ISSN 1752-2935 (online)

# semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

Vol. 5 • Issue 2 • March 2010

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# Accelerating LED growth via improved MOCVD uniformity

SAFC expands UK TMG capacity • TSMC LED fab breaks ground
Mobile World Congress • RFMD's 6" GaAs line makes PV cells

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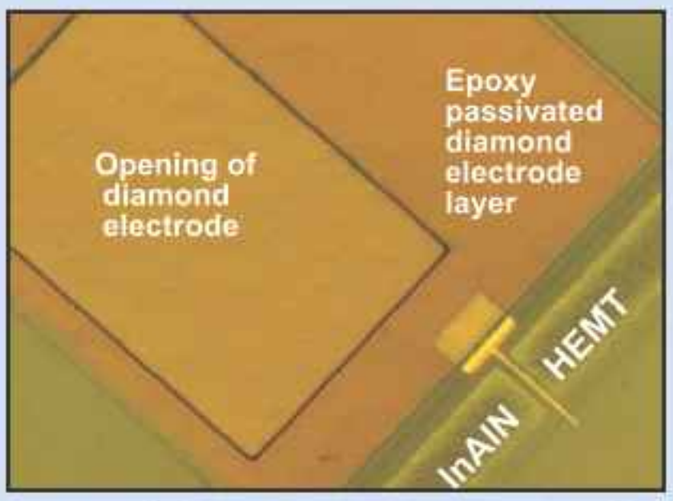


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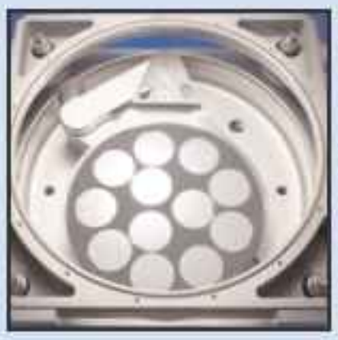


**Cover:** Veeco's K465i MOCVD reactor (launched in January), showing 4" sapphire wafers, removable carrier, and automated loading. New techniques that can improve process uniformity aim to boost capital efficiency, lowering LED production costs and driving adoption for solid-state lighting. **p87**

# editorial

# Growth rates accelerating as TSMC enters LED sector

March saw yet further evidence of the accelerating recovery in market demand, with some of the largest RFIC makers in particular (RFMD, Skyworks and TriQuint) all raising their guidance for March-quarter 2010 revenue (see page 8) as growth from the downturn-driven low of a year ago continues to outpace expectations.

In addition to the increasing volume demand, growth is also coming from more advanced, higher-value mobile telecom products (as exemplified by the host of 3G and 4G product launches at February's 2010 Mobile World Congress in Barcelona, Spain — see pages 10–21) as well as from the rewards of diversifying (during the downturn in core markets) into higher-growth sectors. Skyworks, for example, cites smart-grid applications as a contributor to its raised revenue guidance. Meanwhile, more long term, RFMD has reported what are claimed to be the first photovoltaic cells manufactured in an existing high-volume 6" GaAs wafer fabrication plant (with no equipment modifications).

In addition to increasingly capable gallium arsenide RF products, the commercialization of gallium nitride power transistors is burgeoning, with manufacturers like RFMD, TriQuint, Cree and Nitronex being joined by International Rectifier and EPC (founded just in 2007, controversially, by former International Rectifier CEO Alex Lidow) — see pages 26–27.

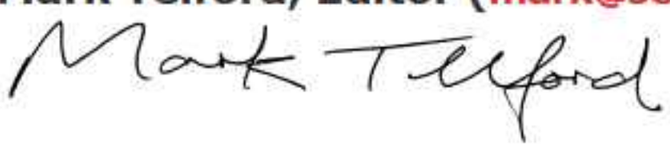
GaN device development is highlighted in the feature article on page 90, including how the technology is maturing in terms of controling parameters like threshold voltage, breakdown, degradation mechanisms etc (with the latter being studied in particular for GaN HEMTs with InAlN rather than AlGaN barrier layers — see the article on page 89),

GaN development is also being driven by the unprecedented demand for high-brightness LEDs for backlighting applications, as well as prospecting solid-state lighting applications. Of the two main MOCVD reactor suppliers, Veeco has reported that its MOCVD revenue more than doubled sequentially in Q4/2009 (page 34), while Aixtron also reported record revenue for both Q4 and full-year 2009, and expects revenue to double in 2010 (page 36).

As well as increasing their system manufacturing capacity, both firms have recently responded to increased demand by launching high-capacity reactors: Aixtron with its AIX G5 (page 37) and Veeco with its K465i (launched in January). In the case of the latter, Veeco is also targeting increased capital efficiency by boosting LED yield via improved process uniformity (see article on page 84). The aim is to reduce LED production costs in concert with the anticipated widespread adoption of HB-LEDs for solid-state lighting (see streetlighting projects on pages 49–50).

While most LED manufacturing is performed in Asia-Pacific (particularly Taiwan), perhaps the greatest market potential is in mainland China. So, it's no surprise that, not only are existing Taiwanese LED chip makers like Epistar and Tyntek planning plants in China, but Taiwan's TSMC has just broken ground on its first LED fab. The entry of the world's biggest silicon wafer foundry into LED making could dwarf even today's growth rates.

**Mark Telford, Editor (mark@semiconductor-today.com)**



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

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

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

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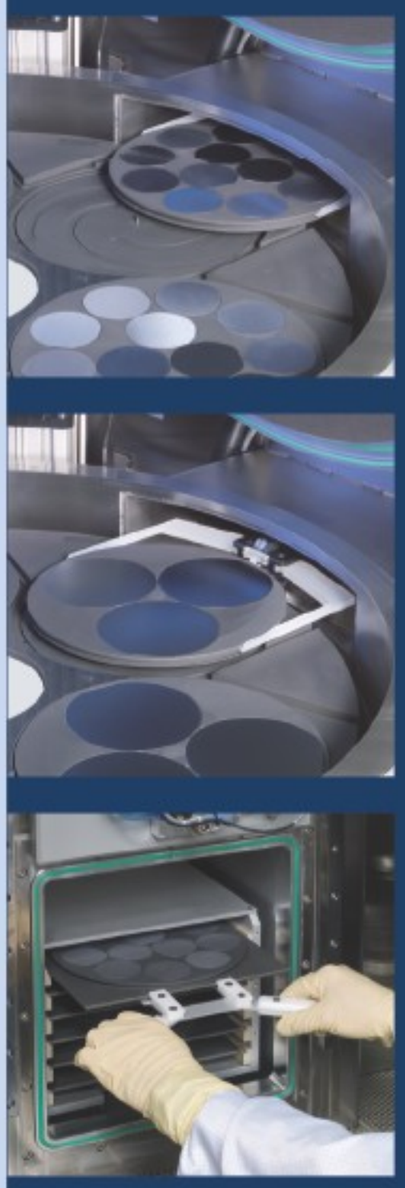

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news

# LED supply shortage looms in 2010

## Undersupply to hit large-screen LCD-TVs most

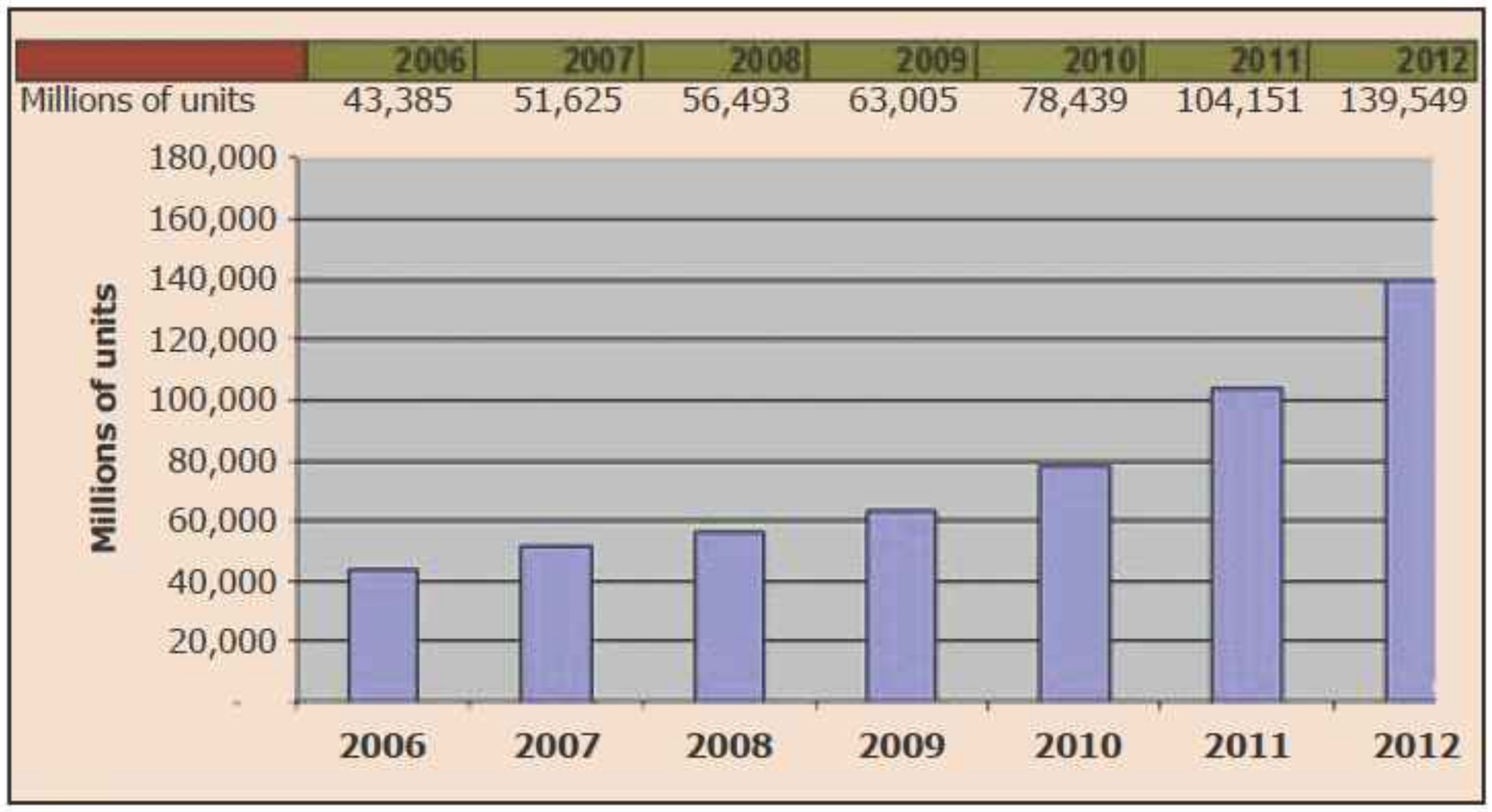
Due to heavy demand, global supply of LEDs is facing a shortage in 2010, and the year may end with an acute undersupply unless production capacity is increased, warns market research firm iSuppli Corp.

Total consumption of LEDs rose 10.5% from 57 billion units in 2008 to 63 billion in 2009. Overall LED consumption last year hence came dangerously close to the industry's total capacity of 75 billion units, indicating that many LED makers were operating at nearly 100% utilization.

"Demand is outstripping supply," says Jagdish Rebello, senior director and principal analyst for wireless research at iSuppli and author of the report 'Solid State Lighting: Backlighting of LCD-TVs and General Illumination Drive a Bright Market for LEDs'. "With LED market growth forecasted to rise by double-digit percentages for at least the next three years—including 2010—a drastic undersupply situation could occur this year unless additional capacity is brought online to meet the increased demand," he adds.

"The shortage predicted in 2010 applies to LEDs used for the backlighting of large-screen LCD-TVs," says Sweta Dash, senior director for LCD research at iSuppli and author of the report 'LCD market tracker, Large-LCD Market Bounces Back with Unit and Revenue Growth'. "The shortage is being spurred by strong consumer desire, given the growing popularity of LED-backlit LCD-TVs due to their super-slim form factors and improvements in picture quality. On the supply side, TV makers are striving to increase their sales of LED-backlit sets."

Unlike notebooks (which typically use 50 LEDs) or monitors (which use about 100 LEDs), LCD-TVs on average consume 300–500 LEDs per panel. Also, with LEDs used for backlighting of LCD-TVs demanding a high level of uniformity, any LED shortages in the industry will mainly impact TV panels.




**Global LED market forecast for 2006–2013.**

LEDs currently find widespread use as the backlighting units not only of large-sized LCDs used in TVs and computer screens but also of smaller LCDs in a broad range of devices, including notebooks, cell phones, portable navigation devices, digital photo frames, digital cameras and keypads.

Furthermore, LEDs are used increasingly in the general illumination market, addressing the needs of residential, commercial and industrial lighting applications. The general illumination market for LEDs is still in its infancy, but will become mainstream during the next two years, says iSuppli.

Applications for standard-brightness LEDs include indicator lamps and alphanumeric LED displays. In comparison, applications for high-brightness (HB) LEDs include large-screen LCDs used in flat-screen TVs, notebook laptops and computer monitors. Ultra-high-brightness (UHB) LEDs are used in next-generation lighting applications for the general illumination of residential dwellings and enterprise offices.

iSuppli says that participants in the LED supply chain are looking for solutions to counter the anticipated shortfall in supply, taking steps to significantly ramp up production capacity in areas ranging from raw materials, to wafers and die production, to packaging and testing of finished LED lamps. In particular, the two main suppliers of MOCVD deposition reactors — Germany's Aixtron and the USA's Veeco Instruments — are planning to double their production capacity by fourth-quarter 2010 compared to the end of 2009. However, the ramp-up of the overall supply chain will take time.

Among LED panel suppliers, the strategy to cope with the shortfall involves vertical integration and a greater move toward in-house sourcing. For example, Samsung Electronics has joined with affiliate Samsung Electro-Mechanics in a joint venture, while LG Display has aligned itself with LG Innotek. The two other major LED panel suppliers — Taiwan's CMO (Chi Mei Optoelectronics) and AUO (AU Optronics) — are also aggressively developing their own internal LED sourcing to ensure continued supply of LEDs.

**www.isuppli.com**

# Solar installations to grow at 23% annually to 2015, but revenue to lag at 14%

Reeling from a stormy 2009, the solar market will soon see lopsided supply and demand rush back into parity, according to Lux Research.

Strong demand growth in Asia and the USA will push the market to 9.3GW ($39bn in revenue) in 2010, while continued price reductions will open new markets and drive the solar market to 26.4GW ($77bn) in 2015. Meanwhile, China — to date a large manufacturer of solar modules and materials but not yet a large buyer of them — will become the world's largest market for solar in 2015. However, the report 'Solar's Shakeout: Europe Loses Leadership as China Rises' underscores that the renewed balance between supply and demand will arrive only after a wave of company failures and lower utilization rates.

The report analyzes competitiveness and other drivers for the six major technologies: crystalline silicon (x-Si), cadmium telluride (CdTe), thin-film silicon (TF-Si), copper indium gallium di-selenide (CIGS), high-concentrating photovoltaics (HCPV), and solar thermal — also known as concentrating solar power (CSP).

"Solar's short-term pain will enable it to exceed growth expectations over the very long term," says senior analyst Ted Sullivan, the report's lead author. "The volume of solar installations will grow at a 23% annual rate from 2010 to 2015, but revenue will grow by just 14%, as prices fall due to remaining over-capacity," he adds. "While current subsidies in China and elsewhere will help soak up some of that capacity, there will be widespread company failures throughout the value chain first."

The report updates earlier market size and demand forecasts, extends Lux's outlook through 2015, and adds three new geographies — Czech Republic, New Jersey, and Ontario — due to their high levels of subsidies and rapidly developing markets. It also compares Lux's demand model for each geography against the expectations of installers and project developers, and against projections for supply-side capacity and production.

Among the report's findings are:

- Capacity remains well above demand, signaling violent changes ahead. The supply and demand curves are expected to move abruptly together over the next few years due to company failures — either through firms folding outright, or becoming 'zombies' that still exist on paper but produce little or no product. Demand will also increase in producing regions such as China, prompted by government subsidies and other factors.
- Low-cost x-Si technologies dominate, but thin-film and CSP nibble at the margins. As financing begins to return to solar in 2010, crystalline silicon players will continue to use low price as a weapon against new technologies that don't share its 'bankability' or scale. Even so, new technologies such as CSP, CIGS and even HCPV will gain at the margins. The future of thin-film silicon remains more questionable.
- Solar adoption is a multi-decade story. While it won't meet outsized expectations in the near-term, solar will wildly beat them long-term — albeit often in unexpected ways. At its core, solar is an energy and construction industry, not a consumer-oriented one like semiconductors or IT. So, its adoption cycle is determined by replacement cycles for residential and commercial roofs (15–20 years) and natural gas power plants (up to 30 years).

"The continuing glut threatens low-quality and high-cost players alike," says Sullivan. "The decline of firms selling low-quality systems is intuitive, but over-capacity also threatens developed players like Evergreen Solar and Uni-Solar, which have incredibly innovative technologies but high operating costs and insufficient scale."

www.luxresearchinc.com

# PV chemicals and materials to grow 27% in 2010

The market for advanced chemicals and materials used in photovoltaic solar cells and modules will grow 27% to $3.1bn in 2010 and then to about $15bn by 2015, according to the third edition of the report 'Chemicals & Materials for Photovoltaic Cells and Modules 2010' from Linx-AEI Consulting, which focuses on the photovoltaics and electronics industries.

The driver of growth in the PV market will be global end-market demand for solar power, which is expected to grow from 5.8GW to 38GW by 2015.

The report includes long-term forecasts by cell type that combine Linx-AEI's perspectives on the levelized cost of energy (LCOE) as a function of module performance with geography-specific considerations such as local incentives and irradiance. The report hence includes perspectives into chemicals needs for individual cell and module types, including crystalline silicon, amorphous silicon, tandem-junction, cadmium telluride (CdTe) and copper indium (gallium) selenide (CI(G)S) cells and modules.

The report also examines the emergence and impact of critical technologies around texturization and cleaning, metallization, selective emitters, backsheets, frontsheets, and encapsulants.

www.linx-consulting.com

# WCDMA rises and GSM & CDMA fall as LTE emerges

WCDMA handset semiconductor revenue will see a compound annual growth rate (CAGR) of more than 10% between 2009 and 2014, exceeding $30bn by 2014. Overall handset semiconductor revenue will see a more moderate five-year CAGR of 2.1%, as semiconductor revenue for CDMA and GSM handsets declines throughout the forecast period, according to market research firm In-Stat in its report 'Worldwide Cellular Phone Components 5-Year Forecast' (priced at $3495).

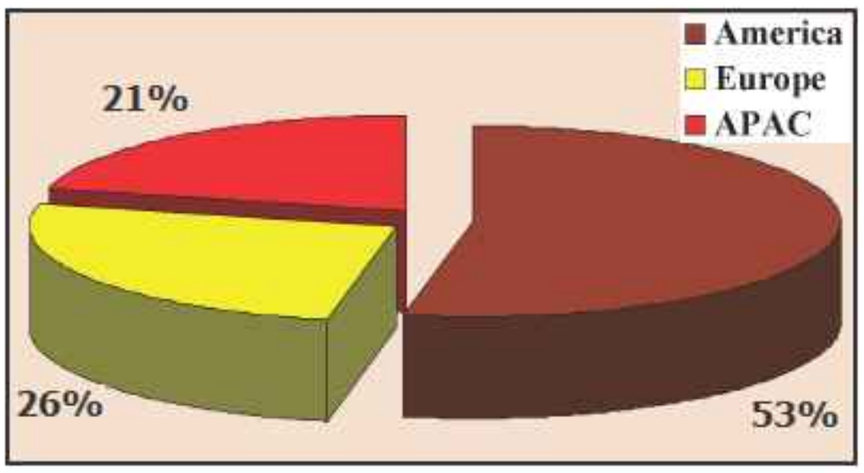
In particular, TD-SCDMA handset semiconductor revenue is accelerating in 2010, increasing more than five-fold compared with nascent 2009 levels, forecasts In-Stat. Meanwhile, long-term evolution (LTE) applications/multimedia processor revenue will exceed $400m by 2014.

On a regional basis, the Latin America region will see some of the most significant growth in WCDMA handset semiconductors, exceeding the Middle East & Africa (MEA) by 2011, and the North American and Eastern European regions by the year 2012.

www.instat.com

# Harsh-environment fiber-optic market $615m in 2009

Global market consumption of fiber-optic components (and supporting devices and parts) designed to operate in harsh environments beyond commercial telecom and datacom (premise) installations totaled $615m in 2009, according to a new market report from ElectroniCast Consultants.




**Harsh-environment fiber-optic component market share by region for 2009 ($615m).**

Of the $615m total, the American region led with 53% market share ($328m), Europe was second (26%) and Asia Pacific third (21%). "Over the 2009–2019 period, however, consumption of these components will expand faster in the European and the Asia Pacific regions," says ElectroniCast chairman & founder Jeff D. Montgomery (director of the study program).

"The environments encountered by the components included in this analysis and forecast often require custom-designed packaging, with much smaller quantities required, compared to packaging of components for conventional/commercial applications," says Montgomery. "The environmental extremes that must be accommodated are greater, there often is a need for minimizing size and weight, and shock and vibration environments are more extreme," he adds.

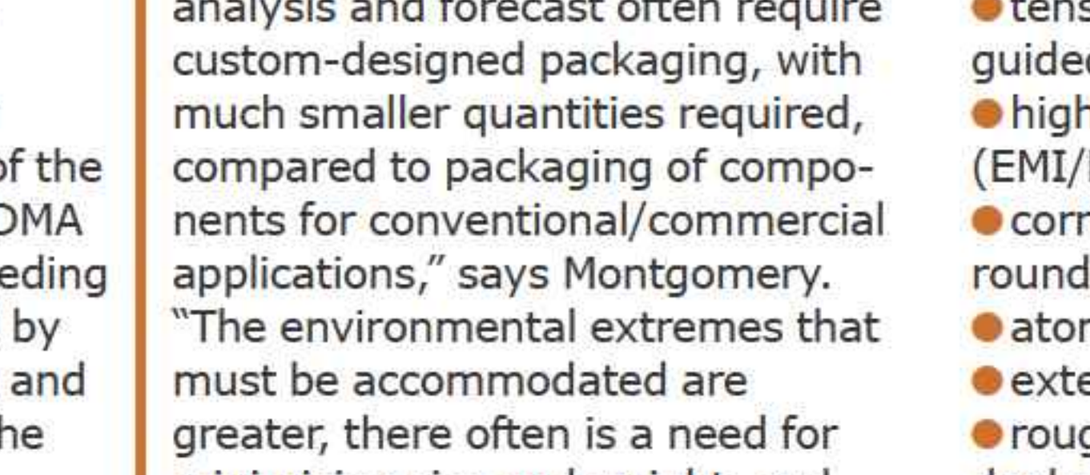
ElectroniCast defines a harsh environment (HE) as an environment beyond the limits normally encountered by commercial telecom, datacom and commercial intra-equipment fiber data links, i.e. involving extremes of:

- temperature (below –40°C or above +75°C);
- shock and vibration;
- tensile strength (e.g. for fiber-guided missiles, tethered sensors);
- high electromagnetic or RF (EMI/RFI/EMP) interference;
- corrosive and/or solvent surroundings;
- atomic and other radiation;
- external pressure extremes; and
- rough handling during installation/deployment.

www.electronicastconsultants.com

# LED lighting market to grow at 8.7% to $8.2bn in 2014

The global market for LEDs was an estimated $5.4bn in 2009, but is expected to grow at a five-year compound annual growth rate (CAGR) of 8.7% to $8.2bn in 2014, according to the report 'Light-Emitting Diodes For Lighting Applications' (SMC018C) from BCC Research.




**LED shipments by industry sector, 2008–2014 ($m).**

While mobile devices will remain the largest application, display backlighting (the second-largest market segment) is expected to grow at a CAGR of 11.1% from $933m in 2009 to nearly $1.6bn in 2014.

The automotive segment should grow at a CAGR of 11.5% from nearly $267m in 2009 to more than $1.3bn in 2014.

General illumination is expected to grow fastest, at 16.4% from nearly $565m in 2009 to $1.2bn in 2014.

Since a solid-state lighting initiative has been in place for 10 years targeted at replacing traditional lighting products such as bulbs, with LEDs, BCC Research provides a comprehensive analysis of the progress to date and its overall market potential.

www.bccresearch.com

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# RFIC makers RFMD, Skyworks and TriQuint raise March-quarter guidance

RF component makers Skyworks, RFMD and TriQuint have all raised March-quarter revenue guidance after seeing accelerating demand.

On 1 March, Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, raised its prior revenue guidance for fiscal second-quarter 2010 (to end March) from $225m (down 8% on last quarter but up 30% on $173m a year ago) to $230–235m (down just 4–6% on last quarter — much better than the seasonal norm of 10–15% — and up 33–36% year-on-year).

When the initial guidance was given (on 20 January, while reporting last quarter's results), the expected revenue growth was attributed to a high mix of less seasonal linear products business, as well as the continued rise in smart grid business. The latest increase in guidance is attributed to strong demand for mobile Internet, smart grid and new high-growth analog applications.

In addition, Skyworks has also raised its guidance for non-GAAP diluted earnings per share from $0.21 to $0.22–0.23 (up from $0.16 last quarter and $0.12 a year ago).

On 8 March, RF Micro Devices Inc of Greensboro, NC, USA raised its revenue guidance for fiscal fourth-quarter 2010 (ending 3 April) to $240–245m (the mid-point of this outlook is up 41% on a year ago). This is down 3% on its fiscal Q3/2010's $250.3m, but better than normal industry seasonality (fiscal Q4/2009 was down 14.7% on Q3/2009, and fiscal Q4/2008 was down 17.2% on Q3/2008).

As a result of the increase in revenue guidance, RFMD hence also expects non-GAAP earnings per share of $0.11–0.12, down slightly from $0.14 per diluted share last quarter but, again, an improvement on a year ago (a loss of $0.10 per diluted share).

RFMD says that it is experiencing broad-based strength in its core business, with current customer demand significantly outpacing original expectations in both the cellular products group (CPG) and multi-market products group (MPG).

The firm adds that it is seeing particular strength in China and Korea and expects continued market share gains across leading cellular baseband providers and handset manufacturers this calendar year.

At its annual Investor and Analyst Day in New York on 18 March, Ralph Quinsey, president & CEO of RF front-end product and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA, said that the firm now expects first-quarter 2010 revenue to be at the high end of its previous guidance of $170–175m (given on 24 February), i.e. up more than 47% year-on-year.

In addition, a tax credit of about $1m will be recorded, and non-GAAP earnings per share is now expected to rise from previous guidance of $0.08–0.10 to about $0.11.

**www.skyworksinc.com**
**www.triquint.com**
**www.rfmd.com**

## Skyworks launches 0–30dB fixed attenuator chips for up to 40GHz

Skyworks has launched the ATN3590 family of ultra-wideband fixed attenuator pads with a unique through-die via and split ground configuration that provide improved high-frequency return loss, attenuation tolerance, flatness, and power handling performance.

The fixed resistive attenuators are ICs comprising thin-film resistors and connection to ground by through-die vias to the die backside metallization (requiring no additional ground connections). The ATN3590 family is optimized for surface mounting on co-planar waveguide or microstrip printed circuit boards. Bond wires or ribbons are used to connect the input and output ports of the attenuators to the external circuit transmission lines. The dice are attached using eutectic solder or conductive epoxy and can operate over a range of –65°C to 150°C. The small 0.700mm x 0.725mm x 0.100mm die also has enhanced power handling capability of 2W of CW RF input power.

The ATN3590's unique die design also eliminates RF ground bonds, enabling improved return loss (from 0 to 30dB) and high attenuation flatness across multi-octave bandwidths (from low frequency to 40GHz or more). The devices are available with 15 relative attenuation values: 0–10dB (in 1dB steps) and 12, 15, 20 and 30dB.

All this make the devices suitable for broadband power-level adjustment applications in microwave and millimeter-wave radios, radars, EW/ECM equipment, and test & measurement equipment.

In addition, the attenuator die solutions assist microwave communications equipment OEMs and system designers with the manufacture of higher-performance hybrid micro-circuit assemblies for both military and commercial applications, the firm adds.

Individual chip samples and a full multi-chip designer kit are available now, with pricing dependent on quantities.

**www.skyworksinc.com**

# Kopin reports record Q4 revenue, up 13% year-on-year

Kopin Corp of Taunton, MA, USA has reported revenue of $114.7m for 2009 (flat on $114.8m in 2008 but exceeding April's guidance of $90–110m). This included $68.2m for CyberDisplay LCDs and $46.5m for III-V heterojunction bipolar transistor (HBT) epiwafers.

For fourth-quarter 2009, revenue was $33m, up 3% on $32m in Q3 and up 13% on $29.1m a year ago. This included CyberDisplay revenue of $18m (up on Q3's $17.7m but down slightly on $18.2m a year ago) and III-V revenue of $15m (up 5% on Q3's $14.3m and 37% on $10.9m a year ago, driven by accelerating consumer demand for smartphones).

"We capped a strong year with the best fourth quarter in our history," says president & CEO Dr John C.C. Fan. "After a difficult economic environment to start the year, III-V revenues ended 2009 with a flourish," he adds. "Our unique GaAs HBT technology is helping the world's leading integrated circuit manufacturers design power amplifiers with the enhanced performance and power efficiency required by today's multimedia mobile devices." Despite the challenging economic climate during much of the past year, business was strong across Kopin's entire III-V customer base in second-half 2009.

Although down on Q3's 32.6%, gross margin of 30.8% is up from 27.8% a year ago, reflecting higher sales of CyberDisplay products for military applications and an increase in III-V product volume. This contributed to full-year gross margin rising from 27.5% in 2008 to 29.7% in 2009.

Though down on Q3's $8.5m, net income was $5.3m, up from $1.8m a year ago. Full-year net income rose from $2.6m in 2008 to a record $19.4m in 2009.

"Record 2009 net income resulted from our strategy, which we implemented several years ago, of focusing on offering higher-margin products and migrating from selling components to more complete system solutions," says Fan.

"We generated $22m of cash from operating activities in 2009 while making significant investments in personnel, new product development and capacity for both products lines, and completing the acquisition of KTC (Kopin Taiwan Corp)," says Fan. So, despite capital expenditure of $3.7m and repurchasing $5.3m of stock under its buy-back program, cash and marketable securities rose during 2009 from $100m to $114.5m.

"Our 2009 results are a testament to our basic philosophy of aggressively investing in technology while being fiscally conservative," asserts Fan. Kopin has no long-term debt.

**Results are a testament to our basic philosophy of aggressively investing in technology while being fiscally conservative**

"Anchored by a strong balance sheet, manufacturing know-how and technology expertise, we are well positioned to generate sustained growth," Fan believes. "While other companies have struggled during the economic downturn, we have capitalized on the opportunity by expanding our technology and product portfolios," he claims. "We have continued to enhance our manufacturing capabilities and capacity, add new management and scientific talents, patent new technologies and develop the advanced new display systems and III-V structures that we believe will become growth engines for the company in the coming years."

Based on the current business environment, for full-year 2010 Kopin expects revenue to rise to $120–130m.

www.kopin.com

IN BRIEF

## New director of Business & Product Development

Kopin has appointed Dr Wayne Johnson as director of New Business and Product Development for the firm's III-V product line.

Kopin says Johnson provides extra resources to take advantage of opportunities arising from the surging demand and enhanced performance requirements for 3G and 4G wireless devices such as smartphones and MIDs (Mobile Internet Devices).

"Johnson brings a wonderful complement of experience and background in III-V materials, processing and devices to our existing technology staff," says Daily Hill, senior VP & general manager of the III-V Group. "With our extensive development over the past two years to stay ahead of the market's enhanced performance requirements, we have added HEMT and BiHEMT to our production portfolio," he adds. Johnson has spent the past eight years developing new products for the III-V industry.

Most recently, Johnson was with Nitronex Corp, responsible for new product development of GaN HEMT and MMIC devices for military and commercial wireless applications. Previously, he spent time developing GaN HEMT processing techniques at Sandia National Laboratories and optimizing MOCVD growth of thin-film optical interference filters at Deposition Sciences Inc. Johnson's work has led to several novel III-V device demonstrations, including GaN-based MOSFETs, HEMTs, diodes, and sensors for applications including wireless communications, power management, and biological detection, says Kopin. He has co-authored more than 100 technical publications in the field of III-V semiconductors and holds six US patents.

# Skyworks launches GaAs and SOI antenna switch modules for 2/3/4G wireless broadband and mobile handsets

At the 2010 Mobile World Congress in Barcelona, Spain (15–18 February), Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, launched a family of antenna switch modules (ASMs) for 2/3/4G handset and data-card platforms that use both gallium arsenide (GaAs) pHEMT and silicon on insulator (SOI) technologies to address the three primary switching functions: main antenna, diversity, and band/mode.

Skyworks says that the compact solutions deliver technology for both high-performance and low-cost architectures (depending on the interface requirements), and that delivering RF switches based on both GaAs and SOI technologies augments the firm's broad portfolio of switches currently used in its front-end modules. The new family of switches comprises:

● The SKY13362 is a single-pole ten-throw (SP10T) ASM with an integrated complementary metal oxide semiconductor (CMOS) decoder and dual low-pass harmonic filters. The small 3.0mm x 3.8mm switch has five 3/4G transmit-receive (TRx) ports, three receive (Rx) ports, and two global system for mobile communications (GSM) transmit signal low-pass harmonic filters, enabling flexibility for multiple combinations of 2/3/4G multimode cellular applications. Using advanced switch technologies, the ASM maintains low insertion loss and high isolation on both transmit, transmit–receive and receive switching paths. Also, the switch was designed to meet or exceed system requirements for 2nd and 3rd harmonics into an antenna mismatch up to 5:1, while delivering linearity (excellent triple beat ratio), and second- and third-order (IP2, IP3) intermodulation distortion performance to provide manufacturers with sufficient margin in the certification process.

● The SKY14152 is a low-cost, single-pole eight-throw (SP8T) ASM for use in multimode embedded data cards. The compact 3.2mm x 3.2mm device is designed for universal mobile telecommunications system (UMTS), code division multiple access (CDMA2000), enhanced data for GSM evolution (EDGE), and GSM applications and supports flexibility with up to five 3/4G TRx bands. The device consists of an SP8T switch, GSM transmit signal low-pass harmonic filters, and a RX SAW filter.

● The SKY14153 is a low-cost, single-pole four-throw (SP4T) switch designed for wideband code division multiple access (WCDMA) and diversity switching applications that demand high linearity and low insertion loss. The compact 2.0mm x 2.0mm switch is optimized for third-generation partnership project (3GPP) 3/4G bands at 0.70–2.7GHz.

**RF switches based on both GaAs and SOI technologies augments the firm's broad portfolio**

● The SKY14155 is a low-cost, double-pole four-throw (DP4T) switch designed for broadband, 3/4G band switching applications which demand low insertion loss, high isolation, and high linearity. The compact 2.0mm x 2.0mm switch is manufactured using an SOI process, and is optimized for 3G WCDMA mode/band switching applications.

● The SKY18106 is a SP8T ASM designed for multimode, high-power switching applications that demand low harmonics and insertion loss. The 3.2mm x 4mm switch is optimized for both 2G GSM/EDGE and 3G WCDMA applications and supports up to six 3/4G TRx ports with very low insertion loss, high isolation and excellent linearity under antenna mismatch conditions.

The new switch, ASM and FEM devices rely on GaAs pHEMT, SOI, integrated passive device (IPD), and wafer-level chip-scale package (WL-CSP) SAW technologies. No external blocking capacitors are required on any of the RF ports, minimizing the bill of materials and occupied board space, says Skyworks.

Skyworks says that samples of the SKY14152, SKY14153, SKY14155 and SKY18106 are available now. The SKY13362 will sample in second-quarter 2010.

www.skyworksinc.com

**New antenna switch modules for 2/3/4G handset and datacard platforms**

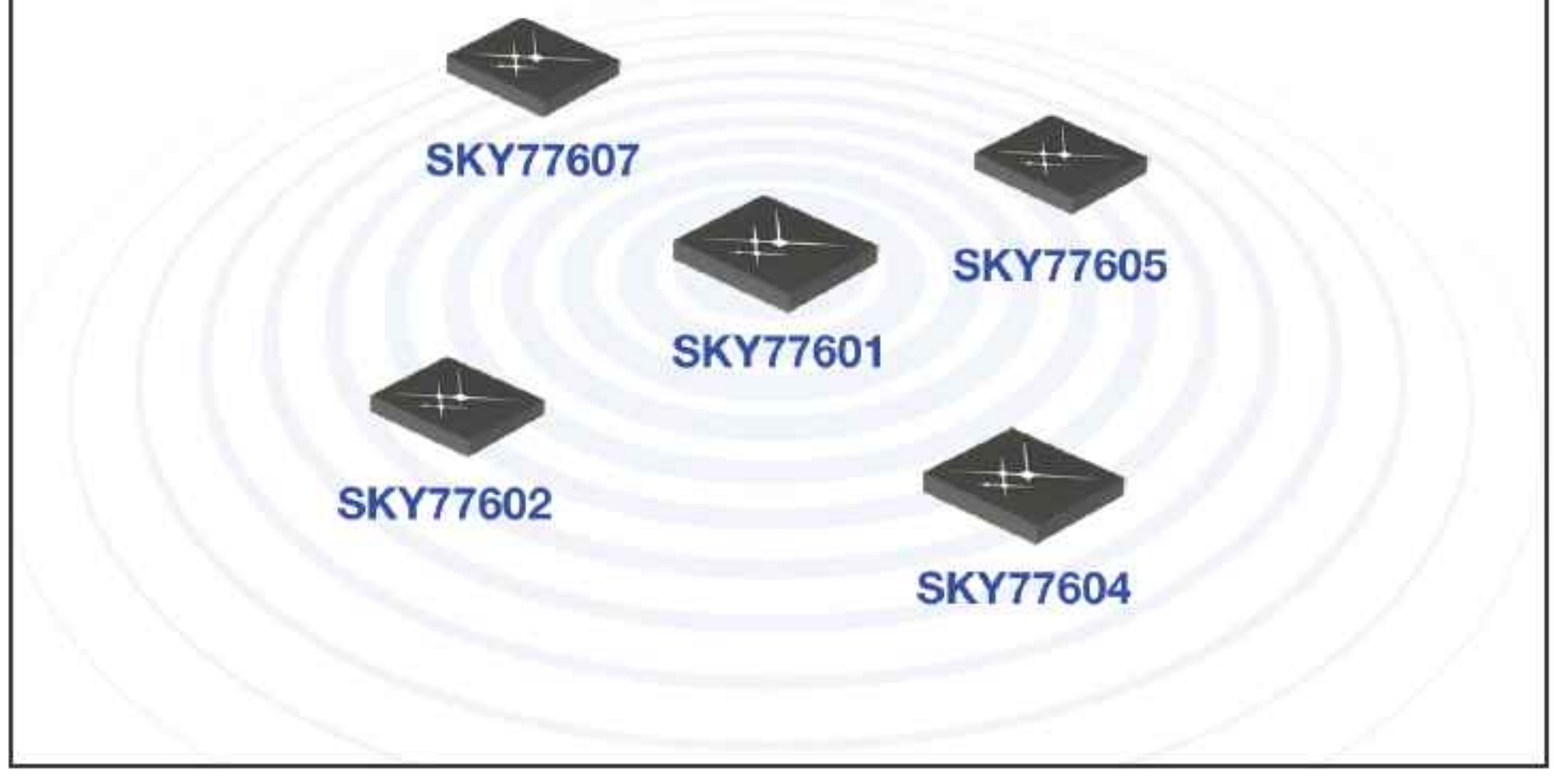
# Multimode WCDMA power amplifier modules unveiled for smart phone and data card applications

At the 2010 Mobile World Congress in Barcelona, Spain, Skyworks Solutions Inc of Woburn, MA, USA introduced several highly integrated multimode power amplifier modules (PAMs) for next-generation smart phones and data cards requiring multiple wideband code division multiple access (WCDMA) bands. The solutions support up to five WCDMA bands and are optimized for specific mobile data requirements.

"Skyworks' new multimode and multiband power amplifier modules meet the need for increased frequency bands while reducing board space," says Gregory L. Waters, Skyworks' executive VP & general manager of front-end solutions.

Skyworks' SKY77601, SKY77604, SKY77605 and SKY77607 are multimode and multiband (MMMB) PAMs for next-generation high-speed packet access (HSPA) 3G phones and data modules. They operate in quad-band general packet radio service (GPRS) and enhanced data for GSM evolution (EDGE), and support bands 1, 2, 5 and 8 for WCDMA and high-speed uplink packet access (HSUPA) modulation.

**Skyworks' new multimode and multiband WCDMA power amplifier modules for next-generation smart phones and data cards**




The firm says that the SKY77601 and SKY77604 have been designed for significantly improved performance under mismatch conditions and have reduced current consumption over the entire power range to maximize handset talk and stand-by times. In addition, to simplify integration on the phone board, they use a serial peripheral interface (SPI) to communicate with the RF transceiver and antenna switch module (ASM).

The SKY77602 PAM is designed for integrated data modules that support up to five WCDMA bands (1, 2, 4, 5 and 8). The new PAM integrates the functionality of five discrete PAs into a single package, leading to significant bill-of-material (BOM) and phone-board size reductions. The device is the first in a family of products to be released throughout 2010 that are optimized for specific mobile data requirements such as fixed supply voltage, reduced output power, and big improvements to heat dissipation.

## Skyworks' power amplifiers and front-end modules now supporting ST-Ericsson's M710 long-term evolution platform

Skyworks says that its portfolio of long-term evolution (LTE) power amplifier (PAs) and front-end modules (FEMs) now supports the M710 solution of ST-Ericsson.

ST-Ericsson's technology enables devices for consumers requiring access to high-speed mobile broadband and global coverage, said Dr Gene A. Tkachenko, Skyworks' senior director of engineering. "We are enabling next-generation platforms across a wide range of frequencies and applications worldwide."

LTE is emerging as the 4G standard of choice worldwide for mobile broadband systems. 4G systems are expected to significantly boost network throughput, improve spectral efficiency and performance, reduce latency, simplify roaming and further drive economies of scale.

According to the Global Mobile Suppliers Association, LTE network commitments increased 100% in the last eight months, with 51 networks in 24 countries worldwide currently committed to LTE. All major handset OEMs, infrastructure suppliers, and operators worldwide are now committed to the technology, with multiple trials underway.

Skyworks' family of LTE products, which includes four FEMs in addition to two PA modules, provide a flexible set of options for manufacturers developing and building 4G-enabled handsets, basestations, wireless PC cards, and a host of other embedded solutions, says the firm. The portfolio includes the industry's first LTE front-end modules for bands I, IV, VII and VIII (the SKY77445, SKY77455, SKY77456 and SKY77458) for worldwide applications, and the industry's first PA modules supporting LTE-FDD for North America (the SKY77449 and SKY77453).

IN BRIEF

## Digi-Key stocking Skyworks' diodes

Electronic component distributor Digi-Key Corp of Thief River Falls, MN, USA is now stocking PIN, Schottky, and varactor diodes from Skyworks, available via its global websites. This follows Skyworks entering into a global distributor agreement with Digi-Key last June.

Regarding PIN diodes, Skyworks' SMP1302 series is designed for high-power, high-volume switch and attenuator applications from 10MHz to beyond 6GHz (encased in a surface-mountable plastic QFN package, capacitance is just 0.3pF). The SMP1345, available in a 0402 package, is designed for low-noise block (LNB), WLAN, and switch applications from 10MHz to 6GHz. The SMP1321 and SMP1340 series have very low capacitance and series resistance for fast-switching, high-isolation applications. The Pi configuration SMP1307-027LF is suited to CATV and infrastructure low-distortion attenuator applications.

The Schottky diodes are low-cost, surface-mountable, plastic-packaged, and designed for RF and microwave mixers and detectors. The devices may be used at frequencies up to 10GHz and are available in SC-70, SC-79, SOD-323, SOT-23, and LGA packages. Wiring configurations include singles, common cathode, series pairs, unconnected pairs, and dual series pairs.

The varactor diodes are designed for use in voltage controlled oscillators (VCOs) with a low tuning voltage operation. The family includes the SMV1234, SMV1247, SMV1249 and SMV1255 series of silicon hyper-abrupt junction diodes. The SMV1413 series is suited to use in VCOs that call for tight capacitance tolerances.

**www.digikey.com**
**www.skyworksinc.com**

# PAs for 4G LTE and 3G HSPA+

Broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has launched a new set of multi-mode, high-performance power amplifiers (PAs) designed for wireless datacards and handsets for the rapidly emerging technologies of 4G long-term evolution (LTE) and 3G advanced HSPA+ (the next evolution of high-speed packet access). The new single-band PAs are built using the fourth generation of Anadigics' patented HELP (High-Efficiency-at-Low-Power) technology to deliver what is claimed to be exceptional performance for USB modules and new-generation handsets based on the LTE standard.

Analyst firm Gartner states that LTE is on track to become one of the dominant 4G technologies for mobile broadband within this decade as the industry expands beyond WCDMA. By 2015, LTE coverage is expected to reach at least 50% of all mobile subscribers in the USA and Western Europe. The HELP4 LTE family of PAs has hence been designed to meet the stringent linearity needs of LTE modulation and offer what is claimed to be the highest power and efficiency in the industry.

"With the HELP4 family, we have reduced the average current consumption by an impressive 30% over previous-generation PAs," says Prasanth Perugupalli, director of Wireless RF Products Line at Anadigics. "We also continue to lead the industry in terms of performance in current savings at the frequently used low power levels in handsets," he adds, claiming the industry's lowest quiescent current (at 3mA), while three mode states maximize power-added efficiency at several power levels during operation of an LTE handset.

The new HELP4 LTE power amplifier family includes the ALT6701, ALT6702, ALT6704, ALT6712 and ALT6713 products (each in 10-pin 3mm x 3mm x1mm packages),


**Anadigics' new ALT6713 long-term evolution (LTE) power amplifier.**

which are tailored to cover UMTS and LTE bands 1, 2, 4, 12 and 13 that are available across various geographic locations (including the USA, Japan, Western Europe and China), as follows:

- ALT6701 — band 1 LTE wireless devices, band 1 (IMT) WCDMA/HSPA wireless devices, and band Class 6 CDMA/EVDO wireless devices;
- ALT6702 — band 2 LTE wireless devices, band 2 (PCS) WCDMA/HSPA wireless devices, and band Class 1 CDMA/EVDO wireless devices;
- ALT6704 — band 4 LTE wireless devices, band 4 (IMT) WCDMA/HSPA wireless devices, and AWS/KPCS CDMA/EVDO wireless devices;
- ALT6712 — band 12 and 17 LTE wireless devices;
- ALT6713 — band 13 and 14 LTE wireless devices.

Each device has been characterized under 16-QPSK, 64-QAM and HSPA+ modulations to ensure compatibility with high-bandwidth applications. Also, an integrated 'daisy chainable' directional coupler with 20dB directivity is included inside the package.

The devices are available for sampling, and evaluation kits are available upon request. Anadigics adds that volume ramp into production is aligned with market needs to meet customer design cycles for introduction of the industry's earliest datacard modules for LTE networks.

**www.anadigics.com**

# First high-efficiency PA to cover 3.3–3.8GHz WiMAX band

Responding to growing global demand for mobile WiMAX services, Anadigics Inc of Warren, NJ, USA, which provides radio frequency integrated circuit (RFICs) for the broadband wireless and wireline communications markets, has made available samples of a new, feature-rich power amplifier (PA), which is designed to boost the performance and efficiency of WiMAX transceivers (supporting mobile WiMAX systems using the IEEE 802.16e standard).

The firm claims that the AWT6283R (which uses InGaP HBT MMIC technology and is optimized for operation over a 500MHz bandwidth) is the first PA to deliver high linear output power (+25dBm) and high power-efficiency (21%) as well as consistent RF performance over the full 3.3–3.8GHz WiMAX frequency band. Low quiescent current increases transmit time and overall efficiency, while low leakage current in shutdown mode increases standby time and battery life.

Anadigics also claims that the AWT6283R is the first 3.5GHz device to incorporate an impedance match


**Anadigics' new AWT6283R WiMAX PA.**

on both the input and output RF ports, a built-in reference voltage regulator (eliminating the need for an external precision reference voltage), a power detector and a step attenuator (allowing use with any OEM's chipset). Its small, low-profile (4mm x 4mm x 1mm) surface-mount package is aimed to simplify design and save board space, suiting space-constrained mobile applications.

Anadigics says that the WiMAX market is continuing to gain momentum, with mobile devices all but displacing fixed-point equipment in new deployments. Commercial WiMAX networks, trial networks, and networks in development are increasing monthly. The WiMAX Forum currently tracks 523 WiMAX deployments in 147 countries, compared with 408 deployments at the end of 2008. According to market research firm In-Stat, new devices drive the market, with USB dongles and mobile PCs embedding WiMAX capability available now, and WiMAX-enabled cellular handsets available soon. Analysts expect steady growth in WiMAX handset sales over the next five years, particularly in emerging markets such as South America, Russia, Eastern Europe, the Middle East and parts of Asia where the majority of deployments are already taking place.

"We're expanding our product portfolio in the fast-growing WiMAX space to deliver the most efficient, high-performance components that ultimately improve the end-user experience," claims Joe Cozzarelli, director of Anadigics' Broadband RF product line. "The AWT6283R complements our existing line of WiMAX devices and offers the linearity, reliability, temperature stability and ruggedness that our customers demand."

## Anadigics launches smallest dual-band CDMA power amplifier

Anadigics has launched the new AWC6323 dual-band CDMA power amplifier (PA), designed for handsets and data cards.

Exhibited at the 2010 Mobile World Congress in Barcelona, Spain (15–18 February), the AWC6323 is the flagship power amplifier in the firm's family of High-Efficiency-at-Low-Power (HELP) CDMA PAs (using InGaP BiFET MMIC technology).

Anadigics claims that, for the first time, high-performance directional couplers have been integrated into a dual-band CDMA PA in the 3mm x 5mm x 1mm footprint, and that the AWC6323 also offers the lowest quiescent current for a CDMA PA (helping to extend the battery life).

Features include:

- Three mode states to achieve high power added efficiencies at several power levels during the phone operation.
- An industry-best idle current for a CDMA power amplifier of 3.5mA (increasing handset talk-time performance without the need for a DC–DC converter).
- A common output port for the directional couplers built inside the package, offering 20dB directivity and 22dB coupling factor (as well as helping to eliminate surface-mount couplers on the phone board).
- Conforms to linearity requirements of CDMA EV-DO Revisions A and B modulations, to offer very high data rates for smart phones and data cards.

