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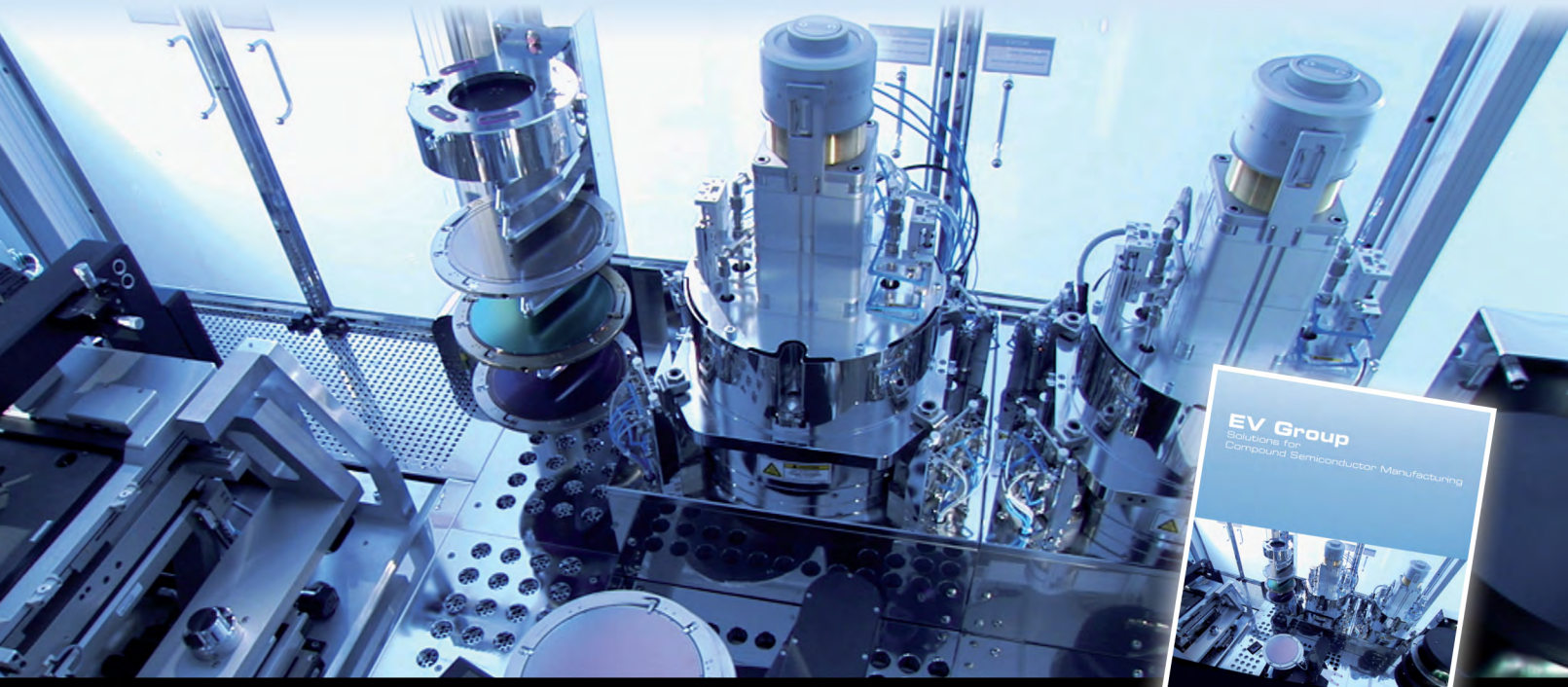

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COMPOUNDS & ADVANCED SILICON

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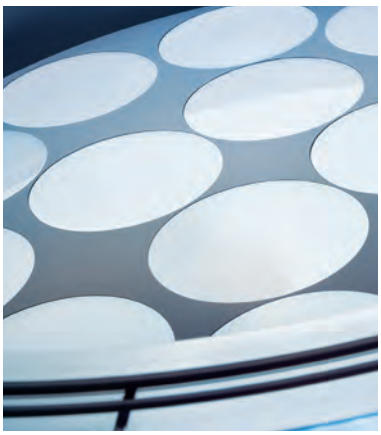
RFMD and TriQuint agree to merge

Report from IEDM: wide-bandgap power devices

MACOM acquires Nitronex • First commercial 150mm InSb
HelioVolt suspends production • CdTe cell record hits 20.4%

Light Up a Brighter World

MaxBright MHP MOCVD System



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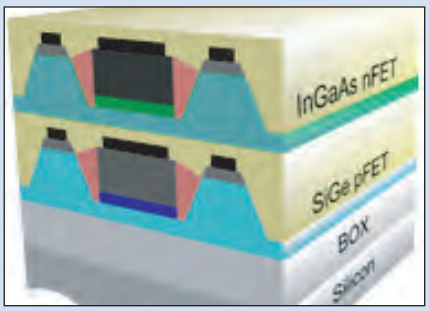
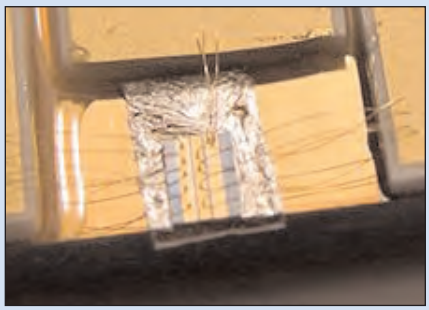


p24 The European project COMPOSE^3 targets the proof of concept of a 14nm 3D-stacked InGaAs/SiGe hybrid SRAM cell within three years.



p71 Leeds University in the UK has demonstrated the first THz laser chip with pulsed peak power exceeding 1W.

p91 South Africa's PTiP opens CIGS solar module pilot-production line , using SINGULUS processing systems for scale-up to commercial production.

Cover: Osram Opto Semiconductors claims to be the first chip maker to switch InGaAlP red and yellow LED fabrication to 6-inch wafers, joining its GaN-based blue LEDs (which it began switching to 6-inch wafers in 2011). **p64**

editorial

Reorganizing infrastructure

On 24 February (just before we closed for press) came the news that US-based firms RF Micro Devices and TriQuint Semiconductor have agreed to merge (see news story on page 12). Subject to approval by shareholders of both firms, the merger is expected to close in second-half 2014.

The merger is said to combine complementary product portfolios for mobile solutions. In particular, while RFMD is strong in power amplifiers (PAs) and switches, TriQuint is strong in filters (competing with Avago).

In terms of the two firm's client bases, RFMD's main customer is Samsung, while TriQuint is a big supplier to Apple (via subcontractor Foxconn).

The merger is also intended to strengthen the combined firms' portfolio for infrastructure and defense/aerospace, and enable gallium nitride (GaN) solutions for additional markets and applications.

RFMD's Cellular Product's Group contributes 83% of RFMD's revenue, compared with 17% from the Multi-Markets Product Group (Wi-Fi, CATV and wireless infrastructure). In contrast, TriQuint's revenue comprises 71% Mobile Devices, 18% Network Infrastructure and 11% Defense & Aerospace. RFMD should hence benefit from greater non-mobile business.

For TriQuint, the merger addresses the interests of parties such as New York-based activist investment fund Starboard Value, which last October took a 7.8% stake in TriQuint, and asked it to consider selling or restructuring its mobile power amplifier business and focus on the network infrastructure,and defense & aerospace businesses. The merger offer is priced at $9.73 per TriQuint share, i.e. a 5.4% premium to TriQuint stockholders on the share price when the merger was announced.

The combined annual revenue for 2013 is over $2bn ($1.17bn for RFMD and $893 for TriQuint), including $500m from infrastructure & defense). By comparison, for the main competitor in the RF component sector, Skyworks Solutions reported total revenue of $1.84bn in calendar 2013 (see quarterly results on page 18). This annual snapshot suggests that the combined RFMD–TriQuint will outweigh Skyworks in terms of business, but that does not account for trends.

While RFMD, TriQuint and Skyworks all grew sequentially for the first three quarters of 2013 (see pages 14, 16 and 18), RFMD's December quarter was down 7% due to weakening at its two largest customers and in low-end cellular markets in China, where RFMD has the majority share (page 16).

Comparing full-year fiscal 2013 with 2011, RFMD has shrunk from $1052m to $964m and TriQuint from $896m to $893m, while Skyworks has grown consistently, from $1072m in 2010 to $1420m in 2011, $1569m in 2012 then $1792m in 2013 (with growth aided by acquisitions, particularly of firms with complementary technology and markets, e.g. for silicon-based devices). For fiscal 2013, RFMD and TriQuint posted GAAP losses of $52m and $38m, respectively, whereas Skyworks made a profit of $278m. The RFMD–TriQuint merger is expected to yield $150m in cost synergies. In addition, the consolidation of RF component suppliers is expected to give more bargaining power over pricing, aiding profitability.

One note of caution is that, especially with the share prices of both RFMD and TriQuint rising after the merger announcement, some TriQuint stockholders may claim that the merger deal undervalues the shares. So, the closure of the merger may yet be contested.

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ALWAYS ONE STEP AHEAD

GaN device market to grow at 24.6% to $2.2bn in 2019

ICT sector to grow fastest, driven by demand for GaN power semiconductors in 4G networks

According to a new report 'GaN Semiconductor Devices (Power semiconductors, Opto semiconductors) Market — Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2013–2019' from Transparency Market Research, the market will increase from $379.82m in 2012 to $2,203.73m by 2019, rising at a compound annual growth rate (CAGR) of 24.6% from 2013 to 2019.

North America was the largest contributor in 2012, accounting for 32.1% of the GaN device market, followed by Europe, Asia Pacific, and the rest of the world (RoW). However, Asia Pacific is expected to be the fastest-growing market during the forecast period, growing at a CAGR of 27.7% from 2013 to 2019, due mainly to the rapid growth in the electronic industry in Asia Pacific.

The growing demand for high-speed, high-temperature and power-handling capabilities has made the semiconductor industry rethink the designs and materials used in semiconductors, notes the report. As various faster and smaller computing devices arise, the use of silicon is making it difficult to sustain Moore's Law. Due to its unique characteristics (such as superior noise factor, high maximum current, high breakdown voltage, and high oscillation frequency), GaN is a unique material of choice for numerous applications such as military, aerospace and defense sector, automotive sector and high-power applications such as industrial, solar, power and wind, says the report. GaN is also power efficient, as it requires less heat-sink compared to silicon.

Growing application areas as well as increased demand from the military is the major driving force for the growth of the GaN device market. The increase in demand is mainly due to the significant reductions in weight and size of devices achievable by using GaN. In addition, developments in improving the breakdown voltage of GaN are expected to boost usage in the field of electro-mobility.

In 2012, optoelectronic semiconductors represented the main product type and accounted for 96.6% of the GaN device market, due mainly to adoption of GaN opto semiconductors in military, aerospace, defense and consumer electronics sector. However, the power semiconductor segment is expected to grow the fastest during the forecast period, due mainly to the rising need for high-power devices in industrial applications.

Among various applications, the military, defense and aerospace sector held the highest market share in 2012, at $81.68m. Consumer electronics was second largest, followed by the ICT and automotive sectors. However, with the introduction of 4G networks, demand for high-power transistors and base-stations is expected to rise, so demand for GaN power semiconductors in ICT is expected to grow the fastest.

The report cites major players among GaN device makers as Fujitsu Ltd (Japan), GaN Systems Inc (Canada), Freescale Semiconductors Inc (USA), International Rectifier Corp (USA), Cree Inc (USA), Nichia Corp (Japan) and RF Micro Devices Inc (USA).

www.transparencymarketresearch.com

LEDs usage in medical & biophotonic devices grows 19.8% to $77.3m in 2013

Global consumption of packaged light-emitting diodes (LEDs) used in biophotonic and medical devices grew 19.8% in 2013 to $77.3m, according to a new market study from ElectroniCast Consultants.

The forecast data are segmented into the following sub-application categories:

- Sensing/Detection and Analytical/Monitoring;
- Phototherapy/Sanitation/Cell Regeneration/Curing;
- Instrumentation Light Source and Imaging.

According ElectroniCast, Sensing/Detection and Analytical/Monitoring devices comprised 62% of worldwide consumption (by value) of packaged LEDs in the selected and medical science and biophotonic devices in 2013. In 2020, LEDs used in Sensing/Detection and Analytical/Monitoring are forecast to decrease in market share, while still rising threefold in consumption value.

LED consumption in Phototherapy/Sanitation/Cell Regeneration/Curing applications, which include water treatment, medical, health & beauty photodynamic therapy (PDT) as well as curing methods, is forecast to growth at more than 30% from $25.78m (33% market share) in 2013. LEDs used in Instrumentation Light Sources and Imaging grew from $3.18m in 2012 to $4.09m in 2013 (5% market share).

By region, the Americas commands well over 40% global market share in 2013. However, both the EMEA (Europe, Middle East and Africa) and APAC (Asia-Pacific) regions market are forecast to grow at a faster rate.

www.electronicast.com

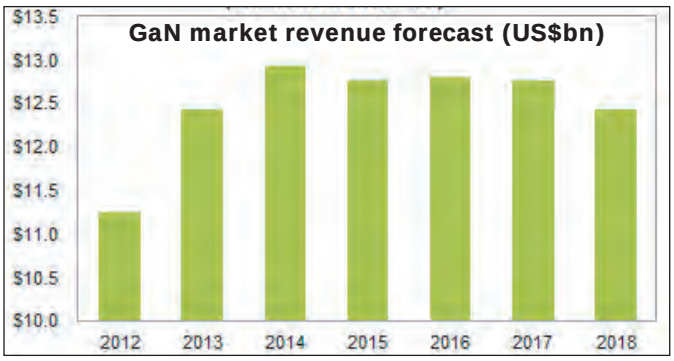
GaN LED revenue rises 10.6% in 2013, but era of fast growth is ending

Growth in lighting but contraction in backlighting to yield flat revenues; unit shipments to grow just 3–4% in 2015–2018

Driven by surging demand from the lighting, tablet and cellphone backlighting segments, global revenue for gallium nitride (GaN) LEDs rose 10.6% from $11.2bn in 2012 to $12.4bn in 2013, but this could mark the last hurrah for the era of double-digit dollar growth for the market, according to IHS Technology, as revenue is forecast to grow just 4% to $12.9bn in 2014. Although unit shipments will continue to rise, the market will enter a sustained period of flatness starting in 2015, based on data from the new IHS report 'Quarterly GaN LED Supply and Demand Market Tracker: Q4'13'.

"The GaN LED market has experienced strong revenue growth in recent years, propelled by the combination of growing demand from the lighting and display backlighting segments," says Jamie Fox, principal analyst for LEDs at IHS.

LEDs are used extensively as backlights for liquid-crystal display (LCD) panels. But backlighting applications including TVs and monitors will soon reach 100% LED saturation. Furthermore, the value of LEDs in each TV and PC monitor shipped has begun to fall. Meanwhile, the fast growth of LEDs in tablets is slowing. The backlighting market in this area is starting to mature in terms of LED technology, and shipments of tablet devices are also not growing as rapidly as before. Overall, the GaN LED backlighting segment is projected to fall from $4.3bn in 2013 to $3.7bn in 2018.



"LED backlighting market revenue has begun to decline — although lighting will continue to expand," Fox notes. The GaN LED lighting segment will rise from $4.2bn in 2013 to $5.9bn in 2018, forecasts IHS. While all GaN LED backlighting applications combined still exceeded the lighting segment in 2013 (at $5.5bn versus $4.2bn), lighting and backlighting revenue will be on a par in 2014 and 2015, before lighting takes a decisive lead in 2016.

"The combination of the contraction in backlighting and rise in lighting will result in flat revenue for the GaN LED market in the coming years," says Fox.

While revenue growth will stall, GaN LED unit shipments will continue to rise in the coming years, but at a more moderate pace than before, forecasts IHS. Following growth of 17.3% in 2013 and 7.3% in 2014, unit shipments will rise 3–4% from 2015 through 2018.

With its latest GaN LED report, IHS has significantly expanded its estimate of the market's size. IHS adjusted its market view to account for all captive revenue (e.g. for captive LED supplier Cree Inc of Durham, NC, USA, which makes both LEDs and lighting products that use them) and also to represent the true size of the Chinese market.

www.ihs.com

Silicon photonics market to grow at 24.5% from $88.6m in 2013 to $410m by 2020

The global silicon photonics market is expected to increase at a compound annual growth rate (CAGR) of 24.5% from $88.6m in 2013 to $410.78m in 2020, according to the report 'Silicon Photonics Market by Products (Silicon Optical Interconnects & Wavelength Division Multiplexer Filters & Others), Applications (Telecommunication, Datacom, High Performance Computing & Others) & Geography — Analysis & Forecast (2013-2020)' from MarketsandMarkets Inc.

Such growth is heralded by telecom and datacom applications. The datacom sector for silicon photonics products is expected to grow rapidly in the coming seven years.

When the geographical markets of North America, Europe, Asia Pacific (APAC) and the Rest of the World are considered, North America has the major share, with revenue of about $47.1m in 2013, and is expected to grow at a CAGR of 22.7% to 2020. However, APAC and Europe are forecasted to be the fastest-growing regions, with CAGRs of 27.4% and 26.1%, respectively, from 2013 to 2020, due to the major growth spurts expected in datacom applications.

The report covers both CMOS-based silicon photonic devices and hybrid silicon photonic products and devices. Key players in the market include US/Israel-based Mellanox Technologies, and Intel, Luxtera, IBM and Molex in the USA, according to the report.

www.marketsandmarkets.com

Decline in packaged LED ASPs slowing as super-high-power LEDs rise to 50% of lighting shipments by 2017

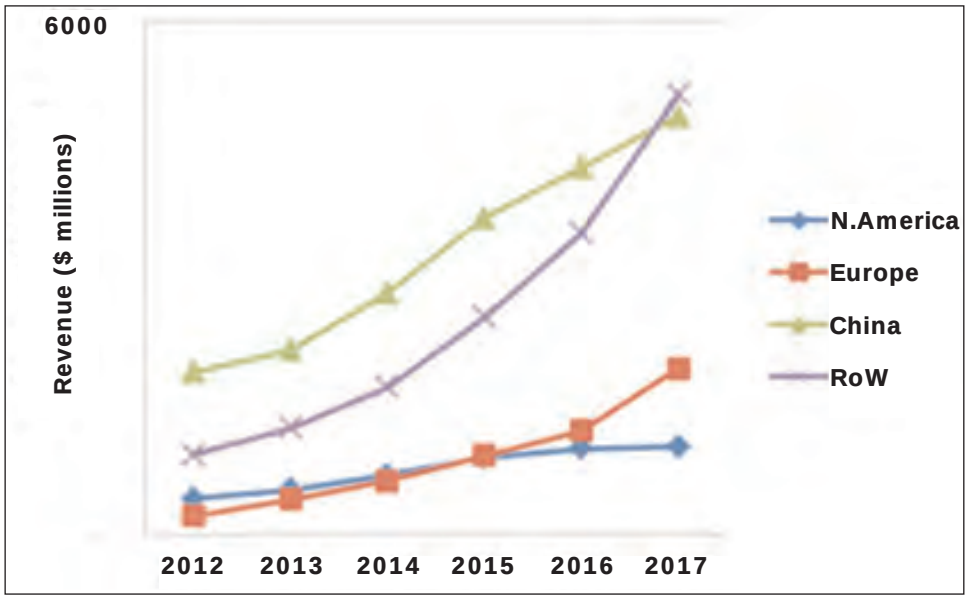
Lighting LED revenue to rise at 30% CAGR to $13bn by 2017

Revenue for LEDs in lighting applications (including both replacement lamps and luminaires) are expected to rise at a compound annual growth rate (CAGR) of 30% to $13bn by 2017, according to a report 'The Market for High-Brightness LEDs in Lighting Applications' from Strategies Unlimited.

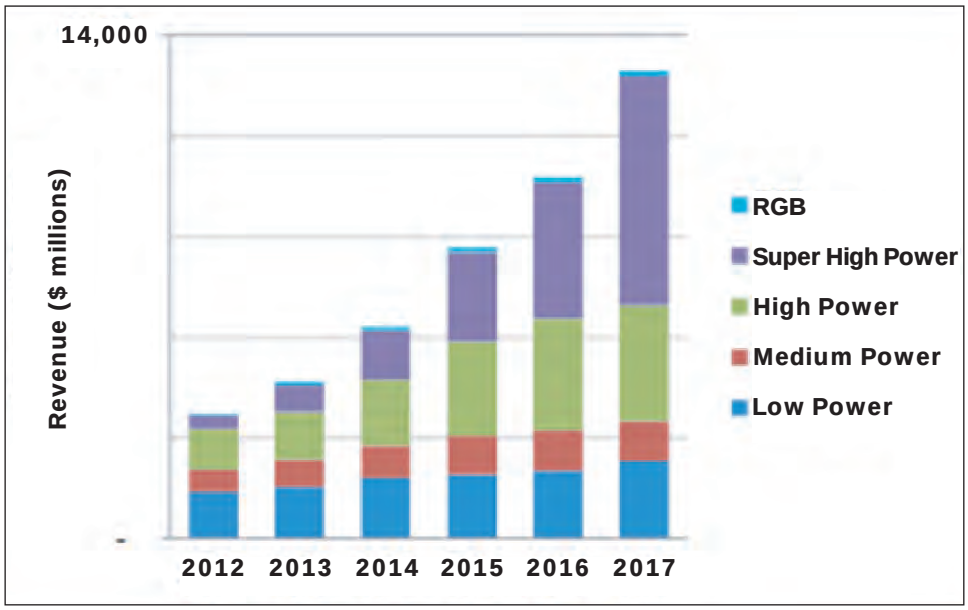
Over the last several years HB-LEDs have seen a precipitous fall in prices, which has helped to reduce the price of LED lamps and luminaires, but this decrease in prices has been slowing down in recent times, says the report. "Average selling prices (ASPs) of packaged LEDs are declining at a slower rate than previous years, as super-high-power LEDs increase in the market," says Philip Smallwood, research director of LEDs and Lighting at Strategies Unlimited. "While prices for all LEDs are decreasing, the increased penetration of these SHP LEDs (which have a higher price) is raising the overall ASP for all packaged LEDs." Super-high-power LEDs are predicted to be in 50% of LED lighting shipments in 2017.

Efficacy improvements are continuing to take place in the market as well, with the average efficacy of commercially available LEDs for lighting applications rising to more than 100 lumens per Watt for 1W packages while multi-chip arrays reached an efficacy of 200 lumens per Watt. LED efficacy is no longer the gating factor for LED applications — cost is, says the report. Lighting applications have seen a variety of different packages used over the last year, including arrays, high-CRI (color rendering index), tighter color bins, directional, multi-directional and high-voltage LEDs.

Strategies Unlimited reports that the growth rate for LED package units and revenue are both expected to be in double digits for the forecast period. "While growth in the market can be attributed to improvements in the technology and decreases in its price, the largest penetration increases seem to be coming from government mandates that either restrict incumbent lighting technologies or push the usage of LEDs," says Smallwood. "One of the largest impacts of these regulations will be seen in 2014 in the USA, as the implementation of the Energy and Independence Security Act of 2007 is phasing out 60 and 40W incandescent A-lamps," he adds.



Market growth for LEDs in lighting by major region.



The growing market share of super-high-power (>5W) LED packages in the coming years.

While prices for all LEDs are decreasing, the increased penetration of these SHP LEDs (which have a higher price) is raising the overall ASP for all packaged LEDs

www.strategies-u.com

LED lighting market to grow from $2bn to $25bn in 2023

Driven by superior features and falling costs, the market for LED luminaires, or optimized permanent light fixtures, will grow more than 12-fold over the next decade — at a compound annual growth rate (CAGR) of 25% from $2bn currently to $25bn in 2023, according to Lux Research.

The market research firm used historical trends as well as projected average price reductions to build a model that calculates the adoption rate of LEDs within each end-market application — office, industrial and street lighting. They found that recessed modular will emerge as the largest LED luminaire market, growing from $1.5bn in 2013 to $14.5bn in 2023 by replacing incumbents such as fluorescent.

"As LED packages rapidly fall in cost and improve in efficiency, the cost structure of LED luminaires will shift, and present opportunities in other components such as secondary optics and drivers," says Lux Research associate Christopher Hwang, lead author of the report 'Casting the Light: Illuminating the Opportunities in 2023's LED Luminaire Market' (part of the Lux Research Energy Electronics Intelligence service). "This trend, in turn, influences the rate of adoption of emerging technologies, such as alternating current (AC) LEDs and high-CRI [color rendering index] LEDs in recessed modular, high-bay and roadway luminaires," he adds.

Lux Research analysts examined the LED landscape in order to identify the largest opportunities within the luminaire market for investors, technology developers and component suppliers. Their findings include the following:

- Efficiencies will drive down LED package costs. LED package costs will fall over 80% to less than $4/klm due to improved efficiency, increased manufacturing yields and utilization. As a result, the bill of materials (BOM) of a standard 3500 lumen recessed modular luminaire will fall 35%, from $85 in 2013 to $55 in 2023.
- High-CRI LED will remain a niche product. AC LED-based luminaires will become cost competitive by 2018, but will provide a technology advantage only in low-power applications, such as recessed modular luminaires. In contrast, high-CRI luminaires will remain a niche product, with a 9% cost premium by 2023, finding adoption in high-occupancy applications.
- Optics market represents a huge opportunity. The LED package market will be dwarfed by opportunities in optics and drivers. The secondary optics market will be the biggest growth opportunity in components, growing to $6.9bn in 2023, while the drivers market will reach $4.9bn.

https://portal.luxresearchinc.com

Power discrete market to grow at 8.43% over 2013–2018

SiC & GaN to lead by 2018, driven by EV/HEV & industrial motor drives

The global market for power discrete devices will rise at a compound annual growth rate (CAGR) of 8.43% over 2013–2018, forecasts a new report from TechNavio (the market research platform of Infiniti Research Ltd).

According to the report, growth of the power discrete market is driven by several factors, including high demand for discrete silicon-based insulated-gate bipolar transistors (IGBTs). Discrete IGBTs enable increased efficiency in electronic devices ranging from consumer electronics to several high-power electronic applications, and they play a major role in the technical advancement of power electronics, says the market research firm .

In addition, silicon carbide (SiC) is currently widely used in the development of power semiconductors, including SiC MOSFETs, SiC JFETs, SiC BJTs, and SiC Schottky diodes. However, as a wide-bandgap material that offers similar performance benefits to SiC but has greater cost-reduction potential, the market for gallium nitride (GaN) power semiconductors is expected to grow rapidly in the coming years. In addition, GaN can be made available using existing silicon substrates, which can enable mass production and reduced cost.

Power semiconductors using next-generation materials such as SiC and GaN are characterized to have lower energy loss, high-speed switching, and higher heat resistance than conventionally used silicon. The adoption of SiC and GaN power semiconductors is hence expected to witness a significant increase, particularly in the electric vehicle/hybrid electric vehicle (EV/HEV) and industrial motor drive segments.

The report 'Global Power Discrete Market 2014-2018' states that demand for power discrete semiconductors is dependent on the growth of various application segments, including the EV/HEV, renewable energy, industrial motor drive, and LED lighting segments. In recent years, the industrial motor drive segment has been witnessing a slowdown because of several factors such as the sluggish economic recovery in the USA, the natural disasters occurring in Japan and the Eurozone debt crisis, notes TechNavio.

The report recognizes the following firms as the key players in the market: Fairchild Semiconductor International, Infineon Technologies, Mitsubishi Electric, STMicroelectronics and Toshiba. Other vendors mentioned in the report are Fuji Electric, International Rectifier, ON Semiconductor, Renesas Electronics and Vishay Intertechnology.

www.technavio.com

Wi-Fi drives Anadigics' 19% annual growth to $134.2m

Expense reduction plus improved product mix targets break-even at $33–34m per quarter

For full-year 2013, broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported revenue of $134.2m, up 19.2% on 2012's $112.6m. "We achieved this top-line performance by developing innovative new products, targeting growth markets, and by strengthening our customer relationship," says chairman & CEO Ron Michels.

Growth was driven by Wi-Fi rising roughly seven-fold from $5.1m in 2012 to $40.5m, while Cellular Wireless contracted by 11.5% to $74.2m (through reductions in CDMA) and Infrastructure fell by 17.5% to $19.5m (as CATV multi-service operator capital spending was deferred). The three greater-than-10% customers were Samsung, Huawei and Murata.

For fourth-quarter 2013, revenue was $36.3m, down 2% on $37m last quarter but up 19.1% on $30.5m a year ago. The year-on-year growth was driven by Wi-Fi revenue rising from $1.1m a year ago to $14.4m, up 44.5% on $10m last quarter. Infrastructure revenue was $5.2m, down 7% on $5.6m a year ago but up 30.8% on $4m last quarter. However, the quarter-to-quarter growth in Wi-Fi and Infrastructure was more than counteracted by Cellular Wireless revenue falling to $16.7m, down 27.6% on $23m last quarter and 29.5% on $23.7m a year ago. The sole greater-than-10% customer in Q4/2013 was Samsung.

The substantial sequential growth in both Wi-Fi and Infrastructure revenue strengthened the overall product mix in support of higher gross margin. On a non-GAAP basis, quarterly gross margin has risen from 2.5% a year ago and 11.9% last quarter to 15%, due to a more profitable product mix both across and within the three business units more than offsetting sequentially lower production. Capacity utilization has fallen from about 70% last quarter to 55%, as more production was moved to Anadigics' smaller-die (hence higher-margin) inter-level dielectric (ILD) process due to the efficiencies it offers. Exiting Q4, ILD is now Anadigics' dominant process and is rising in the mix. "I am very pleased by our fourth quarter results, which completes a year of consistent gross margin improvement," comments Michels.

Full-year operating expenses fell by 10.3% from $68.2m in 2012 to $62.4m in 2013, including R&D expenses falling 12% from $43.9m to $38.6m.

Full-year net loss has been cut from $62m to $44.7m, as quarterly net loss has been cut from $13.9m a year ago and $9.5m last quarter to $8.4m. EBITDA loss has been cut further, from $10.1m a year ago and $5.9m last quarter to $4.9m.

Capital investment was $6.5m for full-year 2013 (up from $2.8m in 2012 as the firm continues to ramp its ILD process), although this slowed from $1.7m in Q3 to $1.3m in Q4.

During the quarter, cash, cash equivalents and short-term marketable securities fell further, from $32m to $24.4m.

"Q4's sequential improvement in gross profit and EBITDA, despite slightly lower revenue, speaks to the operating leverage Anadigics has and the improvements we are making," says VP & chief financial officer Terry Gallagher.

However, due to significant seasonal and inventory-related softness in Cellular and Wi-Fi, for first-quarter 2014 Anadigics expects revenue to fall 34–37% sequentially. Despite this, a substantial reduction in cost structure —combined with greater efficiency and continued improvements in overall product cost and mix — should enable double-digit gross margin. Also, operating expenses should fall by 10%, establishing a lower expense baseline for 2014.

"Anadigics is committed to returning to profitability, which demands a cost structure that is better aligned to our business strategy and direction," says Gallagher. "We continue to see favorable adjustment in our product mix for 2014," he adds.

"This overall transition in our product mix is a critical component in returning the company to profitability," says Michels. "In our Wi-Fi group we are increasing the balance of revenue generated by high-power Wi-Fi power amplifiers for infrastructure applications, which bring richer margins than Wi-Fi and modules in mobile devices. In our Cellular Group, we continue to transition the portfolio and legacy to new products manufactured in our ILD process, which enriches margins as well. Lastly, revenue from our Infrastructure group — which typically has higher gross margin than the other two groups — is growing as a percentage of our total revenue. All three of these transitions contributed substantially to our profitability improvement in the fourth quarter and, more importantly, we anticipate this will continue to do the same looking into our model for 2014," he adds. "Another benefit of this healthy transition is that we have an opportunity to realign our cost structure and better match the new product mix," continues Michels.

"To sustain this forward momentum towards our EBITDA objectives, we have implemented efficiency and expense reduction initiatives that should provide annual savings of over $10m," notes Gallagher. "These savings were the result of two initiatives. First, as we entered 2014 we took efforts to further improve efficiencies in R&D and SG&A, yielding an expected annual savings of over $5.5m. This will help to drive a reduction of greater than 10% in

total R&D and SG&A in Q1 as compared to Q4," he expects. "For the second initiative we implemented a workforce reduction which will reduce our annual payroll related expense by roughly $4.5m. This will result in approximate $1.5m restructuring charge in the first quarter. In total, the anticipated annualized savings of greater than $10m aligns us to a level of operations appropriate to surplus our target revenues and continue toward our goal of reaching targeted EBITDA in the second half of 2015," Gallagher summarizes.

"Achieving these expense reduction — in combination with our improved product mix — should allow Anadigics to reach EBITDA break-even at a revenue per quarter of $33–34m... significantly lower than was modeled previously," comments Michels.

Anadigics expects capital investment to be largely insignificant in 2014, as manufacturing investments are effectively completed.

"Increasing mix of ILD and continued product efficiencies positions us with ample available capacity to support 2014 and beyond," reckons Gallagher.

"Wi-Fi, Cellular and Infrastructure solutions have strong design-win traction," says Michels. "With a sharp focus on new product introduction, product mix improvements and prudent expense management, we believe Anadigics is well positioned on our path to profitability."

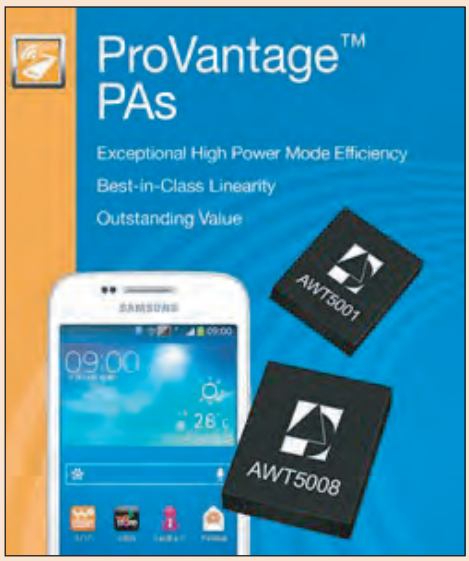
www.anadigics.com

Samsung selects ProVantage power amplifiers for GALAXY Trend 3

Anadigics is shipping production volumes of its AWT5001 and AWT5008 ProVantage power amplifiers (PAs) to Samsung Electronics for the new GALAXY Trend 3.

ProVantage solutions leverage Anadigics' exclusive InGaP-Plus technology to provide high performance, space-saving integration and lower overall system cost. Powered by ProVantage PAs, the GALAXY Trend 3 features a 4.3" display, dual-core 1.2GHz processor, and Android 4.2 Jelly Bean operating system.

"ProVantage solutions deliver outstanding value by providing a best-in-class combination of high power mode efficiency, linearity, and reduced system costs," claims Jerry Miller, senior VP of Cellular Products. "We continue to help Samsung bring to market a diverse set of mobile devices that target a wide range of segments," he adds.



Samsung GALAXY Trend 3 powered by ProVantage power amplifiers.

Anadigics' ProVantage power amplifiers help extend battery life by offering three selectable bias modes that optimize efficiency for low, medium and high output power levels, as well as a shutdown mode with low leakage current. The 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. ProVantage power amplifiers also provide what is claimed to be best-in-class linearity to ensure stable 3G and 4G cellular connectivity and high data throughput.

The complete family of ProVantage solutions are offered in compact 3mm x 3mm x 0.9mm packages and feature internal voltage regulation and integrated DC blocks on the RF ports to reduce requirements on valuable PCB space. RF matching is optimized for output power, efficiency, and linearity in a 50Ω system.

Anadigics appoints Alltek as Asia-Pacific distributor

Anadigics Inc of Warren, NJ, USA has expanded its sales presence by appointing Alltek Technology as a distributor for the Asia-Pacific region.

Specializing in communications component distribution, Alltek leverages sales and applications teams located near major design and manufacturing centers in Asia to provide support throughout the design, sales and production phases. Alltek will represent Anadigics' complete line of WiFi, cellular and Infrastructure products in China, Taiwan, Hong Kong and Singapore.

"As a leading distributor in Asia focused on communications components, we offer valued-added services to a wide array of OEMs, ODMs and manufacturers," says Alltek's president Y.T. Wu.

"The addition of Alltek to Anadigics' network of direct sales, manufacturers' representatives and distribution partners strengthens our ability to provide flexible and responsive service to our customers," comments Michael Canonico, senior VP of worldwide sales at Anadigics. "Alltek's strong industry relationships and communications semiconductor expertise will expand our reach and enable growth in critical Asia-Pacific markets."

www.alltek.com

RFMD and TriQuint to merge, creating $2bn firm

Combined firm targets $150m in cost synergies

RF Micro Devices Inc of Greensboro, NC, USA and RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA have agreed to merge in an all-stock transaction. The new company will have a new name and shared leadership team. The boards of directors of both firms have unanimously approved the transaction.

The merger combines complementary product portfolios — featuring power amplifiers (PAs), power management integrated circuits (PMICs), antenna control solutions, switch-based products and premium filters — and leverages these to deliver what is claimed to be the industry's most comprehensive portfolio of high-performance mobile solutions. It is also reckoned that it will strengthen the combined firms' service to the infrastructure and defense/aerospace industries and enable gallium nitride (GaN) solutions for additional markets and applications.

The merger is expected to create new growth opportunities in three large global markets — mobile devices, network infrastructure and aerospace/defense — with scale advantages, innovative new products and a greatly improved operating model. RFMD and TriQuint reckon that, together, they will offer the industry's broadest portfolio of critical enabling technologies to develop and commercialize tightly integrated solutions. The combination is also expected to foster a new wave of mobile devices that are broadly accessible and offer dramatically higher data throughput. The merger also creates a supplier in infrastructure & defense with about $500m in annual revenue, with a portfolio of products and foundry services supporting applications including radar, next-generation base-stations, optical communications, and the Internet of Things.

TriQuint's total revenue in Q4/2013 was $267.7m, and full-year 2013 revenue was $892.9m. RFMD's December-quarter revenue was $288.5m, while its revenue for full calendar 2013 was $1.17bn.

TriQuint shareholders will receive 1.675 shares of the new firm and RFMD shareholders will receive 1 share of the new firm for each TriQuint or RFMD share held. At the closing of the transaction, the firms will execute a one-for-four reverse stock split, resulting in about 145 million shares outstanding. Former shareholders of RFMD and TriQuint will each own about 50% of the new firm post-merger. The transaction represents an implied price of $9.73 for each TriQuint share, representing a 5.4% premium based on the closing price of $9.23 for TriQuint on 21 February.

The new firm will have a shared leadership team. TriQuint's CEO Ralph Quinsey will serve as non-executive chairman, and RFMD's CEO & president Bob Bruggeworth will serve as chief executive officer. The board of directors will comprise ten directors (five from the existing board of each company). Eight of the ten directors will be independent. TriQuint's chief financial officer Steve Buhaly will be CFO and RFMD's CFO Dean Priddy will be executive VP of administration, reporting to the CEO and responsible for integration and synergy value creation. Additional senior leaders of the combined firm will include RFMD's Eric Creviston as president of Mobile Products, TriQuint's James Klein as president of Infrastructure and Defense Products, TriQuint's Steven Grant as corporate VP for Fab Technology & Manufacturing and RFMD's Jim Stilson as corporate VP for Assembly/Test Technology & Manufacturing. Other leaders will be named later this year.

TriQuint's CEO Ralph Quinsey will serve as non-executive chairman, and RFMD's CEO & president Bob Bruggeworth will serve as CEO

"The world's demand for mobile data is growing exponentially," notes Bruggeworth. "The combination of TriQuint and RFMD creates a new leader in RF solutions with expertise in mobile devices and complex infrastructure and global defense applications. With this merger of equals, we will bring under one roof all of the critical RF building blocks necessary to innovate at the heart of what makes mobile mobile — the crucial back-and-forth data flow between the mobile device and the network. We will harness this innovation for the benefit of all our customers — from mobile to infrastructure to defense," he adds.

"Through this combination of RFMD and TriQuint, we form a diversified market leader with a highly compatible combination of products and technologies and a world-class team focused on innovation and superior financial results," believes Quinsey. "The alignment of culture between the two companies and the well matched products, capabilities and technologies will create compelling new opportunities."

The merger is expected to achieve at least $150m in cost synergies ($75m in annualized synergies exiting the first year after closing and an additional $75m exiting the second year). The transaction is expected to be accretive to non-GAAP earnings per share (EPS) in the first full fiscal year following the closing of the transaction.

The merger is expected to close in second-half 2014, subject to approval by shareholders of both firms, the receipt of regulatory approvals, and other customary closing conditions.

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TriQuint grows 7% in Q4, led by 21% rebound in Networks infrastructure

Premium discrete filter revenue grows 52% in 2013, as transition from lower-margin amplifiers and transmit modules drives cut in gallium arsenide capacity

For fourth-quarter 2013, RF front-end component maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported record revenue of $267.7m, up 15% on $233.6m a year ago (driven by 26% growth in mobile devices) and up 7% on $250.8m last quarter (led by a strong rebound in Networks infrastructure, growing 21%, while Mobile Devices grew 5% and Defense & Aerospace fell 2%).

End-market revenue split was 71% Mobile Devices (down from 72% last quarter), 18% Network Infrastructure (up from 16%), and 11% Defense & Aerospace (down slightly from 12%).

Subcontract assembly firm Foxconn Technology Group was TriQuint's sole customer accounting for more than 10% of total revenue, rising from 35% last quarter to 44%.

Total full-year revenue was $892.9m, up 8% on 2012 due to an increase in Mobile Devices and Defense & Aerospace revenue. Defense & Aerospace revenue rose 50%, with a record number of new products released (among the 190 that TriQuint launched in total during 2013). In Mobile Device, for the second-half in particular, revenue was a record $371m, up 66% on first-half 2013. Premium discrete filter revenue grew 52% to over $90m for full-year 2013. Excluding about $15.5m from the now discontinued non-strategic foundry business, Networks revenue rose just 5% in 2013, but base-station revenue in particular grew 50% (supporting the TD-LTE build-out in China).

"We have been investing in higher-value products including discrete filters, primarily BAW [bulk acoustic wave] and TC-SAW [temperature-compensated surface acoustic wave], MMPA [multi-mode power amplifier] and integrated PA duplexer modules," says president & CEO Ralph Quinsey. "These products are designed to support the growing demand for LTE devices. At the same time we've been reducing our revenue from lower-margin products including commodity power amplifiers and transmit modules. Sales of our high-volume products grew 36% in 2013 due to growing demand for premium filters and high-performance broadband amplifiers — growing much faster than the overall market," he adds. "Offsetting this growth, revenue from lower-margin amplifiers and transmit modules declined 25% in 2013, which represents a major product transition for the company that has lifted gross profit much faster than revenue in 2013, a trend that we expect will continue in 2014."

"In Q4, responding to changes in industry demand, we reduced our overall GaAs capacity [the main cause of a non-recurring charge of $27.1m: $3.9m of cash and $23.2m for asset impairment], resulting in lower cost and better alignment to market requirements," continues Quinsey. "The success of broadband amplifiers which replaced multiple discrete power amplifiers, combined with the growth of SOI switches, has contributed to GaAs capacity concerns."

"By refocusing the company at higher-value products, reducing unused capacity and tightly managing our overall spending, we saw significantly improved financial results and a seasonally strong second half of 2013 compared to the first half," explains Quinsey.

On a non-GAAP basis, gross margin was 37.2% in Q4, down from 38% last quarter but up from 31.7% a year ago (and above the expected 35-36%) due to the higher revenue, cost control and improved mix. Full-year gross margin was 33.2%, up from 30.7% in 2012.

Net income was $26.4m ($0.16 per diluted share, above the $0.12–0.14 guidance), up slightly from $26.3m ($0.16 per diluted share) last quarter and $6.2m ($0.04 per diluted share) a year ago. Net income for full-year 2013 was $14.5m ($0.09 per diluted share), compared with a loss of $2.2m ($0.01 per diluted share) a year ago. Capital expenditure has dropped from $20.8m last quarter (which was primarily for premium filter products) to $9m in Q4.

During the fourth quarter, total cash and investments rose by $52.1m to $79m, and TriQuint closed the year with no debt. The board of directors has increased the firm's authorization to repurchase its stock from the existing balance of $24m to $75m.

For first-quarter 2014, TriQuint expects revenue to fall to $170–180m, due to seasonality and lower demand from a major customer in Mobile Devices that is undergoing short-term inventory corrections. "We expect stronger-than-seasonal demand for most other major customers in Q1, including Samsung, Huawei and ZTE, driven by ramping future demand in the roll-out of TD-LTE infrastructure in China [with Chinese carriers estimated to roll out over 400,000 4G base-stations by the end of 2014]," says Quinsey. "TriQuint has strong relationships with equipment suppliers supporting these LTE deployments, including Huawei, ZTE, Alcatel-Lucent, Ericsson and others. We are fore-

casting sustained demand over the next several quarters to support this infrastructure build-up."

However, due to the lower revenue and utilization, in Q1 gross margin is expected to fall to 28–30%. Net loss per share is expected to be $0.11–0.13. Nevertheless, excluding any share repurchases, cash should still grow by $70m to about $150m.

For full-year 2014 TriQuint expects revenue growth in the mid single digits as strong growth in high-value premium filters (both BAW and TC-SAW) — with over $200m from discrete filters, driving Mobile Devices revenue growth of about 20% — is partially offset by significant reductions in revenue from lower-margin amplifiers (commodity mobile) and non-strategic foundry revenue (which is not expected to be material going forward). Revenue seasonality should be roughly similar to 2013, with about 40% of revenue coming in the first half of the year.

Excluding Q1, gross margins are expected to average 40% for the subsequent three quarters of 2014. For full-year 2014, margin should grow about 500 basis points from 2013 due to increasing handset filter content, strong base-station demand and cost reductions in operations.

To further optimize the firm's GaAs footprint, TriQuint is transitioning its Texas GaAs line (which supports mainly high-performance products for the infrastructure and defense markets) from 4" to 6" in order to improve yield, throughput and cost. "We completed our first 6" wafers for GaAs enhanced on this hybrid line in 2013 and we expect 6" revenue in this line to begin in Q1, with customer transitions continuing into the 2016 timeframe," says Quinsey.

Capital expenditure may fall from $87m in 2013 to $70m for 2014. "In 2014, I see continued product mix improvement with solid gross margin gains complemented by tightly managed overall spend," says Quinsey. "Market trends such as smartphone growth, expanding 4G infrastructure, and the dramatic increase in data traffic have aligned customer needs with our high-value solutions. As a result, we anticipate significant year-over-year improvement in profitability, with favorable same-quarter comparisons to each period throughout the year." The firm believes earnings per share will meet or beat the $0.49 analyst consensus.

TriQuint expects premium filter markets to reach about $2bn in 2016, doubling over 2013. "In preparation, we have invested in filter capacity, doubled our filter R&D team, and accelerated the development of filter-based products, both integrated and discrete," notes Quinsey. "Our BAW filter are currently being designed in, with ramping forecast from multiple customers including Samsung, Huawei, ZTE, LGE and Sony," he adds.

"Additionally, we are seeing good design interaction in Asia for our MMPA family. This traction is with handset customers directly and with chipset partners on reference design platforms," says Quinsey. "While some customers already embrace highly integrated solution, much of the market - including most of China — is still in the early stages of transition from discrete to more integrated solutions," he adds.

"Our strategy is to use our strength in premium discrete filters and broadband MMPAs to leverage future integrated opportunities [capitalizing on the move towards LTE in mobile devices]," summarizes Quinsey. "Recognizing we had excess GaAs capacity, we have already taken steps to reduce our cost structure and plan on taking further actions to enhance profit, while maintaining our ability to design world-class GaAs power amplifiers."

www.triquint.com

TriQuint launches three MMPAs with envelope tracking

TriQuint has launched three new multi-mode, multi-band power amplifier modules (MMPAs), targeted at delivering longer battery life for LTE smartphones while simplifying increasingly complex RF design. The versatile new products, which are already capturing design wins in leading LTE smartphones, feature new envelope tracking technology as well as a new mobile chip interface.

"Building on the success of TriQuint's highly integrated TRIUMF MMPAs, our three newest products add more LTE bands to cover more regional markets, as well as support for power-saving envelope tracking and a versatile new MIPI interface," says Sean Riley, VP of Mobile Products.

Device makers are adopting envelope tracking (ET) in next-generation smartphones to maximize energy efficiency. ET extends battery life by dynamically adjusting the supply voltage to the power amplifier (PA), unlike PAs with conventional constant-supply voltage.

Also, TriQuint's new 5mm x 7mm MMPAs feature a new mobile chip interface — based on an open 'MIPI' standard — used by several chipset providers to increase interoperability among vendors and reduce development time and effort.

As well as designing increasingly sophisticated devices, smartphone makers serving the global market must produce several regional variants of each model to operate in carriers' specific assigned spectrum, notes TriQuint. This is becoming more challenging as numerous new LTE bands are allocated. TriQuint says that the versatile design of its new MMPAs gives manufacturers a common platform to release new products at a faster pace, while controlling design and manufacturing costs. The new TRIUMF multi-mode, multi-band PA modules support a growing number of popular 3G/4G bands for specific regions, i.e. hexa-band W/CDMA/HSPA+/LTE, as well as quad-band GSM/EDGE.

RFMD's sales hit by weakness at two largest customers

Gross margin grows from 36.2% last quarter to 39.7%

For its fiscal third-quarter 2014 (ended 28 December 2013), RF Micro Devices Inc of Greensboro, NC, USA has reported revenue of $288.5m. This up 6.4% on $271.2m a year ago (due mainly to dollar content increases in smartphones) but down 7.1% on last quarter's record $310.7m (rather than the expected "flat to up 5% sequentially").

"We saw gradual erosion in order activity and customer pulls fell short of their forecasts," says president & CEO Bob Bruggeworth. "The reductions in demand were primarily related to the very low end in China, where RFMD has the majority share, as well as progressive weakening throughout the quarter related to our two largest customers."

Cellular Products Group (CPG) revenue was $238.7m, up 7.2% on $222.6m a year ago but down 6.6% on $255.4m last quarter. CPG revenue is now 80% 3G/4G and under 20% 2G.

Multi-Market Products Group (MPG) revenue was $49.8m, up 2.6% on $48.6m a year ago (with growth across multiple markets, including high-performance Wi-Fi, CATV networking, and wireless infrastructure) but down 9.8% on $55.2m last quarter.

Despite the drop in total revenue, RFMD delivered record gross profit. On a non-GAAP basis, gross margin has risen from 35.5% a year ago and 36.2% last quarter to as much as 39.7% (despite the quarter normally being seasonally down). Representing 530 basis points of margin expansion since three quarters ago, this is one quarter ahead of RFMD's targeted margin improvement of 300–400 basis points by the end of the March 2014 quarter. "This is the direct result of our intense focus on cost reduction and our ongoing efforts in support of multiple gross margin expansion initiatives," says chief financial officer Dean Priddy.

"To achieve our margin targets we've implemented a flexible sourcing strategy that is reducing our GaAs and silicon costs, and we've added assembly capabilities that have reduced our packaging costs," Bruggeworth continues. "We are reducing our usage of precious metals in our manufacturing processes and leveraging our new higher-unit volumes across our supply chain to reduce costs," he adds.

"RFMD's flexible sourcing strategy is providing multiple points of benefit," says Priddy. "Over the past few years we have reduced our manufacturing footprint and our fixed asset base significantly. We sold our MBE [molecular beam epitaxy] facility and our gallium arsenide fab in the UK [in Newton Aycliffe] and we've expanded our external sources of supply. We're better able to balance internal and external resources with fluctuations in demand, and this supports a more predictable margin profile. The combined capabilities of our GaAs fab and our external foundries satisfy the full breadth of our customers' performance, size, and cost requirements," he adds.

"Second, we have installed and qualified additional assembly capacity in our Beijing facility. We're seeing a margin lift today as we reduce our reliance on external suppliers, and we'll get an additional lift as our internal assets are fully loaded," continues Priddy.

Reductions in demand were primarily related to the very low end in China, where RFMD has the majority share

"Third, we're seeing continued adoption of our ultra-low-cost CMOS power amplifiers in next-generation handset platforms for emerging markets. We've seen an initial lift in margin as many smaller customers have migrated and we anticipate further margin expansion as our largest customer for CMOS PAs migrates to our ultra-low-cost product. We also anticipate a benefit as we commence shipments to an additional tier-one customer," he adds.

"These are structural changes in various stages of implementation that target fixed and variable costs. They will impact margins favorably in the March quarter and beyond."

In fiscal Q3/2014, operating expenses have fallen slightly from $75.1m last quarter to $74.6m. Of this general & administrative (G&A) has been cut from $12m to $10.7m and sales & marketing from $16,2m to $15.9m while R&D has grown from $47m to $48m.

Operating income has risen from $26.8m a year ago (an operating margin of 10% of sales) and $37.2m last quarter (12% of sales) to $40m (13.9% of sales). Net income has risen from $21.3m ($0.08 per diluted share) a year ago and $33.9m ($0.12 per diluted share) last quarter to $36.4m ($0.13 per diluted share, achieving the target, "reflecting the changes we've incorporated into our operating model", says Bruggeworth).

Net cash provided by operating activities has risen from $21.5m last quarter to $70.4m. Capital expenditure was $15.6m (down from $16.7m). Consequently, free cash flow was $54.8m. Cash, cash equivalents and short-term investments hence rose from $149.5m to $205.5m. During the quarter RFMD repurchased about 200,000 shares of stock at an average price of $4.99.

Capital expenditure included investments in assembly equipment to reduce usage of precious metals. RFMD also made a multi-million dollar investment to secure bulk acoustic wave (BAW) filter capacity and now has preferred access to surface acoustic wave (SAW), temperature-compensated (TC)-SAW and BAW filter capacity from multiple sources.

During fiscal third-quarter 2014, CPG launched a broad family of envelop tracking (ET)-capable RF solutions in support of multiple next-generation smartphones featuring 4G LTE baseband. CPG also experienced strong design activity for its antenna control solutions for leading smartphones and tablets. Meanwhile, MPG secured a major contract funding gallium nitride (GaN) process transfer and development.

"RFMD is executing on multiple opportunities to increase our dollar content generation-over-generation in the world's leading smartphones and tablets while materially enhancing our operating model," says Bruggeworth. "In the March quarter, we anticipate another quarter of margin expansion and year-over-year improvements in operating income and earnings per share."

For fiscal fourth-quarter 2014 (to end-March), although RFMD expects sequential drops in revenue to $250–260m and earnings per share to $0.09–0.10, EPS will be up year-on-year from $0.08 a year ago. Gross margin should rise further, to 40%.

"We expect MPG to grow sequentially in the March quarter and in CPG we're forecasting growth at one top-tier customer and many mid-tier customers and across our China-based entry-tier customers," says Priddy. "In fact, if not for a substantial sequential decline at one large customer, we believe RFMD's revenue would be growing sequentially," he notes.

