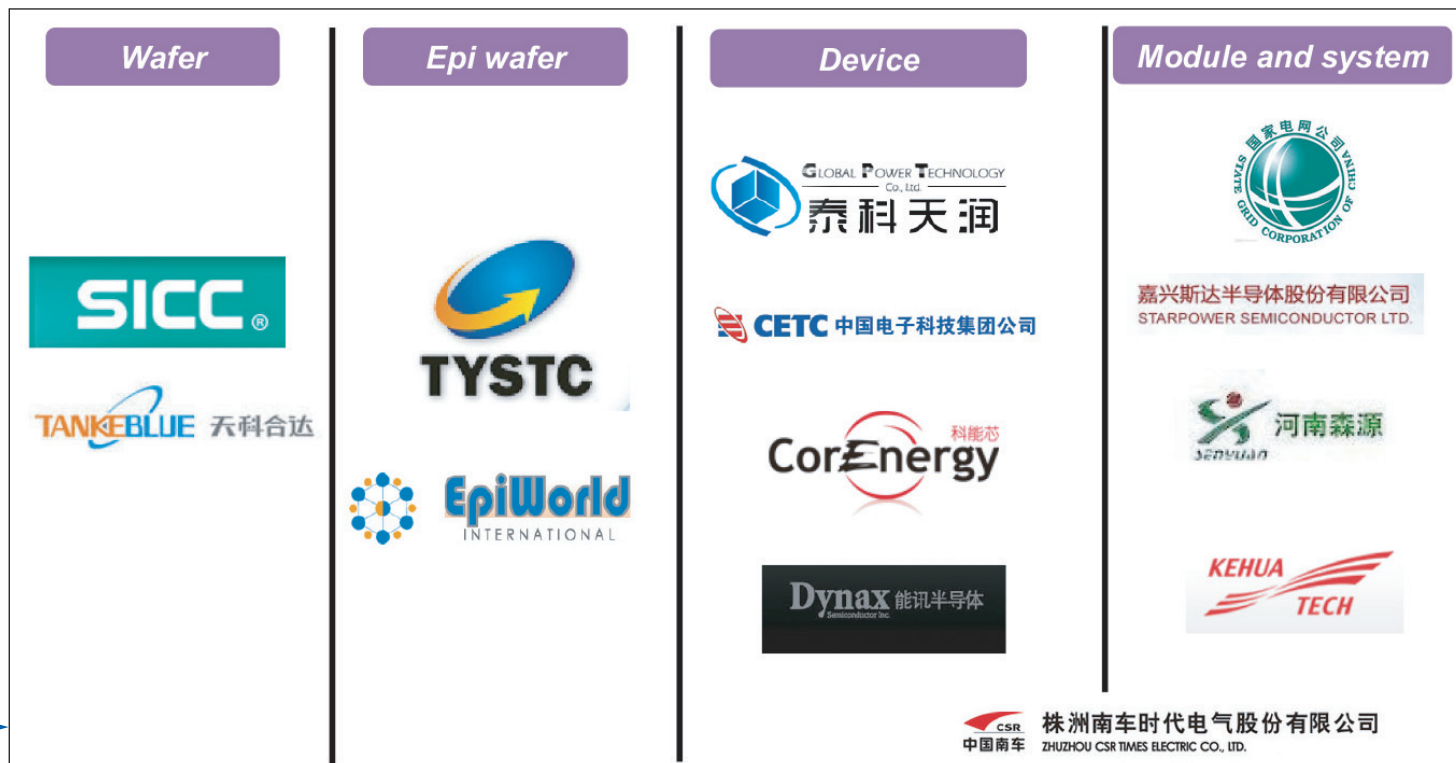
Concerning the players in SiC wafers, Cree remains the market leader by far. II-VI, Dow Corning and SiCrystal follow. Asian players are gaining market share little by little, but their volumes are still small compared to the leading players.

Chinese players entering the SiC field

China is already a big player in the power electronics field with most of the integrators. At the device level, the country has invested significant amounts in the R&D and production of insulated-gate bipolar transistors (IGBTs) in recent years. However, compared with the USA, Europe and Japan, China still has some way to go.

China is hoping to catch up with USA, Europe and Japan in the power electronics field, through the so-called 'third generation of semiconductors' (SiC and GaN etc). Consequently, the Chinese government has provided significant funding for SiC R&D and industrialization. Since 2006, several companies have gradually entered the SiC arena. Now, there are Chinese firms spanning the entire value chain, from materials to devices. In particular, in Asia, Japan leads SiC activities but China is catching up and Korea is coming, says Yole.

www.yole.fr



China wide-bandgap power semiconductor industry alliance.

www.i-micronews.com/compound-semi-report/product/sic-modules-devices-and-substrates-for-power-electronics-market-launch.html

17 September 2014

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updated its investigation and give us today its up-to-date vision of the SiC industry. This 2014 edition includes a bill-of-material comparison SiC versus Si at

the system level, a payback-time simulation and detailed market data. a complete analysis of the SiC industry at the device, module and substrate levels, in the power electronics field; it shows the involvement of key SiC players, the state-of-the art technology.

Power factor corrector (PFC), photovoltaic inverter, motor control etc represented a \$100m in 2013.

SiC adoption spreading to more industrial segments Chinese players are coming into the SiC playground.

The report highlights the SiC vs. Si bill-of-material comparisons for the most significant applications and concludes with the chances of SiC to penetrate each

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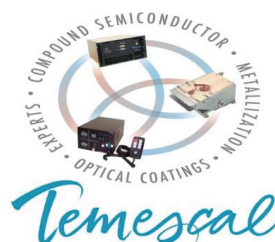
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18 Chip foundry

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The Westin, Pazhou, Guangzhou, China

E-mail: lih@china-led.net

www.sslchina.org/en

11 November 2014

Russia International Forum on Solid State Lighting (SSL RUSSIA 2014)

Russia

E-mail: lih@china-led.net

<http://focus.china-led.net/2014sslRussia>

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)

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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

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COEX, Seoul, Korea

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Clarion Congress Hotel, Prague, Czech Republic

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