"Customers are particularly enthusiastic about the high levels of integration in a very small package," says Prasanth Perugupalli, director of Anadigics' Wireless RF product line. "The innovations inherent to the AWC6323 help simplify design, reduce component count and save on board space. These attributes directly address the needs of today's advanced handsets and data cards," he adds. "Anadigics is also offering extensive support for our customers through a front-end reference design kit, utilizing the most commonly used filters and prescribed matching networks."

The AWC6323 is now ramping into volume production.

**www.anadigics.com**

# TriQuint expands RF portfolio for end-to-end connectivity in mobile devices and networks for voice, data and video

RF front-end device maker TriQuint Semiconductor Inc of Hillsboro, OR, USA has outlined its portfolio expansion strategy to deliver a broad range of high-performance products enabling end-to-end connectivity.

With RF innovation never having been more critical (as service providers race to expand network capacity to handle explosive demand from not only mobile phones but also new genres of mobile devices), the firm exhibited a range of its latest RF solution for OEM customers at February's GSMA Mobile World Congress in Barcelona, Spain.

"Insatiable demand for always-on connectivity is impacting the entire wired and wireless ecosystem," said president & CEO Ralph Quinsey at the recent Needham Growth Conference while outlining TriQuint's opportunities for 2010. "Today's handsets are very sophisticated and include voice, data, video, location services and wireless connectivity options. To support these feature-rich mobile devices, network operators are expanding capacity, re-architecting infrastructure design, increasing 3G base-station deployments, accelerating 4G planning and upgrading the backhaul transport," he adds. "TriQuint has developed a broad product portfolio that services these growing markets."

Shipments of mobile devices (including cellular handsets, mobile Internet devices, netbooks, mobile consumer electronics products, and cellular modems) will nearly double to a total of 2.25bn before 2015, forecasted ABI Research in December. TriQuint reckons that this represents an enormous opportunity for it to expand its total addressable markets by providing its broad RF solutions portfolio for mobile devices and networks.

"Device OEMs are tasked with providing rich solutions with long-lasting battery and strong, clear connections," says Quinsey. "Network operators are expected to deliver large amounts of data quickly and error free. 'Green'-conscious regulators, consumers and providers are looking for efficient systems to mitigate the impact on our environment," he adds. "Innovative technology solutions are required to meet these industry-wide challenges and reduce the footprint of our modern communications systems."

In early February TriQuint launched the TriPower high-efficiency solution for 3G/4G base-station power, as well as the TRITON PA module family (its latest solution for 3G WEDGE mobile phones), and a new HADRON II PA module. TriQuint has also recently exceeded shipments of more than 100 million units of its CuFlip technology and WiFi technology for smartphones. TriQuint says that these represent a small portion of its overall portfolio of end-to-end communications solutions, and augment the recent expansion of its optical, cable and radio broadband solutions. The latter include:

**Network operators are expected to deliver large amounts of data quickly and error free, says CEO Ralph Quinsey. 'Green'-conscious regulators, consumers and providers are looking for efficient systems to mitigate the impact on our environment**

- Optical amplifiers: With networks at the breaking point, carriers are upgrading from 10Gb/s to 40 and 100Gb/s. TriQuint is developing higher-speed and wider-bandwidth network solutions with lower power consumption for operators worldwide. The TGA4943-SL 40Gb/s SMT driver meets the growing appetite for 'greener', high-efficiency data transport systems.
- Triple-play cable solutions: To meet consumer demand for bandwidth to the home, operators are upgrading equipment to provide fiber-to-the-home (FTTH) and DOCSIS 3.0 for cable TV systems. Bolstered by its recent acquisition of TriAccess Technologies, TriQuint says that its cable and FTTH portfolio offers telecom triple-play providers the solutions needed to competitively optimize their network speed, spectrum management and deep fiber approach.
- The TriPower family of power devices for 3G/4G wireless base-stations helps network operators address the explosive demand for higher data rates by enabling high-linearity and high-efficiency power amplifiers.
- Point-to-point radio: With high-capacity backhaul networks demanding linear power, the TGA2706-SM is a new 5.5–9GHz PA that supports the increasingly complex modulation schemes typically required by next-generation backhaul radios.
- Mobile devices: Consumers are now buying both converged multi-purpose devices as well as best-in-class single-purpose mobile devices, increasing the total available market. TriQuint says that device makers are leveraging its RF solutions across a range of standards including GSM/EDGE, CDMA, WCDMA, GPS, WLAN/Bluetooth and LTE to provide connectivity to mobile phones and e-readers, gaming and other personal media devices. The new HADRON PA module and TRITON PA module family offer a full 3G WEDGE radio solution for leading chipsets, says TriQuint.

www.triquint.com

# TriQuint unveils WEDGE product portfolio optimized for Qualcomm's 3G chipsets

TriQuint Semiconductor Inc of Hillsboro, OR, USA has unveiled a new RF front-end solution optimized to support recently released Qualcomm 3G chipsets. The new WEDGE product portfolio combines TriQuint's highly optimized WCDMA and GSM/EDGE products, and includes the TRITON power amplifier (PA) module family for WCDMA and the TQM7M5013, a HADRON II PA module for GSM/EDGE. Highly efficient and optimized for improved current consumption, the firm claims the industry's smallest footprint using discrete components, suiting use in mobile devices (including data cards, netbooks, e-readers and next-generation smartphones).

The TRITON family of 3mm x 3mm discrete PA modules covers all major 3GPP WCDMA bands and is capable of multi-mode operation. The firm says it designed the TRITON family for performance, size and efficiency by leveraging a combination of its proprietary Copper Flip (CuFlip) and TQBiHEMT technologies. CuFlip enables superior RF performance and design flexibility while speeding manufacturing and assembly, while


**The TQM7M5013.**

TQBiHEMT enables the integration of two GaAs processes onto a single die, reducing part count and saving board space. Together, they enable an integrated feature set using a single die inside the module — TriQuint claims that all other solutions on the market require multiple die and/or complex assembly processes.

Builds on the success of the previous-generation HADRON (the TQM7M5012, which TriQuint reckons has more than 50% of the current global market share for EDGE-Polar PAs), the TQM7M5013 is a 5mm x 5mm quad-band HADRON II PA module that provides the GSM/EDGE portion of the WEDGE solution when paired with TRITON modules. As well as having an architecture that enables improved efficiency (resulting in longer talk time), TriQuint says that the TQM7M5013 provides the building blocks for future converged/multi-mode amplifiers. Aligned with a recently released 3G Qualcomm chipset, the TQM7M5013 is highly versatile and is designed into more than a dozen platforms that are expected to launch in 2010.

"The market for discrete WCDMA amplifiers, driven by the increasing number of frequency bands per wireless device, represents a significant opportunity for market share expansion," says Tim Dunn, VP of mobile devices. "TriQuint has worked hard to optimize our technology to offer a highly competitive, complete RF front-end solution for all of the industry's leading 3G chipset providers," he adds. "Lead customers are pleased with the performance of the products and the integration roadmap." TriQuint anticipates strong market adoption for the products, ramping in second-half 2010.

According to Qualcomm's 'Quarterly Regional CDMA Based Device Shipment Estimates', WCDMA experienced 17% growth from 2008–2009 (making it the fastest-growing communications standard), and is expected to grow 28% from 2009 to 2010 (based on midpoint 2010 guidance).

**www.triquint.com**

# TriQuint plans to move Boulder design center to Texas

According to the Boulder County Business Report website, RF front-end device maker TriQuint Semiconductor Inc of Hillsboro, OR, USA plans to move its design center in Boulder, Colorado to Richardson, Texas. However, the firm is said to be offering home-working positions or paid transfers to its 20 or so staff in Boulder. The timing of the office move coincides with the Boulder office lease expiring.

In late 2007, TriQuint spent $15m to acquire Boulder-based Peak Devices Inc, which focused on RF technology for markets

**TriQuint's facility in Richardson, Texas.**

including two-way communications, FM and TV broadcast, telecommunications, avionics, radar and military. By comparison, TriQuint supplies high-performance RF modules and components to communications companies in the mobile devices, 3G and 4G cellular base-station, WLAN, WiMAX, GPS, and defense and aerospace industries.

Director of corporate communications Brandi Frye said that, for efficiency reasons, TriQuint decided to consolidate its design team into the Richardson office, where it employs about 100 staff and will be adding more. No other office consolidations are planned, she adds.

**www.bcbr.com/article.asp?id=104092**

# TriQuint's new TriPower GaAs HV-HBT RF transistors offer 55% efficiency for 3G/4G base-station amplifiers

RF product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has released the first products in its new, high-efficiency 'green' TriPower family of high-power 3G/4G wireless base-station RFICs. The firm says that TriPower devices allow network operators to address the top two challenges of rapidly growing consumer demand for bandwidth-hungry smartphones and similar products: reducing the electricity needed to power network base-station amplifiers, while allowing operators to more easily increase network capacity and speed.

The name 'TriPower' is derived from three primary benefits: high power, high efficiency and high linearity. A more efficient amplifier translates into savings, says TriQuint. For example, for a system with 2000 such amplifiers (as might be used to cover one medium-sized city and surrounding area), a TriPower-based network could cut $CO_2$ emissions by about 340 tons each year compared with the efficiency of amplifiers typically deployed currently, reckons the firm (equivalent of adding more than 130 acres of trees to the ecosystem, since each acre of trees absorbs about 2.6 tons of $CO_2$ annually according to the US Forestry Service).

"The complex modulation requirements of 3G and 4G networks cannot be delivered efficiently by legacy semiconductor technologies," says TriQuint Networks VP, Brian P. Balut. "TriQuint examined the potential for both types of devices [gallium arsenide (GaAs) and gallium nitride (GaN)] in high-power base-station applications. We believe that — for reasons of reliability, cost and efficiency — TriPower's GaAs HV-HBT [high-voltage heterojunction bipolar transistor] technology is the best choice," he adds.


**TriPower GaAs HV-HBT RF transistors offer the highest collector efficiency (55%) for 3G/4G base stations. TriPower can boost much-needed high speed data capacity without additional size or weight for equipment in base-station remote radio heads.**

TriQuint employs a proprietary GaAs HV-HBT process, design and manufacturing techniques to achieve TriPower's efficiency performance. TriPower RFICs can also be easily linearized using conventional digital pre-distortion (DPD) techniques, Balut explains. TriPower products offer wireless base-station makers and network operators a much-desired efficiency improvement while meeting the linearity requirements of 3G/4G cellular systems. "TriPower devices provide the greatest reduction in power consumption available on the market today and can enable new, highly efficient, tower-mounted remote radio head designs," he claims.

**The devices deliver what is claimed to be a record 55% efficiency for reduced electricity demand and smaller carbon footprints, compared with average efficiency approaching 42% in existing systems**

Researchers at the University of California at San Diego (UCSD) have compared key base-station amplifier technologies including silicon LDMOS, GaN and TriPower GaAs HV-HBT technology. Lead researcher, professor Donald Kimball, concluded in the paper 'High Efficiency WCDMA Envelope Tracking Base Station Amplifier Implemented with GaAs HVHBTs' (published in November 2008) that TriPower devices offer a clear efficiency advantage. The devices deliver what is claimed to be a record 55% efficiency for reduced electricity demand and smaller carbon footprints, compared with average efficiency approaching 42% in existing systems.

"There has been a vigorous competition between different transistor technologies for the highest efficiency in base-station amplifiers," says Kimball. "HV-HBT is the greenest device for base-station

radios," Kimball comments. "It will make a significant difference for power reduction in future systems, including ones in remote areas with limited prime power availability."

When used in a symmetric Doherty amplifier application for maximum efficiency boost, two TriQuint TG2H214120 120W devices can deliver over 60W of average WCDMA power with 55% efficiency. Due to TriPower's very high efficiency, operators can place larger amplifiers onto existing cell site towers without a corresponding increase in size or weight, TriQuint reckons. Higher-power amplifiers, in turn, deliver higher data rates to all users in the cell.

"Any technology that can increase overall efficiency of the RF power amplifier, such as TriPower from TriQuint, will allow the industry to meet the more stringent energy requirements for high PAR (peak-to-average ratio) amplifiers going forward," believes Earl J. Lum, president of EJL Wireless Research LLC. "Through 2013, higher-PAR multi-mode 3G WCDMA/HSPA and 4G LTE base stations will rapidly replace legacy 2G GSM for BTS (base transceiver station) shipments and will increase in market share from 25% to over 50% of the market," he forecasts. "On a unit basis, shipments of high-PAR amplifiers for base stations will dramatically increase 85% on an annual basis from 2008 through 2013."


**High-efficiency TriPower RFICs.**

**Through 2013, higher-PAR multi-mode 3G WCDMA/HSPA and 4G LTE base stations will rapidly replace legacy 2G GSM for base transceiver station shipments**

TriQuint's TriPower device family was exhibited at the GSMA Mobile World Congress in Barcelona, Spain (15–18 February). The latest TriPower products are being designed into new generations of 3G/4G base stations, says the firm. TriQuint's two new high-efficiency TriPower devices, [TG2H214120 (120W) and TG2H214220 (220W)] are the first in a series of products that will include more frequency bands and power levels in 2010 and beyond. The new devices aim to expand the 'green' impact of TriPower technology globally to different cellular systems.

**www.triquint.com/tripower**
**http://mwc2010.triquint.com**

# TriQuint and Nujira create record-efficiency 2.1GHz base-station power amplifiers

TriQuint Semiconductor's new TriPower GaAs-based power amplifier (PA) has been integrated with Coolteq.h envelope tracking power modulator technology from Nujira Ltd of Cambridge, UK to create the what is claimed to be world's most efficient 2.1GHz PA for cellular base stations. The design was demonstrated at the GSMA Mobile World Congress in Barcelona, Spain (15–18 February).

The design achieves more than 55% efficiency at 2.1GHz (a band widely licensed for cellular networks globally, and one of the most popular bands for LTE and W-CDMA transmissions). The two firms aim to develop further reference designs as TriQuint extends its TriPower family.

"We are committed to working in partnership with the world's leading PA vendors to reduce the carbon footprint and operating cost of the next generation of cellular base stations," says Nujira's CEO Tim Haynes. "The new generation of Triquint PAs is their most energy efficient ever, and by integrating it with a Nujira Coolteq.h module we have set a new benchmark for transmission energy efficiency at 2.1GHz," he claims.

**The new generation of Triquint PAs is their most energy efficient ever, and by integrating it with a Nujira Coolteq.h module we have set a new benchmark for transmission energy efficiency at 2.1GHz**

"TriPower technology is perfectly suited for integration with Nujira Coolteq.h envelope tracking power modulator modules to deliver best-in-class base-station power efficiency," reckons Gary Lerude, TriQuint's Networks senior product marketing director. "These two technologies are a powerful combination that will help base-station vendors in their drive to reduce their total cost of ownership and $CO_2$ emissions while simultaneously offering higher-power amplifiers for remote radio head and other base-station designs," he adds.

The 2.1 GHz PA test fixture combines the Coolteq.h modulator with a TriPower TG2H214120 device (which was also announced at the Mobile World Congress). The fixture achieves 56% efficiency at the 2.1GHz LTE bandwidth W-CDMA signals (6.5dB PAR) and 52% with LTE signals (8.5dB PAR).

**www.nujira.com**

# RFMD launches PowerSmart power platforms for multimode, multi-band cellular RF architectures

At the 2010 Mobile World Congress in Barcelona, Spain (15–18 February), RF Micro Devices Inc of Greensboro, NC, USA introduced PowerSmart power platforms for multimode, multi-band cellular RF architectures, enabling a new generation of global smartphones and mobile internet devices requiring three or more bands of 3G or 4G.

The platforms feature a new RF Configurable Power Core which, the firm claims, leverages industry-leading functional efficiency and delivers state-of-the-art processing of all known cellular communications modulation schemes, including GSM/GPRS, EDGE, EDGE Evolution, CDMA, 3G (TD-SCDMA or WCDMA/HSPA+) and 4G (LTE or WiMAX). PowerSmart power platforms cover bands 1–6 and 8–10.

The RF Configurable Power Core at the heart of each PowerSmart platform incorporates all power amplification and RF power management functionality. PowerSmart platforms also include all necessary switching and signal conditioning functionality in a compact reference design, providing smartphone manufacturers with a single scalable source for the entire cellular front end.

PowerSmart is modulation scheme agnostic and can support four bands of GSM/GPRS or EDGE and up to five bands of TD-SCDMA, WCDMA/HSPA+, LTE, WiMAX or CDMA — all within a product footprint that is 35% smaller than existing highest-volume quad-band solutions, claims RFMD. In a real-world comparison, versus existing highest-volume triple-band 3G solution using power amplifier duplexer (PAD) modules, PowerSmart reduces board space requirements by greater than 40%.

"RFMD's PowerSmart power platforms deliver smartphone manufacturers enhanced performance and improvements in value and solution size that are unmatched in the cellular RF industry," claims Eric Creviston, president of RFMD's Cellular Products Group (CPG). "PowerSmart platforms process all known cellular modulations at optimum performance, with superior energy efficiency and at the industry's lowest total cost of ownership," he adds. "We anticipate significant customer adoption this year as PowerSmart enables global 3G/4G penta-band implementations with product footprints that are smaller than those of triple-band solutions. With pricing below competitive penta-band WCDMA solutions and a revolutionary architecture that enables both global platform manufacturing and real-time RF configurability of individual smartphone models, PowerSmart is indeed smart power for smartphones."

According to RFMD, PowerSmart platforms help to extend battery life and significantly reduce average thermal dissipation (both critical performance metrics for smartphone makers) by maximizing efficiency across power levels, across data rates (voice-only to LTE) and during non-ideal load conditions (antenna mismatch).

Each PowerSmart platform uses a standardized digital interface (SDI) and is optimized to mate with leading multi-band HSPA+/EDGE/GPRS RF transceivers.

# RFMD adds four transmit modules for 3G entry-level phones

RFMD has added four new products to its range of 3G transmit modules.

The RF3230, RF3231, RF3232 and RF3171 are designed to accelerate the implementation of 3G entry-level feature phones supporting one-to-two bands of WCDMA and two-to-four bands of GSM/GPRS (WGPRS). Each new transmit module (TxM) has a GSM/GPRS power amplifier (PA) and an integrated pHEMT switch to support stringent 3G linearity requirements, providing a highly integrated, low-cost alternative to discrete RF front-end implementations, says RFMD.

"As our customers are working to bring smartphone-type features to mass-market feature phones, RFMD is first to deliver a broad product family that is cost- and feature-set-optimized for this emerging and high-growth category," claims Eric Creviston, president of RFMD's Cellular Products Group (CPG). "We are forecasting strong customer adoption of this new product family, and we continue to expect robust growth in 3G devices in calendar 2010."

The RF3231 and RF3232 are optimized to support Infineon as well as other leading open-market 3G chipset suppliers. The RF3231 is a dual-band GSM/GPRS TxM with one low-loss wideband transmit/receive (TRx) port and two interchangeable GSM Rx ports. It also features an integrated switch, integrated harmonic filtering and RFMD's patented PowerStar integrated power control technology. The RF3232 shares its feature set but increases functionality with one additional wideband TRx port.

The RF3230 is a quad-band TxM with two low-loss wideband TRx ports and four interchangeable GSM Rx ports. The RF3171 adds large signal polar EDGE capability to the lineup and is optimized to support Qualcomm and ST-Ericsson 3G chipsets.

Samples of the RF3231 were available from launch, with samples of the RF3230 and RF3171 becoming available late in the March quarter. The RF3232 will be production released and available for sampling in the June quarter.

# RFMD highlights new products at Mobile World Congress

**3G expanded portfolio with 2nd-generation TD-SCDMA PA**

RFMD has expanded its 3G front-end product portfolio with the RF7234, the firm's second-generation TD-SCDMA power amplifier (PA). The dual-mode RF7234 (TD-SCDMA and WCDMA band 1) follows the RF3266 first-generation TD-SCDMA PA, which has secured multiple design wins across leading TD-SCDMA reference designs and is forecast to support multiple top-tier handset makers in Asia and Europe, RFMD adds. Samples of both the RF3266 and RF7234 are available now.

The firm claims that both the RF7234 and RF3266 deliver superior performance at peak power conditions and ample margin across spectral emissions mask requirements — meeting or exceeding the critical performance metrics of today's TD-SCDMA handsets. Accordingly, RFMD is supporting multiple TD-SCDMA reference designs, including MediaTek and T3G, and it expects robust growth in TD-SCDMA handsets this year, driven by Samsung, ZTE, BYD, LG and other leading handset makers.

"RFMD is introducing a record number of new cellular components this year in support of our customers' new handset builds," says Eric Creviston, president of the firm's Cellular Products Group (CPG). "We are particularly focused on expanding our leadership in 3G with a broad product family that is cost- and feature set-optimized for this rapidly emerging, high-growth category," he adds.

The RF7234 and RF3266 expand RFMD's 3G portfolio, which covers all major RF architectures, including existing mode-specific/band-specific and mode-specific/multi-band architectures as well as emerging multimode/multi-band, converged architectures. RFMD's 3G products also include a broad range of GSM/GPRS and EDGE switch- and power amplifier-based components optimized for 3G mobile internet.

**RFMD starts volume production of RF720x WCDMA/HSPA+ PAs for smartphones and 3G devices**

RFMD has started high-volume production of its RF720x WCDMA/HSPA+ power amplifiers (PAs). The RF720x product family consists of seven PAs designed for smartphones and 3G devices implementing mode-specific, band-specific front-end architectures. The range accommodates all major WCDMA/HSPA+ bands and band combinations and is optimized to mate with reference designs from Qualcomm as well as other leading open-market 3G chipset suppliers.

"RFMD's innovative RF720x product family delivers unmatched ease of implementation," claims Eric Creviston, president of RFMD's Cellular Products Group (CPG). "Accordingly, we anticipate the RF720x product family will extend RFMD's leadership in 3G while supporting our customer diversification goals, particularly in Korea, China and Taiwan," he adds. Based on existing customer design activity, RFMD is forecasting double-digit growth in 3G in 2010.

**RFMD is introducing a record number of new cellular components this year in support of our customers' new handset builds**

The mode-specific/band-specific RF720x product family covers all major 3G frequencies (1–6, 8–11). Each RF720x PA is designed with digitally controlled power modes that optimize performance to increase battery life in both 3G voice and 3G data operation. Also, the RF720x family leverages what is claimed to be leading-edge functional density to integrate critical functions into the PA, significantly reducing the board area required for front-end implementations while lowering mobile device bill-of-material (BOM) costs, says the firm.

**Single-placement RF front ends launched, providing scalable 2G power platform**

At the 2010 Mobile World Congress, RF Micro Devices introduced the RF7178, which it claims is the cellular industry's first front-end module to integrate a quad-band, class 12-compliant GSM/GPRS power amplifier, a pHEMT antenna switch and receive SAW filters.

The RF7178 offers full quad-band transmit performance (GSM850/EGSM900/DCS1800/PCS1900) and four dedicated receive ports in a compact single-placement package. Both the transmit and receive paths are performance optimized to deliver a low-loss, high-efficiency front-end solution without requiring additional matching components.

RFMD also introduced the RF7177 dual-band (EGSM900/DCS1800) front-end module, which is pin-to-pin compatible with the RF7178 and features a similar feature set integrating the pHEMT antenna switch and SAW filters.

RFMD says that, combined, the RF7178 and RF7177 provide a scalable platform solution for handset makers seeking advanced levels of integration, streamlined inventory management, and minimal deployment of RF design resources.

Also, compared to traditional discrete implementations, they each eliminate about ten component placements, reducing assembly costs, improving line yields, and lowering the costs associated with purchasing and managing inventory. In addition, by allowing the use of common printed circuit boards (PCBs) across handset models, the RF7178 and RF7177 reduce handset makers' inventory costs and enable configurable end-products based on regional and/or customer-specific requirements, RFMD says.

The RF7178 is production released and samples are available now. The RF7177 is scheduled for production release in the June quarter, says RFMD.

www.rfmd.com

# RFMD launches its first high-power RF CMOS switches

At the 2010 Mobile World Congress in Barcelona, Spain (15–18 February), RF Micro Devices Inc of Greensboro, NC, USA said that it had qualified and released its first high-power RF CMOS switch using high-resistivity silicon substrates sourced at a leading silicon foundry.

RFMD is leveraging the new process technology, and patent-pending design and circuit-related technology developed by RFMD, to introduce a portfolio of high-performance silicon switch-based products for next-generation 3G and 4G smartphones, as well as other cellular handset, wireless infrastructure, wireless local-area network (WLAN), CATV/broadband and aerospace and defense applications.

"RFMD's CMOS-based cellular switches deliver meaningful performance, size and cost benefits, including excellent linearity and isolation capabilities, which are critical to today's multi-band 3G handsets," claims Eric Creviston, president of the firm's Cellular Products Group (CPG). "We are forecasting significant customer adoption in calendar 2010 driven by leading 3G smartphone manufacturers."

"These new CMOS-based products — and our entire switch and signal conditioning product portfolio — highlight the increasing dollar content opportunities available to RFMD and the continued success of our diversification efforts," says president & CEO Bob Bruggeworth. "Equally important, our CMOS-based switch portfolio enables further improvement in our return on invested capital (ROIC) as we migrate technologies and IP developed by CPG into the markets served by RFMD's multi-market products group (MPG)."

**Subsequent CMOS-based products will address increasing levels of end-product complexity**

RFMD says that its CMOS-based cellular switches meet or exceed the stringent linearity and isolation requirements of next-generation 3G and 4G smartphones while providing superior ESD performance (HBM data rated at 2000V). Also, by integrating the controller and RF switch on the same circuit, RFMD's patent-pending circuit-related technology and the high-resistivity CMOS technology reduce product size while improving performance. Accordingly, RFMD's silicon switches deliver a lower-cost and higher-performance 3G solution than is obtainable from competing silicon process technologies, including silicon-on-sapphire (SOS), the firm claims.

RFMD's first high-power CMOS-based cellular switches include the single-pole, three-throw (SP3T) switch RF1603 and the single-pole four throw (SP4T) switch RF1604. Both have been sampled to tier-one customers, and commercial production is expected to start in first-half 2010. Subsequent CMOS-based products will address increasing levels of end-product complexity and will include RFMD's growing portfolio of switch filter modules and switch duplexer modules for 3G smartphones.

www.rfmd.com

# RFMD expands its family of 2G GSM/GPRS transmit modules; ships 100 millionth RF71xx transmit module in March quarter

RF Micro Devices expanded its family of dual- and quad-band GSM/GPRS transmit modules by launching three new products at the 2010 Mobile World Congress in Barcelona: the RF7170, RF7171 and RF7172.

The RF71xx family of transmit modules is reckoned to be the industry's highest-volume GSM/GPRS transmit module product family, and the GSM/GPRS air interface standards represent the world's largest cellular market by volume. In December, RFMD announced that shipments of RF71xx transmit modules had surpassed 25 million, and that it expects to ship its 100 millionth in this quarter, reflecting increasing customer demand in Korea, China and Taiwan in particular. Quarterly volumes of RF71xx transmit modules are forecasted to grow throughout 2010.

"These new products expand RFMD's RF71xx product family to include 10 transmit modules that cover a full range of functionality and layout requirements across the GSM/GPRS chipsets of all major platform providers," says Paul Augustine, general manager of RFMD's Component Solutions business unit. "Leveraging the proven success of our RF716x dual-band products, these quad-band transmit modules extend end-product coverage to higher-tier handsets while continuing to reduce our customers' costs and accelerate their time-to-market through the implementation of true platform solutions."

The RF71xx product family is designed to meet or exceed the evolving RF component requirements of GSM/GPRS handsets, including high efficiency, reduced solution size and robust ESD protection, while also satisfying the need for quality, reliability and reduced handset bill-of-material (BOM) costs. All three new transmit modules (TxMs) offer quad-band transmit and dual-band receive capability, suiting platform designs. They also feature multiple LGA pin-out options, allowing optimum component routing.

All RF71xx TxMs are now production released, each priced under $1 in quantities of 10,000.

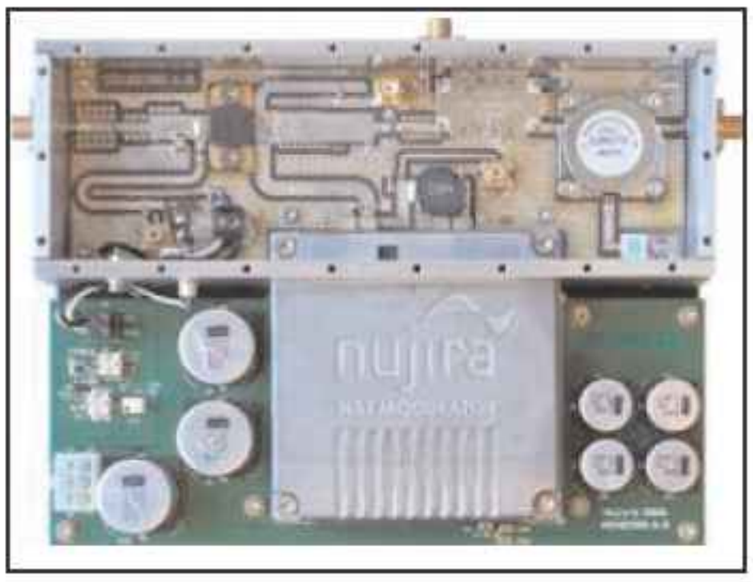
# Nujira uses RFMD's GaN to create 50%-efficient 700–1000MHz PA

At the GSMA Mobile World Congress in Barcelona, Spain (15–18 February), Nujira Ltd of Cambridge, UK and RF Micro Devices Inc of Greensboro, NC, USA demonstrated what is claimed to be world's most efficient broadband power amplifier (PA) design for 4G base-stations. The design integrates Nujira's Coolteq.h envelope tracking power modulators with RFMD's new RFG1M family of gallium nitride (GaN) amplifiers (specifically the RFG1M09180 180W GaN broadband power transistor).

Using just one RFG1M device with a Coolteq.h module, the RF front end transmits over a 728–960MHz band with more than 50% efficiency, covering seven of the frequency bands defined for LTE (long-term evolution) by 3GPP. The results of this broadband GaN-based PA platform surpass competitive wideband Doherty LDMOS solutions, it is claimed. Also, using future GaN devices currently in development at RFMD, the firms expect to cover the full range of the cellular frequency band (700–2600MHz) with just three broadband PAs, allowing wireless infrastructure vendors to develop a single, highly efficient multimode, broadband RF front end that can be deployed to meet various transmission standards anywhere in the world.

"Expect to see GaN, coupled with envelope tracking, in many new RRH designs," comments Lance Wilson, research director, RF Components & Systems, with market analysts ABI Research, which issued the report 'Remote Radio Heads' in December. "With a GaN/envelope tracking amplifier promising such high-efficiency operation, the Doherty circuit configuration can be disposed of and bandwidth will increase incrementally," he adds.

"In partnership with RFMD, we have created a PA which covers the entire 700–1000MHz band without compromising on efficiency," says Nujira's CEO Tim Haynes. "Coolteq




modulators feature the only technology that can deliver this level of efficiency across such a broad bandwidth, extending the software-defined radio approach to the high-value power amplifier," he adds.

"We're delighted to be collaborating with Nujira in setting new standards for energy-efficient transmission performance based on our new RFG1M products and on our state-of-the-art GaN process," says Bob Van Buskirk, president of RFMD's Multi-Market Products Group (MPG), who envisions the combination of envelope tracking and RFMD's GaN technology changing the way base stations are designed.

The joint design addresses a major issue in the 4G cellular base-station market, says Haynes. "Infrastructure vendors are facing a portfolio management crisis, with more than 60 product variants needed to cover all worldwide frequency bands, cellular standards, and power levels. Even if they had the specialist engineering resources available to develop each product, the development costs and timescales would be prohibitive, with each and every variant costing hundreds of thousands of dollars to design, test, type approve, and qualify for production," he adds. "We have delivered a high-efficiency, broadband PA platform which can be deployed across multiple product variants, reducing time-to-market, development costs, and the cost of ownership associated with inventory management."

**www.nujira.com**
**www.rfmd.com**

IN BRIEF

## RFMD and SELEX extend collaboration on MMICs for phased array radar

Defense electronics manufacturer SELEX Galileo (a Finmeccanica Company) and RF Micro Devices have extended their collaboration on developing high-frequency GaAs MMIC solutions focused on SELEX Galileo's next generation of electronically scanned (E-SCAN) phased array radar systems. SELEX Galileo and RFMD have collaborated in GaAs MMICs since signing a strategic cooperation agreement in May 2008.

RFMD has also started production shipments to SELEX Galileo of GaAs MMIC chipsets for insertion into its surveillance and fire control radar systems. RFMD manufactures its high-frequency GaAs MMIC process for SELEX Galileo on 6-inch substrates at its high-volume GaAs wafer fabrication plant in Durham, UK (formerly Filtronic Compound Semiconductor Ltd, acquired by RFMD in February 2008).

"We value our collaboration with SELEX Galileo and look forward to growing our relationship," says Jeff Shealy, VP & general manager of RFMD's Defense and Power business unit.

"SELEX Galileo is a valued strategic customer in our Defense and Power business and we are pleased to announce the strengthening of our collaboration as we move from development phase to production phase," comments RFMD's president & CEO Bob Bruggeworth. "Our combined efforts represent an excellent match for RFMD's strategic mission to extend and leverage our leadership in RF components and compound semiconductors into multiple industries."

**www.selexgalileo.com**

# E-Band receives EU and Russian Federation certifications for Gigabit wireless systems

E-Band Communications Corp of San Diego, CA, USA, which makes ultra-high-capacity point-to-point Gigabit Ethernet wireless transmission systems, says that its E-Link 1000EXR Gigabit wireless systems have received Notified Body Expert Opinion, validating its performance conformity with the European R&TTE Directive 1999/5/EC and compliance with the ETSI Recommendation EN 302 217-3. In addition, the radio has received a certificate of homologation from the Russian Ministry of Communications, enabling E-Band to export the 1000EXR to CIS countries.

"This past year carriers, mobile operators and enterprise customers in Europe, Russia and other CIS countries have shown significant interest in our Gigabit Ethernet 70–80GHz backhaul products, that have been deployed in 4G networks in the US," says chief marketing officer Saul Umbrasas. "The ability to export our latest Gigabit radios to over 40 additional countries opens up a major market opportunity to serve the burgeoning demand for bandwidth that is driven by expanded use of smartphones," he adds. "The CE Mark and Russian Federation certifications for the 1000EXR systems are essential ingredients for enabling deployment of our Gigabit wireless transmission systems by our valued customers in Europe and the CIS."

In early February, E-Band announced that in 2009 it achieved US market share leadership, as carriers deployed high-capacity wireless backhaul infrastructure to support 4G networks. The firm says that the achievement was enabled by implementing advanced monolithic microwave integrated circuit (MMIC) technologies (via an exclusive long-term field-of-use license from Northrop Grumman Corp).

"Our customers appreciate the carrier-class features we've designed into our products," says Jimmy Hannan, director of product management. "We provide the lowest latency in the industry at less than 5µs and highest output power of +22dBm, which translates into the longest-distance and highest-reliability network performance," he claims. "In addition, our E-Link 1000EXR's ability to transparently handle jumbo packets for multimedia applications has been well received by both enterprise customers and telecom service providers."

www.e-band.com

# E-Band claims lead in US 70–80GHz wireless Gigabit backhaul

E-Band Communications has claimed the number one position in the US market for 70–80GHz (E-band) millimeter-wave systems, with an almost 60% share according to publicly available 2009 Federal Communications Commission (FCC) license registration data.

Incorporating monolithic microwave integrated circuit (MMIC) technology via an exclusive long-term field-of-use license from Northrop Grumman Corp, E-Band's millimeter-wave radios are used by telecom firms as the backbone for cellular broadband and backhaul networks, as well as by businesses, hospitals, universities, government agencies and security providers to transmit data and digital video over several miles without the expense and installation challenges of fiber-optic systems.

"2009 turned out to be our breakout year, even in the middle of a recession," says chief marketing officer Saul Umbrasas. "Our ultra-high-capacity backhaul solution is a key infrastructure component for the 4G WiMAX and LTE networks being deployed around the world," he claims. "Adding bandwidth capacity for internet access and for devices such as the Apple iPhone, Google Android and RIM Blackberry is critical to ensuring customer satisfaction and retention for wireless carriers," he adds.

**E-Band expanded its manufacturing capability in January, moving production into a new high-volume plant a few miles from its headquarters**

"In a robust and highly competitive market, which more than doubled from 2008, E-Band was able to gain market share from all competitors... We obtained a clear leadership position of the US market," Umbrasas claims. "Most significantly, the FCC registration database indicates that our unit volume was more than 50% above our nearest competitor," he adds. "Our products are carrying multiple gigabits of data traffic every second, 24 hours a day, in the most advanced 4G networks in the world."

Also, E-Band expanded its manufacturing capability in January, moving production into a new high-volume plant a few miles from its headquarters. "Customers demand up to 99.999% reliability and this ISO-certified factory, with cleanroom conditions and the most advanced manufacturing equipment and processes available, ensures that we continue to meet the quality and volume requirements needed to continue our leadership position in 2010 and beyond," comments Umbrasas.

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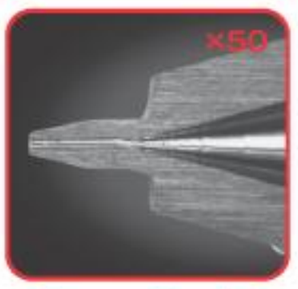


Arque Nozzle

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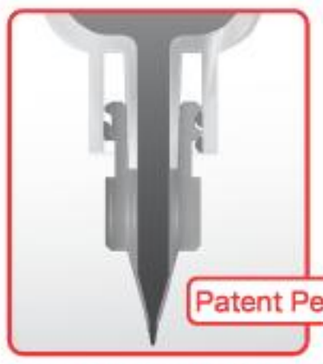


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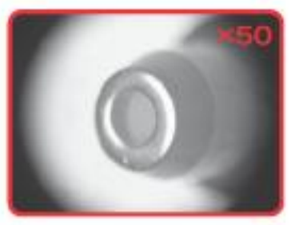


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# EU launches TRAMS project for reliable terascale memory systems

## Variability and unreliability in Late CMOS and Beyond CMOS to be tackled

Financed by its Framework Program 7 (FP7) Future Emerging Technology fund, the European Commission (EC) has launched the three-year joint research project Terascale Reliable Adaptive Memory Systems. 'TRAMS' aims to investigate the impact of increasing variability and unreliability of components in future terascale memory systems and to create new design paradigms that can secure their reliable operation in future multicore processors and system-on-a-chip applications.

The TRAMS consortium includes Intel Corporation Iberia, the nanoelectronics research center IMEC of Leuven, Belgium, the University of Glasgow in Scotland, UK (through its Department of Electronic and Electrical Engineering's Device Modeling Group, led by professor of Device Modelling Asen Asenov), and the Universitat Politècnica de Catalunya (UPC) in Barcelona, Spain (through the research groups 'Architecture and Compilers' (ARCO) and 'High Performance Integrated Circuits and Systems Design' (HIPICS) in the departments of Computer Architecture and Electronics Engineering, respectively), with the latter's professor Antonio Rubio as TRAMS' project coordinator.

It is expected that, as a result of the continuing miniaturization of complementary metal-oxide semiconductor (CMOS) transistors and performance improvement described by Moore's law, in the next decade a single silicon chip will be able to perform many billions of operations per second and provide many billions of bytes per second off-chip bandwidth. These terabyte-per-second computing capabilities should transform not only the throughput of large data centers and computing facilities but also the power, performance and functionality of personal computers, communication devices, computer games and other consumer electronics products.

The project targets transistors, circuits and systems near the end of the International Roadmap for Semiconductors (ITRS) and beyond. A starting point will be the 'Late CMOS' technologies after the 16nm technology generation, including novel multigate device architectures and novel channel and gate stack materials that are expected to reach important scaling challenges below 10nm dimensions. The project will also address 'Beyond-CMOS' emerging technologies such as nanowire transistors, quantum devices, carbon nanotubes, graphene, or molecular electronics, which are expected to scale below 5nm.

Both the Late CMOS and the Beyond CMOS technologies hold the promise of a significant increase in device integration density, complemented by an increase in system performance and functionality.

However, the individual nanoscale transistors in such terascale chips will be much more susceptible to: manufacturing faults (leading to an expected dramatic reduction in single device quality), an unprecedented increase in variability, a severe reduction in the signal-to-noise ratio, and severe reliability problems. Alternative circuit and system solutions therefore need to be investigated to deliver reliable systems out of variable and unreliable components and at a reasonable cost and design effort in order to keep harvesting the benefits fueled by technology scaling.

TRAMS hence aims to be a bridge overcoming the nanoscale challenges to deliver reliable, energy-efficient and cost-effective memory cells for terascale processors in teraflop computing system architectures using nanotechnologies for both late CMOS and emerging devices.

In order to build reliable nanosystems, TRAMS will apply a specific variability and reliability-aware analysis and design flow as well as a hierarchical tolerance design, investigating novel solutions at both circuit and architecture levels.

With device design and simulation work being conducted at the University of Glasgow, central to the project is simulation software developed by Asenov (an authority on the variability of CMOS transistors and microchips) in an earlier £5.3m UK Engineering and Physical Sciences Research Council (EPSRC) eScience pilot project 'NanoCMOS'. The NanoCMOS simulations use grid computing, which employs the processor power of thousands of linked computers to simulate how hundreds of thousands of transistors, each with their own individual characteristics, will function within a circuit.

In addition, Asenov and the University of Glasgow are establishing the firm Gold Standard Simulations to exploit the technology.

"Tera-scale computing will transform the power, performance and functionality of personal computers, phones and other electronic devices as well as large computing facilities such as data centers," believes Asenov.

**www.trams-project.eu**

# Javelin launches first working CMOS 3G power amplifier

At February's Mobile World Congress in Barcelona, Spain, Javelin Semiconductor Inc of Austin, TX, USA introduced the JAV5001 CMOS-based 3G power amplifier (PA) — demonstrated operating inside a cell-phone handset — providing what is claimed to the industry's best performance in a robust, reliable, standards-compliant product.

Based on a patented architecture implemented in standard CMOS, the JAV5001 is a 3G UMTS band I PA that requires only two external components for supply decoupling and features a single connection to the battery, resulting in what is claimed to be the industry's lowest bill-of-materials and enabling rapid adoption by cell-phone makers. It is stable across output loads including protection for open and short circuits, is difficult to damage in harsh environments, and has the lowest out-of-band noise of any cellular PA on the market, Javelin claims.

The JAV5001 minimizes power consumption across output power levels, resulting in what is claimed to be the industry's lowest battery current in real-world 3G operating conditions. The JAV5001 integrates complete circuitry for power regulation, PA bias, input and output matching and power control into an industry-standard 3mm x 3mm package, improving battery life, robustness and reliability while simplifying the design-in process for 3G mobile phones and datacards. By achieving compliance to the stringent, industry-standard 3GPP specifications for W-CDMA and HSPA, Javelin expects the JAV5001 to initiate the long-anticipated shift in wireless PAs from GaAs to CMOS.

Due to its performance, integration and reliability, the JAV5001 can resolve many of the challenges currently facing handset makers, reckons president & CEO Brad Fluke. "With innovations in architecture, circuit implementation and modeling, our uniquely experienced engineering team has achieved first-pass success, avoiding the numerous experiments and design revisions that PA developments have historically required," he notes. Javelin sources its products from the world's largest silicon foundries — including the biggest, Taiwan Semiconductor Manufacturing Co Ltd (TSMC) — opening up virtually unlimited capacity to the PA market, which historically has been subjected to allocation during peak demand cycles, the firm says. "Our first design fully meets 3GPP specifications, supporting a rapid transition to mass production."

**Javelin's JAV5001 CMOS 3G PA.**

"Innovations in CMOS technology have driven an increase in performance and features in the mobile handset," comments Brian Modoff, senior wireless equipment analyst at Deutsche Bank. "The power amplifier is the next major opportunity for CMOS," he adds. "Javelin's accomplishment suggests a well-planned architecture and a solid design methodology. By promising to outperform GaAs PAs, the JAV5001 represents a breakthrough that can initiate the transition to CMOS for 3G mobile handset PAs."

Javelin has 15 patents on its architecture and plans to extend its technology into a full family of CMOS 3G PAs.

The JAV5001 is priced at $1.45 in 10,000 quantities. Samples are available now, with volume production due in June.

**www.javelinsemi.com**

# Sapphicon and AWR partner on SoS PDKs

At February's International Solid State Circuits Conference, high-frequency electronic design automation (EDA) software provider AWR Corp of El Segundo, CA, USA and Sapphicon Semiconductor of Sydney, Australia, a vertically integrated firm that designs high-performance ICs and offers semiconductor manufacturing services based on silicon-on-sapphire (SoS) process technology, have introduced process design kits (PDKs) for AWR software that support Sapphicon's SoS processes.

Developed using AWR's Analog Office RFIC design software because of its ability to provide highly accurate models, Sapphicon offers AWR PDKs for all variants of its 0.25µm process. Sapphicon is also working on PDKs covering its 0.5µm high-frequency RF/mixed signal CMOS processes.

"A key aim is to develop highly accurate models for transistors and passives, like spiral inductors, at frequencies up to 40GHz," says Yash Moghe, Sapphicon design engineering manager. "Analog Office software enables us to accurately model active devices, passives, and interconnects on SoS so that our customers realize first-time-right designs."

"This partnership extends our reach by providing Analog Office customers with access to a wider variety of process technologies, such as Sapphicon's SoS technology which is ideal for RF and mixed signal CMOS designs," adds Graeme Ritchie, AWR's RFIC segment manager.

SoS suits high-frequency and mixed-signal devices, as its insulating substrate eliminates parasitic capacitances from the circuit, allowing higher frequencies, low power consumption, and high-Q passives (e.g. inductor $Q_L > 40$ at 2GHz) to be achieved. Transistors created from SoS also have much lower junction capacitance and thus have fewer non-linearities at high frequencies than those made with standard CMOS processes.

**www.awrcorp.com**

# EPC launches 40–200V E-mode GaN power transistors

## Ex-IR CEO Liddow targets power management applications

Efficient Power Conversion Corp (EPC) of El Segundo, CA, USA has introduced a family of enhancement-mode power transistors, based on its proprietary gallium nitride on silicon (GaN-on-Si) technology, for power management device applications.

Spanning a range of 40–200V and 4–100 milliohms, the power transistors demonstrate performance advantages over incumbent silicon-based power MOSFETs (metal-oxide semiconductor field-effect transistors), EPC claims. The firm's technology produces devices that are smaller than similar-resistance silicon devices and have many times better switching performance. Applications that can benefit are DC–DC power supplies, point-of-load converters, Class-D audio amplifiers, notebook and net-book computers, LED drive circuits, telecom basestations and cell phones.

Privately held fabless firm EPC was founded in 2007 by CEO Alex Lidow and other staff from El Segundo-based International Rectifier Corp (IR). Father Eric Lidow founded IR in 1947, and Alex Lidow joined in 1977 before co-inventing the HEXFET power MOSFET and being made a director and CEO in 1995.

However, after he resigned in October 2007, IR sued Lidow in January 2009, alleging theft of intellectual property related to GaN power devices and that Lidow stalled IR from making its GaN technology public in 2007.

IR also announced it was making prototype devices using a proprietary GaN-based power device technology platform (GaNpowIR, launched in September 2008) based on 150mm GaN-on-Si epitaxy. Based on a native depletion-mode GaN HEMT structure (which can be fabricated using standard CMOS production tools), IR's first GaN products (the iP2010 and iP2011, launched on 23 February) are power stage devices designed


**Size of EPC's 200V GaN device compared to equivalent silicon device.**

for multiphase and point-of-load (POL) applications, including servers, routers, switches and general-purpose POL DC–DC converters.

EPC countered that it was not using IR's GaN technology, and that it had developed a different semiconductor product, In contrast, EPC's GaN technology is enhancement-mode (normally off). The courts dismissed IR's lawsuit on 18 March 2009.

Developed specifically to replace power MOSFETs (which are made by firms such as Fairchild, Infineon, International Rectifier, Texas Instruments, and Vishay), EPC claims that it is the first firm to introduce E-mode GaN-on-Si transistors as power MOSFET replacements for power management applications. The devices are produced in a standard CMOS foundry on 150mm silicon wafers (EPC has received funding from foundry partner Episil of Taiwan). The use of such low-cost infrastructure has allowed EPC to price the initial products aggressively as it aims to accelerate the conversion from silicon power MOSFETs.

**EPC claims that it is the first firm to introduce E-mode GaN-on-Si transistors as power MOSFET replacements**

With products priced between $0.80 and $5.00 in 1000-unit quantities (comparable to high-end MOSFETs), the new technology is ready for commercial use. EPC has posted on its web site results from what it claims is the most extensive reliability testing ever performed on GaN power devices. It has also posted application notes, SPICE models, demo boards and development kits.

"EPC's GaN-on-silicon power transistors represent the first major breakthrough in power conversion technology since the development of the commercial power MOSFET," claims Lidow. "We have developed a very cost-effective and reliable technology that is also very easy for anyone with power MOSFET experience to use in a way that will significantly boost their power management system performance," he adds.

EPC has also announced that electronic component distributor Digi-Key Corp will be the exclusive global distributor for its E-mode GaN power transistors. "EPC's GaN-based power management products bring intriguing next-generation breakthrough benefits to existing MOSFET and bipolar solutions," comments Dave Doherty, Digi-Key's VP of semiconductor product. "Digi-Key has the fastest global logistics and the most efficient supply chain of any distributor with which I have worked over the last 30 years," says Lidow. "This will translate into fast and easy service to all our global customers who want to get access to our enhancement mode GaN transistors to replace their less-efficient power MOSFETs."

EPC is now shipping sample quantities to select strategic customers, and will start delivering product to general customers this quarter.

**www.epc-co.com**
**www.digikey.com**

# IR claims first commercial GaN-based integrated power stage devices

Power management device maker International Rectifier Corp (IR) of El Segundo, CA, USA has introduced what it claims is the industry's first family of commercial integrated power stage products using gallium nitride (GaN)-based power device technology. The iP2010 and iP2011 family of devices is designed for multiphase and point-of-load (POL) applications including servers, routers, switches and general-purpose POL DC-DC converters.

Using IR's GaNpowIR GaN-based power device technology platform (launched in September 2008), the iP2010 and iP2011 integrate an ultra-fast PowIRtune driver IC matched to a multi-switch monolithic GaN-based power device. They are mounted in a flip-chip package platform to deliver higher efficiency and more than double the switching frequency of state-of-the-art silicon-based integrated power stage devices.