"Customer order activity is strengthening," says Bruggeworth. "Our confidence in our financial performance is tied closely to ongoing design-win activity related to the industry's marquee smartphones and tablets, for which volume ramps will begin in the spring, accelerate in the September quarter and continue into the December quarter," he adds.

"While the launch of marquee smartphones and tablets is weighted toward the back-half of this calendar year, our visibility into design-win activity gives us confidence," continues Bruggeworth. "We are forecasting annual revenue growth of approximately 10%, supported by multiple growth drivers. RFMD's underlying markets continue to expand, driven by global macro trends like the Internet of Things, which can be viewed as a massive, overarching movement comprising multiple high-growth trends including embedded connectivity, connected home, automotive WiFi, and wearable technologies," he adds.

We expect MPG to grow sequentially in the March quarter and in CPG we're forecasting growth at one top-tier customer and many mid-tier customers and across our China-based entry-tier customers

"To accommodate the increasing requirements for always-on broadband data, the top tiers of our market are adopting new technologies like envelope tracking, carrier aggregation and transmit MIMO that increase our dollar content opportunities. The carriers are deploying TD-LTE and LTE Advanced as well as driving more LTE content in mid-tier smartphones, while in developing geographies consumers are continuing to migrate from 2G voice phones to high-dollar-content 3G entry smartphones," says Bruggeworth. "We are also capturing incremental content in new and expanding categories like antenna control solutions, power management circuits, diversity switches and a variety of new products integrating filters and duplexes."

For the coming fiscal year, RFMD expects gross margin of greater than 40%, expanding operating margin, and significant EPS growth. "Our organization has identified over 75 initiatives to continue improving gross margin, and we are executing on these initiatives today," says Priddy. "We are targeting industry-leading gross margin, with more predictability and less volatility in our operating results," he adds.

"With this, RFMD expects to deliver robust growth in operating income along with return on invested capital (ROIC) well above our cost of capital," concludes Bruggeworth.

www.rfmd.com

RFMD earns Samsung Quality Grand Award as best quality supplier

In a ceremony at Samsung Electronics' smartphone manufacturing operations in Gumi, South Korea, the firm has presented RF Micro Devices Inc of Greensboro, NC, USA with its Quality Grand Award. The award recognizes "superior execution in product quality and customer satisfaction" and was presented to RFMD on behalf of its Cellular Products Group (CPG) team. RFMD was selected as the best quality supplier among Samsung Mobile's approximately 450 global suppliers.

RFMD is a key supplier to Samsung Electronics, providing a full and growing suite of RF solutions that enable the critical wireless link.

"This award is testament to our global team's ability to execute to the highest standards of quality, as recognized by the world's number one provider of mobile devices," says RFMD's president & CEO Bob Bruggeworth. "This underscores RFMD's ability to provide outstanding quality and service while delivering in very high volumes to support the successful rollout of Samsung's newest mobile products," he adds.

www.samsung.com

Skyworks grows more-than-expected 6% to $505m

For fiscal first-quarter 2014 (to 27 December 2013), Skyworks Solutions Inc of Woburn, MA, USA (which makes analog and mixed-signal semiconductors) has reported revenue of $505.2m, up 11% on $453.7m a year ago and 6% on $477m last quarter (above the forecast of 4.8% growth to $500m). The 10%-customers were Foxconn and Samsung.

As well as ramping SkyOne at HTC and Samsung, launching envelope tracking solutions within multiple 4G platforms, and unveiling a suite of antenna switch modules with dual-mode MIPI capability, highlights of the quarter listed by Skyworks include: capturing navigational-assist content with Volkswagen across next-year models; supporting the energy-efficient, intelligent thermostats and smoke detectors of Nest (recently acquired by Google); commencing volume production of wireless home lighting platforms at Belkin; enabling wearable technologies at Philips for emerging medical applications; securing key sockets within FitBits smart scale and connected wristband systems; leveraging 802.11ac solutions in gaming consoles, set-top boxes, BluRay players and LED/4K TVs for enhanced video streaming applications; introducing 4G-LTE base-station RF subsystems at Ericsson; and shipping LED backlight drivers to a leading smartphone and tablet OEM.

"Fueling our success is the proliferation of connectivity in all of its forms across a broad array of end markets and applications," says CEO & president David J. Aldrich. "This powerful underlying global trend — combined with our growing analog portfolio, expanding broad market opportunities and consistent execution — all translate into superior ongoing financial results," he adds.

On a non-GAAP basis, gross margin has risen further, from 43% a year ago and 44.4% last quarter to 44.5%.

Operating expenses rose from $81.5m last quarter to $82.9m. "All of that increase was in R&D [up from $49.2m to $50.8m]... reflective of some critical investments that we're making in R&D teams to support our continued focus and ability to grow in some of these new vertical markets," says chief financial officer Donald W. Palette.

Despite this, operating income has risen further, from $114.8m (operating margin of 25.3% of revenue) a year ago and $130.3m (margin of 27.3%) last quarter to $141.8m (margin of 28.1%, slightly above the expected 28%). Net income has hence risen further, from $106.6m ($0.55 per share) a year ago and $121.2m ($0.64 per share) last quarter to $127.7m ($0.67 per share, $0.01 better than guidance).

Skyworks generated $159m in cash flow from operations. Capital expenditure was $16m (down from $38m last quarter). During the quarter, cash reserves rose from $511m to $648.6m.

Skyworks also repurchased about 670,000 shares of common stock (representing a $17m investment). Over the last five quarters, the firm has spent about $190m on share buybacks. "We still have over $200m approved by the board of share buybacks. You balance that with maintaining the financial flexibility for strategic growth initiatives," says Palette. "Given our confidence in our business outlook, we continue to believe that repurchasing shares of common stock represents a highly attractive use of our cash," he adds.

"We exceeded guidance and delivered strong performance across all key financial and operational metrics," says Aldrich. "We are capitalizing on unprecedented demand for wireless ubiquity and the Internet of Things. Specifically, Skyworks is empowering connectivity across a number of strategic applications including medical devices, wearable technologies, home automation and hybrid vehicles as well as smartphones and tablets, linking people, places and things to improve the way the world communicates," he adds.

"Skyworks is substantially outpacing the analog semiconductor industry, driven by our broadening market footprint and new product launches."

For fiscal second-quarter 2014, Skyworks expects revenue to be up 11% year-on-year at about $470m ("significantly better than normal seasonality"). Gross margin should be 44–44.5%. With operating expenses rising further to $83.5m, diluted earnings per share should be $0.59 (up 23% year-on-year, the fourth consecutive quarter of over 20% year-on-year earnings growth). "EPS for the first half of 2014, as measured by our first-quarter reported results and second-quarter guidance, is 2.5x the EPS we reported for the first half of 2010, representing a 25% compounded growth rate over that 4-year period," notes Aldrich.

"While March is normally a slower seasonal quarter for the industry, our increasing market diversification and new product ramps are enabling Skyworks to largely offset normal mobile seasonality," notes Aldrich. "We are seeing strength from our expanding portfolio for the networked home, connectivity solutions in the emerging markets, key vertical market opportunities and our ramp of integrated systems solutions like SkyOne. These drivers are helping to mute seasonal trends at some of our OEM customers. This is a clear testament to our diversification."

Capital expenditure should be "something slightly above our depreciation level for now for the last three quarters of the fiscal year," says Palette. "We continue to see opportunities for sustainable margin expansion, as we leverage our capital investments and benefit from growing demand for our margin-enhancing integrated custom solutions and precision analog products," he adds. "We are within striking distance of achieving our mid-term business model of 30% operating margin [requiring about $550m in quarterly revenue], which generates around $3 in annualized earnings per share."

www.skyworksinc.com

Skyworks secures hi-rel designs with aerospace & defense firms

Analog semiconductor maker Skyworks Solutions Inc of Woburn, MA, USA says that is has captured high-reliability (hi-rel) and commercial-off-the-shelf (COTS) sockets with several aerospace and defense suppliers such as Cobham, EADS, Herley and Teledyne.

The firm's products are being leveraged for microwave switching, attenuation, receiver protection and mixer and detector applications in commercial and military radios, avionics systems, software-defined radios and navigation platforms that support major tier-one aerospace and defense companies such as Boeing, L-3 Communications, Northrup Grumman and Raytheon.

"Skyworks is gaining content across a number of hi-rel applications with our diverse product portfolio," says David Stasey, VP & general manager of analog solutions. "Our solutions are ideal for the rapidly growing aerospace and defense industry where customers are seeking effective, efficient and reliable military communication systems that deliver robust, wide-ranging and real-time data and services," he claims.

According to a December report '2013 Semiconductors in Military and Aerospace Electronics' from analyst firm Global Information, the market will grow to over $3bn worldwide in four years. In addition, the fastest adoption rate for solutions in the military/aerospace market will come from COTS platforms, which is forecast to grow at a compounded annual growth rate (CAGR) of 6% over the next five years. This long-term market trend is based on the industry's greater focus on reliability, shorter business cycles and the ability to operate within budget constraints, the report adds.

Skyworks details its analog solutions as follows:

- Gallium arsenide (GaAs) digital attenuators, PIN diode voltage variable attenuators (VVAs) and silicon fixed attenuator pads for infrastructure, test & measurement and other high-performance microwave applications up to 40GHz leverage Skyworks' design knowledge, technology, and manufacturing expertise.
- Low-noise amplifiers (LNAs) meet the needs of cellular infrastructure, WLAN, WiMAX, ISM (industrial, scientific and medical), and all applications requiring LNAs from DC to 6GHz.
- Through Isolink, Skyworks manufactures high-performance miniature hybrids and hermetically sealed devices. Isolink pioneered the miniaturization of advanced optoelectronic components, claims Skyworks, enabling it to manufacture products achieving high isolation voltages, high common mode rejection and radiation tolerance for high-demand environments.
- Skyworks' power management devices include highly complementary analog semiconductor products such as battery chargers, DC/DC converters, voltage regulators and LED drivers.
- Skyworks' diode product range includes PIN, Schottky, varactor and limiter diodes for microwave applications including WLAN, infrastructure, handset, SatCom (LNB/DBS-CATV), automotive, military, test and measurement, metering, medical and RFID (radio-frequency identification).

The fastest adoption rate for solutions in the military/aerospace market will come from COTS platforms, which is forecast to grow at a compounded annual growth rate of 6% over the next five years

www.skyworksinc.com

Skyworks front-end modules, low-noise amplifiers and analog solutions powering leading gaming platforms

Analog semiconductor maker Skyworks Solutions Inc of Woburn, MA, USA says that its front-end modules (FEMs), low-noise amplifiers (LNAs), switches and power detectors are being utilized across the world's foremost gaming platforms such as the Sony PlayStation, Nintendo Wii and Microsoft Xbox. Skyworks has been delivering RF solutions across nearly all gaming platforms for several generations.

"This is yet another example of Skyworks' ability to capitalize on the unprecedented demand for wireless ubiquity across the Internet of Things, with online gaming platforms becoming an increasingly popular form of network access," says Liam K. Griffin, executive VP & corporate general manager.

According to market research firm Gartner's report 'Forecast: Video Game Ecosystem, Worldwide 4Q13', the worldwide video game marketplace (which includes video game console hardware and software, online mobile and PC games) is forecasted to grow from $79bn in 2012 to $111bn by 2015. Sales of existing console hardware alone are forecast to grow from $15.9bn in 2013 to $22.7bn in 2015. Also, IDC Research reports that the number of online console gamers around the globe is on pace to exceed 165 million by 2017. As a result, IDC states that the opportunity to sell these gamers digital assets through Wii U, Xbox One and PS4 online storefronts will grow substantially in the next several years.

IHP and Georgia Tech demo fastest silicon-based device

SiGe heterojunction bipolar transistor operated at 798GHz f_{MAX}; room-temperature performance not far off

A research collaboration between the German government-funded research center IHP-Innovations for High Performance Microelectronics in Frankfurt (Oder) and the USA's Georgia Institute of Technology has demonstrated what is claimed to be the fastest silicon-based device to date: a silicon-germanium (SiGe) transistor operated at 798GHz f_{MAX} (P.S Chakraborty et al, IEEE Electron Device Letters, February issue; DOI 10.1109/LED.2013.2295214). This exceeds the previous record for SiGe chips by about 200GHz.

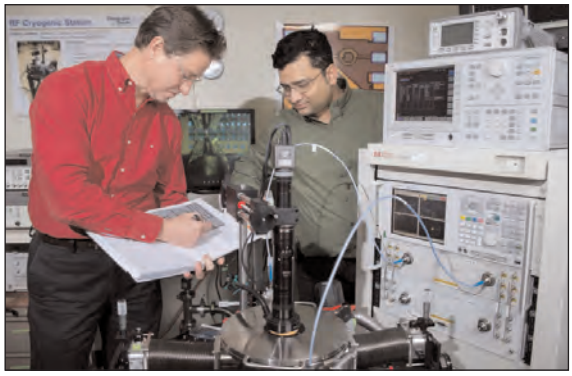
Although the record speed was achieved at an extremely cold temperature of 4.3K, the research suggests that record speeds at room temperature are not far off, says professor John D. Cressler, who led the research for Georgia Tech.

"The transistor we tested was a conservative design, and the results indicate that there is significant potential to achieve similar speeds at room temperature – which would enable potentially world-changing progress in high-data-rate wireless and wired communications, as well as signal processing, imaging, sensing and radar applications," believes Cressler, who holds the Schlumberger Chair in electronics in Georgia Tech's School of Electrical and Computer Engineering. "These results also indicate that the goal of breaking the so-called 'terahertz barrier' — meaning, achieving terahertz speeds in a robust and manufacturable silicon-germanium transistor — is within reach," he adds.

Cressler says that the tested transistor itself could be practical as-is for certain cold-temperature applications. In particular, it could be used in its present form for demanding electronics applications in outer space, where temperatures can be extremely low.

IHP designed and fabricated the heterojunction bipolar transistor (HBT) from nanoscale SiGe alloy embedded within a silicon transistor. Cressler and his Georgia Tech team, including graduate students Partha S. Chakraborty, Adilson Cordoso and Brian R. Wier, performed the work of analyzing, testing and evaluating it.

SiGe chips and measurement probes inside cryogenic probe station in Georgia Tech lab. (Georgia Tech; photo, Rob Felt.)



Professor John Cressler (left) and graduate student Partha Chakraborty confer at a cryogenic probe station at Georgia Tech. (Georgia Tech Photo: Rob Felt)

"The record low-temperature results show the potential for further increasing the transistor speed toward terahertz (THz) at room temperature," says Bernd Tillack, who is leading the technology department at IHP. "This could help enable applications of Si-based technologies in areas in which compound semiconductor technologies are dominant today," he adds. "At IHP, B. Heinemann, H. Rücker, and A. Fox — supported by the whole technology team — are working to develop the next THz transistor generation."

Silicon cannot compete with other materials regarding the extremely high performance needed for certain types of emerging wireless and wired communications, signal processing, radar and other applications, note the researchers.

More costly materials including indium phosphide, gallium arsenide and gallium nitride currently dominate such demanding applications.

However, SiGe devices such as IHP's 800GHz transistor combine SiGe's extremely high performance with silicon's traditional advantages — low cost, high yield, smaller size and high levels of integration and manufacturability — making them competitive with the other materials.

The new transistor has a breakdown voltage of 1.7V, a value which is adequate for most intended applications.

The 800GHz transistor was manufactured using IHP's 130nm BiCMOS process, which has a cost advantage compared with existing highly scaled CMOS silicon technologies. The 130nm SiGe BiCMOS process is offered by IHP in a multi-project wafer foundry service.

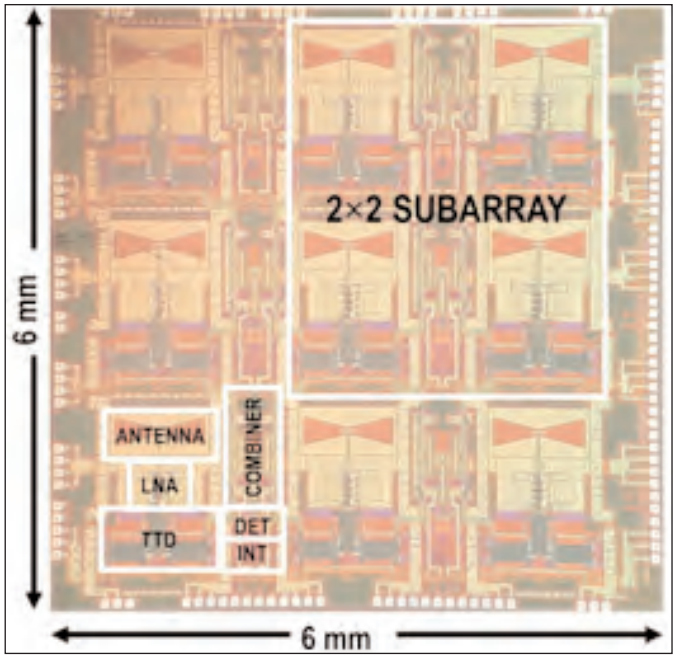
The Georgia Tech team used liquid helium to achieve the low cryogenic temperatures of 4.3K. "When we tested the IHP 800GHz transistor at room temperature during our evaluation, it operated at 417GHz," says Cressler. "At that speed, it is already faster than 98% of all the transistors available right now."

www.ihp-microelectronics.com
www.ece.gatech.edu
http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6701335

UC Irvine and TowerJazz present 9-element fully integrated W-band direct-detection-based receiver

Silicon germanium chip claims lowest ever noise equivalent power for W-band imaging receiver

Specialty foundry TowerJazz (which has fabrication plants at Tower Semiconductor Ltd in Migdal Haemek, Israel, and at its subsidiaries Jazz Semiconductor Inc in Newport Beach, CA, USA and TowerJazz Japan Ltd) says that, at the IEEE International Solid-State Circuits Conference (ISSCC 2014) in San Francisco (9–13 February), researchers from the University of California, Irvine's (UCI's) Nanoscale Communication Integrated Circuits (NCIC) Labs presented results from an integrated circuit operating in the W-band (75–110GHz) comprising a 9-element fully integrated direct-detection-based receiver (RX) array. The fully integrated solution was fabricated in TowerJazz's 0.18µm SiGe BiCMOS process.



Die photo of the 9-element imaging array receiver.

Since the early 1990s, W-band imaging systems have traditionally been designed and implemented in compound semiconductor materials. These III-V imaging solutions are typically in the form of multi-chip modules. The imaging receiver chip designed by NCIC Labs and manufactured by TowerJazz is claimed to be the world's most complex W-band imaging IC, with the lowest noise temperature and highest performance. The fully integrated receiver uses a new concept — spatial-overlapping super-pixels — for millimeter-wave (MMW) imaging applications (used for concealed-weapon detection, airplane navigation in low-visibility conditions, and satellite surveillance).

The use of spatial-overlapping super-pixels results in:
(1) improved signal-to-noise ratio at the pixel level;
(2) the same pixel density as a traditional focal-plane array;
(3) partially correlated adjacent super-pixels;
(4) a 2x2 window averaging function in the RF domain;
(5) the ability to compensate for the systematic phase delay and amplitude variations due to the off-focal-point effect for antennas away from the focal point;
(6) the ability to compensate for mutual coupling effects among the array elements; and
(7) signal processing capabilities in the RF domain.

The receiver chip achieves a peak measured coherent responsivity of 1150MV/W, a measured incoherent responsivity of 1000MV/W and a front-end 3dB bandwidth from 87–108GHz, while consuming 225mW per receiver element. The measured NETD (noise equivalent temperature difference) of the SiGe receiver chip is 0.45K with a 20ms integration time. Finally, the imaging chip achieves the lowest noise equivalent power (NEP) ever reported for any imaging receiver at W-band, it is claimed. This record performance means that, if commercialized, this imaging chip will achieve the best image resolution among all commercial products for security/surveillance applications, TowerJazz reckons.

"Our continued collaboration with TowerJazz through the years to support NCIC Labs at UCI has resulted in the success of a number of significant projects such as the development of several imaging receivers at W-band and the design of the first dual-band radar-on-chip covering 22–29GHz and 77–81GHz," says Payam Heydari, Full Professor of Electrical Engineering and Computer Science, UCI. "TowerJazz's dedicated support and its advanced technology enabled us to achieve silicon-based integrated circuits with comparable or better performance when compared to more expensive III-V technologies," he adds. Besides the ISSCC presentation, the new chip has been showcased as part of several invited talks including a keynote speech to the IEEE Global Conference on Signal and Information Processing (GlobalSIP 2013) in Austin TX, USA (3–5 December).

"UCI's results stem from very clever design architectures and highly optimized circuit block designs," comments Dr David Howard, executive director & fellow at TowerJazz. "These building blocks have methodically evolved over the span of our tight collaboration, and harness our best process and manufacturing technologies."

www.towerjazz.com
http://ncic.eng.uci.edu
www.isscc.org

IN BRIEF

Digi-Key to distribute MACOM's products

M/A-COM Technology Solutions Holdings Inc of Lowell, MA, USA has signed a global distribution agreement with Digi-Key Corp of Thief River Falls, MN, USA, a full service provider of both prototype/design and production quantities of electronic components.

The agreement allows MACOM to promote its portfolio of RF and microwave products through the Digi-Key.com web-site for electronic component sourcing, which reaches over 500,000 design engineers worldwide.

MACOM's portfolio of catalog products includes diodes, GaAs MMICs, silicon and GaN transistors, and components that enable next-generation internet and modern battlefield applications. Diverse markets include high-speed optical, satellite, radar, wired & wireless networks, CATV, automotive, industrial, medical, and mobile devices. The products, which cover frequencies ranging from DC to 110GHz, will now be available through Digi-Key's distribution channel.

"By leveraging their industry expertise, Digi-Key will enable us to provide improved time to market to our customers," reckons Jack Kennedy, MACOM's VP, global sales.

"Over the years MACOM has established a strong leadership position, providing a wide range of standard, catalog products within the high-performance RF and microwave market," comments Mark Zack, VP, global semiconductor products at Digi-Key. "Digi-Key is one of the fastest-growing distributors of electronic components and MACOM's continued focus to maximize short-term results using off-the-shelf products makes this an ideal partnership for both companies."

www.macomtech.com

Hittite's profits fall more than expected in Q4 due to low-margin military development contracts

...but future production contracts at higher margin levels promise growth

For fourth-quarter 2013, Hittite Microwave Corp of Chelmsford, MA, USA (which designs and supplies analog, digital and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems as well as instrumentation) has reported revenue of $68.8m, up slightly on $68.7m last quarter and $68.5m a year ago (and above the expected $66.5–68.5m). Full-year revenue was $273.8m, up 3.6% on 2012's $264.4m.

Of total Q4 revenue, 41.3% ($28.4m) came from customers in the USA (down from 43.4%, or $29.8m, last quarter) and 58.7% ($40.4m) came from customers outside the USA (up from 56.6%, or $38.9m, last quarter).

"We were able to meet our revenue targets despite challenges in some of our markets," comments president & CEO Rick Hess.

However, gross margin has fallen further, from 73.3% a year ago and 71.2% last quarter to 67.3%. Full-year gross margin is down from 73.7% in 2012 to 71.1% for 2013.

Quarterly operating income has fallen from $28m (about 40.8% of revenue) both a year ago and last quarter to $25m (36.3% of revenue) in Q4. Full-year operating income has risen slightly from $107.2m in 2012 to $107.6m in 2013, but fallen as a proportion of revenue from 40.6% to 39.3%.

Full-year net income was $70.9m, up from $68.6m in 2012. However, quarterly net income has fallen from $17.7m a year ago and from $18.7m last quarter to $16.5m in Q4, below the expected $16.7–17.7m. During the quarter, total cash and marketable securities rose by $15.2m to $472.5m.

"The decrease in profitability in the quarter was primarily the result of gross margins that, in the aggregate, were on the low end of our range, due to an unfavorable mix in products and markets, as well as several military development contracts that carry relatively low margins," says Hess. "These contracts, while less profitable in the near term, provide important opportunities for growth through future production contracts at higher margin levels," he adds. "We are confident that our innovation and engineering leadership will continue to drive our business growth."

Net bookings for full-year 2013 were $267.1m, up on $264.2m in 2012. Nevertheless, order backlog at the end of 2013 was $60.5m, down from $67.2m a year previously.

For first-quarter 2014, Hittite expects revenue of $67.5–69.5m and net income of $15.3–16.5m.

Hittite also announced that its board of directors has approved the initiation of a quarterly cash dividend, and has declared a dividend of $0.15 per share, payable on 27 March, to shareholders of record as of the close of business on 4 March. Future dividend declarations, as well as record and payment dates, are subject to board approval.

The board's decision to initiate a quarterly dividend reflects our confidence in our financial position and in our future prospects

"Our operating model provides the financial foundation to support both a dividend and our growth plans," says Hess. "The board's decision to initiate a quarterly dividend reflects our confidence in our financial position and in our future prospects."

www.hittite.com

RFaxis wins North American Frost & Sullivan Award

Fabless semiconductor firm RFaxis Inc of Irvine, CA, USA has been recognized with the 2014 North American Frost & Sullivan Award for Technology Innovation Leadership.

RFaxis has leveraged its highly integrated single-chip/single-die RF front-end integrated circuit (RFeIC) architecture to develop unique RF front-ends for wireless communications, combining performance with affordability as alternatives to conventional gallium arsenide solutions.

RF front-ends are traditionally built by embedding active and passive multiple components on a substrate using GaAs. The hybrid integration of passive and active components forms a multi-chip RF front-end module (FEM), resulting in a large package size and bigger footprint on the PCB, says RFaxis. However, with wireless communications semiconductors moving from bulky, multiple integrated chips to leaner, single chips, RFaxis says that its RFeICs are gaining prominence for being highly integrated on a single silicon-based chip.

Frost & Sullivan's research confirms that RFaxis has developed the first single-chip/single-die RF front-end IC architecture based purely on standard complementary metal oxide semiconductor (CMOS) silicon technology. Quality and performance are comparable with GaAs-based RF front-end solutions, while its cost structure, thermal conductivity and ruggedness are superior, it is said.

"Apart from reducing the time to design and market, RF front-end level of integration offers device manufacturers a very simple solution that can be implemented as a plug and play," says Frost & Sullivan senior research analyst Swapnadeep Nayak. "RFaxis' technology helps OEMs reduce their product development cycles to as low as a few weeks, while competing solutions take months," he adds. "It satisfies every performance criterion set forth by component manufacturers and original equipment manufacturers (OEMs)."

Unlike CMOS, GaAs is a niche that does not have adequate foundry capacity to meet demand from the semiconductor industry and OEMs, reckons RFaxis. Migrating to CMOS lowers strain on the supply chain, helping device makers cope with demand. RFaxis claims its technology offers substantial price reduction compared with incumbent solutions and helps system-on-chip (SoC) vendors and OEMs to integrate the firm's solutions with other modules.

Frost & Sullivan's comparison of RF front-end solutions shows that RFaxis is one of few participants that integrate the key RF front-end components of power amplifiers (PA), low-noise amplifiers (LNAs) and switches into a CMOS SoC. RFaxis says that such a high degree of integration has a direct bearing on RF front-end innovations for the WLAN, LTE/4G, and M2M communications markets.

www.rfaxis.com

European project COMPOSE^3 targets proof of concept of 14nm 3D-stacked InGaAs/SiGe hybrid SRAM cell within three years

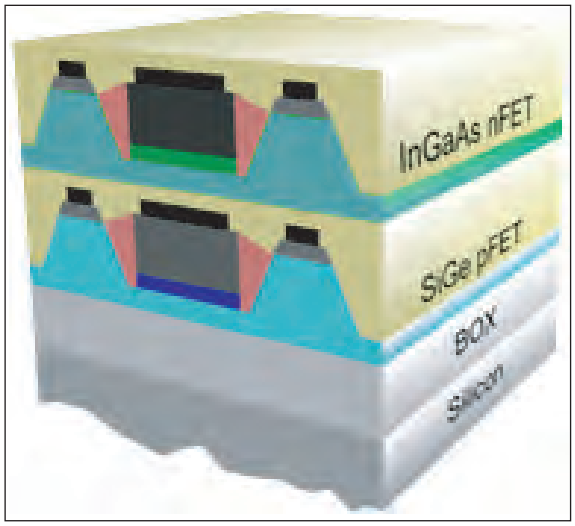
Project aims to demonstrate manufacturability using standard microelectronics industry processes

European scientists from both academia and industry have begun the new research project COMPOSE^3, which is focused on an alternative approach to extend Moore's Law. The goal is to reduce costs and improve the energy efficiency of electronic devices ranging from mobile phones to supercomputers. The project is based on the use of new materials to replace incumbent silicon, and on taking an innovative design approach where transistors are stacked vertically (3D stacking).

Coordinated by IBM Research in Zurich, Switzerland, COMPOSE^3 is a scientific collaboration between industry, research organizations and small- and medium-size enterprises from six European countries: STMicroelectronics, CEA-Leti and the Centre National de la Recherche Scientifique (CNRS) in France; University of Glasgow in the UK; Tyndall National Institute at University College Cork in Ireland; DTF Technology GmbH in Germany; and Fundación IMDEA Materiales in Spain.

Moore's Law predicted that the performance of an integrated circuit would double every 18 months, leading to a drastic reduction in the cost per digital function. First observed more than 50 years ago, this law has now come up against limits due to shrinking chip geometries. For example, a processor's clock speed has barely increased in the past five years, with typical operating frequencies at 2–3GHz. In addition, the energy consumption of electronic devices is growing at a staggering rate, with estimates that it accounts for up to 10% of the total electrical energy generated in industrialized countries.

To address these challenges, the new project aims to develop a static random-access memory (SRAM) cell based on indium gallium arsenide (InGaAs) and silicon germanium (SiGe) rather than silicon. SRAM components are found in processors in a wide range of applications from smartphones to high-performance computers, and are usually fabricated from n-type and p-type field-effect transistors (nFETs and pFETs). In COMPOSE^3, the nFET will use InGaAs, whereas the pFET will use SiGe. An SRAM cell has therefore been selected as the ideal test vehicle to demonstrate this kind of hybrid technology.



As charge carriers can move faster in InGaAs and SiGe than in silicon alone, the transistors can also be operated at a lower voltage, greatly reducing the power consumption of digital circuits. The chemical properties of InGaAs and SiGe also offer the possibility of stacking transistors vertically at the nanometer scale, opening up new avenues to increase the number of devices per unit area, while reducing the manufacturing costs for each transistor.

The nFET will use InGaAs, whereas the pFET will use SiGe. An SRAM cell has therefore been selected as the ideal test vehicle to demonstrate this kind of hybrid technology

"This technology will provide a new paradigm shift in density scaling combined with a dramatic increase in the power efficiency of CMOS circuits," says Dr Jean Fompeyrine, manager of the Advanced Functional Materials group at IBM Research – Zurich. "Our synergistic approach is based on replacing silicon with high-mobility channel materials such as SiGe and InGaAs," he adds. "Using these materials in a technology that delivers performance at low power, and at the same time provides a density increase at reduced costs, is a fantastic challenge that requires the collective knowledge of both industry and academia."

The challenges associated with this approach are significant, particularly with regard to the minimization of electrically active defects in the vicinity of InGaAs and SiGe, the fabrication of transistors with low-resistance contacts, and thermal management during 3D stacking. The consortium partners each bring specific expertise to support this.

Within three years the team expects to unveil a proof of concept for fabricating the first 14nm 3D-stacked SRAM cell based on InGaAs and SiGe materials. The project also aims to demonstrate that the technology can be manufactured using standard processes in the microelectronics industry.

http://compose3.eu

Imec and Vrije Universiteit Brussel report first 79GHz radar transmitter in 28nm CMOS

Complete multi-antenna lab prototype by end 2015 to lead to full SoC

At the IEEE International Solid-State Circuits Conference (ISSCC 2014) in San Francisco (9–13 February), nanoelectronics research center Imec of Leuven, Belgium, In collaboration with Vrije Universiteit Brussel, presented what is claimed to be the first 79GHz radar transmitter implemented in plain digital 28nm CMOS silicon (Giannini et al, 'A 79GHz phase-modulated 4GHz-BW CW Radar TX in 28nm CMOS'). With output power above 10dBm, the transmitter front-end paves the way towards full radar-on-chip solutions for automotive and smart environment applications, says Imec.

Millimeter-wave radar systems, featuring a range resolution finer than 10cm and an angular resolution finer than 10 degrees, will be used in next-generation driver assistance systems to improve safety in blurry conditions (dust, fog and darkness) where image-based driver assistance systems fail. However, the high bandwidth and carrier frequency (needed to achieve such high resolution, wide field of view and high angular resolution) translate into large, expensive and power-hungry mm-wave antenna arrays. A low-power compact radar technology will be key to enabling the application of mm-wave sensors in next-generation automotive and smart environment applications, says the research center.

Imec's continuous-wave radar transmitter operates in the 79GHz band. Implemented in 28nm CMOS, with a supply voltage of 0.9V, it only consumes 121mW and is fully compliant with the spectral mask imposed by the European Telecommunications Standards Institute (ETSI). Phase modulation guarantees high resilience against interference and enables code-domain multiple-input, multiple-output (MIMO) radar.

The integration of analog-to-digital converters and digital logic should lead to a full system-on-chip (SoC)

Imec says that it welcomes industrial and academic partners for joint R&D. After developing receiver functionality (by the end of 2014), it aims to fabricate a complete multi-antenna lab prototype by the end of 2015. Afterwards, the integration of analog-to-digital converters (ADCs) and digital logic should lead to a full system-on-chip (SoC).

www.imec.be
www.vub.ac.be/en
www.isscc.org

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Anvil appoints Martin Lamb as chairman

Ex-Wafer Tech MD to lead commercialization of 3C-SiC for power devices

Following a $1.6m (£1m) investment round closed last November, Anvil Semiconductors Ltd of Coventry, UK has appointed Martin Lamb as chairman to lead the firm as it commercializes its new technology which, it is reckoned, promises to open up high-volume power device markets for silicon carbide (SiC) through unique SiC-on-silicon epitaxial technology offering SiC performance at the costs close to those of silicon.

Anvil was spun off in August 2010 from the University of Warwick's School of Engineering by its technology commercialization subsidiary Warwick Ventures Ltd in order to exploit patented developments in SiC power semiconductor technology. Anvil says that its approach to SiC switches should cost no more than their silicon counterparts. This involves growing a thin layer of cubic SiC (3C-SiC) on silicon seed wafers sufficient to fabricate active power devices. In addition to the fundamental crystal growth expertise, Anvil has IP relating to resolving the problem of the stress that inevitably arises when growing SiC on Si (which to date has prevented the technology from moving forward). The IP has been proven on 100mm silicon wafers and should inherently permit larger wafer diameters to be used without modification.

Anvil's £1m funding round was led by the Low Carbon Innovation Fund (LCIF) and involved Ntensive angel investor group, Cambridge Capital Group, and several individual angel investors, as well as prior investors Midven and Minerva Business Angels. LCIF is a venture capital fund managed by specialist energy and environment merchant bank Turquoise International on behalf of the Low Carbon Group at the University of East Anglia and supported by the East of England Competitiveness Program of the European Regional Development Fund (ERDF, a seven-year investment program part-financed by the European Union).

Lamb, who previously held senior positions including managing director of substrate maker Wafer Technology Ltd and served on the board of epiwafer foundry IQE plc of Cardiff, Wales, UK, has more than 25 years' experience in the compound semiconductor materials industry. Most recently he has been an active angel investor and serves on the boards of several companies within his portfolio, many of which are commercializing novel technologies related to the production or processing of materials.

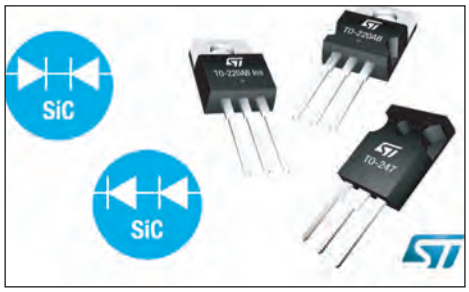
"He brings to the team a depth of experience of semiconductor leadership, having successfully navigated a business through periods of significant growth to a successful exit," comments Anvil's CEO Jill Shaw. "Anvil has some very exciting technology that could prove disruptive in many markets," believes Lamb.

http://anvil-semi.co.uk

ST launches first 650V silicon carbide diodes with dual common-cathode or series configuration

STMicroelectronics of Geneva, Switzerland has launched dual-configuration Schottky silicon-carbide (SiC) diodes that are claimed to be the industry's first such devices with a voltage rating of 650V per diode in a choice of common-cathode or series configurations, allowing use in interleaved or bridgeless power-factor correction (PFC) circuits.

SiC power semiconductors have inherently higher energy efficiency and ruggedness compared to ordinary silicon alternatives, says ST. The firm's STPSC6/8/10TH13TI and STPSC8/12/16/20H065C devices (which have maximum average-current rating of 6A, 8A, 10A, or 8A, 12A, 16A and 20A, respectively) combine SiC performance advantages with the space savings and electromagnetic interference (EMI) reduction of dual integrated diodes. They are suitable for interleaved or bridgeless PFC (power factor correction) topologies that enhance the energy efficiency of equipment such as server and telecom power supplies, solar inverters or electric-vehicle charging stations.



ST's new silicon carbide dual diodes.

The diodes eliminate energy losses due to reverse recovery at turn-off, optimizing switching efficiency, and the 650V voltage rating provides increased safety margin against hazardous reverse-voltage spikes, says ST. Also, ceramic isolation built into the STPSCxxTH13TI's package simplifies attachment to an external heat-sink, allowing removal of the usual external isolation.

The STPSC6TH13TI through STPSC10TH13TI (series configuration in insulated TO-220AB package) and STPSC8H065C through STPSC20H065C (common-cathode in standard TO-220AB package) are available at $4.24 for orders of 1000 pieces. The STPSC20H065C is also available in a TO-247 package.

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US DOE selects NCSU to lead $140m Next Generation Power Electronics Innovation Institute

The Obama administration has selected a consortium (based in Raleigh, NC) of over 25 companies, universities and state and federal organizations to lead a public–private manufacturing innovation institute for next-generation power electronics. Supported by a $70m investment over five years by the Advanced Manufacturing Office within the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) (the largest single grant in NC State history) as well as a matching $70m in non-federal cost-share from the consortium partners, the Next Generation Power Electronics Innovation Institute aims to invent and manufacture wide-bandgap (WBG) semiconductor-based power electronics that, within the next five years, are cost-competitive and 10 times more powerful than current silicon-based technology on the market.

Based at North Carolina State University (NCSU), the consortium includes the State of North Carolina and 18 firms (ABB, APEI, Avogy, Cree, Delphi, Delta Products, DfR Solutions, Gridbridge, Hesse Mechantronics, II-VI, IQE, John Deere, Monolith Semiconductor, RF Micro Devices, Toshiba International, Transphorm, USCi, Vacon) and 7 universities and labs (NCSU, The University of North Carolina, Arizona State University, Florida State University, University of California at Santa Barbara, Virginia Polytechnic Institute, National Renewable Energy Laboratory).

The DoE says that, as we reach the limits of silicon-based electronics for some critical applications in power conversion, wide-bandgap semiconductors are expected to jumpstart the next generation of smaller, faster, cheaper and more efficient power electronics for personal devices, electric vehicles, renewable power interconnection, industrial-scale variable-speed drive motors, and a smarter, more flexible grid.

Revolutionizing power electronics

Silicon-based power electronics (controling or converting electrical energy into usable power) have transformed the computing, communication and energy industries and given consumers and firms more powerful laptops, cell phones and motors. Now, WBG semiconductors offer a new opportunity to achieve unprecedented performance while using less electricity, says the DoE.

WBG semiconductors such as silicon carbide and gallium nitride can operate at higher temperatures and have greater durability and reliability at higher voltages and frequencies. The size of a typical laptop power adapter can be shrunk to a fifth the size of existing adapters, while providing better performance and cutting energy use about 20%. In a typical laptop, a quarter of the power flowing from the wall outlet is lost as waste heat; WBG semiconductors could cut these power conversion losses by up to 90%.

WBG semiconductors could also transform the plug-in electric vehicle industry, making it easier and cheaper to own and drive an electric vehicle, reckons the DoE. For example, they could cut the size of a vehicle cooling system by about 60% and cut the size of a fast DC charging station to the size of a kitchen microwave.

Building a smarter, more reliable and resilient power grid

As the cost of clean energy technologies continues to come down, seamless and efficient grid integration will help to make these resources and products even more affordable, while giving consumers more control over how they use energy in their homes and businesses, says the DoE. WBG semiconductors should help to overcome a range of generation, transmission, distribution and end-use challenges to support a cleaner, affordable and secure energy mix.

Power electronics — e.g. inverters, transformers and transistors — help to control and convert electricity and are playing a growing role in electricity generation, distribution and transmission. According to a study by the Oak Ridge National Laboratory (ORNL), about 30% of all existing power generation utilizes power electronics between the point of generation and its end use. By 2030, this is expected to jump to 80% of generated electricity — supporting greater renewable energy integration and grid reliability. WBG semiconductor-based power electronics should be able to better withstand the power loads and switching frequencies required by next-generation utility technologies.

Power electronics that use WBG semiconductors will also be smaller, more efficient and cost less, notes the DoE. A WBG inverter (switching electricity from DC to AC) could be four times more powerful, half the cost and quarter the size and weight of a traditional inverter. At a larger-scale, WBG semiconductors could help to reduce the size of an 8000lb substation to 100lb and the size of a suitcase, ultimately helping to lower the cost of electricity and build a stronger, more reliable grid.

Supporting economic growth

The new institute supports President Obama's vision for a full National Network of Manufacturing Innovation of up to 45 institutes that aim to boost employment and manufacturing and ensure that US workers have the training they need. It is the first of three manufacturing innovation institutes established through a Federal commitment of $200m across five Federal agencies: Defense, Energy, Commerce, NASA and the National Science Foundation. The other two manufacturing innovation institutes, led by the Department of Defense, will focus on 'Digital Manufacturing and Design Innovation' and 'Lightweight and Modern Metals Manufacturing'.

www.ncsu.edu/power
www1.eere.energy.gov/manufacturing/innovation/facilities/wbg.html

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ABB contributing $2.5m as partner in five-year Next Generation Power Electronics Innovation Institute

SiC-focused power electronics firm to conduct performance and reliability testing of materials for converter

ABB says that it is receiving $2.1m of the $70m grant over five years from the Advanced Manufacturing Office within the US Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) that is funding the new Next Generation Power Electronics Innovation Institute, led by North Carolina State University (NCSU) in Raleigh.

The $70m in federal funding is being matched by $70m in non-federal cost-share from the consortium partners (making $140m in total). ABB will hence contribute at least $2.5m over five years.

ABB of Zurich, Switzerland focuses on electric power engineering and industrial automation, and is the largest manufacturer of power electronics in the consortium. Of its 150,000 staff, the firm employs 700 in Cary and Raleigh, NC, 2000 in North Carolina, more than 20,000 in the USA, and 30,000 in North America. In particular, its North American headquarters, global Power R&D Research Center and regional power divisions are in the Raleigh area. ABB's main role in the Next Generation Power Electronics Innovation Institute will be performance and reliability testing of materials in converter applications.

In announcing its part of the cost-share funding, ABB issued a statement by Greg Scheu, president & CEO of ABB Inc and regional manager for North America, who describes ABB as a global pioneer in wide-bandgap semiconductors research, dating back to its breakthroughs in silicon carbide research in the 1990s.

"ABB has been following closely the development of wide-bandgap semiconductors because we have a wide array of products that employ power electronics as an essential ingredient," says Scheu. "These include solar- and wind-power inverters and converters; low- and medium-voltage drives for propulsion, pumping and compression for such things as ship propulsion and oil and gas pumping; industrial motors; electric car charging; and high-voltage direct current (HVDC) converters," he adds.

"The promise here is for new semiconductor materials to be used for everything from smart phones to smart grids," Scheu continues. "A greater potential for renewable energy can be unleashed when we make these semiconductors and products reliable, especially at high voltages, and make them cost-effective."

The new manufacturing hub in Raleigh "has the potential to fast-forward development of some products by at least a decade," reckons Scheu. "We expect that consumers will start to see some low-voltage products, like residential solar, coming out the quickest and within five years. The high-power products like industrial motors and drives and hog-voltage gear will take a few more years to come to market, mainly due to the rigorous reliability testing requirements of the electric utility industry," he adds.

"The president asked industry to work together and see where we can replace silicon with other semiconductor materials to reduce energy loss — meaning huge energy efficiency — for equipment that can handle higher voltages, higher temperatures and higher frequencies," Scheu says. "For example, can we cut electric consumption of industrial motors — one of largest uses of power — in half? Can wind and solar converters and inverters become more affordable? Can we make car chargers and data-center power supplies more compact? We are talking about new products, new applications and possibly new industries."

ABB makes power electronics for many of these applications, including:

- converters used in industrial motors and drives ("We lead this global market, and the largest US industrial motor maker, Baldor Electric, is an ABB firm," says Scheu);
- efficient solar inverters to reduce power loss (including products from ABB company Power One);
- high-voltage products, such as high-voltage DC (HVDC) equipment;
- emerging low-voltage applications, such as electric vehicle technology and solar micro-inverters and power supplies.

"These are just the immediate areas that relate to ABB's work, but WGB materials can also improve lighting, satellites, electric cars and other applications," notes Scheu.

ABB manufactures power electronics inverters and converters in New Berlin, WI, Fort Smith, AK, Richmond, VA, and Phoenix, AZ, for wind, solar, power supplies and industrial motor applications. ABB companies (including Baldor and Thomas & Betts) have dozens of other manufacturing facilities for motors and low-voltage products that work with these materials.

However, although ABB is evaluating and researching uses, it does not currently use wide-bandgap semiconductors in its products. Nevertheless, ABB's Corporate Research Center (one of seven ABB R&D centers globally) — also located on the NCSU campus — has been involved in wide-bandgap semiconductor R&D (as part of the more than $1bn that ABB spends on worldwide R&D annually).

ABB says it will provide periodic updates on its progress regarding work for the Next Generation Power Electronics Innovation Institute.

www.abb.com

www1.eere.energy.gov/manufacturing/innovation/facilities/wbg.html

Next Generation Power Electronics Innovation Institute

The Next Generation Power Electronics Innovation Institute was announced on 15 January by US President Obama during a visit to consortium leader North Carolina State University (NCSU) in Raleigh.

The formation of the institute is part of the US Government's National Network for Manufacturing Innovation Initiatives (NNMI), announced by The White House in February 2013 to bolster the competitiveness of US manufacturing.

Supported by a $70m investment over five years by the Advanced Manufacturing Office within the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) as well as a matching $70m in non-federal cost-share from the consortium partners (making $140m in total), the Next Generation Power Electronics Innovation Institute aims to invent and manufacture wide-bandgap (WBG) semiconductor-based power electronics that, within the next five years, are cost-competitive and 10 times more powerful than current silicon-based technology on the market.

After a competition for the government funding between several contenders, the DOE selected the NCSU-led US public–private consortium of over 25 companies, universities and state and federal organizations. As well as 7 universities and labs (NCSU, The University of North Carolina, Arizona State University, Florida State University, University of California at Santa Barbara, Virginia Polytechnic Institute, National Renewable Energy Laboratory), the consortium includes 18 industry partners (ABB, APEI, Avogy, Cree, Delphi, Delta Products, DfR Solutions, Gridbridge, Hesse Mechantronics, II-VI, IQE, John Deere, Monolith Semiconductor, RF Micro Devices, Toshiba International, Transphorm, USCi and Vacon).

The institute aims to invent and manufacture wide-bandgap semiconductor-based power electronics that, within the next five years, are cost-competitive and 10 times more powerful than current silicon-based technology on the market

www1.eere.energy.gov/manufacturing/innovation/facilities/wbg.html
www.ncsu.edu/power

Epiwafer foundry IQE to be key partner in Next Generation Power Electronics Innovation Institute

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK is to play a key part in the US public–private consortium of more than 25 companies, universities and state and federal organizations selected to lead the Next Generation Power Electronics Innovation Institute.

IQE has been selected as supplier to the consortium of epitaxial materials for the development of a 150mm gallium nitride on silicon (GaN-on-Si) power electronics capability for high-voltage (600–1200V) applications (an award worth up to $4m over the next five years). GaN-on-Si is a key materials technology not only for highly efficient power semiconductors (with applications ranging from everyday power supplies for consumer electronics to industrial motor controls and hybrid-electric vehicles) but also for RF applications in next generation base-station and small-cell RF communication networks, as well as highly cost-efficient LEDs, high-speed rail and other power-efficient applications.

GaN has been a key materials technology initiative for IQE over the last few years, building on the acquisition of NanoGaN in 2010, Kopin Wireless in 2013, and the development and deployment of gallium nitride on silicon carbide (GaN-on-SiC) technology for high-power RF applications, culminating in the launch of what was claimed to be the world's first 150mm GaN-on-SiC wafer products in 2013.

IQE has been selected as supplier to the consortium of epi materials for the development of a 150mm GaN-on-Si power electronics capability for high-voltage (600–1200V) applications. The institute highlights the importance of materials such as gallium nitride as a key enabling technology for the future

The announcement of the institute "highlights the importance of materials such as gallium nitride as a key enabling technology for the future," says IQE's CEO & president Dr Drew Nelson. "IQE has built a diversified portfolio of advanced compound semiconductor products which are now beginning to impact many aspects of today's and tomorrow's advanced technologies targeting wireless communications, optoelectronics, infrared and x-ray detection, clean energy generation (CPV), power-efficient devices and next-generation CMOS," Nelson adds.

www.iqep.com

Raytheon enters 15th year of GaN technology development

Raytheon Company of Waltham, MA., USA has embarked on its 15th year of gallium nitride (GaN) technology development and system integration. In 1999, Raytheon commenced research in GaN at the Raytheon Foundry in Andover, MA. Today, Raytheon demonstrates the maturity of GaN technology that extends the reach in the battle space by increasing radar ranges, sensitivity and search capabilities.

"GaN technologies are transforming the way we address the evolving needs of our customers," says Paul Ferraro, vice president of Advanced Technology for Raytheon's Integrated Defense Systems (IDS) business in Tewksbury, MA. "Through partnerships with the Office of the Secretary of Defense (OSD) and Defense Advanced Research Projects Agency (DARPA), we are harnessing the revolutionary power, efficiency and performance improvements that GaN provides in programs today including AMDR (US Navy's Air and Missile Defense Radar program) and Next Generation Jammer. We are optimistic about its impact on future initiatives like 3DELRR (Three Dimensional Expeditionary Long-Range Radar) and others."

Notable milestones include:

- In 2000, Raytheon fabricated its first GaN transistor, the building block for monolithic microwave integrated circuits (MMICs, operating at frequencies of 300MHz–300GHz), which typically perform functions such as microwave mixing, power amplification, low-noise amplification and high-frequency switching.
- From 2005–2008, Raytheon worked closely with DARPA on the Wide Bandgap Semiconductor (WBGS) Phase 2 program, meeting all transistor-level technical metrics. The high-power-density, high-efficiency process that emerged during this time helped form the underpinning for current microwave GaN production processes.
- In 2009, Raytheon released GaN for production in its 4" Trusted compound semiconductor foundry.
- Raytheon was honored by the Office of the Secretary of Defense for successful completion of a Defense Production Act (DPA) Title III Gallium Nitride (GaN) production improvement program in 2013, a result of more than a decade of government and Raytheon investment in GaN RF circuit technology.
- Raytheon has demonstrated that the reliability of its GaN technology exceeded the requirement for insertion into production military systems. This maturation of GaN resulted in a Manufacturing Readiness Level (MRL) production capability of '8', the highest level obtained by any organization in the defense industry for this technology. MRL is a measure used by the OSD and major companies worldwide to assess the maturity of manufacturing readiness.
- Also through the OSD Title III program, GaN yield was improved by more than 300% and cost was reduced more than 75% for MMICs.

www.raytheon.com

IQE to report growth of 43% for 2013 to record £126m

Epiwafer foundry & substrate maker IQE plc of Cardiff, UK expects second-half 2013 revenue to show sequential growth, despite weak guidance for Q4/2013 and Q1/2014 from some wireless customers, and a significantly strengthening sterling/dollar exchange rate.

Revenue for full-year 2013 should be an annual record of £126m, up 43% on 2012's £88m. Strong sales growth and improved operational efficiencies are expected to deliver record EBITDA (earnings before interest, taxes, depreciation and amortization) of £24.5m, up on £16.4m in 2012. Adjusted fully diluted earnings per share (EPS) should be 2p, up 32% on 2012's 1.51p.

IQE's high conversion of operating profit into cash should cut net debt to below £35m at the end of 2013 (from £37.7m at end-June), even after paying £14m during 2013 in deferred consideration relating to prior acquisitions. The amount payable in 2014 is expected to reduce from this level.

Near the end of 2013, as well as renewing its contractual relationships with key wireless customers, IQE extended its contractual share of future business. As expected, it continues to diversify its business across non-wireless applications.

In particular, IQE demonstrated:

- strong progress in photonics (vertical-cavity surface-emitting lasers, or VCSELs) via a major contractual agreement with Philips;
- continuing qualifications and technical progress on concentrated photovoltaics (CPV), where a powerful supply chain has been established and is being fully qualified;
- growth in infrared products; and
- excellent progress on power and LED materials employing GaN-on-Si (gallium nitride on silicon) technology.

Also, since year-end IQE's position in GaN-on-Si has been endorsed by its inclusion in the US Next Generation Power Electronics Innovation Institute (announced on 15 January).

The board remains confident that IQE can continue to deliver increased free cash flow over the coming year and beyond, as the business continues to diversify and cost synergies from recent acquisitions are realised.

"We expect to report a record level of revenue and earnings for 2013 as a result of IQE's increasingly strong position within the compound semiconductor industry, and our rapidly strengthening product portfolio," says CEO & president Dr Drew Nelson "We have also successfully reduced net debt and the deferred consideration owing on prior acquisitions," he adds.

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GaN Systems hires director European operations prior to launching commercial products in 2014

GaN Systems Inc of Ottawa, Ontario, Canada, a fabless developer of gallium nitride (GaN)-based power switching semiconductors for power conversion and control applications, has appointed Tony Astley as director of European operations. Astley will have overall responsibility for all aspects of business in Europe, the Middle East and Africa (EMEA) and will further develop the firm's presence in the region, which represents about 20% of the world's total market for power device sales.

GaN Systems says that its cost-effective, high-power gallium nitride transistors feature proprietary Island Technology and overcome the limitations of existing silicon-based semiconductors, bringing much better performance and efficiency to power conversion applications such as alternative energy products and electric and hybrid vehicles (EV/HEV). The EMEA region is a world leader in industrial and automotive technologies, says the firm. Astley's role spans broad-based customers across EMEA as well as large OEMs in the industrial, power and automotive sectors.

Tony Astley.

"This year GaN Systems will commercialize its broad range of GaN-on-silicon products, and European customers, who are long-time global leaders in the industrial and automotive electronics segments, will be some of our earliest adopters," reckons CEO Girvan Patterson.