IR claims that GaNpowIR can provide improvements in key application-specific figures of merit (FOM) of up to a factor of ten compared to state-of-the-art silicon-based technology platforms, boosting performance and cutting energy consumption in end applications in market segments such as computing and communications, automotive and appliances. GaNpowIR is the result of five years of R&D by IR based on its proprietary GaN-on-silicon epitaxial technology. The high-throughput, 150mm GaN-on-Si epitaxy, together with subsequent device fabrication processes that are fully compatible with IR's cost-effective silicon manufacturing facilities, offers a commercially viable manufacturing platform for GaN-based power devices, the firm adds.

"The introduction of this family of GaN-based power devices for DC–DC applications heralds a new era in high-frequency, high-density, highly efficient power conversion


**IR's iP2010 GaNpowIR chip.**

solutions," says Goran Stojcic, executive director for IR's POL Products, Enterprise Power business unit.

"With a switching capability up to 5MHz, the iP201x family enables designers to dramatically reduce the value and size of output capacitors and inductors where space is at premium," says POL product manager John Lambert. "The devices can also be configured to operate at a lower switching frequency for applications that require the highest possible efficiencies."

Operating up to up to 3MHz, the iP2010 has an input voltage range of 7–13.2V and output voltage range of 0.6–5.5V with an output current up to 30A. Operating up to 5MHz, the pin-compatible iP2011 has the same input and output voltage ranges but is optimized for an output current up to 20A. Offering multiple current-rating devices in a common footprint provides flexibility for meeting different requirements in terms of current level, performance and cost, says IR.

Available in a 7.7mm x 6.5mm LGA package with a small footprint, both devices are optimized for very low power loss, feature highly efficient dual-sided cooling, and are RoHS compliant.

Complete datasheets, demo boards and samples are available to qualified customers. Pricing begins at $9 each and $60 each for the iP2010TRPbF and iP2011TRPbF, respectively, in 2500-unit quantities.

**www.irf.com/product-info/ganpowir**

IN BRIEF

## Auriga Measurement Systems becomes Auriga Microwave to reflect module focus

Auriga Measurement Systems LLC of Lowell, MA, USA, which provides design, modeling and measurement products and services for RF, microwave and millimeter-wave device technologies, has changed its name to Auriga Microwave in order to better signify the firm's strength and direction as the firm moves from a predominately test & measurement company to a provider of microwave solutions.

Building upon its strong 'Auriga' brand, Auriga Microwave expands the firm's products and services to include design and manufacture of RF modules, particularly power amplifiers. Leveraging the team's experience, the firm's goal is to provide high-performance microwave modules to system integrators, principally for the US Department of Defense.

"Since mid-2007, we have won seven Phase I SBIR (Small Business Innovative Research) awards, and will have graduated six of them to Phase II SBIRs by Q2 of this year," says Auriga Microwave's president & CEO Bruce Cohen. "Our power amplifier and front-end solutions are principally built on GaN- or GaAs-based technology; and with our modeling background and team-oriented creativity, we are able to deliver balanced solutions that meet or exceed customers' specifications."

Auriga will continue to develop and manufacture test equipment, but anticipates long-term growth to come from designing and making high-performance modules. Solutions aim to provide: higher output power; improved efficiency; better linearity; wider bandwidth; smaller size; and lighter weight, the firm adds.

**www.aurigamicrowave.com**

# Microsemi adds 1500W SiC RF power transistor for UHF pulsed radar in military/aerospace applications

Microsemi Corp of Irvine, CA, USA, which manufactures analog mixed-signal integrated circuits and high-reliability semiconductors, has expanded its portfolio of high-power silicon carbide (SiC) transistors by launching a 1500W broadband transistor designed specifically for UHF-band pulsed radar in military and aerospace applications.

The 0405SC-1500M device from Microsemi's RF Integrated Solutions (RFIS) group uses SiC technology to provide 1500W peak power performance in a simple, compact single-ended impedance-matching package design that replaces complex push–pull balun circuitry found in conventional silicon BJT (bipolar junction transistor) or LDMOS (laterally diffused metal oxide semiconductor) solutions. The size is 50% smaller than equivalent silicon devices, it is reckoned.

The 0405SC-1500M is a common-gate, class AB, high-power transistor designed for UHF frequencies of 406–450MHz. It is fabricated with all-gold metallization and gold wires in a hermetic solder-sealed package, extending operating lifetime and providing military-grade long-term reliability for weather radar and over-the-horizon radar applications.

Microsemi says that the 0405SC-1500M uses a new chip design and processing enhancements to offer high performance, notably in high power, small transistor and circuit size over the specified frequency range with 300 microsecond pulse width and 6% duty cycle.

The firm adds that system benefits include:

- what is claimed to be the industry's highest peak power for reduced system power (4-way combination yields 5kW with margin);
- high operating voltage ($V_{dd}$ = +125V) slashes power-supply size and DC current demand;
- low conducting current minimizes system noise effect; and
- extremely rugged performance improves system yields.

"This new 1500W device demonstrates our ability to extend this advanced technology through aggressive investment," claims Microsemi RFIS vice president Charles Leader. "We now can support next-generation UHF radar designs with a full series of silicon carbide transistors having powers rated at 100W, 500W, 1000W and now the 0405SC-1500M at 1500W," he adds.

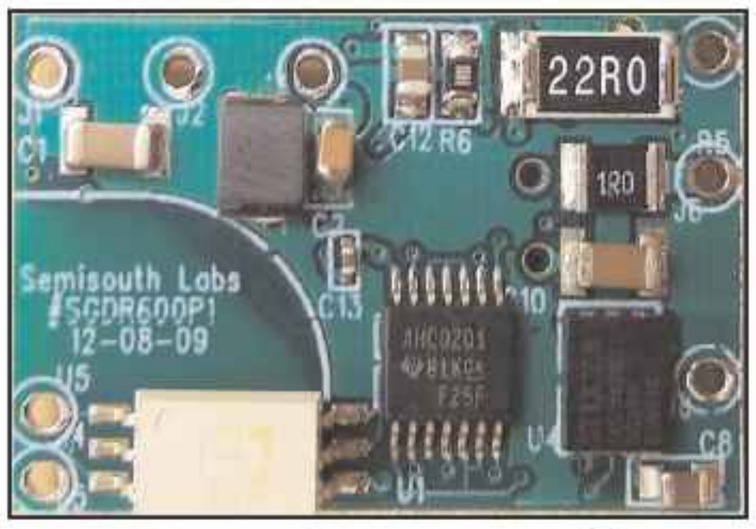
Demo units for the entire line of SiC transistors are available now.

**www.microsemi.com**

# SemiSouth announces reference design for 1200V SiC FET

SemiSouth Laboratories Inc of Starkville, MS, USA, which designs and manufactures silicon carbide (SiC) based discrete power devices and electronics, has made available a new gate reference design for its energy-efficient SiC field-effect transistor (FET), which is a normally-off 63mΩ, 1200V, JFET consuming 7–10 times less switching energy than the silicon-based insulated gate bipolar transistors (IGBTs) typically used in AC distribution networks.

The peak gate current of the driver is +6A/–3A, which the firm says is helpful to those designing in or ramping new designs using SemiSouth's SiC FET since full schematics and a bill of materials are provided in the datasheet. "This new reference design allows our customers to add a standard gate driver with a bill of materials cost that is extremely low, since we are using all standard, off-the-shelf commercial components for the very compact




**SGDR600P1 reference gate driver for 1200V, 63mΩ, normally-off SiC JFET.**

(28mm x 19mm) reference driver board," says Dan Schwob, VP of sales & marketing. SemiSouth says that, since releasing the SiC FET in late 2008, it has seen widespread adoption of the power transistor because of its advantages in energy efficiency, reliability and cost compared with other SiC technologies.

"The SGDR600P1 is an opto-isolated, two-stage driver, used for high-speed, hard-switching of our normally-off 1200V JFET, which enables customers to quickly and easily obtain record low switching (and total) losses at frequencies up to 250kHz," says Dr Jeff Casady, chief technology officer & VP of business development.

SemiSouth says that emerging SiC technology enables energy-efficient operation of power conversion and power management in telecom power supplies, inverters in solar and high-frequency welding, future automotive electric vehicle platforms, and many other products. The firm adds that the promise of SiC is its ability to make power supplies and power inverters up to 50–75% more energy efficient, operate at up to 4–8 times higher frequency, and hence run cooler and be physically smaller. In particular, SiC power JFETs are expected to increase the 'fuel' efficiency of hybrid electric vehicles and help to make them more affordable for consumers.

**www.semisouth.com**

# Agilent launches first single-box analyzer/curve tracer for 40A/3000V power devices

Agilent Technologies of Santa Clara, CA, USA has introduced enhancements to its B1505A Power Device Analyzer/Curve Tracer to make it what is claimed to be the first single-box solution able to characterize semiconductor devices up to 3000V and 40A (compared to 20A when originally launched in November 2008), available for ordering from 1 May.

The high-power device market is growing rapidly each year due to the demand for green engineering and products that conserve energy, says Agilent. Industry segments leading the growth are hybrid and other high-efficiency cars; industrial uses such as robotics, solar cells, wind electricity and electric trains; and, in information technology and consumer electronics, CPU power control circuits that require a highly efficient power device for power conservation.

Silicon-based power MOSFET and IGBT (insulated-gate bipolar transistor) devices are being engineered to reduce energy loss, conserve power and decrease operating costs. However, some new devices are using wide-band gap materials such as silicon carbide (SiC) or gallium nitride (GaN) to achieve high efficiency. In addition, on-wafer testing has become very important for reducing development turn-around times. The upgrade to 40A capability increases the number of power devices and applications that the B1505A can serve, says Agilent.

"Test and measurement of high-power devices is a growing requirement for manufacturers, yet one that demands the utmost accuracy and reliability," says Masaki Yamamoto, general manager of Agilent Hachioji Semiconductor Test Division. "Researchers and development engineers need to know they can be confident in their findings," he adds. "On-wafer as well as packaged device 40A evaluations are strong requirements in the marketplace because they help dramatically decrease time to market."

The B1505A is a single-box solution that provides for ease of use and ease of analysis. Its new 40A capability comes from its ability to support two high-current source monitor units (HCSMUs) in a single device. Existing B1505A owners with a HCSMU can easily add a second HCSMU with an accessory to enable 40A sourcing and measurement for both packaged and on-wafer devices. Agilent says that the all-in-one design provides a simple and clean configuration for 40A sourcing and measurement, allowing easy set-up and providing an uncluttered work environment with space for larger devices. Also, the new design is unlike a measurement system built with multiple instruments, where complicated cabling and user safety considerations are required.

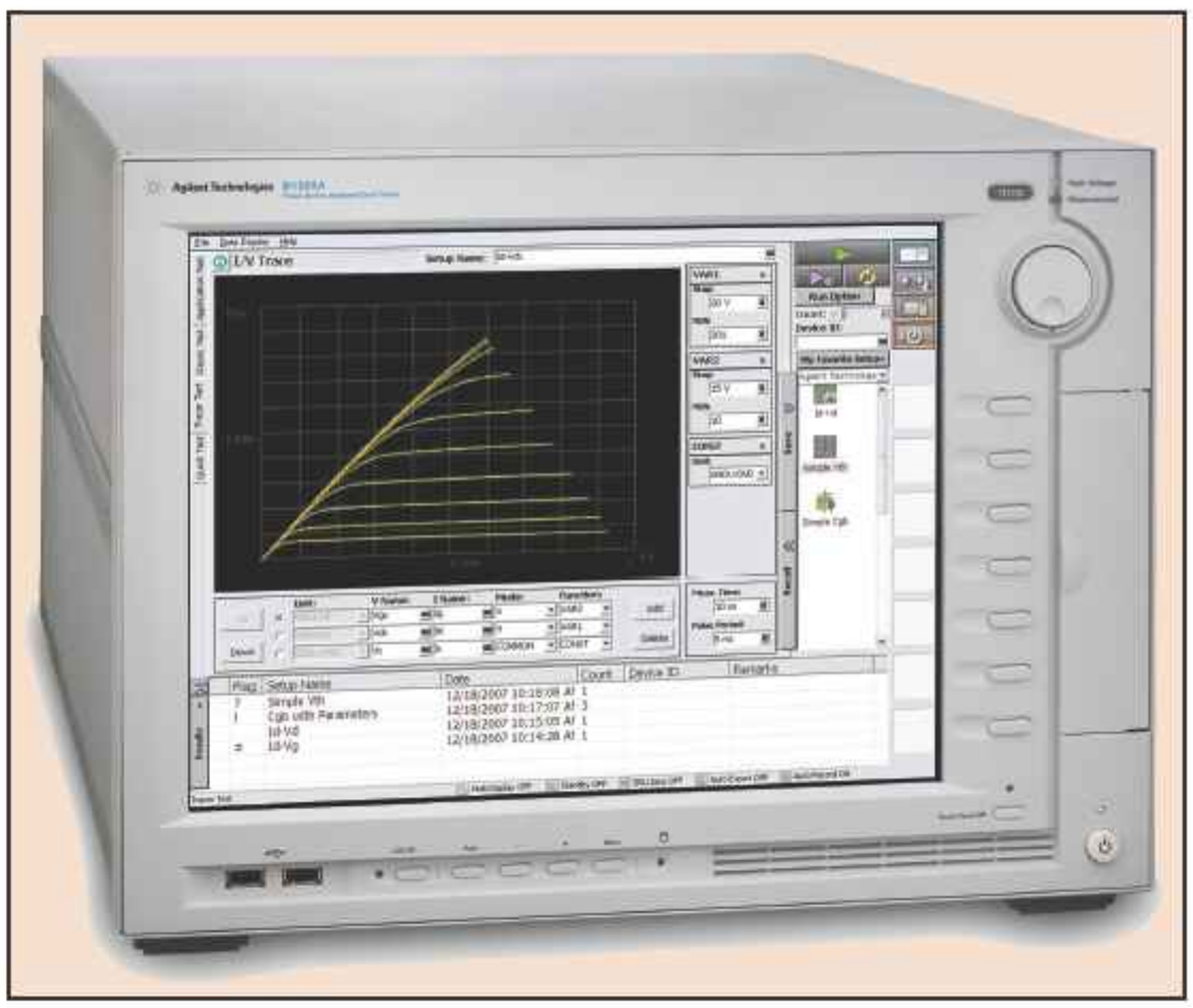
The B1505A can measure currents up to 40A and display the results in various formats, including semi-log or log-log graphs with extracted parameters. The interlock feature ensures safe operation by preventing electrical shock even with the increased current capacity. The module selector supports automatic switching between multiple types of SMU; this allows the measurement of key parameters, such as on-resistance and breakdown voltage in a single measurement sequence. The tracer test mode, which now covers 40A as well as newly developed simultaneous sweep range control in positive and negative directions, provides intuitive and easy-to-use measurement with the same look and feel of the existing B1505A.

Also provided is a new socket module to support the test adapters widely used by conventional curve tracer users, allowing reduced migration costs when replacing old curve tracers with the B1505A.

Key features of the B1505A include:

- device characterization at 3000V and 40A in a single instrument with accuracy down to sub-pA;
- new accessories that allow clean and safe connection for 40A measurement for packaged devices and on-wafer devices;
- capacitance-voltage (CV) measurements with high DC bias up to 3000V;
- a new accessory that supports test adapters widely used in conventional curve tracer; and
- simultaneous sweep range control in positive and negative directions.

**www.agilent.com/find/B1505A**



**Agilent's new B1505A Power Device Analyzer/Curve Tracer for characterizing devices up to 3000V and 40A .**

# AXT's Q4/2009 sales up year-on-year

## Restructuring and raw materials sales drive increased profit

For 2009, AXT Inc of Fremont, CA, USA, which manufactures gallium arsenide, indium phosphide and germanium substrate and raw materials, has reported revenue of $55.4m, down 24% from 2008's $73.1m. Although gross margin rose from 24.6% to 25.1%, the firm's net loss increased from $689,000 to $1.9m.

However, for fourth-quarter 2009, revenue was $17.8m, up 6% on $16.8m in Q3 and 14% on $15.6m a year ago (contrasting with Q3 being down year-on-year).

This growth has been driven by raw materials sales almost tripling from Q3's $1m to $2.8m (though still only just over half the $5.3m a year ago). Germanium substrate revenue also rose slightly from $1.8m to $1.9m (almost triple the $684,000 a year ago).

In contrast, gallium arsenide revenue fell 5% from Q3's $13.3m to $12.6m (though this is up 38% on $9.1m a year ago).

Indium phosphide revenue fell 25% from Q3's $688,000 to $513,000 (though this is still up 8% on $473,000 a year ago).

Operating expenses have been cut from $4.1m a year ago and $3.7m in Q3/2009 to $3m (contributing to full-year expenses falling from $18m in 2008 to $15.5m in 2009).

"Our successful restructuring efforts and ongoing manufacturing efficiency improvements, coupled with stronger-than-expected raw materials revenue, resulted in solid financial results that were ahead of our expectations," comments CEO Morris Young. Net income improved to $2.8m, compared with $2.1m in Q3 and a loss of $2.4m a year ago.

"Our qualifications with new and returning customers continued to progress well, as we have committed increased funding to our engineering and customer support efforts," says Young. "We are also seeing positive long-term trends in each of our key markets that are likely to support our growth in 2010 and beyond," he adds. "AXT is well positioned to accommodate this increasing demand with minimal capital requirements, and we believe that our unique structure will further separate our capabilities from our competitors as all of these markets develop."

For first-quarter 2010, AXT expects the positive demand environment for substrates to offset normal seasonality to yield revenue of $17.8–18.5m (flat to up 4% on Q4/2009).

**www.axt.com**

# SAFC Hitech expanding TMG capacity in UK plant

Chemical manufacturer SAFC Hitech of St Louis, MO, USA (a business segment of SAFC within the Sigma-Aldrich Group) says it plans to invest $2m (about £1.2m) to expand production of trimethylgallium (TMG) at its manufacturing plant in Bromborough, Wirral, UK.

The expansion is supported by Wirral Council and The Mersey Partnership (TMP), which helped to secure additional funding in the form of a £300,000 Grant for Business Investment (GBI) from the Northwest Regional Development Agency (NWDA) as part of 'Solutions for Business', the UK Government's package of publicly funded business support designed to help companies start and grow.

The investment is expected to enable SAFC Hitech to strengthen its position as a global supplier of TMG and satisfy the growing demand for the material in the production of high-brightness LEDs (HB-LEDs) for use in applications such as backlighting in flat-panel television sets and energy-efficient lighting.

The trends to reduce energy consumption and extend energy efficiency are driving the global electronics industry to provide more energy-efficient products and systems, says SAFC Hitech. Demand in the lighting industry in particular has seen improvement with the deployment of LEDs to replace incumbent incandescent light bulbs, fluorescent lighting and compact fluorescent lamp (CFL) derivatives. The industry is hence at the start of a phase of increasing mass-production of HB-LEDs.

TMG has been manufactured at the Bromborough facility for many years, primarily to supply the global semiconductor industry. However, as TMG also fulfills the technical criteria for devices designed for the LED, laser, communication and other markets, the boom in demand for LEDs has led SAFC Hitech to conclude that expanding the plant — with its expertise and specific manufacturing knowledge for the process — was required to meet demand.

"Expanding our TMG capacity not only draws on our Bromborough facility's core competencies, but also reinforces Sigma-Aldrich's overall strategy of leveraging proprietary technologies and capabilities into new, fast-growing market segments, thus differentiating ourselves and our materials offerings through technical innovation," comments Dr Geoff Irvine, VP business development at SAFC Hitech. "This investment is expected to accelerate the delivery of TMG to a growing market position and reinforce our position as a leading global manufacturer and distributor for the growing LED market worldwide, as well as create jobs in the area, which is positive news given the current economic climate."

**www.safchitech.com**

# Umicore completes new US germanium substrate plant

Materials technology firm Umicore of Brussels, Belgium has completed construction of its new germanium substrate production facility in Quapaw, OK, USA, adjacent to the firm's existing site. Construction was started in July 2008.

The 40,000 square foot facility is now undergoing process start-up and qualification runs. The new substrate facility is on the same campus as the Umicore germanium optics and high-purity chemicals operation for the US market and will be integrated in the existing IS014001, 2004 system during 2010. Umicore says that this allows for a completely integrated supply chain operation, emphasizing prompt internal recycling (minimizing inventory stocking requirements of valuable germanium metal).

The production operation is modeled on Umicore's Olen facility in Belgium, which has supplied millions of substrates for space and terrestrial photovoltaic applications.


**Side view of Umicore's new facility for germanium wafers in Quapaw.**

The firm says that its new plant in Quapaw embodies proven equipment and an advanced product tracking system.

"With Quapaw in addition to Olen, our total installed annual production capacity stands at 1 million germanium wafers (4" equivalent)," says Carl Quaeyhaegens, general manager of Umicore's worldwide substrates business line. "With our two Ge wafer plants in Europe and the USA, we're now in an excellent position to meet market demand for the foreseeable future," he adds.

Germanium wafers are a core component of triple-junction III-V high-efficiency solar cells used on the vast majority of satellites launched today. Triple-junction solar cells based on Ge wafers are also widely applied in terrestrial concentrated PV systems (CPV), which are emerging for areas with high direct sunlight irradiation (DNI).

www.substrates.umicore.com

# IQE rebounds by 46% to record £31.2m revenue in H2/09

For full-year 2009, epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK has reported revenue of £52.7m, down 12.9% on 2008's £60.5m. However, the industry-wide inventory adjustments that led to first-half 2009 revenue of just £21.4m was followed by a strong recovery of 46% sequential growth to a record revenue of £31.2m in the second-half (up 3% on second-half 2008's £30.3m).

The rapid destocking that began in fourth-quarter 2008 caused a severe reduction in volumes across all primary markets, says IQE. The impact continued into 2009, but started to ease towards the end of the first half. Demand normalized in July and continued strongly throughout the second half as IQE returned rapidly to high volumes. This was a significant achievement on the back of a major cost-reduction program, comments chief executive Dr Drew Nelson. About 80% of revenue in full-year 2009 came from the wireless market, compared with 15% from optoelectronics and just 5% from silicon-based microelectronics.

Despite the lower volumes, full-year gross margin (before exceptional items) improved from 2008's 19% to 22%, reflecting strong cost control and the benefit of improved efficiencies as a result of the restructuring in 2008.

"2009 was a year of strong progress against the group's strategic, operational and financial objectives, despite the tough economic environment," says Nelson.

High operational gearing and tight cost control delivered second-half earnings before interest, tax, depreciation and amortization (EBITDA) of £6.1m, so full-year EBITDA recovered to £8.1m (almost level with 2008's £8.4m, before exceptional costs and cash flows relating to relocation and restructuring in 2008). Although still down on 2008's £4m, operating profit of £3m was driven by £3.9m in second-half 2009 alone (up from £2.4m in second-half 2008), more than offsetting the £0.8m operating loss in first-half 2009.

Full-year capital expenditure was £1.4m, returning to normal maintenance levels after 2008's £6.6m following the conclusion of 2008's major capital investment program.

Strong operating cash flow and low capital expenditure contributed to a significant improvement in free cash flow (net cash flow before financing activities and debt service) from £0.7m in 2008 to £3.7m in 2009 (before exceptional items), as free-cash absorption of £1.3m in the first half was followed by free-cash generation of £5m in the second half. Net debt has been reduced from 2008's £18.1m to £14.9m (including a reduction of £4.1m in second-half 2009).

**2009 was a year of strong progress against the group's strategic, operational and financial objectives, despite the tough economic environment**

"We demonstrated a high degree of operational and financial resilience through a challenging year," says Nelson. "This positions us well to continue to grow our market share," he adds.

Second-half 2009 operational highlights included:

- fulfilling the goal of achieving qualification with all of the major wireless chip makers (putting IQE in a very strong position to continue to grow its market share organically and mitigating customer risk);
- developing significant intellectual property (IP), including patents relating to solar power and advanced electronics; and
- completing the acquisition of NanoGaN Ltd of Bath, UK, bringing patented IP (including proprietary nanocolumn technology for producing high-quality gallium nitride), accelerating progress in IQE's technology roadmap for solid-state lighting (high-power LEDs for residential and commercial lighting) and blue/green laser applications (projection systems for mobile phones, digital cameras and office applications).

IQE continued investment in R&D throughout the downturn, points out Nelson, highlighting a rise from £1.5m in 2008 to £2.3m in 2009 in development expenditure, relating to the qualification of new wireless products and the development of new solar and GaN products. "We now have a product range that addresses almost all of the rapidly growing markets for compound semiconductor materials," he adds.

"I am extremely pleased with our progress on developing intellectual property for the solar power and advanced electronics markets," says Nelson. Such development activities are expected to generate increased sales as projects are completed in the near future. "These advances are keeping us at the forefront of emerging markets, and give me confidence that we will emerge as a clear leader as these markets move from development phase into production," he adds.

**We now have a product range that addresses almost all of the rapidly growing markets for compound semiconductor materials**

"We continue to make excellent progress in our core wireless business, whilst at the same time are building an IP-rich advanced semiconductor 'power house' that is uniquely positioned to take advantage of the high-growth markets that are rapidly emerging in areas such as solid state lighting (SSL), concentrating photovoltaic (CPV) solar cells and consumer electronics," believes Nelson. "We are confident that IQE is well positioned to achieve continued growth in sales in 2010."

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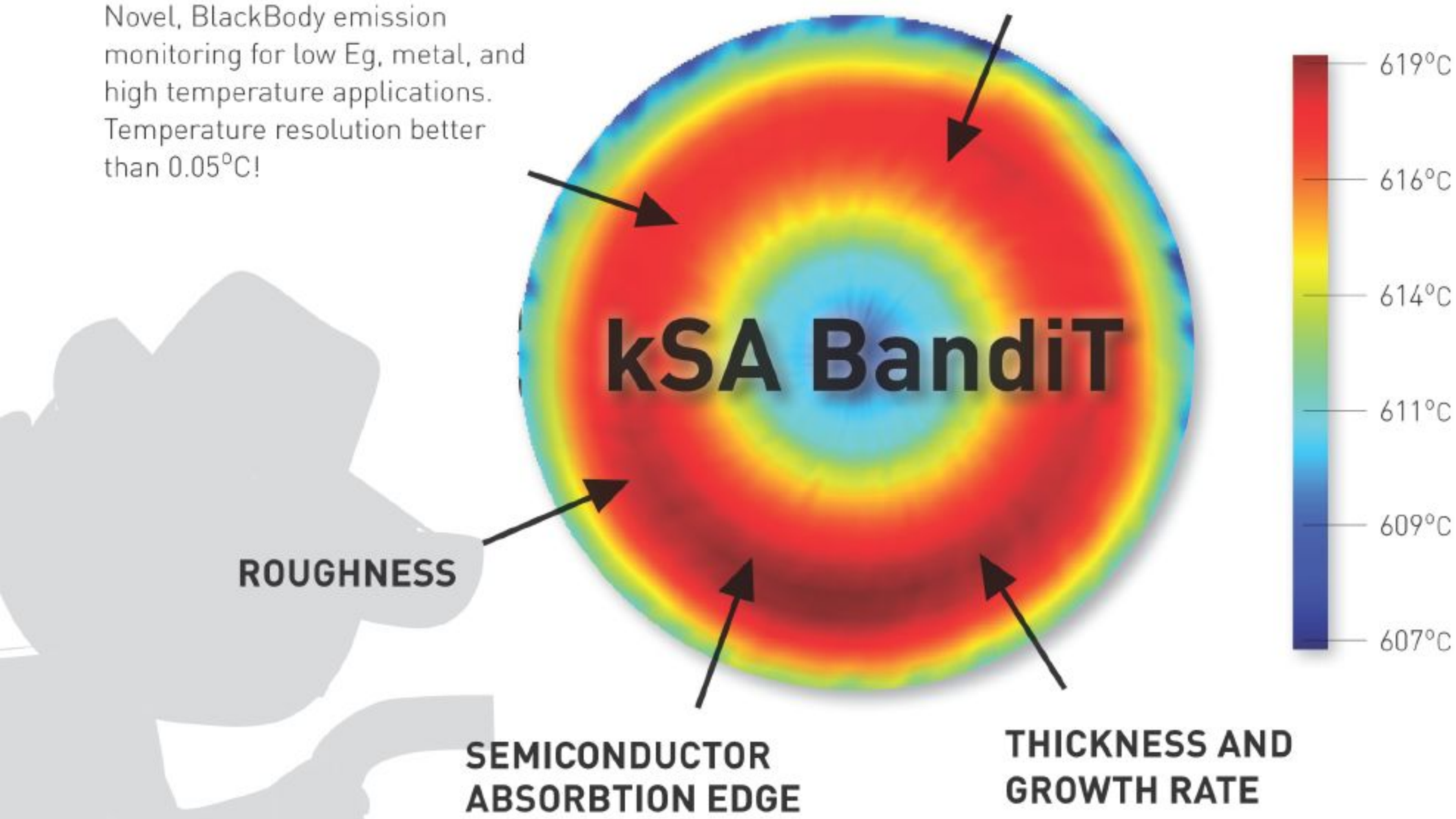


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# Veeco's MOCVD revenue more than doubles sequentially as LED makers ramp up for backlighting & general lighting

For full-year 2009, epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview NY, USA has reported revenue of $380.1m, down 14% on 2008's $442.8m. However, this was due to Data Storage process equipment revenue almost halving and Metrology revenue falling 20%, while LED & Solar process equipment revenues rose 24% (from $165.8m a year ago to $205m) despite the economic downturn.

In particular, fourth-quarter 2009 revenue was a record $146m, up 48% on Q3's $98.9m and up 33% on $110.3m a year ago. Of this, LED & Solar revenues were a record $98m, up 85% on Q3's $53m (as MOCVD revenue more than doubled sequentially) and up on $37.6m a year ago. Meanwhile, Data Storage process equipment revenue was $21m, down slightly from Q3's $21.5m and less than half the $45m a year ago. Metrology revenue was $27.2m, up 13% on Q3's $24m but down slightly from $27.7m a year ago.

For all three business segments, gross margin improved sequentially, boosting overall margin from 41.4% to 45% (ahead of the 43–44% guidance). Q4 operating income was $20.5m, up on just $3.5m in Q3 and a loss of $4m a year ago (in addition to an asset impairment charge of $73m). Non-GAAP earnings before interest, income taxes and amortization (EBITA) for LED & Solar was $27m. Offset slightly by corporate losses, overall non-GAAP EBITA were $25.1m, up on $8.9m in Q3 and $8m a year ago.

During the quarter, Veeco generated $37m in cash from operations, helping to boost cash balance from $109.4m to $148.6m.

In Q4/2009, orders were $262.2m, up 16% on Q3's record $226m and nearly triple the $88.5m a year ago. This boosted 2009 orders to $639.5m (up 50% on 2008's $424m), including LED & Solar orders of $440.8m (up 175% on $160.2m a year ago).

"We continued to see strong MOCVD demand as LED makers ramp production for laptop and TV backlighting as well as general illumination," says CEO John R. Peeler. While Q4 Data Storage orders more than tripled sequentially to $53m and Metrology orders of $32m were the best for six quarters, LED & Solar orders (though roughly level on Q3's $179.2m) have more than quadrupled from $43.6m a year ago to $177m, with 16 LED makers placing orders for TurboDisc MOCVD systems. "It is particularly gratifying to end 2009 with such strong bookings levels in all three Veeco businesses," Peeler stresses.

At the end of December, order backlog was a record $402m (including $317m for LED & Solar). "Veeco begins 2010 with unprecedented momentum," comments Peeler. "Business patterns in LED remain very strong in the first quarter, similar to what we experienced in the latter half of 2009, with multi-tool system orders being quoted to a large number of customers," he adds. "Leading global LED manufacturers are showing strong interest in our newly introduced TurboDisc K465i GaN MOCVD system." Veeco is increasing manufacturing capacity to meet demand, ramping up to 45 or more tools in Q1/2010 and about 70 by Q2, while putting plans in place to reach a capacity of 120 tools by Q4/2010 (according to market requirements). "Our highest priority is to satisfy our customers with on-time deliveries," Peeler says.

For Q1/2010, Veeco expects revenue to rise to $150–165m, operating income to rise to $23.7–29m, and EBITA to rise to $27.6–33m. It also expects all three business segments to grow revenue and profit for full-year 2010.

## MBE business records fourth consecutive year of revenue growth

Veeco Instruments says that its molecular beam epitaxy business had a strong close to 2009, resulting in a fourth consecutive year of revenue growth. The firm added that it is receiving worldwide recognition for its automated growth module cluster tool systems, including the recently introduced GEN10.

"We're energized that we had another strong year in our MBE business, despite the state of the worldwide economy," says Jim Northup, VP & general manager, Veeco MBE. "As the number one manufacturer of MBE, we continue to take a leadership role advancing this important technology," he adds. "Our successful introduction of the GEN10 for R&D applications last year is the most recent example of Veeco's technology leadership."

In Q4/2009, Texas Tech University purchased an automated GEN10 R&D system for its GaN research. "Veeco's components technology and proven nitride performance, along with the automation, were key factors in our decision," said professor Sergey Nikishin.

Veeco adds that the focus on maximum efficiency and the need for independent growth of multiple incompatible materials in a single system architecture has led to an increase in the ramp of orders of its cluster tool systems, including the GEN10 (the most recent addition to the product line) for R&D. Orders over the last year position the GEN10 into all major applications for MBE, including those related to III-Vs, oxides and nitrides, the firm adds.

**www.veeco.com/mbe**

# Toulouse Lab orders Riber MBE reactor for optoelectronics research

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has sold an MBE412 III-V reactor to the CNRS Toulouse System Analysis and Architecture Laboratory (LAAS) in France.

The new system complements the existing equipment base of the technology center, which is a member of the Basic Technological Research — RTB network (a partnership between France's CNRS and CEA).

Riber says that the system sold to LAAS is highly flexible and has a unique design for processing large-size substrates for III-V compound semiconductors. The reactor should help to increase LAAS' research capabilities in the optoelectronic GaAs field and consolidate work on photonic components as well as their integration into a system. Riber adds that it should also allow the design of innovative devices devoted to nano-photonics, quantum well and box components, advanced laser sources such as vertical-cavity surface-emitting lasers (VCSELs), and photonic-crystal laser diodes.

**The reactor should help to increase LAAS' research capabilities in the opto-electronic GaAs field and consolidate work on photonic components**

The MBE412 system, which will be accessible to the community as part of the RTB network, should offer the R&D resources to meet the challenges of micro-nano-technology and of nanoscience research, Riber concludes.

www.riber.com

IN BRIEF

## Indian research institute orders Riber's Compact21 MBE system for GaN

Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has received an order for its Compact21 gallium nitride (GaN) research system from a major research institute in India. Riber did not disclose the customer's name.

The system will be used to research blue and green nitride LEDs and to develop new MBE-based industrial applications.

In January, Riber said sales of its research machines reached a record €10.1m in 2009 (up 26% on 2008's €8.1m). In particular, 14 MBE systems were dedicated to research centers, including 10 sold in second-half 2009.

# Aixtron reports 2009 revenue up 10% to a record €302.9m

## Revenue to double to €600–650m in 2010

After reporting preliminary results for fourth-quarter 2009 on 3 February, deposition equipment maker Aixtron AG of Aachen-Herzogenrath, Germany has now reported final revenue of €117.9m (up 43% on €82m both in Q3/09 and a year ago).

This takes full-year 2009 revenue to a record €302.9m (up 10% on 2008's €274.4m, and the firm's first ever annual revenue above €300m). This is also well above the guidance of €280m (which had already been raised in late October from initial guidance of €200–220m).

The record annual revenue has been achieved despite the global recession, which had a particularly negative influence on Q1/2009. However, since Q1's low of €46.2m, revenues have increased quarter-on-quarter, to €56.7m in Q2 and €82.0m in Q3 then €117.9m in Q4.

Gross margin has risen from 43% a year ago and 42% in Q3/2009 to 47% in Q4, boosting full-year gross margin from 41% in 2008 to 44% in 2009.

Reflecting the operating leverage effect from increased volumes, a more favorable average $/€ exchange rate and strong operating income, earnings before interest and taxes (EBIT) in Q4/2009 was €33.7m (a margin of 29% of revenue), doubling from Q3's €16.7m (20% margin) and more than quadrupling from €7.4m (9% margin) a year ago. Full-year 2009 EBIT was €62.7m (21% margin), almost doubling from €32.5m (12% margin) in 2008.

Net profit in Q4/2009 was €24.4m, more than double Q3's €11.6m and up from €4.1m a year ago. Full-year net profit almost doubled from 2008's €23m to €44.8m (15% of sales).

"After a very difficult start to the year, caused by fiscal uncertainty and recessionary fears at that time, fiscal year 2009 has turned out to be one of the best years in the company's history," comments president & CEO Paul Hyland. "The forward-looking decisions we made more than five years ago — namely to re-engineer our system technology into configurable modules and the decision to re-engineer our manufacturing processes and supply chain structure — have played a decisive part in our ability to react quickly and profitably to the rapid and positive changes in 2009 market conditions," he adds.

Q4 equipment order intake was a record €163.3m, up 39% on Q3's record €117.6m (following sequential increases from Q2's €57.8m and Q1's low of €31.2m) and more than quadruple €40.6m a year ago. Record full-year order intake of €370.1m is up 48% on €250.8m in 2008 (during which revenue, in contrast, fell from quarter to quarter).

During 2009, order backlog hence almost doubled from €105m a year ago to a record €203.8m. After revaluation at $1.50/€ as of 1 January 2010, this is still a 'very solid' €190.9m (all shippable in 2010).

Aixtron's management hence believes that, for full-year 2010, revenue will double to €600–650m and EBIT margin will rise to 25%.

"Looking into 2010 and beyond, we will, once again, make the necessary forward-looking investment decisions to ensure that we have the appropriate new technology and infrastructure in place to ensure that Aixtron remains the leading player in this marketplace during a period of projected growth," Hyland says.

The management board and supervisory board of Aixtron AG is to propose to its shareholders at the general meeting on 18 May to convert its legal form from a German AG (Aktiengesellschaft) to a European company (Societas Europaea, SE) with the name Aixtron SE. The firm will continue to have its registered office in Herzogenrath.

"The decision to convert Aixtron AG into an SE structure is motivated by the increasingly international nature of our business and the potential flexibility that comes with a SE conversion," says Hyland.

www.aixtron.com

## Lattice Power orders tools for backlighting

Aixtron says that in Q4/2009 it took one of its largest ever single orders from China: for several CRIUS (31x2"-wafer) and AIX 2800G4HT MOCVD (42x2"-wafer) production systems from existing customer Lattice Power of Nanchang, Jiangxi, China for the growth of high-power InGaN-on-silicon LEDs.

"It quickly became clear that Aixtron was the company that could deliver this large quantity of high-performance production tools to our tight schedule," says Lattice Power's chairman & CEO Sonny Wu. "Aixtron's delivery and support commitment secured our fast expansion plan for LCD backlighting and general lighting business," adds executive VP Dr Bo Lu.

"We're committed to provide full support for Lattice Power growth and expansion," says Aixtron's Dr Bernd Schulte. "They're one of the best LED contenders, with strong technology on GaN-on-Si."

# Aixtron's new-generation AIX G5 hits productivity targets at Epistar

Deposition equipment maker Aixtron AG of Aachen-Herzogenrath, Germany says that its next-generation MOCVD platform AIX G5 HT has demonstrated high-quality gallium nitride (GaN) deposition at very high growth rates and high pressure above 600mbar, as well as superior GaN/InGaN uniformities. The epitaxial runs were performed at Epistar Corp in the Hsinchu Science-based Industrial Park, Taiwan consecutively without reactor baking or swapping of any parts. The reactor is now being transferred into mass production.

Aixtron claims that, based on its proven Planetary Reactor design, the AIX G5 HT provides the industry's largest wafer capacity available (56x2"/14x4"/8x6") and has revolutionary new reactor design features that allows high growth rates and consecutive runs without baking or swapping of parts, more than doubling throughput compared to the previous-generation system.

The firm says that the new reactor design provides high process flexibility combined with superior process stability. It also claims that AIX G5 HT systems provide the fastest time to production with the highest reproducibility from tool-to-tool, enabling a faster production ramp up compared to other reactors, with easy copy-and-paste process transfer (a key factor in a rapidly booming market with limited numbers of available process experts).

"Aixtron was committed to the challenging targets for the new reactor when we started our cooperation," comments Epistar's president Dr Ming-Jiunn Jou. "The uniformities seen so far have given us confidence to significantly improve our production yield on this new MOCVD reactor. We are now very keen to bring this new tool into production and to benefit from its improvements," Jou adds.

"I am very pleased to see this fast progress at Epistar, as it is in accordance with our expectations," says Gerd Strauch, VP corporate product design & engineering, and responsible for Planetary Reactor Development at Aixtron. "It confirms the excellent target-oriented design of our new reactor chamber, and it is a proof of our advanced CFD modelling and system qualification at our own laboratory," he adds. "We have successfully transferred the epitaxial growth performance from our laboratory 1:1 to the system at Epistar's site," Aixtron's Strauch concludes.

www.epistar.com.tw
www.aixtron.com

# Tekcore orders multiple new-generation AIX G5 HT MOCVD systems for HB-LED making

Aixtron says that, to expand its high-brightness LED (HB-LED) manufacturing capacity, Tekcore Co Ltd of Taiwan has placed a multiple order for its latest AIX G5 HT MOCVD system.

The order was received shortly after Aixtron announced the launch of its next-generation MOCVD systems AIX G5 HT and CRIUS II. Aixtron says that it has already received multiple purchase orders for tools of both technologies.

"With the introduction of our new innovative technologies in our next-generation platform, the AIX G5 HT, we provide a revolutionary new reactor design to our customers that enables more than a doubling of productivity compared to the previous MOCVD generation," says Dr Rainer Beccard, VP marketing.

# Keithley adds ultra-fast current–voltage module to semiconductor characterization system

Keithley Instruments Inc of Cleveland, USA has introduced its Model 4225-PMU Ultra Fast I-V Module, the latest addition to its range of instrumentation options for its Model 4200-SCS Semiconductor Characterization System.

The 4225-PMU is useful for characterizing III-V materials such as gallium nitride and gallium arsenide, says the firm.

The module integrates ultra-fast voltage waveform generation and current/voltage measurement capabilities into the 4200-SCS's test environment to deliver what the firm claims is the industry's broadest dynamic range of voltage, current, and rise/fall/pulse times. Furthermore, the Model 4225-PMU makes ultra-fast I-V sourcing and measurement as easy as making DC measurements, says Keithley. Its wide programmable sourcing and measurement ranges, pulse widths, and rise times make it well-suited for applications that demand both ultra-fast voltage outputs and synchronized measurement.

Unlike previous solutions, which required up to three different test stands to characterize a device, material, or process thoroughly, the Model 4225-PMU's broad dynamic range allows users to characterize the full range of materials, devices, and processes with a single set of instrumentation. It can be configured to handle all three measurement types: precision DC I-V (Model 4200-SMU), AC impedance (Model 4210-CVU C-V Instrument), and ultra-fast I-V or transient I-V (Model 4225-PMU).

Keithley adds that each 4225-PMU module provides two channels of integrated sourcing and measurement, but takes up only one slot in the nine-slot chassis. Each chassis can accommodate up to four modules for a maximum of eight ultra-fast source/measure channels. Each channel combines high-speed voltage outputs (with pulse widths ranging from 60ns to DC) with simultaneous current and voltage measurements. The module provides high-speed voltage pulsing with simultaneous current and voltage measurement, at acquisition rates of up to 200 megasamples/second (MS/s) with 14-bit analog-to-digital converters (A/Ds), using two A/Ds per channel (four A/Ds per card). Users can choose from two voltage source ranges (±10V or ±40V into 1MΩ) and four current measurement ranges (800mA, 200mA, 10mA, 100μA).

The Model 4225-PMU can be equipped with up to two optional Model 4225-RPM Remote Amplifier/Switches, which provide four additional low current ranges. They also reduce cable capacitance effects and support automatic switching between the Model 4225-PMU, the Model 4210-CVU, and other SMUs installed in the chassis. The Model 4220-PGU Pulse Generator Unit, which offers a voltage-sourcing-only alternative to the Model 4225-PMU, is also available.

Together, the 4225-PMU and 4225-RPM provide all the tools necessary to perform a broad array of applications that no other single instrument chassis can support, says Keithley.

Application areas include:

- Characterizing compound semiconductor devices and materials. The Model 4225-PMU allows setting a pulse offset voltage so measurements can be made from a non-zero value, for investigating the amplifier gain or linearity of a device.
- General-purpose ultra-fast I-V measurements. Pulsed I-V testing has a wide variety of uses, including preventing device self-heating by using narrow pulses and/or low duty cycle pulses rather than DC signals.
- CMOS device characterization. The 4225-PMU/4225-RPM's high speed voltage sourcing and current measurement sensitivity make them well-suited for CMOS device characterization, including high-k devices and advanced CMOS technologies like silicon-on-insulator (SOI).
- Non-volatile memory device testing. The system's KTEI software includes toolkits for testing both flash and phase change memory (PCM) devices. The system is well-suited for testing single memory cells or a small array, such as in R&D or process verification.
- NBTI/PBTI reliability tests. The optional Model 4200-BTI-A Ultra-Fast BTI Package combines all the hardware and software needed to implement all known BTI test methodologies with the fastest, most sensitive measurements available. In addition, Automatic Characterization Suite (ACS) software supports full wafer- and cassette-level automation and includes NBTI/PBTI test libraries with easy-to-use GUIs.

The Model 4225-PMU can generate four types of sweeps: Linear Sweep, Pulsed, Arbitrary Waveform, and Segment ARB (patent pending). The Segment ARB mode simplifies creating, storing, and generating waveforms made up of up to 2048 user-defined line segments for exceptional waveform generation flexibility.

An optional multi-measurement performance cable kit connects the Model 4200-SCS to a prober manipulator, simplifying switching between DC I-V, C-V, and ultra-fast I-V testing configurations, eliminating the need for re-cabling, and enhancing signal fidelity.

The price of the Model 4225-PMU is $19,000. A typical configuration of one Model 4225-PMU and two Model 4225-RPMs costs $25,000. The Model 4220-PGU (voltage source only) costs $13,000.
All three products will be available from May.

**www.keithley.com**

# Tegal sells thin-film etch and PVD assets to OEM Group

## Retains DRIE tools while pursuing strategic alternatives

Tegal Corp of Petaluma, CA, USA, which makes plasma etch and deposition systems for the fabrication of micro-electro-mechanical systems (MEMS), power ICs and optoelectronic devices, has sold its legacy thin-film etch and physical vapor deposition (PVD) product lines to OEM Group Inc of Gilbert, AZ, USA for up to $3m (of which a maximum of $1m is subject to OEM Group's achievement of certain target sales levels). OEM Group provides new and remanufactured front-end equipment to manufacturers of silicon devices as well as MEMS, LEDs, RFID devices, power devices, and photovoltaic (with more than 1300 projects completed since 1999).

Included in the sale are the Tegal 900ACS, 980ACS, 6500 HRe- and 6500 Spectra series thin-film etch products, along with the Sputtered Films Endeavor and AMS PVD series products, intellectual property and process know-how. OEM Group will bring continued global support to existing Tegal thin-film etch and PVD customers, and will integrate the technologies into their LEGENDS portfolio, which already includes the MRC Eclipse (PVD), AG Heatpulse (RTP), Lam AutoEtch (etch), and Varian Sunset (Implant) product lines.

"OEM Group is the perfect company for these Tegal products, which represent an important legacy in semiconductor capital equipment and process technology," says Tegal's president & CEO Thomas Mika. "We are pleased that we have been able to place these products and many of the skilled employees associated with them in a company whose business model is built on the continued sales, service and support of late-life-cycle technology into new and existing customers and markets," he adds.

OEM Group is also a global re-manufacturer of systems, chambers, and conversions for the Applied Materials Endura, Centura and P5000; Mattson Aspen II; and Novellus Concept One and Two platforms (including installation, start-up, and warranty support).

"With the addition of the Sputtered Films technologies to our own PVD focus, we believe we will have an unmatched product offering," says OEM Group's president Wayne Jeveli. "Over the course of more than 30 years, Tegal's brand has symbolized innovation, quality and customer focus. We believe these attributes will continue on for many years at OEM Group."

Tegal says that the sale of the thin-film etch and PVD product lines represents a step in the execution of its strategy (announced in mid-2009) to pursue strategic alternatives for the firm. Meanwhile, Tegal intends to continue to sell and support its full range of deep reactive ion etch (DRIE) systems acquired from Alcatel Micro Machining Systems (AMMS) in September 2008, which are critical enablers for etching silicon and dielectric films found in the MEMS, bio-tech, power IC, optoelectronic, and 3D-IC (interconnect) markets. Tegal's DRIE tools are used in MEMS foundries and commercial high-volume manufacturing lines, as well as many academic and commercial R&D laboratories worldwide.

**www.Tegal.com**

# IAF buys reactor for GaN-on-SiC

Aixtron says that in fourth-quarter 2009 it received an order from long-time customer Fraunhofer Institute for Applied Solid State Physics (IAF) in Freiburg, Germany for an AIX 2800G4 HT MOCVD reactor.

To be supplied in 11x4"-wafer configuration, the system will be used for gallium nitride on silicon (GaN-on-SiC) for high-power, high-frequency applications to enable commercialization of GaN devices in the near future. Aixtron's support team will install and commission the reactor in third-quarter 2010.

"We have already made a good start on the development of GaN-on-SiC transistors on our existing Aixtron reactors. However, we now need to significantly expand our capabilities," says Dr Klaus Koehler, deputy department head of IAF's Epitaxy Group. "The new reactor will be used for the growth of AlGaN/GaN-based HEMT structures on 4" semi-insulating SiC substrates," he adds. "With this new system we will achieve the highest uniformity and crystal quality, which is necessary for the fabrication of AlGaN/GaN-based power amplifiers and MMICs."

"The AIX 2800G4 HT will enable us to readily scale up to 11x4" wafers and to 6x6" at a future point," says Koehler. "It has all the characteristics we need such as uniformity and efficiency in a production setting, as required for GaN-on-SiC transistors for high-power, high-frequency commercial applications. In addition, it has the scope to provide us with a GaN-on-Si epiwafer capability, should the application require that."

"The long-standing fruitful scientific cooperation with the IAF will have taken another key step when the AIX 2800G4 HT is delivered later this year," says Dr Frank Schulte, VP of Aixtron Europe. "The system will enable them to further optimize the performance and process technology of these devices."

**www.aixtron.com**

# SPTS' Q4/2009 orders up nearly 150% quarter-on-quarter

SPP Process Technology Systems Ltd (SPTS) of Newport, Wales, UK, the plasma etch & deposition equipment subsidiary of Sumitomo Precision Products Co Ltd (SPP), has announced bookings of nearly $35m in fourth-quarter 2009 from the entities acquired last year from Aviza Technology Inc of Scotts Valley, CA, USA.