Astley joins GaN Systems from Texas Instruments, where he held senior positions at director level in both regional sales and sales operations. Achievements include implementing customer support models in major OEMs, broadening sales channels, and increasing revenue.

www.gansystems.com

Ammono participating in ARPA-E SWITCHES projects

Ammono S.A. of Warsaw, Poland, which produces bulk gallium nitride using ammonothermal technology, is partnering with Kyma Technologies Inc of Raleigh, NC, USA and MicroLink Devices of Niles, IL, USA in two novel projects related to power electronics.

Based on proprietary patented technology, Ammono has developed low-dislocation GaN substrate manufacturing, exporting its products worldwide (with the main applications being high-power transistors, lasers, and LEDs).

Kyma provides crystalline GaN, AlN and AlGaN materials and related products and services. MicroLink specializes in MOCVD growth of semiconductor structures for use in wireless communications devices, and the fabrication of advanced solar cells for space, unmanned aerial vehicle (UAV), and terrestrial use.

"Those two partnerships are based on the development of new concepts, which explore the quality of our low-dislocation GaN and allow new, better and more economic devices," says Ammono's chief commercial officer Piotr Wiliski.

Funded by the US Department of Energy's (DOE) Advanced Research Projects Agency-Energy (ARPA-E) SWITCHES program ('Strategies for Wide-Bandgap, Inexpensive Transistors for Controlling High-Efficiency Systems'), both projects seek new ways to lower the cost and improve the efficiency of power electronics.

"Participation in ARPA-E projects shows the recognition of US industrial players for the breakthrough potential of our products," says Wiliski.

Ammono says its GaN wafers will enable Kyma to produce low-cost, high-performing boules needed for power semiconductor manufacturing. Currently, growing boules from GaN seeds is slow, expensive and inconsistent, which negatively impacts manufacturing yield and electronic device performance. Kyma will select the highest-quality GaN seeds and use its proprietary hydride vapor phase epitaxial (HVPE) process to rapidly grow the seeds into boules while maintaining high crystal structural quality and purity.

"We are excited to win the support of ARPA-E to help Kyma and Ammono explore the natural synergies of our respective GaN crystal growth technologies," says Kyma's president & CEO Keith Evans.

Using Ammono's GaN wafers, MicroLink aims to develop an innovative method to remove the transistor structure from the wafer without damaging any components. In conventional manufacturing processes, this expensive wafer is permanently attached to the transistor and can only be used once. MicroLink's method aims to facilitate wafer reuse while significantly reducing costs to engineer affordable, high-performance transistors needed for power conversion.

MicroLink develops manufacturable epitaxial lift-off technologies that reduce the cost and improve the performance of III-V materials. "Ammono's bulk GaN substrates are the ideal platform on which to grow high-quality epitaxial GaN material," says MicroLink. "We look forward to working with Ammono to develop new technologies that will significantly reduce the cost of providing GaN epitaxial device structures with very low dislocation density."

www.ammono.com
www.kymatech.com
www.mldevices.com

EPC appoints vice president of sales for the Americas

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, says that Andrea Mirenda has joined it as vice president, Americas sales, with the primary responsibilities of creating and implementing sales strategies to achieve the firm's global sales objectives.

Mirenda has over 25 years of marketing and sales operation experience within the semiconductor industry. "Andrea's extensive experience in all aspects of marketing and sales operations within the power semiconductor industry brings valuable insight and demonstrated success to our sales organization," says Steve Colino, VP of marketing & sales.

Andrea Mirenda.

Mirenda joins from Vishay, where most recently she was a VP for regional marketing responsible for leading a team developing, communicating and executing global market penetration strategies in the power MOSFET division. She also spent five years with Fairchild Semiconductor as VP of corporate marketing and global EMS sales, responsible for brand management, company positioning and sales management. Earlier in her career, Mirenda held leadership positions with Hitachi Americas, as well as with Chips and Technologies.

www.epc-co.com

EPC introduces high-current development board for the 100V EPC2001 eGaN FET featuring four half-bridges in parallel

EPC has introduced the EPC9013 development board, featuring the 100V EPC2001 eGaN FET operating up to a 35A maximum output current in Buck mode using a four half-bridge configuration in parallel and a single onboard gate drive. The design increases output power without sacrificing efficiency, says the firm.

The EPC9013 development board is 2" x 2" with eight EPC2001 eGaN FETs in conjunction with the Texas Instruments LM5113 gate driver. It can be operated as a Buck, Boost, or bidirectional, as well as a half-bridge for motor drives and isolated converter applications. Its parallel configuration is recommended for high-current applications. The printed-circuit board layout is designed for optimal switching performance. There are various probe points to facilitate simple waveform measurement and to easily evaluate the eGaN FETs.

EPC says that the development board simplifies the evaluation process of the EPC2001 eGaN FET for high-current operation by including all the critical components on a single board that can be simply connected into any existing converter.

EPC9013 development boards are priced at $150 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 included for reference and ease of use.

http://epc-co.com/epc/Products/DemoBoards/EPC9013.aspx

EPC adds 100V eGaN FET, with high gain into 3GHz range

EPC has extended its family of high-speed transistors with the EPC8010 power transistor.

Sold in die form, the EPC8010 is just 1.75mm^2 with 100V_{DS}. Optimized for high-speed switching, it has a maximum $R_{DS(on)}$ of 160mΩ and input gate charge in the hundreds of pico-coulombs.

The device has switching transition speeds in the sub-nanosecond range, making it uniquely capable of hard-switching applications above 10MHz, says EPC. Even beyond the 10MHz frequency range for which they were designed, it exhibits good small-signal RF performance with high gain well into the low-GHz range, claims the firm, making it suitable for RF applications.

Applications benefiting from the low-power, compact, high-frequency EPC8010 include hard-switching power converters operating in the multi-megahertz range for envelope tracking, RF power amplifiers, and highly resonant wireless power transfer systems for wireless charging of mobile devices.

"It takes EPC and gallium nitride transistor technology to a level of performance that enables applications beyond the capability of the aging MOSFET," reckons co-founder & CEO Alex Lidow. "These eGaN FETs can be used in both power switching and RF applications."

Also available now is the EPC9030 development board, featuring two EPC8010 devices in a half-bridge configuration with minimum switching frequency of 500kHz. Its purpose is to simplify the EPC8010 evaluation process, providing a single board that can be easily connected into any existing converter.

Available now through distributor Digi-Key Corp are evaluation units of the EPC8010 in 2- and 10-piece packs (starting at $40) and the EPC9030 development board ($150).

http://epc-co.com/epc/Products/eGaNFETs/EPC8010.aspx

MACOM acquires Nitronex for $26m

M/A-COM Technology Solutions Inc of Lowell, MA, USA (which makes semiconductors, components and subassemblies for analog, RF, microwave and millimeter-wave applications) has acquired Nitronex LLC of Durham, NC, USA, which designs and makes gallium nitride on silicon (GaN-on-Si)-based RF power devices.

MACOM has bought Nitronex from Silicon Valley-based GaAs Labs LLC (a private investment fund targeting the communications semiconductor market) for about $26m in cash (subject to potential post-closing adjustments). The transaction is financed through a draw of additional indebtedness from MACOM's revolving credit facility. GaAs Labs is an affiliate of the majority stockholder of MACOM's parent company M/A-COM Technology Solutions Holdings Inc, after GaAs Labs acquired M/A-COM Tech from UK-based aerospace technology developer Cobham plc in 2009. GaAs Labs acquired Nitronex in mid-2012.

The acquisition of Nitronex provides MACOM with fundamental GaN-on-Si epitaxial and pendeoepitaxial semiconductor process technology and materials for use in RF applications, broadening MACOM's growing GaN technology portfolio.

Nitronex previously leveraged this technology to offer what was claimed to be the industry's first GaN-on-Si RF discrete devices and MMICs, providing a combination of GaN-based performance, ease of integration, and a cost structure that can support high-volume mainstream markets. MACOM says that the high device linearity, high output power and efficiency characteristics of GaN devices make GaN-on-Si technology ideal for demanding high-bandwidth communications such as CATV, broadband radio, wireless infrastructure, radar and ISM (industrial, scientific & medical) applications.

"GaN technology has been long viewed as the driver of the next generation of RF and microwave applications," says MACOM's president & CEO John Croteau. "MACOM now provides what we believe to be the industry's largest portfolio of GaN devices. MACOM's broadened portfolio of GaN-on-Si and GaN on silicon carbide technologies offers customers the flexibility to utilize the best solution to solve their RF and microwave design challenges," he adds.

The deal "accelerates the deployment of GaN as a dislocating technology and furthers Nitronex's vision of bringing GaN-on-Si to the fullest breadth of commercial and aerospace and defense applications possible," says Nitronex's president & CEO Greg Baker. "MACOM's more than 30 years of experience in high-performance RF power devices can help propel GaN-on-Si to the next level of commercialization, bringing it to a truly mainstream volume production technology."

www.macomtech.com
www.nitronex.com

Agilent's simulation and modeling software selected by Nitronex

Nitronex has chosen Agilent Technologies Inc of Santa Clara, CA, USA to provide a complete GaN design flow that spans both device modeling and circuit simulation.

The flow uses Agilent EEsof EDA's IC-CAP model extraction software and Advanced Design System (ADS) circuit and system simulator — both are RF and microwave design platforms offered by Agilent EEsof EDA (which supplies electronic design automation software).

Nitronex's GaN devices use silicon as a substrate, with an inherent cost advantage. Nonetheless, as with the development of any high-power device, designing for high levels of reliability, performance and yield requires investing in modeling and simulation technology, says Agilent.

"Agilent's software platforms offer a clear advantage for our design process," comments Nitronex's VP of engineering David Runton. "The usability and simulation advancements of ADS, combined with its superior device models and IC-CAP model extraction software, puts us in the best position to offer top-quality GaN parts. And, because Agilent's tools offer a complete design flow, our design process will be more streamlined," he adds.

"We have gotten uniformly positive feedback from companies as they reengineer their design flows with the latest nonlinear modeling technologies and simulator advancements," says Agilent EEsof EDA marketing manager Charles Plott.

ADS delivers usability features to improve designer productivity and efficiency for all applications it supports, as well as capabilities specifically applicable to GaN design. Support for Agilent's newly introduced artificial neural network-based model (extracted by IC-CAP device modeling software), for example, enables more accurate FET modeling and simulation results for high-power GaN FET amplifiers. Also, an electro-thermal simulator (based on a full 3D thermal solver natively integrated into ADS) incorporates dynamic temperature effects to improve accuracy in 'thermally aware' circuit simulation.

IC-CAP features capabilities specifically geared toward high-frequency device modeling, including turnkey extraction of Agilent's neural networked-based model as well as the Angelov-GaN model. GaN models in particular need to be well suited to deal with the impact of trapping and thermal effects on the device electrical characteristics, says Agilent.

www.agilent.com/find/eesof-ads
www.agilent.com/find/eesof-iccap

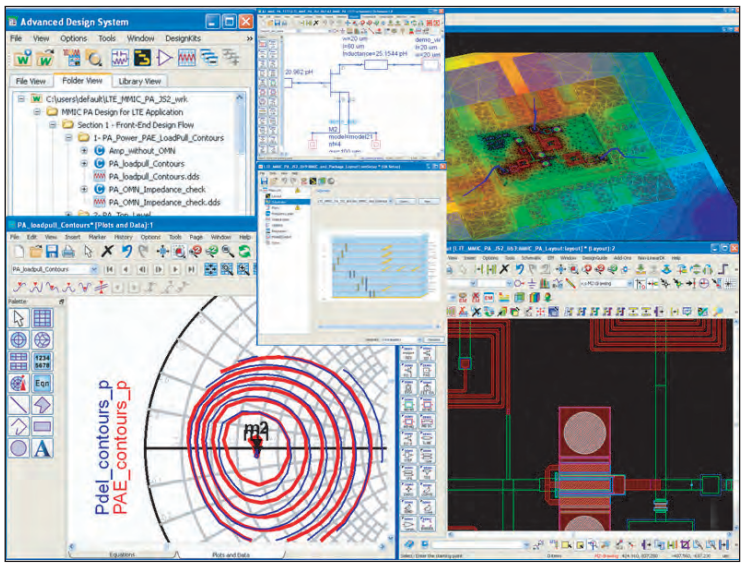
Agilent launches ADS 2014, including simulation support for DynaFET model for III-V FETs

Agilent Technologies Inc of Santa Clara, CA, USA has launched the ADS 2014 version of the Agilent EEsof EDA Advanced Design System electronic design automation software for RF, microwave and signal-integrity applications. Designed to improve design productivity and efficiency with new technologies and capabilities, ADS 2014 is the software's most significant ADS release to date.

ADS 2014 provides new technologies, new capabilities and continued enhancements for silicon RFIC, MMIC, RF printed circuit board, and multi-technology RF module design.

Features include:

- Automatic electromagnetic (EM) simulation setup and design partitioning (which automates the removal of SMD and IC active devices, and placement of ports, then reconnection of the design 10x+ faster and with 20x+ fewer mouse clicks).
- Physical layout-versus-schematic (LVS) with device recognition and an innovative module-level LVS that uncovers multi-technology wiring and pin-swap errors.
- Wireless verification test benches that provide circuit design verification solutions for the newest and most challenging multi-band, wide-bandwidth standards (LTE, LTE-A and 802.11ac) with a simplified user interface.
- Improved layout interconnect design and editing capabilities, including new power and ground planes with smoothing and thermal relief, new intelligent vias and interconnect routes.
- Controlled Impedance Line Designer for quickly and accurately optimizing stack-up and line geometry for multi-gigabit-per-second chip-to-chip links.
- Silicon RFIC schematic interoperability with Virtuoso for bi-directional schematic interoperability between ADS and Cadence Virtuoso.
- ADS Board Link, the next-generation printed circuit board integration solution for bi-directional transfer of layouts, schematics and libraries between ADS and enterprise PCB tools.
- Simulation support for Agilent's DynaFET model, an advanced neural network model for III-V FETs (GaAs and GaN), to accurately model the effects of trapping, de-trapping, and self-heating, in a single, global model, valid for all (active) applications, without the need for tuning.



ADS 2014 adds new technologies and capabilities to improve design productivity and efficiency.

ADS 2014 is expected to ship in first-quarter 2014. Pricing starts below $9900.

www.agilent.com/find/eesof-ads2014

Momentive expands manufacturing capacity for tantalum carbide coatings

Momentive Performance Materials Quartz Inc (MPM) has increased and expanded its manufacturing capacity of tantalum carbide coatings (TaC) in response to the growing demand for silicon carbide (SiC) power devices and the increased need for improved dimensional control for gallium nitride (GaN) LEDs. TaC coatings are used in metal-organic chemical vapor deposition (MOCVD) systems for the production of GaN and SiC devices.

With the expansion, MPM has the capability to produce up to 750mm-diameter parts, compared with the previous 500mm limitation. The diameter increase can help to enable next-generation SiC epi tools and can provide improved dimensional control for the current GaN tools now using alternate protective coatings, says MPM.

MPM's TaC is manufactured using a proprietary coating process, which yields resistance to hot hydrogen during epitaxial processes. SiC coatings can start to decompose at 1200–1400°C, whereas TaC generally is stable to over 2000°C. Also, the coatings can provide what is claimed to be exceptional dimensional control and hence a uniform and conformal coating, even on wafer pockets and complex shapes.

MPM is an indirect subsidiary of specialty chemicals and materials provider Momentive Performance Materials Inc of Columbus, OH, USA.

www.Momentive.com

IN BRIEF

Order to refurbish production system

Riber has received a major order for the modernization of the fleet of R&D and pilot production MBE systems used by III-V Lab, the joint Alcatel-Lucent, Thales and CEA-Leti industrial research lab.

The order (included in Riber's backlog at end-December 2013) concerns the full refurbishment of a production system. This will help to increase III-V Lab's production capacity for optoelectronic and microelectronic components (destined for the telecoms and defense industries) while extending the system's lifetime.

The new order is Riber's biggest system upgrade project to-date, covering all functions and parts of the MBE production system. The firm says it also confirms its customer service strategy, which involves strengthening its technical and commercial organization and developing standard products for upgrading the installed base of production systems.

III-V Lab's mission is to perform R&D on components, from basic research to product development, exploiting synergy between technologies developed for the different markets addressed by Thales and Alcatel-Lucent (e.g. telecoms, space, defence and security).

III-V Lab also has the capacity to produce and sell components (epiwafers, processed wafers, modules) in small-to-medium quantities, as one of its main business development aims. Such capacity is adapted to flexibly address rapid market evolution, allowing partners (module or system makers, including Thales and Alcatel-Lucent) to have early access to components. In a second step, if larger quantities are required, the technology can be transferred to a partner with larger production capacities.

www.3-5lab.fr

Riber's full-year revenue falls 14% to €23.5m in 2013

but sales of MBE systems for research rise 9%

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has reported revenue of €13.2m for fourth-quarter 2013, up 23.4% on €10.7m a year ago. However, full-year 2013 revenue was €23.5m, down 14% on 2012's €27.4m. This was also slightly below the target of €24–26m, as a result of an order that was initially scheduled for 2013 being deferred. Nevertheless, Riber expects to record a profit for 2013.

In 2013, despite a sluggish economic environment, Riber benefited from its strategic positioning in research markets, compensating for a downturn in industrial markets due to excess capacity. Business with industrial customers represented just 4% of total revenue, down from 23% in 2012.

Compared with MBE system revenue of €19.4m in 2012 (€15.6m for research and €3.8m for production), MBE system revenue in 2013 is down 13% to €16.9m (all for research). Sales of systems to research customers are hence up 9% on 2012 (17 machines invoiced, versus 15 in 2012), as Riber is benefiting from growth in research projects for new optoelectronics or power electronics applications. No production systems were sold, compared with two in 2012, due to the current excess capacity in RF component manufacturing. Riber is hence focusing its activities on developing MBE for new applications.

The weak level of demand from industrial RF customers has affected production MBE service activities, for which revenue is down 44% from €1.2m to €0.7m. This has been offset by the development of sales of MBE cells and related accessories to other types of customer (up 33% from €1.3m to €1.8m), reflecting the impact of the commercial action plan rolled out at the end of 2012.

Sales of cells for industrial operators in the organic light-emitting diode (OLED) flat-screen and thin-film solar panel markets have remained low, following the slowdown in investment in both of these sectors due to the general environment. Revenue for services, accessories and cells fell 78% from €1.2m in 2012 to just €0.3m in 2013. However, Riber says that it has continued to strengthen its position in these high-potential markets by focusing on innovation (developing new ranges of cells) and technical and commercial proximity to the leading players (with Riber Korea being created in second-half 2013).

Total revenue for services & accessories fell 13% from €6m in 2012 to €5.3m in 2013. Total revenue for cells & sources fell 35% from €2m in 2012 to €1.3m in 2013.

As of the end of December 2013, the geographic breakdown of Riber's revenue was: Asia (45%), Europe (31%, including Russia) and the American continent (24%).

The order book at end-December 2013 totaled €7m, down 42% on €12.1m a year ago. However, with four research systems ordered in China, France and Belgium during Q4/2013, Riber saw a considerable improvement in orders compared with the previous three quarters (followed by an additional order recorded at the start of 2014 in the USA). Although for full-year 2013 systems orders are down 60% from €10.1m in 2012 to €4m, this includes five research MBE systems for delivery in 2014. Also, Riber is benefiting from orders for services and accessories rising by 63% from €1.7m to €2.8m. Orders for cells and sources are down 50% from €0.2m to €0.1m.

Riber will report its earnings for full-year 2013 on 3 April.

www.riber.com

McGill orders Veeco GENxplor R&D MBE system for nitride light-emitting and power electronic devices

Epitaxial deposition and process equipment maker Veeco Instruments Inc of Plainview, NY, USA says that McGill University in Montréal, Québec, Canada has ordered a multi-chamber GENxplor R&D molecular beam epitaxy system for its Electrical and Computer Engineering Department, as part of a research grant from Canada's Foundation for Innovation.

Launched last August, the GENxplor is a fully integrated system that deposits high-quality epitaxial layers on substrates up to 3" in diameter and is suitable for compound semiconductor research on a wide variety of materials including arsenides, nitrides and oxides.

The GENxplor will be used by Dr Zetian Mi and his team for the development of nitride materials in light-emitting and power electronic devices. Nitride materials have demonstrated significant advantages over traditional silicon-based power electronics devices using high power and high temperatures, notes Veeco. As a result, nitride materials are attracting investments to develop new devices and processes for this emerging market.

"We are excited about the impact that Dr Mi and his team will have on the development of more efficient power electronic devices using Veeco's new GENxplor," comments Jim Northup, VP, general manager for Veeco's MBE Operations. "The GENxplor, currently nominated for a CS Industry 2014 award, has quickly become the R&D system of choice for leading research institutions," he adds. "Its modular and flexible design allows multiple deposition chambers, which made it an ideal fit for McGill University."

GENxplor will be used by Dr Zetian Mi and his team for the development of nitride materials in light-emitting and power electronic devices

The GENxplor brings to market a low-cost, vertically oriented reactor. A single-frame cantilevered design with fully integrated electronics and controls not only reduces the footprint by 40% compared to other systems, it is reckoned, but also improves the usability, serviceability, and installation time. When coupled with Veeco's bellows-free retractable sources, the system allows for virtually uninterrupted operation, allowing users' more time to focus on research, says the firm.

www.veeco.com/genxplor
http://people.mcgill.ca/zetian.mi
www.innovation.ca

IN BRIEF

VPEC places repeat Aixtron system order for microwave epi

Deposition equipment maker Aixtron SE of Aachen, Germany has announced a new order from long-standing customer Visual Photonics Epitaxy Co Ltd (VPEC) of Ping-Jen City, Taiwan for two further AIX 2600G3 IC MOCVD systems fully equipped to handle seven 6-inch substrates (7x6") in a single run. Pure-play epitaxial wafer foundry VPEC placed the order to expand its microwave epiwafer volume production. The systems have been installed by Aixtron's local Taiwanese office.

"Our RF microwave device business operation unit will be using the new systems to support our latest capacity expansion designed to meet ever higher demand," says VPEC vice president Neil Chen. "We have been using the AIX 2600G3 for more than 10 years now, with our last multiple systems order having been completed in 2010," he adds. "This last production capacity addition has put us in the solid commercial position to invest once more in Aixtron's high-quality equipment."

VPEC chose the systems due to their robustness and extended uptime, along with high throughput. "Aixtron excels at supplying equipment with these features, along with prompt service and process support, all of which are vital for our successful business," Chen comments.

"Driven by the demand for mobile phones and Wi-Fi, the need for RF power amplifiers based on compound semiconductor heterojunction bipolar transistors (HBTs) continues to rise, and microwave device makers are presently adding MOCVD production capacities," notes Aixtron's VP Southeast Asia Dr Christian Geng.

www.aixtron.com

Oxford Instruments receives cluster system order from Glasgow University

UK-based etch and deposition system maker Oxford Instruments says that it has recently received a multi-million pound order for a complex deposition and analysis cluster system from the James Watt Nanofabrication Centre at the University of Glasgow in Scotland (which houses over £22m of nanofabrication tools in a 750m^2 cleanroom run as a pseudo-industrial operation by 14 technicians and 4 PhD-level research technologists). The system will enable development to improve the energy-efficiency performance of electronic and optoelectronic devices for a large range of applications. Through its Plasma Technology and Omicron Nanoscience businesses, Oxford Instruments' Nanotechnology Tools business sector was able to provide the broad range of technologies necessary for this 'Powerhouse' multi-chamber and multi-function system.

The Oxford Instruments four-chamber cluster system combines: Plasma Technology's FlexAL atomic-layer deposition (ALD) tool for depositing very thin films of metals, oxides and nitrides using both thermal and inductively coupled plasma (ICP) ALD processes, a PlasmaPro System100 ICP for etching compound semiconductor materials, and a PlasmaPro System100 ICP for high-density plasma-enhanced chemical vapour deposition (PECVD) system providing low-damage, low-temperature thin films; plus the Omicron Nanoscience NanoSAM LAB for surface-sensitive chemical analysis and high-resolution imaging of small (micro and nano)-structures by scanning Auger microscopy (SAM) and scanning electron microscopy (SEM).

These systems will be combined in a unique configuration, and under vacuum, allowing device manufacturing and characterization measurements to be performed on device interfaces and surfaces without exposure to atmosphere.

The cluster system will be used in projects that aim to develop applications and improve the efficiencies of electronic and optoelectronic devices, and aid in the reduction of ICT energy consumption and carbon emissions. Projects include 'Silicon compatible GaN power electronics' developing energy-efficient power electronics, and 'Scalable solar thermoelectrics and photovoltaics' where the objective is to dramatically reduce the cost of large-scale exploitation of solar energy and hence massively decrease the carbon dioxide emissions associated with electrical and thermal power generation.

"We chose Oxford Instruments' systems for a number of reasons: our long and successful collaboration history, Oxford Instruments was the manufacturer who could integrate an analysis chamber with sub-10nm resolution for chemical analysis (essential for many nanodevices), and also because of the very strong third-party recommendations we received about the capability of their ALD system," comments professor Douglas Paul, director of the James Watt Nanofabrication Centre @ Glasgow. "We are looking forward to the extensive research opportunities this system will enable," he adds.

"Our group of businesses offers the research community the opportunity to integrate a range of our high-technology fabrication and analysis tools, rather than having to approach multiple suppliers," says Mark Sefton, sector head for Oxford Instruments Nanotechnology Tools. "Longer-term benefits are that our dedicated process, service and support team will be able to offer Glasgow University the cohesive process applications and system support on the entire system that they will require."

www.jwnc.gla.ac.uk

Showa Denko doubles high-purity ammonia production capacity in China

Annual capacity in Japan, Taiwan and China increased from 5000 tons per year to 6000 tons per year

Tokyo-based Showa Denko K.K. (SDK) has increased the production capacity for high-purity ammonia at its manufacturing subsidiary in Zhejiang Province, China, from 1000 tons per year to 2000 tons per year. The expanded facility started operation in January.

High-purity ammonia is used for nitride film deposition in manufacturing liquid-crystal display (LCD) panels and light-emitting diodes (LEDs). While LEDs are used for general lighting and backlights for LCDs, the LED market in China is growing for new applications such as landscape lighting and large screens, in addition to general lighting. SDK says that it has hence strengthened its supply system to meet the growing demand for high-purity ammonia in East Asia, where electronics production sites are integrated.

SDK operates three high-purity ammonia plants, one each in Japan (the 1500t/y Kawasaki Plant in Kawasaki City), Taiwan (the 2500t/y Taiwan Showa Chemicals Manufacturing Co Ltd in Tainan City) and China (the 2000 t/y Zhejiang Quzhou Juhua Showa Electronic Chemical Materials Co Ltd in Quzhou City, Zhejiang Province). After the capacity expansion in China, SDK now has a total high-purity ammonia production capacity of 6000 tons per year (as of 31 January). Previously, in second-half 2011, SDK increased capacity from 3000tpy to 5000tpy.

SDK says that it has strengthened its supply system to meet the growing demand for high-purity ammonia in East Asia

Under its consolidated business plan PEGASUS Phase II, SDK classifies the semiconductor-processing high-purity gas business as a 'Growth' business. SDK will hence aim to further globalize the business this year, strengthening its production/distribution system in Asia and expanding sales.

www.sdk.co.jp

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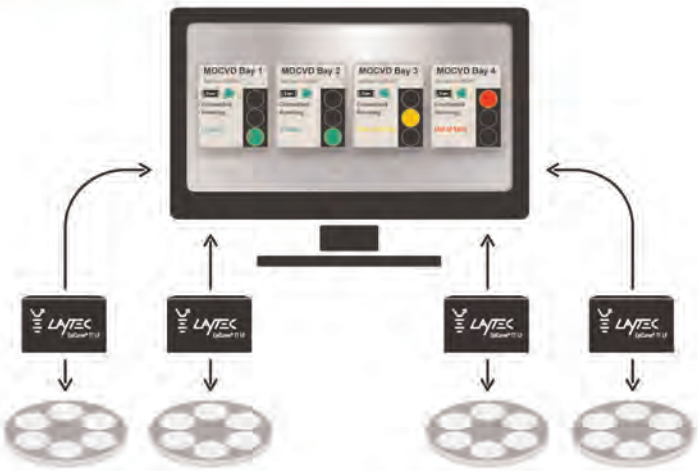

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IN BRIEF

SPTS promotes COO

Plasma etch, deposition and thermal wafer processing equipment maker SPTS Technologies Ltd of Newport, Wales, UK has promoted Kevin Crofton to president, along with his current role of chief operating officer (COO).

Crofton has over25 years of senior management experience in the industry and was instrumental in forming and growing SPTS, serving as executive VP and COO.

"This change is in recognition of Kevin's contributions to SPTS since the formation of the company in 2009, and his stellar performance in managing the sales & service, product lines and factory operations," says CEO William Johnson. "SPTS has improved customer satisfaction metrics, delivered operational excellence in the factories, and gained customers and market share each year," he adds.

www.spts.com

OIPT appoints vice president of sales & service in USA

UK-based etch and deposition system maker Oxford Instruments Plasma Technology (OIPT) has appointed Andrew McQuarrie as VP of sales & service in the USA.

McQuarrie has more than 28 years of experience in semiconductor and related high-technology businesses, including Surface Technology Systems, Lam Research and Applied Materials, as well as previous employment with Oxford Plasma Technology.

OIPT says that McQuarrie has a track record throughout this period of establishing, developing and leading businesses, with an in-depth understanding of the technologies employed. Key objectives are to further develop the firm's North and South American business, in industrial and research markets, leading the sales and service teams and establishing relationships with significant current and potential customers globally.

Andrew McQuarrie.

"The USA is clearly a key territory for Oxford Instruments," says Dr David Haynes, OIPT's global sales and service director. "We have a highly skilled workforce dedicated to growing our business, and through Andy McQuarrie's experience of business development and leadership across a range of international technology companies, we intend to improve further on the success we have achieved so far."

www.oxford-instruments.com

Oxford Instruments and IEMN co-hosting workshop on MEMS and NEMS processing

UK-based etch and deposition system maker Oxford Instruments says that 'Nanoscale Processing for NEMS and MEMS' is the topic for its next technical workshop, being hosted in conjunction with the Institute of Electronics Microelectronics and Nanotechnology (IEMN) in Lille, France on 8 April.

Aimed at scientists working in research and manufacturing with an interest in MEMS and NEMS, the one-day interactive technical seminar is designed to keep participants abreast of the latest technologies and trends in these industry research topics. Presentations will include research results from guest speakers, process and application talks and advice, and hints and tips from the experts at Oxford Instruments.

Talks will include:

- Micro-electro-mechanical systems (MEMS) — how to make the macro-world smaller;
- Nanoscale etch;
- MEMS research applications and results — IEMN;
- Looking towards the next generation of MEMS devices — a leading research organization;
- Atomic layer deposition (ALD) for MEMS — Eindhoven University;
- ALD research and results — Guest speaker.

The Indian Institute of Technology (IIT) in Bombay hosted Oxford Instruments' most recent Workshop last December. "Events such as this are an excellent opportunity not just for our researchers at IIT Bombay to learn about latest techniques but also for our colleagues outside this establishment to network and keep up to date with scientific advances," comments IIT's professor V.Ramgopal Rao.

"We organize an annual series of technical events worldwide, with extremely informative talks from a diverse range of speakers," says Oxford Instruments' sales & marketing director Dr David Haynes.

The technical seminar is designed to keep participants abreast of the latest technologies

"They are a great means of finding out about new techniques and meeting colleagues facing the same challenges and opportunities in an informal setting."

www.oxford-instruments.com

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IN BRIEF

Evatec enhances gallium arsenide PVD processing capabilities in US fab

Evatec Ltd of Flums, Switzerland, which makes thin-film deposition and etch processing equipment for semiconductor, MEMS, optical and optoelectronic applications, has delivered multiple RADIANCE cluster sputter tools to a major US gallium arsenide (GaAs) fab supplying products to the RF industry.

The tools support expansion of the fab's 6" GaAs production requirements, enabling implementation of new bump metallization and high-fill-ratio barrier layer processes leading to significant cost savings. Evatec says that it was chosen for its high throughput and superior process stability, leading to increased yield and reliability performance.

RADIANCE is a sputter tool that can be configured for multiple technologies on a single platform. 'Single' process modules can be configured for physical vapor deposition (PVD), plasma-enhanced chemical vapor deposition (PECVD) or inductively coupled plasma (ICP) etch, whilst a six-process-position 'BATCH' module can be equipped for sputter and etch processes, allowing for in-situ processes on the same platform.

The RADIANCE flexibility - combined with process knobs such as substrate rotation, target-to-substrate distance and in-situ metrology capabilities such as optical monitoring - makes the tool a suitable choice for development and production facilities across a wide range of market applications from compound semiconductors to optoelectronic applications, says Evatec.

www.evatecnet.com

SAMCO to buy 90% stake in plasma cleaning system maker UCP

Liechtenstein office to give to better access to Germany, France and Italy markets

SAMCO Inc of Kyoto, Japan, a supplier of plasma etch, chemical vapour deposition (CVD) and surface treatment systems to compound semiconductors device makers, has agreed to purchase 90% of the issued shares of plasma cleaning system maker UCP Processing Ltd (a wholly owned subsidiary of Büchel Holding of Ruggell, Liechtenstein). UCP founded in 2003 (when it became independent from Balzers & Leybold AG). As of December 2013, it had fewer than 10 directors and employees, and annual revenue of just over CHF2m.

Founded in 1979, SAMCO has been primarily engaged in manufacturing thin-film deposition (PECVD), etching (ICP, RIE, DRIE) and surface treatment (plasma and UV-ozone cleaning) process equipment for compound semiconductor production, especially applications such as LEDs and power devices. The firm has been focused on expanding its product sales internationally, and currently has direct sales and service offices in the USA, China, Taiwan, South Korea, Singapore, and Vietnam. Furthermore, SAMCO has been seeking to establish sales and/or service offices in Europe.

The acquisition of UCP will lead to the establishment of a SAMCO office at UCP in Liechtenstein, in central continental Europe, giving it better access to customers in three key European markets: Germany, France and Italy.

SAMCO also foresees synergy, as both SAMCO and UCP have experience in the manufacture and sale of plasma cleaning systems. After the acquisition, SAMCO plans to sell its products (e.g. plasma etching and CVD systems) using UCP's existing sales network in Europe.

The acquisition is expected to be finalized by the end of April.

www.ucpgroup.com
www.samcointl.com

MEI wins first order from Taiwan, for batch copper and titanium wet etch of 200mm compound semiconductor or MEMS wafers

MEI Wet Processing Systems and Services (a subsidiary of MEI LLC) of Albany, OR, USA has received an order from a Taiwan-based customer for its advanced etch solution, based on MEI's Revolution Wet Processing System, a semi-automated rotary tool for batch wet processing (etch or solvent) for semiconductor and micro-electromechanical system (MEMS) applications.

The shipment marks MEI's entrance into the Taiwanese market. The wet bench will be used for copper etch and titanium etch wet chemical processing of 200mm compound semiconductor or MEMS wafers.

"This is a prime example of the advanced etch applications market that MEI specializes in supporting," says sales manager Ed Jean. "Most wet process equipment suppliers tend to focus on either single-wafer processing or generic equipment sales," he adds. "There is a real need for semiconductor processing solutions that focus on challenging applications solutions, and MEI Wet Processing Systems and Services is meeting these specialized application needs, including proprietary advanced etch, gold etch, InGaP etch and patented metal lift-off solutions."

www.meillc.com

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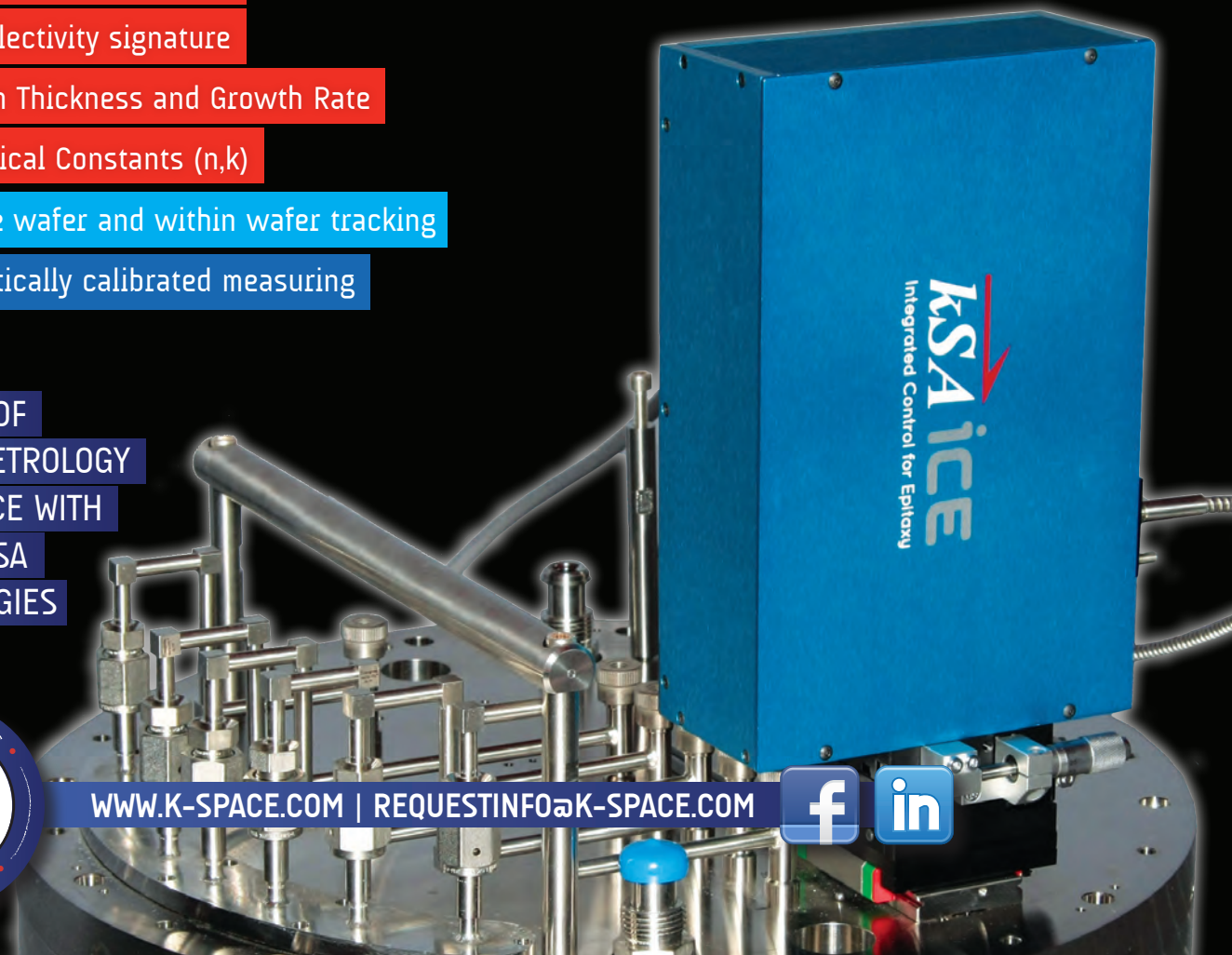

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Oerlikon Leybold launches TURBOVAC i range of pumps

At the 2014 PITTCON Conference & Expo in Chicago (2–6 March), Oerlikon Leybold Vacuum is presenting the new TURBOVAC i product line of turbo-molecular pumps with integrated drive electronics, offering the highest performance even for widely differing requirements, it is claimed.

Through their extra compression stage, the TURBOVAC 350 i and 450 i are suited to ultra-high-vacuum applications and for integration within compact pump system solutions. Offering a pumping speed for light gases that is up to 60% above that of comparative products, it is claimed, and a compression level about 100 times higher than previous-generation products, the pumps were designed especially for processes with small backing pumps. Designed with classic rotors, the TURBOVAC T 350 i and T 450 i have high gas throughput, fast run-up time and insensitivity to particulates, and are hence optimized for process applications and high gas loads.

The TURBOVAC 350-400 i Multi Inlet pumps have been developed specifically to meet the requirements of analytical instrumentation by offering an extremely high degree of flexibility and allowing the customization of the number, height and position of the vacuum connections. Also, there is the option of adapting the pump housing or customizing the pump to a specific vacuum chamber.

The new pumps have the best ratio between performance and size in the ISO 100- and 160-range, it is claimed. Rotors and Holweck stages have been optimized. "The result is excellent vacuum performance and a previously unattainable pumping speed. This accelerates pumping especially in connection with light gases," says Dr Martin Füllenbach. The maintenance and oil-free hybrid bearings with lifetime lubrication are reliable and durable, making regular maintenance by way of oil changes superfluous.

The bearing system ensures low-vibration and low-noise operation, making it less demanding with respect to applications that are sensitive to vibrations. The ceramic ball bearings are replaceable on-site, if necessary. The optimized thermal design of the TURBOVAC i ensures optimum cooling of the bearings. To protect the bearings against critical gases or particles, all pumps have been equipped with a purge gas connection, increasing not only significantly service life but also system uptime in general.

The TURBOVAC i family offers numerous options for a wide range of different requirements. Both the 350 i and 450 i are available with an additional inter-stage port, allowing pumping down of an additional chamber.

To keep installation, operation and maintenance as simple as possible, the TURBOVAC i is equipped with a rotatable vacuum flange connection, integrated drive electronics with direct 24/48V_{DC} supply as well as a flexible communication interface with USB, RS 485 and digital I/O ports. Additional interface options are available upon request.

The new product line is supplemented by a flexible and comprehensive range of accessories, including cost-effective power supplies for 100–240V mains supplies (either on-board or stand-alone), adjustable air or water cooling units, heating jackets, venting and purge gas accessories (actively controlled, passive) as well as installation and mounting kits that readily assist commissioning.

www.oerlikon.com/leyboldvacuum/en

Edwards launches large-capacity turbo pump with improved gas flow and high-temperature management

Edwards Ltd of Crawley, UK has launched the STP-iXA4506 large-capacity turbomolecular pump (TMP), designed to deliver significant savings for cost-sensitive manufacturers of semiconductors, flat-panel displays, LEDs and solar panels.

"The new STP-iXA4506 turbo pump is the all-in-one solution with improved pumping performance," says TMP product marketing manager Shinichi Yoshino. "It pairs Edwards' latest rotor design with the well-established, highly reliable, on-board controller of the iXA series to maximize the allowable gas throughput and hence minimize the number of pumps required for high-flow processes, particularly in solar and flat panel applications," he adds. "The fully integrated controller eliminates the need and cost of cables and a separate controller rack, resulting in a compact package that is fast and easy to install in a variety of applications," he claims "Like all of our magnetically levitated turbo pumps, the absence of mechanical bearings practically eliminates the cost of periodic maintenance."

The pump's high speed (4300l/s N_2) and throughput (up to 4300sccm N_2), combined with its ability to efficiently pump both light and heavy gases, make the STP-iXA4506 suitable for a wide range of large-volume, high-flow applications, including semiconductor etch and solar physical vapor deposition (PVD). Its tightly integrated design includes a completely sealed electronic module for robust, reliable operation in the most demanding factory environments, says Edwards. When needed, a thermal management system can be added to reduce the accumulation of deposits and particulates from process byproducts.

www.edwardsvacuum.com

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Rubicon grows for a third consecutive quarter, driven by LED general lighting and non-LED mobile applications

PSS, 6" adoption & move into 4" polishing to drive growth in wafers

Rubicon Technology Inc of Bensenville, IL, USA (which makes monocrystalline sapphire substrates and products for the LED, semiconductor and optical industries) has reported revenue of $41.5m for full-year 2013, down 38% on $67.2m for 2012.

However, for the fourth-quarter, although still almost halved from the peak of $20.1m a year ago, revenue was $11.5m, up 3.6% on $11.1m last quarter (rising for a third consecutive quarter).

Overall demand for sapphire continued its rebound with the growing momentum of the general lighting segment of the LED market and demand from non-LED applications for mobile devices (such as the sapphire home button on the iPhone 5S, as well as the sapphire camera lens cover and dual flash now being adopted by more smartphone makers).

Despite this, revenue for finished optical products plus R&D activities was $1.6m, down from $1.9m last quarter due to lower R&D revenue.

Revenue from 2" and 4" sapphire core sales was $9.2m, up 28% on $7.2m last quarter. Half of the growth came from another sequential increase in pricing and the other half came from increased volume. Capacity for producing cores has been operating at near full utilization for the past few quarters but, after adding some core fabrication capacity towards the end of Q3, the firm was able to increase volumes, allowing it to fabricate and sell all crystals produced in a given period regardless of the mix of products ordered. "While pricing for 2" and 4" cores is still very low compared with historical pricing, the steady rise in price throughout most of 2013 has brought the pricing for 2" and 4" cores back to around breakeven levels," says chief financial officer Bill Weissman.

Higher revenue from cores was largely offset by revenue from wafers dropping from $2.1m last quarter to $800,000. This was due to sales for the sapphire-on-silicon (SoS) market falling from $1.8m to just $500,000. "The lower revenue was due to the excess sapphire inventory and technology changes at our SoS customer," notes president & CEO Raja Parvez.

Rubicon began increasing utilization of its crystal growth facilities last quarter, and those facilities are now operating at full capacity. Reduced idle plant costs (down from $3.9m last quarter to $3.3m) and higher pricing for 2" and 4" core products, offset in part by the impact of lower wafer sales and higher development costs, resulted in an improvement in gross loss of $507,000 (from $6.3m to $5.8m). "The majority of our negative gross margin in 2013 resulted from idle plant costs associated with low utilization of our manufacturing facilities," notes chief financial officer William Weissman.

While pricing for 2" and 4" cores is still very low compared with historical pricing, the steady rise in price throughout most of 2013 has brought the pricing for 2" and 4" cores back to around breakeven levels

Operating expenses were $3.2m, slightly higher than $3.1m last quarter. But, due to the improvement in gross margin, operating loss was cut by about $600,000 sequentially to $9m. On a non-GAAP basis, net loss was $5m, cut from $5.8m last quarter.

Capital expenditure (mostly on PSS infrastructure) is down from $4m last quarter to $1.4m. During the quarter, cash and short-term investments fell only slightly, from $36.6m to $35m (with no debt). "We raised an additional $40m in January through the sale of common stock in order to ensure that we can expand capacity as the market strengthens," notes Weissman.

"A significant amount of the pressure on earnings continues to come from idled plant cost associated with low utilization, but that is changing," says Parvez. "We have just completed the re-starting of all of our crystal growth furnaces and we expect to see significant increases in wafer production over the course of this year, which will continue to lower our idle plant costs," adds Weissman.

"While wafer revenue was low in the fourth quarter, we continued to make good progress on our patterned sapphire substrate (PSS) and polished wafer initiatives," says Parvez. "We announced the introduction of the PSS product in October and we have already received requests for samples from 16 different customers. In the fourth quarter, we shipped PSS wafers to nine of these customers," he adds. "Based on the progress we have made in the past quarter, we're confident in delivering our target PSS revenue of at least $15m in 2014," Parvez notes.

"We have decided to move into 4" wafer sales in addition to selling 4" cores for two reasons," says Parvez. "First, while our plan for offering pattern substrates was primarily focused on the developing 6" market, we decided to offer 4" PSS, therefore, to increase utilization of the patterning infrastructure until the 6" market expands. Second, since we will be polishing 4" wafers for internal PSS operation, we decided to offer 4" polished wafers in order to increase utilization at our polishing operation in Malaysia, again until the 6" demand increases," he adds.

"We received our first production order of 4" polished wafers for the first quarter and expect orders ►

from existing customers of 6" LED wafers to begin picking up in the second quarter," Parvez continues. "We're also seeing an increased interest among LED chip manufacturers and a possible shift to 6" substrates now that their utilization rates are relatively high...Most chip manufacturers that move to a 6" platform will likely move directly to purchasing patterned 6" wafers as opposed to wafers that are just polished," he adds. "Wafer revenue growth should accelerate in the back half of the year as we qualify PSS customers, see an increase in 6" polished wafer orders from existing customers, and gain market share in 4" polished wafers."

"In the past several quarters we have seen a meaningful improvement in the demand for sapphire, with steady price increases as a result," Parvez notes. "Based on our conversations with others in the market, we believe that trend will continue this year," he adds. "The seasonality of the LED backlighting market however has temporarily slowed the growth over the past couple of months, and therefore we expect first quarter pricing for 2" and 4" cores to be similar to pricing in the prior quarter. Wafer orders will begin to increase starting in the first quarter and should accelerate during the remainder of the year."

For first-quarter 2014, Rubicon expects revenue to rise to $13m. Wafer revenue will be a larger proportion of total revenue, but there will be development costs associated with the new wafer orders, which will reduce margins in the near term. However, a reduction in idle plant costs by at least $400,000 (due to running at full utilization in the crystal growth for nearly the entire quarter — ahead of schedule) should offset much of that impact, so operating loss should be similar to Q4/2013.

"I have been to Asia several times already this year, and everyone I have spoken with in the industry expects strong demand this year and believes that the more moderate demand that we have seen so far in the first quarter is due primarily to seasonality," says Parvez.

We also saw some rationalization of the competitive landscape, with a number of new entrants at various parts of the sapphire supply chain exiting the market after recognizing that they could not effectively compete

"In 2014 we will see continued strengthening of the demand for sapphire from both the LED and mobile device market," believes Parvez. "Both of these market drivers are in their infancy and we expect very strong growth from these applications for years to come," he adds.

"We also expect strong growth in our wafer business this year with the positive early feedback on PSS, greater 6" adoption, and our move into 4" polishing," Parvez says. "As we move into production volumes, wafer costs will continue to come down," he adds.

"Reduction of the idle plant cost associated with our polishing operations will happen gradually over the course of this year as wafer volumes increase. With the improving factory utilization and pricing improvement, we expect considerable improvement in margins this year," Parvez continues.

"We also saw some rationalization of the competitive landscape, with a number of new entrants at various parts of the sapphire supply chain exiting the market after recognizing that they could not effectively compete," notes Parvez.

www.rubicon-es2.com

Rubicon shows large-diameter patterned substrates at LED Korea

Rubicon Technology Inc of Bensenville, IL, USA (which makes monocrystalline sapphire substrates and products for the LED, RFIC, semiconductor and optical industries) showcased its large-diameter patterned sapphire substrates (PSS) — launched last October — as well as its line of 6"polished sapphire wafers for LEDs at LED Korea 2014 (12–14 February).

Technology innovation is helping companies in the LED supply chain prepare for dramatic growth in LED lighting, says Rubicon. Most high-brightness LED makers etch a pattern into the sapphire wafers in order to both improve epitaxial growth and extract more light from each chip. Patterned sapphire substrates have been available for purchase in smaller diameters, but Rubicon claims to be the first to offer highly customizable 6" and 8" PSS. Rubicon is providing LED chip makers with a ready-made source of PSS in 4", 6" and 8"-diameters to serve the needs of the rapidly growing LED general lighting industry.

"As the world's most experienced provider of 6" sapphire wafers, Rubicon is uniquely positioned to drive the evolution of substrates – patterning large-diameter sapphire substrates," claims says president & CEO Raja M. Parvez. "This advance helps LED manufacturers gain the efficiency of larger diameters, combined with the industry's most precise patterning capability," he adds.

Rubicon offers fully customizable sub-micron patterning capability with tight dimensional tolerances (within ±0.1µm). The firm adds that, with an edge exclusion zone as small as 1mm, it offers more usable area to maximize the number of chips per wafer. Patterning is available in a range of shapes including cone, dome and pyramid, and in a range of orientations.

www.rubicontechnology.com

ALSI becomes ASM Laser Separation International

Laser dicing systems maker now a subsidiary of ASM Pacific Technology

Laser dicing systems maker Advanced Laser Separation International (ALSI) N.V. of Beuningen, The Netherlands is to continue its existing business (including relationships with key customers, suppliers and other partners) as ASM Laser Separation International (ASM ALSI) B.V. after becoming a subsidiary of ASM Pacific Technology Ltd (ASMPT).

Richard Boulanger will continue as managing director of ASM ALSI, and all key employees of ALSI have expressed their commitment to continue with ASM ALSI, says the firm.

Listed on the Hong Kong Stock Exchange, ASMPT is 40% owned by wafer processing equipment maker ASM International N.V. (ASMI) of Almere, The Netherlands, and is the world's largest assembly & packaging equipment supplier for the semiconductor and LED industries, as well as the world's third largest SMT equipment supplier.

ALSI's laser dicing technology is based on patented multi-beam laser technology. Systems are installed worldwide and are used for the dicing or grooving of LED, RFIC, T&D (transistor and diode) and IC applications.

ASM ALSI says that being a subsidiary of ASMPT group brings the ALSI business both the financial and technological strength that it needs to move to the next phase of expansion and development.

"The multi-beam laser technology developed by ALSI offers customers unparalleled value," comments ASMPT's CEO WK Lee. "With the strong sales and service network of ASMPT, we can help to bring unique value to many customers at much faster pace," he adds.

ALSI introduced multi-beam laser technology and has developed unique processes for dicing gallium arsenide (GaAs), transistors and diodes, and high- and ultra-high-brightness LEDs. It has now introduced the Matrix Grooving Process for the IC market.

"ASMPT's excellent reputation and global sales and service network will accelerate our market penetration, especially for the grooving market as well as our other established markets," believes Boulanger. "It will also increase our level of commitment and support to our customers."

www.alsi-international.com
www.asmpacific.com

GT licenses Kyma's PVDNC technology for low-cost, epi-ready LED wafer production

GT Advanced Technologies Inc of Nashua, NH, USA (a provider of polysilicon production technology as well as sapphire and silicon crystal growth systems and materials for the solar, LED and electronics markets) has acquired exclusive rights from Kyma Technologies Inc of Raleigh, NC, USA for its plasma vapor deposition process technology and know-how.

The PVD of nano-columns (PVDNC) technology developed by Kyma deposits a high-quality growth initiation layer of aluminium nitride (AlN) on wafers prior to gallium nitride (GaN) deposition. GT plans to commercialize a PVD tool that will complement its hydride vapor phase epitaxy (HVPE) system, which is currently in development (after in February 2013 entering development and licensing agreements with Soitec of Bernin, France to develop, manufacture and commercialize a high-volume, multi-wafer HVPE system). The combined offering is aimed to provide LED makers with a higher-throughput, lower-cost solution to produce GaN templates on patterned or planar wafers. GT already has a high-volume prototype tool incorporating Kyma's PVDNC technology and expects to offer a production-ready tool in first-half 2015.

"Kyma's innovative 'nano-columnar' PVDNC technology adds an important component to our expanding LED product base," says president & CEO Tom Gutierrez. "Our goal is to offer a range of solutions that improve the quality and lower the cost of LED manufacturing. The combination of GT's PVD AlN tool, coupled with the HVPE system we are developing, is expected to offer LED manufacturers a lower-cost solution to producing epi-ready wafers compared with today's current manufacturing techniques," he adds.

GT plans to commercialize a PVD tool that will complement its HVPE system currently in development

"Through years of innovation and production of AlN templates, we are convinced of the real and demonstrated benefits of nano-columnar AlN films to the LED industry," comments Kyma's president & CEO Keith Evans.

Currently, GaN deposition on epi-wafers is done in slower and more expensive metal-organic chemical vapor deposition (MOCVD) tools, says GT. By using the combined PVD and HVPE processes to create low-cost GaN templates, LED makers will be able to increase the throughput of their existing production lines and lower their capital expenditures because they will need fewer MOCVD tools, reckons the firm.

www.gtat.com
www.kymatech.com

Plessey orders ALSI laser dicing tool for GaN-on-Si LEDs

Laser dicing systems maker Advanced Laser Separation International NV (ALSI) of Beuningen, The Netherlands has received an order for a laser dicing system from Plessey Semiconductors Ltd for its LED manufacturing facility in Plymouth, UK.

"An essential process step to achieve our cost and LED performance targets is the singulation of the finished wafer into LED dies," says Plessey's chief technology officer Dr Keith Strickland. "ALSI demonstrated their experience in dicing and proved in short turn-around time to be able to meet our challenging process, cost and delivery requirements. ALSI's multi-beam process will be key to the back-end processes to be included in the fabrication line in Plymouth," he adds.

"Plessey has introduced and started to commercialize new GaN-on-Si LEDs and we are very pleased that Plessey selected our system to support the roadmap for lowering the cost of LEDs," says Rene Hendriks, ALSI's director of commerce. "Once more the multi-beam demonstrated to be able to dice wafers with high productivity while requiring very narrow dicing streets, allowing high wafer yield for such small devices on very fragile base material."

Plessey develops and manufactures semiconductor products used in sensing, measurement and controls applications. The products are found in a wide range of markets including communications, medical, defense, aerospace and automotive. The firm has started to commercialize low-cost high-brightness LED products, and also plans to develop a range of smart-lighting products that incorporate Plessey's existing sensing and control technologies.

ALSI's laser dicing technology is based on patented multi-beam laser technology. Systems are installed worldwide and are used for the dicing or grooving of LED, RFIC, T&D (transistor and diode) and IC applications.

www.alsi-international.com
www.plesseysemiconductors.com

3D-Micromac laser micromaching tool maker acquires Jenoptik's thermal laser separation dicing technology

As part of an asset deal, as of 1 January, Jenoptik of Jena, Germany has transferred expertise, patents and results relating to thermal laser separation (TLS-Dicing) technology developed by its Laser & Materials Processing Division to 3D-Micromac AG of Chemnitz, Germany (which has supplied laser micromachining systems as well coating and printing technologies since 2002), enabling immediate commercialization.

3D-Micromac says that the acquisition reinforces its know-how as a provider of laser systems in the semiconductor industry and advances the expansion of its product portfolio in this area. Jenoptik's Laser & Materials Processing Division will continue to focus on the 3D processing of plastics and metals (e.g. in the automobile industry).

"With TLS-Dicing we obtain a technology that will perfectly complement our product portfolio in the semiconductor industry and enable us to expand our market position," believes 3D-Micromac's CEO Tino Petsch. "In addition to component processing at wafer level, we can now also offer innovative solutions for separating of microchips," he adds. "In the coming months, we will continue to further develop the process in co-operation with the Fraunhofer IISB [Institute of Integrated Systems and Device Technology) in Erlangen, Germany] and implement it in industry-ready machine technology," he continues.

"Jenoptik's Laser & Materials Processing Division has increasingly focused on its core markets and sharpened its portfolio in recent months," notes Dietmar Wagner, general manager of JENOPTIK Automatisierungstechnik GmbH. "With 3D-Micromac AG we have found a buyer for TLS-Dicing, which wants to successfully commercialize the technology in the shortest possible time."

The method is suitable for most brittle materials, including silicon, silicon carbide, germanium and gallium arsenide wafers

TLS-Dicing (thermal laser beam separation) is used in the semiconductor industry's back-end to separate semiconductor wafer in components. A laser heats up the material locally and a cooling medium cools it down immediately afterwards. The thermally induced mechanical stress leads to a complete cleaving of the wafer.

The method is suitable for most brittle materials, including silicon, silicon carbide (SiC), germanium (Ge) and gallium arsenide (GaAs) wafers. Compared with traditional separation technologies, TLS-Dicing yields clean, micro-crack-free edges and hence greater bending strength, it is claimed.

Process speeds of 200–300mm/s are possible and generally lead to a multiplication of throughput.

High throughput and wear-free processing offer great potential for reducing production costs and cost of ownership, comments 3D-Micromac.

http://tls-dicing.com
http://3d-micromac.com
www.jenoptik.com/lm

IN BRIEF

Vishay launches AlInGaP power LEDs emitting 4900mcd

Vishay Intertechnology Inc of Malvern, PA, USA has launched a series of power MiniLEDs in ultra-compact 2.3mm by 1.3mm by 1.4mm SMD packages. Using the latest AlInGaP technology, the VLMx234.. series provides luminous intensity of 3500mcd (typical) and 4900mcd (maximum) at a drive current of 70mA, while delivering improved thermal performance compared to previous-generation LEDs.

The high-intensity LEDs provide low thermal resistance junction/ambient of 325K/W and power dissipation up to 200mW, which in turn enables high drive currents up to 70mA. The devices' small size and high luminous intensity suit automotive applications. Offered in 900–2240mcd super red (630nm) and 1400–3550mcd red (625nm), amber (616nm) and yellow (589nm) colors, the AEC-Q101-qualified LEDs are usable for interior and exterior lighting, dashboard illumination, indicators and backlighting for A/V and industrial equipment, LCD switches and symbols, and illuminated advertising.

VLMx234 devices feature a ±60° angle of half-intensity and a luminous intensity ratio per packing unit of less than 1.6, and are categorized, per packing unit, for luminous intensity and color.

Available in 8mm tape, the LEDs are compatible with IR-reflow soldering processes and preconditioning according to JEDEC Level 2a, and offer an ESD-withstand voltage up to 2kV according to JESD22-A114-B.

Samples of the new LEDs are available now. Production quantities were made available in December, with lead times of six weeks for larger orders.

www.vishay.com

SemiLEDs' quarterly revenue levels out; rebound expected next quarter

Lighting product revenue rises 25% sequentially

For fiscal first-quarter 2014 (to end-November 2013), LED chip and component maker SemiLEDs Corp of Hsinchu, Taiwan has reported revenue of $3.4m, down 45% on $6.2m a year ago but level with last quarter.

However, LED chip, component and lighting product sales comprised a greater proportion of total revenue than last quarter. Revenue from LED chips rose 6% sequentially (comprising 29% of total revenue, up from 27% last quarter). Revenue from LED components rose 4% sequentially (comprising 34% of total revenue, the same as last quarter). Revenue from lighting products rose 25% sequentially (comprising 36% of total revenue, up from 29% last quarter).

While R&D expenses have remained steady at $1.1–1.2m, selling, general & administrative (SG&A) expenses have been cut further, from $3.7m a year ago and $2.9m last quarter to $2.6m. Total operating expenses have hence fallen further, from $4.9m a year ago and $4.1m last quarter to $3.8m.

Due to the reduction in revenue and an excess capacity charge for LED chips and LED components, gross margin was negative 68%, worse than the negative 53% a year ago. However, this is an improvement on negative 103% last quarter.

"We are encouraged by the progress we have made in the most recent quarter," says chairman, president & CEO Trung Doan. "While we are still in the early stages of executing on our strategy, the sequential improvement in gross margin demonstrates the initial impact of our efforts."

On a non-GAAP basis, net loss has been cut further, from $8.6m a year ago and $7.3m last quarter to $5.8m.

Cash used in operating activities has risen further, from $3.3m a year ago and $4.7m last quarter to $5.4m. However, capital expenditure has been cut from $1.7m a year ago to just $483,000. Also, SemiLEDs paid about $1.6m as partial payment for an LED component production line and related products and technology acquired last quarter (prior to an additional payment of $450,000 in December). Hence, total cash burn (free cash flow) has risen from $4.9m a year ago to $5.9m. During the quarter, cash and cash equivalents fell from $36.3m to $28.1m.

"Starting almost a year ago we made a conscious decision to refocus our business on profitable segments within niche LED markets such as UV and specialty lighting (e.g. architectural)," says Doan. "Given the level of chip commoditization in high-volume markets such as back-lighting and general illumination, we have chosen to focus our effort on selected markets where we can also differentiate solutions and generate a higher margin," he adds. "As a part of this strategy we are also focused on developing greater value-added products such as components and lighting solutions. While we are still in the midst of executing on our strategy, we believe the combination of focusing on niche market opportunities and the greater value-add products will allow us to substantially improve our gross margins and bottom line."

We are also focused on developing greater value-added products such as components and lighting solutions

For fiscal second-quarter 2014, SemiLEDs expects revenue to rebound to $4–5m. Gross margin is expected to continue to be negative, as SemiLEDs will not fully utilize its production capacity. However, net loss should be cut slightly.

www.semileds.com

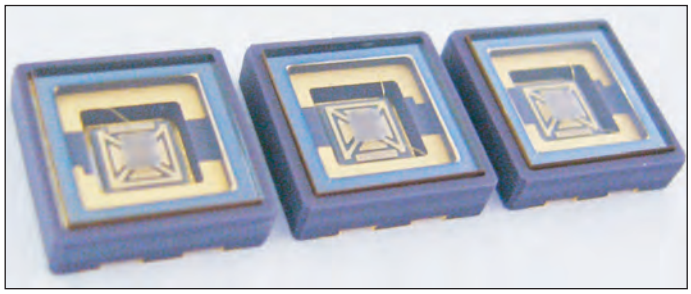
Nikkiso setting up deep UV LED production plant

UVB and UVC illumination sources being exhibited at Photonics West

Tokyo-based Nikkiso Co Ltd, which is developing and commercializing deep ultraviolet (UV) LEDs, says that it is establishing a new factory in Japan's Ishikawa Prefecture. The firm aims to start production in mid-2014 and install annual capacity in excess of 1 million units for its UVB and UVC illumination sources.

Nikkiso introduced its new deep UV LED product line for the first time in North America at SPIE Photonics West 2014 in San Francisco (4–6 February), exhibiting products with wavelengths of 255–350nm, including several power levels and package types to enable key applications in a wide variety of sectors. Those with immediate demand include surface curing of resins and inks, biomedical instrumentation, dermatology, air purification, and water and surface sterilization.

Nikkiso says that proprietary aluminium gallium arsenide (AlGaN) technology allows its UVB and UVC LEDs to offer substantial advantages over UV lamps, including mercury-free operation, compact and lightweight form factor, flexible emission wavelength, directional illumination, instantaneous analog power control via current modulation, and low-voltage operation. Power levels up to 40mW per package are available, with customized multi-chip assemblies capable of emitting more than 1W. The devices can be used in standalone light sources, or integrated seamlessly as OEM components into end-customers' final product solutions.



Nikkiso's deep UV LED package.

Nikkiso's new factory has a total floor area of 1500m^2 and production technology that enables mass manufacturing on a commercial basis. This includes new epitaxial equipment, wafer fabrication, and clean room facilities for volume manufacturing of deep UV LEDs.

Representing a $22m investment in Nikkiso's deep UV LED business, the firm says that the production plant will ensure the stable supply of deep UV LED products to its partners, accelerating the development of deep-UV LED applications.

www.nikkiso.com

Seoul Semiconductor reports record revenue of 1 trillion Korean Won in 2013, driven by LED lighting

Driven by both growth in the IT and lighting sectors, in 2013 South Korean LED maker Seoul Semiconductor Co Ltd surpassed 1 trillion Korean Won in annual revenue for the first time, reaching a record 1.0321 trillion Korean Won (up 20% on 2012). Operating profit was 965,000m Korean Won (up by 190% on 2013).

Following the boom of the LED lighting market, Seoul Semiconductor has grown sales by focusing on Acrich2 LED modules (claimed to be the first LEDs driven by alternating current) and steady-selling products such as mid-power and high-power packaged LEDs. Revenues have been increased in America, Europe, China, Japan and many other countries, the firm adds.

Applying patented Black Hole Lens technology to direct-type LEDs for TVs in the IT sector, Seoul Semiconductor has increased IT-related sales. In addition, sales of tablet-PC-related products also present tangible evidence of their rise in the market, says the firm.

After being listed on the Korea Stock Market (KOSDAQ) in 2002, another contributing factor to reaching 1 trillion Korean Won in sales after 12 years (since the company was founded in 1987) is the establishment of a patent portfolio consisting of more than 11,000 patents. Seoul Semiconductor invests about 10% of revenue each year in LED product R&D. The firm was also the sole LED device maker to be ranked on the Institute of Electrical and Electronics Engineers (IEEE)'s Patent Power ranking in 2012 and 2013.

Since the establishment of its subsidiary Seoul Viosys (formerly Seoul Optodevice) in January 2002, Seoul Semiconductor has produced LEDs through vertical integration of the entire manufacturing process, from chips to packages to modules. The firm says that, to better manage the fast-growing LED lighting market due to trends in global incandescent manufacturing as well as policies of usage prohibition and energy reduction, it has procured various products in all categories of LED lighting and is currently supplying products to lighting companies worldwide.

For first-quarter 2014, Seoul Semiconductor expects revenue of 240–260bn Korean Won and 6–8% operating profit (a conservative estimate, considering the annual low season in the IT industry).

www.seoulsemicon.com/en

Samsung boosts efficacy of chip-on-board LED packages and adds 3500K version to LC series

South Korea's Samsung Electronics says that, using its phosphor technology and chip fabrication techniques, it has raised the light efficacy for its chip-on-board (COB) family of LED packages to what is claimed to be the highest in the industry. The LC013B, LC026B and LC040B feature a compact light-emitting surface (LES) with high light output that is designed for use in high-performance LED products.

The improved COB-type LC series offers a light efficacy of 130lm/W at a correlated color temperature (CCT) of 3000K and 143lm/W at 5000K with a color rendering index (CRI) of over 80. This represents a significant improvement from the light efficacy of 120lm/W at 3000K and 129lm/W at 5000K, respectively, that Samsung has been offering with its LC series since April 2013.

Samsung's LC series is also Zhaga-compliant, making the packages convenient for assembling most LED lighting products. Samsung's latest LC series is hence expected to be applied in a wide range of interior LED lighting applications, including downlights, spotlights and directional retrofits such as MR/PAR lamps.

In addition, by leveraging the chromaticity control standard 3-step MacAdam ellipses, the LC series offers high color uniformity and light quality, claims Samsung. The packages also provide low thermal resistance and superior heat dissipation (which enable high reliability) and have completed LM-80 testing (the test method for lumen maintenance developed by the Illuminating Engineering Society).

The LC series has been available in 2700K, 3000K, 4000K and 5000K versions, with a 3500K version now added. Samsung's latest LC series also offers a diversity of wattages (13W, 26W and 40W versions, depending on the particular LED product with which the packages are used).

The LC013B, LC026B and LC040B with improved light efficacy are available on the market in February and will be updated to have a CRI above 90 in first-half 2014.

www.samsung.com

Samsung introduces LED components for advanced mobile devices

South Korea's Samsung Electronics Co Ltd has introduced a range of LED components for use in advanced mobile devices such as smartphones and tablets.

The LEDs include two reflector-integrated flash LED packages — 3432 1.8t (FH341A) and 3432 1.4t (FH341B) — plus a flip-chip flash LED 2016 (FH201A), as well as two side-view LEDs — the 3810 0.6t (MS062F) and 3810 0.8t (MS082F).

The new LEDs were showcased at the Mobile World Congress 2014 in Barcelona, Spain (24–27 February). Samsung will start mass producing the new mobile-market LEDs in March, which are likely to then begin appearing in the open market in second-quarter 2014.

Reflector-integrated flash LED for high-end mobile devices

Because high-quality smartphone cameras require a wider FOV (field of view) angle for better picture quality, Samsung's new reflector-integrated flash LEDs are designed to enable great flexibility by providing a wide FOV within a small space through the integration of a light source, a lead frame, and a reflector with its own optics and diffusion features.

Of the latest LED mobile offerings, Samsung's new 3432 1.8t (FH341A) reflector-integrated flash LED delivers over 165 lux at 1A and minimum CRI (color rendering index) of 80. The 3432 1.8t is being used in the next Galaxy smartphone, for introduction in February.

Also new to the reflector-integrated flash LED line-up, the 3432 1.4t (FH341B) is designed specifically for mobile OEMs seeking extra-slim LED solutions. The 3432 1.4t package includes a reflector and is only 1.4mm thick, suiting smartphones and tablets thinner than 7mm. In addition, it provides minimum illuminance of 165 lux.

Standard flash LED with high light quality

The new standard flash LED 2016 (FH201A) applies Samsung's proprietary cell-film phosphor technology to flip-chip packages, which applies a thin film of phosphor to each package. Providing design flexibility, Samsung's first 2016-sized flash LED package offers 220lm output and improves color deviation by about 40% compared with packages using Samsung's previous technology that dispensed phosphor onto each chip. This more affordable LED solution also offers a high level of color quality (rare to traditional flash LED products).

High-brightness side-view LEDs

The 3810 0.6t (MS062F) and 3810 0.8t (MS082F) side-view LEDs feature high color reproducibility, due to their high brightness levels. Their packages are also power-efficient, operating on less than 2.9V.

The 3810 0.6t provides 3.1cd, while having a z-height of just 0.6mm, suiting slim smartphones and tablets. The 3810 0.8t offers more luminous intensity (3.2cd), with a 0.8mm thickness, making it suitable for tablet and notebook PCs.

www.samsung.com

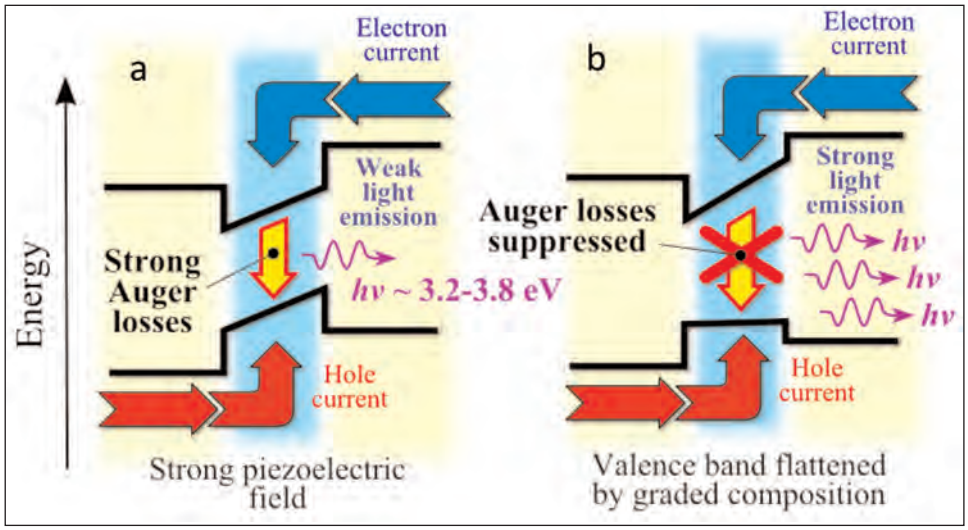
NRL-Technion-Ioffe team outlines roadmap to efficient green-blue-ultraviolet LEDs

Softening GaN/AlN QW confinement potential by varying alloy composition along growth direction expected to suppress piezoelectric field that enhances Auger-induced droop

Scientists at the US Naval Research Laboratory (NRL) have suggested a method that could significantly increase the efficiency of green-blue-ultraviolet LEDs based on GaInN/GaN, AlGaN/GaN and AlInN/GaN quantum wells. It is reckoned that their approach could enable advances in solid-state lightening and the creation of low-threshold lasers and high-power LEDs (Applied Physics Letters, 25 January 2014 and 26 November 2013 issues).

Epitaxial perfection in the growth of quantum wells has been the key to achieving light-emitting diodes and laser diodes of superior power, efficiency, and performance. Ternary group-III nitride LEDs based on GaInN/GaN, AlGaN/GaN and AlInN/GaN quantum wells now find widespread application in energy-efficient as well as decorative solid-state lighting. But their use in high-power lighting applications is currently hindered by a significant loss in efficiency, even at modest electrical currents, notes NRL. Indeed, the quantum efficiency of the LEDs peaks at relatively low currents — a few tens of amperes per square centimetre — and then steadily drops, by almost half, as the current increases. This droop in efficiency is observed in the visible, blue, as well as ultraviolet spectral regions.

Scientists at NRL's Center for Computational Materials Science, in collaboration with researchers at the Technion, Israel, and Ioffe Physical-Technical Institute, Russia, have created computational models showing that the observed droop effect arises from non-radiative Auger recombination of the injected carriers. The rate of the Auger recombination is proportional to the cube of the carrier concentration.



Schematic of processes responsible for LED operation. Thick black lines show energy band diagram of conventional (a) and proposed (b) LEDs based on GaN / AlN QWs. In conventional GaN / AlN QW LEDs the GaN layer's polarization field strongly enhances the non-radiative Auger rate, leading to a reduction in photoluminescence quantum yield and hence to efficiency droop with increasing electric current. In the proposed LEDs (b) the electric field acting on holes in the QW is compensated by a gradual composition variation of the variable-gap GaAlN alloy, resulting in a flat valence-band potential. Auger processes are suppressed and no droop effect is expected. (Photo: U.S. Naval Research Laboratory)

As a result, the non-radiative Auger decay rate grows rapidly with current density, quenching the generation of light.

To suppress these non-radiative Auger processes, one needs to create quantum wells with a soft confinement potential. Dr Alexander Efros, a senior researcher in NRL's Materials Science and Technology Division, previously showed theoretically that a softened electrostatic potential prevents carriers from acquiring the momentum needed for non-radiative Auger processes, and thus suppresses the Auger decay rate. This concept was patented by NRL in March 2013. The latest calculations by the NRL–Technion–Ioffe research team demonstrate that softening the confinement potential — by varying the alloy composition along the growth direction — also completely suppresses the piezoelectric field that normally enhances non-radiative Auger processes in GaN/AlN QWs. The calculations show that the droop effect in such quantum wells can be significantly or even completely suppressed.

A softened electrostatic potential prevents carriers from acquiring the momentum needed for non-radiative Auger processes

In addition to Dr Efros at NRL, research team members include Roman Vaxenburg and Efrat Lifshitz from Israel Institute of Technology, Haifa, Israel, and Anna Rodina from Ioffe Physical-Technical Institute, St. Petersburg, Russia.

www.nrl.navy.mil

Soraa unveils first full-visible-spectrum LED AR111 lamps

At the EuroShop event in Dusseldorf, Germany (16–20 February), Soraa Inc of Fremont, CA, USA, which develops solid-state lighting technology built on 'GaN on GaN' (gallium nitride on gallium nitride) substrates, displayed its new AR111 lamp.

The lamp is claimed to be the market's first full-visible-spectrum LED AR111, and targets the large lamp arena (e.g. retail lighting) with Soraa's uniform beams casting sharp single shadows.

"This year, we will expand our portfolio beyond our award-winning MR16 GU5.3 and GU10 lamps to create a full line of four-inch lamps powered by our GaN-on-GaN LED technology," says Nick Farraway, senior VP – International at Soraa.

At EuroShop, Soraa is displaying a full-visible-spectrum 8 Degree AR111 LED lamp, with a color rendering index (CRI) of 95 and R9 of 95. Available in June, it will have a peak luminous intensity of 27,500Cd and light output of 980 lumens (claimed to be the best in the market). Soraa will also offer 80-CRI AR111 lamps with a peak luminous intensity of 34,000Cd (twice that of the nearest competitor, it is claimed).

The high lumen density of the GaN-on-GaN LED enables the single source, high luminous intensity, and beam control that characterize all of Soraa's lamps, the firm says. The violet light in its full-visible-spectrum LED excites the optical brightening agents present in many white products, so whites appear brilliant rather than yellow and dull.

The AR111 lamp is dimmable, will be available in a wide range of color temperatures and beam angles, works in fully enclosed fixtures, and conforms to the IEC/ANSI AR111 form factor, ensuring compatibility with a broad range of fixtures. The 8 Degree AR111 lamp works with Soraa's SNAP system, a set of easy-to-use magnetic beam spreaders and color shifters that allows flexibility in design and display.

www.soraa.com

First high-color rendering, line voltage GU10 230V LED lamps

Soraa has launched what it claims is the first line of high color and white rendering, high-light-output LED GU10 230V dimmable lamps. Uniquely, the firm has released a 10° spot version (not available in halogen or from other LED makers, it says) as well as a 25° version that has a peak intensity higher than halogen and all other LED GU10 products. Transformer-free, full-visible-spectrum Soraa LED GU10 lamps are now available that render colors and whites without beam striations, artifacts or multiple shadows visible in other manufacturers' LED products, it is claimed.

The LEDs also offer full dimmability, long lamp life, improved energy efficiency, and compatibility, says CEO Jeff Parker. "All these features are made possible through our proprietary GaN-on-GaN LED technology and innovative lamp design."

With a color rendering index (CRI) of 95 and R9 greater than 90, Soraa's continuous full-visible-spectrum Vivid 2 LED GU10 lamps render deep reds and cyans accurately and have no artificial spectral 'blue-peak'. Also, like natural light, the violet component of the full

visible spectrum makes whites in fabrics and fibers stand out in their intended brightness and tint, the firm adds.

Soraa's GaN-on-GaN LEDs emit ten times more light per unit area of LED material than LEDs built on lower quality foreign substrates, the firm reckons. Its lamps hence have a single light source that casts a perfect beam and a single sharp shadow, bringing out textures and contrast.

"Customers no longer need a transformer and we've made available beam and output options that were previously unattainable in the market, because of limitations with all other technologies," says Parker. The products are suited to fully enclosed, non-ventilated fixtures, where other LED lamps struggle to perform, he adds.

Built with design flexibility in mind, Soraa's new LED GU10 lamps are available in a wide range of light output, beam angles and color temperatures. The Premium 2 LED GU10 10° lamp has a peak intensity of 7760Cd, and 2420Cd for the 25° option (twice that of halogen). The LED GU10 lamps are available in 10°, 25°, 36° and 60° beam angles and 2700K, 3000K, 4000K and 5000K color temperatures.

Also, the 10° lamp works with the firm's magnetic accessory SNAP System. With a simple magnetic accessory attachment, beam shapes can be altered and color temperature can be modified, allowing endless design and display possibilities, it is claimed.

The new LED GU10 lamps are compatible with a wide range of dimmers, having been tested and characterized through the Works with Soraa program. Also, the firm's novel heat-sink design and thermal management system make its lamps suitable for use in fully enclosed, non-ventilated fixtures, damp locations and outdoor applications.

The existing Soraa VIVID 2 and Premium 2 LED GU10 lamps are also available in 120V versions.

Bridgelux names former Cree and Micron technologist Cem Basceri as chief technology officer

Bridgelux Inc of Livermore, CA, USA, vertically integrated LED manufacturer of solid-state light sources specifically for lighting applications, says that semiconductor industry veteran Dr Cem Basceri (previously on the firm's advisory board) has joined its executive staff as chief technology officer, overseeing technology and product development programs.

Basceri's charter will be to propel innovation, provide technology vision, drive technology differentiation and strategic technology investments, and increase intellectual property (IP) development. His aim is to fuel core technology programs and advance fast-cycle product creation; delivering efficient, high-performance and cost-effective product solutions, helping the firm to increase expand into new markets. Basceri will also be responsible for driving Bridgelux's fabrication partnership with Tokyo-based semiconductor manufacturer Toshiba Corp and additional joint technology development activities related to this critical partnership around gallium nitride on silicon (GaN-on-Si) technology optimized for solid-state-lighting (SSL) applications.

"Basceri's recruitment to the company further re-enforces both Bridgelux's strategy and leadership in the convergence of LED and semiconductor technologies," reckons CEO Brad Bullington. "Our next-generation SSL solutions will leverage GaN-on-Si and high-scale, chip-centric packaging technology to drive dramatic cost reduction while delivering improvements in features and functionality to our products," he adds. "Basceri is well known in the industry as a pioneer of next-generation LEDs, and we look forward to aggressively driving our roadmap forward under his leadership."

Prior to joining Bridgelux, Basceri was senior director & chief technologist in Corporate Development and Corporate R&D at memory manufacturer Micron Technology Inc for more than 10 years, during which he was responsible for establishing and mapping out technology, business and IP development strategies for existing and new market opportunities. Additionally, he managed and directed technology and product development teams. He also managed Micron's Core Partnership Program at IMEC of Leuven, Belgium for 8-inch GaN Power and LED technology development programs. Most recently, Basceri's responsibilities included strategic M&A, partnerships, investments, divestitures and technology licensing deals within Micron's Corporate Development organization. He also served as chair of the Silicon & Systems Group's advisory board and business unit representative in Micron's TLP Global Technical Committee.

Previously, Basceri held management positions at Cree and Intrinsic Semiconductor, where he led wide-band gap (WBG) technology development programs. Basceri earned his Ph.D. degree in Materials Science and Engineering from North Carolina State University.

During his career, Basceri has conceived and designed many technology innovations, as evidenced by his 213 issued US patents. He has expertise in semiconductors and integrated solutions (including WBG technologies such as LED, SSL and Power/RF) and has published more than 25 technical articles in refereed journals.

www.bridgelux.com

Everlight's lab obtains EPA recognition and ILAC-MRA qualification for LED testing

Everlight Electronics Co Ltd (Taiwan's largest LED assembly manufacturer) says that its laboratory in Tucheng, Taipei has received the highest standard recognition by the US government agency Environmental Protection Agency (EPA). It was also simultaneously qualified to use the ILAC-MRA mark — the signet for Mutual Recognition Arrangement (MRA) of the International Laboratory Accreditation Cooperation (ILAC) — on its laboratory reports.

As a result, EPA qualification allows Everlight to publish its LM-80 reports themselves as of August 2013. ISO17025 says that it is rare that companies gain both ISO17025 and LM80 certifications at the same time. There are only 81 technologically equivalent certified authorities (third-party labs and companies) in 67 countries that have achieved the ILAC-MRA status.

LM-80 testing is the main criteria for LED lighting components to ensure lumen maintenance after 6000 hours of operation. LM-80 is also an essential document to apply for Energy Star certification of a lighting product. Several Everlight Lighting LED ranges have already completed LM-80 6,000 testing so far, including low-power (PLCC 3020), mid-power (PLCC 5630), high-power (2323 and 3535) and COB (chip-on-board) LED series. Official test reports are available upon request.

In 2014, Everlight plans more LM-80 testing to demonstrate the durability and consistency of its LED lighting products and to provide quality confidence to customers.

www.everlight.com

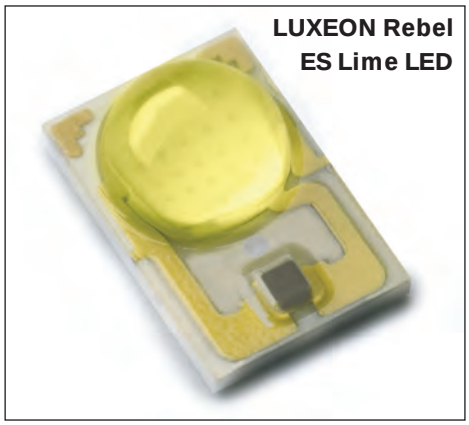
Lumileds launches LUXEON Rebel ES Lime emitters with 200lm/W efficacy for tunable white light

Philips Lumileds of San Jose, CA, USA says that Lime, the newest addition to its LUXEON color portfolio of LEDs, enables lighting designers to take the next step in delivering tunable white light in bulbs and fixtures.

LUXEON Rebel ES Lime is the proprietary LED technology in the Philips hue bulb, where it combines with LUXEON Rebel Red-Orange and Rebel Royal Blue emitters to deliver more than 16 million color options — all controlled from an iOS device. Philips hue can use color-tunable Light Recipes to help set mood and energy level in the home, office, retail, classroom and hospital environments.

"LUXEON Rebel ES Lime emitters can be combined with other Rebel color and white emitters to achieve higher CRI [color rendering index] and R9 combinations than any previous-generation emitters or arrays," says Rahul Bammi, VP of product management.

Lime is the highest-efficacy LUXEON LED manufactured to date. It hence enables highly efficient color mixing by providing a convenient above-blackbody color point with optimal standalone efficiency of 200lm/W at 350mA and 85°C. The spectral output is closely aligned with the wavelength to which human eye cones are most sensitive (555nm). "Customers are very interested in Lime due to the outstanding efficiency and flux it brings to every lighting application," says Bammi.



LUXEON Rebel ES Lime LED

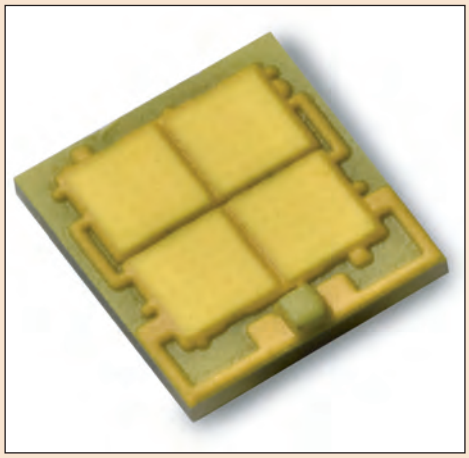
In addition to LUXEON Rebel ES, the Lime technology is offered in the LUXEON Z format, an undomed, 2.2mm^2 LED that is 75% smaller than most high-power LEDs, it is reckoned. In spotlight and downlight applications, the LUXEON Z enables tighter packing density and better color mixing control, the firm says. The LUXEON Z Lime can be combined with Red and Blue LEDs to achieve a broad spectrum of saturated colors. Alternatively, tunable white light with high efficacy can be achieved over 1800–6500K along the blackbody curve.

Because Lime is closer to the blackbody curve than green LEDs, much less inefficient red is needed to make white light with Lime instead of green, especially at warmer color temperatures, notes Lumileds. For instance, color tuning of 2250–2950K can be achieved with an R9>90, CRI>90 and efficacy of 90lm/W using LUXEON Z combinations. When using a similar combination of Red, Green and Blue LEDs to create 3000K white light, the CRI is close to 20.

LUXEON MZ doubles lumen density and center-beam candle power

Philips Lumileds of San Jose, CA, USA says that its newest high-power LED, the LUXEON MZ, enables the creation of tighter beam angles with higher lumen density at a lower cost than was previously possible, delivering optical control in a 600–1000lm package. Also, due to its design compatibility with the proven LUXEON M emitter, outdoor, industrial and area lamps as well as spotlights and downlights can benefit from faster qualification and time to market, says the firm.

"With the LUXEON MZ in combination with LUXEON M, designers can create two solutions with one optic and one PCB, thereby lowering overall costs," says senior VP Emmanuel Dieppedalle. "Customers are already designing platforms with LUXEON M and LUXEON MZ to create multiple SKUs [stock keeping units] using less engineering resources."



Lumileds' new LUXEON MZ LED.

In an MR16 the new LUXEON MZ LED delivers 50,000 candela center-beam candle power (CBCP) compared with encapsulated emitters that only achieve half the beam intensity using the same sized optics, reckons Lumileds. Flood lamps that formerly required large optics now deliver the necessary brightness and range with smaller optics and off-the-shelf drivers.

The LUXEON MZ LED has a forward voltage of 11.2V, a small light-emitting surface of 4.2mm diameter, and an undomed design to deliver smaller beam angles. Lumileds is offering the emitter family across the full range of correlated color temperature (2700–6500K CCT) and color rendering index (70, 80, 90 CRI) options.

www.philipslumileds.com

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Cree grows 20% year-on-year to record $415m

Annual CapEx target raised from $120m to $145m to support new product priorities and to provide incremental capacity

For fiscal second-quarter 2014 (ended 29 December 2013), LED chip, lamp and lighting maker Cree of Durham, NC, USA has reported revenue of $415.1m, up 20% on $346.3m a year ago and 6% on $391m last quarter (and at the high-end of the $400–420m guidance), driven by strong growth in LED lighting fixtures and LED bulbs.

Specifically, by product sector:

- Power & RF product revenue was $26.4m, up 5% on $25.1m last quarter and 17% on $22.6m a year ago (remaining about 6–7% of total revenue). Power & RF product gross margin of 58% is up on 56.6% a year ago and 53.7% last quarter, due to higher sales, cost reductions and product mix.
- LED product revenue (LED components, LED chips and SiC materials) was $215m, on the lower end of the target range and down slightly on $218m last quarter, but up7% on $201m a year ago (though still falling from 58% of total revenue to 52%). LED product gross margin of 45.4% is up on 41.9% a year ago but down from 46.6% last quarter.
- Lighting product revenue was $173.7m, up 17% on $147.9m last quarter and 42% on $122.7m a year ago (rising from 35% of total revenue to 42%) — on the high end of the target range, driven by strong sales of both LED fixtures and LED bulbs. Although still down on 33.7% a year ago, Lighting product gross margin has risen from 26.9% last quarter to 27.9%, due to a combination of lower-cost new products, cost reductions and higher factory utilization.

Overall gross margin (on a non-GAAP basis) has fallen from 39.2% last quarter to 38.2% (slightly down on the expected 38.5%), reflecting the higher mix of Lighting products in overall sales (with lower margin than both LED products and Power & RF products).

Recent highlights include: releasing the LEDway High Output (HO) LED street light to address large multi-lane freeways and expressway applications, replacing inefficient high-pressure sodium (HPS) lighting up to 400W; introducing the CXB High-Bay LED luminaire (which halves energy consumption and nearly eliminates maintenance costs, making it a replacement for energy-wasting fluorescent and HID high-bay luminaires); launching the XLamp CXA 3590 LED array (to replace 250W metal-halide fixtures), delivering up to 16,225lm at 85ºC (68% more lumens compared to Cree's previous brightest array); and expanding the firm's product line with the new Cree LED 75W Replacement Bulb.

Despite the drop in gross margin, net income has risen further, from $36.9m a year ago and $47.3m last quarter to $56.8m. This exceeds the expected $44–50m due to the catch-up benefit from the award in November — under Phase II of the Advanced Energy Manufacturing Tax Credit (48C) program, initiated under the American Recovery and Reinvestment Act of 2009 (ARRA) — of up to $30m in federal tax credits (hence immediately earning credits on qualified capital investments made beginning in fiscal 2013 through fiscal first-quarter 2014).

Cash from operations was $98.8m, up from $69.2m last quarter. However, capital expenditures (for property, plant and equipment) have risen again, from $33.7m to $49.8m (again, excluding about $5m related to patents). Hence, free cash flow rose from $30.8m to $43.7m. During the quarter, cash and investments increased by $95.6m, from $1.024bn to $1.2bn, due to higher profitability, good working capital management, and proceeds from common stock issued in connection with option exercises.

This increase from the previous forecast is to make capacity investments to support forecasted growth

For fiscal third-quarter 2014 (ending 30 March), Cree expects revenue of $390–420m, with order backlog down quarter-on-quarter but in line with seasonal trends in LEDs and Lighting. In particular, LED component product sales should be seasonally down 5–7% due to the Chinese New Year holiday. Revenue should be level for Lighting products (as strong growth in fixtures is offset by lower LED bulb sales to Cree's channel partner as they look to balance inventory levels). Revenue should also be level for Power & RF products.

Despite this, due to operational improvement and a more favorable Lighting product mix offsetting the lower LED product sales, gross margin should rise slightly to 38.5%. Net income should be $42–51m.

For fiscal Q4/2014, the trends in the business suggest that Cree is in a good position to grow LED fixtures, LED bulbs and LED components, concludes the firm. "LED lighting remains a largely untapped opportunity and we plan to continue to make significant investments in new products, new channels and building the Cree brand to grow the company as we remain focused on our long-term customer goal of 100% upgrade to LED lighting," says chairman & CEO Chuck Swoboda.

"For fiscal 2014, we have raised our target to about $145m of property, plant equipment spending [from $120m] to support our new product priorities and provide an incremental capacity, as needed," says Swoboda. "This increase from the previous forecast is just to make capacity investments to support forecasted growth to the business over the next year."

www.cree.com

Cree named to MIT Technology Review's 2014 50 Smartest Companies list

Cree has been identified as one of 2014's 50 Smartest Companies in MIT Technology Review's annual list of the world's most innovative technology companies. Honorees are nominated by MIT Technology Review's editors, who look for companies that have demonstrated original and valuable technology over the last year, are bringing that technology to market at significant scale, and are clearly influencing their competitors. Companies on the list represent the disruptive innovations most likely to change people's lives.

"This issue celebrates organizations at the forefront, displaying 'disruptive innovation' that will prove to surpass the competition, transform an industry and change our lives," says publisher & editor in chief Jason Pontin.

Cree was selected because of its "transformational leadership in the lighting industry". The firm says that it has launched several products during the past year that have contributed to the changing LED lighting landscape. The Cree LED Bulb is claimed to work as good as or better than traditional incandescent bulbs at a price that gives consumers a reason to switch to LEDs. At $99, the XSPR LED street light delivered the benefits of LED lighting at up-front cost parity to traditional street lights. Most recently, Cree introduced SmartCast Technology, the first self-programming wireless lighting-control system to bring the energy-saving benefits of lighting controls to the masses with the touch of one button, at half the cost of traditional lighting controls.

"As the industry's only fully vertically integrated pure-play LED lighting company, this prestigious recognition validates Cree's long-standing belief that a cultural commitment to continuous innovation results in the creation of breakthrough products that transform markets," says David Elien, Cree's VP, corporate marketing & business development.

Cree and the other honorees are being featured in the March/April edition of MIT Technology Review (published online on 18 February).

www.cree.com/lighting

Cree appoints John Replogle to board

Cree Inc of Durham, NC, USA says that John Replogle, president & CEO of Seventh Generation (a manufacturer and distributor of sustainable household products) since March 2011, has been appointed to its board of directors, effective 28 January.

"He has a proven track record of successfully managing global companies and brands," comments chairman & CEO Chuck Swoboda.

Before joining Seventh Generation, Replogle was president & CEO of Burt's Bees Inc from 2006 to 2011 and general manager of Unilever's Skin Care division from 2003 to 2006. Prior to Unilever, he worked for Diageo Plc for seven years in various capacities, including as president of Guinness Bass Import Company and managing director of Guinness Great Britain. Replogle started his career with the Boston Consulting Group. He has also served as a director of Sealy Corp from 2010 to 2013.

Replogle has a Master of Business Administration degree in General and Entrepreneurial Management from Harvard Business School and a Bachelor of Arts degree in Political Science from Dartmouth College. He also serves on the board of trustees at Dartmouth.

www.cree.com

Cree demonstrates first 200lm/W LED luminaire

Cree Inc of Durham, NC, USA has demonstrated what it claims is the first 200 lumen-per-watt (LPW) LED concept luminaire (more than twice the efficiency of the best linear fluorescent luminaires).

The latest US Department of Energy projections (according to the DoE Solid State Lighting Research and Development Multi-Year Program Plan, 2013) had estimated that this level of luminaire efficiency would not occur until after 2020, but Cree says that its latest innovation has made this possible six years sooner than projected. The prototype leverages Cree's vertical integration via innovations in LED chips, optics, materials technology and novel system design.

The 3200 lumen concept luminaire delivered greater than 200LPW at 80 CRI (color rendering index) at thermal equilibrium while remaining within the ANSI color specification for 3000K. Cree reckons that the innovations behind the concept luminaire will enable the firm to deliver increased performance in LED luminaire applications at a lower cost to accelerate LED adoption.

"Demonstrating the industry's first 200 lumen-per-watt luminaire once again illustrates Cree's leadership in LED lighting," says Norbert Hiller, Cree executive vice president, lighting. "The innovation required to achieve this record performance will usher in a new era of increased performance, quality and affordability for our LED lighting customers."

www.cree.com/lighting

Cree launches 6000 lumen high-CRI LED module

Cree Inc of Durham, NC, USA claims that its new 6000 lumen LMH2 LED module is the industry's brightest module to offer color quality greater than 90 CRI (color rendering index) at a consistent efficacy of 85 lumens per watt across a wide range of color temperatures (3000K, 3500K and 4000K). The LED module is suitable as a replacement for 100-watt ceramic metal halide (CMH) lamps in high-ceiling applications, says Cree, as it uses 30% less power, lasts three times as long, and delivers instant-on, dimmable light.

"The need for high-CRI and high-lumen-output LED luminaires has been growing rapidly over the last year," comments Larry Rosenwinkel, fixtures and specifications manager at Facilities Solutions Group (FSG). "We constantly have requests for these luminaires to be used in shopping malls, airports, convention centers and theaters," he adds. "Before the introduction of the 6000 lumen Cree LMH2 LED module, there were no feasible LED solutions to light these spaces, but now we can specify LED light sources for these spaces."

Cree claims that the LMH2 family of modules delivers the only light source that can address such a wide range of lighting applications in a common form factor. This allows lighting manufacturers to create an entire product portfolio with just one set of tooling and one optical design. Lighting products based on the LMH2 LED module also enable lighting designers to illuminate a space with one light source and technology, helping to eliminate the problems that come with using different lighting technologies such as color consistency and re-lamping, adds Cree.

"We have designs based on the 850, 1250, 2000, 3000 and 4000lm LMH2 LED modules," comments said Wesley Johnson, director of national sales at Hi-Lite Manufacturing Company. "The 6000 lumen LMH2 will allow us to further expand the breadth of our products using the same form factor," he adds. "Our customers will now have a full suite of LED pendant lights and wall-mounted fixtures with the same high CRI, same color and same warranty that allows them to address a variety of ceiling height applications."

Lighting manufacturers looking to shorten the time to market for their luminaire design can also take advantage of Cree's LMD600 universal driver, which is designed to power the new 6000 lumen LHM2. Dimmable to 1%, the LMD600 is optimized for a controllable, indoor architectural environment. It can also handle a case temperature of up to 90°C and it has a low-voltage limited-energy (LVLE) driver rating that does not require special enclosures or large gauge wires, delivering design flexibility and a low system cost for lighting manufacturers. Cree also offers a range of reflectors and heat sinks, as well as a splice box for the entire LMH2 LED module family.

The complete LMH2 module family is available in a range of lumens (850–6000) and color temperatures (2700–4000K), delivering efficacy up to 108lm/W and a CRI greater than 90. These lighting characteristics, combined with multiple driver options including Digital Addressable Lighting Interface (DALI) and DALI touch dimming driver options, enable lighting manufacturers to expand their portfolio quickly and easily, says Cree. Designed for 50,000 hours of operation, the LMH2 module comes with Cree's five-year warranty. The LMH2 is also UL-recognized and complies with multiple international regulatory and safety standards. Luminaire makers seeking ENERGY STAR qualification will have access to specification and performance data (including LM-80 reports), which can speed regulatory approvals.

www.cree.com/lmh2

Cree launches 23,000 lumen high-bay LED luminaire

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has introduced the CXB High Bay LED luminaire, claimed to be the first LED fixture designed to compete directly with the 67 million traditional high-bay luminaires currently installed in North America.

Paying for itself in less than three years (calculated against 400W metal halide and based on commercial usage of 12 hours per-day and the national average of $0.11 per kWh electric costs), the CXB High Bay LED luminaire delivers 23,000 lumens and provides a combination of high performance and affordability, says Cree, eliminating the need for energy-wasting fluorescent and HID high bay luminaires. Suitable as a replacement for warehouse, industrial, education and other commercial high bay applications, it cuts energy consumption in half and nearly eliminates maintenance costs with what Cree claims is industry-leading price performance.

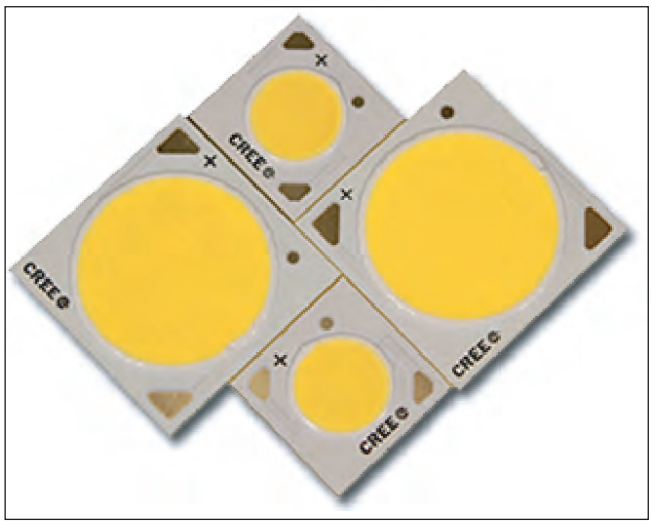
The CXB High Bay LED luminaire's design enables a low-profile luminaire at half the weight of incumbent technologies, it is said. Offering versatile mounting options for one-for-one replacement of up to 400W high-intensity discharge (HID) fixtures and multi-lamp fluorescent high bay luminaires, the new luminaire simplifies installation and reduces labor costs during its 70,000-hour rated lifetime. The CXB luminaire is backed by Cree's 10-year limited warranty.

www.cree.com/lighting/CXBSeries

Lumen density increased for XLamp CXA LED arrays

Cree has launched three new high-density XLamp CXA LED arrays. The CXA2590, CXA1850 and CXA1310 double the light output of existing standard-density CXA LED arrays without increasing the size. This increase in lumen density delivers what are claimed to be new levels of light intensity, which enables the complete replacement of ceramic metal halide (CMH) light sources, expands the possibilities of LED spotlights, and enables applications that could not be addressed by previous LED technologies.

By emitting more than 15,500lm from a 19mm light source, the CXA2590 enables luminaires with the same center-beam candlepower (CBCP) and light quality of a 150W CMH light source at lower power, longer lifetime and with better control. Delivering more than 9000lm from a 12mm light source, the CXA1850 enables lighting solutions with the same CBCP and light quality as 70-watt CMH while using half the power. The CXA1310 provides more than 2000 lumens in a 6mm light source, which allows lighting manufacturers to design smaller, more efficient track lights, reduce the size of halogen replacements by half, and deliver twice the CBCP of CMH at 30% less power.



A variety of Cree CXA LED arrays.

Cree claims that it offers the largest portfolio of integrated LED arrays, and the only portfolio of high-density LED arrays. Having multiple size and lumen output options from the extended CXA product family helps lighting manufacturers address a wide range of lighting applications from small-form-factor halogen and CMH to sports and stadium lighting.

Lighting manufacturers can also use the CXA's ability to increase light output without increasing size.

"Having access to such intense light sources without having to account for lots of variation in size is a tremendous benefit to our product design process," comments Seok-Ki Park, CEO of Hwang-Duck Engineering Co Ltd. "We have the flexibility to increase our design options while protecting our investment in ongoing product development."

Characterized and binned at 85°C, XLamp CXA LED arrays are available in ANSI White and EasyWhite color temperatures (2700–6500K) and color rendering index (CRI) options of 70, 80 and 95.

Samples of all three new high-density LED arrays are available now and production quantities are available with standard lead times.

www.cree.com/cxa

Cree introduces 90CRI ZR Series LED troffer for under $100

LED chip, lamp and lighting maker Cree Inc of Durham, NC, USA has launched the ZR Series LED troffer, which — featuring Cree TrueWhite Technology — has a color rendering index (CRI) of >90 in an ultra-slim package at an initial price of $99.

The ZR Series LED troffer halves energy consumption claims Cree and, with standard 0-10V dimming, can accelerate its already rapid two-year payback (calculated against a fluorescent three-lamp fixture - with lamp and ballast equal to 88 system watts - and based on typical commercial usage of 12 hours per day and $0.11 per kWh electric costs).

"It takes more than incremental improvements in performance to achieve widespread adoption of LED lighting," says Norbert Hiller, Cree executive VP, lighting. "Cree innovation starts with a clean slate, designing a new troffer with an attractive appearance that provides superior light quality, high efficiency and also enables fast installation," he adds.

Cree's ZR Series LED troffer

The ZR Series LED troffer's thin 3.9" height and lightweight design enables faster installation without costly ceiling alterations, says Cree. Offering a quick and easy one-for-one replacement of inefficient fluorescent troffers in education, healthcare and commercial building applications, the LED troffer simplifies installation and significantly reduces labor costs during its 75,000-hour lifetime in all 1'x4', 2'x4' and 2'x2' configurations, says Cree.

The ZR Series LED troffer is sold via Cree lighting sales channels throughout the USA and Canada.

www.cree.com/lighting/ZRSeries

Osram claimed to be first chip maker to switch red and yellow LED fabrication to 6” wafers

InGaAlP LED production capacity expanded

Osram Opto Semiconductors says that, to keep pace with constant market growth, it is switching its fabrication of red, orange and yellow light-emitting diodes to 6-inch wafers. The firm is therefore extending the fabrication of all large-wafer LEDs to the indium gallium aluminium phosphide (InGaAlP) material system and hence expanding its production capacity. The company began switching fabrication of blue LED chips to 6-inch wafers in 2011. Osram Opto claims to have also been the first manufacturer to switch all LED colors worldwide to 4-inch wafers many years ago, and is now continuing this approach with 6-inch wafers.

The latest switch involves chips for LEDs intended for a wide range of applications. Red and yellow LEDs are used in virtually every sector: as turn indicators, brake lights and interior vehicle lighting in the automotive sector, in displays, for projection, for signage and for color mixing systems in general illumination.

The assembly system at Osram Opto transporting a 6-inch wafer; 4-inch wafers can be seen on the left.

“Demand for light-emitting diodes in red, orange and yellow continues to grow,” says CEO Aldo Kamper. “We are keeping pace with this demand by being the first manufacturer in the world to switch fabrication to 6-inch wafers,” he adds. “The switch will involve all product families and was initiated at the start of the year. The red, yellow and orange chips will be fabricated at the company headquarters in Regensburg. Indium gallium nitride (InGaN) chips for blue, green and white LEDs are also produced there, as well as in Penang, Malaysia.”

Osram Opto says that experience from 6-inch wafer production so far has flowed directly into the current process – as have results from projects funded by the German Federal Ministry of Education and Research (the ‘GallEff’ project and the ‘Greight’ project for scaling InGaN wafers). Osram Opto is therefore pursuing its platform strategy and is already looking to the next stage in development as part of its research activities, namely even larger wafer diameters and alternative substrates. Promising projects are already under way in its laboratories and in other more general funded projects, says the firm.

www.osram-os.com

Yellow Oslon Compact LED launched for vehicle front turn indicators

Osram Opto Semiconductors GmbH of Regensburg, Germany says that its new yellow Oslon Compact LED opens up new design options for turn indicators in vehicle forward lighting.

With package dimensions of 1.5mm x 1.9mm x 0.7mm, the new version is small and yet so powerful that it is suitable for use in light guide applications. Based on indium gallium nitride (InGaN), the high-power LED offers output of more than 120 lumen even at high currents and application temperatures of 100°C (junction temperature, T_j, in the chip).