SPTS was formed by SPP last October to merge predecessor firm Surface Technology Systems plc (STS) together with Aviza's Newport-based single-wafer process equipment subsidiary Aviza Technology Ltd (ATL) and Aviza's Scotts Valley-based Thermal Products business.

The new orders included etch, chemical vapor deposition (CVD), and physical vapor deposition (PVD) single-wafer tools for customers in the MEMS (micro-electro-mechanical system), TSV (through-silicon via), and compound semiconductor sectors booked by SPTS' Newport-based UK Division, as well as furnaces, upgrades, and an atmospheric-pressure chemical vapor deposition (APCVD) system booked by the newly formed Thermal Products Division. Combined with the orders received by the former STS business unit of SPTS, total fourth-quarter bookings were about $50m, up almost 150% quarter-on-quarter from Q3/2009 in combined orders. SPTS says that the synergies of the acquisition were immediately apparent, with the firm receiving its first cross-over order of PVD equipment from a traditional STS customer.

"We are pleased with the initial positive customer response to our acquisition, which confirms the vision of SPP in forming SPTS," says SPTS' president & CEO William Johnson. "As we continue to focus on our customers in the MEMS, compound semiconductor, TSV/advanced packaging, data storage and power device industries, our goal is to provide both R&D and production solutions for today and tomorrow," he adds. "It is particularly gratifying to see the positive response from our thermal products customers, as our Scotts Valley team reconfirms the Thermal Products Division as the factory-certified source for parts, upgrades, support and new thermal products systems with Watkins-Johnson, SVG, and Aviza lineage."

www.stsystems.com

# Plasma-Therm celebrates first year of independence

On 19 February, in the presence of Florida Governor Charlie Crist and St Petersburg's Mayor Bill Foster, Plasma-Therm LLC of St Petersburg, FL, USA celebrated its first year of independence. The firm also reported positive financial results for 2009.

"Our first anniversary celebration as an independent company coincides with the 35th anniversary of Plasma-Therm being in business," said CEO Abdul Lateef. "Our commitment to our customers and technology has remained our core focus throughout the evolution of Plasma-Therm," he added. "We are grateful for the support provided by city, county and state officials to small business growth, especially during a struggling economy. This support has allowed us the chance to maintain key technology development and the related high value jobs in the US."

"I congratulate Plasma-Therm on their first anniversary and for their success creating jobs for the people of Florida," commented Crist.

Plasma-Therm Inc was originally founded in March 1975, and sold to Swiss industrial conglomerate Unaxis (later re-branded Oerlikon) in 2000. In January 2009, Plasma-Therm went through a management buyout to separate from Oerlikon. The buyout was made possible through government support like the Qualified Target Industry (QTI) tax incentive program, supported by Governor Crist as part of Florida's strategic economic development platform.

**From left to right: Plasma-Therm's executive VP of sales & marketing Ed Ostan; Florida's Governor Charlie Crist, CTO Russ Westerman, COO Jim Pollock and CEO Abdul Lateef.**

Plasma-Therm manufactures plasma process equipment that caters to specialty semiconductor markets, including compound semiconductor, solid-state lighting, thin-film head, solar, and MEMS. The firm offers both dry etch and PECVD technologies, and has sale and service locations throughout North America, Europe and the Asia-Pacific.

Last November, Plasma-Therm announced the sale of a multi-module VERSALINE ICP production etch system to a major III-V foundry. The system is configured with three chambers for GaAs via-etch processing, resulting in high productivity, says the firm. The VERSALINE ICP modules also feature actively controlled source heating, which enables a stable process environment and reduces downtime due to maintenance. Additionally, the modules also incorporate fully integrated EndpointWorks for accurate and repeatable end-point process control.

www.plasmatherm.com

# OIPT launches spectrometer option to improve end-pointing on its etch and deposition tools

UK-based Oxford Instruments Plasma Technology (OIPT) has introduced its CCD1 Spectrometer system, which the firm says improves the end-pointing capability of its plasma etch and deposition tools.

Capable of providing both a process end-pointing capability and UV/vis spectrum capture, the CCD1 is available as a standard option on all new tools or as an upgrade option (dependent on system age, type, and configuration) for existing Oxford Instruments customers.

The CCD1 is a UV/VIS CCD spectrometer that can monitor a wide range of plasma emissions over the wavelengths 200–880nm. It can be used in one of two ways: process end-point detection via OIPT's PC2000 software, or full spectrum viewing and recording. OIPT says that this provides detailed plasma spectroscopy information, which can be used for monitoring the concentrations of species within the plasma. The spectra can also be compared to previous spectral data, for system monitoring, fault detection and potential fault classification.


**OIPT's CCD1.**

**www.oxford-instruments.com**

## Seminars & workshops

OIPT is to hold and co-host several seminars and workshops in conjunction with key research institutes and universities:

- 15–16 July — 'New Frontiers in Plasma Nanopatterning', hosted by The Molecular Foundry, Lawrence Berkeley National Laboratory, CA, USA (Semicon West week).
- 27–28 September — 'Dry processing for Nanoelectronics and Micromechanics: growth, deposition and etching', hosted by University of Freiburg/IMTEK, Germany.

OIPT also plans to hold a Seminar/Workshop in the UK, with the date to be confirmed.

Speakers will come from the host universities and from other institutes and industry, in addition to process and applications experts from OIPT.

IN BRIEF

## RASIRC appoints North American sales manager

Steam purification firm RASIRC of San Diego, CA, USA has appointed Brian Kingston as North American sales manager, responsible for sales of products and services for semiconductor, MEMS, nanotechnology, photovoltaics and other manufacturing applications. In addition, he will be directly responsible for setting up the new distribution channel featuring Matheson Tri-Gas in the USA.

With more than 12 years experience of semiconductor and solar industry businesses, Kingston was most recently a business manager of abatement at Applied Materials. Previously, he was product marketing manager for ATMI and North American regional manager for Delatech, where he managed a distributed staff of engineers. Kingston has a B.S. degree in business management and an MBA in marketing, and has studied telecom engineering at Christchurch Polytechnic, New Zealand.

"Brian's strong background in the semiconductor equipment subsystem segment as well as his previous success in customer relationship building fits well with our focus on delivering innovative technology to the microelectronics market," says RASIRC founder & president Jeffrey Spiegelman. "As our products move from R&D to production, it is critical that our customer support also matures," he adds.

"RASIRC products have the potential to dramatically improve manufacturing processes in the microelectronics market," believes Kingston.

www.rasirc.com

# Meller Optics makes available sapphire wafer carriers perforated with custom patterns

Meller Optics Inc of Providence, RI, USA, which manufactures optics for defense, medical, laser and industrial markets, has made available a low-cost line of sapphire wafer carriers that are considerably stronger and more durable than quartz and other materials (since sapphire is second only to diamond in terms of hardness).

Meller's sapphire wafer carriers are designed for thinning semiconductor materials including GaAs and can be perforated with custom patterns for vacuum hold-down or delamination. Featuring Moh 9 hardness, Meller says that sapphire offers superior mechanical strength due to its off-axis crystal growth, which permits the custom fabrication of wafer carriers as thin as 0.018".

Available with diameters from 2" to 6" with flats and laser markings, Meller's sapphire wafer carriers are chip-, chemical-, scratch-resistant, and can withstand repeated use.

The sapphire wafer carriers are priced 30% less expensive than conventional perforated carries, claims the firm. Delivery is typically 4–6 weeks. Pricing and literature are available upon request.

www.melleroptics.com

# EVG ships wafer bonding systems to the University of Michigan's Lurie Nanofabrication Facility

Wafer bonding and lithography equipment maker EV Group (EVG) of St. Florian, Austria has shipped two wafer bonding systems (EVG 520IS and EVG510) to the University of Michigan's Lurie Nanofabrication Facility (LNF), a center for MEMS and microsystems research and a member of the National Nanotechnology Infrastructure Network (NNIN), which is supported by the National Science Foundation.

With a wafer bonder and aligner already installed at the facility, the new systems will increase the level of the university's overall MEMS research efforts by providing high-force wafer bonding capabilities, says EVG. The firm adds that the order is strategic, as it poises EVG for a long-term relationship with another major university with a strong MEMS research focus.

Installation of both bonding systems at the customer site is due to be completed in Q1/2010.

The bonders will be used for a wide range of MEMS-related research in fields such optoelectronics. Both systems offer high-force bonding capabilities enabling metal-to-metal bonding and specifically allow triple stack anodic bonding, says EVG.

"As a member of NNIN, we are always looking for the most advanced technical processing capabilities — not only for our own research efforts, but also in the interest of other research groups dedicated to advancing MEMS technology," said Professor Ken Wise of the University of Michigan and director of the Lurie Nanofabrication Facility. "Following thorough evaluation of a number of wafer bonding systems, we selected EVG's bonding solutions for their superior technology capabilities. The combination of EVG's demo results, strong support network and the affordability of their system were all critical to our decision."

www.EVGroup.com

# TDI wins $600,000 to boost solid-state lighting materials production

Oxford Instruments subsidiary Technologies and Devices International Inc (TDI) of Silver Spring, MD, USA, which develops hydride vapor phase epitaxy (HVPE) processes and techniques for the production of compound semiconductor materials including GaN, AlN, AlGaN, InN, and InGaN, has been awarded $600,000 by the USA's Maryland Energy Administration to expand its workforce and help to expedite broad industry adoption of energy-efficient LED lighting, as well as to better position Maryland to become a national leader in solid-state lighting materials and equipment manufacturing.

TDI says that the Clean Energy Economic Development Initiative award will enable it to hire three new scientists and engineers this year and put it on track to create dozens more direct and indirect high-tech jobs by 2015. It should also help to complete materials and process development and begin transferring the production technology to drive down manufacturing costs associated with LED lighting.

"This award will not only benefit TDI and Maryland, but also better position the USA to compete in the global solid-state lighting market," believes TDI's president Bernard Scanlan. "Governor O'Malley and his team are working to create jobs by putting Maryland on the road to benefit from emerging technologies that will create jobs, cut taxpayers' electricity bills, and reduce US dependence on foreign oil," he adds.

Aimed at the LED, high-efficiency laser, solar, and power IC devices markets, TDI's proprietary HVPE technology has allowed it to develop CrystalFlex, a prototype high-volume, industrial-scale manufacturing reactor for free-standing gallium nitride (GaN) materials. Collaborators include the University of Maryland as well as other US researchers and manufacturers.

The US Department of Energy (DOE) has identified the development of free-standing GaN substrates and their manufacture by HVPE as key technologies to enable reduced LED manufacturing costs with improved LED performance. TDI says that, upon project completion, its high-volume manufacturing equipment should permit increased US production of free-standing GaN substrates to meet growing global demand.

Federal studies have shown that 22% of all electricity consumed in the US is for lighting. The DOE forecasts that replacing incandescent light bulbs and fluorescent tubes with highly efficient LEDs would save taxpayers more than $17bn in annual energy costs and result in a 33% reduction in US electricity consumption relative to a scenario with no SSL on the market. The broad adoption of LEDs would also result in the need for 29 million fewer barrels of oil annually for electricity generation and reduce $CO_2$ gas emissions by 155 million tons, it is reckoned.

www.oxford-instruments.com

# TDI general manager appointed

TDI has appointed Neil Wester as general manager, responsible for overseeing product and process developments at Silver Spring.

With a Masters degree in Material Science and Engineering, Wester has extensive R&D and product development experience with key

players in the IC, solar, and optoelectronic material and device industries, including TDI's focus area of HB-LEDs.

# Ultratech launches lithography system for HB-LED manufacturers

Lithography and laser-processing system maker Ultratech Inc of San Jose, CA, USA has launched the Sapphire 100 lithography system for high-brightness light-emitting diode (HB-LED) manufacturing, designed to enable users to meet the growing demand for illumination products.

Ultratech says that demand is being driven by strong growth in LED backlighting applications, with even greater potential from the implementation of energy-saving LED-based solid-state lighting.

Illumination is expected to become the fastest-growing segment of the HB-LED market, growing at a compound annual growth rate (CAGR) of 36% from 2007 to 2012, according to market research firm Strategies Unlimited. Future growth in the LED lighting market is expected to come from a mix of sources, such as street and parking lights, and indoor residential and office applications. Potential annual energy cost savings are estimated to be $10–100bn per country. Building on this expectation, Ultratech says that it has designed the Sapphire 100 to provide competitive advantages for HB-LED manufacturing.

"Today, approximately 25% of electricity is used for lighting," says Doug Anberg, VP of advanced stepper technology. "As energy conservation efforts continue to increase, we expect lighting products with HB-LED technology to be in high demand."

Ultratech says that the Sapphire 100 was specifically designed to meet the wide range of lithography needs for HB-LED manufacturing. Building on the cost and performance advantages of the firm's 1500 platform, the Sapphire 100 offers the added advantage of Ultratech's patented Machine Vision System (MVS), which delivers alignment flexibility with significant advantages over standard alignment techniques, it is claimed.

Currently in beta testing, the production-ready Sapphire 100 system will be available for volume shipment in second-half 2010.

www.ultratech.com

# Taiwan's largest LED chip maker orders Sapphire 100 lithography system

Ultratech has received an order from Taiwan's largest LED chip maker for a Sapphire 100 LED lithography system, which is specifically designed and optimized for high-brightness LED manufacturing. Furthermore, the customer has given Ultratech a conditional commitment to purchase additional Sapphire 100 systems to meet its ramp requirements over the next few quarters.

The customer was not named but it says that, after integration of the first Sapphire 100 into its manufacturing line, the additional systems will be used to support its HB-LED capacity expansion plans.

"This strong commitment from a top-tier Taiwan customer reinforces the value Ultratech's new Sapphire 100 system provides to HB-LED manufacturers," said Doug Anberg, Ultratech's VP of advanced stepper technology. "HB-LEDs are expected to see strong growth over the next few years as they become increasingly integrated into the products we use in our everyday life," he adds. "Ultratech's systems are specifically designed to provide cost-of-ownership advantages for leading HB-LED manufacturing facilities around the world."

**High-brightness LEDs are expected to see strong growth over the next few years as they become increasingly integrated into the products we use in our everyday life**

www.ultratech.com

# UniLite SAT-approves Obducat tool

Obducat AB of Malmö, Sweden, which supplies systems based on nano-imprint lithography (NIL) and electron-beam lithography, says that, following several months in production use at Taiwan-based LED chip maker UniLite Corp (formerly Luxaltek), its Sindre400 system has received SAT-approval.

Launched in 2008, Sindre400 is Obducat's first fully automated tool for mass producing LEDs. The first machine was sold to UniLite.

"The SAT-approval means that UniLite confirms that our Sindre400 system meets the requirements for large-scale industrial production of LED components," says Obducat's CEO Lars Tilly.

www.obducat.com

Obducat's Sindre400 litho system.

# Jenoptik opens Korean laser center

After starting construction last July and moving in last November, Germany's Jenoptik Group has opened its new sales, application and service site in the southern Korean city of Pyeongtaek (Gyeonggi province, 70 km south of Seoul) in the presence of about 100 invited guests from business and politics as well as customers and partners in Asia.

The new center is part of the expansion of Jenoptik Korea Corp Ltd, which was founded last July as a partnership between Jenoptik AG (66.6%) and Telstar-Hommel Corp (33.3%), a long-standing Jenoptik joint venture partner in the Industrial Metrology division. "Without the close and intensive collaboration, we would not have been able to build the laser application center so quickly," said Jenoptik Group's chairman of the executive board Dr Michael Mertin and chief financial officer Frank Einhellinger in thanking Telstar-Hommel's president & CEO Buyng-Hoon Im.

A total of over 60 Jenoptik laser systems for various applications are currently in use in Asia, and 14 further systems have been commissioned and will be delivered or installed in the coming months. The firm says that JENOPTIK Korea Corp Ltd achieved its first successes more quickly than expected and has received new orders worth about €5m in recent months.

Covering 500m$^2$ (including 80m$^2$ of cleanroom) on a campus shared with Telstar-Hommel and costing $4.4m (€3.4m/Won 5.4bn), the new laser application center has initially been equipped with two laser systems for processes in the electronic as well as photovoltaics and flat-panel industries. The Jenoptik VOTAN Semi 300 is designed for machining wafers (Si, GaAs or SiC) and thus also for ultra-precise applications in cleanroom environments. The special separation process developed by Jenoptik — TLS-Dicing (where TLS = Thermal Laser Separation) — enables quick, efficient and damage-free separation of semiconductor wafers, says the firm. With the Jenoptik VOTAN Advanced laser system, the TLS process specifically addresses the photovoltaics and flat-panel industry for separating thin-film solar cells and display glass.


**Jenoptik's new laser sales, application and service site in Pyeongtaek, Korea, equipped with a VOTAN Semi 300 system for machining wafers.**

Customers and interested parties from across Asia in the areas of electronic, flat panel as well as photovoltaics and automotive can now test lasers and laser applications for their own production environments on site with their own materials. In addition to tests, together with Jenoptik engineers they can also develop individual processes on the systems, manufacture pilot runs and small batches, and commission feasibility studies. Also, in the coming months, Jenoptik plans to expand the application center with additional laser systems.

**The center has initially been equipped with two laser systems for processes in the electronic as well as photovoltaics and flat-panel industries**

With eight staff, Jenoptik Korea Corp Ltd is also in charge of all after-sales service in Asia together with other Jenoptik firms, e.g. in Japan. The Jenoptik Group currently has a total of about 150 staff in its own or in joint venture firms in Asia since, in addition to Korea, it is also present in China and Japan.

"This moves our process of internationalization a major step forward," said Mertin of the new center. "Direct market access and a trained service team are indispensable for complex systems," he added. "With the new center, we have laid the foundation for further business activities of all divisions of the Jenoptik Group."

According to preliminary figures, sales of the Jenoptik Group in Asia comprised just under 8% of the group's overall sales of about €470m in 2009; just under 10% of overall sales in the Lasers & Optical Systems segment were in Asia. "We see more great potential for the overall group in Asia," said Mertin. "With our direct local presence, we can now approach the market better and more intensively."

**www.jenoptik.com**
**/jenoptikGroup_Asia**

IN BRIEF

## Cascade sees Q4 revenue rebound to 2008 level

For fourth-quarter 2009, Cascade Microtech Inc of Beaverton, OR, USA, which provides production test products including unique probe cards and test sockets for wafers, ICs, packages, circuit boards and modules, as well as MEMS and LED devices, has reported revenue of $15.5m (not including revenue from the acquisition of Suss MicroTech Test Systems division, announced on 27 January). This is up 11% on $14m in Q3/2009 and 1% on $15.4m a year ago.

"We saw an increase in bookings and revenues to levels last seen in 2008," comments chairman & CEO Dr F. Paul Carlson.

Net loss has been cut from $31.4m a year ago (which included a non-cash impairment charge of $27.7m) and $1.4m ($0.11 per share) in Q3/2009 to $0.5m ($0.04 per share) (although that includes a $2.7m tax benefit that reflect tax law changes). Cash and investment balances fell by $1.5m to $33.6m.

"Our focus in 2010 is on achieving continued revenue growth and leveraging our earnings model," says Carlson. "Our previously announced acquisition of the Suss MicroTech Test Systems division in January is a key strategic move for Cascade Microtech which strengthens our product portfolio and should enable us to leverage the combined resources and competencies in 2010 and beyond," he adds.

For Q1/2010, Cascade forecasts revenue of $19–23m (including revenue from Suss MicroTech Test Systems).

**www.cascademicrotech.com**

## Jordan Valley grows 10% in 2009

For year-end 2009, Jordan Valley Semiconductors Ltd (JVS) of Migdal Haemek, Israel, which makes x-ray metrology tools for semiconductor and high-brightness LED (HB-LED) manufacturing, has surpassed its financial plan with 10% year-on-year revenue growth, rather than an anticipated 8% loss.

Despite difficult market conditions, JVS says the results were boosted by technology buys and repeat orders for its flagship product — JVX6200 multi-channel metrology tools for front-end-of-line (FEOL), back-end-of-line (BEOL) and wafer-level packaging (WLP) applications.

During 2009, JVS also launched three new products:

- The JVX7200, designed for challenging SiGe process monitoring, is claimed to be the first production-worthy tool combining HRXRD and XRR technology for strain, composition, and thickness measurement of SiGe stacks (a critical element of the sub-45nm technology nodes);
- The JVX6200RD enables high-level silicide and metal quality control, based on fast WAXRD technology;
- The QC3, based on well-established diffractometery technology, is a quality control solution for the emerging HB-LED market.

"Although 2009 was the company's most challenging year, we forged ahead with enhancement of our product line while practicing caution and control on cash management, in order to provide the semiconductor and HB-LED industries with more powerful metrology solutions," says CEO Isaac Mazor. "As of Q1/2010, we are already realizing rewards from this strategy."

**www.jvsemi.com**

## Testar expanding LED chip testing

Testar Electronics Corp of Taipei, Taiwan (which was founded in 2007 as a subsidiary of Chroma ATE Inc and specializes in testing and optimizing LED chips and ICs) has signed definitive agreements to become an independent entity and to receive an institutional investment from WI Harper Group.

The new investment will allow it to expand its operations and further establish its role in providing testing services for LED chip makers across Asia.

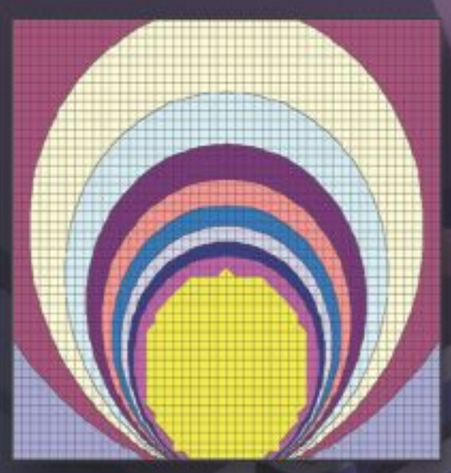
"LEDs are now used in street lighting, consumer electronics such as backlit TVs, vehicles and numerous unique applications," says Leo Huang, founder, CEO & chairman of Chroma and founder of Testar Electronics. "We recognized early on that LED chip manufacturers have limited testing capability and must comply with evolving standards. By outsourcing LED testing, customers benefit from increased efficiency and improved quality, ensuring that manufacturers can achieve competitive prices for their high-grade chips." The proliferation of LED-related products is making LED chip testing a new professional services sector, he adds.

"Testar is ideally positioned to take advantage of the vast business opportunity in LED testing services," believes WI Harper Group chairman Peter Liu. "The insatiable demand for LEDs is placing pressure on chip manufacturers to increase throughput and Testar plays a critical role in this strategic market."

Founded in 1993, WI Harper Group is a venture capital firm that invests in early- and expansion-stage companies with significant operations in China. It has more than 100 investments in the technology, clean technology and healthcare sectors, and manages over $500m in capital from offices in Beijing, Taipei and San Francisco. Testar continues WI Harper's LED investment program, which includes LED chipmaker SemiLEDs Corp and LED emitter, light engine and fixture provider NeoPac Lighting Group.

**www.testar.com.tw/english**

# No Guesswork...



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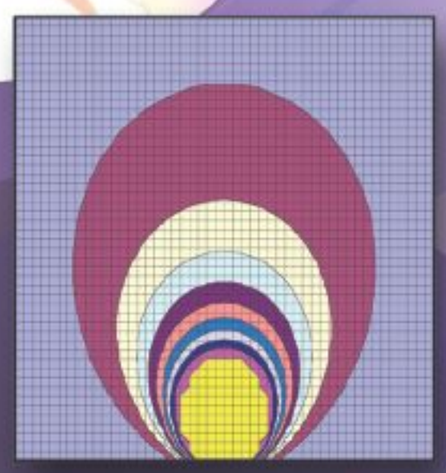

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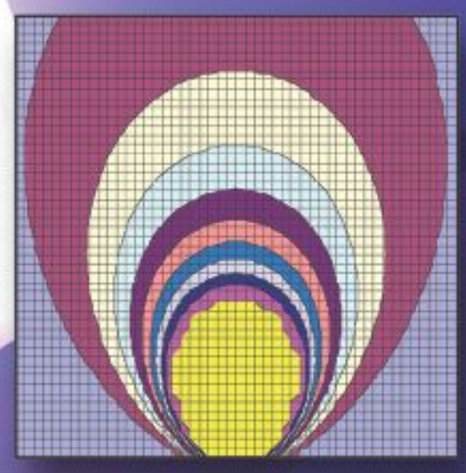

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*www.temescal.net*

# Sheffield University spin-off Seren Photonics targets high-efficiency white LED lighting

Under its exclusive agreement with the University of Sheffield, the university IP commercialization firm Fusion IP plc has formed the new start-up Seren Photonics, in which it has a 60% holding. Founded on the work of Dr Tao Wang (a reader in the Department of Electronic and Electrical Engineering), Seren aims to produce ultra-high-efficient LEDs.

Wang leads a research team working on III-nitride based optoelectronic devices that has strong links with the UK Engineering and Physical Sciences Research Council's National Centre for III-V Technologies in Sheffield, which is a research center for compound semiconductors with comprehensive facilities for the fabrication of a wide range of optoelectronic devices.

Wang's processing technique combines nanoscience and fundamental physics to greatly increase the efficiency at which an LED converts energy into light. Demonstrations of the technology have so far resulted in a doubling of the light output compared to untreated devices, so that either much brighter lamps can be manufactured or power consumption of lamps can be further reduced to a single watt.

Seren's technology is targeted at the fast-growing white LED market, for applications such as laptop and TV backlighting, signs and displays, as well as domestic and architectural lighting. Worth an estimated $5bn at present, the market is forecast to grow rapidly to $12bn by 2013.

"Fusion's commercial, managerial and financial support, combined with the support of the university and my department, have been vital for the creation of Seren," says Wang. "Seren Photonics hopes to unlock the full potential of nitride-based, ultra-high-efficient white LEDs and complete the illumination revolution we are currently experiencing," Wang adds.

"Seren Photonics has the potential to revolutionise the illumination markets, be a key contributor to reducing greenhouse gas emissions, and realise a considerable return for all of its shareholders," comments Seren's managing director Dr Carl Griffiths.

**www.shef.ac.uk/eee/research/nc35t/movpe/nitride.html**

# General Frank Akers to represent Sunovia's LED lighting products to US government

Sunovia Energy Technologies Inc of Sarasota, FL, USA, which is commercializing cadmium telluride on silicon (CdTe/Si) solar technology as well as LED lighting products, says that General Frank Akers is to represent Sunovia's LED lighting products for sales to the US government (including the military).

Sunovia recently announced a 1100-fixture contract with the Camp Lejeune Marine base in North Carolina for the installation of its proprietary EvoLucia-brand cobra head LED light fixtures.

Dr Akers is currently president & CEO of Oak Ridge Strategies Group Inc (ORSG), a Small Disabled Veteran Owned (SDVO) company specializing in technology discovery, exploitation of disruptive technologies, customer relationship development, and strategic planning.

Previously, Akers was associate laboratory director for National Security at Oak Ridge National Laboratory (ORNL), responsible for managing a focused R&D portfolio that included nonproliferation and threat reduction, arms and export control, homeland security, and counter-terrorism technologies for the US National Nuclear Security Administration and the US Department of Energy. Akers also coordinated ORNL activities with the US Department of Defense and other federal agencies with a mission involving national security, homeland security, law enforcement, and public safety.

After retiring from the US Army as a Brigadier General and prior to joining UT-Battelle, Akers served as VP, Advanced Technologies, for BWXT Y-12 LLC, and Lockheed Martin Energy Systems, where he had leadership and management responsibilities for business units with a technical focus that included the National Prototype Center, Advanced Computing Technologies (ACT), Advanced Infrastructure Management Technologies (AIMTech), National Security Program Office (NSPO), and Oak Ridge Centers for Manufacturing Technology (ORCMT).

"Sunovia has hit the nail on the head with its proprietary Aimed Optics LED lighting platform," says Akers. "The LED is typically the most expensive component in roadway luminaires, and aiming the LEDs to achieve the required photometric will allow Sunovia to offer virtually any LED lighting fixture at prices that will be difficult to compete with," he adds.

Akers will play a critical role in the execution of Sunovia's Government sales strategy, says president Bob Fugerer. "His knowledge, experience and resources will be vital as we further penetrate the governmental and military markets."

**www.sunoviaenergy.com**
**www.epir.com**

# Nakamura joins Seoul Semiconductor as consultant

Blue LED pioneer Shuji Nakamura has joined Korean LED maker Seoul Semiconductor Co Ltd as a scientific adviser.

A professor in the Materials Department of the College of Engineering at University of California, Santa Barbara (UCSB) since 2000, Nakamura is best known for developing high-brightness blue LEDs based on gallium nitride (GaN) in 1993 while at Nichia Corp in Japan.

Nakamura's pioneering work allowed manufacturers to produce LEDs with three primary colors (red, green and blue), which could be mixed to produce 16 million colors. Most importantly, this led to the commercial production of GaN-based white LEDs. He was also part of a UCSB team that developed the world's first nonpolar blue-violet laser diodes.

At UCSB, Nakamura is co-director of the Solid State Lighting and Energy Center (SSLEC), where he is developing next-generation LEDs and laser diodes based on the blue LED, as well as a GaN-based solar cell.

**Seoul Semiconductor Inc's CEO Chung Hoon Lee (left) welcomes Shuji Nakamura (right).**

"Seoul Semiconductor Co Ltd is proud to be one of the industrial sponsors of the Solid State Lighting and Energy Center

"Seoul Semiconductor Co Ltd is proud to be one of the industrial sponsors of the SSLEC," says Seoul Semiconductor senior VP S.M. Lee.

Previous international awards for Nakamura in recognition of his research include: the Harvey Prize from Israel's Technion (2009); Spain's Prince of Asturias Award for Technical and Scientific Research (2008); Finland's Millennium Technology Prize (2006); and the Benjamin Franklin Medal in the engineering segment (2004), previously conferred upon Thomas Edison and Albert Einstein. Nakamura has also received Japan's Takeda Award, as well as an Innovation Award from UK magazine The Economist.

Nakamura is a co-author of "The Blue Laser Diode: The Complete Story" (Springer, 2000), and his work is chronicled in the book "Brilliant! Shuji Nakamura And the Revolution in Lighting Technology" by Bob Johnstone (Prometheus Books, 2007).

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

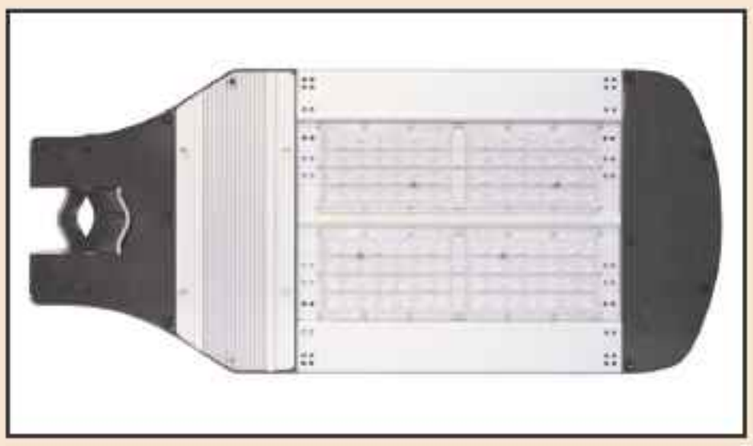
# Seoul Semiconductor light up street lamps in Valencia

Korean LED maker Seoul Semiconductor says that streets will be brighter, tourists safer, and electrical bills smaller in the Mediterranean resort of Valencia, Spain due to 1000 new energy-efficient and cost-effective street lights using its LEDs that have been installed in the municipality of Rafelbunyol.

Installation is part of a program initiated by Spain's Revolution LED to replace existing light bulbs on streets and in public facilities throughout the country with high-quality, energy-efficient lighting, and follows a year of testing of Seoul Semiconductor's LEDs by Revolution LED. The firm says its LEDs offer efficacy of 100lm/W from a single light source, and that they reliably deliver the necessary brightness and last three times longer than traditional street lights.

**Street lights in Valencia.**

The three models of lighting products used in the street lights contain 56, 112 and 168 LEDs made by Seoul Semiconductor, respectively. The 56W LED light bulb replaces the existing 160W bulb and lasts three times as long. Revolution LED reports that, as a result of replacing 160W light bulbs with Seoul Semiconductor's LEDs, energy consumption has been reduced 65%. The performance of the light bulbs was verified by Polytechnic University of Valencia and the Valencian Institute of Technology.



**Detail of LED-based lamp.**

Seoul Semiconductor's senior vice president S.M. Lee says that 3000 additional lighting fixtures will soon be installed throughout the Valencian Community. In addition, product testing is underway in the Atlantic coastal community of Jerez, Spain, where 23,000 street lights will be replaced.

www.acriche.com

# US Vice President Biden and Energy Secretary Chu visit North Carolina LED maker Cree

On 18 March, US Vice President Joe Biden and Secretary of Energy Steven Chu visited LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA to discuss the Obama administration's commitment to issues including creating manufacturing jobs and building the clean energy economy. The administration cites Cree as an example of job growth through adapting to a clean-energy economy by manufacturing energy-efficient products.

Previously, Cree's chairman & CEO Chuck Swoboda met President Obama at the White House last July as part of a roundtable discussion on US innovation and clean energy technology. Swoboda subsequently joined Chu last October at the Clean Energy Economy Forum in Washington to discuss science, innovation and job creation in the new clean economy.

As part of last year's economic stimulus package, the American Recovery and Reinvestment Act's Advanced Energy Manufacturing tax credit program included $2.3bn for manufacturers of clean-energy products, shared between 183 firms in 43 states. As the only recipient in North Carolina, in January Cree received $39m in federal tax credits. This represents 30% of the money that Cree will invest in new manufacturing capacity and jobs at its Durham plant to boost its production of LEDs for high-efficiency lighting.

"The ongoing support from the Obama administration is important as we promote the value of energy efficiency and sustainability in today's economy," said Swoboda. "Cree is creating American clean-tech jobs right now." To meet the booming demand for LEDs, since February 2009 Cree has hired about 375 staff engineers, office staff and production workers (adding to about 1500 staff in Durham).

North Carolina has lost more than 100,000 manufacturing jobs since the recession began in December 2007, raising the state's unemployment rate to 11.1% in January (the highest since records began in 1976), according to a report in The Charlotte Observer.

# Renovated resort hotel lit by Cree LED Lighting

The Hyatt Regency Grand Cypress Resort in Orlando, FL, USA has installed LED lighting from Cree in order to boost its energy efficiency. One of Orlando's largest resorts (close to Walt Disney World), the hotel recently completed a multi-million dollar renovation, including replacing traditional lighting fixtures in its 54 hallways and its newly refurbished 10,000ft$^2$ lobby.

The hotel began its remodel to comply with the Florida Department of Environmental Protection's Green Lodging program, a voluntary initiative for hotels and motels across the state to adopt cost-saving green practices to conserve energy, reduce water consumption, protect air quality and reduce waste. Aiming to become a more environmentally conscious organization as well as reducing its utility costs, resort management turned to Regency Lighting to consult on energy conservation measures and to install LED lighting throughout the hotel.

"Our lobbies and hallways are lit 24-hours a day, seven days a week," says resort chief engineer Rick Jackson. "Working with Regency Lighting, we were able to compare the cost and energy savings of Cree LED products with the traditional lighting," he adds. "LED lighting installations in the hotel hallways and lobby are not only significantly reducing our electric bill and saving on maintenance costs, but are providing better-quality lighting."

The hotel replaced halogen lighting fixtures between each hotel room with Cree LR6 LED recessed downlights, which consume just 10.5W (a 90% energy saving over the two 50W halogen bulbs they replaced). The downlights' 50,000-hour lifetime also reduces maintenance costs.

The second application included exchanging halogen lighting in the lobby with Cree LRP-38 LED bulbs, saving more than 80% on energy. The bulb was specified by Regency Lighting on the basis of its high color rendering index (CRI=92) and tightly focused beam (20$^o$), required for highlighting the palm trees and indoor garden.

"Accent lighting is often sacrificed when you make the switch to more energy-conscious lighting," explains Regency Lighting's Tommy Mydlo. "The Cree LRP-38 adds back in the beautiful accent lighting guests are accustomed to experiencing."

Replacing the hallway lighting with Cree LR6s is projected to save $131,659 cumulatively in the first year, with a return on investment of about nine months. This includes projected energy, labor and cooling expenses, as well as the cost of the lamps. Savings of more than $0.5m are predicted by the fourth year of installation.

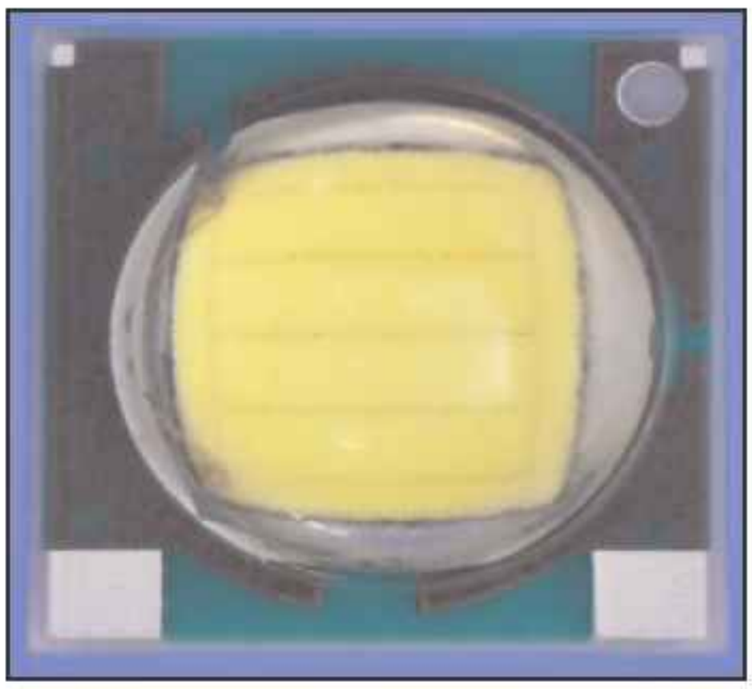
**www.CreeLEDlighting.com**

# Cree claims most energy-efficient neutral- and warm-white lighting-class LEDs: 109lm/W at 3000K for XP-G

Cree has announced commercial availability of its XLamp XP-G LED in warm- and neutral-white color temperatures (2600–5000K CCT). The new XP-G LEDs extend Cree's highest level of light output and efficacy across the white color spectrum, driving general lighting applications such as LED replacement lamps, outdoor area and commercial luminaires.

The warm-white (3000K) XP-G outputs up to 114lm and 109lm/W at a drive current of 350mA, and up to 285lm and 84lm/W at 1.0A (four times the output of the highest available XLamp XR-E warm-white LED at equal efficacy).

The neutral-white (4000K) XLamp XP-G provides up to 139lm and 132lm/W at 350mA, and up to 463lm driven at 1.5A (four times the output of the XLamp XR-E cool-white LED at equal efficacy).



**Cree's XP-G LED chip.**

Cree says that its XP-G LEDs' high efficacy at high current can reduce the number of LEDs required, as well as the size and cost of LED fixtures. "The extremely high efficacy levels are enabling us to offer our Aimed Optics luminaires in a neutral color while maintaining the same pace-setting mounting-height-to-pole-spacing ratio and fitted target efficiency that we previously achieved with cool-white color temperatures," comments Bob Fugerer, president of LED lighting firm Sunovia Energy Technologies Inc of Sarasota, FL, USA.

"These new XP-G LEDs can enable LED lighting products that not only meet but exceed the current ENERGY STAR luminaire and lamp requirements," says Paul Thieken, Cree's director of marketing, LED Components.

Neutral-white and warm-white XP-G LEDs are commercially available in the industry's smallest ANSI-based chromaticity bins.

## Cree boosts performance of its XLamp XP-E and XP-G LEDs

Cree has announced commercial availability of higher-flux bins for warm- and cool-white XLamp XP-E LEDs and higher maximum forward currents for both XLamp XP-E and XP-G LEDs.

XLamp XP-E cool-white LEDs are now available in the R3 bin, 122–130 lumens at 350mA, delivering up to 116 lumens per watt. Warm-white (3000K) XP-E LEDs are available in the Q3 bin, 94–100 lumens at 350mA. The maximum forward current for all XLamp XP-E white LEDs is now increased to 1A, enabling more design flexibility and higher light-output applications.

For XLamp XP-G LEDs, the maximum forward current has been raised to 1.5A, delivering up to 493 lumens at 92 lumens per watt. By delivering high efficacy at high current, XP-Gs can allow new high-performance LED applications where more light in less space is necessary, says Cree.

Other firms continue to offer 100lm LEDs as their highest performance level, claims Paul Thieken, director of marketing, LED components.

www.cree.com

## Third anniversary of Raleigh becoming first LED City

Three years ago, Raleigh became the first city to join Cree's LED City program, an international initiative to deploy and promote LED lighting.

Raleigh now has more than 40 installations, from accent and indoor lighting to street and parking lot lighting. "Raleigh now favors LED lighting for all renovations and new projects," explains city assistant manager Daniel Howe. "Working with Cree and becoming the world's first LED City has given Raleigh the opportunity to jump ahead in deploying energy-efficient, solid-state lighting technology."

Cree says that LED lighting can help cities save money through reduced energy consumption and reduced maintenance costs, as LED lights last longer and require less replacement than traditional lighting sources. Raleigh conservatively estimate that the current use of LED lighting can save it more than $200,000 annually.

"As Raleigh enjoys some of the lowest energy rates in the country, if the business case works here, it most likely works anywhere," comments mayor Charles Meeker.

"Raleigh has made a tremendous commitment to LED lighting during the past three years, and has become a global leader in deployment and promotion," says Cree's chairman & CEO Chuck Swoboda. "Other municipalities around the world often look to Raleigh to guide their own evaluation and installation of energy-efficient LED lighting."

www.ledcity.org

# TSMC breaks ground on LED fab

## World's biggest silicon foundry targets LED lighting

The world's largest silicon wafer foundry Taiwan Semiconductor Manufacturing Co (TSMC) of Hsinchu, Taiwan has held a ground-breaking ceremony for its LED lighting R&D center and fab on Li-Hsin Road 4 of Hsinchu Science Park, marking a key step in the firm's diversification into 'green energy'.

TSMC is developing new businesses such as LED lighting and solar power to further strengthen long-term growth in revenue and profit, says chairman & CEO Dr Morris Chang. "The strategy, goals, and execution of our new businesses have developed very successfully in the past several months... I look forward to even more progress once construction is complete," he adds.

"LED lighting is a promising industry, and we will make full use of TSMC's technology leadership and manufacturing excellence in semiconductors to develop and integrate LED technology, process, and packaging and testing," says Dr Rick Tsai, TSMC's president of New Businesses. "We will enter the market next year by offering LED light sources and light engines to pursue the broad business opportunities of the LED lighting industry."

The fab will be built in two phases. Investment in plant and equipment for the first phase is expected to reach NT$5.5bn (US$172m). Equipment move-in (initially with 8–12 MOCVD reactors, says Tsai) is scheduled for fourth-quarter 2010, with volume production in first-quarter 2011. The workforce is expected to rise to 130, said Tsai. TSMC says that it will make decisions on construction of the second phase depending on future business needs. Taiwan is already the world's biggest producer of LEDs.

TSMC is recruiting for its LED lighting business in areas including technology development, process integration, product mechanical engineering, packaging, testing, equipment engineering, facilities, and business development.

- According to a report by CNA English News, Chang said at the ground-breaking ceremony that he cannot agree with the allegation that the LED industry, like the solar energy industry, is a low-return sector, as many firms have competed to cash in on it. "TSMC is not interested in competing for petty profits with other rivals," he said, adding that TSMC targets success through advanced technologies and high production capacity. "The LED operation will become one of the most important segments of the TSMC in 5–10 years," Chang predicts.

www.tsmc.com

# Tyntek plans epiwafer plant for mainland China

Attractive government incentives and vast market potential has LED chipmaker Taiwan's Tyntek Corp considering establishing an epi-wafer production facility in mainland China, according to a report by Ken Liu in the Taiwan Economic Times. Chairman Bosco Foo says that the facility would have more than 100 MOCVD reactors, and that the formation of a joint venture is the most likely scenario for the firm's mainland investment plan.

"The mainland's authorities offer a subsidy of RMB10m [US$1.4m] for each MOCVD chamber, which is tantamount to half of the investment capital," says Foo. "Also, investors are allowed to halve the mandatory depreciation period," he adds. "Operating a plant in the mainland would increase our chances of wining local orders there."

**Mainland China's vast streetlight market is swaying Tyntek to open an epi-wafer plant there.**

Already, Tyntek has contracts to install 13,000 LED streetlights at an aerospace science zone in Xian, Shannxi Province, China by the end of 2010, and the city government plans to add traffic lights and indoor lights to the contracts as part of its plan to install 270,000 LED streetlights throughout the city, says the report.

Tyntek anticipates that burgeoning business from China will boost its revenue growth to more than 50% in 2010, to about NT$4bn (US$125m). In response to growing demand, the firm plans to add 26 MOCVD reactors by January 2011, boosting its total to more than 30.

Tyntek has also acquired the Ubilux Optoelectronics Corp, which will provide some of the added capacity with two MOCVD reactors for making nitride-based blue LED epiwafers and two for making AlInGaP LED epiwafers.

Foo estimates that the epiwafer operation will contribute NT$600m (US$18.7m) to the company's 2010 revenue, with the remainder coming from chips, LED components, and lighting modules.

www.tyntek.com.tw

# Taiwan's Epistar entering mainland China LED manufacturing

## Epiwafer and LED plants to be set up with Taiwan's UMC and Lite-On

LED epiwafer- and chip-maker Epistar Corp is teaming with fellow Taiwan-based firms Lite-On Technology Corp (which packages LEDs) and silicon wafer foundry United Microelectronics Corp (UMC, which has a 15% stake in Epistar) to enter into the mainland China LED market, according to SinoCast Daily Business Beat.

Epistar and Lite-On, together with a home appliance maker from the mainland, are to jointly set up an LED manufacturing plant in Changzhou City, Jiangsu Province with a total investment of US$120m (TWD3.84bn). Epistar will invest US$60–70m (TWD2.24bn) and take a stake of more than 50%. In the future, LED epiwafers and chips produced by Epistar will be packaged by Lite-On and delivered to LED TV makers in the mainland.

A spokesperson from Epistar said that Lite-On and Everlight Electronics Co Ltd previously purchased LED chips from it for packaging after obtaining orders from mobile phone makers.

Meanwhile, Epistar and UMC plan to build a joint 50:50 LED epiwafer plant in China's Shandong Province. Epistar will produce epiwafers while UMC will focus on downstream R&D on applications. The plant's R&D team will come from Epistar.

The first phase of the plant has a registered capital of US$16m (TWD510m), half from Epistar, which says that it currently has plenty of cash in hand since it initiated a share placement in 2009. In less than half a year, Epistar has since invested in LED chip-maker Tekcore and Nan Ya Photonics Inc (NPI), an affiliate of the Formosa Plastics Group (FPG) specializing in high-brightness LED wafers and chips, together with joint investors including UMC and FPG.

SinoCast says that, because government regulators in mainland China are actively promoting energy saving and emissions reduction, in the future they will speed up the replacement of traditional lamps by LED-based lamps. Epistar aims to attract more local LED TV and lighting customers and obtain subsidies through setting up plants in the region.

Unlike other Taiwanese firms, Epistar still focuses on upstream epiwafer and chip manufacturing rather than pursuing vertical integration covering upstream, midstream and downstream fields. However, the firm has in the past said that it aimed to achieve a similar impact through cooperation with major partners.

SinoCast says that UMC's affiliated LED street-lamp maker Power Light Technology Co Ltd has previously built a plant in Shandong Province, and that, in its expansion into the LED field, UMC has overtaken rival Taiwan Semiconductor Manufacturing Co Ltd (TSMC, the world's biggest silicon wafer foundry).

**www.epistar.com.tw**
**www.sinocast.com/readbeatarticle.do?id=41589**

# Tekcore raising capital to boost number of MOCVD reactors from 27 to 37–38 by mid-2010

Driven by surging demand for high-brightness (HB) LEDs for LCD TV backlighting, Taiwan-based LED chipmaker Tekcore plans to issue 100 million new shares through a private placement that could raise NT$3bn (US$94.4m) to fund the purchase of new MOCVD reactors, reports Digitimes. Tekcore says that it aims to boost its number of MOCVD reactors from 27 at the end of 2009 to 37–38 by the end of second-quarter 2010.

Currently, epiwafer and LED chip maker Epistar is Tekcore's biggest shareholder with a 19.3% stake, while LED packaging house Everlight Electronics has a 9.9% stake.

Although down 10.06% sequentially from NT$147.6m in January, Tekcore reported revenue of NT$132.75m in February, up 93% on NT$68.76m a year ago. Revenues for January–February totaled NT$280.36m, up 156% year-on-year.

In March, revenue is expected to rise more than 20% sequentially to NT$160m amid increasing demand for HB-LEDs used in backlights for large-size panels and general lighting. In second-half 2010, monthly revenue is expected to reach NT$250m, and revenues for the whole year should grow 50–60% on 2009, Tekcore added.

**In March, revenue is expected to rise more than 20% sequentially**

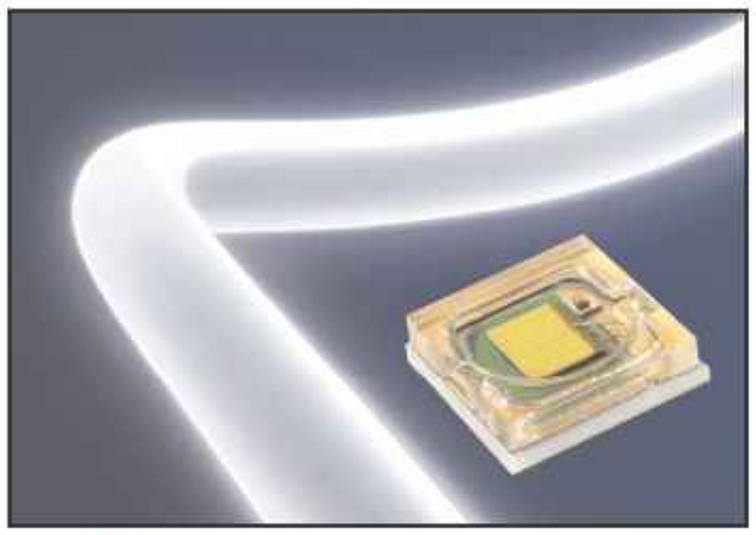
Although Tekcore reported a net loss of NT$160m in 2009, the net loss of NT$227m for the first three quarters was counter-balanced by a net profit of NT$60m for fourth-quarter 2009. Also, despite a sequential drop in revenue of about 3% in first-quarter 2010, the firm expects to record a profit.