The yellow Oslon Compact is an addition to the two white versions of the Oslon Compact and is suitable for front turn indicators. Due to its compact design, it can be used in particular to create light guide solutions. Light guides themselves measure less than 10mm in diameter, so the LEDs have to make full use of the available area by being packed very close together. “For turn indicators or daytime running lights (DRLs), the new Oslon Compact is suitable especially for light guide solutions, just like the other members of the product family,” says Andreas Geistreiter, marketing LED Automotive at Osram Opto. “Thanks in particular to its high luminous efficacy and compact size, it represents a further step in the direction of miniaturization and greater freedom of design, opening up such possibilities as quasi-3D effects. This special design element is of huge interest in the premium automotive segment.”

The yellow light from the new LED is not generated directly but by ceramic conversion from a blue chip (C^3 technology). This, in combination with UX:3 chip technology, is behind the Oslon Compact’s high output and thermal stability — especially at high currents and temperatures. At room temperature and 700mA, the LED achieves a typical brightness of 140lm. At application temperatures of 100°C (T_j) the Oslon Compact still achieves 120lm.

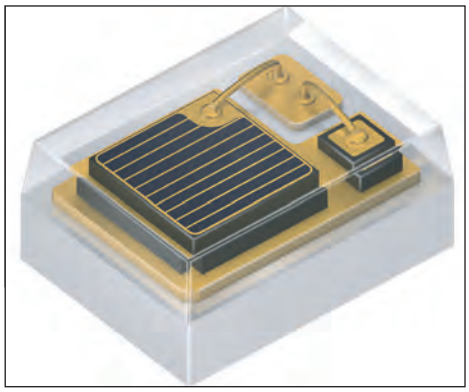
www.osram-os.com

Osram launches small mid-power infrared LED for industrial and machine vision applications

Osram Opto Semiconductors GmbH of Regensburg, Germany says that its new Oslon Compact SFH 4710 infrared light-emitting diode (IRED) closes the gap between high-power and low-power IREDs. Offering high output in a very small package (barely larger than the chip itself), it can be used for applications such as surveillance, digital image processing, 3D measurement, pattern recognition and gesture detection.

The SFH 4710 has been designed specifically for industrial applications. As a mid-power LED with typical optical output of 270mW from an operating current of 500mA, it offers an output range midway between Osram's Power TopLED and Oslon Black IREDs, rounding out the firm's IRED product range.

The new IRED includes a small but powerful chip with an edge length of 750µm — half the footprint of standard chips in the Oslon Black family. With package dimensions of 1.6mm x 1.2mm x 0.8mm, the Oslon Compact LED is claimed to be one of the smallest IREDs in its output class.



Osram's Oslon Compact SFH 4710 LED.

"Our new Oslon Compact has excellent heat dissipation properties and can operate at high currents," claims IR product marketing manager Sevugan Nagappan. "The high output is made possible with state-of-the-art thin-film chip technology and, combined with the small package, opens up numerous new applications, particularly where there is very little available space but performance demands are high," he adds. "If required, components can be packed very close together to increase the optical output with a high degree of flexibility."

If required, components can be packed very close together to increase the optical output with a high degree of flexibility

The infrared LED has an emission angle of ±65° and does not need internal optics or reflectors. Its light can however be successfully injected into narrow-angle external optics.

With external optics, it is suitable for illumination in surveillance applications and for machine vision tasks such as pattern recognition and 3D measurement, because the 850nm wavelength is barely perceptible to the human eye but can be easily detected by camera systems.

Without external optics, the IRED covers the near-field range of a few meters and is suitable for applications such as eye tracking and gesture detection, says the firm.

www.osram-os.com

Vishay releases 850nm IR emitter in top-view SMD package with integrated lens

Vishay Intertechnology Inc of Malvern, PA, USA has broadened its optoelectronics portfolio with the release of a 850nm infrared (IR) emitter in a compact 3.85mm by 3.85mm by 2.24mm top-view SMD package. Based on SurfLight surface-emitter chip technology and featuring an integrated lens, the VSMY98545 offers high drive current capability, high radiant intensity, and high optical power, while providing low thermal resistivity.

The new device has a 42mil x 42mil emitter chip that supports a low thermal resistance of 10K/W junction-to-pin and enables high drive currents up to 1A and pulses up to 5A. The emitter's integrated lens supports a ±45° angle of half intensity, resulting in ultra-high radiant intensity of 350mW/sr at 1A and 1600mW/sr at 5A (pulses). This is more than double the radiant intensity of devices without lenses, it is reckoned.

With high drive current capabilities and optical power to 660mW at 1A, the VSMY98545 can replace multiple standard SMD devices, allowing designers to reduce the component count and improve performance in a wide variety of applications, it is claimed. The emitter is optimized for IR illumination in CCTV, gaming and road cash systems, in addition to long-range proximity applications such as presence detection for wake-up functions in office equipment.

The new device offers fast switching speeds down to 15ns, low forward voltages down to 1.8V at 1A, and operating temperatures from –40°C to +95°C. The VSMY98545 ensures a shelf-life of 168 hours and provides a moisture sensitivity level (MSL) of 3 in accordance with J-STD-020, says Vishay. Supporting lead (Pb)-free reflow soldering, the device is RoHS-compliant and halogen-free.

Samples and production quantities are available now, with lead times of 8–10 weeks for larger orders.

www.vishay.com

Lehigh University crosses threshold for laser cooling by III-V semiconductor

The hardness, crystalline structure and wide bandgap of gallium nitride (GaN) make it ideal for a variety of applications, including LEDs, laser diodes that read blu-ray discs, transistors that operate at high temperatures, solar cell arrays for satellites, biochemical sensors and, because of GaN's relative biocompatibility, electronic implants in humans. But Yujie Ding, professor of electrical and computer engineering at Lehigh University, sees another, potentially more revolutionary role for GaN.

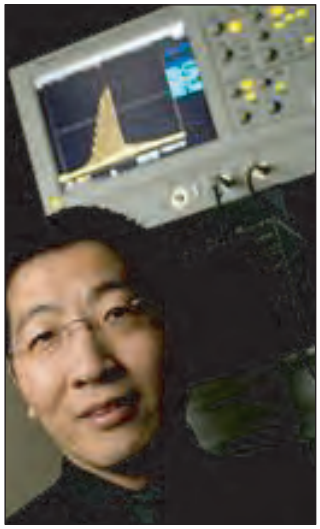
The compound can be engineered so that light passing through GaN actually cools it instead of heating it, he says. This phenomenon of laser cooling (or laser refrigeration) would eliminate the need for costly heat-dispersion methods that are employed to prevent electronic devices from overheating.

"GaN can be used to make lasers, optoelectronic and electronic devices," notes Ding, who is a fellow of both the Institute of Electrical and Electronics Engineers and the Optical Society of America. "What if we could also use GaN for cooling? This would be one-stop shopping. We could monolithically integrate everything — the laser, the laser-cooling device and the electronic devices — on the same substrate."

Overturning the Stokes ratios

Ding's group has reached the threshold for achieving laser refrigeration by utilizing the anti-Stokes photoluminescence (APSL) phenomenon, which refers to the small fraction of photons whose frequency increases after striking a material. Stokes scattering occurs when the frequency of scattered photons is lower than the frequency of incident photons.

The ratio of the occurrence of Stokes to anti-Stokes scattering is typically 35:1, says Ding. Scientists would like to reduce this to 1:1, at which point a material neither heats nor cools when struck by light, and even further when, with more anti-Stokes than Stokes scattering, a material imparts its energy, and thus its heat, to the light passing through it.



Lehigh's Yujie Ding.

Two years ago, Ding and his students — working with Jacob B. Khurgin, professor of electrical and computer engineering at Johns Hopkins — succeeded in reducing the ratio of Stokes to anti-Stokes to 2:1 in GaN, in numerical simulations and in lab experiments. The ratio was the most favorable achieved to that point. Recently, the group improved upon their results and recorded a ratio of 1:4. "We have not yet demonstrated cooling," says Ding. "That will require further work. But we have demonstrated that we are above the threshold for laser cooling."

The cooling potential of phonons

Laser cooling was first demonstrated 20 years ago on glass doped with a rare earth element. This method is ineffective, says Ding, because only the relatively small portion of the material that is doped contributes to cooling.

By contrast, GaN's crystalline structure makes it possible for a much larger portion of the compound to play a role in cooling. Of critical importance are the phonons (collective vibrations at a uniform frequency) of the GaN molecules in the compound's crystalline lattice.

"Because of the nonlinear properties of the lattices, phonons vibrating at very high frequency break down to lower-frequency vibrations," says Ding. "At this lower acoustical vibrational frequency, the phonons become heat."

To prevent the breakdown of phononic vibrations, Ding's group combines the higher-frequency-vibration phonons with incoming photons. The high-frequency phononic vibrations are hence removed before they break down, and the vibrations, instead of generating heat, are emitted as high-frequency photons.

"The advantage of GaN is that the collective vibration of all the GaN molecules in the lattice makes it possible for the entire lattice to potentially contribute to cooling by promoting the upconversion of high-frequency phonons," says Ding.

"We have learned how to use ASPL to convert input photons with low energy to outgoing photons with higher energy. To do this, we remove phonons by using resonance enhancement of outgoing photons' energy with energy states of GaN. Thus we enhance ASPL," he adds. "This is the best way to achieve laser cooling, because once the breakdown of high-frequency phonons occurs and produces heat, the process is not reversible. You have to work to remove heat, and this is never effective," Ding continues. "It shows that laser refrigeration can be obtained with a III-V semiconductor, that is, with the very materials from which the optoelectronic devices that require cooling are themselves made."

The project is funded by the US Defense Advanced Research Projects Agency (DARPA). Ding's other collaborators include Guan Sun (who gained his Ph.D. from Lehigh in 2013) and Ruolin Chen (a Ph.D. candidate). Sun now works for optical communications component maker JDS Uniphase Corp of San Jose, CA.

www.ece.lehigh.edu

DILAS appoints Special Systems as distributor in Russia, Belarus and Ukraine

Diode laser maker DILAS of Mainz, Germany has announced a strategic partnership (effective 1 January) naming Saint-Petersburg-based Special Systems LLC as its exclusive distributor in Russia (Belarus and Ukraine).

"For this region, we see a growing demand for our high-power diode laser components for applications such as DPSSL [diode-pumped solid-state lasers] and fiber pumping, medical, defense and materials processing," says Dr Jörg Neukum, DILAS' director marketing & sales. "With the appointment of Special Systems LLC, our existing customers will profit from a much better service and continuity and we will have a better access to the growing markets in this region".

Founded in 2007, Special Systems distributes photonic solutions and offers technical support through all project stages.

www.dilas.com
www.en.spec-s.ru

Innolume launches diode laser family for pulse operation at 1030–1130nm

Quantum dot (QD) diode laser manufacturer Innolume GmbH of Dortmund, Germany has launched a diode laser product family designed for pulse operation.

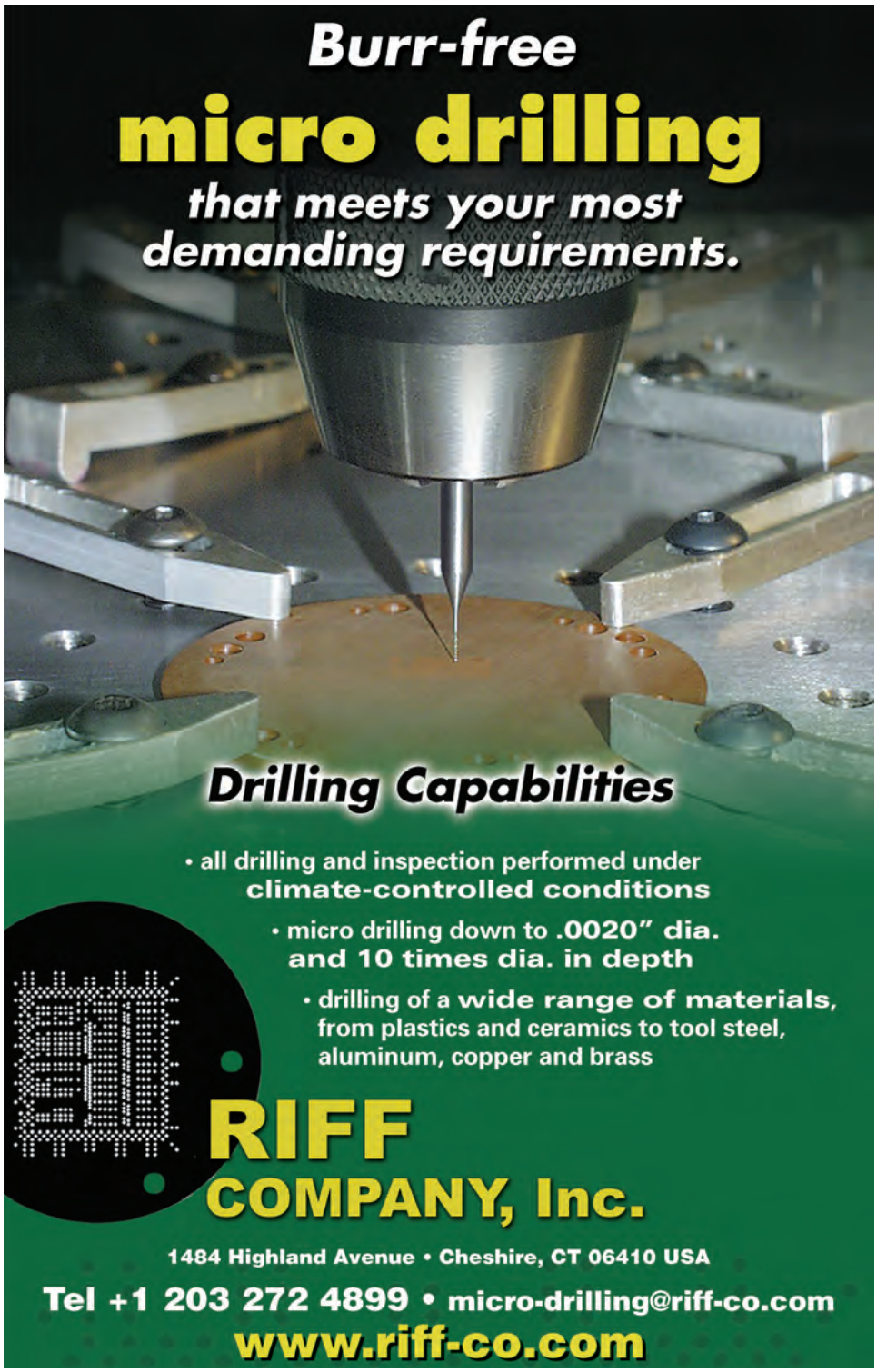
Dedicated to operate as a seed source in Yb- and Nd-doped fiber laser systems, the LD-10XX-BF-p1000 series is available at any wavelength between 1030 and 1130nm (e.g. 1064nm).

Having rise and fall times in the nanosecond range, the lasers feature up to 1.2W peak optical power in sub-microsecond pulse mode. In contrast to continuous-wave (CW) high-power devices like the LD-1064-BF-600, the new series of lasers has no warm-up period, showing stable radiation right after switching on.

The lasers are available in an industry-standard 14-pin butterfly package with build-in thermo-electric cooler (TEC) and thermistor, and are equipped with HI1060 fiber or with polarization-maintaining PM-980 fiber. In the case of PM fiber, the output light is linearly polarized and oriented along the slow axis with high polarization extinction ratio (PER).

Innolume displayed the product at the Photonics West 2014 exhibition in San Francisco (4–6 February).

www.innolume.com



II-VI expands seed laser portfolio for pulsed fiber lasers

At Photonics West 2014 in San Francisco (1–6 February), semiconductor laser manufacturer II-VI Laser Enterprise GmbH of Zurich, Switzerland is debuting new products from its expanded Seed Laser portfolio. These include a new Fabry–Perot (FP) laser diode module with ultra-broadband fiber Bragg grating (FBG) for high peak power pulsed fiber lasers and a distributed feedback (DFB) laser diode module designed for seeding of sub-nanosecond fiber and solid-state lasers.

II-VI Laser Enterprise is a subsidiary in the active optical products segment of engineering materials and optoelectronic components provider II-VI Inc of Saxonburg, PA, USA that was acquired last September from optical communications component maker Oclaro Inc of San Jose, CA, USA.

The expanded seed laser portfolio comprehensively addresses all pulsed fiber laser applications and includes:

- A DFB single-mode laser diode with an on-chip distributed feedback grating that enables pulsed fiber lasers to operate at picosecond pulse widths as well as enabling frequency conversion into green and UV wavelength ranges. Available at 1064nm and 1030nm, the seed laser is capable of high peak powers of up to 800mW for a pulse width as short as 150ps tunable up to 4ns with programmable pulse shapes and a spectral line-width well below 100pm.
- A FP seed laser module with a 4nm ultra-broadband chirped FBG, tailored to control spectral properties for the suppression of SBS (stimulated Brillouin scattering), a common problem in pulsed fiber lasers that occurs above 10ns pulse width and at high peak power operation of pulsed fiber lasers. Available at 1064nm, the module can be operated at peak currents of up to 2A.
- A narrow-band FBG FP laser module for pulsed frequency conversion applications. The laser module with less than 0.3nm bandwidth and FBG at a short distance is available at 1064nm and 1030nm.

As different applications and architectures for pulsed fiber lasers continue to grow, tailored seed solutions allow optimized material interaction and improved quality

All seed laser modules feature a standard telecom-grade butterfly-type package that includes a thermistor and back-facet monitor photodiode. Reliability of seed laser modules had been proven with pulsed reliability tests over 10,000 hours at 2A peak current. For the DFB seed laser, a multi-cell life-test of over 8000 hours at accelerated operating conditions has been performed with zero failures.

"As different applications and architectures for pulsed fiber lasers continue to grow, tailored seed solutions allow optimized material interaction and improved quality at the work piece," says product line manager Dominik Jaeggi.

Technology development for this product has been supported partly by the EU-funded FP7 ALPINE project (number. 229231).

www.ii-vi.com/business_units/II-VI-Laser-Enterprise.html

II-VI expands laser stack product portfolio to 14xx and 10xx nm

II-VI Laser Enterprise GmbH of Zurich, Switzerland has debuted new products from its expanded portfolio of high-power Multi-Bar Stack laser diode modules. This includes a wavelength extension to14xx nm and 10xx nm, targeting industrial applications such as plastic and metal welding and medical applications including acne treatment, skin rejuvenation and surgery.

Leveraging the latest advances in chip technology, the multi-bar modules deliver higher output power and superior power conversion efficiency at 14xx and 10xx nm wavelength with proven reliability, says the firm.

At 1440nm wavelength, CW (continuous wave) output powers of 50W and 70W from passively cooled and actively cooled bars, respectively, have been demonstrated. In a stacked configuration, 300W of CW output power can be achieved with power conversion efficiency of >35%, significantly reducing cooling power requirements and paving the path for new applications in the 14xx nm regime.

At 10xx nm wavelength, >250W CW output power from a mounted bar has been demonstrated with a power conversion efficiency of >60%. As a result, up to kilowatt power levels can be achieved by stacking the bars in a compact and reliable package.

The latest 14xx nm and 10xx nm stacks are available in the same compact framed or frameless stack configurations as existing 8xx nm and 9xx nm stack products. Multi-bar modules or stacks can be customized for output power and beam profile through lensing options.

"The latest introduction of new stack products underscores our ability to continuously advance our chip technology and expand the application space for laser diodes," says product line manager Larry Shi. "As a vertically integrated laser diode supplier, we can optimize our chip and packaging design to address the growing power and efficiency demands of the industry," he adds.

Modulight broadens OEM laser system family to single-mode and multi-wavelength laser modules

Modulight Inc, an ISO13485-certified laser manufacturer based in Tampere, Finland and San Jose, CA, USA, has announced two complementary additions to its OEM laser system platform.

Whereas the ML6500 (launched in 2013) introduced what was claimed to be the smallest form factor and widest wavelength spread high-power multimode laser modules, this is now complemented by the ML6400 single-mode laser systems and ML6600 multi-wavelength laser systems. The smaller 2"x2"-footprint ML6400 and the larger 6"x6"-footprint ML6600 house up to three different wavelengths in a single easy-to-use laser module.

"This is again a direct response to the market needs we have already identified when developing the single-wavelength multi-mode laser ML6500 modules," says president & CEO Dr Petteri Uusimaa. "Stable and easy-to-integrate UV and visible single-mode laser modules at 405–690nm are of great interest in the field of biophotonics and fluorescence microscopy. We complement these with our single-mode laser diode products at NIR (near-infrared) region up to 1650nm to introduce again the widest wavelength span of such laser systems in the industry," he adds.

"The ML6400 and ML6600 laser systems share the same design language, interfaces and key features as the flagship ML6500 modules," explains Sampsa Kuusiluoma, manager for New Product Introduction. All versions have driving and cooling controls integrated into the module, and they can be controlled by external set voltage. Additionally, direct control is available through an easy-to-use PC user interface that supports multiple laser units or multiple wavelength channels simultaneously. "We have really tried here to take the effort to transform all needs and wishes we have got from our systems integrator customers about usability and flexibility of integrating laser diode solution into systems, with the whole range from low-power single-mode sources to larger multi-watt and multi-wavelength laser modules used in industrial and life-science applications," he adds.

"The key features of the ML6400 are stable CW output power and wide wavelength range from UV to NIR. ML6600 systems boast a true 3-in-1 solution, where we can basically take any of our single-wavelength ML6500 performance and squeeze that into a individually addressable multi-wavelength laser source with single output and control interface," says Kuusiluoma.

"This feature is demonstrated nicely with our pilot product ML6600-RGB, designed for display and projection application [demonstrated at February's Photonics West in San Francisco]." This product combines the separate 1W ML6500-RGB laser sources into a single 3W system that can either have 3W of each color or 3W combined RGB (635nm/532nm/465nm) output in an easy-to-use color controllable module. "We can take any of the wavelengths between 405–1650nm that we support already with ML6500 and mix or combine those in the ML6600 platform to address multi-wavelength applications or scale power at a single wavelength," says Kuusiluoma. Applications range from multi-wavelength laser systems in laser projection, surgery, dentistry, laser therapy to optical pumping solutions.

www.modulight.com

Oclaro launches 700mW 638nm red laser diode in 5.6mm package for laser TV and projection

At the Photonics West 2014 show in San Francisco, CA (4–6 February), optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA launched the HL63193MG, a 638nm-wavelength red laser diode with 700mW output power, multiple transverse mode and a small 5.6mm-diameter TO package, targeted at the emerging laser TV and projection markets.

High-power red laser diodes are a critical building block for laser TV and display applications, says Oclaro. New projectors require several 10s of Watts of combined red, green and blue laser optical power to meet expectations for brightness and image quality. Oclaro says its 700mW red laser diodes enable users to maximize overall output power without increasing the number of components inside the projector.

With a high wall-plug efficiency of about 38%, the HL63193MG reduces the electrical power consumption and also the amount of heat that has to be removed from the package, allowing more compact and integrated designs, the firm claims. The new aluminum gallium indium phosphide (AlGaInP) red laser diode's features also include: an operating temperature up to 40°C and an operating current of 900mA.

"We are ready for mass production with this product [after completing qualification in December] and believe it will enable new and exciting consumer applications for red lasers," says Yves LeMaitre, president of Oclaro's Optical Connectivity Business.

www.oclaro.com

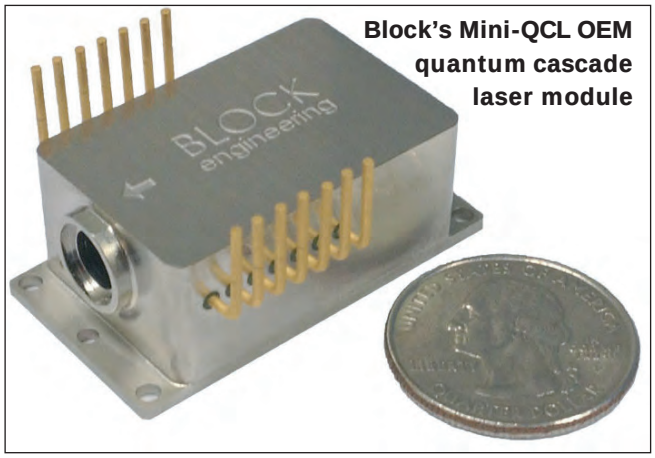
Block launches ultra-miniaturized QCL products

Block Engineering LLC of Marlborough, MA, USA, which makes quantum cascade laser (QCL) and FTIR spectrometers for commercial, industrial, military and government users, has launched two ultra-miniaturized QCL products, the Mini-QCL module and the LaserTune Infrared Source.

The Mini-QCL is a widely tunable QCL module for original equipment manufacturers (OEMs), weighing only 75g (~2.5oz). The next-generation LaserTune infrared source has been miniaturized to a compact (16.5cm x 12.7cm x 11cm) wirelessly controllable system, while offering what is claimed to be the widest contiguous tuning range on the market (greater than 1000cm^{-1}).

"We are receiving tremendous interest in these new products from universities, corporate R&D labs, and a wide range of OEMs," claims Scott Riggi, VP of sales. "Block has now introduced the world's most compact, full-function QCL source with the widest contiguous spectral tuning range. The demand for these devices in gas sensing, metrology, and academic and corporate R&D applications is significant," he adds.

"These two new products are the result of Block's innovation spirit, engineering strength, and optical packaging capabilities," says CEO Petros Kotidis. "They meet a strong market need for ultra-compact, ultra-widely tunable sources for OEM integration and all-in-one laser sources," he adds. "These devices are now enabling new applications, which were not available to the past generations of QCLs due to size, ruggedness and performance limitations."



Block's Mini-QCL OEM quantum cascade laser module

The Mini-QCL module is available in spectral ranges greater than 250cm^{-1} per module, and multiple modules can be combined by OEMs. The module can be used in a variety of real-time gas analysis applications requiring a mid-infrared laser source, including greenhouse-gas monitoring, automotive combustion analysis, oil and gas exploration, and air quality monitoring. It is also designed to be integrated into spectroscopic instruments, including products used in photoacoustic spectroscopy (PAS), cavity ring-down spectroscopy (CRDS), infrared microscopy, and atomic force microscopy (AFM).

As well as being significantly reduced in size and having a wide contiguous tuning range, the new LaserTune infrared source has a 2mm x 4mm collimated beam that can now be programmed to operate in several modes with a manual step, programmable step, and programmable sweep. It offers fast scan capability at 25cm^{-1} per millisecond, and the source can be programmed to emit pulses from 20ns to 500ns, while maintaining a duty-cycle up to ~30%. Computer control of the LaserTune is via wireless or Ethernet/HDMI with analog and digital control for monitoring and controlling the laser wavelength.

Block demonstrated the new products at SPIE's Photonics West event and BiOS event in San Francisco (1–6 February).

www.blockeng.com

Marktech launches InGaAs/InP 800–1750nm PIN diodes

Marktech Optoelectronics of Latham, NY, USA, whose capabilities span wafer growth through finished packaging and custom solutions, has launched its line of PIN photodiode components based on InGaAs/InP technology. The devices are available (via Digi-Key) in a TO-46 flat top package with a spectral sensitivity in the 800-1750nm range. Custom package options and die are also available.

Photodiode chip active area sizes from 0.1mm to 3.0mm are available to provide the optimum balance between low dark current, high speed and light sensitivity. This allows for increased flexibility and options in a variety of applications ranging from fiber optics and high-speed optical communications to medical and chemical analysis, says Marktech.

No integrated thermal-electric cooling (TEC) is used on any of the firm's PIN photodiodes, reducing costs and improving overall efficiency.

In addition to PIN photodiodes, Marktech offers foundry services for epitaxial growth of short-wave infrared (SWIR) wafers in the 1.0–2.6µm range, using InP material as the base substrate. Marktech is currently producing these high-reliability wafers in 2", 3" and 4" diameters. Among the applications for these wafers are photodetectors, linear arrays and image sensors. Marktech says that photodetectors processed using the epiwafers provide advantages including lower dark current, better shunt resistance and overall improved performance at lower operating temperatures.

Marktech exhibited at Photonics West in San Francisco (4–6 February).

www.marktechopto.com

Leeds University demos first THz laser chip with pulsed peak power exceeding 1W

Broad-area quantum cascade laser operated at 3.4THz and 10K more than doubles output power record

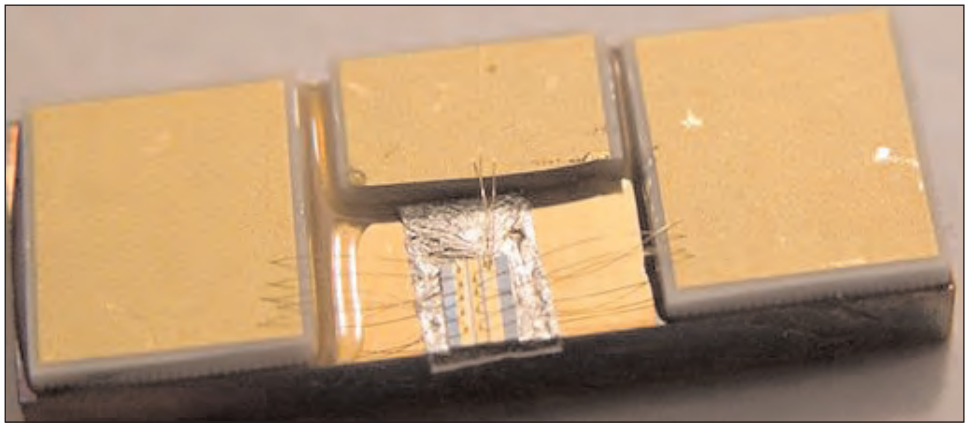
The UK's University of Leeds has fabricated what is claimed to be the world's most powerful terahertz (THz) laser chip, exceeding 1 Watt output power from a quantum cascade laser (QCL) (Lianhe Li et al, 'Terahertz quantum cascade lasers with >1W output powers', Electronics Letters (2014) Vol 50, Issue 4, p309).

Terahertz waves (lying between infrared and microwave in the electromagnetic spectrum) can penetrate materials that block visible light and have a wide range of possible uses including chemical analysis, security scanning, medical imaging, and telecoms. Potential applications include monitoring pharmaceutical products, the remote sensing of chemical signatures of explosives in unopened envelopes, and the non-invasive detection of cancers in the human body. However, one of the main challenges is making the lasers powerful and compact enough to be useful.

"Although it is possible to build large instruments that generate powerful beams of terahertz radiation, these instruments are only useful for a limited set of applications," says Edmund Linfield, professor of Terahertz Electronics at Leeds University's School of Electronic and Electrical Engineering. "We need terahertz lasers that not only offer high power but are also portable and low cost." The quantum cascade terahertz lasers being developed by Leeds are only a few square millimetres in size.

Last October, Austria's Vienna University of Technology reported an output power of 0.47 Watt from a single laser facet of a quantum cascade terahertz laser, nearly doubling the prior record of Massachusetts Institute of Technology (MIT).

Now, Leeds has fabricated broad-area high-power THz QCLs by growing an aluminum gallium arsenide-based ($Al_{0.16}Ga_{0.84}As/GaAs$) heterostructure on a semi-insulating GaAs substrate, then photolithographically creating 145–425μm-wide ridges. Cooled by liquid helium, the resultant lasers were operated at a temperature of 10K, and in pulsed mode (at 10kHz and a 2% duty cycle). A version with a 425μm-wide ridge and a 3mm-long cavity gave a peak power output of 780mW. However, by applying a high-reflectivity coating to the rear facet of a 4.2mm-long cavity, the single-facet peak power output (at an emission frequency of 3.4THz) was boosted to a record 1.01 Watts, more than doubling the landmark set by Vienna University of Technology. For the 3mm-long cavity, even at a higher operating temperature of 77K, the peak power output was still 420mW. The maximum operating temperature is 123K.



Leeds University's THz laser chip.

This work is a key step toward increasing the power of these lasers while keeping them compact and affordable.

An increase in the power output should be expected if the QCL design is scaled to higher emission frequencies

"The record power of our new laser is due to the expertise that we have developed at Leeds in fabricating these layered semiconductors, together with our ability to engineer these materials subsequently into suitable and powerful laser devices," says Linfield.

"The University of Leeds has been an international leader in terahertz engineering for many years," comments Giles Davies, professor of Electronic and Photonic Engineering. "This work is a key step toward increasing the power of these lasers while keeping them compact and affordable enough to deliver the range of applications promised by terahertz technology."

The researchers note that an increase in the power output should be expected if the QCL design is scaled to higher emission frequencies.

The work of the Leeds team was funded mainly by the UK's Engineering and Physical Sciences Research Council (EPSRC).

http://digital-library.theiet.org/content/journals/10.1049/el.2013.4035
www.engineering.leeds.ac.uk/imp/research/terahertz-electronics-photonics

IQE's VCSEL epiwafers used by TU-Berlin for record power efficiencies in optical interconnects

Record low energy consumption in error-free operation at 40Gb/s

Epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK says that its laser epiwafer technology has been employed to develop ultra-high-efficiency optical interconnects, as reported in two technical papers presented by Germany's Technische Universität (TU) Berlin at Photonics West 2014 in San Francisco (2–6 February).

Vertical-cavity surface-emitting laser (VCSEL) wafers, manufactured at IQE's Cardiff facility, were used by researchers at TU-Berlin to produce high-performance communications lasers that achieved error-free operation at speeds up to 40Gb/s with record low energy consumption. The VCSELs also demonstrated extreme temperature stability during high-speed operation up to 85°C.

It is widely recognised that the expanding growth in data communications is rapidly approaching a serious bottleneck as demand for higher performance battles with the need to reduce power consumption, particularly in increasingly large data centers, notes IQE.

This is driving the move from copper cables to optical fiber communications, which is essential in enabling the transmission of the high data volumes demanded from cloud computing, big data and the Internet of Things, the firm adds. Furthermore, the efficiencies achieved with VCSELs is a critical factor in reducing the overall energy consumption of optical interconnects used in data centers.

"Energy-hungry data centers are increasingly co-located alongside major industrial power plants," notes IQE's president & CEO Dr Drew Nelson. "Data volumes are forecast to continue growing and, with more than 20 billion devices being interconnected by 2020, the energy demand is rapidly becoming unsustainable," he adds. "Data centers are already early adopters of VCSEL technology to help reduce energy demand and are likely to continue to drive the trend for optical communications for industrial and commercial applications."

"Error-free operation of 850nm VCSELs at 25Gb/s was achieved with record-low dissipated energy of 56fJ/bit," says professor Dieter Bimberg, head of the Solid State Physics Institute at TU-Berlin. "This is the lowest reported value of dissipated energy at error-free operation for any semiconductor laser diode at any wavelength or bit rate. This result is achieved at a low current density of 10kA/cm^2, demonstrating the suitability of our devices for application in reliable and sustainable commercial optical interconnects," he adds. "At 40Gb/s the IQE/TU-Berlin VCSELs dissipate only 108fJ per transmitted bit, which is at least four times less than any other published result for semiconductor laser diodes."

Further work also presented at Photonics West reported on high-efficiency operation of IQE's VCSEL materials carried out by TU-Berlin in collaboration with the Photonics Modelling Group at the Institute of Physics, Technical University of Lodz, Poland.

The papers resulted in Philip Moser and his team at TU-Berlin being presented with the SPIE Green Photonics Award for Communications 2014.

www.iqep.com

IQE announces first commercial 150mm-diameter indium antimonide substrates

6" InSb targeted at MWIR focal-plane infrared detectors

At the SPIE Photonics West 2014 conference in San Francisco (3–6 February), epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK is presenting a series of invited papers on recent developments in photonic technologies:

- 'Growth and characterization of 6" InSb substrates for use in large-area infrared imaging applications' announces what is claimed to be an industry first; commercial 6"-diameter indium antimonide suitable for use in the fabrication of mid-wave infrared (MWIR) focal-plane IR detectors.

In addition, IQE's Infrared division is presenting a further two invited papers:

- 'GaSb-based photodetectors covering short-wave to long-wave IR grown by molecular beam epitaxy', covering the MBE growth of gallium antimonide-based photodetector structures spanning the short-wave to long-wave IR spectral range - barrier-type 'nBn' detectors, grown on 4-inch GaSb or 6-inch GaAs substrates.
- 'Multi-wafer growth of GaInAs photodetectors on 4" InP by MOCVD for SWIR imaging applications' covers the growth of indium phosphide/indium gallium arsenide photodetectors on 4-inch indium phosphide by metal-organic chemical vapour deposition (MOCVD).

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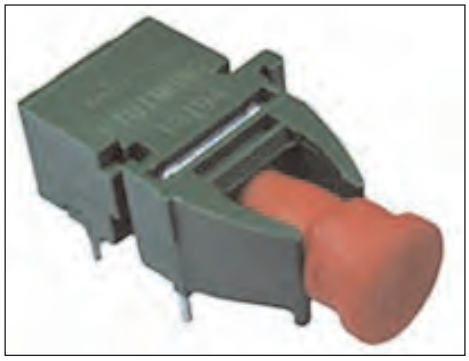
Firecomms launches 530nm long-reach RedLink transmitter for 1Mb applications over 200m of POF

Firecomms Ltd of Cork, Ireland and Tongxiang, China, which manufactures fiber-optic solutions and optical transceivers, has announced availability of its 530nm DC–1Mb RedLink transmitter for applications requiring extended link lengths over plastic optical fiber (POF).

Operating in the green spectrum at 530nm, the FT01MHNG exploits one of the lower attenuation windows of POF. At 0.1dB/m, the attenuation of the FT01MHNG is considerably lower than that of traditional POF transmitters that operate in the red spectrum, Firecomms claims, with attenuation of about 0.2dB/m. These characteristics make it possible to implement POF links up to 150m or even 200m, where traditionally link lengths have been limited to 50m.

Suitable for sensing, CANbus/RS485/RS232 links, gaming, smart meter or other industrial command and control applications, the FT01MHNG transmitter opens up new possibilities for the equipment designer to replace more expensive silica-based solutions with POF, remove repeaters which are no longer needed, and implement new designs requiring galvanic or optical isolation where costs or distances have been previously prohibitive, says Firecomms.



Firecomms' 530nm DC–1Mb RedLink transmitter.

At 0.1dB/m, the attenuation of the FT01MHNG is considerably lower than that of traditional POF transmitters that operate in the red spectrum, with attenuation of about 0.2dB/m.

Firecomms has been developing resonant-cavity LEDs (RCLEDs) for the past decade, says chief technology officer John Lambkin. "This announcement of a 530nm-based transmitter using extremely rugged InGaN semiconductors is another example of Firecomms' commitment to innovation and investment in our RedLink product line," he adds.

Firecomms has now completed full qualification of these devices, verifying how the wavelength and output power remain stable over the entire industrial temperature range of –40°C to +85°C, and demonstrating their suitability for the most demanding applications.

Link tests performed using the new transmitter with Firecomms' FR01MHIR receiver have demonstrated transmission distances of up to 200m (depending on actual throughput).

The FT01MHNG transmitter is available for sampling through Firecomms' sales offices and distribution channels.

www.firecomms.com

Firecomms' RedLink transmitters and receivers now available in vertical package options to simplify factory installation

Firecomms has announced the availability of its full line of RedLink transmitters and receivers in vertical-style packages. In response to demand for versatility in the RedLink connection styles, the firm is now offering the complete product family in both horizontal and vertical packaging options.

Firecomms says that its RedLink industrial transmitters are frequently installed in large industrial enclosures where final cable assembly can be difficult when the products are horizontally aligned with the internal PCB. To provide flexibility for both the final installation on the factory floor and end-user maintenance, Firecomms has hence expanded its RedLink product range to include vertically aligned transmitters and receivers.

"RedLink products are frequently found in large-scale industrial equipment such as wind turbines, locomotive traction control units or grid-tied converters," says Hugh Hennessy, VP of sales & marketing. "As manufacturers of these appliances appreciate any opportunity to reduce final assembly and maintenance cycle times, we are happy to respond to our customers' demands for this greater flexibility."

Drop-in compatible with the Versatile Link range of products, the RedLink product line extends the Firecomms' capabilities for high-speed plastic optical fiber (POF) transceivers and interface innovation into highly reliable industrial-grade optical transmitters and receivers.

The RedLink product line includes DC–1Mb, DC–5Mb, DC–10Mb and DC–50Mb transmitters and receivers, all rated at the extended industrial temperature range of –40°C to +85°C for use in even the harshest industrial environments.

All vertical RedLink devices are now available for sampling through Firecomms' sales offices and distribution channels.

POET announces executive changes plus restructured University of Connecticut license agreement

POET Technologies Inc of Toronto, Canada — which, through subsidiary OPEL Defense Integrated Systems (ODIS Inc) of Storrs, CT, USA, has developed the proprietary planar-optoelectronic technology (POET) platform for monolithic fabrication of integrated III-V-based electronic and optical devices on a single wafer — has announced changes to its executive team and board:

- Peter Copetti has been named executive chairman & interim CEO. Copetti was previously executive director & chair of the Special Strategic Committee (SSC), which was dissolved (as reported in January) following its final report to POET's board of directors.
- Co-founder Leon M. Pierhal has stepped aside as CEO and will continue his role as president and member of the board.
- Mark Benadiba has stepped down as executive chairman but will remain a member of the board, as vice chairman.

"I would like thank Mark and Leon for their commitment and contributions, and will continue to work with both of them in progressing POET's story to the next phase, which is expected to culminate in the monetization of POET's proprietary platform and processes," says Copetti. "POET is at an advanced stage in its 16-year development history. We are determined to be first to market with a practical compound semiconductor solution in the industry's race to sustain Moore's Law beyond the constraints of traditional silicon," he adds.

"POET intends to go to market with the world's first completely integrated optical and electrical device operating on a single die, and to fulfill its promise of vastly superior processing speed and energy utilization in a patented production process that can ultimately be retrofitted to conventional fabs," Copetti concludes.

"I steered the company through infancy, and shepherded POET safely through turbulent change," says Pierhal. "POET has since evolved from its origins as pure R&D, to a publicly traded going concern trading on two markets in Canada and the USA, to where it stands today — at an inflection point, where monetization of the POET platform is on the horizon, with fully integrated optical-electronic chips leading the way for the semiconductor industry's next-generation chip technology," he adds.

"This change in role allows me to spend time with family, and tend to overdue personal commitments that had been put aside, due to the arduous demands needed to bring POET to where it is today," Pierhal continues. "Having worked closely with Peter Copetti over the past 18 months, I am confident in Peter's ability to serve as CEO... Peter will play a pivotal role in bringing the company's technology to market."

The firm has also entered into a term sheet with the University of Connecticut to restructure its license agreement of 8 April 2003. The licenses granted pursuant to the license agreement are in full force and are irrevocable.

While the maintenance fee provisions of the license agreement remain unchained, the parties agreed to restructure the payment provisions by reducing the royalty payment to 3% of amounts received from unaffiliated third parties in respect of the exploitation of the intellectual property defined in the license agreement.

In consideration for the favorable restructuring of the royalty terms, POET will provide the university 2,000,000 common shares, subject to approval by the TSX Venture Exchange. Trading of these shares is restricted until 31 May 2016. The restructuring is subject to final execution of the formal amendment to the license agreement.

"I am extremely pleased with the University of Connecticut's vote of confidence in POET, exhibited by their taking an equity stake in the company as an alternative to a higher potential royalty revenue stream," Copetti states. "Their decision will greatly enhance the company's ability to monetize the POET technology and create shareholder value."

The firm says that it remains on track with its technology roadmap, and will soon be providing updates to all stakeholders on progress and achieved milestones to date.

www.poet-technologies.com

Finisar honors Multek with Most Consistent Quality Award

During the recent customer supplier day of fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA, the Most Consistent Quality Award was presented to Flextronics subsidiary Multek, a global manufacturer of printed circuit board technologies that offers PCB engineering and manufacturing expertise including high-density interconnect, multilayer, flexible circuit and assembly solutions.

"This award is a testament to Multek's commitment to providing our customers with the highest level of quality," says Multek's president Franck Lize.

The award recognizes Multek's long track record of high article acceptance rates and zero supplier corrective actions initiated while manufacturing both rigid and flexible circuit boards for multiple Finisar product lines.

www.multek.com
www.finisar.com

GigOptix and CPqD form Brazil joint venture BrPhotonics

Silicon photonics plus TFPS technologies target 100Gbps–1Tbps long-haul, metro links and cloud-connectivity in CFP2 and CFP4

GigOptix Inc of San Jose, CA, USA (a fabless supplier of analog semiconductor and optical communications components for fiber-optic and wireless networks) and CPqD, an independent Brazil-based research center focused on information & communication technologies (ICTs) with activities in system- and device-level optical communications, have agreed to form the joint venture BrPhotonics Produtos Optoeletrônicos LTDA (BrP) of Campinas, Brazil.

Both partners will transfer into BrPhotonics their knowledge-base and intellectual property of existing technologies, and will jointly work through the partnership to enhance, develop and commercialize products based on them. GigOptix will transfer to Brazil its Thin Film Polymer on Silicon (TFPS) technology, inventory related to the TFPS platform, and all the production line equipment currently at its facility in Bothell, WA. CPqD will transfer to BrPhotonics its silicon photonics (SiPh) technology, optical packaging expertise, and design and testing capabilities. It will also provide space for the BrPhotonics corporate headquarters as well as funding for the BrPhotonics operations.

CPqD will control a 51% stake in BrPhotonics and GigOptix the remaining 49%. The JV will be managed by a team of three officers and four board directors. The board of directors will include two representatives from GigOptix and two from CPqD, and will be initially chaired by GigOptix chairman & CEO Dr Avi Katz. BrPhotonics is launching operations immediately and will soon announce the nominated executives and board members.

GigOptix will act as BrPhotonics' global exclusive sales and marketing agent for all its products, except in Brazil, where sales will be undertaken directly by BrPhotonics. GigOptix reckons that BrPhotonics will enable it to extend its business footprint in Brazil through access to a regional office and sales force.

BrPhotonics' headquarters will be located within the CPqD campus. Logistics of the transfer of equipment and IP to BrPhotonics facility are beginning immediately.

"The creation of BrPhotonics is another innovative business strategy from GigOptix to gain access to advanced technologies and partner with some of the most highly skilled technical teams in the world," says Katz. "This latest agreement follows our long history of similar access to new technologies, including when GigOptix licensed the silicon germanium (SiGe) millimeter-wave technology from IBM for E-band chipsets in June 2012, and several successful corporate acquisitions. More so, with the inception of BrPhotonics, GigOptix is setting a new and solid foothold in Brazil, which is one of the fastest-growing markets for our entire high-speed communications devices portfolio, as part of our global reach enhancement," he adds.

The creation of BrPhotonics is "a strategic step to the increase photonic companies' ecosystem in Brazil," says CPqD's CEO Helio Graciosa. "BrPhotonics creation represents an opportunity to reach the market with the latest advances in integrated photonics developed at CPqD in the last few years, supported by the Brazilian Government (Ministry of Communications/ FUNTTEL and Ministry of Science, Technology and Innovation/FINEP). The complementary R&D activities between CPqD and GigOptix are key drivers to BrPhotonics roadmap and future products," he adds.

"This partnership leverages expertise from GigOptix and CPqD to bring small-form-factor Thin Film Polymer on Silicon (TFPS) modulation devices and silicon photonics (SiPh) based products to the market in the fastest and most efficient manner," says Katz. "CPqD brings a wealth of silicon photonics knowledge, device designs, optical device packaging, and world-renowned systems capability to the partnership, and GigOptix reciprocates with our well-developed TFPS technology and our world-wide deep commercialization reach," he adds. "GigOptix will continue to enhance our fabless, process-agnostic business model and to focus our efforts on the design and commercialization of semiconductor devices for high-speed communication links. This enables information streaming, end-to-end, over the network from the content generator and into the end-user appliances," Katz continues.

"We are also pleased with the strong support that we have received from the Brazilian government," says Graciosa. "The business plan for BrPhotonics that has been put together with CPqD and GigOptix represents a significant development opportunity for new optical components, reference platforms, and technologies."

BrPhotonics' roadmap will include a 100Gbps DP-QPSK TOSA (transmitter optical sub-assembly) and ROSA (receive optical sub-assembly) for CFP2 form-factor reference platforms with the integration of a TFPS modulator. Future products are expected to include the development of a next-generation 100Gbps-1Tbps TOSA and ROSA for CFP4 form-factor reference platforms utilizing silicon photonics components. The TFPS technology is a zero-chirp medium for electro-optical modulation and is capable of very high data rates in advanced linear and multi-level modulation systems. Silicon photonics has potential advantages including longer optical link distances, lower power and cost, and smaller form factors, say the firms. This may enable novel communications

architectures and platforms to address capacity concerns with growing cloud services, entertainment on-demand, and big data processing, they add.

In the January MarketsandMarkets report 'Silicon Photonics Market by Products (Silicon Optical Interconnects & Wavelength Division Multiplexer Filters & Others), Applications (Telecommunication, Datacom, High Performance Computing & Others) & Geography — Analysis & Forecast (2013-2020)', the global silicon photonics market is estimated to rise at a compound annual growth rate (CAGR) of 24.5% from $88.66m in 2013 to $410.78m in 2020. This growth will be led by the telecom and datacom applications market for silicon photonics products, it adds. The report also projects that silicon photonics applications in the high-performance computing sector are expected to grow rapidly in the coming seven years, with a CAGR of 48%.

BrPhotonics' products will utilize TFPS and SiPh technologies to advance 100Gbps-1Tbps fiber-optics long-haul, metro links and cloud connectivity. What is claimed to be a unique portfolio of small-form-factor components will address CFP2 and CFP4 applications by enabling greater network capacity through superior linearization, multi-level modulation, and other advanced techniques, say the firms.

BrPhotonics is showcasing a 100Gbps TOSA for CFP2 reference designs in GigOptix's booth #1531 at the Optical Fiber Communication conference (OFC 2014) in San Francisco (11–13 March).

www.gigoptix.com
www.cpqd.com.br/en
www.brphotonics.com

GigOptix's revenue grows more-than-expected 7% to $7.8m in Q4

For fourth-quarter 2013, GigOptix has reported revenue of $7.8m, up 10% on $7.1m (excluding $0.9m in government contracts) a year ago and up 7% on $7.3m last quarter (above the guidance of 5% growth, led by a nearly 40% increase in datacom-related revenue and a near doubling for E-band products).

For full-year 2013, revenue has fallen 21% from $36.7m in 2012 to $28.9m, due mainly to the decline in end-of-life (EOL) related sales from the firm's ASIC and RF product groups (relating to the acquisitions of Santa Clara-based ChipX Inc in 2009 and San Jose-based Endwave Corp in 2011, respectively) as well as the government contract revenue in Q4/2012.

On a non-GAAP basis, Q4 gross margin was 60% (at or above 60% for the fifth consecutive quarter). Full-year gross margin has risen from 56% in 2012 to 63% in 2013.

Q4 net income was $0.1m, compared with net losses of $0.7m last quarter and $0.1m a year ago. Full-year net loss was $0.4m, compared with net income of $0.4m in 2012. Full-year adjusted EBITDA (earnings before interest, taxes, depreciation, and amortization) has fallen from $3.6m in 2012 to $2.4m in 2013. However, adjusted EBITDA in Q4/2013 was $0.9m, up on $0.1m last quarter and $0.7m a year ago.

At the end of December, cash and cash equivalents were $20.4m, with no debt outstanding. This compares with $9.3m (excluding $6m drawn from the firm's line of credit) at the end of September.

"We had a very strong finish to fiscal 2013, with fourth quarter revenue growing 7% sequentially, on top of the 7% sequential growth we recorded in the prior quarter, and returning to non-GAAP profitability," says chairman & CEO Dr Avi Katz.

In late December, GigOptix completed a stock offering that raised about $13.6m (before expenses). "We expect to use these additional funds for possible strategic alternatives, and to accelerate our strategic R&D initiatives as we look to bring several products to market in 2014,"says Katz. "This includes extending our leadership offering in the 100Gbps coherent telecom market, expanding our delivery of 40Gbps and 100Gbps devices for data-center connectivity, and our new offering for natural interfaces, gesture tracking and other advanced application devices for the consumer market," he adds. "Taken together, I am confident this year we will deliver meaningful revenue growth over 2013."

GigOptix has also entered the silicon photonics arena by forming the joint venture BrPhotonics Produtos Optoeletrônicos LTDA in with Brazil-based optical communications R&D organization CPqD "This mutually exclusive partnership leverages GigOptix's small-form-factor Thin Film Polymer on Silicon (TFPS) modulation devices expertise, and CPqD's Silicon Photonics (SiPh) based product expertise," says Katz. "We expect BrPhotonics will provide advanced high-speed components for optical communications utilizing silicon photonics and Thin Film Polymer on Silicon technologies to advance the development and deployment of 100Gbps–1Tbps fiber-optic long-haul, metro links and Cloud-connectivity in the next-generation CFP2 and CFP4 applications," he adds. "With GigOptix being the exclusive worldwide sales agent for BrPhotonics, we believe that this progressive business arrangement will significantly enhance our product portfolio."

"Revenue will decline due to the normal seasonal pricing reductions that occur in our High-Speed Communications business," notes Katz. For Q1/2014, GigOptix expects $7.2m (up 4% year-on-year, but down 8% on last quarter), reflecting normal seasonal trends impacting the served optics markets. "After the first quarter, revenue will grow steadily over the rest of the fiscal year and increase over 2013 levels," says chief financial officer Curt Sacks.

Oclaro's 40 and 100G transmission product revenue grew 20% for second quarter

Restructuring targets adjusted EBITDA breakeven in December quarter

Excluding results from its Zurich-based laser diode business and its Amplifier and Micro-Optics business (sold to II-VI Inc on 12 September and 1 November 2013, respectively), for its fiscal second-quarter 2014 (to 28 December 2013) Oclaro Inc of San Jose, CA, USA (which provides components, modules and subsystems for optical communications) has reported revenue of $102.9m, up 6.5% on $96.6m last quarter but down 8% on $112.1m a year ago.

By application, revenue was 44% Datacoms, 49% Telecoms and 7% Industrial & Consumer. Datacom revenue grew by 10%, driven mainly by 100G client CFP and CFP2 products and by 40G pluggable transceivers. Telecom revenue grew by almost 4%, driven by strong demand for 40G line-cards (used in North American telecom networks, which continue to build out 40G capacity). "We are now expecting the 40G business to last longer than we thought and continue to be healthy, with modest reductions over the rest of this calendar year," says CEO Greg Dougherty. "We also saw strength in demand for our 100G coherent products such as lithium niobate modulators and narrow-linewidth tunable lasers," he adds.

By data rate, while 10G and lower business remained the largest product group (with 48% share), 40 and 100G transmission product revenue grew about 20% for the second consecutive quarter.

Business in China grew by over 10% sequentially, driven partly by demand from customers preparing to participate in China Telecom's 100G program. "We expect our business in China to remain at about this level as we anticipate seeing continued business from some of the same customers once China Mobile's 100G tender is awarded, which we understand to be sometime in the first half of this year," says Dougherty.

Of total revenue, customers in Europe contributed 32%, China 25%, America 18%, Southeast Asia 16% and Japan 9% (compared with 27%, 24%, 23%, 14% and 13% respectively last quarter, indicating a shift from the Americas to Europe).