**www.tekcore.com.tw**
**www.digitimes.com/news/a20100315PD211.html**

# Osram's OSTAR Compact LED targets light-guide-based daytime running lights using just two LEDs

Osram Opto Semiconductors GmbH of Regensburg, Germany says that it has developed the high-power OSTAR Compact LED specifically for use in vehicle headlights, in particular for daytime running light (DRL) applications based on the use of light guides. The LED's compact dimensions and capability for high drive current suit both existing and new headlight designs, says the firm. In addition to the usual point-like LED lighting solutions, linear or two-dimensional designs can be produced using only a small number of light sources.

The use of LEDs for daytime running light applications is increasing, and not only in top-of-the-line models: the energy-saving light sources are fast becoming the light source of choice in mid-range vehicles as well. Osram Opto Semiconductors is hence extending its offering of LEDs for DRL applications with the surface-mounted (SMT) OSTAR Compact. The entire automotive LED portfolio of a headlight manufacturer can now be perfectly matched, says the firm, because the high-current LEDs (such as the OSTAR Headlamp and the OSLON ECE) are available in the finely graded color classes of ECE color binning, bringing color harmony to the front of the vehicle.



**OSTAR Compact SMT LED provides the basis for new designs for daytime running lights that do not rely on points of light, suiting light guide systems.**

With power consumption of just 5W and an operating current of 1.4A, the OSTAR Compact achieves a typical brightness of 300lm, and its 2mm$^2$ chip provides high luminance. With such a small, high-power light source, light guide systems can be produced with just two LEDs, says Osram. The robust component also has the optimum heat removal rate of 6K/W, suiting the high-temperature zones at the front of an automobile. OSTAR Compact also requires neither a reflector nor a lens.

"Light guides are available in many different designs, from a simple rod to complex 3D versions," says Automotive Division marketing director Peter Knittl. "To offer new designs in variable forms and an alternative to point-like DRL designs, you need one thing above all else – a small high-power light source."

Osram Opto says that, due to its SMT package, the OSTAR Compact is easy to handle. It will also last as long as the vehicle, eliminating the need for replacement and hence saving on costs. In addition, the red and yellow versions of the OSTAR Compact can be used for signal lighting.

www.osram-os.com

IN BRIEF

## Lumileds adopts 2D barcode tracking

Philips Lumileds of San Jose, CA, USA has implemented complete forward and backward traceability for its LUXEON power LEDs.

2D barcode technology enables it to identify down to wafer level exactly when, where and how each LUXEON power LED was made and to track it through the manufacturing process. Such traceability is often required of automotive and consumer electronics suppliers. Lumileds reckons that it is the first power LED maker to adopt and implement such a manufacturing control system.

www.philipslumileds.com

# Digi-Key to distribute Seoul Semiconductor's LEDs worldwide

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

"With technology breakthroughs increasing brightness, or lumens per watt, at lower price points, the interest in LEDs continues to grow dramatically," says Dave Doherty, Digi-Key's VP of semiconductor product. "With products such as Seoul Semiconductor's Acriche AC LED, we are confident a global partnership will benefit our customers," he adds.

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

www.digikey.com
www.acriche.com

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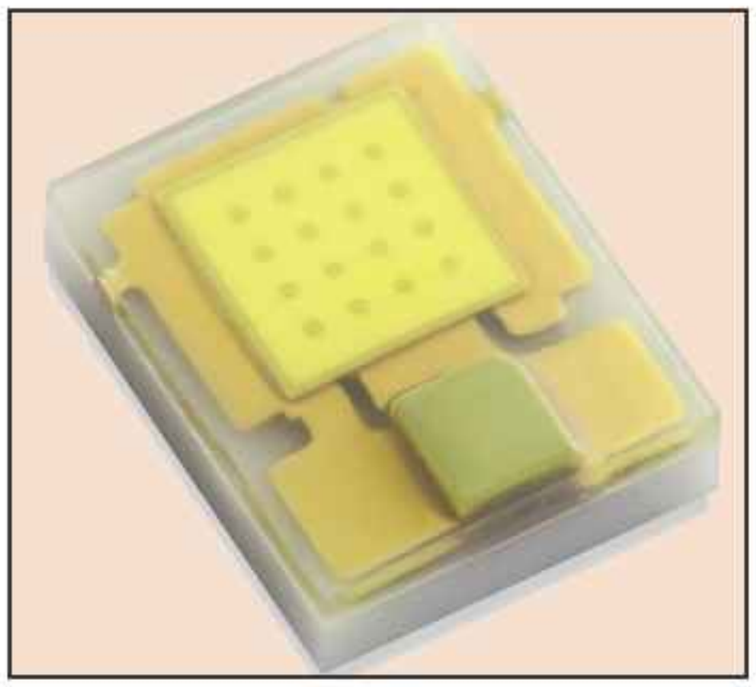
# Lumileds adds ultra-compact LUXEON c to power LED range for appliance, portable and personal lighting

To address the lighting industry's need for smaller, more powerful, and long-lasting LEDs for applications like refrigerators, freezers, and washing machines, LED maker Philips Lumileds of San Jose, CA, USA is adding to its portfolio of LUXEON power LEDs by introducing the small-form-factor (2.04mm x 1.64mm x 0.7mm) LUXEON c LED.

Specifications of the LUXEON c include: typical luminous efficacy of 82 lumens per watt and light output of 85 lumens; a typical forward voltage of 2.95V; ANSI-aligned binning CCT 5000–5700K; and 70% lumen maintenance at 20,000 hours.

Lumileds claims that LUXEON c enables more efficient, cost-effective, environmentally friendly lighting solutions for the tens of millions of appliances, tools, and portable applications that typically use a 10–40W conventional light bulb. The firm adds that, for owners and users of these applications, implementing LUXEON c can reduce operating costs and energy consumption.



**Lumileds' LUXEON c power LED.**

"There are hundreds if not thousands of different lighting applications each with their own light source requirements," says Frank Harder, VP of product marketing. "We have two objectives," he adds. "First, to provide a path for our customers to move to a solution that makes sense for their business, and second to enable them to rethink their design, take full advantage of the size and power of our LUXEON LEDs, and deliver a solution that adds value when compared to the original bulb-based solutions."

LUXEON c is available from Future Lighting Solutions, which also offers engineering and complementary infrastructure resources to assist customers with rapid development and market introduction of solutions using LUXEON c.

**www.futurelightingsolutions.com**

# Lumileds receives ISO/TS16949 auto industry certification

LED maker Philips Lumileds of San Jose, CA, USA says that each of its three design, development and manufacturing sites (in San Jose, Penang in Malaysia, and Singapore) have received ISO/TS16949 certification within weeks of each other, with zero non-conformities.

ISO/TS16949 is an international standard that defines quality management system requirements for automotive industry suppliers. As a supplier of LEDs for exterior vehicle applications, Lumileds says that it is dedicated to establishing a framework for continued improvements.

ISO/TS16949 certification requires two separate audit programs at each site. The first verifies that the company and site are ready for a full assessment. The second confirms that the management system in place conforms to the requirements. Any non-conformance to the standards must be corrected prior to certification.

**Lumileds' San Jose headquarters.**

**LUXEON Rebel warm-white power LED.**

Although designed for the automotive industry, the benefits of ISO/TS16949 quality management can be realized by customers in the lighting and consumer electronics industries as well, reckons Lumileds. In particular, in the solid-state lighting environment (where LED components are often 'fit-for-life'), knowing that a supplier is committed and has sound practices with respect to quality are essential requirements, the firm adds.

"This is an ongoing effort through which we will continue to minimize defects, variance and waste in the production process for our LUXEON, SnapLED and SuperFlux products," comments Darren Smith, vice president for quality & zero defect.

Lumileds announced the broad release of its white automotive-rated LUXEON Rebel LEDs late last October.

**www.philipslumileds.com**

# PLACE-it project targets light, flat, flexible LED products

## Foil, elastic and fabric substrates to be co-developed for heterogeneous integration

With €10.9m in funding under the European Community's Seventh Framework Program, European companies and research institutes involved in lighting and flexible electronics have joined forces to co-develop methods for integrating light into people's everyday surroundings (ceilings, walls, floors, furniture, soft furnishings, and even garments).

The ultimate goal of the initiative PLACE-it (Platform for Large Area Comformable Electronics by InTegration) is to realize — within three and a half years — an industrial platform for thin, lightweight and flexible optoelectronics systems that will not only open new dimensions in product design, but will also create unique opportunities for on-body applications in healthcare and wellness.

PLACE-it's 12 project partners include Centexbel, Freudenberg Forschungsdienste KG, Freudenberg NOK Mechatronics, Freudenberg Mektec Europe, Grupo Antolin, IMEC's associated laboratory at Ghent University, Philips Research, Philips Lighting, Philips Lumalive, Netherlands Organisation for Applied Scientific Research (Holst Centre/TNO), Ohmatex, RWTH Aachen, Technische Universität Berlin, TITV Greiz and the University of Heidelberg.

PLACE-it intends to exploit the energy-efficient and small-form-factor characteristics of new lighting technologies including LEDs and OLEDs (organic LEDs) to develop products such as lamps that can be designed in any shape or even blended into the surroundings, curtains that emit light to mimic natural daylight conditions, illuminating childrens' cycling jackets, and even bandages that shine light on the body to treat skin diseases.

**The integration of light therapy into baby's blankets by Holland's Philips Research.**

"Until now, large-area electronics R&D has been carried out independently for flexible, elastic and fabric-based technologies," says project leader Liesbeth van Pieterson, senior scientist at Philips Research of Eindhoven, The Netherlands. "In the PLACE-it project, foil, elastic and fabric substrate technologies will be systematically co-developed with the common goal of heterogeneous integration."

The project therefore aims to:

- develop an integration platform of foil, elastic and fabric optoelectronic technologies;
- create foil, elastic and fabric-based devices for light emission, electronics and sensing;
- formulate industry design guidelines for light-emitting flexible surfaces and textiles; and
- build demonstrators of compelling beyond-the-bulb applications.

PLACE-it will share the outcome of the project with third parties and start a dialogue with designers, architects, governments, industry and other stakeholders to discuss the future of comfortable ambient lighting and the requirements/conditions for an industrial platform.

**www.place-it-project.eu**

IN BRIEF

## Luminus licenses Forepi for small-chip PhlatLight LEDs

Luminus Devices has licensed Taiwan-based LED maker Formosa Epitaxy (Forepi) to make small and mid-power chip blue and green GaN LEDs based on its PhlatLight platform.

Luminus says that, by licensing and incorporating PhlatLight (Photonic Lattice) chip technology, Forepi can now produce high-performance vertical-GaN chips for markets that require the performance of PhlatLight technology, but in a small and mid-power chip form-factor.

"By working with an innovative company like Forepi, the benefit of the PhlatLight chip-platform is now available for smaller form-factor chips," says Luminus" chief technology officer Alexei Erchak. "Luminus has been granted more than 40 patents for our PhlatLight technology with over 100 more applications on file. Although our primary business remains manufacturing big-chip LEDs, we are pleased that through licensing these patents we can help solid-state lighting grow even faster in small-chip applications," he adds.

"We chose to license PhlatLight technology because it provides the highest-efficiency chip design in the industry for all chip sizes," says Forepi's president & CEO Frank Chien.

Designed to provide an ultra-bright, reliable light source, PhlatLight big-chip LEDs are used in display applications by some of the largest electronics firms such as Acer, LG, Sony, Samsung and Toshiba, says Luminus. PhlatLight LEDs are also enabling new general illumination applications in lighting markets such as architectural, entertainment, retail, residential, roadways, digital signage and industrial high-bay lighting.

**www.forepi.com.tw**

# Luminus raises $19m more VC funds

Luminus Devices Inc of Billerica, MA, USA, which makes LED solid-state light sources for illumination applications (including high-definition TVs, video projectors, avionics displays, and lighting systems), has closed a $19m round of funding, led by current investors Argonaut Private Equity, Braemar Energy Ventures, Paladin Capital Group and Stata Venture Partners.

The latest funding is a recapitalization for Luminus, which has raised $172m since being spun out of MIT in 2002. In early January, the terms of a $15.1m loan were renegotiated while bridge funding was raised. This followed settling of a lawsuit against lender Hercules Technology Growth Capital Inc of Palo Alto, CA, which had blocked Luminus from accessing $12m in accounts (claiming it had defaulted on the loan).

Luminus says that the new investment creates a fully funded operating plan to increase profitability, maintain minimal debt, and support growth and the expansion of Luminus' products and applications. This includes 'big chip' LEDs in specialty lighting applications, projection displays, digital signage and ultra-violet industrial processes.

"Luminus' investor syndicate is one of the strongest groups of venture-backed talent in the clean energy technology space," reckons president & CEO Keith T.S. Ward. "With their experience investing in solid-state lighting companies, their support facilitates our leadership team's implementation of a strong growth strategy across a diverse portfolio of global markets, products and applications," he adds. "This financing has dramatically improved our balance sheet, simplified our equity structure, while better aligning investor objectives with management's market-focused strategy."

Designed to provide an ultra-bright, reliable light source, Luminus' PhlatLight (Photonic Lattice) LEDs are used by some of the world's largest firms, including Acer, LG, Philips Vari*Lite, Sony, Samsung and Toshiba. Luminus' display business is thriving, as PhlatLights are now in every projection platform technology, including DLP, 3LCD and LCOS. The firm says that its technology enables products that use LEDs in all projector categories, including pico, pocket and data, as well as home theater.

"We continue to be bullish on energy efficiency, especially in the area of LEDs and solid-state lighting, which makes up a large portion of our portfolio," says Braemar Energy Ventures' managing partner Dennis Costello. "With our expertise in the area and Luminus' dominance as a LED manufacturer and supplier across multiple market segments, it provides a great investment opportunity," he believes. "We're pleased to see more and more lighting applications are using PhlatLight LEDs," he adds. Paladin Capital Group principal Dr Paul Conley notes the rapid adoption of PhlatLight LED products in a diverse range of commercial, industrial and defense applications.

"This funding will allow Luminus to fully execute its operating plan to achieve profitable growth," says Stata Venture Partners' managing partner Lee Barbieri. "PhlatLight LEDs uniquely enable new technologies in a broad spectrum of applications," he adds. "Their management team is highly focused on supporting their existing customers and enabling new markets."

"In December we had the largest month in our history and in January we had a larger month," Ward notes in an interview in Mass High Tech (The Journal of New England Technology). "In February we are going to beat our projection by 20–25%," he adds. Luminus hence expects its revenue this year to more than double from nearly $10m in 2009 (which itself was double 2008's revenue).

**www.luminus.com**

**www.masshightech.com**

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# Taiwan's Walsin Lihwa to co-develop integrated light-source packaging with UCSB spin-off Kaai

Taiwan-based Walsin Lihwa Corp has signed a cooperation agreement with Kaai Inc of Goleta, CA, USA for a three-year program to co-develop a new generation of environmentally friendly integrated light-source packaging solutions, targeted at portable applications including mobile phones and netbooks.

Kaai was co-founded in 2008 by nitride-based semiconductor laser pioneers Shuji Nakamura, Steven Denbaars and James Speck, who are professors in the Solid State Lighting & Display Center of University of California, Santa Barbara (UCSB) and had previously developed the first non-polar nitride laser in 2007. Kaai aims to commercialize green and blue laser diodes based on indium gallium nitride (InGaN) for consumer, biomedical, defense, and industrial applications.

Kaai has since demonstrated the first continuous-wave green GaN lasers. This January, Kaai achieved what was claimed to be the longest-wavelength green laser diode operating in continuous-wave (cw) mode, extending its record of 523nm to 525nm. Kaai had previously demonstrated 520–522nm lasers last September.

Walsin Lihwa was founded in 1966 to make copper cables and wires, power cables and wires, and specialty steel products, becoming a leader in the Greater China market. In 2000, it started developing micro-electromechanical systems (MEMS). In the past few years, the firm has dedicated itself to developing integrated light-source packaging and wafer-level packaging solutions for environmentally friendly optical, mechanical and electronic applications, securing almost 200 patents.

Walsin Lihwa says its MEMS team has been effective in attracting both local and overseas talent, enabling independence in R&D to become a provider of miniaturized modules.

The firm has previously worked with UCSB for over three years on developing unique packaging technologies for laser light sources.

Ching Hu, president of Walsin Lihwa's Micro-Optical-Mechanical-Electronic Group, together with Kaai's CEO Richard Craig, presided over the agreement's signing ceremony, in the presence of Nakamura, Denbaars and Speck (who have been invited to become science advisors to Walsin Lihwa).

Kaai's blue and green laser technologies will be critical to Walsin Lihwa's integrated light-source business development, says Hu, and the R&D cooperation between the firms is expected to generate synergy in effective sharing of resources and expertise. Walsin Lihwa is due to deliver samples of integrated light-source packaging solutions for verification within a year.

www.kaai.com
www.walsin.com.tw

# Osram details record output & efficiency continuous-wave direct-emitting green InGaN laser diodes

In an invited talk at the SPIE Photonics West 2010 event in San Francisco in late January, the team of Dr Stephan Lutgen from Osram Opto Semiconductors GmbH in Regensburg, Germany presented R&D data demonstrating the first direct-emitting 'true green' indium gallium nitride (InGaN) ridge-waveguide (RWG) laser diode emitting at a wavelength of 515nm in continuous-wave (cw) mode with record output power up to 50mW. The work has since been published online and will appear as 'Progress of blue and green InGaN laser diodes' by S. Lutgen et al in Proc. SPIE, Vol. 7616, 76160G (2010).

Osram Opto says that this level of optical power is necessary for RGB scanning beam laser projection, with 10–15 lumens on the screen.


The green laser diode is grown on a commercially available c-plane GaN substrate. Also, the laser demonstrated a wall-plug efficiency of 2.7%, which the firm describes as a key milestone towards the success of direct green InGaN-based laser diodes for laser displays.

To achieve true green laser emission in continuous-wave operation, several key obstacles needed to be resolved, says Osram Opto.

Perhaps most important was the low crystal quality of the light-emitting active layers ($In_xGa_{1-x}N$ quantum wells) caused by the high indium content needed to reach green emission wavelengths of 515nm and above. Minimization of Ga/In alloy fluctuations and point defects during epitaxial growth was essential to achieve higher cw output.

"These compact, direct green laser diodes will reach efficiencies and output power to revolutionize the current markets for green lasers," believes Dr Volker Haerle, VP of R&D.

The work is sponsored by the German Ministry for Education and Research (FKZ 13N9373) as part of a project for ultra-compact and mobile laser projection systems.

http://dx.doi.org/10.1117/12.842131
www.osram-os.com

# Intense adds ultra-compact, high-brightness 600W Mini stacked array laser

Intense Ltd of North Brunswick, NJ, USA, which makes monolithic laser array products and integrated high-power laser diodes, has added the 600W Mini Stack to its Hermes family of high-power quasi-continuous-wave (QCW) stacked arrays.

The 600W Mini Stack is an ultra-compact 600W QCW high-brightness stack with an emission area of less than 3mm x 3mm, generating output of about 7.6kW/cm$^2$. The design is fabricated in standard wavelengths of 808nm and 940nm. Custom wavelengths, including multi-color options, are available.

"The Mini stack offers 50% higher optical power density than some 2kW stacks that use standard bar technology," says Intense Ltd's chief commercial officer Kevin Laughlin. This, combined with a compact footprint and small emission area, makes the Mini stack suitable for high-power end pumping of DPSS (diode-pumped solid-state) laser sources, he adds. "Its ultra-compact form factor and high optical power density offer a real opportunity to reduce size and cost, and dramatically improve system operating efficiency for solid-state laser manufacturers currently using flash lamps or standard diode bar pump technology."

The standard 600W Mini stack is offered for operating conditions up to 60°C. High-temperature versions of most Hermes bars and stacks, covering 70–130°C, are available. Power levels and emission areas can also be custom designed to meet specific needs of OEM customers.

**Defense customers are always looking to reduce the footprint/weight ratio, and improve battery life and system performance**

"The 600W Mini stack was designed with the defense market in mind," says Laughlin. "Defense customers are always looking to reduce the footprint/weight ratio, and improve battery life and system performance, particularly under harsh conditions," he adds. "The 600W Mini is an extremely compact, ruggedized end-pump diode array solution."

The 600W Mini stack and all Hermes bars and stacked arrays incorporate Intense's patented quantum well intermixing (QWI) technology, which boosts the brightness and reliability of the lasers while reducing instances of catastrophic optical damage (COMD).

The entire line of Hermes QCW bars and stacks is assembled using AuSn hard solder and designed for a wide range of aerospace, defense and industrial applications.

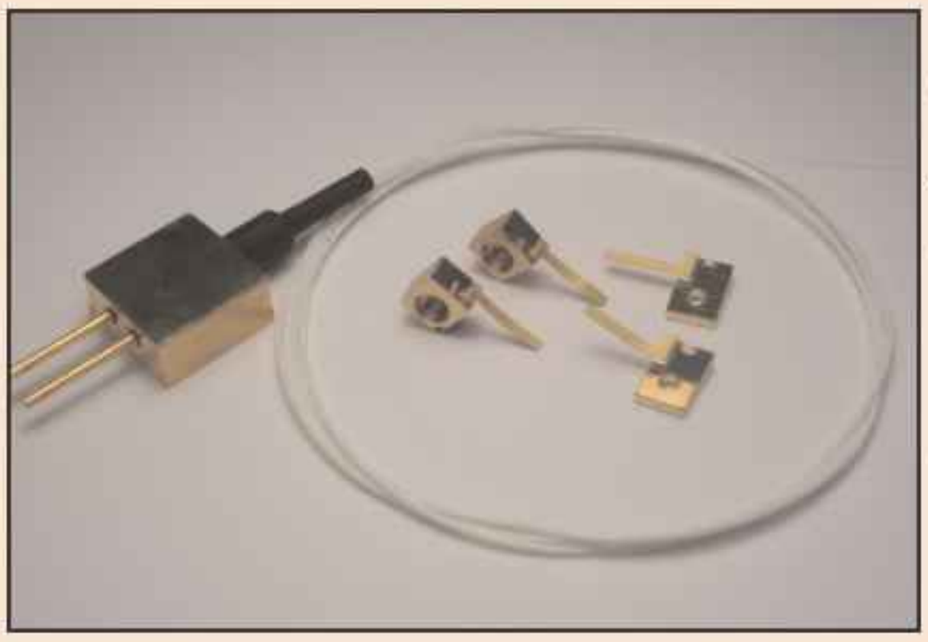
www.intenseco.com/products/hermes

# Intense expands Power Core 808 laser engine chip platform

Intense Ltd has launched two new ultra-high-brightness (0.5W and 2.0W) versions of its Power Core 808, a line of 808nm multi-mode laser engine chips that can be customized for a variety of optics applications (other wavelengths are available on request).

Designed for thermal print, graphics, and coding applications, the free-space laser diodes have small emitting apertures of 25µm (0.5W) and 45µm (2.0W), so low beam divergence produces very high brightness in a small, simple-to-integrate, chip-level device.

The high-brightness, multi-mode laser diodes are designed to be packaged in 9mm cans in both free-space and fiber-coupled versions. In the fiber-coupled configuration, the diodes are offered with a standard core diameter of 60µm and with a numerical aperture of 0.15.



**Intense's Power Core 808 multi-mode laser engine, now available at 0.5W and 2.0W.**

**These lasers represent some of the industry's highest output power levels from small-aperture devices**

"These lasers represent some of the industry's highest output power levels from small-aperture devices," claims Intense's chief commercial officer Kevin Laughlin.

"We have leveraged our patented QWI technology to develop high-power sources, making these ultra-high-brightness lasers extremely reliable and therefore able to meet the demands of the print and imaging and coding and marking markets," he adds.

"These lasers are ideally suited for applications where compact devices capable of being focused into a small spot provide key advantages in simplifying the design of print and thermal coding and marking heads," Laughlin concludes.

www.intenseco.com/products/hpd

# Long-wavelength VCSEL for low-power high-speed comms

A research team led by CEA-LETI of Grenoble, France has developed long-wavelength vertical-cavity surface-emitting lasers (VCSELs) for next-generation high-speed communication systems under the European project MOSEL. The aim of the three-year joint research program was to push long-wavelength VCSEL technology from lab to industry, in order to find an efficient and reliable answer to the ever-growing demand for bandwidth in telecom networks. VCSELs offer low power consumption (from 5–10 times less than the conventional edge-emitting lasers) and can also be manufactured in volume at low cost.

The ever-growing demand for bandwidth in telecom networks, caused mainly by unprecedented growth in data traffic in local and access networks, necessitates the development of new, low-cost, high-speed optical links in the 1–100Gb/s range. In contrast to the evolution of optical fiber networks, the needs for high-bandwidth transmission have shifted from high-capacity links (such as intercontinental and intercity) towards the network environment of the end users. This puts the emphasis on low-cost, intelligent and scalable networks that can be deployed throughout the entire network hierarchy, ranging from metropolitan- and local-area networks (LANs) to access networks such as fiber-to-the-home (FTTH) and passive optical networks (PONs).

MOSEL also included three academic partners (Denmark's DTU Fotonik, Switzerland's EPFL, and Sweden's KTH) and two industrial partners (Alight Technologies of Denmark and BeamExpress of Switzerland).

The project allowed the industrial partners to address different previously established standards and pursue commercialization. Meanwhile, the academic partners have demonstrated different proofs of innovative concepts, preparing the basis for the next device generation.

Employing novel concepts for mode control and current injection has enabled MOSEL to demonstrate device performances similar to or, in some cases, surpassing those of conventional edge-emitting lasers.

The project demonstrated error-free 10GBASE-LR operation up to 100°C, concurrent with record performance: single-mode (>30dB SMSR) power of >1mW up to 100°C (>2mW at room temperature) and 10Gb/s modulation and transmission over 10km single-mode fiber with BER $<10^{11}$ up to 100°C with <1dB power penalty.

This paves the way to next-generation devices and commercialization, say the researchers. Due to their intrinsic performances (power consumption, beam quality) and low-cost potential, long-wavelength VCSELs provide a technical solution to an economical problem, they add.

**www.ist-mosel.org**

The six consortium partners focused on different areas of development:

- DTU Fotonik (formerly COM) has performed numerical investigation of VCSELs, aiming at high single-mode output. It found that nano- and micro-structures can suppress higher-order modes or shape the optical mode profile to match well with a gain profile, promising three times enhanced strength of single-mode operation. A hybrid VCSEL structure with a III-V gain region and a silicon photonic crystal mirror was suggested for improved laser performance and looser alignment precision in silicon photonics.
- Alight refined its long-wavelength GaInNAs/GaAs VCSEL's photonic crystal structure (used to ensure stable single-mode operation over the entire operation range) and worked on extending high-speed operation, demonstrating error-free 10GBASE-LR operation up to 100°C.
- EPFL and BeamExpress worked to improve the performance of 1310nm-waveband VCSELs based on proprietary InP-GaAs wafer-fusion. The devices use 2″ wafers, patterned tunnel junctions and intracavity structuring elements for efficient carrier and photon confinement, and show record performance: single-mode (>30dB SMSR) power of >1mW up to 100°C (>2mW at room temperature) and 10Gb/s modulation and transmission over 10km single-mode fiber with BER $<10^{11}$ up to 100°C with <1dB power penalty. Wafer fusion yielded VCSELs with similar high performance in the entire 1200–1600nm range. Combining this with precise (few nm) wavelength-setting ability makes them applicable in multiple-wavelength CWDM arrays for increasing the transmission bandwidth and providing bandwidth-on-demand. BeamExpress is working with a manufacturing partner in Europe to commercialize long-wavelength VCSELs. First samples were available in Q4/2009.
- KTH has used novel re-growth with mode-selective elements for high-power single-mode emission. The technology is based entirely on standard materials and processing methods, allowing implementation in a short-wavelength VCSEL processing line and hence demonstrating potential for improved efficiency, manufacturability and reliability.
- CEA-Leti developed a new VCSEL design with a high-reflectivity mirror based on sub-wavelength grating mirrors. First results show sub-mA threshold current, linearly polarized emission, and single-mode maximum output at 980nm of over 4mW at room temperature (70°C). A high-index contrast between the photonic crystal membrane and the underlying material is obtained by selective oxidation of a high-aluminum-content layer instead of a fragile air-gap geometry. Leti says the results build a bridge between a standard VCSEL and a hybrid laser, enabling potential use for silicon photonics.

# GigOptix introduced universal limiting TIA

GigOptix Inc of Palo Alto, CA, USA, which designs modulator and laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials as well as polymer electro-optic modulators, has launched the GX3101, a high-performance universal limiting TIA for use in fiber-optic communication systems such as Fiber Channel, Ethernet, SONET transceivers and in wireless backhaul. The GX3101 is designed to enable one solution to support a variety of optical reaches, speeds and standards that require a limiting TIA.

Key features include:

- bandwidth selection to support operation from 2Gb/s up to 11Gb/s;
- high sensitivity, with 16kOhm differential gain to support reaches up to 80km;
- AGC (automatic gain control) and DC cancellation circuitry to ensure high performance over a large range of operating conditions;
- large output voltage swing, eliminating the need for a post-amplifier; and
- low power consumption.

GigOptix says that the GX3101 helps to simplify ROSA (receive optical sub-assembly) manufacturers' supply chains by enabling the use of one part to address a wide range of speeds, reaches and standards that have previously been addressed by different TIA solutions from multiple vendors. Also, the universal TIA allows cost efficiencies through combined purchase of the high-volume low-data-rate applications together with the smaller but growing segment of 10Gb/s applications.

"The GX3101 is being very well received by our optical transceiver customers. It was developed in close collaboration with a leading ROSA manufacturer to ensure that it would cover as wide as possible range of applications," says Julie Tipton, VP marketing. "It is intended to help simplify our customers supply chain and to bring cost advantages, since we are able to offer attractive prices in high volume while not compromising on performance," she adds.

"GigOptix initially developed the device for the Ethernet and Fibre Channel market segments, and we are now beginning to see significant demand for the device from 3G/4G wireless backhaul segment operating at 6Gb/s data rate," Tipton continues. "This segment is moving to higher-capacity optical fiber implementations to satisfy consumer's fast-growing demand for mobile audio and video services."

"We recently reported that the transceiver market showed considerable improvement in the second half of 2009, with purchasing resuming in order to replenish depleted inventories," comments Dr Vladimir Kozlov, founder & CEO of market research firm LightCounting LLC. "Datacom applications requiring Fibre Channel and Ethernet appear to be recovering the earliest," he adds. In its September 2009 market forecast, Lightcounting projected that over 1.8 million 10G Ethernet and over 11 million Fiber Channel transceivers would be shipped in 2010.

The GX3101 is available now for sampling and will be in full production in second-quarter 2010.

www.GigOptix.com

# GigOptix launches linear TIA for 40G coherent receivers

GigOptix has made available samples of its GX3122 dual-channel linear transimpedance amplifier (TIA) designed for use in next-generation 40Gb/s dense wavelength division multiplexing (DWDM) coherent optical receivers.

The GX3122 TIA consists of two balanced linear 10Gb/s TIA channels in a single die (in order to reduce system complexity and cost). The device forms the gain interface between the photodiodes and the analog-to-digital converters (ADC) and digital signal processor (DSP) in a coherent optical receiver, and it is designed to have the required large dynamic range and to handle the high AC and DC currents with a consistently low total harmonic distortion (THD) of less than 5%.

Other key features include:

- linear gain over 20dB of dynamic range;
- automatic or manual gain control options;
- peak detection function;
- low power consumption; and
- receive strength signal indicator.

"The GX3122 further expands our TIA portfolio by providing a dedicated solution for the emerging 40G coherent market," says Julie Tipton, VP of marketing. The GX3122 is form-factor compatible with GigOptix's 100Gb/s DP-QPSK dual-channel TIA, so receivers designed using the firm's 100G dual-channel linear TIA solution for 100G DP-QPSK can now be easily re-targeted to 40G DP-QPSK operation using the lower-cost GX3122. "Similarly, customers who implement a design with our GX3122 can now move more rapidly to a 100G receiver design using our 100G TIA solution," she adds. "This is a big win for customers who are resourced constrained and are looking to leverage existing engineering designs into new markets."

GigOptix says that 40G coherent systems are seen as being a significant segment in future 40G DWDM networks due to the format's capability for long-haul reach, its high tolerance to signal distortions, and its expected operating expenditure (OpEx) savings over other 40G formats.

# Finisar grows 32% year-on-year

## Target operating margin of 10% within reach this quarter

For its fiscal third-quarter 2010 (to end-January), fiber-optic communications component and subsystem maker Finisar Corp of Sunnyvale, CA, USA has reported revenue from continuing operations of $166.9m (far exceeding December's guidance of $148–158m). This is also up 32.4% on $126.1m a year ago and up 14.6% on Q2/2010's $145.7m (following growth of 19.8% and 13.2% in Q1/2010 and Q4/2009).

"This marks our third consecutive quarter of growth in revenues at double digit rates... a result of a winning product portfolio and strong customer support as we worked to meet a surge in product demand," says executive chairman Jerry Rawls.

Of the $21.2m rise in revenue from last quarter, products for greater than 10Gbps grew $12.1m (23%), products less than 10Gbps grew $4.5m, and reconfigurable optical add-drop multiplexer (ROADM) products grew $3.7m.

Non-GAAP gross margin rose from 28.7% a year ago and 29.6% last quarter to 32.2%, due to spreading fixed manufacturing costs over a larger number of units and a more favorable product mix.

"I am delighted with our progress in manufacturing operations and the improvements we were able to achieve in manufacturing yields," says CEO Eitan Gertel.

However, non-GAAP operating expenses were $39.7m, up $5.5m on $34.2m last quarter and up $5.8m on $33.8m a year ago, due partly to the restoration of salary cuts taken during the previous year as well as variable compensation associated with the firm's improved performance. About $2m of the increase on last quarter was for items other than those related to compensation.

Non-GAAP operating income rose from $2.4m (1.9% of revenue) a year ago and $8.9m (6.1% operating margin) last quarter to $14.1m (8.5% margin). Net income was $11.5m, up on $7.5m last quarter and $1.6m a year ago.

"A robust order trend and healthy backlog have continued into our fourth fiscal quarter, which should enable us to make a strong finish to this fiscal year," says Rawls.

For fiscal fourth-quarter 2010 (to end-April), Finisar expects revenue of $175–185m (up 5–11% on fiscal Q3). Gross margin should be level on fiscal Q3, and operating margin should be 8.5–10%.

"Our ongoing efforts to reduce product costs and transition production to our off-shore locations during the fourth fiscal quarter should position us well for realizing our previous target of 10% operating margin on a non-GAAP basis in the near future," says Gertel.

● Steve Workman (chief financial officer since joining the firm in 1999 prior to its initial public offering) is to assume the role of senior vice president of corporate development & investor relations, superseded by Kurt Adzema (VP of strategy & corporate development since joining in 2005), effective upon the filing of the firm's Form 10-Q for fiscal Q3/2010.

"During Steve's tenure our optic revenues have grown more than 30x and he has successfully guided us through two financial crises," says Rawls. "We felt that this redefinition of roles will help in managing the next phase of growth here at Finisar, and that now was an optimal time for this transition with the former-Optium business [acquired in August 2008] largely integrated with the rest of Finisar," he adds. "Steve helped coordinate our corporate development efforts in the early days, including Infineon and Honeywell," Rawls continues.

"Since joining in 2005, Kurt has led our corporate development initiatives, including the merger with Optium and the divestiture of the Network Tools division," Rawls says. "The experience he gained though his current role and his strong finance background will serve him well in his new role."

www.finisar.com

## Finisar closes public offering, raising net proceeds of $131.2m

Finisar has closed its public offering of its common stock at a price to the public of $14 per share.

Originally announced on 15 March at 7,200,000 shares, on 17 March the offering was increased to 8,640,000 shares (boosting expected gross proceeds to $121m).

In addition, the underwriters' 30-day over-allotment option was increased from 931,093 to 1,147,093.

Together with 148,907 shares sold by certain selling stockholders to cover over-allotments, 1,296,000 shares were hence sold upon the full exercise of the underwriters' over-allotment option on 22 March.

The total sale of 9,936,000 shares hence yielded total gross proceeds of $139.1m. After deducting underwriting discounts and commissions and estimated offering expenses, net proceeds were $131.2m to the company (from its 9,787,093 shares sold) and $2m to the selling stockholders (from their 148,907 shares) after deducting underwriting discounts and commissions.

Finisar previously said that net proceeds may be used for general corporate purposes, including acquisitions, capital expenditure and the repayment of debt.

# Orange launches OptoLock-enabled home installations

Firecomms Ltd of Cork, Ireland, a developer of high-speed plastic optical fiber (POF) transceivers, says that its OptoLock transceiver is a key component of the home networking solution being deployed by Orange. A key brand of France Telecom, one of the world's leading telecoms operators, Orange is deploying POF as the medium of choice in the home to reduce installation times, guarantee network reliability, and enhance customer satisfaction ratings.

Firecomms says that Orange's OptoLock-enabled fiber-optic kits offer a reliable home networking solution by allowing the distribution of a POF network throughout the house. The ready-to-install fiber-optic kit enables Orange customers and installers to connect a TV or computer within a high-speed home network in just minutes, Firecomms adds, minimizing the visual impact of the connection due to POF's ultra-thin diameter.

Orange has cited technical performance, simplicity of installation, and discreet design as benefits of the fiber-optic kit. According to Orange field trial results, 98% of users expressed satisfaction with the technology.

"This POF product offering by one of the largest telecommunications companies in the world demonstrates the overwhelming benefits of POF to operators and customers alike," says Hugh Hennessy, Firecomms' VP of sales & marketing. "This deployment is one of many as operators and installers seek ways to overcome the disadvantages associated with traditional wired technologies."

OptoLock's design enables the fiber to be cut and terminated to the exact required length on site, allowing novice consumer to quickly and easily terminate the bare optical fiber, and enabling the advantages of optical fiber to be brought into the home with do-it-yourself simplicity and costs, says Firecomms. The benefits of such a simple, robust high-speed interface will be significant as high-speed services like 100Mb IPTV are delivered into the home, the firm adds.

Due to its ease of use, large core tolerances and low costs, POF is enjoying substantial growth in home network and point-to-point interconnection. Research by Information Gatekeepers forecasts that the global POF market will grow to more than $2.5bn in 2011.

www.firecomms.com

## OptoLock powers POF products from NYCE and offered by SMC

High-speed optical component supplier Firecomms of Cork, Ireland is collaborating with SMC Networks of Irvine, CA, USA, which supplies customer premise equipment to broadband service providers, and NYCE Networks of Vancouver, BC, Canada, a provider of plastic optical fiber to copper Ethernet products, in which its OptoLock plastic optical fiber (POF) transceiver will power the first product in a new range of POF-based customer premise equipment.

Through the collaboration — which targets accelerated innovation and manufacturing efficiencies in the POF product market — Firecomms will supply OptoLock plugless fiber-optic transceivers for SMC's line of fiber-optic products, which are developed by NYCE. The first product, the SMCEPM-2, is a copper to POF media converter switch that allows broadband service providers to quickly and easily create Ethernet POF networks for their residential and business-class customers.

"Many of our valued broadband service providers need a copper-to-fiber product to create a high-speed Ethernet network for their residential and business-class customers that have outdated wiring and cabling," says Todd Babic, SMC's VP of sales, broadband business development. "The SMCEPM-2 enables quick installation of POF networks and is the fastest, easiest, and most inexpensive to deploy," he claims. "Our collaboration with Firecomms and NYCE allows us to bring a highly valuable POF product to market quickly to meet our customers' needs."

Just millimeters thick, plastic optical fiber is highly durable and flexible, easy to cut, and is much easier to install and conceal than traditional CAT-5/5e/6 cabling. POF is also highly immune to cable electrical noise and provides a higher Quality of Service (QoS) than traditional CAT-5/5e/6 electrical cable networks, so it experiences minimal network congestion (common from bandwidth-intensive applications like VOIP, IPTV, and online gaming).

"These innovative POF devices by SMC and NYCE Networks will enable operators, installers and consumers to connect their IPTV and home networking nodes using a high-quality, interference-free link with the simplicity of a home speaker wire connection," says Lawrence Thorne, Firecomms' VP of sales & marketing for the Americas. "SMC's reputation within the operator community as a provider of highly reliable, cost-effective customer premise equipment further validates the increasing interest in the deployment of POF networking solutions that will enable broadband service providers to guarantee network reliability, reduce subscriber installation costs, and maximize ARPU (average revenue per user)," he adds.

www.smc.com
www.nycetechnology.com

# ITC rules in favor of Avago in parallel fiber optics case

## Initial determination finds patent infringement by Emcore

Avago Technologies Ltd, which designs and supplies analog semiconductor interface components (with a focus on III-V based products) for communications, industrial and consumer applications, says that on 12 March, the US International Trade Commission (ITC) issued the initial determination, finding a violation of Section 337 of the Tariff Act of 1930, as amended, 19 U.S.C. § 1337, in favor of Avago, upholding the validity of its patents and finding that Emcore Corp of Albuquerque, NM infringes Avago's intellectual property by importing and selling certain optoelectronics products used in optical communication systems. After a one-week hearing last November and a post-hearing briefing, the ITC also rejected Emcore's invalidity and other defenses.

In March 2009, the ITC voted to institute an investigation (337-TA-669) based on a complaint filed on 3 February by Avago Technologies Fiber IP (Singapore) Pte Ltd, Avago Technologies General IP (Singapore) Pte Ltd, and Avago Technologies Ltd of San Jose, CA alleging that Emcore was making fiber-optic components that infringe claims 1-6 of Avago's US patent number 5,359,447 and claim 8 of US patent number 5,761,229.

In last week's initial determination, the ITC found that Avago patents cover parallel fiber optics products and components made and sold by Emcore and used for data communications for core routing and enterprise networking.

"Avago remains committed to protecting and, where necessary, taking action to enforce its valuable patent and intellectual property rights," says the firm's general counsel Patricia H. McCall. "Our belief in the strength of our intellectual property in parallel fiber optics is validated by this decision."

In the next phase of the case, the ITC will consider the appropriate scope of an exclusion order enjoining Emcore from importing the infringing optoelectronic products and systems employing these components into the US for the term of Avago's patents. The ITC has recommended an exclusion order to prevent further importation, and also recommended a cease and desist order to prevent Emcore from selling already imported infringing products.

Prior to the ITC case, in December 2008 Avago sued Emcore in the US District Court for the Northern District of California, claiming damages for infringement of the patents. The District Court case is temporarily stayed until an ITC order becomes final. Avago says that it will pursue the infringement charges in the District Court when the stay is lifted.

Prior to the complaint against Emcore, a lawsuit regarding these patents had previously been filed by Avago in the Delaware district court in 2006 against Finisar Corp. Also, before that (in 2000), Avago's predecessor Agilent Technologies filed lawsuits in the Delaware district court against Methode Electronics and Stratos Lightwave and (in 2001) in the Northern District of California against E20 and E20 Communications. In all cases, settlement was reached before trial.

www.avagotech.com

# Avago first to demonstrate 25Gb/s SerDes in 40nm CMOS

Avago Technologies has demonstrated serial 25Gb/s SerDes performance in 40nm CMOS technology, which the firm proclaims as the latest achievement in its history of ASIC Intellectual Property (IP) performance.

Avago says that key differentiators of its SerDes cores are its unique decision feedback equalization (DFE), which results in lower overall power usage, as well as best-in-class data latency, noise immunity, jitter, and crosstalk performance. Also, due to Avago's modular, multi-rate architecture, its SerDes cores are highly integratable, and channel counts in the hundreds are common.

Offering designers great flexibility, the firm's broad SerDes portfolio suits optical, copper, and backplane applications. Supported standards include PCI Express, Fibre Channel, XAUI, CEI-11G, 10GBASE-KR, and SFI.

"With the demonstration of 25Gb/s performance, Avago's legacy of IP leadership continues," says Frank Ostojic, VP & general manager of Avago's ASIC Products Division. "Our early achievement of this milestone reflects Avago's ongoing commitment to providing SerDes IP that enables our customers to address the demand for ever-increasing bandwidth."

**Due to Avago's modular, multi-rate architecture, its SerDes cores are highly integratable, and channel counts in the hundreds are common**

With over 95 million SerDes channels shipped, Avago has established a history of delivering reliable, high-performance ASICs. Three decades of design experience, hierarchical design methodology, and an IP portfolio covering multiple standards, form the foundation for supplying complex ASICs for networking, computing, and storage applications.

# Mindspeed collaborates with Emcore on subsystems using new low-power optical PMD chipset for 3G/4G wireless base-stations

Mindspeed Technologies Inc of Newport Beach, CA, USA, which designs and develops semiconductors for communications applications in wireline and wireless network infrastructure, has announced a high-performance, low-power physical media device (PMD) chipset that includes all necessary components required for common public radio interface (CPRI)-based optical transceivers that economically connect 3G/4G wireless base-station servers to one or more remote radio heads (RRHs) over optical fiber.

Mindspeed has also collaborated with the Fiber Optics Division of Emcore of Albuquerque, NM, USA to develop a family of transmit and receive optical subassembly solutions based on its PMD devices. The family of products will allow base-station servers to transmit over longer distances and at significantly higher data rates than can be supported with copper links.

"The wireless infrastructure is a rapidly growing market and we are excited to work with Mindspeed to develop a family of optical components for next-generation base station platforms," says Chris Wiggins, Emcore's director of sales & marketing. "By leveraging our broad optoelectronic device portfolio, this collaboration effort provides key components with optimized performance to our customers. This will significantly reduce the time to market of their integrated products," he reckons.

"The industry's migration to a 3G/4G mobile infrastructure is creating the need for significantly improved base-station performance – not just for baseband processing, but also for the links between the main base-station server and one or more distributed RRH units," says Gary Shah, executive director of product marketing with Mindspeed's high-performance analog business unit. As a supplier of high-speed PMD solutions for fiber-access networks, Mindspeed is now applying that expertise to a new generation of power-efficient CPRI-enabled optical PMD solutions for 3G/4G base-stations, he adds. The PMDs join Mindspeed's recently announced Transcede multi-core baseband processing system-on-chips (SoCs) to address key challenges in next-generation mobile infrastructure.

Mindspeed's CPRI optical PMD chipsets fully support the latest CPRI V4.1 2009-02-18 specification and are optimized for 4.915Gb/s and 6.144Gb/s operation with lower power consumption compared with traditional 10Gb/s PMD chipsets. They support data rates of 614.4–6144Mb/s over 20km single-mode fiber (SMF) and 500m multi-mode fiber (MMF). The receiver solution includes the M02020 transimpedance amplifier (TIA) combined with the M02049 limiting amplifier optimized for 4.915Gb/s, or the M02129 TIA combined with the M02142 limiting amplifier for 6.144Gb/s. The limiting amplifiers each feature selectable bandwidth for optimal receiver sensitivity across CPRI rates. On the transmit side, solutions include the M02061 laser driver for long-wave laser diodes and the M02069 driver for short-wave vertical-cavity surface-emitting lasers (VCSELs).

Mindspeed's CPRI optical PMD chipsets are available now, along with a small-form-factor reference design for data rates up to 6.144Gb/s. The firm says that, by offering seamless chipset solutions, its CPRI optical PMD family enables optical transceiver vendors to get to market quickly with cost-competitive solutions that deliver industry-leading performance.

**www.mindspeed.com**
**www.emcore.com**

# Emcore releases 100mW ultra-low-RIN DWDM laser modules

Emcore has made available a new line of high-power (>100mW) CW source laser modules for 1550nm DWDM applications.

Available in all ITU grid wavelengths, the modules (model number 1782) offer solutions for the growing demands of high optical power in DWDM, cable TV networks, and free-space optics applications, says Emcore.

The laser module is DC-coupled with a built-in thermo-electric cooler (TEC), thermistor, and monitor photodiode. The device is mounted in a 14-pin, OC-48 pinout compatible butterfly package, with the optical isolator mounted on the TEC. The operating temperature ranges from –20°C to +65°C, and the maximum laser bias current is 450mA. However, the module incorporates an high-efficiency coupling scheme to deliver more than 100mW CW optical output power at a low bias current. The RIN (relative intensity noise) is typically less than –170dB/Hz.

"The ultra low RIN and high optical power makes this product family an excellent choice to design into externally modulated transmitters that require high optical power or dual optical power outputs for RFoG [radio frequency over glass] and FTTx networks," says Vu Tran, Optical Component product line manager for Emcore Broadband.

IN BRIEF

## Circadian Solar recruits business development manager

Circadian Solar of Coventry, UK, which is developing concentrated photovoltaic (CPV) systems incorporating gallium arsenide multi-junction photovoltaic cells, has appointed Richard Sammut as its new business development manager, responsible for developing relationships with key partners and users of its systems as well as ensuring that recent growth continues strongly as the firm moves towards full-scale commercialization. Circadian has several demonstration projects in progress and is now designing its large-scale manufacturing operation.

Sammut has broad expertise in customer-facing roles, including 17 years' experience in technical product support, sales and marketing at engineering consultancy Ricardo UK. Additional background in project management, developing advanced technology products and supporting innovative technologies will be central to Circadian's goal of becoming a major player in supplying CPV systems.

"Over the past six months we have successfully rebranded [from the firm's former name AdvanceSis], increased the system's efficiency still further and moved forward with a number of global projects," says CEO Dr Robin Godfrey. "It is now time, with Richard's help, to focus on growing Circadian Solar's reputation and reach in the CPV industry," he adds.

The appointment marks a new phase for Circadian and is likely to be followed by further senior appointments in the coming months.

**www.circadiansolar.com**

# CPV Consortium appoints board members from NREL and Fraunhofer ISE

The CPV Consortium, a non-profit concentrator photovoltaic (CPV) solar industry organization, has added two solar industry veterans to its board: Andreas Bett PhD and Martha Symko-Davies PhD. The appointments come at a time when the consortium has commissioned the University of California, Berkeley to undertake an economic analysis of the CPV carbon footprint, cradle-to-cradle.

The CPV Consortium is dedicated to supporting the development and optimizing the success of CPV technology as a mainstream energy source for distributed and utility-scale deployments. The global organization consists of members from all segments of the CPV industry including system manufacturers, cell suppliers, power generators, tracker suppliers, system integrators, project developers, universities and research laboratories.

Dr Bett is a deputy director of the Fraunhofer Institute for Solar Energy ISE in Freiburg, Germany, where he leads a department focused on materials for solar cells and technology. Dr Symko-Davies is a senior supervisor of research at the US Department of Energy's National Renewable Energy Laboratory (NREL). Both have been elected by members of the consortium to serve on its board of directors. "With the appointments of Drs. Bett and Symko-Davies, the CPV Consortium gains decades of expertise from the highest levels of solar industry research and development," says consortium director Nancy Hartsoch. "Their insight from Fraunhofer, the DOE and NREL will broaden the perspective of the organization, and hopefully facilitate the benefits that public and private cooperation can bring to an emerging technology at a critical time for CPV commercialization."