The top 10 customers contributed 75% of revenue, with three greater than 10%: Coriant (formally the Optical Networks business of Nokia Siemens Networks) became the top customer (15% of total revenue, driving much of 40G business), followed by Cisco (13%) and Huawei (10%). Now that Marlin Equity Partners (which owns Coriant) has completed its acquisition of Tellabs and the firms have combined, the new Coriant would have represented 18% of sales, notes Oclaro.

On a non-GAAP basis, gross margin was 17.1%, up from 12.6% last quarter (and just 7.3% the quarter before that), driven by the richer mix of 100G, product cost improvement in high-volume business, and higher sales leveraging fixed overhead.

"The decision to continue to manufacture our high-performance indium phosphide components in Shenzhen was the right call. It has allowed us to ramp up our contract manufacturing partners in a more controlled way and to do a better job of product transitioning [after delays in manufacturing transfer led to supply constraints last quarter]," comments Dougherty. "This decision has provided a level of stability to our manufacturing plants."

As a result of the improved gross margin and reduced operating expenses (cut by $4.4m to $34.4m), operating loss was $16.8m, cut from $26.6m last quarter. However, due mainly to interest expense of $8.5m (including a make-whole provision associated with $25m of convertible notes exercised in December), net loss was $27m, down only slightly from $27.4m last quarter. Adjusted EBITDA (earnings before interest, taxes, depreciation and amortization) was –$10.7m, cut by 45% from –$19.6m last quarter.

But despite the adjusted EBITDA of –$10.7m and interest expense of $8.5m plus restructuring expenses of $6.7m and transaction costs of $2.7m, net cash received from the Amplifier business sale of $79.6m led to cash, cash equivalents, restricted cash and short-term investments rising by almost $50m during the quarter, from $94.7m to $144m. "We enter 2014 with a much stronger balance sheet and are virtually debt free, having retired our convertible notes in December," Dougherty says.

"The results for our fiscal second quarter demonstrate solid progress in our turnaround plan as revenue, gross margin and adjusted EBITDA were better than expected," says Dougherty. "Our restructuring efforts are progressing ahead of schedule, as are the previously announced headcount reduction plans."

"We completed the last step of our announced workforce restructuring by launching programs in China, Japan and Thailand. All regions where Oclaro operates have now shared the pain of these adjustments," notes Dougherty. On 1 July 2013, staffing was about 3000, with plans to halve that in one year. As of early January, it was down to about 2000 compared to the planned 2200. "We remain on track to be under 1500 people by July of this year," Dougherty says. "Our downsizing has been staged, so the associated expense reductions will not always materialize in the period when the actions are taken. Therefore, we expect the cost benefits to be realized over the next few quarters."

Oclaro also continues to reduce its number of global sites as part of its plan to streamline and simplify the ►

firm. "We have gone from 20 sites to 14 and still expect to be at 10 by July," says Dougherty. "The smaller footprint is allowing us to begin building better business practices and processes," he adds. "I expect that being simpler with better processes will make us more efficient in all areas."

In fiscal Q2, Oclaro spent $6.7m of the $20–25m restructuring plan. It expects this level to continue for the next two quarters and then tail off to $1–2m per quarter in second-half calendar 2014.

$ in Millions	Q213	Q114	Q214
Total Revenues	112.1	96.6	102.9
Gross Profit (non-GAAP)	14.9	12.2	17.6
Gross Margin %	13.3%	12.6%	17.1%
R&D (non-GAAP)	20.2	17.8	16.2
SG&A (non-GAAP)	19.0	20.9	18.2
Non-GAAP Operating Income (Loss)	(24.4)	(26.6)	(16.8)
Adjusted EBITDA	(16.9)	(19.6)	(10.7)

Oclaro's financial results for Q2 / 2014 compared with last quarter and a year ago.

"Last quarter was a typical time for annual price negotiations with many of our key customers," notes Dougherty. "The outcome of the negotiations was pretty well in line with both our expectations and the average range for industry in prior years," he adds. "We will see the impact of these price adjustments in our current quarter."

For fiscal third-quarter 2014 (to 29 March), Oclaro expects revenue of $93–103m, with gross margin falling to 13–17%. Adjusted EBITDA should be –$13m to –$9m. Operating expenses should fall by a further $3m. "We expect to establish a $40m working capital line of credit, but do not plan to utilize the facility this year," says chief financial officer Pete Mangan.

"We are starting to see the results of our efforts to right-size the company and align with our more focused and simplified strategy," says Dougherty. "We are still on track to achieve breakeven adjusted EBITDA by the December quarter," he adds. "The targets in that model are not reflective of a long-term model from the company. However, they are intended to set realistic milestones for us to achieve breakeven."

Oclaro expects further cash usage in calendar 2014 in the following four areas:

(1) to fund remaining restructuring; (2) to fund negative adjusted EBITDA; (3) to normalize accounts payable post-divestiture (which is expected to require $25–30m in cash); and (4) to fund normal capital expenditure (CapEx) of $3–4m per quarter and capital lease payments of about $1m per quarter ($4–5m per quarter together).

Following completion of the restructuring, Oclaro continues to expect that, on revenues of about $110m per quarter, gross margins of 20% and operating expenses of 25% of sales, it will achieve adjusted EBITDA breakeven in the December quarter. "This will be followed by the goals to break even on a non-GAAP operating base, which we expect will require further improvements in our gross margins," says Mangan.

"One of our challenges as we look forward is the phasing out of some of our legacy and discontinued products such as previous generations of 10G pluggable transceivers, 40G QPSK modules as well as our WSS [wavelength-selectable switch] product line," notes Dougherty. "While I am confident that we have many promising developments in our R&D pipeline, we will need to continue to improve our execution in introducing new products into volume manufacturing to address this challenge," he adds.

"We remain focused on the concept of photonic integration, laser innovation and advanced packaging to enable the emerging needs for higher speeds, lower power consumption, higher port counts and density and lower cost for both telecom and datacom applications," says Dougherty. "These emerging market trends played very well to our core strength.

"We have targeted development activity in the high-growth areas of components and modules for 100G coherent application, indium phosphide integrated circuits, 100G client interfaces, 40G and 100G modules for data-centers as well as tunable SFP+," Dougherty continues. "As evidenced with some of our progress and focus at OFC [Optical Fiber Communications conference] next month, we will present two exciting papers on our photonic integrated circuits for use in 100G coherent networks." One paper discusses a highly integrated balance receiver and the other an integrated tunable laser plus modulator in a small package. "Both of these papers highlight our ability to provide photonic integrated circuits in indium phosphide with world-class performance," Dougherty adds. "In addition, one of our key customers will actually present a paper demonstrating the performance that they achieved by using our integrated indium phosphide optical components with their proprietary DSP [digital signal processor] in a 100G coherent system."

www.oclaro.com

JDSU's quarterly revenue grows 4% to more-than-expected $447.6m

Growth driven by tunable XFP & SFP+ products and TrueFlex ROADMs

For its fiscal second-quarter 2014 (ended 28 December 2013), JDSU of Milpitas, CA, USA has reported revenue of $447.6m, up 4% on $429m last quarter and $429.4m a year ago (and above the guidance of $420–440m).

By sector, 44.2% of revenue came from Communications and Commercial Optical Products (CCOP), 43.6% from Network and Service Enablement (NSE, formerly Communications Test & Measurement, or CommTest) and 12.2% from Optical Security and Performance (OSP). This compares with 47.7%, 40.1% and 12.2% last quarter, i.e. a swing back from CCOP to NSE.

CCOP revenue was $198m, up 6.6% on $185.8m a year ago but down 3.2% on last quarter's $204.6m (and below the guidance of flat on last quarter). Within CCOP, Lasers revenue was $23.5m, down 22.2% on $30.2% a year ago and 17.3% on $28.4m last quarter. Optical Communications revenue was $174.5m, up 12.1% on $155.6m a year ago but down 1% on $176.2m last quarter (reflecting the anticipated seasonal drop-off in gesture recognition revenue, partially offset by increased telecom business). Demand for 100G line-side telecom components was strong (26% of transmission revenue). Revenue doubled for TrueFlex ROADM s (reconfigurable optical add-drop multiplexers) and revenue for tunable XFP and SFP+ products grew by more than 14%. Amplifier revenue fell 10%, and provides a good leading indicator for continued transmission product growth for tunable XFP and SFP+ in the build-out for more metro and edge 10G applications, says JDSU.

On a non-GAAP basis, gross margin was 48.5%, up on 46.3% last quarter and 48% a year ago (and the best quarter since fiscal Q2/2011). In particular, CCOP gross margin rose from 32% to 32.3%, reflecting favorable product mix and operational improvements despite the sequentially lower revenue. Of this, Optical Communications gross margin rose from 29.5% to 30% and Laser's gross margin rose from 47.5% to 49.4%.

Operating margin was 11%, up on 8.3% last quarter (and above the expected 8.5–10.5%) but down on 11.4% a year ago, due mainly to increased investments in R&D and NSE and CCOP, as well as incremental expenses from the acquisition of Arieso. In particular, CCOP operating margin was 12.1%, down from 13.3% last quarter (and at the low end of the 12–14% guidance), impacted by the lower CCOP revenue and increased R&D investments.

Net income was $45.3m, up from $30.2m last quarter and $42.3m a year ago. Driven by the higher sales and better margins, operating cash flow has nearly doubled from $29.5m last quarter to $54.4m. Capital expenditure was a higher-than-expected $31.9m, due to the $14.7m purchase of the firm's largest fabrication facility in California (to protect its capital investment in this facility, reflecting a long-term commitment to the site as well as providing operational flexibility and cost savings). During the quarter, total cash and investments rose from $1087.3m to $1095.6m.

"We are pleased with the performance of our organic business, the progress of our continuing investments in new offerings which align with customer requirements and market trends, and our continuing M&A strategy to expand our product portfolio into mobility and service enablement," says president & CEO Tom Waechter. New products (less than 2 years old) represented 65% of revenue. "We believe JDSU is well-positioned to leverage our technical leadership in new markets in network infrastructure, commercial lasers and anti-counterfeiting in calendar 2014."

We continue to see strong datacom market demand, particularly in the data center and cloud segment as Internet and cloud service providers expand their infrastructure

For fiscal third-quarter 2014 (ending 29 March), JDSU expects revenue to fall to $420–440m, including $175–185m from NSE, $49–51m from OSP and $195–205m from CCOP. Operating margin should be 6-8%, including 5–7% for NSE, 10–12% for CCOP and 34–36% for OSP.

In CCOP, the sequential decline reflects an expected decline in gesture revenue offset by improvements in telecoms, datacoms and Commercial Lasers. "In CCOP, we see a healthy demand for our 100G products and are working to increase reduction capacity on these products," says Waechter. "We're excited about the early success of our tunable and TrueFlex product lines and pleased with our penetration into the datacom market with our 10G and 40G products," he adds.

"We continue to see strong datacom market demand, particularly in the data center and cloud segment as Internet and cloud service providers expand their infrastructure," Waechter continues. "Datacom was healthy for CCOP's 10G and 40G portfolio in the first half of fiscal 14 and is expected to continue being an area of growth for CCOP as we expand our product offering for this space and penetrate new accounts."

www.jdsu.com

Advanced Photonix's growth pauses while silicon photodiode production shut down

Annual growth forecast lowered to 25%

For fiscal third-quarter 2014 (ended 27 December 2013), Advanced Photonix Inc of Ann Arbor, MI, USA (which designs and makes APD, PIN, and FILTRODE photodetectors, HSOR high-speed optical receivers, and T-Ray terahertz instrumentation) has reported sales of $7.45m, level with last quarter but up 28% on $5.8m a year ago.

Due primarily to a one-time accelerated depreciation charge related to the shutdown of silicon photodiode production, gross margin was 25.3%, down from 37% last quarter and 42% a year ago.

Operating expenses have been cut from $3.47m (59% of revenue) a year ago and $3.34m last quarter to $3.2m (43% of revenue).

Nevertheless, after being cut from –$485,000 a year ago, adjusted EBITDA (earnings before interest, taxes, depreciation, amortization and stock compensation) was –$205,000, compared with +$20,000 last quarter. During the quarter, cash and cash equivalents have fallen from $371,000 to $116,000.

"While we are disappointed in the pause we saw this quarter in our revenue growth, we are encouraged by the traction we are getting in the 100G transmission market and the large funnel of potential sales developing for Terahertz," says CEO Richard Kurtz. "We are actively assessing strategic options to shore up our liquidity to fund the expected future growth for these opportunities," he adds.

"Due to the government sequestration that impacted our development contracts and pushed out the timing of the expected revenue, we have lowered our revenue growth for fiscal 2014 to be approximately 25% relative to the prior year."

● Subsidiary Picometrix has been chosen to supply its CR-100D receiver for the 100G optical transport network equipment of a leading Chinese telecoms equipment and networks solutions provider. Initial orders total nearly $500,000, with potential revenue of over $2m for the next fiscal year.

"This is part of the much anticipated 'China hockey stick' that is expected to be the world's largest 100G backbone deployment to date," says Rob Risser, general manager of Picometrix and chief operating officer & director of API.

"100G markets are in the early adoption phase, and are expected to grow rapidly over the next five years to become the dominant modulation format deployed in the long-haul and metro markets," he adds.

www.advancedphotonix.com

Infinera's annual revenue up 24%, driving return to profit

For fourth-quarter 2013, Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own InP-based photonic integrated circuits (PICs), has reported revenue of $139.1m, down 2% on $142m last quarter but up 8.6% on $128.1m a year ago. Full-year revenue was $544.1m, up 24% on $438.4m in 2012.

On a non-GAAP basis, gross margin for Q4 was 41%, down from 49% last quarter of 2013 but up from 36% a year ago. Full-year gross margin has risen from 38% to 42%.

Net loss for Q4 was $0.2m, compared to net income of $12.8m last quarter but an improvement on net loss of $6m a year ago. Full-year 2013 has yielded net income of $4m, compared with a net loss of $43.5m in 2012. Net free cash flow for the year was $12m.

"The fourth quarter was a solid finish to a very good year for Infinera, driven by continued acceptance of the DTN-X," says CEO Tom Fallon. "We received purchase commitments from three additional customers in the quarter, including one new to Infinera, and we set another quarterly record for 100G port shipments," he adds.

"Our financial results for 2013 demonstrate the strong potential of the DTN-X," believes Fallon. "Revenues grew 24%, at least double the long-haul DWDM market growth estimated by industry analysts," he adds. Since its introduction in mid 2012, Infinera has received purchase commitments for the DTN-X from 42 customers, representing a cross section of industries including tier-1 carriers, cable operators, Internet content providers and bandwidth wholesalers. Of these, 15 are new customers. "These achievements met or exceeded the targets that we provided at our Analyst Day in December of 2012," notes Fallon.

"As we look ahead, we believe the opportunity for the DTN-X remains wide open with the 100G cycle still in its early stages," continues Fallon. "Infinera's Intelligent Transport Network and the DTN-X offers important differentiated features, including its super-channel scale, converged OTN switching and GMPLS network automation," he adds. "For 2014, we plan to continue our focus on winning new deployments and gaining market share, while driving enhanced profitability, and we remain optimistic about our outlook over the short, intermediate and long-term," Fallon concludes.

www.infinera.com

Emcore's record quarter for Photovoltaics drives revenue to $44.2m

Breakeven reduced to $45–47m as tunable products ramp and costs cut

For fiscal first-quarter 2014 (to end-December 2013), Emcore Corp of Albuquerque, NM, USA, which makes compound semiconductor-based components and subsystems for the fiber-optic and solar power markets, has reported revenue of $44.2m, up 2.6% on $43.1m last quarter but down 10% on $49.3m a year ago.

Photovoltaics revenue was a record $20.9m, up 2% on $20.5m last quarter (unchanged from 47% of total revenue) and up 6.6% on $19.6m a year ago (40% of total revenue).

Fiber Optics revenue was $23.3m, up 3.1% on $22.6m last quarter (unchanged from 53% of total revenue). In the telecom division, shipment volumes of ITLAs (integrable tunable laser assemblies) were at a record level (with revenue up 7% for this product line), while revenue for tunable XFP modules was relatively flat quarter-to-quarter (at about $1m). In the broadband division, most of the $14.7m revenue came from a significant rise in shipments for cable TV applications. However, Fiber Optics revenue is still 22% down on $29.7m a year ago (60% of total revenue). "Our business in cable TV is recovering. However the rebound in demand for high-end transmitters from the slump in early 2013 has not been as rapid as our customers previously anticipated," notes president & CEO Dr Hong Q. Hou. "When we conducted a more in-depth analysis from the breakdown of the 2013 CapEx spending as reported by two major cable TV service providers last week, it was very evident that their spending on customer premises equipment (CPE) and the equipment for the node increased in 2013 substantially," he adds. "However, the spending on the high-end equipment has been on a slower growth path."

Overall gross margin was 22.9%, up on 12.5% last quarter (due mainly to the higher Photovoltaics revenue) and above the 22.2% a year ago.

Photovoltaics gross margin was 37%, up greatly from 13.5% last quarter (due mainly to a significant increase in higher-margin shipments) and above 30.5% a year ago. "We continue to believe that this [Photovoltaics] business' target gross margin is at roughly 30%," says chief financial officer Mark B. Weinswig.

Fiber Optics gross margin fell to 10.3% from 11.6% last quarter (and 16.7% a year ago). "While we have seen a significant improvement in our tunable XFP product yields and margins, the manufacturing line is still under-utilized and margins are below our average," says Weinswig.

Operating expenses have fallen slightly from $12.5m last quarter to $12.4m, though up on $8.1m a year ago (which benefited from flood-related insurance proceeds of $4.2m) due to certain audit-related and corporate costs plus higher severance cost.

Operating loss was $2.2m, cut from $7.1m last quarter but still down from a profit of $2.8m a year ago. By sector, Photovoltaics has rebounded from the operating loss of $0.25m last quarter to an operating profit of $4.3m (one of the sector's most profitable quarters), exceeding the $3.2m profit a year ago. Fiber Optics operating loss has been cut from last quarter's $6.9m to $6.6m, although this compared with just $0.4m a year ago.

On a non-GAAP basis, net loss was $0.5m, cut from $5.8m last quarter but worse than $0.1m a year ago.

Nevertheless, during the quarter, cash and cash equivalents rose by $2m, from $16.1m to $18.1m, due mainly to the collection of receivables that were outstanding at the end of the quarter.

In the past quarter, the Space Photovoltaic division was awarded or authorized to begin work on a total of 13 separate contracts (with a total value of over $10m). Customers include the US government and several domestic and international aerospace defense and satellite integrators. "Although the business outlook is robust, we continue to rigorously manage the business with emphasis on technical and operational excellence. We reduced the cost structure in early January for this segment to further improve the business competitiveness," Hou says. "We continue to expand our space solar market share by expanding the customer base, also by increasing the level of integration such as to provide fully integrated solar panel products instead of just providing solar cells," he adds. "In the meantime we are aggressively pursuing adjacent market opportunities such as high-end mobile power for defense applications. Preliminary market study indicates that the high-end mobile power market is very elastic. In addition to the key requirement of high efficiency, net weight and flexibility, competitive cost structure is essential to enable adjacent applications to take-off."

As of end-December, order backlog for Photovoltaics (Space Solar) was $55.3m, down 3.2% on last quarter's $57.1m. "However, several significant contract awards are expected during fiscal Q2," notes Hou. "These expected long-term purchase agreements should increase our 12-month backlog significantly above the $55m and also provide long-term commitment and business outlook to a level that Emcore has not previously seen," he adds.

Regarding Fiber Optics, in the telecom division: "We continue to see strong demand in ITLAs for coherent 100G deployment," notes Hou. "Order activity for this quarter is

very strong. It is likely that the shipment volumes of ITLAs in the March quarter will reach a new record."

For fiscal Q2/2014 (to end-March), Emcore expects overall revenue to fall to $40-44m. "The Space Photovoltaic segment can be quite lumpy due to the binary nature of a certain large orders to either ship all of them or none of them by the end of the quarter. So this wider range is primarily from the uncertainty on the Photovoltaic side," comments Hou. The decrease in Space Photovoltaics revenue will outweigh an increase in Fiber Optics revenue.

"During the annual price and market share allocation negotiations [with telecom customers] at the end of last year, price erosion was approximately 10% with existing customers," notes Hou. "A significant portion of our volumes shipped in the December quarter came from the new pricing for some customers, and we have realigned our engineering resources to not only developing new products but also define cost reductions in the future for our current products."

Regarding broadband business, production consolidation has been largely completed and Emcore's cost structure is more competitive. "We are continuing to defend and expand our leading position in cable TV. In the meantime, we want to pursue a higher-margin growth opportunity to selected niche market by leveraging our core competency and infrastructure with significant opportunity for future business growth in our broadband division," says Hou.

Emcore expects quarterly operating expenses to be down to about $11.5m per quarter going forward. "We continue to improve our cost structure and believe that we can reach breakeven at a quarterly revenue level at approximately $45–47m, depending on the product mix," says Hou. This is down from the $47–48 breakeven revenue figure given in December.

"Recently, we started a new program to drastically reduce the cost of tunable TOSA [transmitter optical subassembly], confident about the competitive advantage of the Emcore tunable XFP, both negative- and zero-chirp, with full-band tunability and better OSNR [optical signal-to-noise ratio] and a higher output power," says Hou. "These are the key attribute requirements for replacing 300-pin transponders, which started last year," he adds.

"Over the next two quarters, with the launch of the micro-ITLA, we expect our margins to be slightly under pressure," says Weinswig. "Customer demand [for micro-ITLAs] has been increasing moderately recently," says Hou. "Recently, however, we are seeing an accelerated effort from all customers to migrate to micro-ITLA platform before the end of the calendar year 2014," he adds. "It is largely driven by our customers' desire to increase their line charge sensitivity and also design for metro applications using coherent transmissions."

"We have seen some more aggressive pricing for our flagship ITLA product," Weinswig says. "We expect our overall gross margins in the Fiber Optic segment will improve in future quarters as we complete the ramp-up of our new product line at our contract manufacturer and our Fiber Optic revenues continue to increase.

"The recent earning releases from the leading cable service providers in the North America, such as Comcast and Time Warner Cable indicated that the 2014 CapEx spending approached about 14.5% of their revenues, while Comcast it is a substantial increase from 12.9% of their revenue in 2013 and for Time Warner Cable it is in line with their 2013 percentage of spending on CapEx," says Hou. "Although we do not have the exact breakdown of their spending between CPE and infrastructure, we are hopeful that, when choke points near customer interfaces and node in HSB networks are removed through the recent spending in 2013, demand for higher-end products will increase more rapidly in the near future."

www.emcore.com

Emcore awarded solar panel manufacturing contract by ATK

Emcore has been awarded a contract by aerospace, defense and commercial products firm ATK to design and make solar panels for NASA's InSight Mars Lander. The mission, managed by NASA's Jet Propulsion Laboratory (JPL), is planned for launch in March 2016.

Solar panels using Emcore's ZTJ triple-junction solar cells will power the InSight spacecraft, which will be built and operated by Lockheed Martin Space Systems Company in Denver, CO, USA. ATK will integrate Emcore's solar panels into its heritage-designed UltraFlex solar arrays for the final flight configuration of the spacecraft.

InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) is a NASA Discovery Program mission to place a single geophysical lander on Mars to study its deep interior. InSight will also act as a terrestrial planet explorer, opening a window into the processes that shaped the rocky planets of the inner solar system (including Earth) more than 4 billion years ago.

"Emcore has partnered with ATK on many successful programs and has supported several high-profile NASA-JPL missions including the Mars Science Laboratory (MSL) that carried the rover 'Curiosity'," says Dr Brad Clevenger, executive VP & general manager of Emcore's Photovoltaics Division.

"Emcore is in the process of delivering solar panels for several other NASA missions, including the Green Propellant Infusion Mission (GPIM) with ATK," notes Navid Fatemi, VP of business development.

Soitec launches higher-capacity off-grid CPV system

Soitec of Bernin, France has launched the Plug&Sun+, a higher-capacity version of its off-grid concentrator photovoltaic (CPV) product Plug&Sun (launched in 2011).

The Plug&Sun+ can be coupled with batteries and/or a diesel generator to provide electricity 24/7 and is designed to address the needs of medium-scale solar-energy installations at remote sites with limited or no access to grid power. The new system is available now and already generating orders.

The firm says that the original Plug&Sun is a robust, reliable, easy-to-deploy CPV tracking system designed to meet the energy needs of small-scale isolated sites. The new, configurable Plug&Sun+ provides an enhanced mix of technical and economic performance. It uses three of Soitec's latest generation of CPV modules — with a total surface area of 26.3m^2 — and is linked to an energy management system, allowing peak-power output of 7.3kWp while providing hundreds of watts of power throughout the day and night. The system also can be configured with more than one dual-axis tracker. Additionally, when Plug&Sun+ is used in hybrid installations, it provides a renewable energy source that complements existing power generators. This can yield technical and economic benefits such as reducing diesel consumption and maintenance costs, says Soitec.

The Plug&Sun+ system is configurable to meet installation requirements for different applications including housing (lodges, houses, camps etc), industrial sites, outdoor lighting, water treatment (pumping, desalinization etc) and telecoms base-stations. Soitec has already received an order for its new system configured with two trackers from "a European leader in energy and information technology services" for a pilot installation that will supply electricity to a French city.

Soitec also continues to sell and support its original Plug&Sun system. This deployable power generating system is adapted to the needs of individual electricity generation, says the firm. In recent weeks, Plug&Sun systems have been ordered by a solar-project developer in Qatar (that will employ Soitec's system for exterior lighting) and Logsys Power Services (an electrical installation and maintenance company in Australia and a new distributor of the Plug & Sun product line in that country). Logsys is currently using the product for a remote water-pumping application.

"The immediate customer demand for our newest flexible, configurable CPV system demonstrates the value of the Plug&Sun product portfolio as the most efficient solar generator of clean, off-grid electricity," claims José Beriot, VP of solar projects development with Soitec's Solar Energy Division. "Our new system also fits well with our strategic mission to be a leader in the off-grid energy market by spearheading the development of very efficient and robust CPV technology that is perfectly suited for remote regions with high solar radiation," he adds.

Soitec's CPV technology uses triple-junction cells mounted on a glass plate. Fresnel lenses, manufactured using silicone on glass, concentrate sunlight 500 times before it reaches the cells. A metal frame holds two glass plates to form what are described as highly robust, durable and resilient modules. By combining several modules on biaxial trackers (which use a proprietary algorithm to automatically optimize their position based on the path of the sun) Soitec's technology maximizes energy generation throughout the day, the firm concludes.

www.soitec.com

Fraunhofer ISE and Fukushima prefecture sign MoU

A memorandum of understanding has been signed between Japan's prefecture of Fukushima and the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany (Europe's largest solar energy research institute) in order to promote cooperation. Fukushima (which was struck by a severe nuclear accident three years ago) is aiming to become a new hub for renewable energy research, and in April will open the new Fukushima Renewable Energy Institute.

"Applied research is a key factor in the technological development of companies, especially in the field of renewable energy," says Fukushima's vice governor Fumio Murata. "It will assist in revitalizing and enhancing the industrial competitiveness in the Fukushima area," he adds.

"Solar technologies will be a main pillar of the future energy system which will be sustainable and carbon-free," believes Fraunhofer ISE's director professor Eicke R. Weber. "To this end, we must cooperate in research at an international level." Two years ago, Fraunhofer ISE formed the Global Alliance of Solar Energy Research Institutes (GASERI) with the Japanese National Institute of Advanced Industrial Science and Technology (AIST) and the US Department of Energy's National Renewable Energy Laboratory (NREL).

Scientific exchange as well as joint workshops and symposia comprise the core of the new international cooperation between Freiburg and Fukushima. The idea of a partnership arose at the German-Japanese Solar Day, which took place in Tokyo in November 2012 and was further developed at the Renewable Energy Industry Fair (REIF) in Fukushima in 2013.

www.ise.fraunhofer.de

Argonne and University of Texas team boost solar cells by capturing high-energy photons more efficiently

Photonic curing of nanocrystalline CIS allows multi-exciton

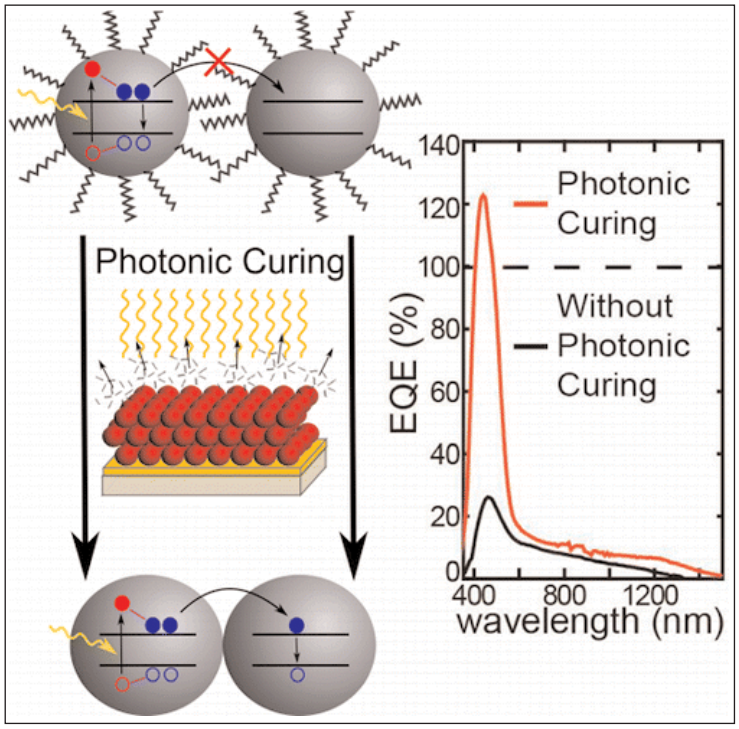
The US Department of Energy's Argonne National Laboratory and the University of Texas at Austin have co-developed inexpensive material that has the potential to capture and convert solar energy — particularly from the bluer part of the spectrum — much more efficiently than before, it is claimed (C J Stolle et al, 'Multiexciton Solar Cells of $CuInSe_2$ Nanocrystals', J. Phys. Chem. Lett., 2014, 5 (2), 304; DOI: 10.1021/jz402596v).

Most simple solar cells handle these bluish hues of the electromagnetic spectrum inefficiently. This is because blue photons striking the solar cell actually have excess energy that a conventional solar cell cannot capture.

"Some photons come in with more energy than the cell is optimized to handle, and so a lot of that energy is lost as heat," says University of Texas professor Brian Korgel.

Because of this limitation, scientists had originally believed that simple solar cells would never be able to convert more than about 34% of incoming solar radiation to electricity. However, about a decade ago, researchers saw the potential for a single high-energy photon to stimulate multiple excitons (pairs of a negatively charged electron and a positively charged hole) instead of just one. "We were still skeptical that we could get the electrons out of the material," Korgel says.

His research team used specialized spectroscopic equipment at Argonne's Center for Nanoscale Materials — one of the Department of Energy's five Nanoscale Science Research Centers (NSRCs) — to look at multi-exciton generation in copper indium selenide (CIS), rather than the more commonly produced material copper indium gallium diselenide (CIGS) which holds the record for the most efficient thin-film photovoltaic cell.



Peak external quantum efficiencies (EQEs) of just over 120% were observed in of $CuInSe_2$ nanocrystal PV devices prepared by photonic curing. The extraction of more than one electron/hole pair as a result of the absorption of a single photon can occur if multiple excitons are generated and extracted. Multi-exciton generation (MEG) in the nanocrystal films was substantiated by transient absorption spectroscopy. It is proposed that photonic curing leads to sufficient electronic coupling between nanocrystals to enable multi-exciton extraction under typical solar illumination conditions. Under low light conditions, however, the EQE drops significantly, indicating that photonic curing-induced ligand desorption creates a significant amount of traps in the film that limit the overall power conversion efficiency of the device.

"This is one of the first studies done of multiple exciton generation in such a familiar and inexpensive material," says Argonne nanoscientist Richard Schaller.

"Argonne's spectroscopic techniques played a critical role in the detection of the multi-excitons," Korgel says. "These kinds of measurements can't be made many places."

To deposit thin films of the nanocrystalline material, the researchers used photonic curing (involving the split-second heating up and cooling down of the top layer of the material). This curing process not only prevents the melting of the glass that contains the nanocrystals, but also vaporizes organic molecules that inhibit multiple exciton extraction.

Although the study mostly proves that the efficiency boost provided by multiple exciton extraction is possible in mass-producible materials, the major hurdle will be to incorporate these materials into real-world devices.

"The holy grail of our research is not necessarily to boost efficiencies as high as they can theoretically go, but rather to combine increases in efficiency to the kind of large-scale roll-to-roll printing or processing technologies that will help us drive down costs," Korgel says.

The study was supported by grants from the Department of Energy's Office of Science and the US National Science Foundation (NSF).

http://pubs.acs.org/doi/abs/10.1021/jz402596v
www.che.utexas.edu/korgel-group
http://nano.anl.gov
http://science.energy.gov

First Solar raises CdTe solar cell efficiency record to 20.4%, matching multi-crystalline silicon record

Technology partnership builds on GE's prior record of 19.6%

cadmium telluride (CdTe) thin-film photovoltaic module manufacturer First Solar Inc of Tempe, AZ, USA has set a record for CdTe solar cell conversion efficiency of 20.4%, as certified at Newport Corp's Technology and Applications Center (TAC) PV Lab and confirmed by the US Department of Energy's National Renewable Energy Laboratory (NREL). The record cell was fabricated at First Solar's factory and Research & Development Center in Perrysburg, OH.

The certified result beats the previous record of 19.6% conversion efficiency set by GE Global Research in 2013 (after First Solar previously raised the record to 18.7% in the February). Last April a solar technology partnership was announced in which First Solar acquired GE's CdTe solar intellectual property and secured a collaborative research partnership with GE's R&D team. The partnership was formed to accelerate innovation in PV technology and accelerate solar module performance at manufacturing scale.

We are demonstrating improvement in CdTe PV performance at a rate that dramatically outstrips the trajectory of conventional silicon

"We are demonstrating improvement in CdTe PV performance at a rate that dramatically outstrips the trajectory of conventional silicon technologies, which have already plateaued near their ultimate entitlements," says First Solar's chief technology officer Raffi Garabedian. The new CdTe research cell conversion efficiency matches the research cell efficiency record of multi-crystalline silicon. "The synergy realized in our partnership with GE also demonstrates the value of our consistent and strong investment in R&D," he adds. "The advanced technologies and processes we developed for this record-setting cell are already being commercialized and will positively impact performance of our future production modules and power plants."

First Solar says that it has continued to transfer its results in the R&D lab into its commercial modules, increasing its average production module efficiency to 13.4% in fourth-quarter 2013, up 0.6% from 12.9% in fourth-quarter 2012. At the end of 2013, the firm's lead manufacturing line was producing modules with 13.9% average efficiency.

First Solar recognizes top suppliers with 2013 achievement awards

First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services, has announced the recipients of its 2013 NOVA award for outstanding performance by suppliers.

The awardees – SMA Solar Technology AG, OMCO Solar, Airgas USA LLC and Air Liquide Malaysia Sdn. Bhd – have been recognized for providing "enduring value to First Solar's manufacturing and EPC project activities".

- SMA Solar Technology AG of Niestetal, Germany was recognized for its continued partnership on key strategic initiatives, including third-party sales support, around the world, while maintaining quality and controlling costs.
- OMCO Solar of Phoenix, AZ, USA was recognized for demonstrating considerable manufacturing flexibility that accommodated First Solar's dynamic EPC project schedules in North America.
- Airgas USA LLC of Radnor, PA, USA was recognized for ensuring continued, uninterrupted supply of manufacturing materials to First Solar's production facility in Perrysburg, OH, as well as personal protection equipment and safety equipment, while remaining open to creative approaches to managing inventory and reducing costs.
- Air Liquide Malaysia Sdn Bhd (ALM) was recognized for delivering an expanded nitrogen generation system in support of new manufacturing processes at First Solar's production facility in Kulim, Malaysia, and for supporting the firm's requirements at competitive rates.

"Our suppliers play a critical role in fulfilling our mission to create enduring value by enabling a world powered by clean, affordable solar electricity," said Shellie Molina, First Solar's VP, Global Supply Chain. "We appreciate the exceptional efforts of these NOVA award recipients and the value they provide through the highest standards of quality, cost and performance in both the manufacturing and EPC environments."

First Solar estimates that its business operations support about 33,000 supply chain jobs on a global basis. The firm established the NOVA Award in 2011 to honor suppliers that significantly support its mission.

www.sma-solar.com
www.omcosolar.com
www.airgas.com
www.my.airliquide.com
www.firstsolar.com

First Solar's sales fall 28% year-on-year to $768m in Q4

Profits impacted by write-down of idle Vietnam facility

First Solar Inc of Tempe, AZ, USA – which makes thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services — has reported full-year net sales of $3.309bn for 2013, down 1.8% from 2012's $3.369bn, and below the guidance of $3.4–3.6bn (which had been lowered last November from the prior guidance of $3.6–3.8bn).

For Q4/2013, net sales were $768m, down 28.5% on $1075m a year ago and 39% on $1266m last quarter, due mainly to lower systems business project revenues (as initial revenue recognition for the Desert Sunlight and sale of the ABW projects in Ontario, Canada, were both achieved in Q3/2013).

Impacted by pre-tax restructuring and asset impairment charges of $24.9m (related mainly to an additional write-down, due to a change in marketing strategy, in the value of the firm's idle Vietnam facility), GAAP net income was $65.3m ($0.64 per fully diluted share), down from $195m ($1.94 per fully diluted share) last quarter and $154m ($1.74 per fully diluted share) a year ago. Full-year GAAP net income has improved from a loss of $96m ($1.11 per fully diluted share) in 2012 to a profit of $353m ($3.70 per fully diluted share) for 2013, even after including the impact of pre-tax charges of $86.9m related to restructuring activities, the sale of the facility in Mesa, AZ, USA, and the write-down of the Vietnam facility. However, this is below the earnings per share guidance of $4.25–4.50 (which had been raised last November from the prior guidance of $3.75–4.25).

Excluding the impact of the restructuring and asset impairment charges, non-GAAP net income was $90.3m ($0.89 per fully diluted share) for Q4/2013, down from $229.3m ($2.28 per fully diluted share) last quarter and $180.4m ($2.04 per fully diluted share) a year ago. Full-year non-GAAP net income has fallen from $430m ($4.90 per fully diluted share) in 2012 to $415.6m ($4.35 per fully diluted share) for 2013.

Operating cash flow was $192m in Q4/2013, down from $375.1m last quarter and $328m a year ago. Full-year operating cash flow was $856m (within the guidance of $0.7–0.9bn, lowered last November from prior guidance of $0.8–1.0bn). During the quarter, cash and marketable securities rose by $232m from $1.53bn to $1.76bn. Net cash grew from $1.3bn to $1.5bn.

"The fourth quarter and full-year 2013 shows our company's continued progress in achieving the strategic objectives we outlined during our Analyst Day event in April," notes CEO Jim Hughes. "For the year completed we delivered on several key objectives, including additional bookings of approximately 1.7GW_{DC}, significant reductions to our module manufacturing cost, and a strong financial performance," he adds. "As we move into 2014, the company remains focused on continuing to achieve our strategic objectives."

Over the past year, First Solar has achieved several milestones:

- setting a record for CdTe cell efficiency of 20.4% (after the firm set a record of 18.7% just a year ago).
- reducing the average module manufacturing costs on its best plant by 17% from $0.64 per watt in Q4/2012 to $0.53 per watt in Q4/2013 (excluding under-utilization and upgrades).
- Raising cumulative production from 7GWDC at the end of 2012 to over 8GW_{DC} at the end of 2013 (enough to provide electricity for about 4 million homes and displace 5.2 million metric tons of CO_2 annually);
- adding 1.7GW_{DC} of new projects to the project pipeline.
- acquiring TetraSun of San Jose, CA, USA (which has developed a proprietary monocrystalline silicon solar cell architecture capable of efficiencies exceeding 21%) to expand addressable market opportunity; and
- completing its first utility-scale project in the Middle East and the largest operating solar PV plant in the region.

For Q1/2014, First Solar expects net sales to rebound to $800–900m, earnings per fully diluted share of $0.50–0.60, and cash used in operating activities of $300–400m.

First Solar appoints general counsel

First Solar has named Paul Kaleta as executive VP & general counsel, with comprehensive leadership responsibility for its global legal function (effective 3 March).

"Paul's notable experience in the energy sector is a considerable asset to First Solar," says CEO Jim Hughes. "He is a seasoned professional, with more than 20 years of experience as a general counsel, who brings highly relevant, market-specific depth to our leadership team."

Most recently, Kaleta was executive VP, shared services, general counsel & secretary, and chief compliance officer, for NV Energy Inc. Before that, he was VP & general counsel for Koch Industries Inc, as well as serving in legal and other leadership roles for Koch firms. Previously, he was VP & general counsel of Niagara Mohawk Power Corp (now part of National Grid), and was a partner in law firm Swidler & Berlin and an associate at Skadden, Arps, Slate, Meagher & Flom. He also been a federal judicial clerk.

www.firstsolar.com

First Solar breaks ground on AGL's 102MW Nyngan Solar Project in New South Wales

Cadmium telluride (CdTe) thin-film photovoltaic modules First Solar Inc of Tempe, AZ, USA has begun construction of Australia's largest utility-scale solar project, a 250 hectare solar plant in Nyngan, New South Wales (NSW).

Less than six months after Sydney-based AGL Energy Ltd (Australia's largest private owner and operator of renewable energy assets) achieved financial close for the project, First Solar has broken ground on the installation of about 1,350,000 modules.

In addition to construction, First Solar is also providing engineering and procurement services for the project and will provide maintenance services for a period of five years after commissioning. Expected to be completed in mid-2015, the project will produce $102MW_{AC}$ (enough electricity to power more than 33,000 average NSW homes). The energy supplied will abate more than 203,000 tonnes of CO_2 every year (equivalent to taking more than 53,000 cars off Australia's roads).

"Each project that First Solar constructs builds acceptance of and confidence in utility-scale solar as an effective source of power generation in Australia," says Jack Curtis, First Solar's VP of business development for Asia Pacific. "As the Nyngan project develops, we look forward to seeing its impact, not only in generating important local job opportunities, but also in strengthening the solar industry's position within Australia's energy mix."

Each project that First Solar constructs builds acceptance of and confidence in utility-scale solar as an effective source of power generation in Australia

First Solar expects to create an estimated 300 direct construction jobs during building of the Nyngan solar plant.

The firm is also engaging with local contractors and will make announcements as contracts are issued. In total, the project is expected to add nearly 2% to the gross regional product of the community.

The Nyngan solar plant is the first of two utility-scale solar projects to have received funding by the Commonwealth Government through the Australian Renewable Energy Agency (ARENA) and the NSW Government. First Solar expects to start construction of the second project in Broken Hill, NSW, in mid-2014.

www.firstsolar.com

Construction started on Phase I of 22MW project in West Texas

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement & construction (EPC) services, has begun construction on Phase I of the Barilla Solar Project in Pecos County, Texas, west of Fort Stockton. The $22MW_{AC}$ project is expected to begin commercial operation in mid-2014.

First Solar will build, commission and operate the power plant, and offer the output to customers, including municipal utilities, electric cooperatives, and larger commercial and industrial users. The project, located in West Texas, will have access to one of the best solar resource areas in the state and can provide electricity to more heavily populated areas with greater peak energy demand.

"The Barilla Solar Project demonstrates First Solar's capability to rapidly develop, construct and commission a solar project offering clean, reliable energy at competitive rates to the market when and where it is required," says Tim Rebhorn, senior VP of business development for First Solar. "The project will contribute to Texas' immediate energy needs and demonstrate how solar power can provide a generating resource that can be effectively integrated into the ERCOT [Electric Reliability Council of Texas] grid and help meet Texas' energy demand, particularly during critical peak hours," he adds.

"An additional benefit is that solar power plants require no water to generate electricity," says Brian Kunz, First Solar's VP of project development. "This is important in West Texas, where scarce water resources must be preserved," he notes.

"This is an important step forward in our efforts to establish West Texas as a center for renewable energy," believes Pecos County judge Joe Shuster. "We are not resting on our legacy of leadership in oil and gas. We welcome solar as the next new component in our portfolio of energy resources," he adds.

"Industry diversification is critical to this community's growth," concludes Doug May, director of the Fort Stockton Economic Development Corporation. "This opportunity to harvest the ample solar resources of the region will encourage and support further development."

Eventually, according to Rebhorn, First Solar would consider selling the Barilla Solar Project to a long-term owner.

www.firstsolar.com

EPSRC awards £2m for PVTEAM project on PV technology using Earth-abundant materials

UK universities target material development & characterization plus device fabrication, testing and integration into modules

A research project led by the University of Bristol that aims to develop new active materials for photovoltaic solar cells based on Earth-abundant and low-cost elements has been awarded £2m funding by the UK Engineering and Physical Sciences Research Council (EPSRC).

Led by professor David Fermin of Bristol's School of Chemistry, the study 'Photovoltaic Technology based on Earth Abundant Materials' (PVTEAM) is one of four research projects to be awarded a total of £10.3m by the EPSRC. Each aims to find safer, more sustainable alternatives to many of the raw materials used by manufacturing industries.

The Bristol-led project aims to replace key elements — such as gallium, indium, cadmium and tellurium — used in solar cell manufacturing, while also implementing processes compatible with large-scale manufacturing. As these elements have low abundance, high costs and high toxicity, finding alternatives to them represents an extraordinary opportunity, it is reckoned.

"The aim of this program is to lay the foundations of sustainable thin-film photovoltaic technology based on Earth-abundant materials and scalable manufacturing processes," Fermin says. "This will be achieved by developing processes and production technologies for materials and material systems to a level they can be taken up by manufacturing industries," he adds.

"PVTEAM will specify a carefully selected range of chemical compounds (chalcogenides and oxides) as substitutes to proven commercial materials," Fermin continues. "Using a multi-level screening approach, we will incorporate the best performing candidates into established solar cell architectures."

The consortium involves five universities (Bristol, Bath, Northumbria, Swansea and Loughborough) with state-of-the-art infrastructure for material development and characterization as well as for device fabrication, testing and integration into photovoltaic modules.

Material processing will be based on facilities available at the Sustainable Product Engineering Centre for Innovative Functional Industrial Coatings (SPECIFIC, an academic and industrial consortium led by Swansea University, with Tata Steel as the main industrial partner, funded by EPSRC, the UK's Technology Strategy Board and the Welsh Government). SPECIFIC will be in charge of designing scale-up strategies and preparing techno-economic assessment.

The PVTEAM industrial partners (Tata Steel, Pilkington NSG and Johnson Matthey) have a global footprint in materials for the construction, coating and chemical industries.

The consortium also includes the small and medium enterprises (SMEs) M-Solve and Semimetrics, which will provide means for the exploitation of new PVTEAM technologies in module fabrication and metrology.

www.epsrc.ac.uk
www.bristol.ac.uk/chemistry
www.specific.eu.com/research

Ascent Solar completes $10m Ironridge financing

Funding to expand EnerPlex product lines and retail channels

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 completed the $5m second closing under its Series B preferred stock purchase agreement (announced at the end of October) with institutional investor Ironridge Technology Co (a division of Ironridge Global IV Ltd). The firm received the first $5m from Ironridge in November and has now received the second $5m.

In both closings, Ascent issued Ironridge shares of its Series B-1 preferred stock, which is convertible into shares of common stock at a fixed conversion price of $1.15 per common share.

"We are pleased to close on the second $5m tranche earlier than anticipated, and to help facilitate the expansion of the EnerPlex brand through strengthening Ascent Solar's balance sheet," comments Ironridge Global Partners' managing director John C. Kirkland.

Ascent Solar intends to use the proceeds of the offering to fund continuing operations and accelerated expansion of both traditional and kiosk-centric retail channels for its EnerPlex products, aggressive brand building, as well as the launch of additional EnerPlex products and product lines in 2014. The company says that there are no restrictions on its use of the proceeds of the fundraising.

www.ironridgeglobal.com
www.AscentSolar.com
www.goenerplex.com

Avancis achieves 16.6% efficiency record for encapsulated CIS thin-film PV modules

Avancis GmbH of Torgau, Germany, a subsidiary of Saint-Gobain of Courbevoie, France since autumn 2009 which manufacturers copper indium selenide (CIS) thin-film photovoltaic modules, has achieved a new efficiency record for encapsulated thin-film modules. On a 30cm x 30cm cadmium (Cd)-free CIS solar module, the firm has achieved a peak value of 16.6%, independently confirmed by the US Department of Energy's National Renewable Energy Laboratory (NREL). Avancis set the last externally certified efficiency record of 15.1% in 2011.

The aperture efficiency of 16.6% for the champion module was certified by NREL in January and will be listed in the official record efficiency table in the next edition of the journal Progress in Photovoltaics: Research and Applications (Solar Efficiency Tables, Table II: Confirmed terrestrial module efficiencies). Together with the 20.8% efficiency for a laboratory cell reported by Germany's ZSW (Center for Solar Energy and Hydrogen Research — Baden-Württemberg), the result demonstrates the extraordinary potential of CIS-based thin-film technologies, says Avancis.

"A transfer of the pilot process to production would lead to an impressive module performance of nearly 160Wp of the approximately $1m^2$-sized PowerMax modules," reckons Dr Jörg Palm, head of process development at Avancis. "The very good homogeneity of the CIS absorber properties based on production dimensions of 158cm x 66cm were demonstrated by the minor deviation of 0.15% absolute between different 30cm x 30cm modules from the same full-size absorber," he adds.

The 30cm x 30cm champion module used a mass-produced CIS absorber from Avancis' second factory in Torgau, followed by buffer processing at the firm's R&D center in Munich.

The improvement in efficiency is based on optimization of the buffer layer with respect to the In_xS_y energy bandgap, band matching, and in particular transmission in the short-wavelength range. In addition, the transmittance and sheet resistance of the sputtered ZnO:Al front contact was optimized and the dead area between the series-connected cells was reduced by using picosecond laser processes.

www.Avancis.de

HelioVolt suspends production while seeking strategic investment alternatives as partner SK withdraws

HelioVolt Corp of Austin, TX, USA, which makes monolithically integrated copper indium gallium diselenide (CIGS) thin-film photovoltaic modules for the commercial rooftop and utility markets, says that its board of directors has authorized the evaluation of strategic alternatives for the firm's photovoltaic development and manufacturing business. To maximize value in its CIGS technology, HelioVolt intends to consider a range of alternatives, including investments, joint ventures or a merger and acquisition (M&A) transaction that fits its strategic objectives.

The firm has suspended manufacturing operations to align its short-term cost structure with the objective of preserving maximum value in its intellectual property and demonstration facility while a suitable alternative is identified. HelioVolt will reduce personnel over the next 60 days as appropriate to support its evolving strategy.

"We are initiating this process because our strategic partner, SK Group [of Seoul, South Korea], for reasons related to their business strategy, has informed us that they will no longer pursue their prior global solar PV goals," says founder & chief science officer B.J. Stanbery. "While we continue to highly value the relationship with SK and have made tremendous technical progress in partnership with them, we are disappointed by their decision at a moment when we believe the solar market is poised for exceptional growth," he adds.

In September 2011, SK TIC (Technology Innovation Company) and SK Innovation (members of Seoul-based energy, chemicals and telecoms firm SK Group, which is Korea's third largest conglomerate) invested $50m to expand HelioVolt's Austin operations and launch global manufacturing expansion.

HelioVolt was founded in 2001 by Dr Billy J. Stanbery based on his proprietary FASST manufacturing process for rapid printing of thin-film CIGS material, either directly onto glass substrates for solar modules or onto flexible plastic substrate for embedding in building-integrated photovoltaic (BIPV) products.

"HelioVolt's technology and strength of its commercial-ready manufacturing process have been greatly improved, having achieved new performance levels and reduced cost of ownership (COO), potentially becoming a world leader," comments Dong Kim, HelioVolt's executive chairman and president of the SK PV Task Force. "We are devoted to continue developing relationships with potential partners/investors who will pursue the manufacturing initiative with HelioVolt technology."

www.heliovolt.com

South Africa's PTiP opens module pilot-production line

SINGULUS to supply systems for scale-up to commercial production

In the presence of guests from Germany and South Africa (including politicians, business and technical partners), Photovoltaic Technology Intellectual Property (Pty) Ltd (PTiP) — a spin-off from the University of Johannesburg (UJ) — has officially commissioned its pilot-production line for manufacturing copper indium gallium diselenide (CIGS) thin-film solar modules. Singulus Technologies AG of Kahl am Main, Germany, which makes production equipment for the Optical Disc and Solar sectors, supplied the engineering technology and support for the key production processes.

The demonstration plant in the Techno Park near Stellenbosch was established on the back of CIGS solar module development over the past 20 years in University of Johannesburg's research laboratories. The facility will conduct R&D for commercial-scale and market-ready 1200mm x 600mm CIGS modules. Commercial development of the PTiP process is in the spotlight of the South African government. The Industrial Development Corporation (IDC) is a strategic shareholder and is financially supporting PtiP's expansion in Techno Park. PTiP received additional financial support from the Technology Innovation Agency (TIA), an initiative of the Department of Science and Technology. With the new CIGS line, the module development can be improved, it is reckoned, with particular regard to efficiency and the specific demands of the African market.

SINGULUS' Vistaris system at PTiP.

"The commissioning and official opening of this CIGS pilot facility in South Africa confirms the goals of the South African government to support and promote alternative and renewable energies, based on locally developed IP and skills," says PTiP's CEO professor Vivian Alberts. "The immediate goal is to set-up a commercially viable production plant for CIGS thin-film modules in South Africa in order to supply products with high local content to existing and future PV projects in South Africa," he adds. "The European Investment Bank already announced its support for the establishment of a PTiP production plant and the mass production of PV modules. With the core production equipment and support from our partner SINGULUS, we are able to industrially and efficiently implement our developed process."

SINGULUS has been working with the University of Johannesburg for the past 3 years and, in the course of the cooperation, delivered the first laboratory systems in 2011. "With the vacuum coating, the selenization as well as two work steps in the wet-chemical area, in total we supplied four key process steps for a CIGS line," notes SINGULUS' CEO Dr.-Ing. Stefan Rinck. "With our partner PTiP, we intend to continue to successfully implement the additional expansion stages as well."

www.singulus.de

Hanergy secures $3.3bn financing for renewable energy

CIGS PV technology to be developed further

In early January, China's leading clean energy firm Hanergy Holding Group of Beijing (parent of thin-film photovoltaic module maker Hanergy Solar) has signed a trilateral framework agreement with China Minsheng Banking Corp and the Asia Financial Cooperation Association (AFCA), a regional organization (launched in 2013 following the lead of China Minsheng Bank, Baoshang Bank and Harbin Bank) comprising small- and medium-sized banks and financial institutions.