Bett's department at Fraunhofer ISE includes the group 'III-V-epitaxy and solar cells', which is one of the largest groups active in R&D for CPV cells, modules and components. He is also an active member in the IEC (International Electrotechnical Commission), which develops standards for CPV. Bett is currently the chair and main organizer of the 6th International Conference on Concentrating Photovoltaic Systems (CPV-6), to be held in Freiburg in April.

Symko-Davies has worked for NREL since receiving her doctorate in 1997. She has been manager of the PV Technology Incubator since its inception three years ago. At NREL she has held a variety of positions including photovoltaic (PV) manufacturing technology technical manager and high-performance PV project manager. Symko-Davies is also an organizing committee member for the IEEE Photovoltaic Specialists Conference (PVSC) and a member of the American Physical Society (APS). She has authored or co-authored over 30 publications about the PV industry and CPV technology.

As a non-profit organization, all of the CPV Consortium's activities and affairs are managed by the board of directors. Bett and Symko-Davies join the board along with re-elected members Jan Hildebrandt of 3M and Gerhard Strobl of solar cell maker AZUR SPACE of Heilbronn, Germany.

Founding board members include Pedro Banda of Spain's Institute of Concentration Photovoltaic Systems (ISFOC), Brian Gibson of component, module and system maker Emcore in Albuquerque, NM, USA, Nancy Hartsoch of CPV system maker SolFocus in Sunnyvale, CA, USA, and Hansjörg Lerchenmüller of Concentrix Solar GmbH in Freiburg, Germany.

**www.cpvconsortium.org**

# RFMD makes PV cells using high-volume 6" GaAs line

Radio-frequency microelectronic component maker RF Micro Devices Inc of Greensboro, NC, USA says that it has manufactured what is claimed to be the industry's first photovoltaic (PV) cell using high-volume 6" GaAs wafer fabrication equipment (in its existing fab, with no equipment modifications).

The firm says that this is the first in a series of anticipated achievements to commercialize high-performance multi-junction PV cells. Last July, RFMD entered into a cooperative agreement with the US Department of Energy's National Renewable Energy Laboratory (NREL) to develop a commercially viable and high-volume-capable compound semiconductor-based process for high-performance multi-junction PV cells.

"NREL's collaboration with RFMD demonstrates our commitment to developing the best technologies for renewable energy and aligning with the most capable partners to commercialize and deploy each technology," comments NREL director Dan Arvizu. "We applaud RFMD's successful achievement of this first technical performance milestone," he adds.

"By combining NREL's technology leadership and decades of research with RFMD's industry-leading cost structure and technical expertise in commercializing high-performance, reliability-proven compound semiconductors, we are accelerating the commercialization of a next-generation process technology that promises the solar industry's lowest-cost, highest-performance PV cells," says RFMD's president & CEO Bob Bruggeworth.

"Semiconductor firms have the potential to change the dynamics in the concentrated PV market, since they may be able to produce low-cost, high-efficiency solar cells on their existing, depreciated equipment and robust manufacturing processes," comments Alfonso Velosa, research director, Semiconductors for market research firm Gartner. "Within a few years the concentrated PV market may be able to deliver large volumes of renewable electricity, based in part on obtaining large volumes of high-quality — yet low cost — solar cells, from 'bankable' manufacturers," he adds.

RFMD achieved the PV cell milestone in the Foundation Phase of the NREL agreement, during which the capability to make basic PV cells at its manufacturing facilities is being established. A subsequent Technology Demonstration Phase will then begin, during which PV cells leveraging NREL's IP and technology will be fabricated. In the final Production Readiness Phase, RFMD aims for its high-volume, 6-inch fabrication plants to demonstrate high-performance PV cells with high yields, high reliability, high reproducibility and low cost.

Execution of RFMD's multi-year agreement with NREL is expected to result in high-volume production of PV cells in RFMD's fabs as early as 2012, using technology capable of best-in-class solar cell conversion efficiency. NREL's technology has demonstrated one of the world's highest reported solar cell conversion efficiencies (40.8%), and continued substantial improvements in efficiency are expected.

**www.rfmd.com**

# Semprius and Siemens to co-develop solar technology

Semprius Inc of Durham, NC, USA and Atlanta-based Siemens Industry Inc (the US affiliate of Siemens' global Industry Sector business) have entered into a joint development agreement to co-develop and deploy plug-and-play demonstration systems based on Siemens' automation and control components and Semprius' Solar Module Arrays, which are based on patented micro-transfer printing to deposit semiconductors onto any substrate (including glass and plastic). The systems are slated to be installed at test sites around the world, including major utilities, commercial sites, international test locations and government facilities.

Semprius says its Solar Module Arrays for concentrator photovoltaics (CPV) offer the benefits of low installed cost and high capacity factor which, combined, enable very low energy costs in sunny, dry climates. Their high-efficiency, scalable design makes them applicable to a wide range of projects, from distributed commercial and industrial to large-scale utility installations.

Siemens supplies automation systems, power conversion and control systems. It provides technology to the photovoltaic industry as part of its environmental portfolio, which generated revenue of $31bn (EUR23bn) in fiscal 2009. In an effort to make PV module arrays more efficient, Siemens will integrate its components with Semprius PV module arrays and, together, the companies will implement the test systems to validate performance of the combined technologies.

"Our PV module arrays will make the generation of solar power economically viable in clear, sunny climates found in many parts of the world," says Semprius' president & CEO Joe Carr.

"Competitive project deployment cost for CPV will be the key for the success of this technology," says Peter Krause, business segment manager at Siemens Industry Inc. "Combining Siemens' advanced automation and control equipment with Semprius Module Arrays has the potential to deliver electricity at grid level prices to both industrial and utility scale customers."

**www.semprius.com**
**www.usa.siemens.com/Industry**

# OPEL and BETASOL secure Spanish feed-in tariff for 330kW utility-grade HCPV solar farm

Together with its Spanish partner BETASOL (which builds utility-grade solar farm installations for subsequent sale to investor groups), OPEL Solar Inc (a subsidiary of OPEL International Inc of Shelton, CT and Toronto, ON, Canada which makes high-concentration photovoltaic panels), has announced that its 330kW utility-grade solar photovoltaic power plant in Spain is eligible to begin receiving the feed-in tariff (FIT) from the Spanish Government. This makes the OPEL Solar project one of the first high-concentration photovoltaic (HCPV) installations to be recognized with an FIT and guaranteed investment rate of return.

The Spanish listing, called the Photovoltaic Allocation Registry, was published in mid-February and denotes projects approved for the feed-in tariff starting in first-quarter 2010. As one of the first commercial HCPV installations, the 330kW solar farm at Vilalba del Arcs will be eligible for a FIT of 28.1 Eurocents per kilowatt of electric power generated. The FIT will be provided for a 20-year period.

"Approval of the Vilalba del Arcs utility solar farm for the Spanish Feed-In Tariff Program is a significant business milestone for OPEL Solar and its HCPV technology," says OPEL Solar's CEO Robert Pico. "This demonstrates that HCPV is a viable technology for generating electricity from the sun at utility-scale levels and for providing guaranteed revenue to its owners, such as BETASOL in this case," he adds. "From an investment viewpoint, this project offers a very attractive rate of return to any investor."

The utility-grade solar farm is one of the first operable solar grid fields in the world using OPEL's HCPV solar technology. It generates 330kW of electricity to the power grid, increasing revenue for BETASOL. The installation is located in the Tarragona region of Spain, which is a prime location for solar development.

OPEL built the installation using its Mk-I HCPV solar panels mounted on dual-axis trackers, which combine to result in a higher power production per unit of land (acre/hectare) than silicon or thin-film flat panels, with a potential to increase photovoltaic yields by up to 40%, the firm claims.

**www.opelinc.com**

# Concentrix enters US market with 1MW CPV

Concentrated photovoltaic (CPV) system maker Concentrix Solar GmbH of Freiburg im Breisgau, Germany has signed a contract with Chevron Technology Ventures for the installation of a 1MW solar power plant using its FLATCON CPV technology at a Chevron Mining facility in Questa, NM, USA. The power produced will be sold through a power purchase agreement with the Kit Carson Electric Cooperative.

This will be the largest CPV installation in the US and one of the world's largest CPV power plants, claims Concentrix, confirming full commercial readiness of its system for worldwide deployment and paving the way to utility-scale CPV projects.

Concentrix was founded in 2005 as a privately held spin-off of the Fraunhofer Institute for Solar Energy Systems ISE. In December, about 80% of its shares were acquired by the Soitec Group of Bernin, France, which manufactures engineered substrates including silicon-on-insulator (SOI) wafers (as well as III-V epiwafers through its Picogiga International division).

The firm's FLATCON technology uses Fresnel lenses to focus sunlight almost 500-fold onto a small area of high-efficiency solar cells, reducing the need for costly materials and increasing system efficiency. Last August, Concentrix said that, by using its new CX-75 generation of modules, it had raised its record for CPV AC (alternating-current) system efficiency from 23% (achieved in May 2008) to 25% under full field operating conditions (almost twice as high as those achieved by conventional silicon technology), as confirmed at demonstration tracking system installations on the University of California San Diego campus in the USA, and in Puertollano, Spain. Also, in late January, Concentrix said it had received IEC certification 62108 for its CX-75 FLATCON module generation.

A FLATCON CPV tracking system has a nominal power output of 6kW, so 1MW consists of about 175 systems, which can be placed in an area of 7 acres. Concentrix operates a fully automated CPV module manufacturing line in Freiburg with a capacity of 25MW, and further expansion is planned.

"This commercial deployment [in Questa, NM] is a key milestone for us and our US strategy," says Concentrix's CEO Hansjorg Lerchenmuller. "It is an important reference for our technology, and the next logical step considering the outstanding performance demonstrated at our Spanish power plants," he adds.

"With their high direct normal irradiance and their high energy demand, the Southwestern states of the USA are perfectly suited for our CPV technology," says Lerchenmuller. The FLATCON high-precision, two-axis tracking system helps utilities to match US peak power demands, he adds. Concentrix is planning new investments to further expand business in the Southwest USA in the near future.

**www.concentrix-solar.de**

# Solar Junction raises $13.3m in Series C funding:

## Targets customer sampling of high-efficiency multi-junction CPV cells

Solar Junction Corp of San Jose, CA, USA has raised $13.3m in a Series C round of funding from existing investors Draper Fisher Jurvetson, Advanced Technology Ventures and New Enterprise Associates, reports Greentech Media.

This follows $3m in funding in late January from the National Renewable Energy Laboratory (NREL) as part of the Department of Energy's Photovoltaic (PV) Incubator Program, which aims to "support the development of early-stage solar energy technologies and help them advance to full commercial scale".

Solar Junction is developing a manufacturing process to produce a very high-efficiency multi-junction cell, for use by concentrating photovoltaic (CPV) manufacturers to produce lower-cost CPV systems.

The firm's management team includes: co-founders Jim Weldon as CEO (formerly VP of business development & technology at semiconductor process & metrology equipment firm Veeco Instruments Inc), Dr Homan Yuen as VP R&D (who has experience of materials deposition and characterization for applications including solar cells, optoelectronics, silicon photonics and CMOS electronics), Dr Vijit Sabnis as VP Technology (who has over 15 years of experience with III-V optoelectronic device design, wafer processing, and characterization), and Dr Michael Wiemer as VP Device Development (who has over 12 years of device design & fabrication experience) — the latter three all with PhDs from Stanford University. They are joined by Dr Richard Chicotka as VP engineering (who has over 40 years of experience in engineering and operations management, and is a 30 year veteran of IBM) and Dr John A. Herb as VP business development (who has over 25 years of experience managing the development and commercialization of high-tech products, most recently as VP of Advanced Technology for CPV firm GreenVolts).

Solar Junction says that it aims to use the latest funds to achieve higher efficiencies for multi-junction solar cells and to move forward with customer sampling.

**www.sj-solar.com**
**www.greentechmedia.com/**

# Victor Valley College installs 1MW SolFocus CPV plant

SolFocus Inc of Mountain View, CA, USA is installing a 1MW facility of high-concentrator photovoltaic (CPV) systems at Victor Valley College in Victorville, CA. The solar micro-generating facility will produce 2.5 million kW-hr per year (about 30% of the college's electricity demand).

Construction of the 6 acre plant, consisting of 122 8.4kW arrays, is underway on the college's main campus. When completed in May, it will be the largest facility of its kind in North America, says SolFocus.

At a time when education is suffering unprecedented losses in funding, the project achieves three key goals: reduces energy costs, increases revenue streams from outside sources, and creates training opportunities for well paying jobs in the new energy economy. Project funding was provided in part by a capital construction bond, Measure JJ, approved by voters in November 2008 along with other capital funds. The college will also benefit from about $4m paid over five years through performance-based incentives as part of the California Solar Initiative (CSI).

"After reviewing several options for a solar provider, SolFocus demonstrated that it could deliver the best value," says the college's president Dr Robert Silverman. "This project can be a model for other colleges and universities in meeting energy needs and supporting a green jobs economy."

SolFocus will be supporting the college in its curriculum development around advanced solar energy technology (a critical element in supporting US President Barack Obama's green jobs initiatives).

"This project between SolFocus and Victor Valley College is the first of its kind in North America," claims SolFocus' president & CEO Mark Crowley. "SolFocus technology can scale up or down very easily to accommodate a wide variety of energy demands from smaller distributed generation projects to utility-scale projects."

According to the report 'Solar Panels on Campus' by the Association for the Advancement of Sustainability in Higher Education, 75% of the solar installations at colleges and universities around the country have less than 100kW of capacity. "This 1MW installation puts the college and SolFocus in the top echelon of campus installations," says Crowley. "A small proportion of the 4000 college and university campuses in the US have begun solar projects, so the market opportunity for this sector is promising as the CPV industry scales up to utility deployments."

SolFocus' CPV design uses patented reflective optics (curved mirrors) to concentrate sunlight 650 times onto GaAs-based solar cells that have high conversion efficiency (nearing 40%, more than twice that of traditional silicon solar cells). The firm's SF-1100S system uses about a thousandth of the active solar cell material compared to traditional silicon-based PV panels, but boosts panel conversion efficiency from 18% to over 25%.

**www.solfocus.com**

# NYSERDA awards UAlbany NanoCollege incubator $1.5m:
## Magnolia Solar becomes iCLEAN program's first corporate partner

The New York State Energy Research and Development Authority (NYSERDA) is providing $1.5m to establish the Incubators for Collaborating and Leveraging Energy and Nanotechnology (iCLEAN) clean energy incubator program, spearheaded by the Energy and Environmental Technology Applications Center (E2TAC) at the University at Albany's College of Nanoscale Science and Engineering (CNSE). The objective of iCLEAN is to help growing companies develop and commercialize clean energy technologies and create jobs in the Tech Valley. The announcement was made at the UAlbany NanoCollege by NYSERDA president & CEO Francis J. Murray Jr, State University of New York (SUNY) chancellor Nancy Zimpher, and CNSE senior VP & CEO Dr Alain Kaloyeros.

The sixth clean energy business incubator created by NYSERDA over the past year (and the third to be located on a SUNY campus), iCLEAN is a partnership between CNSE's E2TAC and the Hudson Valley Center for Innovation (HVCFI) in Kingston, and will seek to expand existing incubator programs at these facilities and create a new, larger incubation center at the NYSERDA-owned Saratoga Technology + Energy Park (STEP) in Malta, NY.

CNSE has also attracted an additional $1.5m in private investment to support iCLEAN's activities, as well as the program's first corporate partner. Magnolia Solar Corp of Woburn, MA, USA, which develops nanostructure-based thin-film solar cells for terrestrial applications for defense and commercial applications, is partnering with E2TAC on research to enable the development of high-efficiency, low-cost solar cells. Earlier this month, Magnolia received a $1m award from NYSERDA to develop its solar cells in partnership with CNSE. The firm uses nitride-based materials on low-cost substrates to capture a broader spectrum of the sun's energy, and incorporates nanostructure-based antireflection coatings to reduce energy losses and boost solar energy conversion efficiency.


**iCLEAN's official announcement.**

Over the next four years, iCLEAN expects to incubate 25 firms, with the potential for creating 125 new jobs and investing nearly $125m into the regional economy.

"With its wealth of talent and clean energy expertise, the College of Nanoscale Science and Engineering of the University at Albany is an ideal location for a new business incubator that will help early-stage businesses grow, create jobs in Tech Valley [a 19-county region encompassing the Capital Region, parts of the North Country, Hudson Valley, and Mohawk Valley], and compete in the national economy," says Murray. The funding represents Governor David Paterson's commitment to invest in infrastructure to help innovators develop their products, take their ideas to the market, and expand New York's clean energy industries, he adds. "This partnership leverages our collective strengths in developing the economy while focusing on sustainable, low-cost energy," comments Zimpher.

"The world-class educational and research portfolios at UAlbany's College of Nanoscale Science and Engineering will be further enhanced through this vital funding from NYSERDA," reckons University at Albany president George M. Philip. "The creation of this innovative clean energy incubator also illustrates the NanoCollege's unique ability to drive economic investment and growth, particularly in the most critical sectors of our economy, including alternative energy technologies," he adds.

"This funding will enable advanced research at the UAlbany NanoCollege that is essential for the commercialization of innovative green energy technologies, and also provide opportunities to attract alternative and renewable energy companies and green collar jobs to New York," says Kaloyeros.

iCLEAN partners will have access to CNSE's laboratories and cleanroom facilities, gain networking opportunities through regional and national partnerships to raise funding through venture capital, and receive professional services. Also, the program will host an Entrepreneurial Development Series on clean energy to train and transition corporate executives into the clean energy industry.

"The iCLEAN program will allow CNSE's E2TAC to help accelerate the development of clean energy technologies that are important for New York's environmental and economic future," says E2TAC director Dr Pradeep Haldar. "We are particularly pleased to support the growth of emerging alternative energy companies, as evidenced by our partnership with Magnolia Solar, and look forward to working with our partners at the Hudson Valley Center for Innovation to enable additional collaborations in the future."

Magnolia's president & CEO Dr Ashok K. Sood reckons that its partnership with CNSE will allow access to world-class intellectual and technological capabilities, and help bring its technology for low-cost, high-efficiency thin-film PV panels to market more quickly. "Accelerating time to market with CNSE and NYSERDA support is necessary for our future success," he adds.

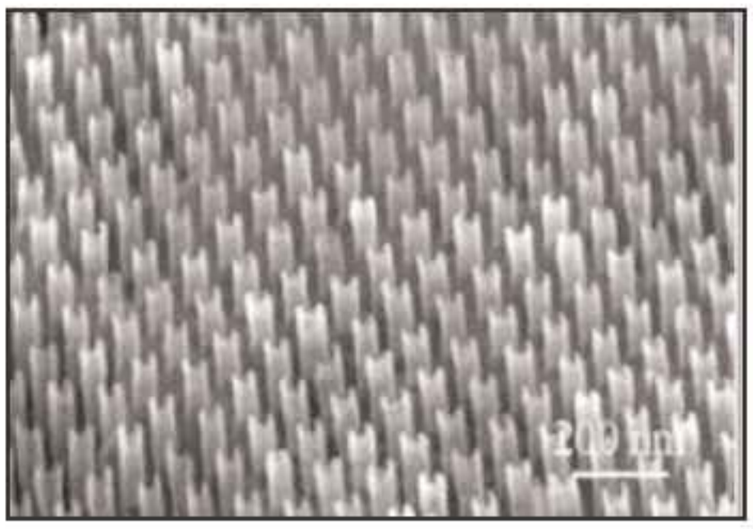
**http://cnse.albany.edu**
**www.magnoliasolar.com**

# Magnolia Solar wins NYSERDA award to develop low-cost nano-based thin-film photovoltaic cells

Magnolia Solar Corp of Woburn, MA, USA, which develops nano-technology-based thin-film photovoltaic modules for terrestrial use in defense and commercial applications, has announced that its subsidiary Magnolia Solar Inc has received a $1m award from the New York State Energy Research and Development Authority (NYSERDA) to develop thin-film solar cells in partnership with the College of Nanoscale Science and Engineering (CNSE) of the University at Albany.

Magnolia Solar says that its technology — which uses non-toxic nitride-based materials on low-cost substrates — can capture a broader spectrum of the sun's energy and incorporates nanostructure-based antireflection coating to reduce energy losses, producing high-efficiency solar cells. Magnolia will collaborate with faculty and scientists from CNSE's Energy and Environmental Technology Applications Center (E2TAC) at CNSE's Albany NanoTech Complex to demonstrate its technologies in nanostructure-based thin-film solar cells. The program, which is designed to improve energy efficiency while reducing production costs, is also being supported by professor Fred Schubert at Rensselaer Polytechnic Institute in Troy, NY. Magnolia has received a NYSERDA order for the first phase of this three-phase development program.

"We are committed to growing in the Albany region, supported by the world-class intellectual and technological infrastructure at CNSE's Albany NanoTech Complex," says Magnolia's president & CEO Dr Ashok K. Sood. "Magnolia Solar's mission is to provide environmentally responsible and low-cost solutions for the solar power industry, and to be an integral part of New York's green energy future," he adds.




**Nanostructured surface.**

"This partnership further demonstrates CNSE's growing portfolio in supporting both innovative technologies and companies in the critical alternative energy sector," comments Dr Pradeep Haldar, CNSE professor and head of Nano-Engineering and executive director of E2TAC.

"NYSERDA's early-stage investments in innovative, environmentally friendly technologies offer the promise of new jobs and industries for New York in the future," says NYSERDA's president & CEO Francis J. Murray Jr. "The new products that result from these investments will help us realize Governor David Paterson's vision for a clean energy economy that uses new and emerging technologies to save energy, create jobs, and improve our environment."

**New products that result from these investments will help us realize Governor David Paterson's vision for a clean energy economy that uses new and emerging technologies to save energy, create jobs, and improve our environment**

www.magnoliasolar.com

IN BRIEF

## Magnolia completes reverse merger; becomes publicly traded corporation

Magnolia Solar Inc of Woburn, MA, USA recently said that, on 31 December, it completed a reverse merger with publicly traded firm Mobilis Relocation Service Holdings Inc. Magnolia merged with Mobilis Relocation Services Inc, a Nevada corporation, becoming a subsidiary of Mobilis, as well as its principal operating business. Following the merger, Mobilis changed its name to Magnolia Solar Corp.

Incorporated in the State of Delaware in January 2008, Magnolia is developing nitride-based thin-film solar cells that incorporate nanostructured anti-reflection coating technology to capture a larger part of the solar spectrum and hence boost energy conversion efficiency. The cells can also be deposited on low-cost substrates (such as glass and flexible structures such as polymers) to reduce the cost per watt for terrestrial applications.

In 2008, while not generating revenue, Magnolia Solar generated losses totaling $38,904. A 'going concern' statement filed with the US Securities and Exchange Commission (SEC), says that the firm needs to raise additional funds to carry out its business plan, and that continuation of operations is dependent on continued financial support from its shareholders and its ability to obtain necessary equity financing.

"Becoming a publicly traded corporation will help us gain access to the capital markets that we need to more aggressively grow our thin-film solar business," says Magnolia Solar's co-founder, president & CEO Dr Ashok K. Sood.

www.magnoliasolar.com

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# First Solar grows 33% sequentially

## ...but increased project revenue suppresses margins

First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement and construction (EPC) services, has reported revenue for 2009 of $2,066m, up 66% on 2008's $1,246m. Net income rose from $348.3m to $640.1m.

In particular, fourth-quarter 2009 revenue was $641.3m, up 48% on $433.7m a year ago and up 33% on Q3's $480.9m (driven by higher module production volumes, system revenue recognition for the 20MW AC Sarnia and 21MW AC Blythe projects, offset party by lower module ASPs). Production was 311MW (up 6.4% on Q3), boosting 2009 to 1.1GW (up 121% on 2008) and more than 2GW cumulatively. First Solar reckons that it has hence doubled its share of the solar market year-over-year to 18–19%.

Gross margin has fallen from Q3's 50.9% to 41.5% (with full-year gross margin falling from 54% in 2008 to 50.6% in 2009). However, this is due to the rise in lower-margin EPC/project development business (to 14% of sales). During Q4, First Solar sold more than 100MW of projects, including the 20MW Sarnia project to Enbridge plus a 60MW expansion, and the 21MW Blythe project to NRG Energy. Project development includes acquiring Edison Mission Group solar sites in southwestern USA (a dozen projects on private land, of 20–150MW each), and beginning construction of two new utility-scale plants — the 48MW Copper Mountain project (an expansion of El Dorado for Sempra Generation) and the 60MW Sarnia Ontario expansion — as well as receiving BLM fast-track priority for the 550MW Sunlight project, which will start construction in Q4/2010.

Q4 net income was $141.6m, up from $132.8m a year ago but down on $153.3m in Q3.

Full-year 2009 operating cash flow was $675m. So, after $280m of capital expenditure (exceeding the $260–275m forecasted in Q3/2009), full-year 2009 free cash flow was $395m. Of this, $345m came in Q4 (operating cash flow of $414m minus $69m of CapEx). Cash and marketable securities were boosted by $284m to $1.1bn.

Due to energy conversion efficiency rising from 11% to 11.1%, lower material costs and annualized capacity per line rising from 53MW to 53.4MW, module manufacturing cost has been cut further, from $0.85/Watt to $0.84/Watt (or $0.80/Watt, excluding the impact of about $0.02 due to expanding the plant in Perrysburg, OH to four lines and $0.02 due to stock-based compensation).

**Module manufacturing cost has been cut further, from $0.85/W to $0.84/W (or $0.80/W, excluding the impact of about $0.02 due to expanding the plant in Perrysburg, OH to four lines**

For 2010, First Solar expects sales to rise about 35% to $2.7–2.9bn (including module sales of $2.1bn and EPC/project development sales of $600–800m). The firm correspondingly expects gross margin to fall from 50.6% to 38% (including 48–50% for modules but only 5–6% for EPC/project development) and operating margin to fall from 32.9% to 23–24% (30–33% for modules, but only break-even for EPC/project development).

Despite operating cash flow rising from $675m to $730–790m, free cash flow should fall from $395m to $180–290m, due to total capital spending almost doubling from $280m to $500–550m, plus start-up expenses of about $25m to expand the firm's manufacturing center in Kulim, Malaysia. Of the $500–550m in CapEx, First Solar is investing $365m in Malaysia to add eight production lines (in two production plants — plants 5 and 6 — consisting of four manufacturing lines each), starting operation in first-half 2011 at 427MW (bringing total annual capacity to 1.7GW).

Together with the two-line factory in France being built with Paris-based EDF Energies Nouvelles (announced in July, and projected for full annual production of 107MW by 2012), First Solar expects to add 10 production lines during 2010–2011, raising capacity by over 48% from current levels. With the total number of lines due to rise from 23 to 34, this should bring annual or announced production capacity to about 1.8GW by 2012 (based on current production levels). Annualized capacity per line should rise to 80MW by 2014.

First Solar began full commercial operation of its initial manufacturing line only in late 2004, and annual production capacity was not much more than 500MW as recently as 2008, before doubling to more than 1GW in 2009. Revenue more than doubled from $504m in 2007 to $1,246.3m in 2008, so 2010's projection of $2.7–2.9bn is more than double that.

**With the total number of lines to rise from 23 to 34, this should bring annual or announced production capacity to about 1.8 GigaWatts by 2012 (based on current production levels)**

www.firstsolar.com

# CdTe PV maker First Solar becomes associated partner of Desertec Industrial Initiative

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe) as well as providing engineering, procurement and construction (EPC) services, has joined the Desertec Industrial Initiative (DII) as an associated partner to demonstrate the potential of photovoltaic (PV) solar technology to provide clean, sustainable energy on a vast scale by harnessing the desert sun.

As a provider of utility-scale solar power plants, First Solar says that it is the first pure PV company to join Desertec. Initiated last year by non-profit-organization Desertec Foundation and reinsurance company Munich Re (together with other founding members ABB, energy groups E.ON and RWE, Deutsche Bank, HSH Nordbank, M+W Zander, MAN Solar Millenium, SCHOTT Solar, SIEMENS, Spain's ABENGOA Solar and Algeria's Cevital industrial group), DII aims to provide a significant portion of the electricity for the Middle East and Northern Africa as well as Europe by 2050 via a network of solar and wind energy sources.


**Areas addressed by Desertec Industrial Initiative.**

"We look forward to working with Desertec to demonstrate the potential of renewable energies — and PV in particular — to deliver clean, reliable power to the people of Africa and the Middle East as well as Europe," says Stephan Hansen, managing director of First Solar GmbH, the firm's European sales & customer service unit for Europe, the Middle East and Africa. "The challenges of energy security and global warming demand bold solutions, and Desertec certainly provides an ambitious vision," he adds.

**First Solar will contribute utility-scale PV expertise in Desertec working groups**

"As a high-performance, low-maintenance technology that can be deployed in stages and deliver clean energy quickly, PV is the ideal complement to other renewable energies already represented in Desertec," says Hansen, claiming that First Solar's thin-film technology delivers superior energy yields even under hot desert conditions.

As an associated partner of Desertec for an initial period of three years, First Solar will contribute utility-scale PV expertise in Desertec working groups and prepare the ground for reference projects and a roll-out plan. Desertec's founders include other leading companies in the solar and wind energy business as well as in electricity distribution.

First Solar has already built utility-scale solar power plants in desert conditions in the USA and United Arab Emirates and is preparing the way for a 2GW solar power plant in Ordos City, Inner Mongolia.

www.desertec.org

# First Solar to supply PG&E with 300MW from Desert Sunlight plant

First Solar has announced a power purchase agreement to supply Pacific Gas and Electric Company (PG&E) with renewable electricity from a 300MW (AC) utility-scale photovoltaic solar power facility that First Solar is developing in Southern California.

The Desert Sunlight project, to be located near Desert Center in eastern Riverside County, CA, will have a total capacity of 550MW, enough to power about 160,000 area homes (about 480,000 residents). The other 250MW portion of the project is already under contract to Southern California Edison (SCE) following an agreement last August (in which First Solar is also supplying SCE with 300MW from the Stateline PV project in northeastern San Bernardino County). The power purchase agreements with PG&E and SCE are subject to the approval of the California Public Utilities Commission.

First Solar will build the project using its photovoltaic solar modules and provide project development, engineering, procurement and construction capabilities. With construction expected to start by the end of 2010 and complete as early as 2013, the project will create about 430 construction jobs and displace 300,000 metric tons of $CO_2$ per year (equivalent to taking 60,000 cars off the road, it is reckoned). The permit application has been fast tracked by the Bureau of Land Management.

"First Solar is one of the few companies that has all the capabilities required to realize very large, utility-scale solar projects like Desert Sunlight, which are important in helping our customers and California reach the state's renewable energy goals," claims the firm's CEO Rob Gillette.

First Solar has 1700MW of utility-scale power projects with power purchase agreements in North America.

# 5N Plus reports dip in sales, but solar demand strong

For its fiscal second-quarter 2010 (to end-November 2009), 5N Plus Inc of Montreal, Quebec, Canada has reported (in Canadian dollars) revenue of $15.8m, down 13.1% on $18.1m a year ago and 2% on $16.1m last quarter.

5N produces high-purity metals such as tellurium, cadmium and selenium, as well as II-VI compounds such as cadmium telluride (CdTe) and cadmium sulphide (CdS) as precursors for the growth of crystals for electronic applications, including infrared detectors for night-vision systems, gamma-ray detectors for nuclear imaging in medicine, thermo-electric modules for cooling, and thin-film photovoltaic cells.

Net earnings of $3.2m were up slightly from $3m last quarter, but down from $5.9m a year ago. Nevertheless, cash and cash equivalents have increased by $4.4m on a year ago.

"Results of our second quarter continue to reflect a healthy demand for our solar-grade products," says president & CEO Jacques L'Écuyer. "We expect this trend to continue, with new manufacturers entering the market and recent announcements of additional CdTe solar module manufacturing capacity," he adds. 5N Plus supplies to booming CdTe solar cell maker First Solar Inc of Tempe, AZ, USA.

"Our second quarter results were, however, also negatively impacted by the relatively strong showing of the Canadian dollar with respect to its US counterpart, which also reduced our backlog," notes L'Écuyer. At the end of November, the backlog of orders expected to translate into sales over the following 12 months was $53.3m, down 2.7% on $54.7m a year ago.

Also, 5N Plus began incurring significant R&D expenses related to ZT Plus, the joint venture with BSST (a subsidiary of Amerigon Inc) unveiled at the end of the fiscal first quarter. "Markets for our other products continued to be challenging in the quarter, but we expect this situation to correct itself and remain therefore optimistic for the future."

"We continue to seek opportunities for expansion of our corporation through acquisitions and partnerships," L'Ecuyer continues. In December, 5N acquired Firebird Technologies Inc of Trail, British Columbia — which produces indium antimonide (InSb) wafers as well as antimony, indium and tin pure metals — and signed a memorandum of understanding with Teck Metals Ltd for the long-term supply of strategic minor metals (including indium, cadmium and germanium feedstock). "This will form the basis of a new platform aimed at addressing the semiconductor wafer business as well as additional opportunities in the solar market including copper indium gallium selenide (CIGS) and germanium," L'Ecuyer says. "Combined with ZT Plus, we believe that this will provide us with significant additional growth opportunities."

5N aims to continue executing its growth plan through diversification of its product range and accretive acquisitions, L'Ecuyer concludes.

www.5nplus.com

# Supply and recycling deals with CdTe PV makers Calyxo and Abound

5N Plus and CdTe thin-film PV module maker Abound Solar of Loveland, CO, USA (formerly AVA Solar until last March) have entered into a module recycling agreement and signed a memorandum of understanding (MOU) for the supply of 5N Plus products.

5N will provide recycling services for solar modules and manufacturing scrap produced by Abound. The output will be recyclable glass and raw chemicals, ready to be processed into new products.

The MOU is for 5N to supply semiconductor compounds to be used to manufacture Abound's modules. It is expected to lead to a long-term supply agreement.

"This recycling agreement with Abound Solar is in line with our strategy aimed at providing value to our customers as they develop product stewardship schemes and aim to optimize product life cycles," says 5N's president & CEO Jacques L'Écuyer. "We intend to continue to invest in our new facility in Wisconsin to recycle Abound's solar modules and expand our capabilities in this area. Our relationship with Abound is further strengthened by our memorandum of understanding and we are excited about the prospects of further developing our CdTe and CdS business," he adds.

"This extension of our relationship with 5N Plus will ensure that, at end-of-life, our modules will be recycled in the most sustainable manner and secure a long-term supply for our raw materials," says Abound's president & CEO Tom Tiller. "Their expertise will maximize recycling yields and create a true cradle-to-cradle solution."

Also, in late January, 5N signed a long-term supply and recycling agreement with CdTe PV maker Calyxo GmbH (founded in 2005 by solar cell maker Q-Cells) of Bitterfeld-Wolfen, Germany.

5N will provide compounds including CdTe and CdS, as well as module and production scrap recycling services (optimized for Calyxo's specific requirements).

"Calyxo and Q-cells have been at the forefront of PV technology for many years," says L'Écuyer. "In 2006, we made the strategic decision to set-up a new manufacturing facility in Germany to support the growth of the German and European PV industry. Our German subsidiary 5N PV GmbH is now ideally suited to provide both the critical semiconductor compounds and recycling services."

# GE increasing investment in thin-film PV

## GE Global Research to focus on PrimeStar's CdTe PV development

With the race on to have the most efficient, low-cost solar module on the market, General Electric (GE) says that it is focusing its solar power R&D efforts on thin-film photovoltaic (PV) technology in conjunction with PrimeStar Solar Inc of Arvada, CO, USA, aiming to launch a product for utility and commercial markets in 2011.

**General Electric's solar panels.**

GE previously made solar panels using traditional silicon. Silicon solar cells are durable and (at over 20%) more efficient than thin-film solar cells. However, thin-film solar cells offer lower production costs than silicon, due partly to lower material usage and manufacturing costs.

PrimeStar was founded in Golden, CO in June 2006 to develop cadmium telluride (CdTe) thin-film photovoltaic modules using technology from the US Department of Energy's National Renewable Energy Laboratory (NREL), based in Golden. After acquiring a minority stake in September 2007, GE's power generation division GE Energy of Atlanta, GA, USA took a majority stake in PrimeStar in June 2008.

GE says that, working closely with PrimeStar, it is bringing to bear the full scale of its four GE Global Research operations (in Niskayuna, NY, USA; Bangalore, India; Shanghai, China; and Munich, Germany) to address the challenges required to bring a new product to market.

"After having completed an exhaustive survey of the PV landscape, we determined that thin films were the optimum path for GE," says Danielle Merfeld, GE's solar R&D leader in Niskayuna. "The CdTe technology from PrimeStar has great potential [for lower cost per watt]," he reckons. "Bringing together world-class materials expertise, unique materials and systems modeling and design capabilities, and state-of-the-art indoor and outdoor solar testing facilities, GE researchers are innovating across our four global research centers—literally around the clock—to deliver a breakthrough product to market."

The GE/PrimeStar product is being developed at PrimeStar's headquarters. A team of PrimeStar technologists with more than 100 years of combined thin-film deposition expertise is working closely with GE researchers, who are focused on several key areas including device efficiency, reliability, production and installation costs, and manufacturability. GE says that hundreds of technologists in Germany, China, India and the USA are currently working on its solar technologies.

**After having completed an exhaustive survey of the PV landscape, we determined that thin films were the optimum path for GE**

The team in Munich (at the heart of the global solar industry) is using indoor and outdoor solar system test facilities where they study finished module performance to identify and address degradation mechanisms and packaging issues. The team also has expertise at the system level, allowing them to define system-level optimized features and metrics for the module.

In China (where most of the world's CdTe raw materials are found) researchers at GE's China Technology Center in Shanghai are focusing on CdTe materials and the impact they have on device performance (with improving material quality and developing advanced materials characterization techniques being key topics).

In India, GE is leveraging modeling capabilities at its John F. Welch Technology Centre in Bangalore. Unlike the exclusively experimental approach favored by many in this field, according to GE, dramatic improvements in device performance and reliability can be realized through a deeper understanding of the materials and basic physics of the device, it is believed. The Bangalore team is hence building comprehensive models to help guide advanced device design.

GE's research team in Niskayuna is working on all facets of CdTe module development, including material growth, device development and robust process development, using technical expertise spanning diverse fields such as surface chemistry, laser processing and plasma physics, as well as diverse product development experience derived from GE's other technology-focused businesses (such as healthcare, lighting and batteries).

GE Research projects that it can boost CdTe PV efficiency to 12% and potentially higher (compared to incumbent CdTe PV maker and cost leader First Solar's 11%). GE says that it is looking at ways of managing an entire solar array in a large installation built by a utility or commercial customer, and also plans a recycling program for its panels.

**www.primestarsolar.com**
**www.ge.com/research**

# JGU's Felser receives IBM award for CIGS PV research

In a ceremony on 12 February at Johannes Gutenberg University (JGU) Mainz, Germany, professor Dr Claudia Felser of the Institute of Inorganic Chemistry and Analytical Chemistry received IBM's Shared University Research Award (which is awarded two to three times per year in order to support joint work with research institutions worldwide).

The award to JGU — in recognition and support of research on copper indium gallium diselenide (CIGS) solar cells — is founded on an almost 15-year-long working relationship between IBM and Felser, an expert in computer-supported materials design. Felser's research group has been working for two years on computer modeling of thin-film solar cells, in order to improve their efficiency and to reduce the proportion of environmentally harmful and rare-earth elements such as cadmium and indium. The award provides JGU with around $450,000 worth of computer systems, which will be used for modeling new materials for solar cells.

The research, led by Dr Thomas Gruhn, focuses on CIGS solar cells, which to date show an efficiency of almost 20%. However, until now, no appropriate material has been discovered to replace the use of the environmentally harmful heavy metal cadmium in CIGS solar cells. The Mainz group hopes to find a replacement material made from so-called half-Heusler compounds. Half-Heusler compounds and the structurally similar Heusler materials are intermetallic compounds made from three elements that form a cubic crystal structure. Felser is one of the world's leading specialists in this field.

**Claudia Felser (left) and Erwin Jung, director of IBM Science Relations.**

The new computer facilities will make it possible to expand the search for optimal materials to other potential materials, and to predict their behaviour with the help of computer modelling. A further aim is to increase the efficiency of thin-film solar cells. CIGS solar cells present scientists with a riddle that has remained unsolved for many, the 'indium/gallium' puzzle. The ratio of the two elements to one another is critical to the efficiency of solar cells. In practice, solar cells with a higher proportion of indium show a higher efficiency than solar cells with a higher proportion of gallium, in contrast to predictions. JGU says that the reason for this may soon be demonstrated by new computer simulations, and that it might then be possible to further improve the already high efficiency levels of CIGS solar cells.

Felser has been a professor at JGU since 2003. She is the spokesperson of the 'New Materials with High Spin Polarization' research unit of the German Research Foundation and director of the 'Materials Science in Mainz' Graduate School. In 2001, Felser received the State Order of Merit of Rhineland-Palatinate for establishing a laboratory for pupils at Mainz University. In autumn 2009, she received the title of 'Distinguished Lecturer' from the American IEEE Magnetics for her work on raw materials in spintronics.

**www.uni-mainz.de/eng/13352.php**

# Smit Ovens wins repeat thermal processing order

Smit Ovens of Eindhoven, The Netherlands has agreed to supply a major existing customer with several further thermal process solutions, covering vapor transport deposition (VTD) systems for the mass production of copper indium gallium diselenide (CIGS) thin-film photovoltaic (PV) cells as well as a scaled-down system (suitable for research into process optimization) for the deposition of selenium and the crystallization of CIGS precursors.

The scaled-down deposition system is based on a standard mass production system, and can enable the user to develop process optimizations that can be easily transferred to a real-world production line, says the firm.

The VTD systems will be used for depositing the selenium layer following deposition of the copper, indium and gallium precursors. After this, rapid thermal processing (RTP) is used for optimal crystallization during soaking. Smit says its systems ensure maximum flexibility in temperature and timings for subsequent soaking and cooling. With its background in the glass industry, the equipment's flexibility provides fine control so that large glass substrates cool uniformly without risk of deformation or breakage, claims the firm.

"This repeat order underscores the strong relationship we have with this customer, which aims to be a leading player in the global CIGS cell market," says Smit Ovens' CEO Wiro Ziilmans. "Thermal processes are a key way to achieve competitiveness in this growing market. We're already seeing cell efficiencies of 10–12%," he adds. "With advance thermal processes, manufacturers can get close to production costs of $1 per Watt — a crucial threshold for creating a mass market for thin-film CIGS photovoltaics."

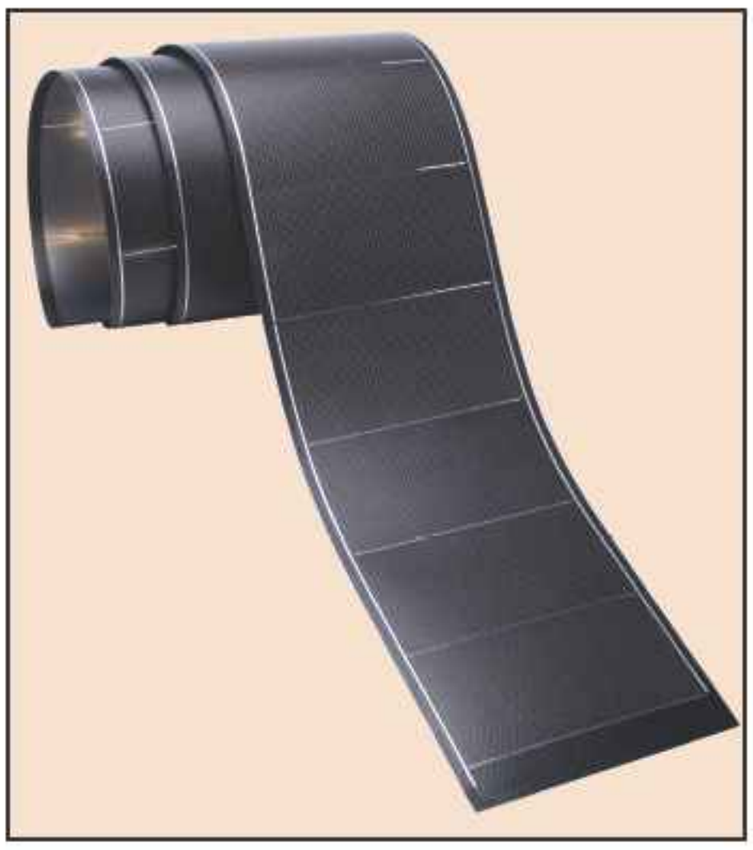
**www.smitovens.nl**

# Ascent to supply FTL with modules for defense/disaster relief and portable power

Ascent Solar Technologies Inc of Thornton, CO, USA, which manufactures flexible thin-film photovoltaic (PV) modules based on copper indium gallium diselenide (CIGS), has signed a strategic alliance supply agreement with FTL Solar LLC of Austin, TX, USA, which provides patent-pending lightweight solar structures and products that are claimed to be the world's only pre-fabricated, mass-produced PV tensile structures. The agreement includes a minimum purchase commitment of $6.5m over a three-year period.

"FTL Solar is a US distributor for Ascent's light weight photovoltaic (PV) modules for fabric awnings, airbeams, tents, tensile structures, sailboat sails, tarps and umbrellas," says FTL Solar's CEO Tony Saxton. "Integrated with Ascent's high-output light-weight flexible modules, FTL Solar's products are the optimal means for capturing electricity from sunlight, as well as providing second functions such as shelter," he adds.

"We have hit the market with FTL Solar's PowerMod tents with Ascent Solar PV modules 'outside' for military and tent rental industry sales, and with FTL Solar's PowerFold hand-held battery chargers for military and consumer sales," Saxton continues. "We see this as the beginning of an epochal change across all of the fabric structure industries... the fabric structure industry is going to become renewable electricity providers in the future in addition to being the flexible fabric product providers that they have traditionally been."



**A roll of Ascent Solar's flexible CIGS solar cells.**

FTL has committed to minimum purchases of $6.5m of flexible CIGS photovoltaic 2 meter and premier modules during the three-year contract period. Ascent is scheduled to begin shipments to FTL for market seeding of emerging market opportunities with their lightweight solar integrated tensile fabric product line. This specialty product line is intended to serve defense/disaster relief and the portable power segments (including awnings, fabric airbeams, fabric automobile covers, sailboat sails, tarps, tents, and umbrellas).

"FTL Solar has designed a world-class lightweight solar integrated tensile fabric product line," comments Ascent Solar's president & CEO Farhad Moghadam. "This contract represents sales velocity for specialty products that require certain customization and affirms our ability to demonstrate our breadth of integration," he says.

Ascent's product certification under MIL-STD 810G for defense applications in late February has opened up market potential in defense/disaster relief, with fabric integrated portable solar applications for both tent and personal portable power integration, Moghadam continues. "FTL Solar is at the forefront of changing the way solar can be utilized on a daily basis by defense, disaster relief agencies and consumers alike," he adds. "Enabling products to be integrated with our unique light-weight CIGS photovoltaic modules is the foundation of Ascent's market penetration of specialty products."

**wwww.ftlsolar.com**

# Ascent Solar's CIGS photovoltaic modules certified to Mil-Spec 810G for defense applications

Ascent Solar Technologies Inc of Thornton, CO, USA says that its Premier and 2 Meter flexible copper indium gallium diselenide (CIGS) thin-film photovoltaic modules have been certified by an independent laboratory on a variety of US Department of Defense (DOD) military ruggedization standards known as MIL-STD-810G.

MIL-STD-810G focuses on environmental engineering issues and requires products to pass various laboratory tests to ensure that military equipment operates in worldwide environments.

"MIL-STD-810G certification is a significant step forward in penetrating the defense application market for military and disaster-relief integrated products," says Ascent Solar's president and CEO Farhad Moghadam. "These certified modules are equipped with a non-reflective coating to prevent glare and have demonstrated the ability to withstand humidity, shock and sand blasting," he adds. "Specialty markets which include defense applications are vital to our ability to demonstrate the diverse market opportunities with partners and customers using our unique flexible CIGS modules."

**www.AscentSolar.com**

IN BRIEF

## CEO for DayStar

DayStar Technologies Inc of Santa Clara, CA, USA, which is developing copper indium gallium diselenide (CIGS) thin-film photovoltaic products, has appointed Magnus Ryde as CEO and director of its board.

William Steckel has resigned as CEO & CFO but continues to serve on the board of directors.

Prior to joining DayStar, Ryde was president of TSMC-USA, the US operation of Taiwan Semiconductor Manufacturing Company (the world's biggest silicon wafer foundry). He also held numerous senior executive positions during 18 years at process control and yield management firm KLA-Tencor, including VP of worldwide field operations, manufacturing manager, KLA Europe Director, and VP of corporate sales.

Ryde is a graduate of Sweden's Linkoping University and received an Industrial Engineering MS degree from Stanford University.

"Magnus is an executive possessing a unique combination of skills and experiences that make him the ideal leader for DayStar as the company commercializes its CIGS PV modules," says chairman Peter Lacey. "Magnus has extensive experience with world-class semiconductor manufacturers and high technology companies."

"DayStar has a robust technology roadmap which calls for commercial CIGS PV modules with a conversion efficiency of greater than 13% and less than $0.85 cost per watt at full production scale," says Ryde. "There is wide consensus that CIGS is the most promising photovoltaic thin-film platform. DayStar has demonstrated repeatable high efficiency CIGS with its one-step sputter deposition process and I am confident in our ability to scale this process and commercialize our product."

**www.daystartech.com**

## Avancis claims record 15.1% CIS photovoltaic efficiency

Solar module manufacturer Avancis GmbH & Co KG of Torgau, Saxony, Germany has reported a record for CIS (copper indium selenide) photovoltaic efficiency with a 30cm x 30cm fully encapsulated CIS PV module.

Based on an aperture area of 668cm$^2$, an efficiency of 15.1% has been confirmed by the US National Renewable Energy Laboratory (NREL), says the firm. Avancis claims that, with this result (achieved at its R&D department in Munich, which has more than 40 staff), it heads the list of independently certified world records in thin-film solar modules published in the journal 'Progress in Photovoltaics'.

"This world record is testimony to the fact that CIS boasts the best performance of all thin-film technologies and, with our patented, two-stage manufacturing method, we have an unrivalled production process at our disposal," says chief technology officer Dr Franz Karg. "Since the start of production in October 2008, we have been able to increase the efficiency of standard production modules from an initial 9% to 11% [for the highest performance class (120Wp) of its PowerMax modules]," he adds. In October 2009, running in four-shift operation seven days a week to meet the demand, Avancis' first plant (which has more than 150 staff) reached its maximum annual production capacity of 20MWp, concluding its start-up phase.