The strategic partnership will provide up to 20bn yuan ($3.26bn) in financing over the next three years as well as diverse financial instruments to fund photovoltaic (PV) and hydropower projects plus the development of copper indium gallium diselenide (CIGS) thin-film technology.

Hanergy is one of the world's largest thin-film module makers. In the last year or so, Hanergy Solar has acquired three CIGS PV firms: Germany's Solibro GmbH (from Q.Cells SE) and US firms MiaSolé of Santa Clara, CA, and Global Solar Energy Inc (GSE) of Tucson, AZ.

The firm will use the new financing to further develop its CIGS technology. Already thin-film PV module solar energy conversion efficiencies of 19.6% in research and 15.7% in mass production have been achieved.

www.hanergy.com

Siva Power achieves 18.8% efficiency in 10 months

Solar device and manufacturing technology firm Siva Power of San Jose, CA, USA says that its copper indium gallium diselenide (CIGS) panel technology has achieved near-record conversion efficiency — approaching 19% — in just 10 months.

Also, solar energy expert Charlie Gay Ph.D. has joined the firm's Technical Advisory Board. Dr Gay joins Rommel Noufi Ph.D., John Benner and Markus Beck Ph.D. to support Siva Power as it aims to create a profitable path to sub-$0.40 per watt solar power as well as what it reckons will be unprecedented production scale.

Siva Power repositioned itself in February 2013 by transitioning to CIGS thin-film technology. In December 2013, the US National Renewable Energy Laboratory (NREL) has now certified Siva Power as achieving a laboratory efficiency of 18.8% — less than a year after the firm shifted its technology focus.

Siva Power says that, in achieving 18.8% efficiency, it has nearly equaled accredited international research institutes such as NREL, the Swiss Federal Laboratory for Materials Science and Technology (EMPA) and ZSW Center for Solar Energy and Hydrogen Research, all of which have engaged in R&D on CIGS for up to 20 years. Siva Power also claims to have surpassed most solar companies using CIGS technology, many of which have taken more than five years to achieve this level of panel efficiency. Siva Power says that its success is directly attributable largely to the deposition approach that it selected. All CIGS efficiency records over the past two decades have been achieved using three-stage co-evaporation, which is the method that Siva Power has chosen to scale to high-volume manufacturing.

"This efficiency milestone speaks to our team's expertise, and we welcome Charlie's knowledge and experience as a critical component toward helping us achieve even more," says CEO Brad Mattson.

With more than 30 years of solar industry experience, Gay is an internationally recognized pioneer in photovoltaics, says Siva Power. In 2013, he was elected to the US National Academy of Engineering. Currently, he is co-founder & president of Greenstar Foundation, which is dedicated to enabling micro-enterprise development in rural communities.

Gay began the early part of his career working for ARCO Solar, where he forged the transition of single-crystalline silicon from R&D to mass production. In 1994, he was elected director of NREL, where he managed an annual budget of over $235m, with a staff of more than 1000. He was subsequently president of ASE Americas. From 2001 to 2005, Gay served as chairman of the SunPower Advisory Board. He then joined Applied Materials in 2006 as corporate VP & general manager of the Solar Business Group. He was named president of Applied Solar and chairman of the Applied Solar Council in 2009.

"I am honored to join such an experienced team with Beck, Noufi, and Benner," says Gay. "Collectively, they represent one of the most experienced groups ever assembled for CIGS technology and high-volume manufacturing."

www.sivapower.com

XsunX targets 1MW/month system sales and installations

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, has provided business updates to its solar power project development and installation services, and its outlook for growth through these services in 2014.

In mid-October the firm announced a business expansion to include the sales, design and installation of PV systems to commercial facilities in California — statistically the largest and fastest growing solar market in the USA. XsunX subsequently provided several progress updates including announcing initial sales agreements for PV system installations. Now it says that, before 2013 ended, it also received payment for PV project-related invoicing that it had sent out, and one project lender issued its purchase order for another PV system under contract.

The overall process from start to completion and final payment can vary, but in general most commercial projects will take 4–6 weeks to complete, at which point XsunX would typically book the revenue, the firm believes. Planning, permitting and getting the local utility to complete their work is where the majority of time required can come into play, it adds.

Marketing efforts are producing results, the firm claims. Despite the recent holiday period, business and commercial property owners from Ventura to Los Angeles and Riverside called for quotes, with five quote requests and one on-site customer visit occurring in just one day alone.

"Our goal in 2014 is to grow our commercial and industrial PV systems design and installation business to at least 1MW of new system sales per month," says the firm. "What we are finding is that many commercial projects will require 100kW or more in PV system sizing. So, in general it would take about 10 system sales per month to meet our goal," it adds. "We are now gearing up to meet the demand and we will be looking to expand our sales response capabilities to maintain a focus on providing the most responsive services."

www.xsunx.com

Dutch consortium develops solar testing system, for commercial availability in first-half 2015

A Dutch consortium, consisting of Delft University of Technology spin-off Eternal Sun B.V. (which specializes in solar simulation technology for product and material testing), environmental simulation system maker Hielkema Testequipment B.V., Radboud University Nijmegen spin-off and PV measurement system maker ReRa Solutions B.V., and ECN (the energy research institute of The Netherlands) and TNO (the Netherlands Organization for Applied Scientific Research in Delft) — partners in Solliance (the European R&D consortium that focuses on thin-film photovoltaic solar energy) — is to develop a climate chamber with AAA-class-accuracy simulated sunlight to simultaneously test the performance and degradation of all types of solar cells and mini-modules.

The new hybrid test setup will be based on an existing model that has already been used by TNO for 3 years. The combination of a climate chamber and solar simulator is used for research on the performance and degradation of copper indium gallium diselenide (CIGS) cells at the new Solliance facility at the High Tech Campus in Eindhoven, The Netherlands. The new setup is a combination of a modified climate chamber, a multi cell IV-measurement system and a large-area solar simulator. This simulator uses an array of lamps to produce AAA-class (<2% accurate) sunlight, which is used to provide nearly flawless performance and degradation measurements of all types of solar cells and mini-modules.

The ultimate objective of the joint project is to gain insight into the behaviour of all types of solar cells and mini-modules. Because the new hybrid test setup can simultaneously measure performance and degradation, the unique combination is able to gather data that was previously unattainable, it is reckoned. It is expected that this data will enable new research, focused on the performance of cells and mini-modules during the degradation process. The setup enables Solliance to perform most existing IEC tests as well as newly developed test procedures, with the use of a single test setup, and enables them to gain new insight into the behaviour of all types of PV cells and mini-modules.

"This new test system will be interesting for all solar research facilities around the globe," reckons Stefan Roest, chief technology officer & co-founder of Eternal Sun, which specializes in solar simulation technology for product and material testing.

"The existing test setup has been very successfully used to learn more about the degradation behavior of new types of solar cells," comments Solliance researcher Mirjam Theelen. "There was a lot of interest from other research institutes for this setup, and we are very content with the fact that Dutch companies will bring it to the market in cooperation with us."

The equipment is expected to become commercially available in first-half 2015.

www.solliance.eu
www.eternalsun.com
www.hielkematest.nl
www.rera.nl

Ascent Solar debuts EnerPlex Surfr battery & solar case for iPhone 5 and 5s at CES

At the 2014 International Consumer Electronics Show (CES) in Las Vegas (7–10 January), Ascent Solar Technologies Inc of Thornton, CO, USA, which makes lightweight, flexible copper indium gallium diselenide thin-film photovoltaic modules that it integrates into its EnerPlex series of consumer products, debuted the Surfr phone case for the iPhone 5 and 5s (the world's only case designed for the phones utilizing both battery and solar technology), along with the firm's full line of EnerPlex products and accessories.

Ascent says that the Surfr case provides not only protection but doubles the battery life of the iPhone, giving users hours of additional audio, web and talk time.

The Surfr phone case for the iPhone 5.

Its lightweight design is enabled by the thin form factor of Ascent's proprietary CIGS solar technology, allowing solar to be integrated into the thinnest and lightest solar-enabled case on the market, it is claimed. The Surfr case has a 2000mAh lithium ion battery built in and comes in black and five other colors.

"EnerPlex has designed an exceptional case which maintains the beauty, form and function of the iPhone while adding the additional battery life consumers so desperately need," comments Ascent's president & CEO Victor Lee.

www.AscentSolar.com

InP nanowire solar cells with improved short-wavelength response

Internal quantum efficiency beats planar InP photovoltaic cell record holder in the 300–570nm wavelength range.

Researchers in Japan have created indium phosphide (InP) nanowire (NW) solar cell structures with internal quantum efficiencies (IQEs) that beat the performance of bulk InP-based devices in the short-wavelength range of 300-570nm [Masatoshi Yoshimura, et al, Appl. Phys. Lett., vol103, p243111, 2013].

The InP nanowires had a single p-type doping profile. The photovoltaic junction arose from the further deposition of indium tin oxide (ITO) as a transparent

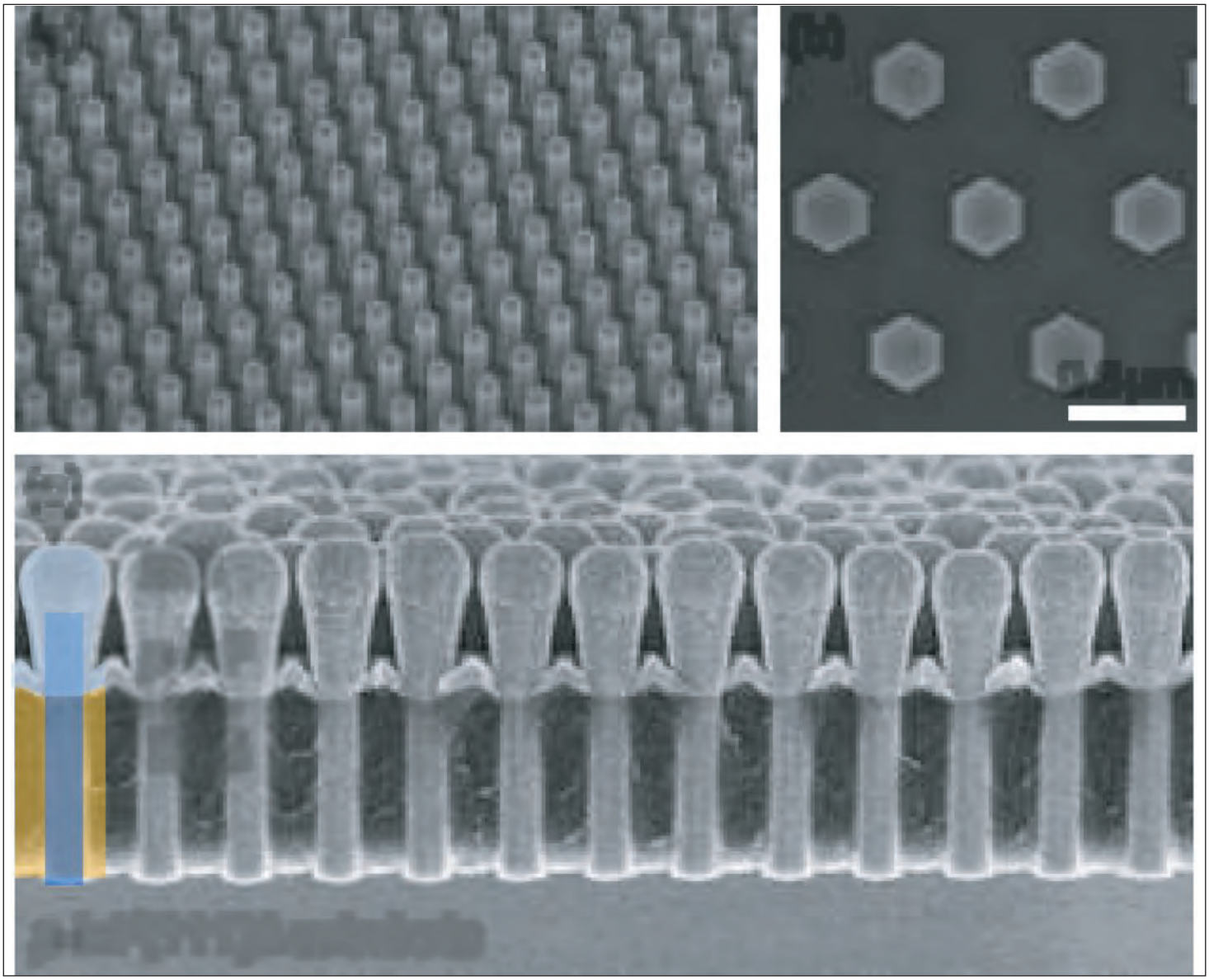


Figure 1. (a) 20°-tilted view scanning electron micrograph (SEM) of p-InP NW array. (b) Top-view SEM of NWs. (c) SEM cross-section of ITO/p-InP heterojunction NW solar cell.

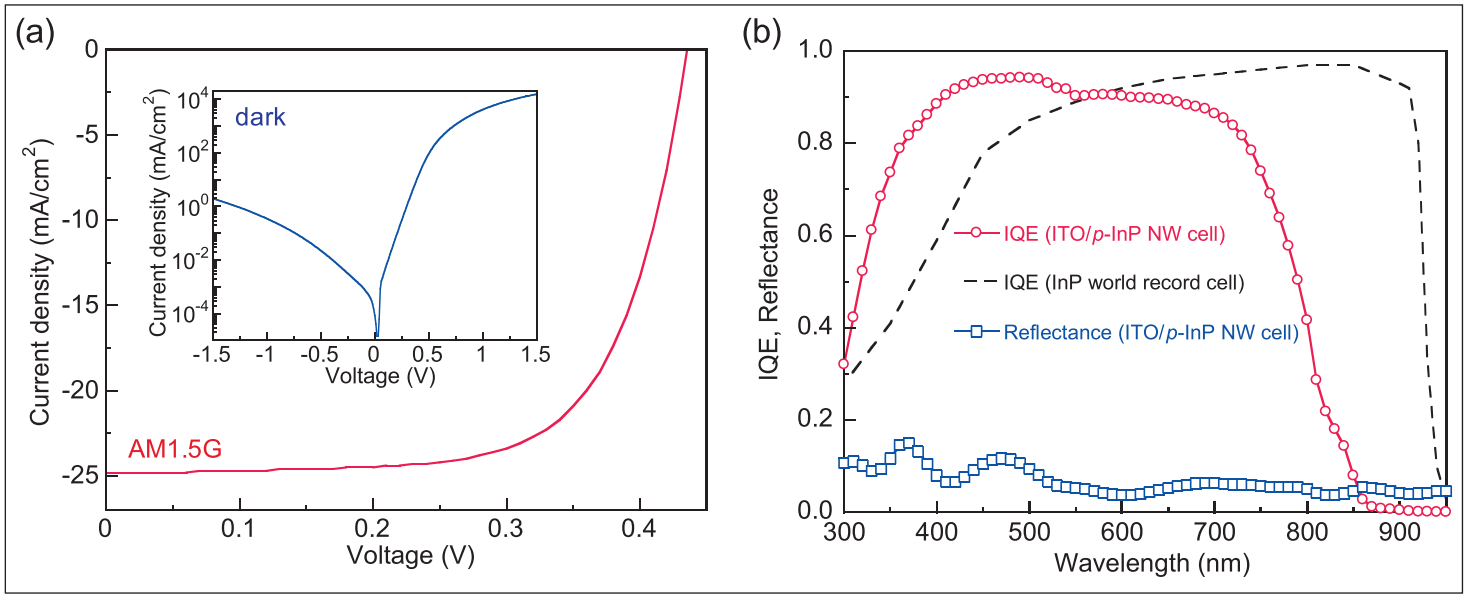


Figure 2. (a) Illuminated current-voltage (J–V) characteristics of TO/p-InP NW cell under AM1.5G. Inset: dark J–V characteristics (semilog scale). (b) IQE and reflectance of ITO/p-InP NW cell. Also included is IQE of InP world record planar cell.

electrode. By growing nanowires with only p-InP, rather than a p-InP/n-InP junction, the researchers say that the process is potentially more controllable and less costly.

The work was carried out by Hokkaido University and Japan Science and Technology Agency (JST).

The p-type InP nanowires were grown using selective-area metal-organic vapor phase epitaxy (SA-MOVPE) on p-type InP substrates. The selective-area mask consisted of 20nm silicon dioxide patterned with 200nm-diameter holes in a triangular array of 400nm pitch in an area of 1.2mm x 1.2mm. After the growth of the nanowires out of the holes in the mask, they were embedded in spin-coated benzocyclobutene (BCB) from Dow Chemical.

The ITO was rf sputtered after the nanowire tips were exposed by etching back the BCB. U-shaped metal electrodes consisted of silver on the ITO and gold-tin on the back-side of the substrate. The effective area of the device was 0.62mm2. This area contained 4.5×10^6 nanowires that filled about 18% of the geometric area of the device (Figure 1).

The researchers believe the deposition process of ITO as the transparent conductor layer forms an n^+ defect region near the surface, giving a 'buried n^+/p homo-junction'.

Under AM1.5G solar illumination (Figure 2), the open-circuit voltage (V_{oc}) was 0.436V, the short-circuit current density (J_{sc}) was 24.8mA/cm^2, and the fill factor (maximum power density/V_{oc}xJ_{sc}) was 0.682. The overall power conversion efficiency was 7.37%. Planar ITO/InP solar cells have achieved 18.9% efficiency.

Considering that 82% of the active area of the device was space between the wires, "this high J_{sc} for a NW-array-based device resulted from the combination of near-field-optics enhanced absorption and anti-reflection effects," the researchers comment. Although there was no anti-reflective coating, the device had an effective reflectance of only 6.2%.

Investigation of IQE gave a value of more than 80% in the 400–750nm range. The researchers write: "The IQE at shorter wavelengths was much higher than the previous reported InP NW solar cell, and the device had peak IQE of 0.943 at 490nm without employing a window layer for reflecting minority carriers moving toward the front ITO layer."

The IQE in the range 300–570nm beat that of the record holder for a planar InP structure. The researchers attribute this to reduced surface recombination, and to improved separation and collection of photogenerated carriers. The reduced recombination was a result of minority carrier reflection by the wide-bandgap ITO window layer. The more efficient separation/collection was due to a junction forming also on the sides of the nanowires as a result of the ITO forming hemispherical caps.

The researchers estimate that light with wavelength shorter than 500nm was absorbed within 300nm in their InP nanowires. The absorption edge on the long-wavelength/low-energy side is somewhat blue-shifted to 870nm from the 925nm bandgap of bulk InP. Selective-area electron diffraction (SAED) patterns in a high-resolution transmission electron microscope (HR-TEM) system suggest that the nanowires have a wurzite structure, which has a bandgap that is about 80meV wider than that of the zincblende structure usual with bulk InP. A wider bandgap would lead to blue-shifting of the absorption edge. ■

http://dx.doi.org/10.1063/1.4847355

Author: Mike Cooke

MOCVD surface roughening for photon absorption boost in InGaN solar cell

UCSB shows how surface roughening of a nitride photovoltaic cell improves both external quantum efficiency and short-circuit current.

Researchers at University of California Santa Barbara (UCSB) have used low-temperature metal-organic chemical vapor deposition (MOCVD) of p-type gallium nitride (GaN) to achieve intentional surface roughening of a solar cell device, thereby increasing photon absorption and boosting performance [R. M. Farrell et al, Appl. Phys. Lett., vol103, p241104, 2013]. Funding for the work came from US Defense Advanced Research Projects Agency (DARPA) High Performance InGaN-Based Solar Cells Program, the California Advanced Solar Technologies Institute, and the US Solid State Lighting and Energy Center (SSLEC).

The absorbing layer of the device (Figure 1) consisted of intrinsic indium gallium nitride (InGaN). It is hoped to develop such solar cells that convert shorter-wavelength photons from the sun as part of a photovoltaic system where different wavelength bands are separated for efficient-energy conversion by suitable devices.

The UCSB nitride semiconductor photovoltaic (PV) device could be used to extend the 44% conversion efficiency achieved by GaInP/GaAs/GaInNAs multi-junction cells, hopefully to beyond 50%. However, because of the surface roughening needed to improve the nitride semiconductor photon absorption, the UCSB technique is not really suitable for a stacked multi-junction PV format.

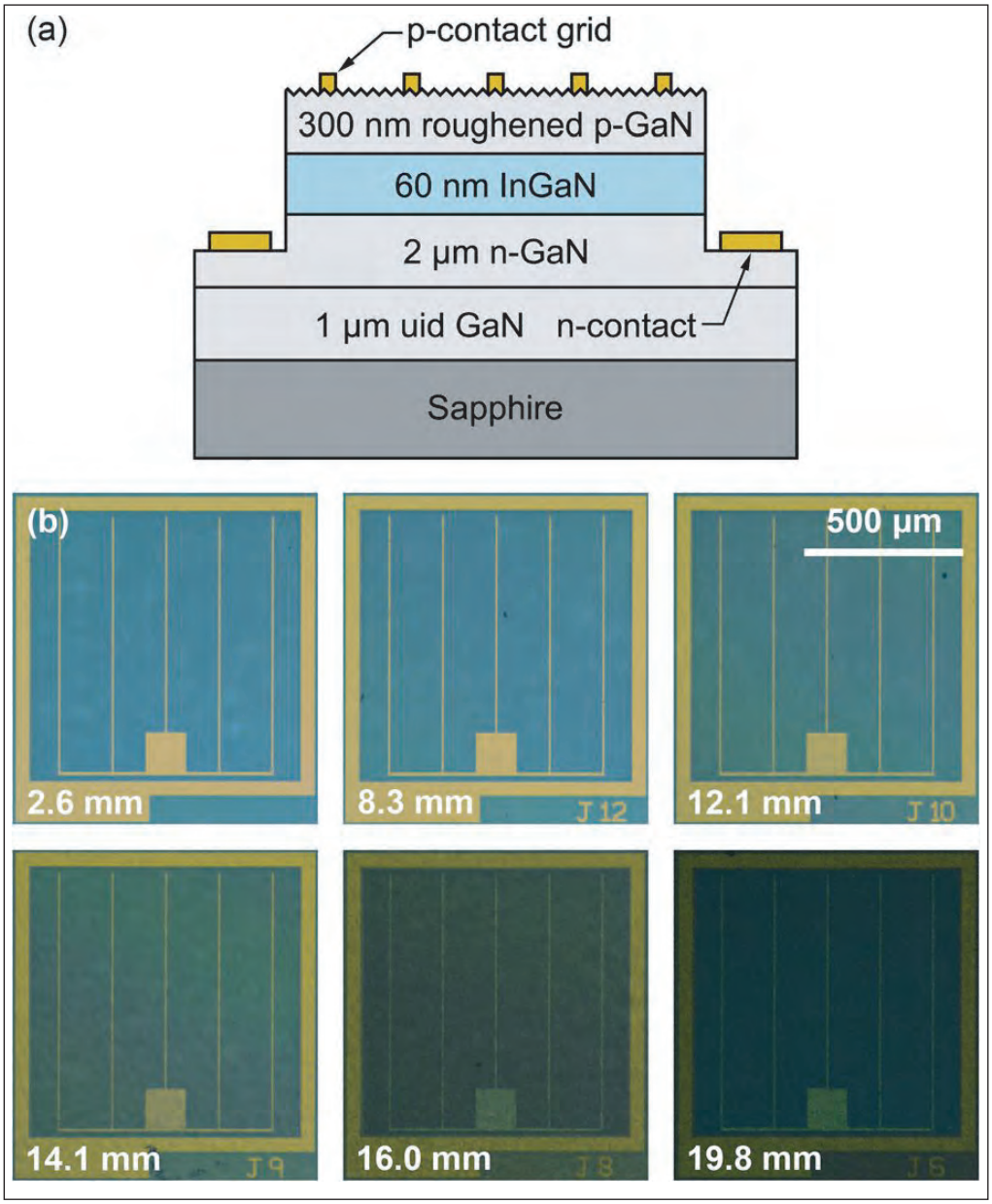


Figure 1. (a) Cross-sectional schematic of device structure. (b) Optical micrographs of fabricated solar cells at six different positions along sample's radius.

The UCSB team also believes that the surface roughening technique could be used in the other direction to improve light extraction efficiency of InGaN-based LEDs.

The p-type/intrinsic/n-type (p-i-n) epitaxial layers of nitride semiconductor for the solar cell were grown by MOCVD on 50mm (0001) sapphire. The surface roughening of the p-GaN layer was achieved by relatively fast growth at low temperature. The roughness increased toward the edges of the wafer due to temperature variation in the reaction chamber. The roughened surface was faceted with a high density of V-defects.

The increasing roughness along the radius of the sample reduces the reflectivity of the surfaces, as seen in the optical micrographs of Figure 1b. Atomic force microscopy (AFM) showed an increase in root mean square (RMS) roughness from around 7nm to 36nm. The largest value for roughness came around 20mm along the radius of the sample, after which it declined slightly.

The solar cells were fabricated using standard processes. The 1mm x 1mm mesas were created using dry etching. The p-contacts consisted of palladium/gold applied in a grid pattern. The n-contact was a ring of aluminium/gold at the base of the mesa.

The increased roughness leads to increased external quantum efficiency (EQE) and short-circuit current (Figure 2). At 3.8mm radial position the peak EQE (at about 380nm wavelength) was 61.0% — this increased to 77.5% (+27.1%) at 21.7mm. The long-wavelength absorption edge also shifted with radial position — from ~430nm at 3.8mm to ~450nm at 21.7mm. The improved absorption of longer wavelengths is attributed to an increased indium content of the InGaN layer. At the high growth temperatures typically used for p-GaN growth the indium of the InGaN layer tends to dissociate, reducing the concentration.

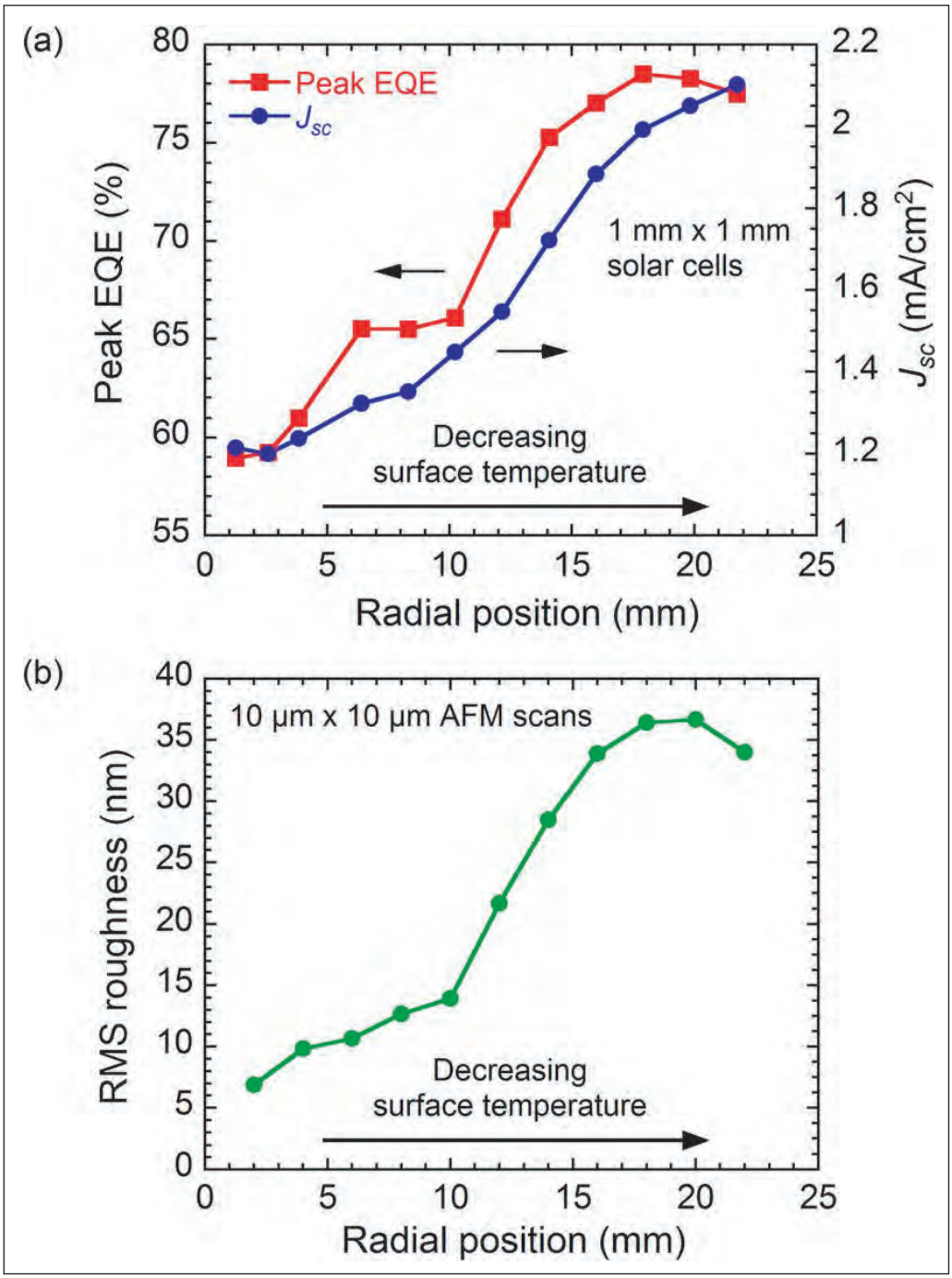


Figure 2. (a) Dependence of peak EQE and short-circuit current density (J_{sc}) on radial position. (b) Dependence of RMS roughness on radial position.

The short-circuit current was measured under AM1.5G illumination. At 3.8mm radial position the short-circuit current density was 1.24mA/cm^2. At 21.7mm this was increased by 69.4% to 2.10mA/cm^2. The increase is attributed to both the improve peak EQE and the shift of the absorption edge to longer wavelengths.

On the other hand, the open-circuit voltage is reduced by increasing surface roughness, being 1.93V at 3.8mm and 1.54V at 21.7mm. This effect is related to an increase in dark current and current leakage caused by the V-defects. The researchers point out that more advanced device designs are available to ameliorate this effect where the p-GaN is applied in a series of layers to avoid the V-defects extending down to the active InGaN layer. ■

http://dx.doi.org/10.1063/1.4844955

Author: Mike Cooke

Evanescent wave coupling to increase light extraction efficiency

Light output power has been increased by factor of 3.8 in red LEDs.

Researchers at the National Institute of Advanced Industrial Science and Technology (AIST) in Japan have used evanescent wave coupling to enhance the light output power of red light-emitting diodes (LEDs) by a factor of 3.8 [Guo-Dong Hao and Xue-Lun Wang, Appl. Phys. Lett., vol103, p231112, 2013]. The researchers comment: "We believe that our technique represents a significant step in the development of ultrahigh-efficiency LEDs."

Guo-Dong Hao and Xue-Lun Wang designed ridge structures (Figure 1) to generate evanescent near-field electromagnetic waves that propagate along the semiconductor-air interface to the sub-wavelength ridge top and there be transformed into light.

Normal flat surface LEDs suffer from narrow escape cones where all light with an angle of incidence beyond some critical value is reflected back into the device, killing light extraction efficiency. The critical angle is controlled by the difference in refractive index between the LED and air.

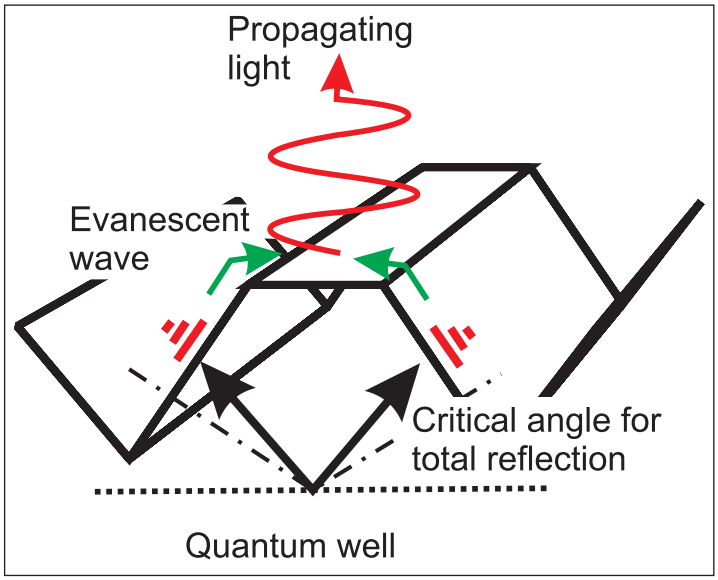


Figure 1. Evanescent wave coupling effect in sub-wavelength ridge structure.

The semiconductor structures for the AIST LEDs (Table 1) were grown on a 12mm x 13mm (001) gallium arsenide (GaAs) substrate by metal-organic vapor phase epitaxy (MOCVD). The substrate was mis-oriented 10degrees in the [110] direction to suppress spontaneous ordering of the alloyed compound semiconductor layers. Silicon (Si) and zinc (Zn) were used as doping for n- and p-type layers, respectively. The resulting wafer was annealed at 500°C for 2 minutes to activate the zinc doping.

The LED processing began with deposition of 1µm-diameter titanium/platinum/gold circular electrodes with 1% surface coverage on the p-GaAs ohmic contact layer. Further layers consisted of a silver (Ag) mirror, titanium/platinum diffusion barrier, and gold-tin eutectic bonding for flipping and attachment to an n-GaAs submount wafer with gold-germanium/nickel/gold ohmic contact layers on the back side and also a gold-tin eutectic bonding layer on the top. The eutectic layers were bonded at 380°C and 0.2MPa pressure.

The epitaxial growth substrate was removed by first milling down to 50µm and then wet etching the remaining material. The AlGaAs etch stop layer was removed with a different selective wet etch. A further wet etch was used with photolithography to create ridges for the evanescent wave coupling (Figure 2). The dimensions were chosen based on finite-difference time-domain simulation.

Table 1. Epitaxial layers used for LEDs.

Ohmic contact	p+-GaAs:Zn	10nm
Current spreading	p-$(Al_{0.7}Ga_{0.3})_{0.5}In_{0.5}P$:Zn	2µm
Cladding	$(Al_{0.7}Ga_{0.3})_{0.5}In_{0.5}P$	0.2µm
MQW	3x($(Al_{0.7}Ga_{0.3})_{0.5}In_{0.5}P/Ga_{0.5}In_{0.5}P$	Well ~ 7nm
Cladding	$(Al_{0.7}Ga_{0.3})_{0.5}In_{0.5}P$	0.1µm
Current spreading	n-$(Al_{0.7}Ga_{0.3})_{0.5}In_{0.5}P$:Si	2µm
Ridges	n-$Al_{0.7}Ga_{0.3}As$:Si	0.8µm
Ohmic contact	n-GaAs:Si	30nm
Etch stop	n-$Al_{0.7}Ga_{0.3}As$:Si	0.4µm
Substrate	(001) GaAs	

While the p-electrodes covered the entire back surface of the GaAs submount, the n-electrode (consisting of palladium/germanium/gold) was patterned into four whirlpool-shaped fingers covering about 4% of the n-contact surface. The resulting 1mm x 1mm LEDs were singulated with a final wet etch.

Two types of LED were produced from the same material: one type with ridges (R-LED) and the other without (F-LED). Current versus voltage measurements showed a series resistance that was higher for the R-LED (9Ω) than for the F-LED (4.5Ω). This was blamed on the smaller contact area of the R-LED (~1/4) and "suboptimal ohmic contact resistance". The researchers report that they are working to optimize the contact resistance.

In terms of light output power (Figure 3), the ridges gave a 3.8x enhancement at low injection currents of ~5mA, but this factor reduced to ~3x at 100mA. The researchers point out that these enhancements are greater than that typically achieved using alternative techniques such as random surface roughening or photonic crystals (1.5–1.8x).

The team attributes the more efficient light extraction of evanescent wave coupling to it not needing multiple reflections before radiation can emerge from the device. They comment: "A conventional AlGaInP-based LED requires at least 10 reflection events for light generated in its active layer to escape to the air even with an ideal diffuse surface." Such a long light-path naturally leads to losses in the LED materials and at each reflection event.

The researchers explain the decline in enhancement at high current injection as being due to a faster decline in current-spreading efficiency for the device with ridges. Simulations suggest that the devices have a maximum current-spreading efficiency of 96% at low currents of 5mA. The flat F-LED current-spreading efficiency declines to 83% at 100mA, while the ridged R-LED's efficiency degrades much faster to 64% at 100mA. Correcting the light output power enhancement factor for the current-spreading efficiency declines gives a steady performance of ~3.8x up to 100mA. ■

http://dx.doi.org/10.1063/1.4842215

Author: Mike Cooke

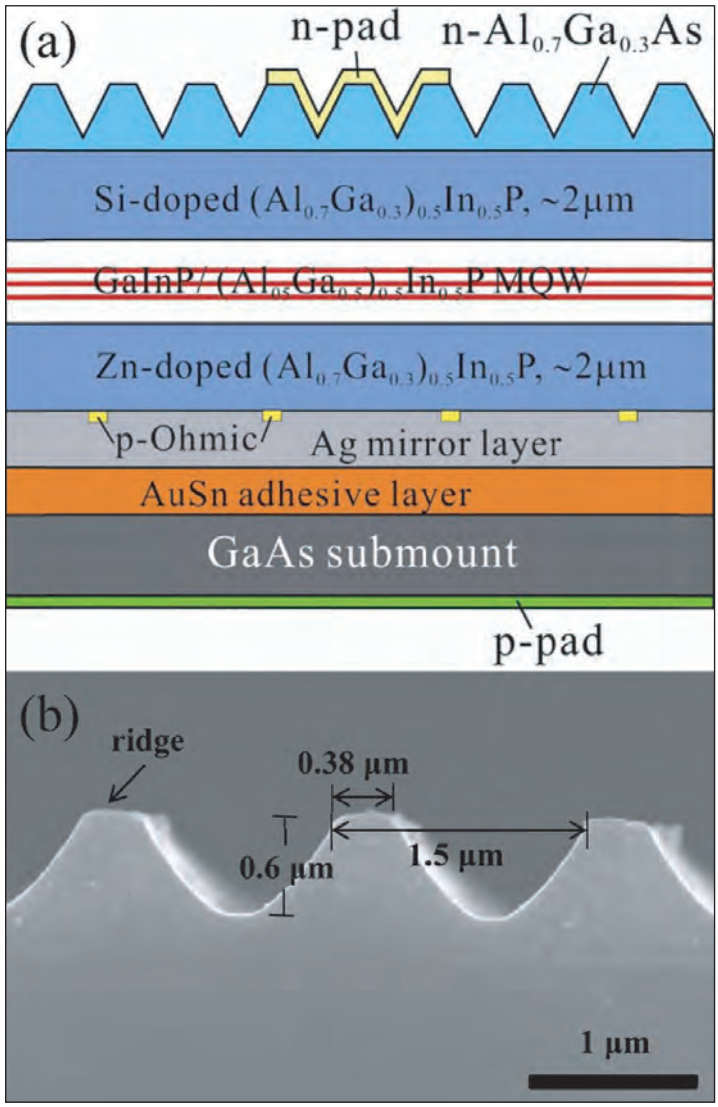


Figure 2. Schematic cross-section of AlGaInP LED with sub-wavelength ridge structure on light-extraction surface.

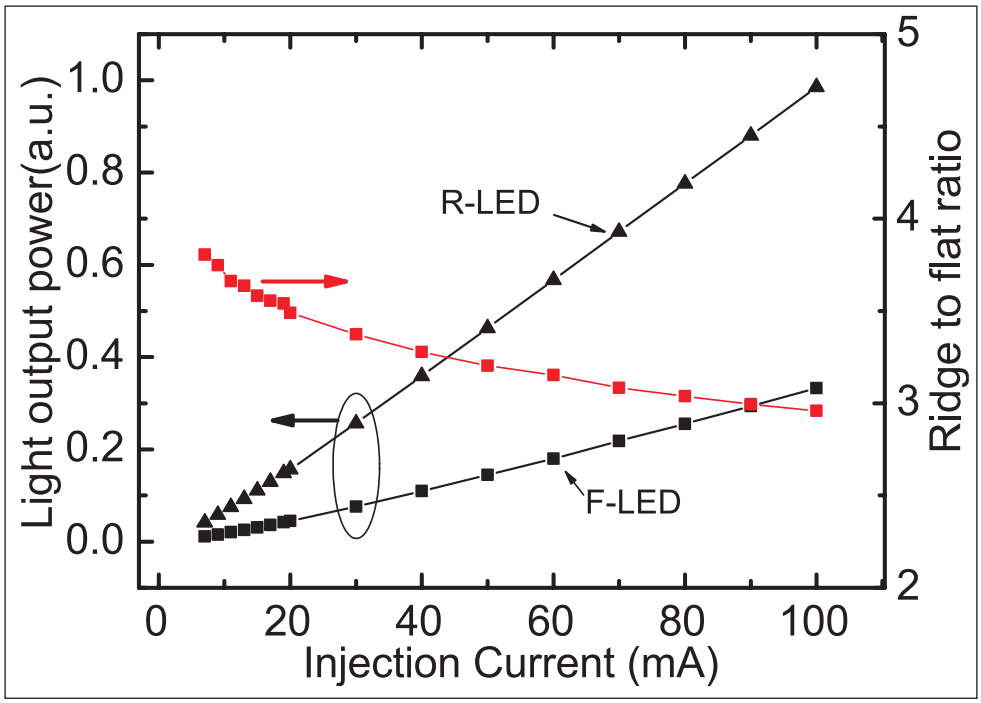


Figure 3. Comparison of measured light output power versus injection current (L-I) characteristics of F-RED and R-LED and enhancement ratio of the light output power of an R-LED compared to an F-LED.

Thinning nitride LED substrate for increased green emission efficiency

Wall-plug efficiency (WPE) has been increased from 11.5% to 17.1% by thinning the substrate from 200µm to 80µm.

Researchers based in Korea and Egypt have used wafer thinning to increase the efficiency of nitride semiconductor green light-emitting diodes (LEDs) [Wael Z. Tawfik et al, Appl. Phys. Express, vol6, p122103, 2013]. The contributing organizations were Chonnam National University in Korea, Beni-Suef University in Egypt, and Korea Photonics Technology Institute.

The effect of the thinning is to reduce residual compressive stress in the nitride semiconductor structures, which has the knock-on effect of reducing piezoelectric fields in the LED structure. The stress derives from differing thermal expansion coefficients between gallium nitride and sapphire leading to large compressive stress building up as the structure is cooled after the epitaxial crystal growth process.

Contact	p^+-GaN	70nm
Contact	p-GaN	40nm
Multiple quantum well	5x($In_{0.26}Ga_{0.74}N$/GaN)	5x(3nm/12nm)
Contact	n-GaN	3µm
Buffer	GaN	2µm
Nucleation	GaN	30nm
Substrate	c-plane sapphire	430µm

Figure 1. LED epitaxial structure.

The effect of the electric fields is to reduce the probability for electrons and holes to recombine into photons. The problem is particularly acute in high-indium-content (more than 20%) indium gallium nitride (InGaN) alloy, as needed for green light emission. While blue InGaN-based LEDs have efficiencies of the order of 50%, the higher-indium-content green LEDs are typically limited to less than 10%.

The LED structures (Figure 1) were grown on 2-inch c-plane sapphire substrates using metal-organic chemical vapor deposition (MOCVD). The substrate thickness was 430µm. The material was formed into 240µm x 600µm LED chips using conventional processes.

The substrate thinning was achieved using back-side lapping and soft polishing. These processes were used to minimize thinning-related damage. After thinning, the chips were singulated in a scribe and break process. Measurements of wafer bowing and residual stress in the n-GaN contact layer showed an increased bow and reduced stress as the wafer was thinned between 200µm and 80µm.

Electroluminescence spectra at 20mA injection current showed an increase in intensity as the substrate was thinned. Also, the peak position shifted from 520.1nm (2.38eV) to 515.7nm (2.40eV) for 200µm- and 80µm-thick substrates, respectively. The researchers explain: "These findings clearly indicate that the mechanical stress introduced by the wafer bowing may change the piezoelectric field in the InGaN/GaN MQW active region and modify the energy band profile. Thus, the blue-shift in peak wavelength and energy are attributed to the increase in effective bandgap due to the decrease in piezoelectric field in InGaN/GaN MQWs."

The thinning of the substrate also improved internal quantum efficiency (IQE) and light output power, while not degrading the current versus voltage behavior. The

light output powers at 20mA increased from 7.8mW with 200µm thickness to 11.5mW with the 80µm-thick substrate. Again, this is credited to the decrease in piezoelectric field enhancing the performance. The forward voltage at 20mA was almost constant at 3.4V across the different thicknesses (200µm, 170µm, 140µm, 110µm, 80µm).

The peak external quantum efficiency (EQE) increased from 16.3% to 24% over the same range of substrate thicknesses (Figure 2). The researchers compare their green LED EQE performance with the best achieved so far on semi-polar free-standing GaN substrates: 20.4% in the (20-21) orientation and 18.9% in the (11-22) orientation. Using semi-polar substrates is another way to reduce piezoelectric effects in GaN-based LEDs. However, such substrates are very expensive.

The researchers used a room-temperature IQE measurement system from Korean company Eta-Max (DOSA-IQE). At less than 10mA injection current the system gave 92% maximum IQE with 80µm substrate thickness. At 20mA, the IQE improved from 58.2% to 68.9% as the substrate was thinned from 200µm to 80µm.

By comparing the EQE and IQE, the researchers determined that there was an increase in light extraction efficiency (LEE) with a thinner substrate (Table 1). The improved extraction is attributed to less photon absorption in the sapphire substrate and a higher escape probability from the sapphire edges of the device.

Finally, wall-plug efficiency (WPE) was increased from 11.5% to 17.1% with the same substrate thinning. ■

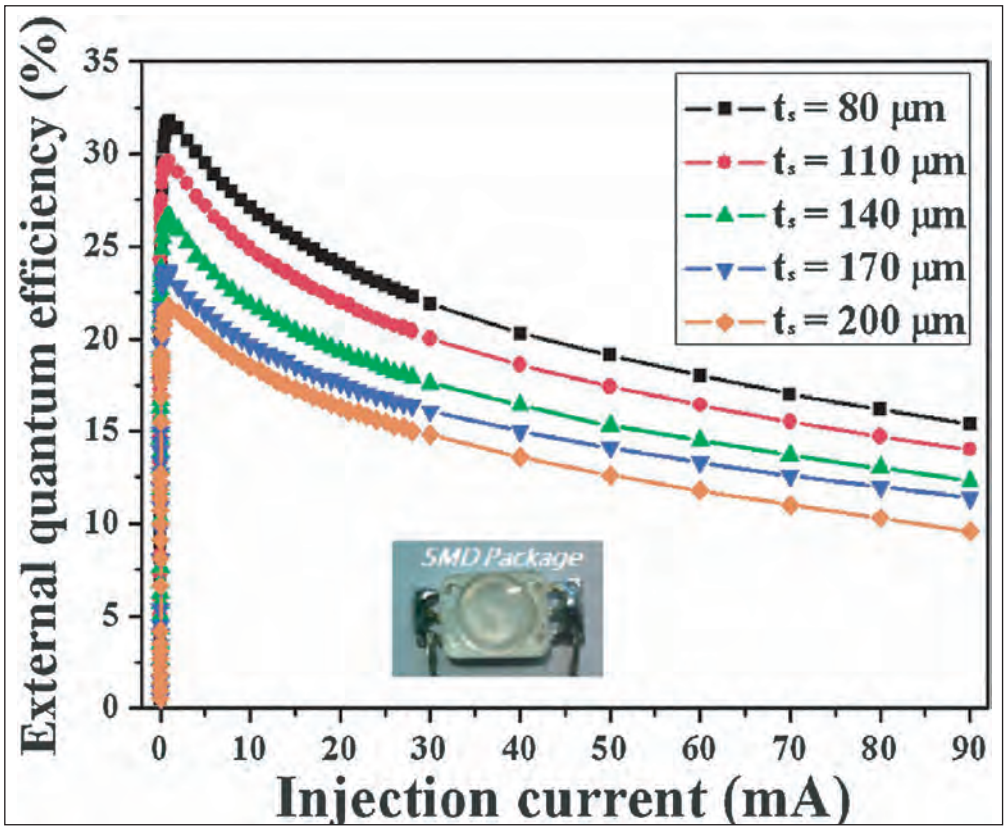


Figure 2. External quantum efficiency (EQE) of green LED as function of injection current with different sapphire substrate thickness. Inset: packaged chip.

Table 1. Characteristic values of green InGaN/GaN MQW LEDs at an injection current of 20mA with different sapphire substrate thicknesses.

Sapphire substrate thickness (µm)	80	110	140	170	200
Curvature (/m)	4.48	3.2	2.21	1.82	1.57
Residual stress (GPa)	0.32	0.44	0.49	0.59	0.71
Peak wavelength (nm)	515.7	516.2	517.1	518.8	520.1
Output power (mW)	11.5	10.6	9.3	8.4	7.8
IQE (%)	68.9	64.8	62.6	60.5	58.2
EQE (%)	24.0	22.0	19.3	17.6	16.3
LEE (%)	34.8	33.9	30.8	29.1	28.0
WPE (%)	17.1	15.6	13.7	12.4	11.5

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White light-emitting diodes from selective area epitaxy GaN nanopyramids

Phosphor-free devices have been fabricated that emit light across the 400–600nm wavelength range.

Researchers in China have developed a selective area epitaxy (SAE) approach to create nanopyramids of nitride semiconductor 'white' light-emitting diodes (LEDs) without using phosphors [Kui Wu et al, Appl. Phys. Lett., vol103, p241107, 2013]. The research involved various Chinese Academy of Sciences institutes – Institute of Semiconductors, Institute of Mechanics, and Suzhou Institute of Nano-tech and Nano-bionics – and Tsinghua University.

The prospect of using nanopyramids for white light emission was raised earlier this year by Taiwan researchers who produced green, olivine and amber LEDs [www.semiconductor-today.com/news_items/2013/OCT/NCTU_041013.shtml].

The template for the Chinese nanopyramids was a 2µm n-GaN layer on c-plane sapphire, produced through metal-organic chemical vapor deposition (MOCVD). The GaN surface was then covered with 400nm silicon dioxide that was patterned with holes in a hexagonal array created by ultraviolet nanospherical-lens photolithography (NLP) through a mask consisting of close-packed polystyrene nanospheres (Figure 1).

The template was then returned to the MOCVD equipment for SAE growth of n-GaN nanopyramids and then a 2nm indium gallium nitride (InGaN) well and 18nm GaN barrier as strain compensation. The active region consisted of a five-period InGaN/GaN (3nm/8nm) multiple quantum well/barrier structure. The p-type contact regions consisted of a 20nm aluminium gallium nitride ($Al_{0.15}Ga_{0.85}N$) electron-blocking layer and 30nm of GaN cladding.

The nanopyramids consist of six-sided structures on a hexagonal base with side-walls in the $\{10\bar{1}1\}$ crystal

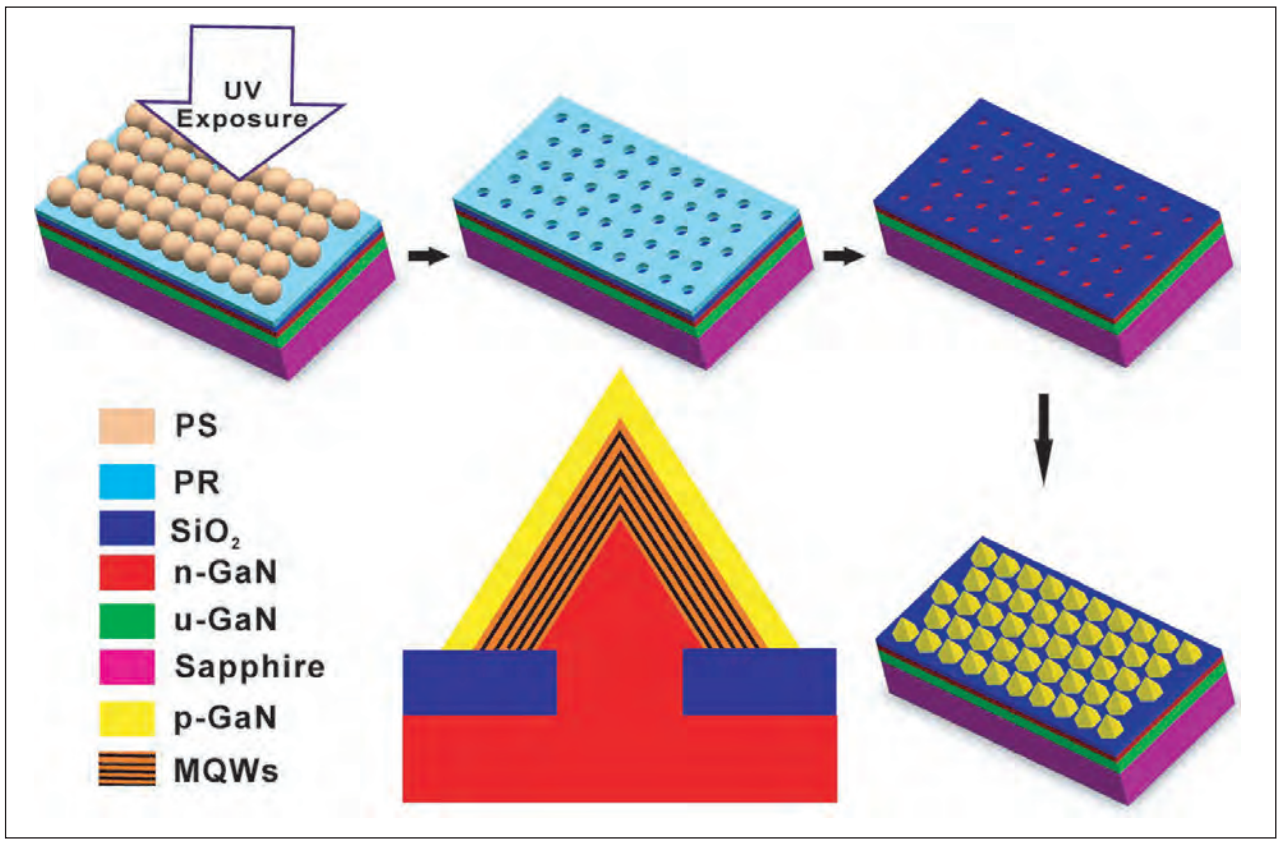

Figure 1. Schematic illustrations of the process for fabricating phosphor-free nanopyramid white GaN LEDs by NLP method.

orientation. One effect of SAE is the blocking of dislocations threading from the template into the nanopyramids. By creating structures free of threading dislocations, one source of current leakage is avoided. The $\{10\bar{1}1\}$ orientation is semi-polar, meaning the strain-dependent and spontaneous electric fields arising from the polarization of the various III-nitrogen bonds are reduced. The reduced fields lead to a decrease in the quantum-confined Stark effect (QCSE), where the electrons and holes are impeded from recombining into photons. These QCSEs become more severe for longer-wavelength emissions such as green and yellow from InGaN wells.