Avancis stresses that, in order to turn the record performance into an industry standard as quickly as possible, its research department only uses processes and materials that are also used in series production.

Avancis was formed in November 2006 as a 50:50 joint venture between Netherlands-based energy company Royal Dutch Shell plc and France-based glass and construction materials maker Saint-Gobain SA, in order to combine the know-how of Shell research, development and production in CIS thin-film technologies and Saint-Gobain's expertise in manufacturing glass and building materials. However, last August, Saint-Gobain acquired Shell's 50% stake in the joint venture, making Avancis a wholly owned subsidiary.

**www.avancis.de**

## Ritek breaks ground on China plant

On 28 February, Taipei-based Ritek Corp, Taiwan's second biggest optical disc maker, started building an RMB2bn CIGS PV plant in Yangzhou, China, reports Xinhuanew.com. The plant is expected to be the first CIGS thin-film solar cell production line in East China's Jiangsu Province.

The project is in two phases: one 30MW production line to be completed by end 2010 and a second 30MW line by end 2011.

At October's PV Taiwan 2009 event, Ritek launched Taiwan's first 600mm x 1200mm CIGS thin-film PV modules, which have an energy-conversion efficiency of 17% (the highest achieved in Taiwan so far, it is claimed, and approaching the 20% of monocrystalline silicon).

In January, Ritek made a further investment of NT$800m (US$24.8m) to boost its stake to 40% in Taiwan-based PVNext Corp, its 50:50 joint venture for CIGS PV module manufacturing formed in October 2008 with crystalline silicon solar cell maker Scheuten Solar Holding BV of Venlo, The Netherlands. Previously, in July, the National Development Fund of the Taiwan Cabinet invested NT$500m (US$15.3m) in a 28.59% stake in PVNext (shrinking the stakes of Scheuten and Ritek to 42.26% and 23.15%, respectively). Proceeds were put towards procuring production equipment.

**www.ritek.com**

# CIGS firm SoloPower appoints CEO

SoloPower Inc of San Jose, CA, USA, which makes thin-film copper indium gallium diselenide (CIGS) photovoltaic (PV) cells and light-weight flexible solar modules, has appointed Tim Harris as president & CEO, to lead the firm as it commercializes its flexible solar modules and expands manufacturing capacity to enter high-volume production later this year. He replaces Lou DiNardo (interim CEO since July), who remains as executive chairman of the board of directors.

"SoloPower has focused on the development of innovative, light-weight flexible modules which add significant value in commercial and industrial rooftop applications, utility-scale ground-mounted facilities, and the emerging building-integrated PV market (BIPV)," says DiNardo. "The company has demonstrated product efficiency that exceeds current alternatives and is building the infrastructure necessary for commercialization and high-volume manufacturing," he adds. "The company now is in a position to advance to its next milestones and raise its next round of funding to expand capacity."

"My career has been focused on building teams and ramping great technology products in cost-sensitive environments," says Harris. With more than 20 years executive experience, most recently Harris was CEO & president of semiconductor and solar equipment maker Celerity. Previously, he was CEO at Komag, COO at venture-backed high-powered tunable telecom laser maker iolon and, while at hard disk drive maker Seagate Technology from 1990 to 2000, senior VP of worldwide technology manufacturing (responsible for wafer fabs, slider development and operations, as well as the OEM Tape Head business).

SoloPower says that, using its proprietary, patented electroplating process, it has achieved 13.76% cell efficiency on small-area (~0.5cm$^2$) cells on flexible stainless-steel substrates. The firm recently demonstrated similar results on larger cells: 13.4% efficiency on 12cm$^2$ lab cells and 11.7% efficiency on 178cm$^2$ cells from its roll-to-roll manufacturing line. Using its CIGS-based flexible cells, SoloPower has also developed a flexible module, which has demonstrated aperture efficiency of 10.74%.

In January, SoloPower's CIGS thin-film flexible module passed a damp-heat test, achieving over 1000 hours at 85% humidity and 85°C while showing minimal (<5% $P_{max}$) power degradation. SoloPower expects to submit its first flexible module for independent certification by April 2010.

The firm is confident that its flexible module products will pass similar tests performed by independent certification laboratories. SoloPower expects to submit its first flexible module for independent certification by April. The firm claims to have been first to market with a flat-plate CIGS module certified to ANSI/UL 1703 safety standards and expects to be the first to market with a certified flexible CIGS module in commercial production.

The firm is now in the process of raising funds to support the build-out of an additional nameplate 60MW of capacity at its existing manufacturing facility. The funds raised are also expected to be used as the equity-match portion of a Loan Guarantee from the Department of Energy in support of a new nameplate 250MW manufacturing facility in San Jose.

**www.SoloPower.com**

IN BRIEF

## IEC certification prompts volume CIS PV production

Odersun AG of Berlin, Germany, which designs and makes flexible thin-film solar cells and modules using proprietary CISCuT (copper indium disulfide on copper tape) reel-to-reel manufacturing technology, has achieved the International Electrotechnical Commission (IEC) certification for its standard CIS-based solar modules on first submittal, prompting the start of volume production.

Odersun says that the IEC 61646 and 61730 certifications demonstrate that its modules meet the IEC's strict norms regarding function, quality and safety. The certificates of compliance were awarded by the German Engineering Association VDE for the firm's 1m x 1.7m framed glass-foil modules.

Odersun is now starting ramp-up of its 20MW manufacturing facilities in Fürstenwalde (Spree), Germany, which should enable it to deliver modules to its customer base this quarter. "This is an excellent foundation for us to further expand our product portfolio with customized solar modules for architectural building integration," says CEO Hein van der Zeeuw. "For this, we are cooperating with various partners from the building industry."

Odersun says that its unique technology allows full customization of solar modules, which is necessary to meet the demanding functional and aesthetic standards of modern architecture. In its proprietary reel-to-reel process Odersun uses flexible copper tape as a basic component and carrier for the CIS solar cell. The firm says the flexible basis enables fabrication of modules to customer specifications in any size, power and design.

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# Accelerating the growth of the HB-LED industry

**Jim Jenson of Veeco's MOCVD business explains how improving MOCVD process uniformity can boost yields and capital efficiency, hence lowering LED manufacturing costs and speeding adoption of LEDs for display backlighting and solid-state lighting.**

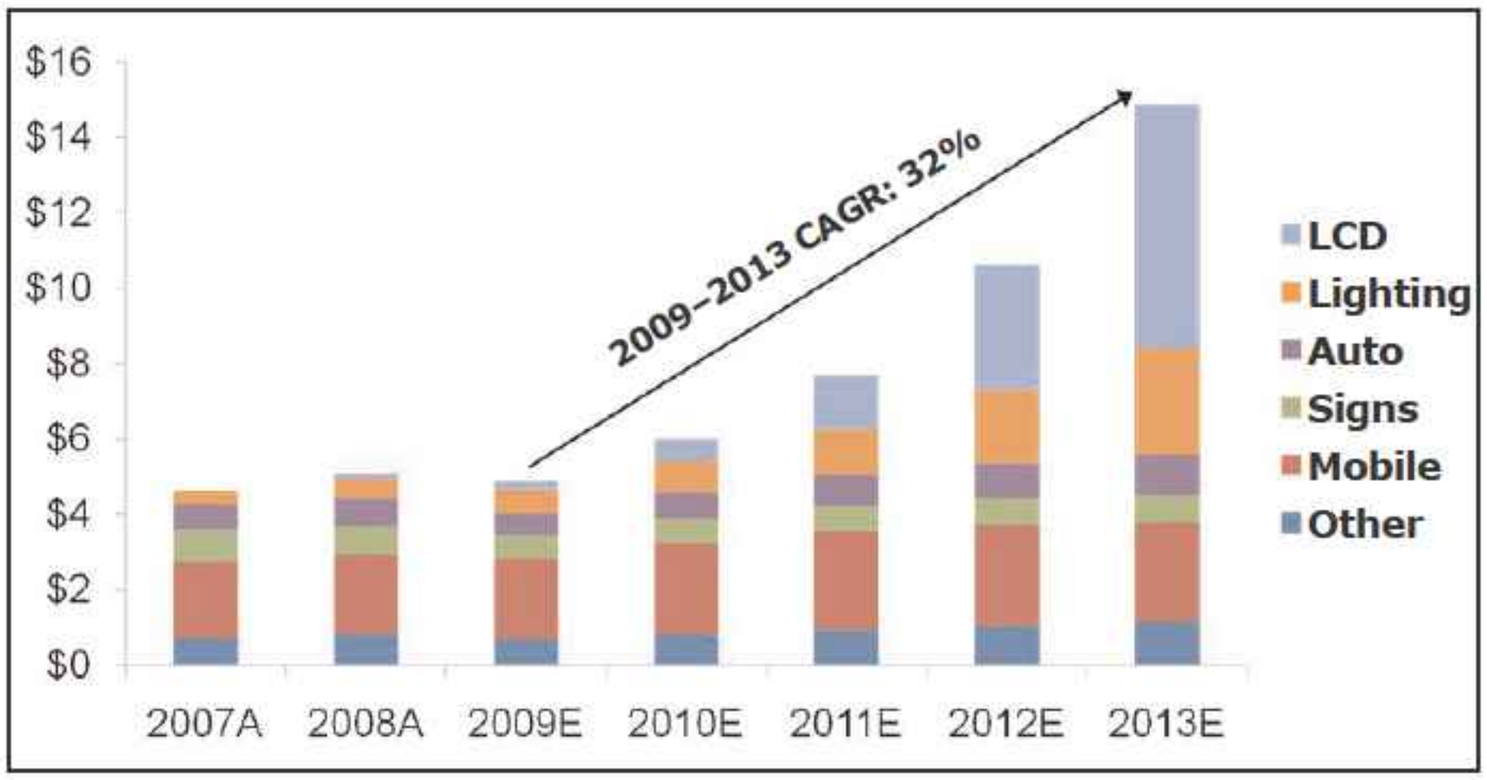


**Figure 1: HB-LED market ($bn): Strategies Unlimited, August 2009.**

The high-brightness light-emitting diode (HB-LED) market is poised for another period of explosive growth. This time it's driven by rapid adoption into LCD display backlighting and penetration into general lighting as advances in cost and performance are enabling them to compete with traditional light sources in these applications.

Metal-organic chemical vapor deposition (MOCVD) systems used to manufacture HB-LEDs perform the most critical process step in determining their brightness, yield, and total cost. The entire HB-LED device is created in this manufacturing step and the investment in MOCVD equipment can make up more than 50% of an LED fab's total capital expenditure. Therefore, it's critical that these systems are highly productive and produce high-quality LEDs.

MOCVD system suppliers must make rapid advances in yield and productivity in order for HB-LED manufacturers to execute their efficiency and cost improvement roadmaps. Veeco Instruments has fully embraced this challenge. To enable broad adoption of LEDs in display backlighting and solid-state lighting, Veeco is developing and introducing new MOCVD technologies to improve capital efficiency, including the recently announced TurboDisc® K465i™ GaN MOCVD system.

## LED market growth in its infancy

Almost every illumination function in mobile devices such as cell phones and handheld music players is performed by HB-LEDs today. This mass adoption in mobile devices produced a $4bn HB-LED industry (see Figure 1). And that was just the opening act.

According to Strategies Unlimited in their August 2009 forecast update, the HB-LED market is forecasted to grow more than 30% per year between now and 2013. Although mobile device applications will still make up a large part of the HB-LED market, it is the rapid adoption for LCD display backlighting and general-lighting applications that are driving growth this time around.

The declining costs and improving performance of HB-LEDs has made them a viable competitor to conventional cold-cathode fluorescents (CCFLs) for backlighting LCD televisions. When compared to CCFL technology, HB-LED backlights require less power, enable thinner form-factors, are mercury-free, and can deliver superior display color and contrast. Most major manufacturers including Samsung, Sharp, and LG have introduced HB-LED backlit LCD televisions, with more models, from companies like Visio, Sony and others, being introduced every day. There is nothing subtle about this shift to HB-LED-backlit LCD panels.

The market research firm DisplaySearch is forecasting that, over the next five years, HB-LEDs are expected to become the prevailing LCD backlighting technology and by 2011 achieve a 56% market share.

The potential for HB-LEDs in general illumination applications represents the largest overall market. Until recently, most uses for HB-LEDs in general lighting have been in niche applications such as architectural and decorative lighting. However, recently white LEDs have begun to penetrate mainstream lighting applications such as retail display, outdoor, and residential

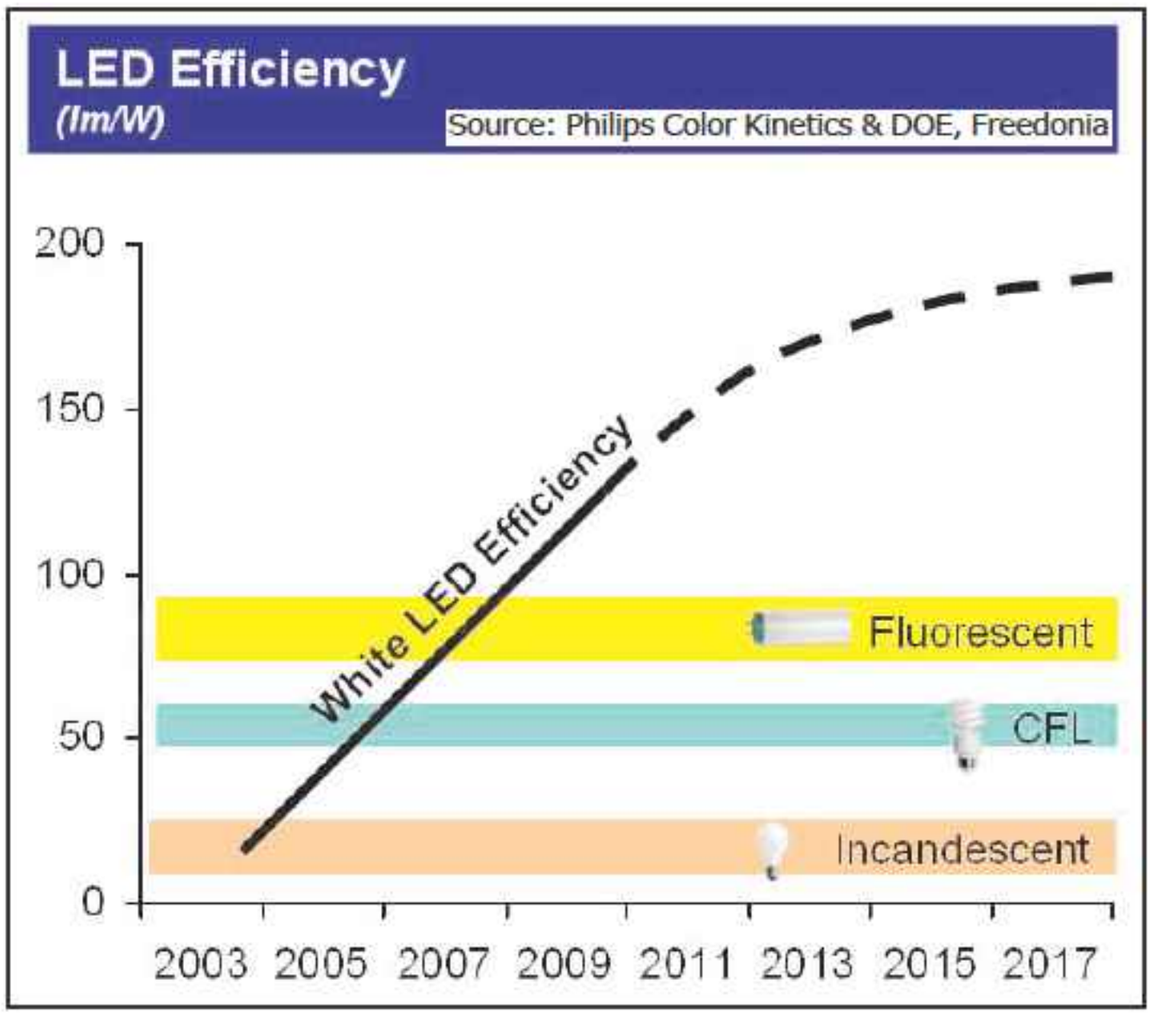


**Figure 2: LED efficiency improvement roadmap.**

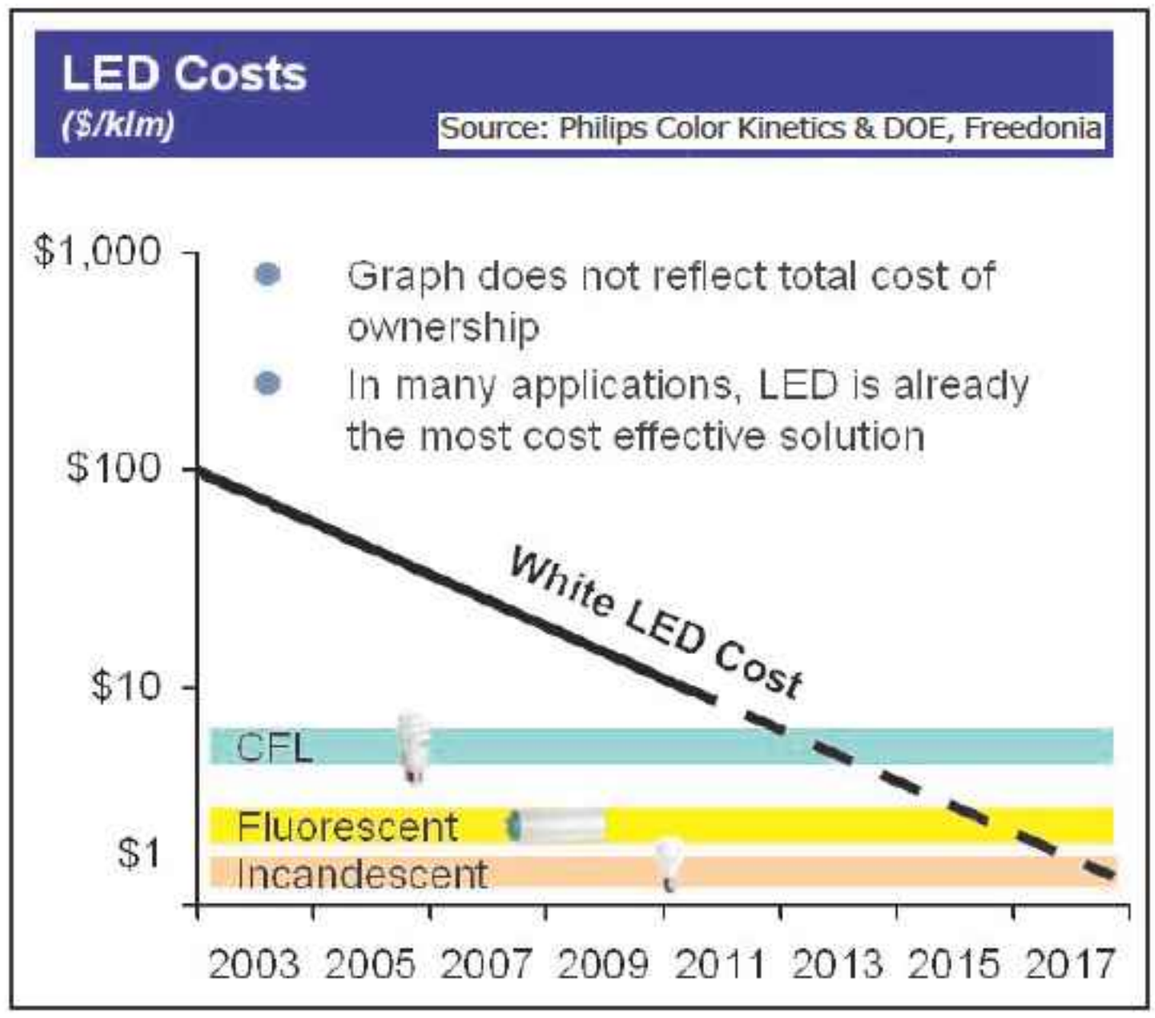


**Figure 3: LED cost-reduction roadmap.**

lighting. This penetration into general lighting applications is expected to accelerate as costs come down and performance improves. For example, HB-LEDs are becoming mainstream for general lighting in China, with government incentives accelerating the pace of adoption. Just recently there have been meaningful solid-state lighting announcements, such as Samsung partnering with Acuity Brands for LED lighting products and Philips reporting that 10% of its lighting business today is from LED products.

The success of HB-LEDs in mobile devices was just the beginning. Rapid adoption of HB-LEDs for LCD display backlighting and general illumination signals several years of double-digit growth for the industry.

## Lowering costs and improving performance drive LED success

Today, in many applications, HB-LEDs are already the most cost-effective solution, especially when their long life is considered. However, to fully capitalize on the display and general-lighting markets, HB-LEDs must continue to drive down the cost of each lumen of light that they produce. This cost per lumen is a function of an HB-LED's luminous efficiency (amount light produced from electricity supplied) and its manufacturing costs.

LED efficiency is measured in lumens per watt (lm/w). Most of the research and development in the HB-LED industry is focused on improving this measure for the white HB-LEDs used in display and general lighting applications. As the chart in Figure 2 shows, HB-LEDs have already surpassed the efficiency of traditional incandescent and fluorescent light sources. This improvement is expected to continue as researchers and manufacturers make further advances in chip design, light extraction technology, packaging methods, and driver performance.

LED efficiency improvements translate directly into lower costs. As the efficiency of an HB-LED increases, the quantity of HB-LEDs needed to produce a target total lumens of output decreases. Fewer HB-LEDs results in lower total cost. But the cost reduction challenge does not end there. The industry must also focus on improving manufacturing yield and cost.

Currently the largest factor — about 42% of the total cost associated with HB-LED manufacture — is attributed to yield loss. Yield losses occur when emission wavelength, electrical properties, and efficiency fail to meet target specifications. Variations in any of these three parameters can produce 'off-spec' devices that are either unsalable or only adequate for commodity applications.

For example, achieving very tight distributions around target specifications is necessary to penetrate the fast-growing LCD television backlighting application. The backlight unit in an HB-LED backlit LCD TV is typically made from an array of 400–1500 individual HB-LEDs. Even small variations in individual HB-LED wavelength emission or efficiency will appear to the TV owner as non-uniformities in color and brightness across the display and would be unacceptable.

In addition to yield, manufacturers are also focused on reducing manufacturing costs. These costs include all the materials, equipment, facilities, labor, and other operating costs that go into manufacturing HB-LEDs. One of the biggest determinants of total cost of manufacturing HB-LEDs is the efficiency of the equipment employed. Manufacturing equipment performance affects overall factory productivity, materials usage, and yield. It follows then that the industry's manufacturing equipment suppliers must rapidly innovate in lock step with HB-LED manufactures to ensure that they stay on their steep cost-reduction curve (see Figure 3).

## MOCVD advances key to LED cost and performance improvements

In the fabrication of the fundamental device in CMOS memory and logic chips (the transistor) dozens of equipment types and a multitude of manufacturing steps are required. In sharp contrast to the CMOS semiconductor process, the entire fundamental device in an HB-LED, as mentioned above, is fabricated in a single piece of equipment — the MOCVD system. MOCVD is the most critical process step when it comes to determining HB-LED brightness, yield, and total cost. Therefore, it is critical that these systems are highly productive and produce high-quality LEDs.

High-performance LEDs like those used in display backlights and general lighting are complicated layered structures using different compositions of AlInGaN alloys layered one on top of the other. Today's high-performance LEDs can have more than 100 separate layers. Each of these layers needs to have just the right thickness, crystalline quality, purity and composition to produce high-performance HB-LEDs.

All of these layers are 'grown' in an epitaxial deposition process using MOCVD equipment to form the HB-LED. The heart of the MOCVD system is the growth chamber where gaseous compounds flow over heated substrates where they decompose into their constituent elements and then recombine to form thin epitaxial layers. Following the MOCVD step, these epitaxial wafers are patterned with electrical contacts, singulated into individual die, and packaged. See Figure 4 for a high-level summary of the HB-LED manufacturing process.

In the MOCVD step, the maximum available light out is determined by the HB-LED structure grown in it. All subsequent steps are focused on getting as much of that light out as possible. A key factor in an MOCVD system's ability to enable brighter devices is its process window. An MOCVD system process window is the range of process gas flows, pressures, and temperatures with which uniform epitaxial material can be grown. A wide process window gives HB-LED manufacturers the freedom and flexibility to create advanced epitaxial growth structures.

Improvements in the MOCVD process can have a dramatic effect on overall LED manufacturing costs. The majority of manufacturing yield losses occurs in epitaxial growth and chip fabrication steps. Yield losses are due to structural variations attributable to variations in layer thickness, stoichiometry, and crystal defect densities induced during the MOCVD process. These yield losses typically come in the form of emission wavelength or brightness non-uniformities.

In the case of wavelength non-uniformities, process gas flow and temperature control in the MOCVD process are critical. One atomic percent difference in the indium content of an InGaN layer will result in a 12nm difference in wavelength. Similarly, 1 angstrom of thickness variation will result in a 3nm variation, and a 1°C variation will result in up to 1.8nm shift. To reduce these variations, MOCVD system suppliers must focus on achieving uniform process gas flow to the substrates and substrate heating.

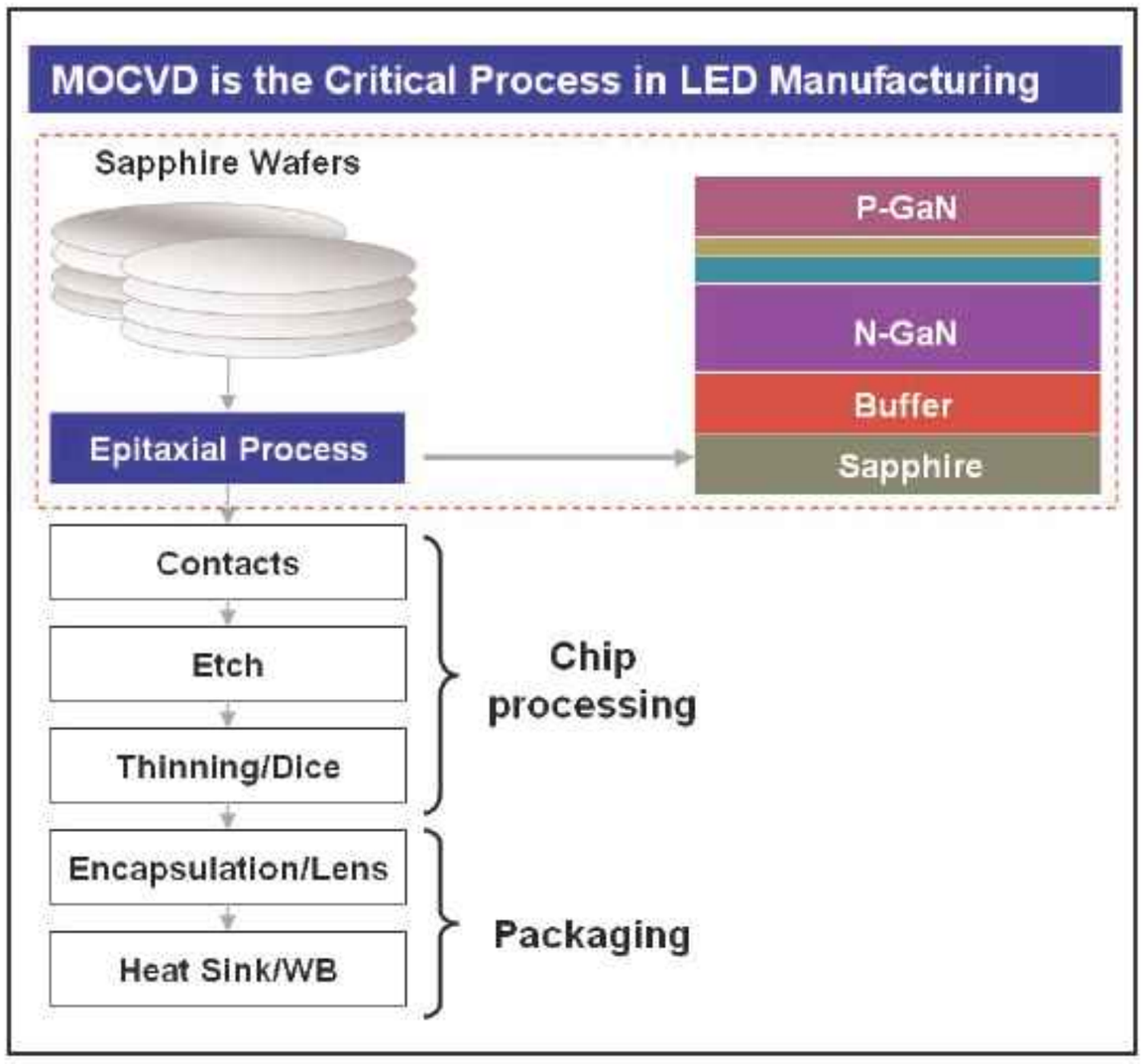


**Figure 4: High-level HB-LED manufacturing process.**

Reducing yield loss associated with brightness variations will also reduce the overall cost of HB-LED manufacturing. The brightness non-uniformity and overall HB-LED light output are tied to the quality of the crystalline layers in the LED structure. This quality is degraded by defects in the crystal structure caused by residual strain at the substrate-layer interface, parasitic gas phase reactions, and impurities or contaminants. All of these are influenced by MOCVD system design.

Epitaxial growth is an inherently slow process that can take from five to nine hours, or more, including setup times, depending on the device design and manufacturing process. So, on the productivity front, improvements in the MOCVD process can pay large dividends in HB-LED cost reduction. Throughput for MOCVD systems is driven by the system setup time, process time and overall system uptime.

Setup times can be minimized through the use of automated MOCVD reactor loading and unloading. Non-automated systems must be cooled down sufficiently for a human operator to handle the substrates and must be completely unloaded before a new batch is loaded. Automatic load and unload systems enable processed wafers to be removed from the reactor at much higher temperatures and, as a result, eliminate a significant portion of the process time allotted to system cool-down. Also, automation schemes that employ multiple carriers allow the next batch of wafers to be pre-loaded onto a carrier while another batch is running.

By placing the next-batch wafer loading step in parallel with the current-batch processing step, total process time is reduced.

Process time is largely dependent on deposition rates. However, increasing the deposition rate is difficult and can present trade-offs with crystal quality. If deposition is too fast, crystal defects increase and, as a result, LED efficiency deteriorates. Fast deposition technologies such as hydride vapor phase epitaxy (HVPE) are being explored due their higher deposition rates. However, HVPE has not been proven to be a cost-effective and manufacturable process for large-area substrates.

The most important factor in system uptime is the number of runs before maintenance events. During the MOCVD process, materials build up on the reactor walls. Eventually that material builds to such a level that it must be removed to avoid compromising the epitaxial growth process. The longer an MOCVD reactor can operate without having to remove material from the reactor walls, the higher its overall throughput will be.

The MOCVD system is the heart of the HB-LED fabrication process. This single piece of equipment manufactures the entire fundamental device — literally substrate in, HB-LED out. Therefore, it is imperative that MOCVD system suppliers rapidly advance the capability of their systems to enable HB-LED makers to achieve their brightness, yield, and total cost objectives.

## How Veeco is driving LED industry success

Veeco has a history of collaborating with LED makers to create MOCVD process cost and performance improvements. Today, more than 80% of key LED makers use Veeco MOCVD equipment.

Veeco has fully embraced the challenge of improving MOCVD process yields and lowering its costs, combining these two challenges into the single concept of capital efficiency which is simply defined as the number of good wafers produced by the system for each capital dollar invested. To enable broad adoption of LEDs in display backlighting and solid-state lighting, Veeco is developing and introducing new MOCVD technologies with a goal to ultimately quadruple capital efficiency.

In support of this goal, Veeco has increased 2010 R&D spending 100% compared to 2009 to support a multi-generational product roadmap. In addition, Veeco has secured an 'R&D matching' grant from the US Department of Energy to accelerate its development of next-generation, high-volume MOCVD systems to lower epitaxial growth cost for HB-LEDs.

**Veeco has secured an 'R&D matching' grant from the US Department of Energy to accelerate its development of next-generation, high-volume MOCVD systems to lower epitaxial growth cost for HB LEDs**

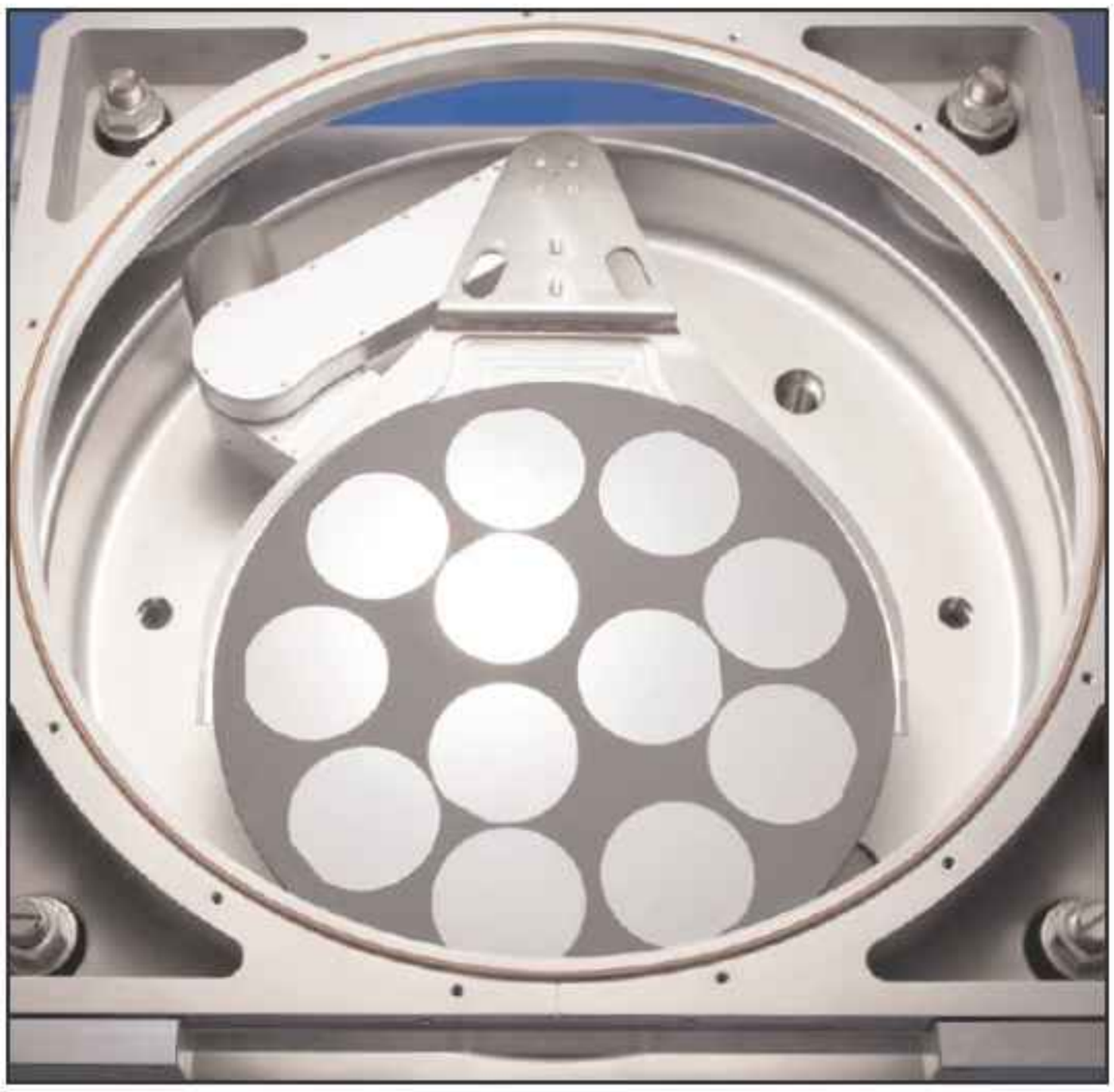

**Figure 5: K465i, showing 4" sapphire wafers, removable carrier, and automated loading.**

The most recent evidence of our progress is the introduction of the TurboDisc K465i GaN MOCVD system, Veeco's latest-generation production MOCVD tool. At the heart of the system is Veeco's Uniform FlowFlange® technology, which creates a uniform alkyl and hydride flow pattern across all wafers. As a result, the K465i delivers superior uniformity and repeatability with the industry's lowest particle generation. The K465i can enable customers to achieve world-class results: 90% yield in a 5nm bin size. That's the result of a 25% improvement in both wavelength uniformity and run-to-run wavelength repeatability. Also, the FlowFlange's simplified design provides ease-of-tuning for fast process optimization on wafer sizes up to 8 inches and fast tool recovery time after maintenance.

The K465i has completed its beta phase, where HB-LED manufacturers quickly qualified it for high-volume production. Veeco has already received orders for the system from multiple HB-LED customers throughout the Asia Pacific region and, as of this writing, interest for the tool from world-leading LED makers is strong.

Demand for HB-LEDs is high and expected to increase in the coming years. By increasing R&D investment, introducing innovative new technologies, and ramping MOCVD production capacity, Veeco is ready to help enable lower-cost and higher-performing HB-LEDs and accelerate their adoption into display backlighting and general illumination applications. ■

*Jim Jenson, Vice President of Marketing, Veeco Instruments Inc, MOCVD Business*
**www.veeco.com/mocvd**

# Gate control of terahertz transistor emission frequency

Researchers in Europe and Japan have demonstrated terahertz (THz) electromagnetic radiation from HEMTs whose emission frequency peaks are tunable by the gate voltage [El Fatimy et al, J. Appl. Phys., vol107, p024504, 2010].

Field-effect transistors (FETs) have been known to emit THz and sub-THz wave since the 1980s. This radiation is thought to arise from plasma waves in the device either from heating of the electrons by the external field or from instabilities of the electron flow due to plasma wave amplification from reflections at device boundaries.

It has been expected that the plasma wave frequency characteristics should be tunable by the gate voltage, although previously this has only been shown in the detection of THz radiation by FETs. Among the mechanisms possibly obscuring tunable emission, hot plasmon or edge plasma wave instabilities with wide spectral characteristics have been proposed.

The new work uses AlGaN-on-GaN HEMTs (Figure 1) grown by MOCVD. A 4H silicon carbide (SiC) substrate was used. The gate structure was T-shaped with dimensions 2x50μm and 2x100μm, giving two different samples (1 and 2, respectively — see Table 1). The ohmic source–drain contacts were Ti/Al/Ni/Au layers and the gate metal stack was Ni/Au.

The emissions came from square source–drain pulses with a 30Hz frequency and a 0.5 duty cycle at room temperature. The registration of the radiation was performed by a silicon bolometer at 4K with spectral analysis performed by a Fourier transform spectrometer under vacuum. The frequency range of the bolometer was 0.2–4.5THz. The results were normalized according to a reference spectrum from the HEMT in the spectrometer's vacuum chamber with no applied voltage. The spectra hence reflect the relative increase in emission from the HEMT.

The researchers report that they had improved their experimental

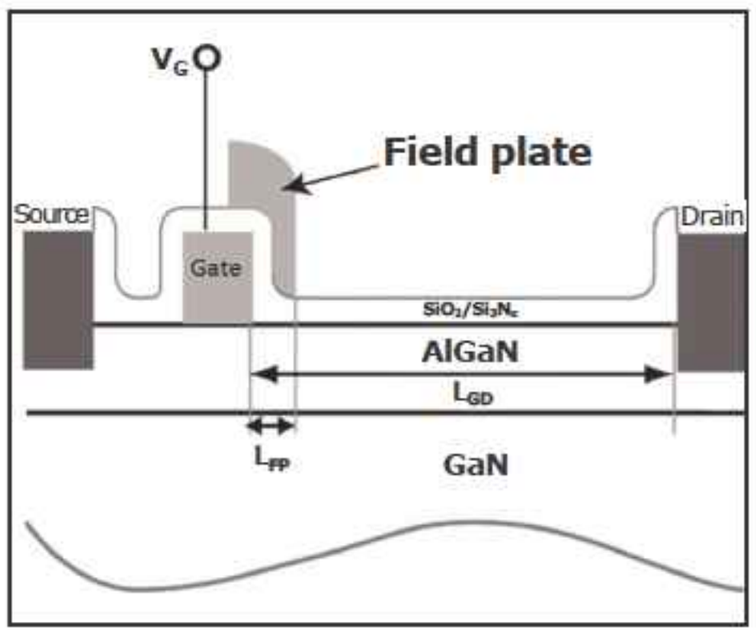


**Figure 1. Gate covered by field plate.**

configuration compared with their previous work, allowing a narrowing of spectral resolution from wave numbers of 15/cm to 1/cm.

It is found that the THz emission appears in a threshold-like manner, depending on the drain–source bias ($V_{ds}$). Increasing the negative gate bias pushes the onset of emission to lower $V_{ds}$. The frequency shift with gate voltage for the longer-gate device accords well with theoretical expectations that the emission results from the excitation of plasma waves (Figure 2, solid line). The prediction for the shorter device (with different 'effective gate length' and 'gate-to-channel voltage swing') is only followed 'in a qualitative way' in the sense that the frequencies are higher for the shorter-gate sample and decrease somewhat for increasing negative gate bias. The predictions are based on the behavior of the fundamental frequency of the plasma waves in the device.

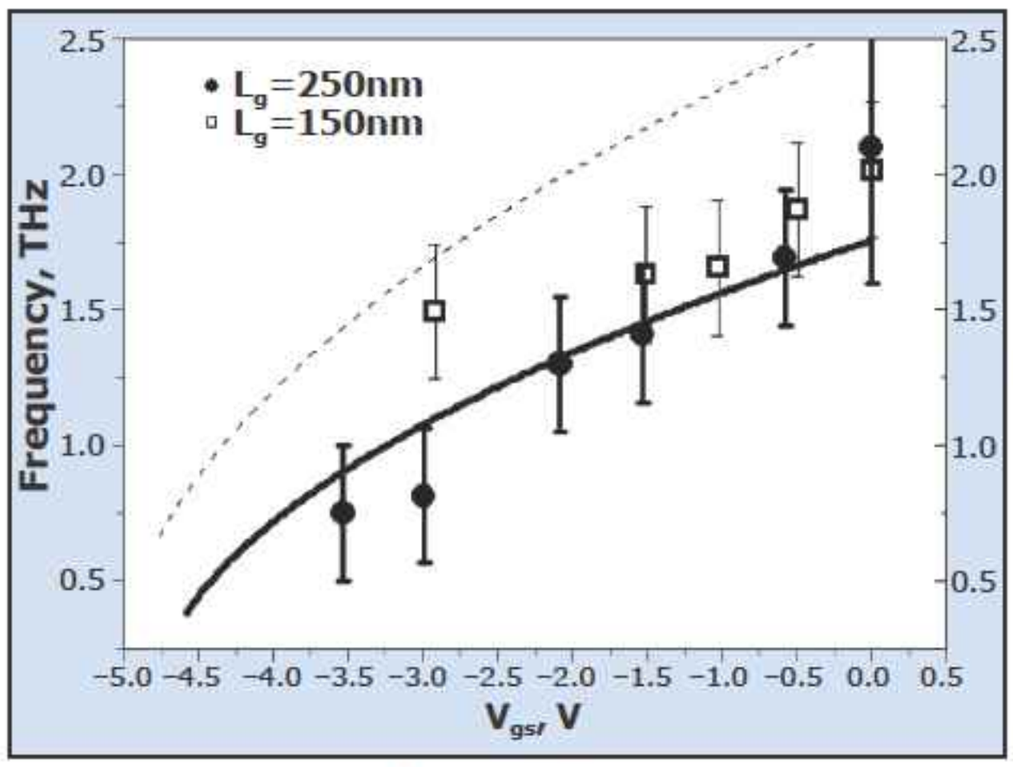


**Figure 2. Position of emission spectrum peak vs gate bias for HEMTs with 150nm and 250nm gate lengths at $V_{ds}$ = 4V. Lines (solid, 250nm gate; dotted, 150nm): calculations-based plasma wave fundamental frequency dependence.**

**Table. Physical characteristics of HEMTs used in study.**

| Sample | | 1 | 2 |
|---|---|---|---|
| Gate width | μm | 2x50 | 2x100 |
| Gate length | nm | 150 | 250 |
| $V_{th}$ | V | –5.1 | –4.8 |
| Field plate? | | no | yes |

The gate dependence of the emission line-widths is also seen as confirmation of this theoretical mechanism. The line-width depends on damping of the plasma waves and hence on the mobility. The mobility degrades with increasing carrier density in the channel. At low negative gate bias (~0V), the full-width at half maximum (FWHM) is about 2.5THz. This reduces to around 1.6THz at –3.5V where the carrier density is reduced (increasing the mobility).

"We estimate that the observed spectrum broadening corresponds to the mobility degradation from 1700 to 1100cm$^2$/V-s, which are quite reasonable values for our samples," the researchers comment.

The corresponding author of the paper, Abdel El Fatimy, is based at the universities of Tohoku (Japan) and Cardiff (Wales, UK). Along with another researcher from Tohoku, the work involved scientists from the universities of Montpellier (France) and Salamanca (Spain), Institut d'Electronique et de Microélectronique du Nord (France), Thales Research and Technology (France) and Institute of High Pressure Physics (UNIPRESS, Poland).

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*Author: Mike Cooke.*

# Reducing GaN HEMT degradation with InAlN barrier

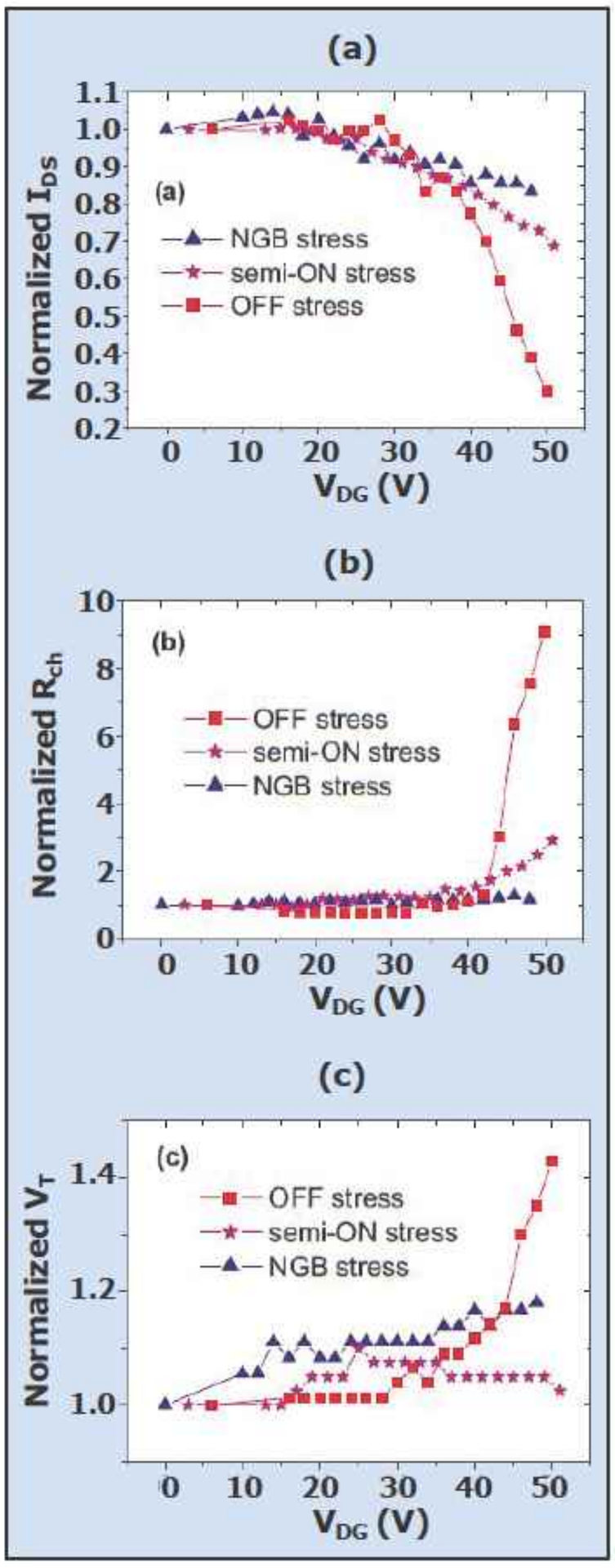
Researchers from Austria, Slovakia and Switzerland have performed a wide-ranging study of degradation mechanisms in InAlN/GaN high-electron-mobility transistors (HEMTs) [Kuzmik et al, J. Appl. Phys., vol106, p124503, 2009].

By using indium aluminum nitride (InAlN) rather than the more usual aluminum gallium nitride (AlGaN) as the barrier layer, one can lattice match ($In_{0.17}Al_{0.83}N$) with the underlying gallium nitride (GaN), removing strain effects. It is found that spontaneous polarization in the nitride semiconductor materials is sufficient to create the two-dimensional electron gas (2DEG) channel at the barrier/substrate interface that is necessary for HEMT operation. In other words, one does not need strain-induced (piezoelectric) polarization from a mismatched barrier to produce GaN HEMTs.

While strain can produce desirable effects in some semiconductors, such as increased mobility in certain directions, it can also lead to unstable structures that can fail under electrical and thermal stress. Among the achievements for InAlN/GaN HEMTs have been drain current densities exceeding 3A/mm and HEMT operation at 1000°C without permanent damage.

The researchers from the Technische Universität Wien (TU Vienna), Institute of Electrical Engineering Slovak Academy of Sciences and École Polytechnique Fédérale de Lausanne (EPFL) aimed to fill the gap in the analysis of possible degradation mechanisms in InAlN/GaN HEMTs at various device working points and electrical stressing conditions in a similar way to other groups studying AlGaN/GaN devices. The team also hoped to confirm its expectation that the absence of strain in InAlN can reduce some device degradation processes.

The epitaxial layers (10nm InAlN/1nm AlN/1μm GaN/150nm AlN) for the tested devices were constructed using MOCVD. Source/drain contacts consisted of titanium, aluminum, nickel and gold, while the Schottky barrier for the gate consisted of nickel and gold. No passivation procedure was used.




**Comparisons of normalized drain current (a), intrinsic channel resistance (b), and threshold voltage (c) after negative gate bias (NGB), off, and semi-on stresses at the same drain-gate potential VDG. $V_{GS}$=−3V during semi-on stresses. Corresponding bias conditions are $V_{DG} = -V_G = V_{DS} - V_{GS}$.**

Stressing experiments were carried out under negative gate bias (NGB), off and semi-on conditions. NGB stresses are found to damage AlGaN/GaN devices because inverse piezoelectric effects (strain produced from electric fields) generate defects. The InAlN/GaN devices were also subjected to testing under different temperature conditions up to 250°C. Five or six devices were subjected to each test and it was found that there were no qualitative differences in behavior.