Photoluminescence (PL) from the nanopyramids showed a wide-band response in the wavelength range 400–600nm (Figure 2). The growth temperature of the strain compensation and active regions affects the peak of the spectral response. The higher temperature of 780°C gave a material with a peak around 450nm (with a secondary broader peak at ~550nm).

With 740°C growth, the short-wavelength peak disappeared, leaving a broad peak around 550nm. The 500nm wavelength corresponds to yellow emission, the light to which the human eye is most sensitive. The 740°C nanopyramids also give a 'white' light electroluminescence (EL) under 20mA injection current. The turn-on voltage is about 3V.

The broadband radiation is due to variations in indium incorporation and well thickness from the base to apex of the nanopyramids. By firing an electron beam and observing a nanopyramid's response, one finds that radiation from the base tends to have high yellow content while that from the apex is blue. Blue-green emissions come from the middle region of the facets. ■

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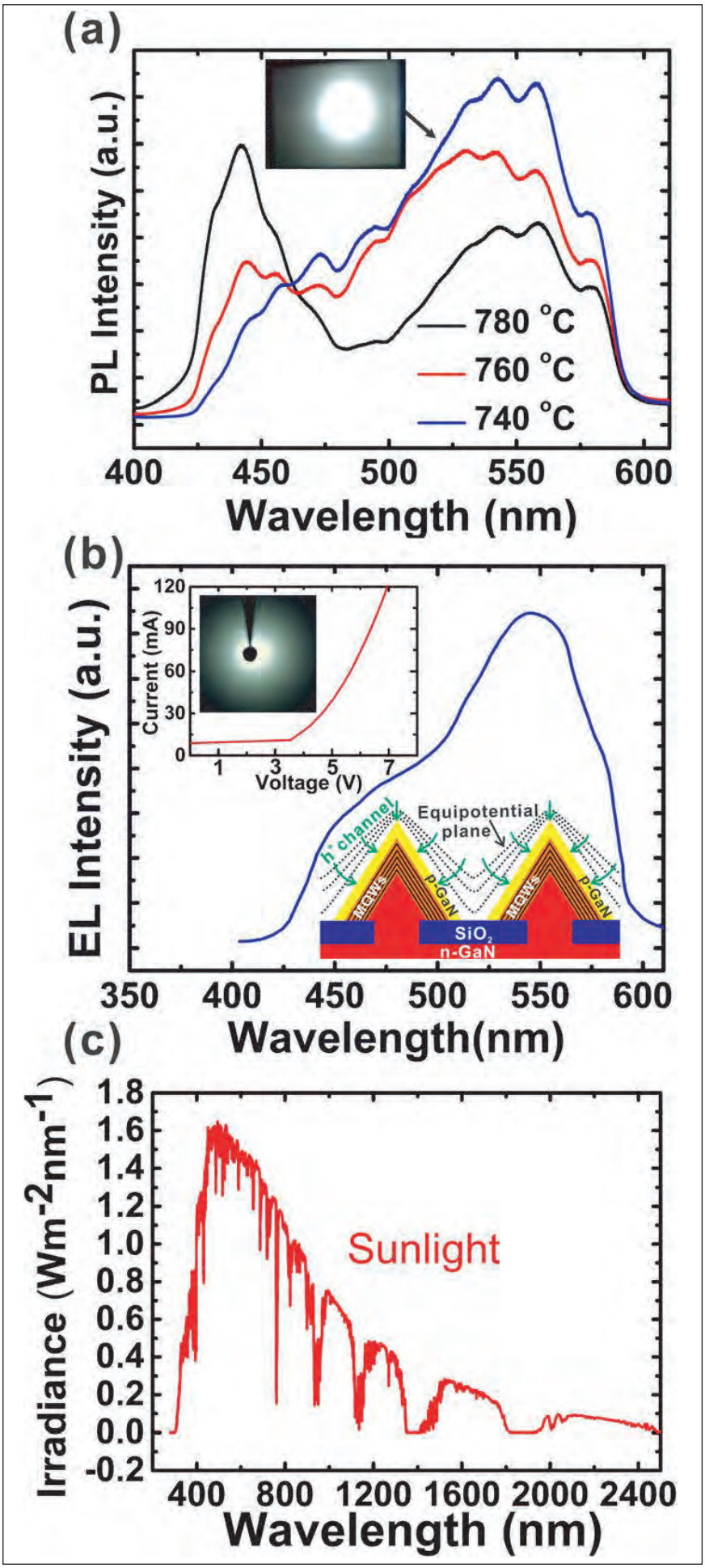

Figure 2. (a) Room-temperature PL spectra from MQWs of nanopyramid LEDs grown at different temperatures; inset shows optical microscope image taken from PL measurement. (b) EL emission spectra of LEDs at a 20mA current. Inset shows the current–voltage (I–V) characteristic and schematic diagram of current distribution of nanopyramid LEDs. (c) Sunlight spectrum (data from www.nrel.gov/rredc/solar_data.html).

Golden path to improved contact between graphene and gallium nitride

Near-ultraviolet light-emitting diode brightness has been increased by 10% by using a graphene on gold nanocluster electrode.

Researchers at Korea's Chonbuk National University and Korea Institute of Science and Technology have improved the contact of graphene with p-type gallium nitride (p-GaN), resulting in improved near-ultraviolet (NUV) light-emitting diodes (LEDs) [Tae Hoon Seo et al, J. Appl. Phys., vol114, p223105, 2013].

It has been found that bare graphene makes a Schottky rectifying contact with p-GaN. This is due to a large difference in graphene's work function of 4.5eV with that of p-GaN at 7.5eV. Gold bridges the gap with a work function of 5.1eV. The researchers used a thin gold (Au) interlayer between the p-GaN and graphene to convert it to an ohmic non-rectifying behavior. Further, annealing the structure caused the gold to form nanoclusters that reduced the resistance.

Gold nanoparticles have been used before to improve graphene performance as transparent current-spreading electrode. However, the new work applies the gold before the graphene rather than after (by 'decorating' graphene with gold nanoparticles from gold chloride solution).

The target wavelength of the LEDs was 373nm NUV (Figure 1). The metal-organic chemical vapor deposition (MOCVD) of nitride semiconductor layers on c-plane sapphire began with 25nm of low-temperature 550°C GaN, 1.5µm of high-temperature 1040°C GaN, and 2µm of high-temperature silicon-doped n-GaN.

The active region consisted of a 5-period multiple quantum well (MQW) of pairs of indium gallium nitride ($In_{0.03}Ga_{0.97}N$) wells and aluminium gallium nitride ($Al_{0.08}Ga_{0.92}N$) barriers, grown at 780°C.

The high-temperature magnesium-doped p-type regions consisted of 25nm $Al_{0.25}Ga_{0.75}N$ electron-blocking and 100nm GaN contact layers. The p-type doping was activated with a 940°C, 40-second anneal in nitrogen.

The 350µm x 350µm UV chips were fabricated beginning with mesa etch to expose the n-GaN contact layer, and the deposition of 2nm of gold on the p-contact. One sample was annealed in oxygen and nitrogen at 600°C for a minute, creating the gold nanoclusters.

The graphene was prepared on copper foil using chemical vapor deposition (CVD) and transferred to the LED p-contact on poly methyl methacrylate (PMMA). The samples were then annealed again at 500°C for 30 minutes in hydrogen and argon, preventing oxidation and removing the PMMA film. The graphene film was then patterned and etched in oxygen plasma.

The fabrication process was completed with the deposition of chromium/gold electrodes on the n-GaN and graphene p-contact.

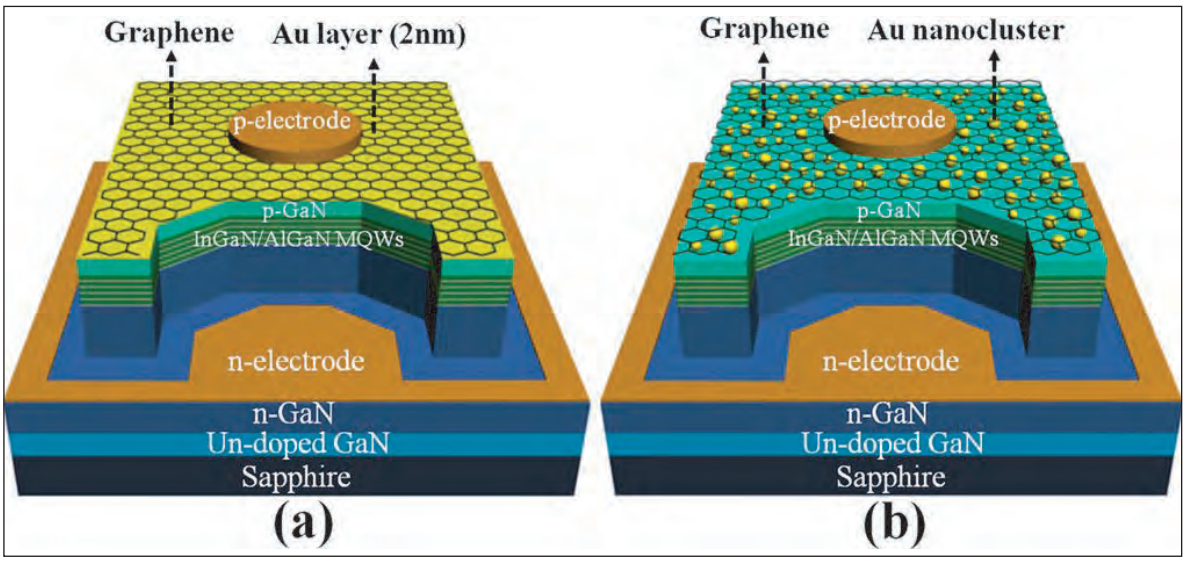

Figure 1. Schematic diagram of fabricated InGaN/AlGaN MQW-based UV LED with graphene film on (a) Au layer and (b) Au nanoclusters as transparent current-spreading electrode.

Independent measurements on silicon dioxide/silicon substrates suggest that the gold clusters have a diameter of order 30nm with a density of $10^{10}/cm^2$. Transmittance tests at 373nm on glass give 92.8% for bare graphene, 78% for graphene on gold, 82.7% for graphene on gold nanoclusters, and 60% for indium tin oxide (ITO). Respective electrical sheet resistances were 500±60Ω/square, 200±20Ω/square, 150±20Ω/square and 48±2Ω/square.

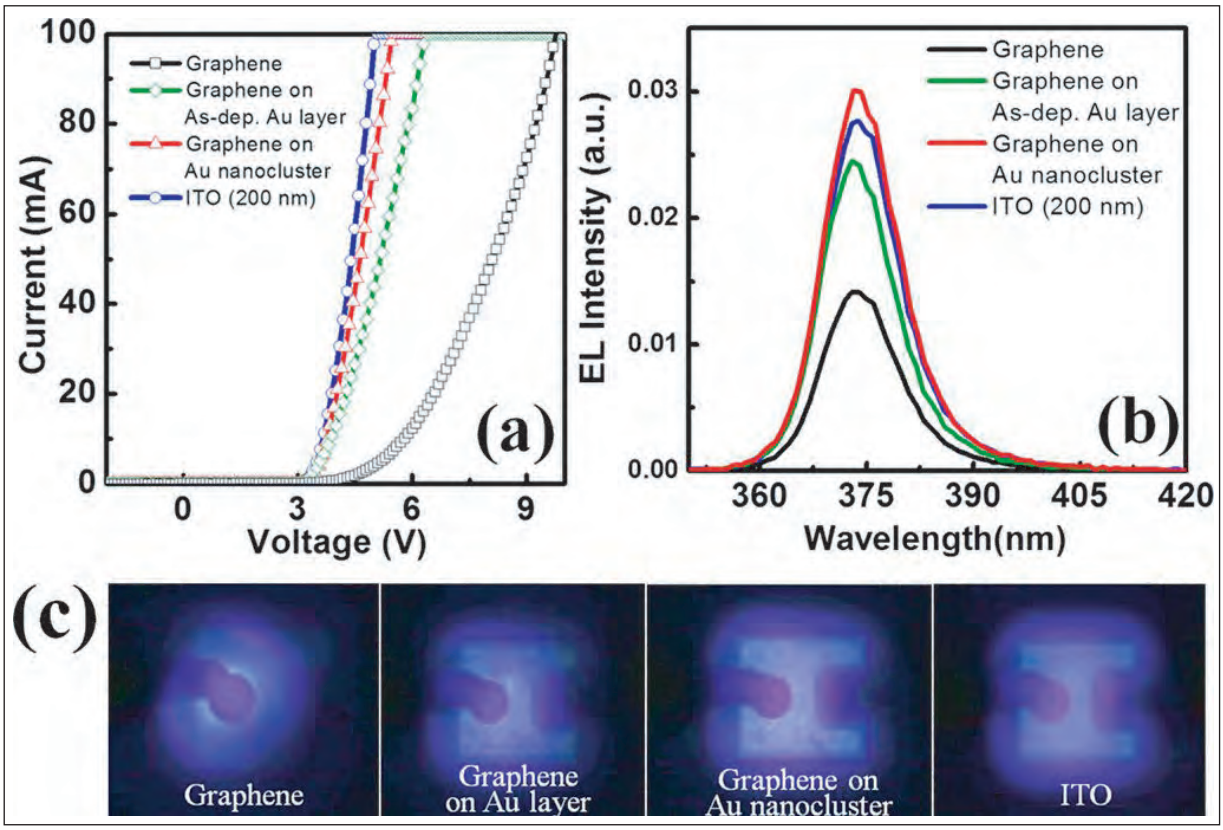

Figure 2. (a) Current–voltage characteristics, (b) electroluminescence spectra and (c) photography at 20mA injection current in InGaN/AlGaN MQW NUV-LEDs with various transparent current-spreading electrodes.

It is believed that the high resistance of bare graphene is due to defects inherited from the crystal grains of the copper foil growth substrate. The researchers comment that the gold layer or nanoparticles can bridge the high-resistance regions around the defects. The lower resistance of the nanoclusters is attributed to the Au nanoparticle and graphene composite providing a doping effect from direct charge transfer between the components.

Current–voltage measurements using the circular transfer length method showed that the gold interlayer converted the Schottky contact of bare graphene on p-GaN to an ohmic contact. Annealing to form nanoclusters reduced the specific contact resistance to 18mΩ-cm^2, from 800mΩ-cm^2 without annealing.

The reduction in specific contact resistance by thermal annealing is attributed to "the combined effects of the reduced Schottky barrier height caused by the shift of the surface Fermi level toward the valence-band edge, increased carrier concentration owing to the generation of gallium vacancies upon thermal annealing, and enhanced tunneling transport caused by a strong enhancement in the electric field through interfacial nanostructures."

The graphene with gold nanoclusters showed the brightest electroluminescence (EL) at 20mA injection (Figure 2). The EL response of the bare graphene was the poorest and the forward voltage of the bare graphene LED was also very high at 7.2V. High forward voltage indicates energy losses through resistive effects.

By inserting the gold interlayer and annealing to form nanoclusters, the forward voltage was reduced progressively to 4.25V and then 4.02V. The comparison sample with a conventional 200nm ITO transparent conducting electrode had a forward voltage of 3.94V at 20mA, but at slightly reduced electroluminescence compared with the gold-nanocluster graphene, which was about 10% brighter.

In addition to poor performance at 20mA, the bare graphene LED suffered from burn-out at higher currents. The photographs in figure 2c show that bare graphene also has poor current-spreading capability, with most of the illumination concentrated around the p-electrode.

The researchers comment further: "When using the graphene on Au layer and Au nanocluster, a bright and uniform light emitting was observed in the whole emission area due to effective current spreading by reduced sheet resistance. Also, the UV LED with graphene on Au nanoclusters does not show any joule heating or oxidation up to the injection currents of 100mA investigated in this work and operates without any degradation under continuous current injection up to 300s." ■

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Author: Mike Cooke

Wide-bandgap materials and power applications

Efforts continue to realize the potential of wide-bandgap semiconductors for power switching applications. Researchers presented a number of papers at December's International Electron Devices Meeting (IEDM) in Washington DC. Mike Cooke reports.

Materials with high critical breakdown fields and high electron saturation velocities should lead to more efficient and compact power handling systems. Wideband materials such as silicon carbide (SiC) and gallium nitride (GaN) have such properties, but moving from principles to practice is not straightforward.

For GaN-based devices, one of the leading obstacles has been the fact that characteristics achieved in direct current (DC) measurements are not maintained when switching speed increases. In particular, the current 'collapses', indicating that the dynamic resistance of the on-state has increased.

SiC material quality and more difficult processing are some of the impediments on the alternative branch towards efficient, compact power handling. Some of the materials problems such as 'micropipe' defects have been tackled in particular cases. Manufacturing difficulties include the hardness of the material and the high temperature at which processing has to be carried out – ~1600°C as opposed to ~1000°C for GaN.

Here we look at some of the presentations at IEDM that touched on these issues and others. Next issue, we will cover IEDM progress reports toward combining III-V transistors with CMOS.

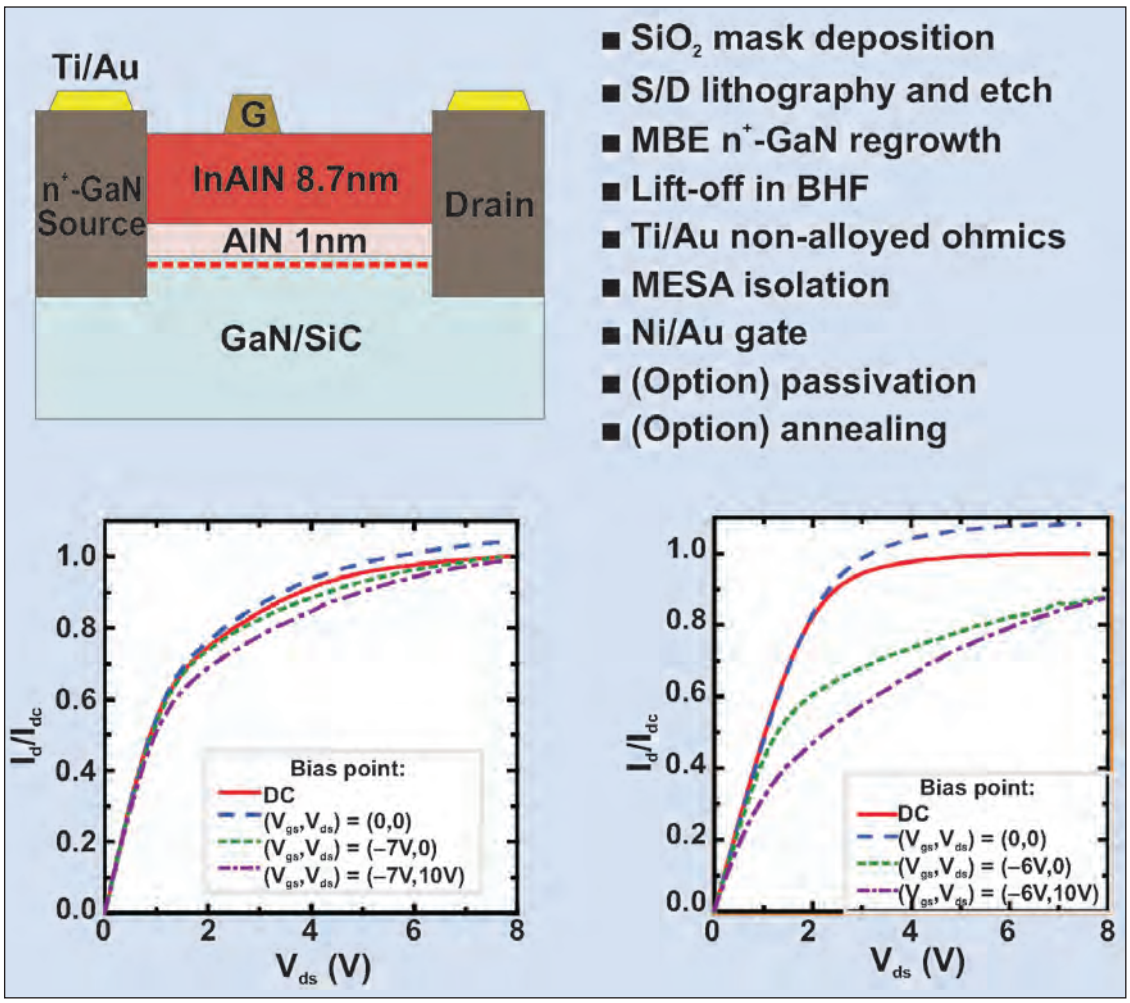

Figure 1. UND / IQE InAlN-based HEMTs with non-alloyed re-grown contacts and no passivation: Device schematics (top left) and process flow (top right). Pulsed current-voltage (I–V) characteristics using 300ns pulses and duty cycle of 0.5ms, and 0V gate potential, without annealing (bottom left) and with annealing at 650°C for 30 seconds in nitrogen (bottom right).

Dispersion / current collapse

University of Notre Dame and IQE have been studying how to obtain 'dispersion-free' operation in indium aluminium nitride (InAlN) barrier high-electron-mobility transistors (HEMTs) [Ronghua Wang et al, session 28.6]. Dispersion away from DC performance when operated in pulsed switch-mode is often attributed to surface states near the gate that trap and release elec-

trons. 'Current collapse' is another term for such behavior in gallium nitride (GaN) HEMTs.

Although passivation schemes have been developed to avoid surface states, it is important that such efforts do not negatively impact carrier densities in the channel.

Dielectric deposition is one technique to reduce the surface states that produce dispersion. However, dielectrics can also extend the effective length of the gate, creating a 'virtual gate', along with introducing parasitic capacitance that increases delays — both effects reducing performance.

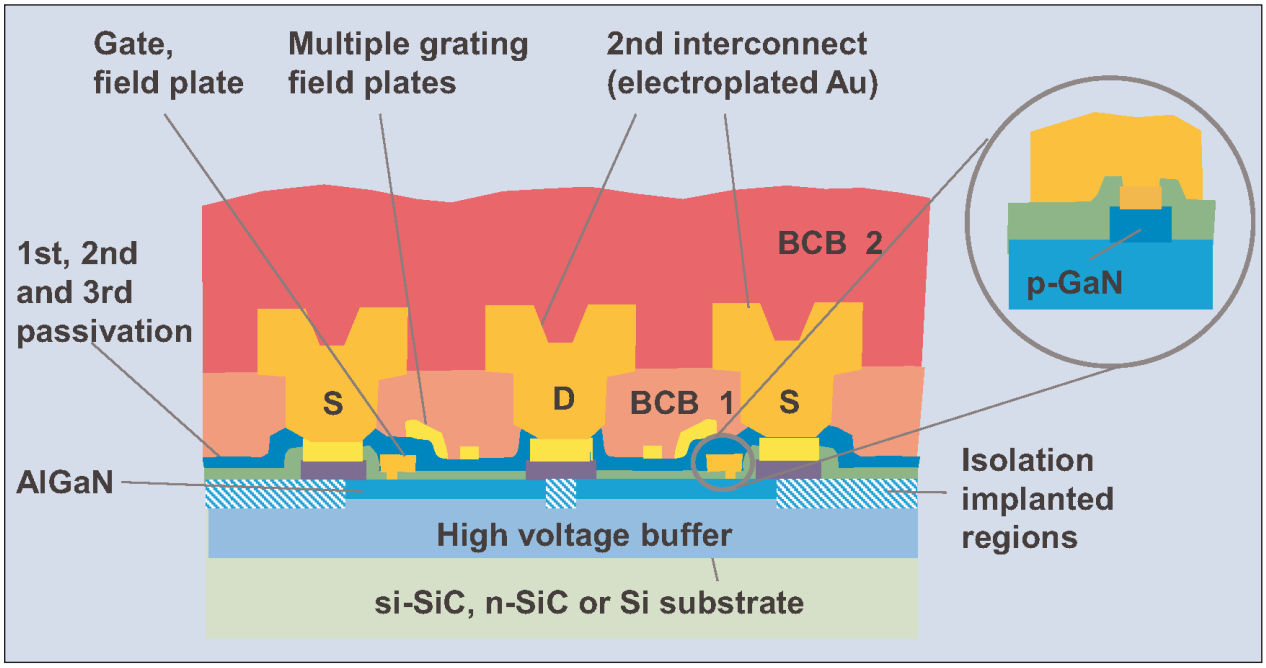

Figure 2. High-voltage switching GaN technology developed at Ferdinand-Braun-Institut: normally-on and normally-off devices are fabricated in same process with the exception of the gate module. Inset details related to p-type GaN gate which renders devices normally-off.

UND/IQE studied devices based on epitaxial layers that included near-lattice-matched ternary $In_{0.17}Al_{0.83}N$ or quaternary $In_{0.13}Al_{0.83}Ga_{0.04}N$ barriers, deposited on GaN buffers on silicon carbide (SiC) substrates. The barrier thicknesses were in the range 4–11nm.

One type of ohmic contact was based on UND's 650°C molecular beam epitaxy (MBE) GaN re-growth process followed by non-alloyed titanium/gold metal, giving a contact resistance of 0.27Ω-mm. Devices with alloyed contacts were also produced with 0.38Ω-mm contact resistance. The alloying is achieved with a high-temperature anneal that is avoided with the MBE re-growth technique. The re-growth involves a silicon dioxide mask that protects the InAl(Ga)N barrier surface from oxidation during the 650°C MBE.

Various passivation schemes were evaluated: plasma-enhanced chemical vapor deposition (PECVD) of silicon nitride (SiN), atomic layer deposition (ALD) of aluminium oxide (Al_2O_3), and an oxygen/argon plasma treatment of the InAl(Ga)N surface to give an oxide layer that was developed by UND as a 'dielectric-free passivation'. The researchers now designate the dielectric-free passivation as a "plasma oxide, to be more accurate".

The tested devices featured a range of gate lengths from 30nm up to 250nm. The gate width was 2x50μm. The source–drain distance was 1.6μm in devices with alloyed contacts and 1μm for non-alloyed/MBE re-grown contacts.

Devices with non-alloyed/re-grown contacts without passivation showed "essentially no dispersion" (Figure 1) and a high cut-off frequency (f_T) of 180–220GHz for gate lengths in the range 60–100nm. The use of ALD passivation reduced f_T by about 10%. The passivation also created dispersion of about 50%.

The alloyed-contact HEMTs without passivation had a low f_T of 125GHz for 60nm gates and exhibited strong dispersion. For these devices, passivation with SiN or Al_2O_3 increased f_T and reduced dispersion effects.

The UND oxide-plasma process avoids the problems of dielectric deposition techniques. The plasma treatment is thought to amorphorize the top InAlGaN barrier (~ 4nm) in the access region into an Al-rich oxide passivation layer. With alloyed contacts the process gives an f_T of 220GHz and 'negligible dispersion', similar to the HEMTs with non-alloyed ohmic contacts.

The researchers report that the characteristics "stayed largely the same over months of study". Further improvement of device stability needs "a low-permittivity moisture barrier or hermetic packaging".

Massachusetts Institute of Technology (MIT) and Texas Instruments also reported on current collapse in GaN metal-insulator-semiconductor HEMTs [D. Jin et al, 6.2]. The MIT/TI group studied operation at more than 600V, finding extreme trapping in the OFF-state, leading to total current collapse. The researchers attribute this to high-field tunneling-induced electron trapping ('Zener trapping').

"This finding gives urgency to defect control during epitaxial growth and appropriate field-plate structures for high-voltage MIS-HEMTs," the team comments.

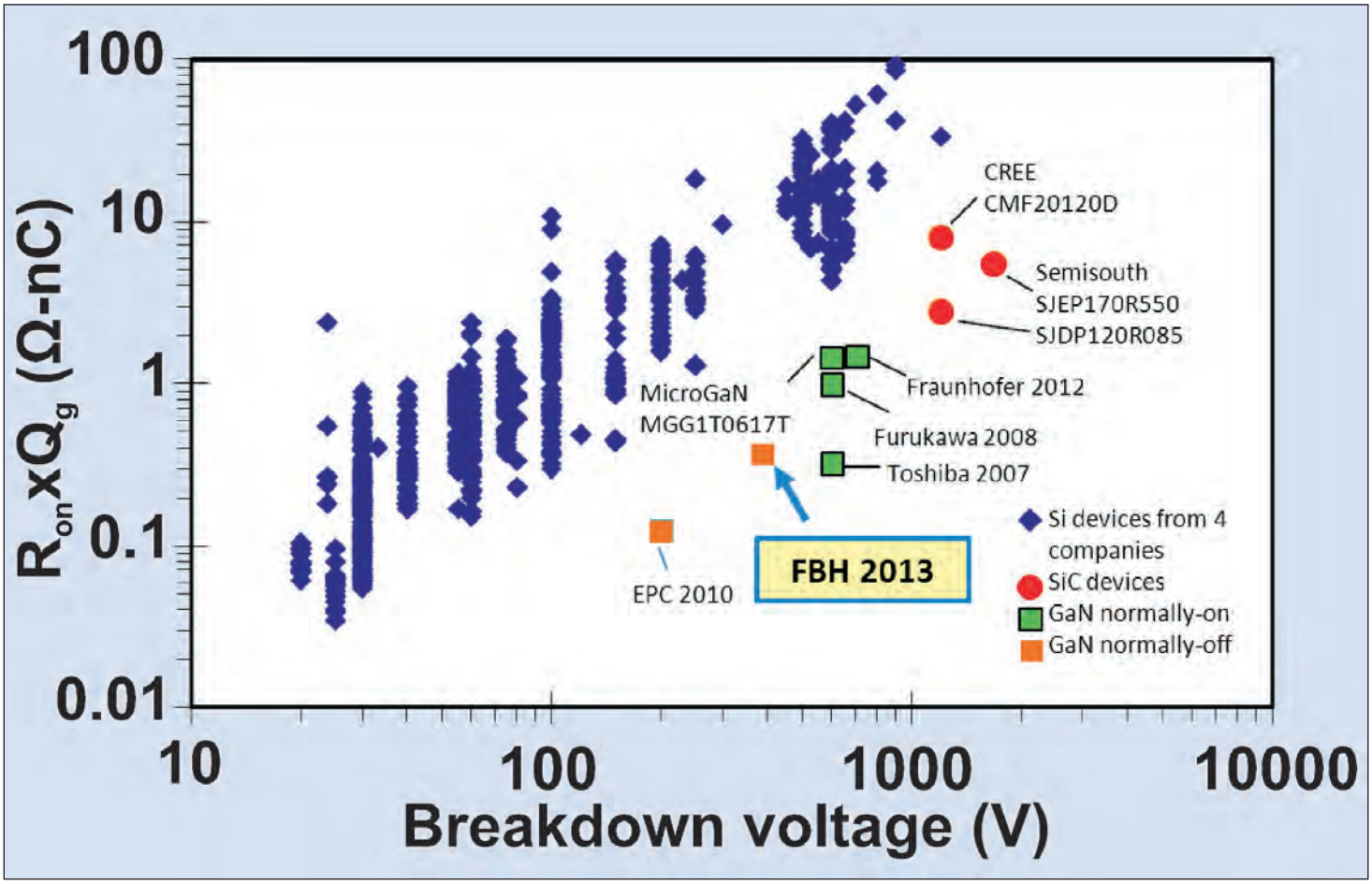

Figure 3. Comparison of product of specific on-state resistance R_{ON} and gate charge Q_g versus breakdown voltage for different device families. R_{ON} relates to on-state device losses and gate charge Q_g limits maximum obtainable switching speed.

Dynamic response

Ferdinand-Braun-Institut, Leibniz Institut für Höchstfrequenztechnik (FBH) reported on dynamic switching limitations of GaN power transistors [J. Würfl et al, 6.1]. Dynamic on-resistance is another way of expressing the problems of dispersion/current collapse.

The researchers produced both normally-on and normally-off HEMTs using different gate stack process modules (Figure 2). The normally-off HEMTs included p-GaN in the gate region. The normally-on transistor used a metal stack of iridium/titanium/gold. Benzocyclobutene (BCB) was used for passivation. Isolation was achieved with ion implantation. Although the process can be used with GaN/Si substrates, the reported work involved only n-SiC substrates.

The researchers carried out a series of process variations designed to investigate the effects of epitaxial buffer design. For power switching devices, one wants high values of breakdown strength combined with low dynamic on-resistance. Unfortunately, devices produced with buffers exhibiting 170V/μm breakdown values often have unusably high dynamic on-resistance.

One technique to increase breakdown strength is to increase carbon concentration. Alternatives include iron-doping and adding an AlGaN back-barrier beneath the channel layer. While these techniques reduce dynamic on-resistance, they also reduce the breakdown range to 40–50V/μm. The carbon-doping method introduces deep acceptor levels that charge and discharge slowly and thus affect the dynamic performance.

Finally, the researchers developed a combination of GaN:C with an AlGaN back-barrier close to the channel layer that increased the breakdown to 80V/μm and reduced the dynamic/static on-resistance ratio to 1.1 at 65V switching.

Tests with 500V drain bias showed that dynamic on-resistance increases by factors of 880 after switching and 220 after 10μs for a device with heavily doped GaN:C ($2x10^{19}/cm^3$) buffer. By contrast, the dynamic on-resistance factor was only 2.5 for a device with AlGaN back barrier on GaN:C doped at $4x10^{18}/cm^3$.

The researchers comment: "This is a breakthrough, showing that GaN devices really outperform Si-power devices in terms of the $R_{ON}xQ_g$ product and therefore in terms of potential system efficiency."

A normally-off device switching at 400V demonstrated an $R_{ON}xQ_g$ product as low as 0.4Ω-nC using an iron-doped buffer (Figure 3).

Monolithic E/D MIS-HEMTs

Hong Kong University of Science and Technology and Chinese Academy of Sciences' Institute of Microelectronics reported on a monolithic process for creating integrated 600V enhancement-mode (normally-off) and depletion-mode (E/D) MIS-HEMTs [Zhikai Tang et al, 6.4].

While power-switching GaN device research tends to focus on the difficult-to-achieve enhancement-mode behavior, the Chinese researchers see potential applications arising from the ability to produce both types of device on one chip.

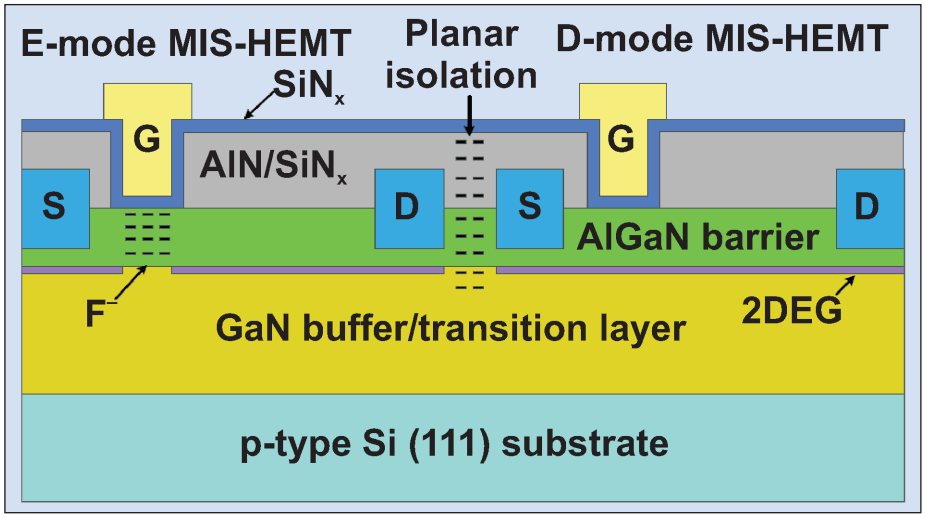

Figure 4. Schematic cross section of monolithically integrated E/D-mode SiNx/AlGaN/GaN MIS-HEMTs.

As an example, they designed and created a high-voltage start-up circuit for off-line switched-mode power supplies (SMPSs) using their integrated E/D-transistor process. Such circuits are used to charge up the capacitor in pulse-width modulation ICs in start-up mode. After start-up, this charging is supplied by the power stage. Conventional start-up circuits use silicon-based D-mode junction field-effect transistors (JFET) along with E-mode MOSFETs.

The GaN-based circuit used one D-mode and two E-mode transistors. A silicon-based op-amp was also used as hysteretic comparator with 2.8V reference voltage.

Other potential applications for integrated E/D GaN transistors include level-shifting and low-voltage control/sensing/protection functional blocks.

The devices (Figure 4) were grown on (111) Si substrates. The 21nm barrier layer consisted of GaN/$Al_{0.25}Ga_{0.75}N$/AlN. The GaN buffer/transition layer was 3.8μm thick. The ohmic contacts were achieved with titanium/aluminium/nickel/gold annealed at 850ºC for 30 seconds in nitrogen. A passivation layer of AlN/SiN was applied using plasma-enhanced atomic layer deposition (PE-ALD) and plasma-enhanced chemical vapor deposition (PE-CVD), respectively.

Multi-energy fluorine ion implantation achieved device isolation. Fluorine ion implantation of the gate region also created enhancement-mode transistors. The gate stack consisted of silicon nitride insulator and nickel/gold electrodes.

The device measurements were 1μm/10μm gate length/width, 1μm gate-source distance, and 15μm gate-drain. The 1μA/mm drain current off-state breakdown (BV) performance with grounded substrate was 604/640V, respectively, for the E-/D-mode devices (Figure 5). The corresponding specific on-resistances (R_{ON}) were 2.1mΩ-cm^2/1.5mΩ-cm^2.

Pulsed measurements showed negligible difference between the DC and pulsed I–V measurements of drain current in the linear region, "indicating effective suppression of current collapse". The dynamic on-resistance at 100mA/mm drain current was maintained at a low value after a 650V off-state stress. ►

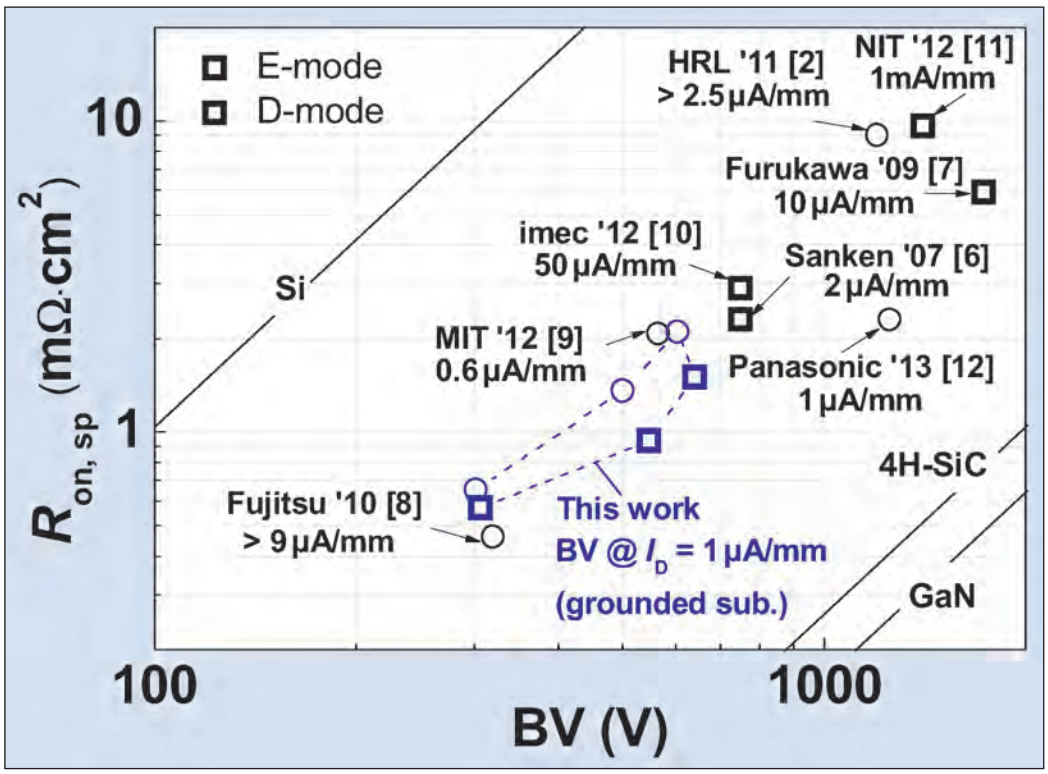

Figure 5. Specific RON versus off-state BV for a range of GaN power devices.

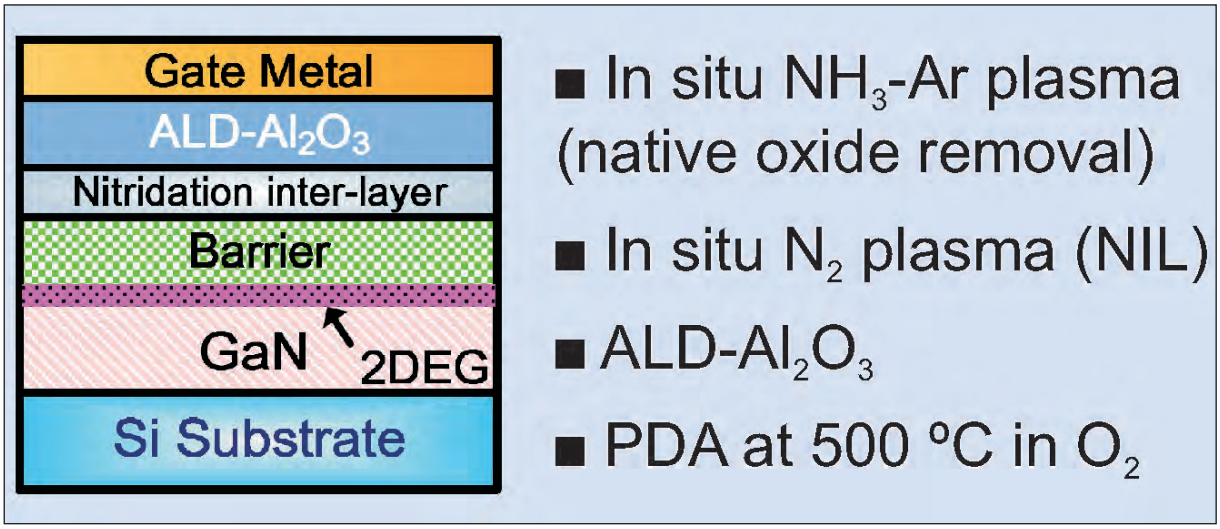

Figure 6. Schematic cross section and key process steps of Al_2O_3(NIL)/GaN/AlGaN/GaN gate dielectric stack with in-situ low-damage remote plasma pre-treatment before gate dielectric deposition.

Reducing charge trapping in metal–insulator–semiconductor structures

Hong Kong University of Science and Technology and TSMC's Analog/Power & Specialty Technology Division have developed a high-quality Al_2O_3/GaN-cap interface for Al_2O_3/GaN/AlGaN/GaN MIS-structures with low interface trap densities in the range 10^{12}–10^{13}/cm^2-eV [Shu Yang et al, 6.3]. Normally, such interfaces have trap densities in the range 10^{13}–10^{14}/cm^2-eV. Such charge trapping under the gate affects threshold voltage stability.

The process involved an in-situ low-damage NH_3-Ar-N_2 plasma pre-gate treatment in a plasma-enhanced atomic layer deposition system at 300ºC (Figure 6). The researchers attribute their achievement to "effective removal of native oxide and the subsequent formation of a monocrystal-like nitridation inter-layer on the GaN surface".

The oxide removal was achieved with NH_3-Ar plasma, while the nitridation was achieved with N_2 plasma. After the process, a 25nm layer of Al_2O_3 insulation was added in the PE-ALD chamber.

X-ray photo-electron spectroscopy (XPS) and transmission electron microscopy (TEM) were used to analyze the difference between stacks with and without the plasma treatment. Without treatment, the Al_2O_3/GaN cap surface is rough and amorphous due to a high density of Ga–O bonds at the interface. These bonds are suppressed in the treated stack by the presence of the nitrided interlayer. This results in a "uniform and sharp interface".

The trap density was measured using frequency- and temperature-dependent capacitance-voltage (C–V)-based techniques to overcome the difficulty posed for traditional C–V measurements due to the relatively large separation between the dielectric/III-N interface and the conducting channel.

Silicon carbide

Researchers in Japan have achieved an ultra-high blocking of 16kV with a silicon carbide insulated-gate bipolar transistor (IGBT) [Yoshiyuki Yonezawa et al, 6.6]. At the same time, the on-state forward voltage was only 5V at 100A/cm^2 current density. The n-channel device used the flipped back-side of the n-SiC substrate to take advantage of the higher mobility of 100cm^2/V-s of the C-face (000$\bar{1}$) of the crystal structure. Si-face (0001) mobilities are typically in the range 20–30cm^2/V-s.

A further advantage of flipping the substrate and forming p^{++} regions on the back-side is that n^{++} substrates can be used. The crystal quality of p^{++} SiC substrates are very poor with high micropipe densities, leading to low conductivity. By contrast, these problems are well controlled in n^{++} SiC wafer growth.

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The researchers used a combination of implantation and epitaxial (IE) deposition to achieve selective p-wells for the emitter region. The use of epitaxy in the final stage of the p-well gives a smoother surface, enabling higher channel mobility.

The researchers used a combination of implantation and epitaxial (IE) deposition to achieve selective p-wells for the emitter region. The use of epitaxy in the final stage of the p-well gives a smoother surface

The potential applications of the IGBT include smart grid and high-voltage DC, according to the team from Japan's National Institute of Advanced Industrial Science and Technology

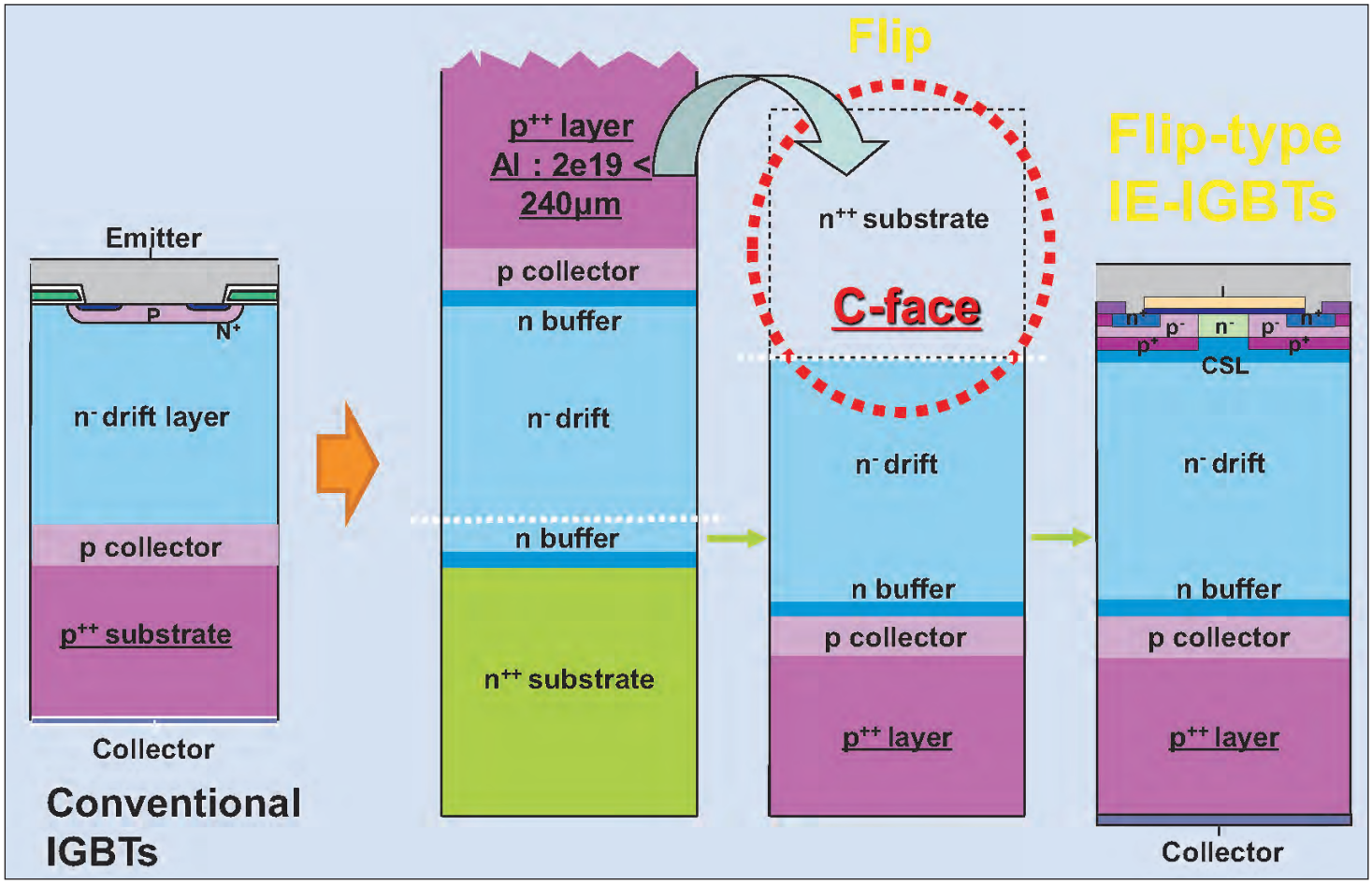

Figure 7. Fabrication process flow of flip-type IE-IGBT on 4H-SiC (000-1) carbon face.

(AIST), Fuji Electric Co Ltd, New Japan Radio Co Ltd, Tokyo Electron Yamanashi Ltd, and Kyoto University. Particular devices where SiC IGBTs could be used to increase voltage handling include static synchronous compensators (STATCOMs) and solid-state transformers (SSTs).

Epitaxial growth of the semiconductor material began with growth on the Si-face of the substrate to give the collector and drift structures (Figure 7). The n-type drift layer of more than 150μm thickness was grown on a buffer layer that converted basal plane dislocations into threading edge dislocations. A second 1–2μm buffer on top of the drift layer was grown before an aluminium-doped p-type collector. The pre-flip structure was completed with more than 100μm of p^{++} SiC as the flipped substrate layer.

After flipping, the n^{++} substrate was removed and the new surface subjected to chemical mechanical polishing (CMP). The flipped growth proceeded by first adding a 2μm charge storage layer (CSL).

The p-wells were then formed with a selective implantation of aluminium, followed by epitaxial growth of 0.5μm p^--SiC. The JFET n-channel and n-extension were achieved using selective implantation of nitrogen into the p^--SiC.

The gate oxide was achieved with a combination of dry and wet oxidation. The wet oxidation was carried out in a hydrogen-rich environment that suppressed threshold voltage shift to 0.1V at ±30V gate potentials. The researchers say that this could show that hydrogen atoms provide an effective termination for SiO_2/SiC interface states.

The 3mm x 3mm device consisted of a series of 14.8μm-pitch unit cells in a striped array. With a 1.6μm JFET gate length, the breakdown occurred at 16kV. The peak field-effect mobility (μ_{FE}) was 75cm^2/V-s and at 20V gate-emitter voltage it was still 60cm^2/V-s. The researchers comment: "This is considerably higher than the μ_{FE} of MOSFETs on a Si face."

The collector-emitter voltage behavior remained relatively stable, with 10V gate potential over a wide temperature range of 100–250°C.

A larger 5.3mm x 5.3mm IE-IGBT was produced on a different substrate. This second device achieved a higher 16.5kV breakdown with a forward voltage of 5.2V at 100A/cm^2. The researchers believe longer carrier lifetimes of 10μs could be achieved with carbon implantation and longer oxidation processes. Longer lifetimes are expected to improve the IE-IGBT performance. ■

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

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E-mail: registration@ipc.org
www.IPCAPEXEXPO.org

25–27 March 2014
Intersolar China 2013
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31 March – 3 April 2014
GOMAC Tech 2014 (39th annual Government Microcircuit Applications & Critical Technology Conference)
Embassy Suites Hotel, North Charleston, SC, USA
E-mail: mgoldfarb@pcm411.com
www.gomactech.net

14–17 April 2014
SPIE Photonics Europe 2014
SQUARE Brussels Meeting Centre, Belgium
E-mail: customerservice@spie.org
http://spie.org/photonics-europe.xml

23–25 April 2014
SEMICON Singapore
Marina Bay Sands Expo & Convention Center, Singapore
E-mail: semiconsingapore@semi.org
www.semiconsingapore.org

5–9 May 2014
SPIE DSS 2014, incorporating: SPIE Security + Defence 2014 SPIE Sensing Technology + Applications 2014
Baltimore Convention Center, MD, USA
E-mail: customerservice@spie.org
http://spie.org/defense-security-sensing.xml

11–15 May 2014
Compound Semiconductor Week 2014, inc: 41st International Symposium on Compound Semiconductors (ISCS 2014) 26th International Conference on Indium Phosphide and Related Materials (IPRM 2014)
Montpellier, France
E-mail: csw2014@csw2014.org
www.csw2014.org

11–16 May 2014
225th Electrochemical Society (ECS) Meeting
Orlando, FL, USA
E-mail: meetings@electrochem.org
www.electrochem.org/meetings/biannual/fut_mtgs.htm

14–15 May 2014
SEMICON Russia
Moscow, Russia
E-mail: yulia.solovieva@businessmediarussia.ru
www.semiconrussia.org

19–21 May 2014
25th annual SEMI Advanced Semiconductor Manufacturing Conference (ASMC 2014)
Saratoga Springs, NY, USA
E-mail: mkindling@semi.org
www.semi.org/asmc2014

19–22 May 2014
2014 International Conference on Compound Semiconductor Manufacturing Technology (CS MANTECH)
Sheraton Denver Downtown Hotel, CO, USA
E-mail: conferencechairman@gaasmantech.org
www.csmantech.org

1-6 June 2014
Microwave Week 2014: IEEE Microwave Theory and Techniques Society's (MTT-S) 2014 International Microwave Symposium (IMS 2014) 2014 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium 15th annual IEEE Wireless and Microwave Technology Conference (WAMICON 2014) Automatic RF Techniques Group (ARFTG) 83rd Microwave Measurement Conference
Tampa Bay, FL, USA
E-mail: tpc_chairs@ims2014.org
www.ims2014.org

9–13 June 2014
2014 Symposia on VLSI Technology and Circuits
Hilton Hawaiian Village, Honolulu, Hawaii
E-mail: vlsi@vlsisymposium.org
www.vlsisymposium.org

22–25 June 2014
The ConFab 2014
Encore at the Wynn Resort, Las Vegas, NV, USA
E-mail: psinger@extensionmedia.com
www.theconfab.com

8–10 July 2014
SEMICON West
Moscone Center, San Francisco, CA, USA
E-mail: semiconwest@semi.org
www.semiconwest.org

9–10 July 2014
UK Semiconductors 2014
Sheffield UK
E-mail: info@uksemiconductors.com
www.uksemiconductors.com

14–16 July 2014
2014 IEEE Photonics Society Summer Topical Meeting Series
Delta Montreal Hotel, Montreal, Quebec, Canada
Paper submission deadline: 10 March 2014
E-mail: i.donnelly@ieee.org
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