NGB tests revealed less variability in parameters when compared with published results for AlGaN/GaN HEMTs. Although gate leakage is initially a little higher for InAlN/GaN with gate-source voltage ($V_{GS}$) less than −26V, it increases by less than 80% in going to −50V (catastrophic breakdown), in contrast to the four-order-of-magnitude increase for AlGaN/GaN. Further, when degradation does occur, it is reversible, unlike the traditional AlGaN/GaN HEMT set-up. While some parameters need several hours to recover their initial values, the drain and gate leakage currents need only about 100 minutes.

Irreversible damage was seen in off and semi-on tests when the drain-gate voltage ($V_{DG}$) exceeds 38V. In the off-state the intrinsic channel resistance ($R_{ch}$) and drain current are most affected. The resistance increased by one order of magnitude and the drain current decreased by 70% after off-state bias tests to a $V_{DG}$ of 50V. The researchers believe that these degradation effects are related to hot-carrier injection into the GaN buffer layer, creating defects and ionizing existing states.

Improvements may be sought using double-heterostructure channels, field plates or recessed gates, with the aim of reducing the hot-carrier injection. Surface passivation is another possible route to more reliable InAlN/GaN HEMTs.

The research was supported by the EU's MORGaN project.

**www.morganproject.eu**

**http://link.aip.org/link/?JAPIAU/106/124503/1**

*Author: Mike Cooke.*

# Nitride transistors get ready for market

**The nitride semiconductor materials that alloy aluminum, gallium and indium in various proportions with nitrogen (AlGaInN) have been widely used to create devices that emit light ranging from green to ultraviolet. More recently, the wide bandgap of these materials has been of interest in radio and microwave electronics, since this property comes with the advantage of larger breakdown voltages. Mike Cooke reports on the application of nitrides to transistor devices.**

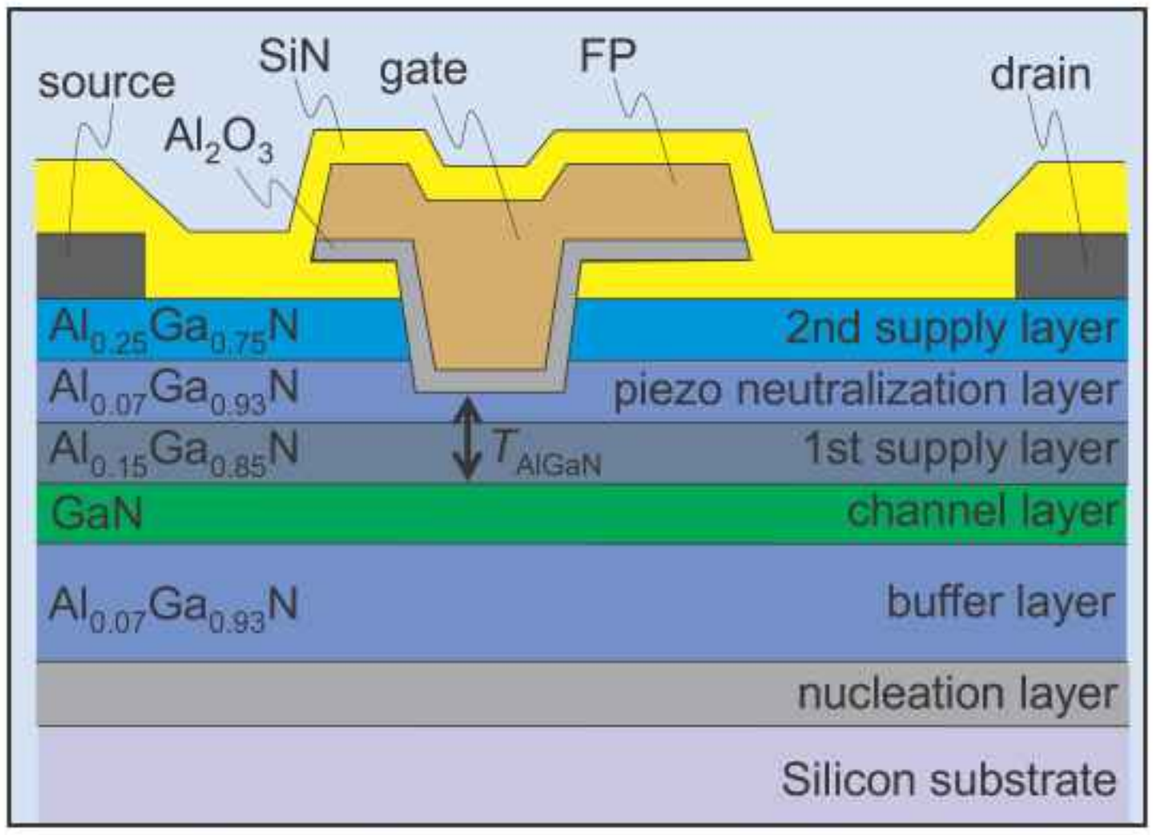



**Figure 1. Schematic cross-section of NEC normally-off GaN MISFET with a piezo neutralization (PNT) structure.**

RF power amplifiers and high-voltage power switching systems based on nitride semiconductors are reaching maturity. Demonstration devices and samples now need to meet the requirements of reliability and to be characterized in terms of degradation mechanisms. Companies that have reported the development of nitride devices aimed at power (RF and switching) in the past year include Cree, Fujitsu, HR Laboratories, International Rectifier, Toshiba, RF Micro Devices and TriQuint Semiconductor.

Many academic institutions are also taking part in this development work, along with presenting new proposals for applications such as creating vertical transistors targeting higher-voltage operation and using plasma oscillation effects to create useful devices for handling terahertz radiation. At present, silicon carbide (SiC) has the lead in vertical device development and seems a more likely bet for extreme voltage handling, such as is needed for plumbing renewable energy into the electric power transmission systems.

Here, we highlight the nitride developments that are nearing maturity, and hopefully commercial products in the near term.

## Threshold control

NEC has been developing a technique that uses a 'piezo-neutralization' (PNT) layer to give better threshold voltage ($V_{th}$) control in GaN FETs [1]. The intended applications for the device are power electronics where silicon MOSFETs and insulated-gate bipolar transistors (IGBTs) are presently used. These applications require normally-off behavior with a low on-resistance. A high switching speed is also desirable. Although gates that are recessed using etch processes have achieved the desired normally-off behavior, there are problems in achieving a uniform threshold voltage because there is no suitable etch-stop layer material.

The new NEC device uses an AlGaN buffer layer with 7% Al to achieve a positive threshold voltage (Figure 1). The PNT layer has a similar composition and is placed between two 'supply' layers with higher Al composition. The bottom of the gate is recessed within the PNT layer. The purpose of giving the PNT layer the same AlGaN composition as the buffer is to cancel the intervening polarization charges and hence give a flat-band condition in the PNT layer under the gate (Figure 2). Hence some variation in the thickness of the barrier between the gate and the channel due to the recess etch should not affect the threshold voltage unduly. The top supply layer, giving access from the source/drain electrodes to the channel, leads to a large electron concentration at the junction with the PNT layer (Figure 3).

Using these principles, NEC has produced GaN FETs on low-cost 3-inch (75mm) p-type silicon substrates using MOCVD. All layers were unintentionally doped. The ohmic S/D electrodes were an alloyed Ti-Al-Ni-Au metal stack. A nitrogen implant was used for device isolation.

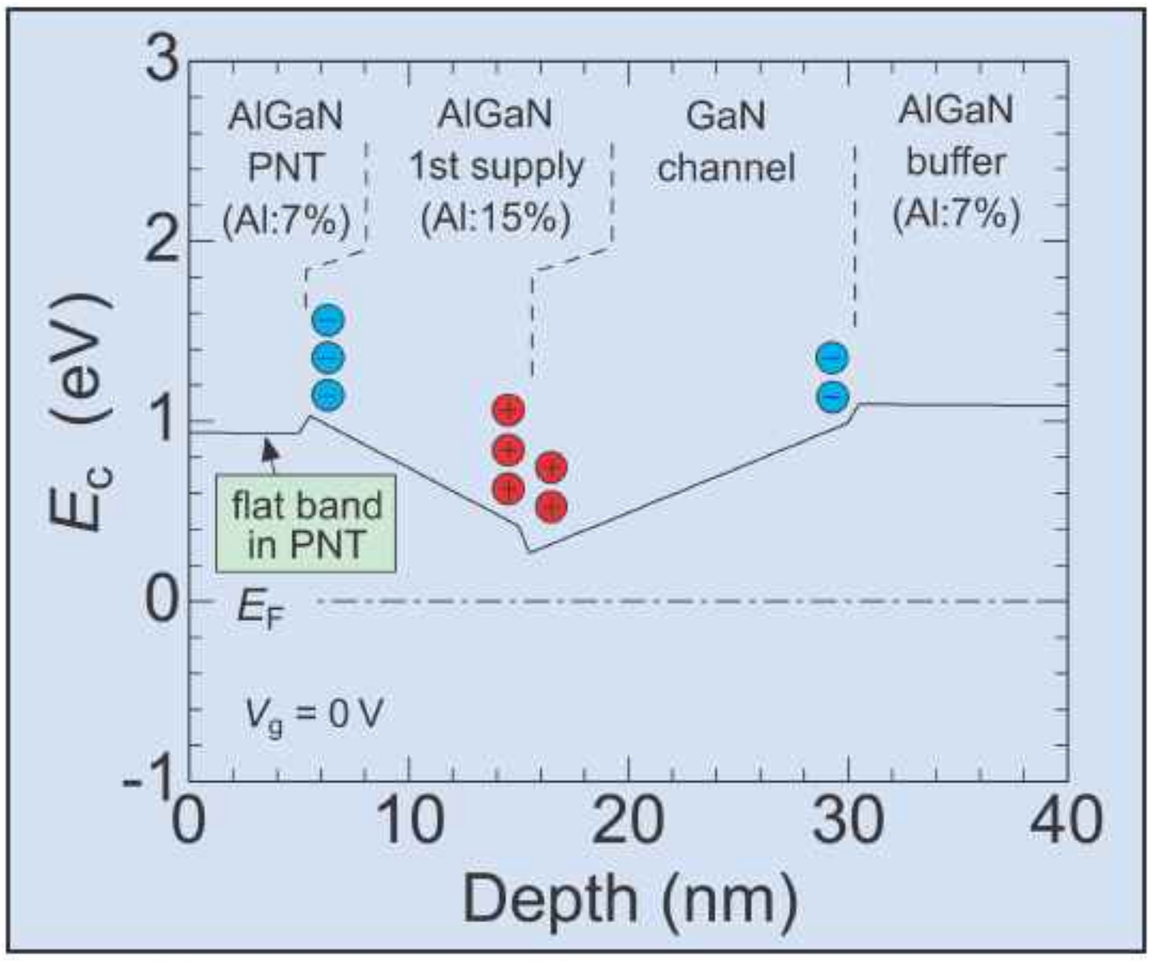



**Figure 2. Conduction band diagram under the gate electrode of the NEC GaN FET with the proposed PNT structure.**

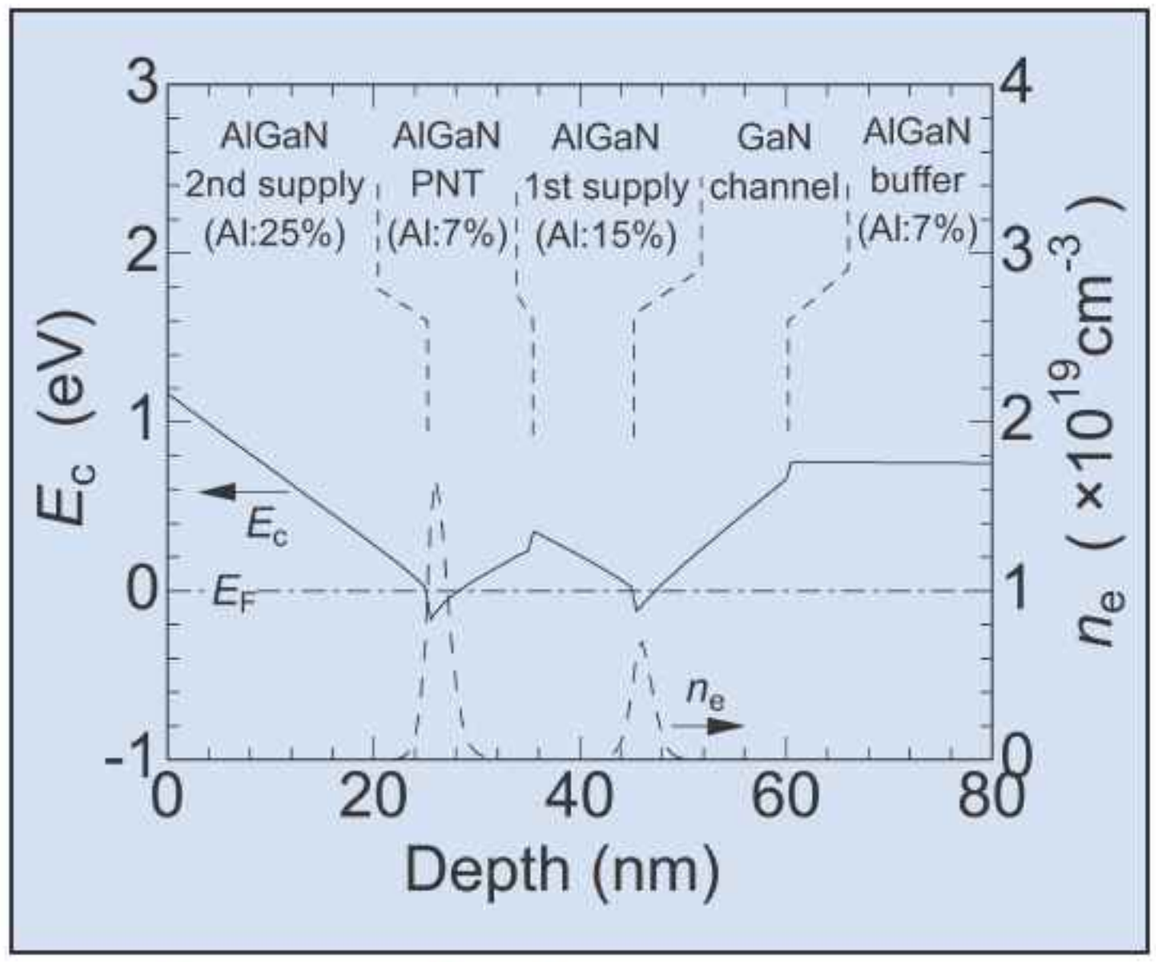



**Figure 3. Conduction band and electron concentration profile at the region outside the gate electrode of the NEC GaN FET with the proposed PNT structure.**

The silicon nitride (SiN) passivation was achieved using plasma-enhanced CVD, and the gate recess was etched using boron trichloride ($BCl_3$) plasma. The depth variation of the etch process was 5nm across the wafer (greater than the thickness of the PNT layer).

Both insulated (MISFET) and Schottky gate structures were formed. $Al_2O_3$ was used as insulator, and Ni-Au was used as gate metal in both cases. With a Schottky gate, the variation in $V_{th}$ (voltage with 1mA/mm drain current and 10V drain voltage) was 18mV, which is a factor of ten better than that achieved with a single conventional $Al_{0.15}Ga_{0.85}N$/GaN single-heterojunction structure. The result is also comparable with easier-to-manufacture normally-on AlGaN/GaN HEMT devices (~21mV variation).

The MISFET was also normally-off with a $V_{th}$ of +1.5V. The maximum drain current was 240mA/mm and the specific on-resistance is estimated at 500Ωmm$^2$. The three-terminal breakdown voltage was more than 1000V.

## Enhanced breakdown

The European IMEC semiconductor research center [2] has been building enhancement-mode (normally-off) GaN double-heterostructure field-effect transistors (DHFETs) on 4-inch (~100mm) silicon substrates (Figure 4).

This is enabled by an in-situ MOCVD-grown SiN layer grown on top of the nitride epitaxial layers. The SiN neutralizes the AlGaN top barrier surface charge so that it no longer contributes to the depletion of the two-dimensional electron gas (2DEG) conducting layer (Figure 4a).

The gate is created by removing the SiN with a $SF_6$ inductively coupled plasma etch and then applying a Ni/Au metal electrode. With the SiN removed, the 2DEG is depleted, turning off the channel (Figure 4b). However, the neighboring source–gate and gate–drain regions are not depleted, lowering the access resist-

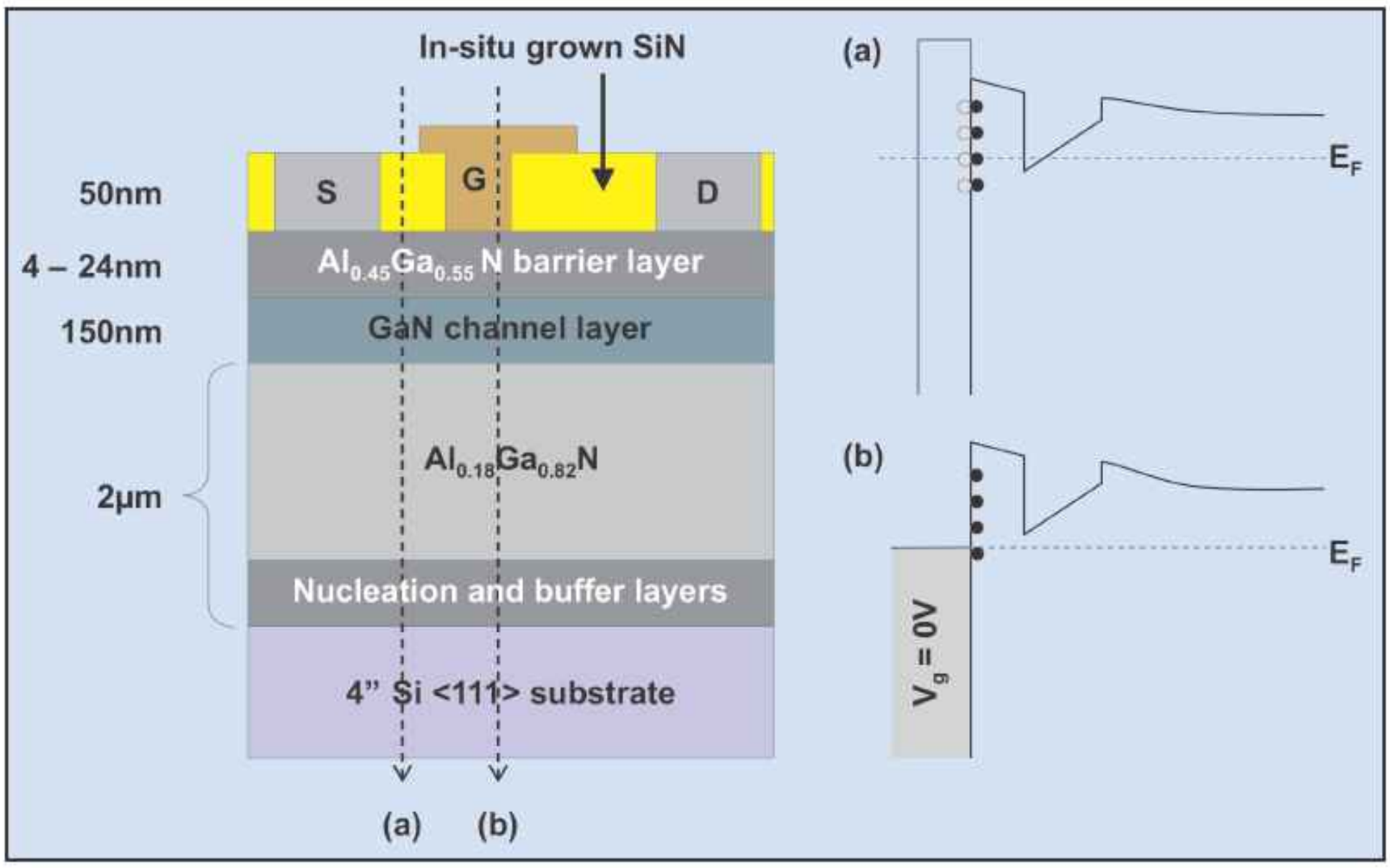



**Figure 4. Schematic epilayer stack (left) and band diagrams (right) in access areas (a) and under the gate for thin $Al_{0.45}Ga_{0.55}N$ barriers (b) for IMEC's enhancement-mode (normally-off) GaN/Si DHFETs.**

ances to the source and drain electrodes (TiAlMoAu ohmic contacts). A high-power etch can result in more positive threshold voltages due to fluorine implantation. However, a low-power etch is preferred by IMEC for a threshold that is more stable under thermal stress, and for avoiding shallow traps that lead to dispersion phenomena in DC-to-RF operation.

The devices with the thinnest AlGaN top barrier (4nm) show the most positive threshold voltage. Compared with depletion-mode (normally-on) devices, the on-resistance is about twice as high and the S/D saturation current is low (0.25A/mm compared with 0.6A/mm). These problems are related to the use of a Schottky diode for the gate. The drain leakage at zero gate voltage for one of the new devices with a gate length of 1.5μm and gate–drain distance of 8μm experienced hard breakdown around 710V — at 560V the drain current was a mere 5μA/mm. The breakdown behavior was consistent with depletion-mode DHFETs previously produced at IMEC. This was explained previously as being due to firstly breakdown in the top part of the device structure for small gate-drain gaps, but for larger distances as being due to vertical conduction down to the silicon substrate, along and then up (double vertical leakage).

## Degradation

The Italian universities of Padova and of Modena and Reggio Emilia have been studying correlations between DC and RF degradation in AlGaN/GaN HEMTs [3]. These researchers believe that they have demonstrated that deep levels with an activation energy of 0.5eV are responsible for degradation during RF aging. This degradation is induced by traps created by the RF driving conditions. The damage occurs at the gate–drain edge.

The work was carried out with HEMTs having an $Al_{0.28}Ga_{0.72}N$ barrier on GaN. The layers were grown on SiC substrates using MOCVD. The gate width was 4x25, 4x50 or 4x75μm with a length of 0.25μm. The gate–drain distance was 2.05μm and the source–gate distance 1.4μm.

DC step stressing of the gate from 0V to –45V was carried out in steps of –5V with a step duration of 2 minutes. The drain was grounded, while the source was floating. Reverse gate–drain voltages of more than 30V showed degradation of both dynamic (dispersion between DC and pulsed behavior) and static (decrease in saturation current) characteristics. Current deep-level transient spectroscopy (DLTS) of the pulse measurements showed an increase in thermally activated 0.5eV traps with time constants of the order of milliseconds.

Degradation was also induced using continuous-wave (cw) 2GHz RF signals. Again a 30V gate–drain bias in some of these tests appears to be a critical value for the device dispersion characteristic to increase while the saturated output power degrades. Surprisingly, degradation was more severe in 'back-off' tests where the RF stress signal is placed on a gate bias below saturation, rather than in 'compression' (i.e. above saturation).

From the RF work, the researchers propose two competing mechanisms for degradation: a slow process creating defects, giving enhanced electron injection through tunneling; and a fast process where hot electrons are injected and trapped over the gate–drain region, decreasing the electric field (reducing the likelihood of defect generation) and reducing the gate current. The defects are generated at drain voltages above 25V, but take longer to emerge in an RF setting. Simulations of the tests were performed using these ideas and 'good agreement' with the experimental results was found.

This work was partially funded by the European KORRIGAN consortium of companies looking to apply GaN HEMTs to defense radar and communication applications. Other funds came from the Italian government.

## Inverter circuit

Panasonic has been working on GaN integrated circuits, producing an inverter IC containing six normally-off gate-injection transistors (GITs) [4]. The circuit (Figure 5) was used to drive a three-phase electric motor, claimed as the first to be successfully driven by GaN. No external fast-recovery diodes (FRDs) were needed. At low power (20W), an efficiency of 93% is claimed for a 100W motor (better than for silicon). The researchers believe that this efficiency can be further improved by reducing the on-state resistance with the use of larger chips.

The enabler for the GaN-based inverter ICs is iron (Fe) implantation, used to isolate the GaN devices from each other. Panasonic is aiming at appliances and industrial applications.

GaN offers low on-resistance, but the low power efficiency is usually hit due to the biasing requirements of normally-on devices, giving silicon the advantage at

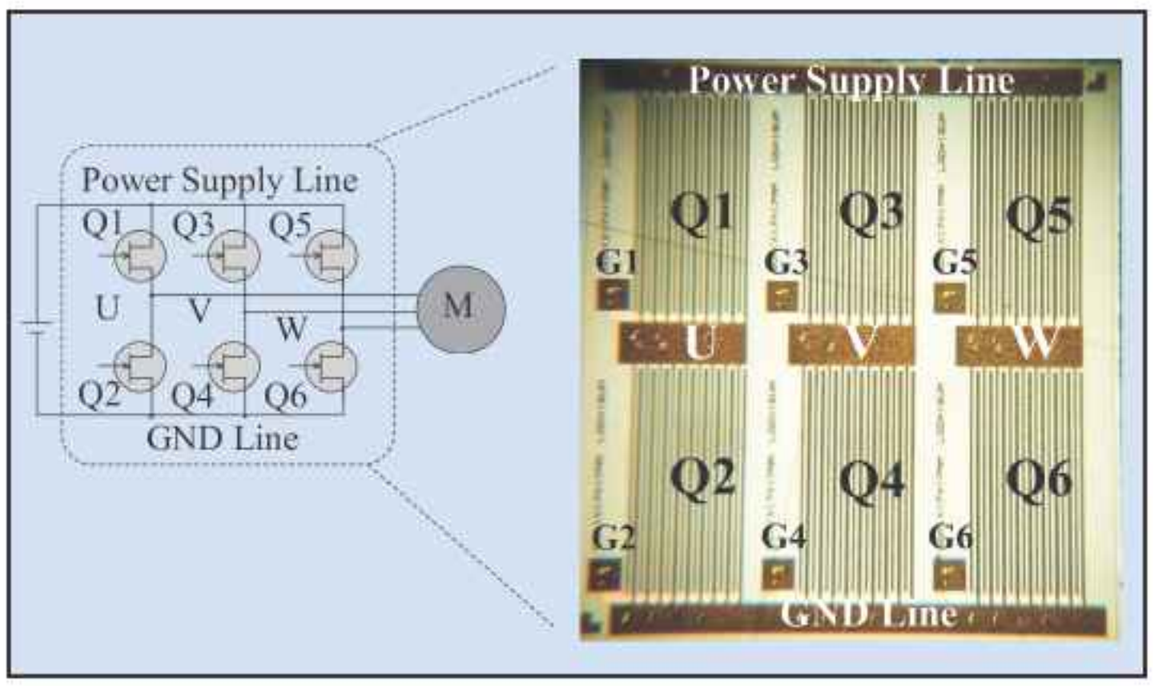



**Figure 5. Circuit diagram and chip photograph of Panasonic's fabricated GaN monolithic inverter IC in which six gate-injection transistors are integrated.**

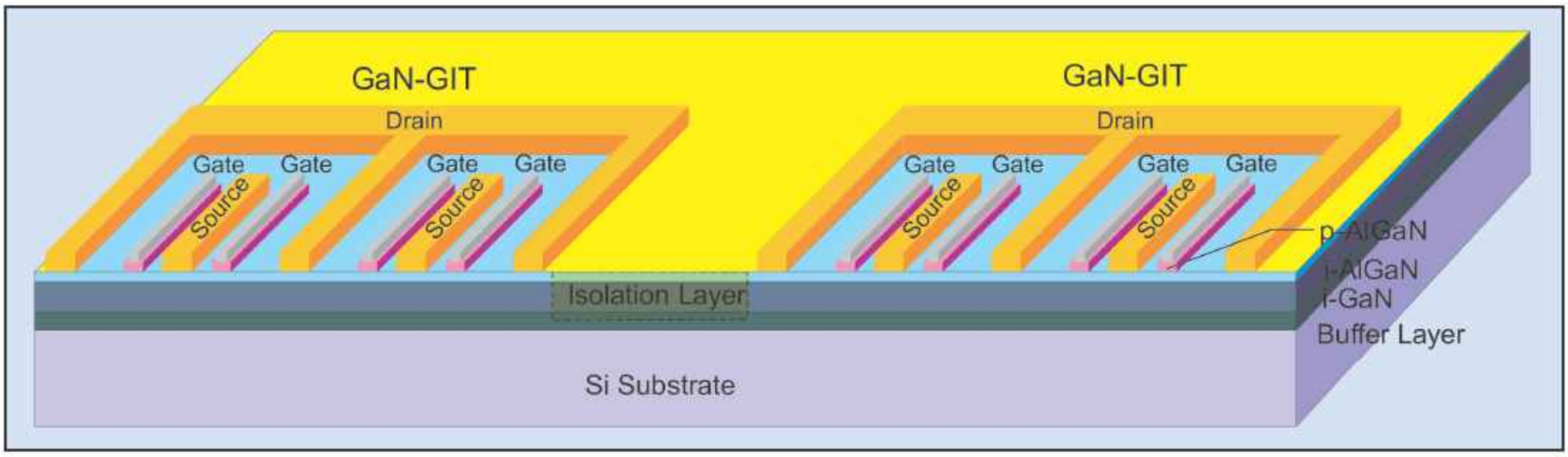



**Figure 6. Cross section of two AlGaN/GaN gate-injection transistors in Panasonic's monolithic inverter system.**

present. However, single-chip silicon inverters are not possible because they are usually constructed from vertical IGBT or MOSFET devices, as opposed to the planar configuration of FETs.

The GITs (Figure 6) consist of a p-AlGaN gate on an AlGaN/GaN heterostructure. This gives a normally-off operating condition. The GIT achieves low resistance in the on-state by modulating the conductivity with holes injected by the p-type gate.

With low cost in mind, the researchers have developed the device using MOCVD growth on silicon substrates. This would enable substrates up to 6-inch diameters. It is found that the Fe isolation offers thermal stability beyond 1000°C, a property not available with alternative implants such as boron or carbon. Tests of Fe and B isolation before and after an anneal process at 1200°C show only a slight impact on Fe's performance, but that B's ability to stop current flow is more than halved.

The GIT devices operate in a diode-like mode in reverse bias, the property that enables the circuit to be built without the FRDs needed for IGBT-based inverters. The GaN solution allows recovery times as low as 20ns, while IGBTs with FRDs are slower at 50ns, and the MOSFET option requires 200ns.

The off-state breakdown voltage of the GITs is 700V due to the use of a thick buffer layer on the Si substrate. A bias-temperature reliability test showed stable threshold voltage and off-state leakage currents after 1000 hours.

## European GaN

There is much interest in Europe for developing these nitride semiconductor applications, coordinated around two European Union research collaborations: UltraGaN and its successor MORGaN. These projects have also interacted with Diamond Research on Interfaces for Versatile Electronics (DRIVE) [5] that finished work in 2008. In terms of patent applications, Europe has tended to lag behind the activities of Japan, the US and even Korea. When UltraGaN was set up in 2005, the latest 100 patents broke down as Japan 46%, USA 24%, Korea 11%, and Europe 9%.

MORGaN is a European Union Framework 7 (FP7) project researching new materials for electronic devices and sensors that operate in extreme conditions, especially high temperatures and high electric fields [6]. The project has four areas: diamond substrates, III-N materials, harsh environment devices, and packaging and metallization. The consortium began in late 2008, and started publishing results during 2009.

As part of the MORGaN consortium, researchers from Austria, Slovakia and Switzerland have performed a wide-ranging study of degradation mechanisms in InAlN/GaN high-electron-mobility transistors (HEMTs) [7].

By using indium aluminum nitride (InAlN) rather than the more usual aluminum gallium nitride (AlGaN) as the barrier layer, one can lattice match ($In_{0.17}Al_{0.83}N$) with the underlying gallium nitride (GaN), removing strain effects. It is found that spontaneous polarization in the nitride semiconductor materials is sufficient to create the two-dimensional electron gas (2DEG) channel at the barrier/substrate interface necessary for HEMT operation. In other words, one does not need strain-induced (piezoelectric) polarization from a mismatched barrier to produce GaN HEMTs.

While strain can produce desirable effects in some semiconductors, such as increased mobility in certain directions, it can also lead to unstable structures that can fail under electrical and thermal stress. Among the achievements for InAlN/GaN HEMTs have been drain current densities exceeding 3A/mm and HEMT operation at 1000°C without permanent damage.

The researchers from the Technische Universität Wien (TU Vienna), Institute of Electrical Engineering Slovak Academy of Sciences and École Polytechnique Fédérale de Lausanne (EPFL) aimed to fill the gap in the analysis of possible degradation mechanisms in InAlN/GaN HEMTs at various device working points and electrical stressing conditions in a similar way to other groups studying AlGaN/GaN devices. The team also hoped to confirm its expectation that the absence of strain in InAlN can reduce some device degradation processes.

The epitaxial layers (10nm InAlN/1nm AlN/1μm GaN/150nm AlN) for the tested devices were constructed

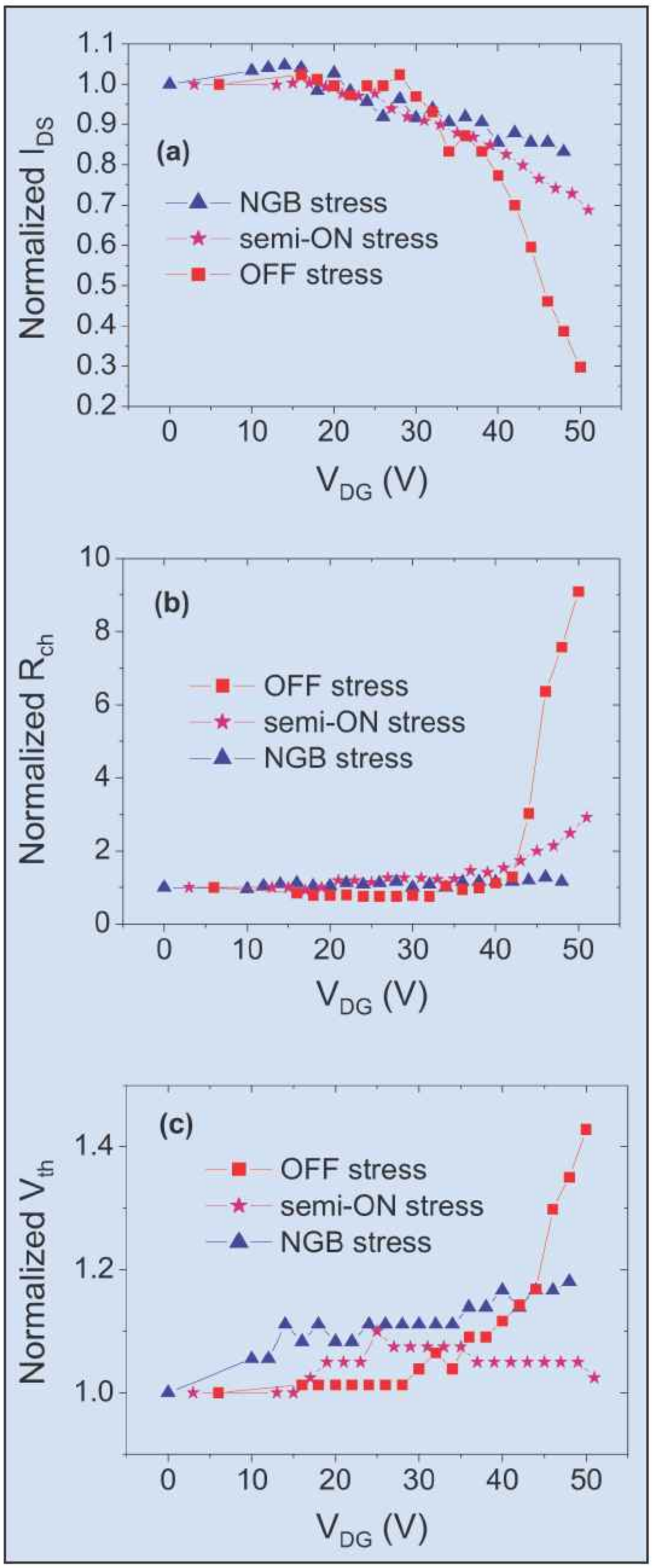



**Figure 7. Comparisons carried out under the European MORGaN consortium of normalized $I_{DS}$ (a), $R_{ch}$ (b), and $V_{th}$ (c) after NGB, off, and semi-on stresses at the same drain–gate potential $V_{DG}$. $V_{GS}$ = -3V during semi-on stresses. Corresponding bias conditions are $V_{DG} = -V_G = V_{DS} - V_{GS}$.**

using metal-organic chemical vapor deposition (MOCVD). Source/drain contacts consisted of titanium, aluminum, nickel and gold, while the Schottky barrier for the gate consisted of nickel and gold. No passivation procedure was used.

Stressing experiments were carried out under negative gate bias (NGB), off and semi-on conditions (Figure 7). NGB stresses are found to damage AlGaN/GaN devices through inverse piezoelectric effects (strain produced from electric fields) generating defects. The InAlN/GaN devices were also subjected to testing under different temperature conditions up to 250°C. Five or six devices were subjected to each test and it was found that there were no qualitative differences in behavior.

NGB tests revealed less variability in parameters when compared with published results for AlGaN/GaN HEMTs. Although gate leakage is initially a little higher for InAlN/GaN with gate–source voltage ($V_{GS}$) less than –26V, it increases by less than 80% in going to –50V (catastrophic breakdown), in contrast to the four-order-of-magnitude increase for AlGaN/GaN. Further, when degradation does occur, it is reversible, unlike the traditional AlGaN/GaN HEMT setup. While some parameters need several hours to recover their initial values, the drain and gate leakage currents need only about 100 minutes.

Irreversible damage was seen in off and semi-on tests when the drain-gate voltage ($V_{DG}$)exceeds 38V. In the off-state the intrinsic channel resistance ($R_{ch}$) and drain current are most affected. The resistance increased by one order of magnitude and the drain current decreased by 70% after off-state bias tests to a $V_{DG}$ of 50V. The researchers believe these degradation effects are related to hot-carrier injection into the GaN buffer layer, creating defects and ionizing existing states.

Improvements may be sought through using double-heterostructure channels, field plates or recessed gates, with the aim of reducing the hot-carrier injection. Surface passivation is another possible route to more reliable InAlN/GaN HEMTs.

UltraGaN (FP6) explored new heterostructures using InAlN/(In)GaN alloys, aiming to triple HEMTs power densities compared with state-of-the-art large-periphery AlGaN/GaN HEMTs [8]. This requires InAlN/(In)GaN HEMTs to demonstrate power densities of 30W/mm at 2–12GHz.

Lattice-matched InAlN/GaN devices have also shown high chemical stability and robustness [9]. One proof-of-concept device operated for a short time at 1000°C in vacuum. This is surprising, given that GaN begins to decompose at 650°C in air. The channel sheet charge of AlGaN/GaN starts to degrade above 800°C. One problem with high-temperature testing is that the metal contact materials are often the weak point of the experiments, requiring new recipes or the use of tungsten-carbide needles. One achievement has been the maintenance

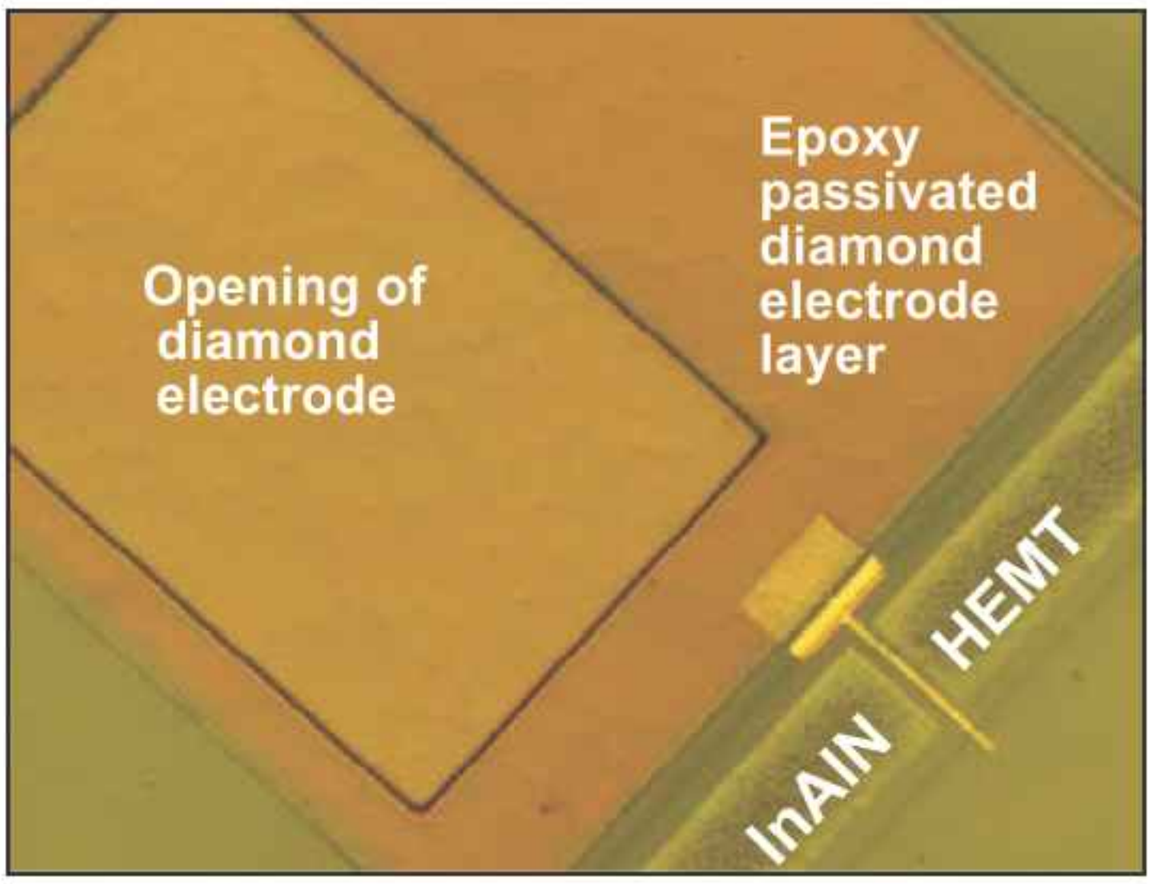



**Figure 8. InAlN/GaN HEMT structure with nanodiamond electrode in an extended-gate ISFET structure, produced in the European collaborations UltraGaN and DRIVE.**

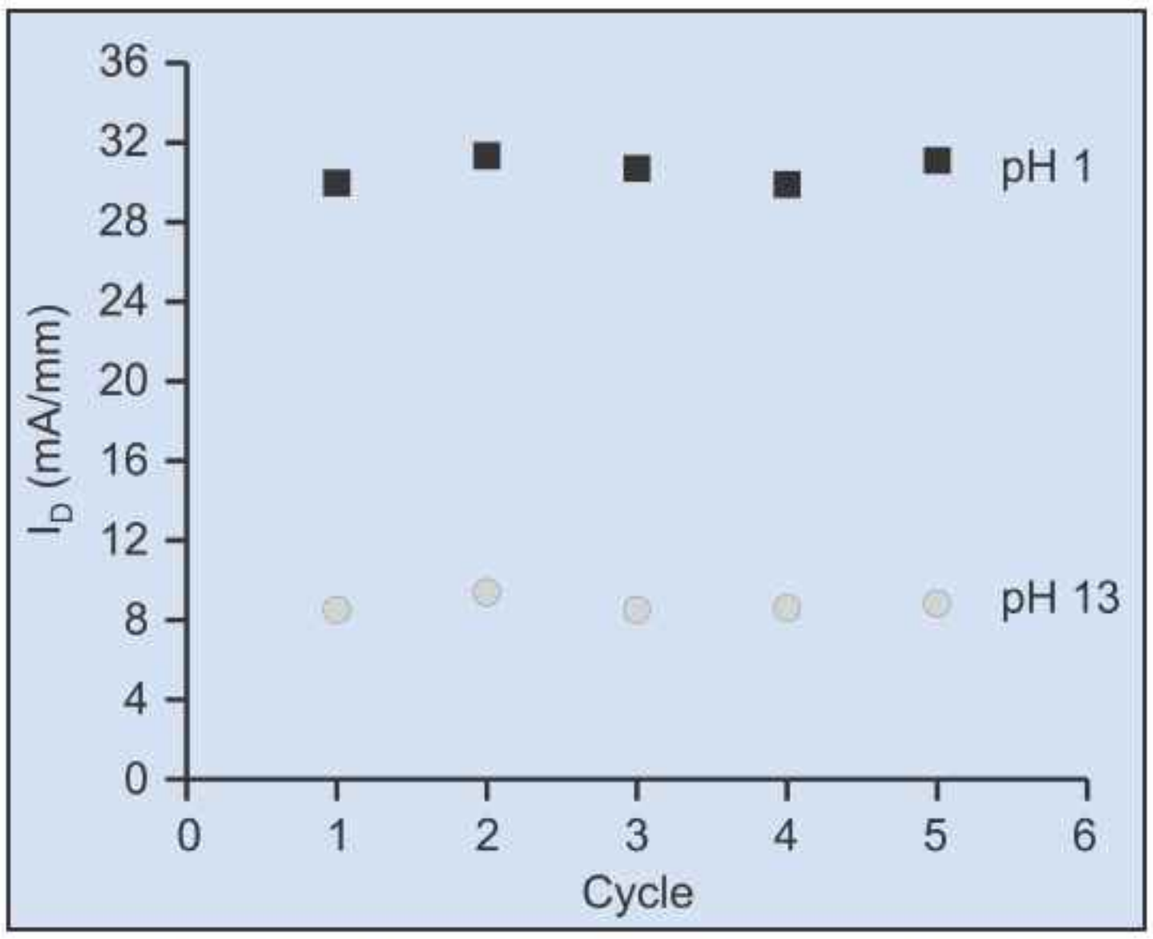



**Figure 9. pH cycling between pH 1 and pH 13 at InAlN/GaN HEMT (Figure 8) bias point in saturation and $V_G$ = 0.6V versus drain current ($I_D$).**

of DC/1MHz amplifier performance up to 800ºC.

The high-temperature performance of the InAlN/GaN interface also enables overgrowth with diamond films. Indeed, this structure is the only active semiconductor substrate on which such overgrowth has been successfully performed. This is because one needs a high-temperature growth condition with a high density of H-radicals to etch any graphitic regions, resulting in nanocrystalline diamond films with low graphitic content grain boundaries. Diamond films of 4μm thickness (on a thin nucleation layer) have been achieved on ungated FET structures without degrading polarization-induced sheet charge densities. One possible application for the overgrown material is as a heat spreader.

Diamond overlayer InAlN/GaN structures have been the basis for an electrochemical ion-sensitive FET sensor (Figure 8). The diamond layer constitutes a monolithically integrated electrode allowing operation in highly corrosive potassium hydroxide (KOH) environments with pH levels up to 13. At a $V_G$ of 0.6V, the drain current cycles between 30mA/mm for pH 1 to 8mA/mm for pH 13 environments, showing no degradation or drift (Figure 9).

One also finds promising thermal oxidation properties that have similarities to those of silicon. This means that traditional HEMTs and metal-oxide-semiconductor HEMTs (MOSHEMTs) have been realized. Indeed, using a SiN mask, a self-aligned gate has been accomplished, giving a 6W/mm device at 4GHz with a source–drain voltage of 20V and a maximum drain current of 2.3A/mm. The power-added efficiency (PAE) was only 32%, however. This was due to a high contact resistance.

The substrate materials sapphire, silicon and silicon carbide have been used. The highest open-channel current densities of 2A/mm have been achieved with SiC substrates, presumably due to its better thermal conductivity compared with the other possible materials.

Other supporters of European GaN research are the IMEC microelectronics research center in Belgium and Western European Armaments Organisation (WEAO) research cell (WRC) of the European Defense Agency (EDA).

IMEC launched a GaN industrial affiliation program (IIAP) last year (2009), aiming at both power conversion and solid-state lighting applications [10]. A key goal is to lower the cost of GaN technology by using large-diameter (up to 200mm) silicon wafers.

The Key Organisation for Research in Integrated Circuits in GaN Technology (KORRIGAN) consortium, set up in 2005 under the lead of Thales Airborne Systems, is working to develop independent GaN HEMT foundries in the continent and works in the microelectronics Common European Priorities Area 2 (CEPA 2) of WRC [11]. ■

*Mike Cooke is a freelance technology journalist who has worked in the semiconductor & advanced technology sectors since 1997.*

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## 7 Wafer processing materials

**Air Products and Chemicals Inc**
7201 Hamilton Blvd.,
Allentown, PA 18195, USA
Tel: +1 610 481 4911
www.airproducts.com/compound

**MicroChem Corp**
1254 Chestnut St. Newton,
MA 02464, USA
Tel: +1 617 965 5511
Fax: +1 617 965 5818
E-mail: sales@microchem.com
www.microchem.com

**Power + Energy Inc**
(see section 8 for full contact details)

**Praxair Electronics**
(see section 5 for full contact details)

## 8 Wafer processing equipment

**EV Group**
DI Erich Thallner Strasse 1,
St. Florian/Inn, 4782,
Austria
Tel: +43 7712 5311 0
Fax: +43 7712 5311 4600
www.EVGroup.com
Technology and market leader for wafer processing equipment. Worldwide industry standards for aligned wafer bonding, resist processing for the MEMS, nano and semiconductor industry.

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Old Kilpatrick, near Glasgow G60 5EU,
Scotland, UK
Tel: +44 (0) 1389 875 444
Fax: +44 (0) 1389 879 042
www.logitech.uk.com

**Oxford Instruments Plasma Technology**
(see section 6 for full contact details)

**Power + Energy Inc**
(see section 8 for full contact details)

**SAMCO International Inc**
532 Weddell Drive, Sunnyvale, CA,
USA
Tel: +1 408 734 0459
Fax: +1 408 734 0961
www.samcointl.com

**SPP Process Technology Systems Ltd**
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Wales, UK
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1024 Ecublens,
Switzerland
Tel: +41 21 694 35 00
Fax: +41 21 694 35 01
www.synova.ch

**TECDIA Inc**
(see section 16 for full contact details)

**Tegal Corp**
2201 S McDowell Boulevard,
Petaluma, CA 94954,
USA
Tel: +1 707 763 5600
www.tegal.com

**Veeco Instruments Inc**
(see section 6 for full contact details)

## 9 Materials & metals

**Goodfellow Cambridge Ltd**
Ermine Business Park,
Huntingdon, Cambridgeshire
PE29 6WR,
UK
Tel: +44 (0) 1480 424800
Fax: +44 (0) 1480 424900
www.goodfellow.com
Goodfellow supplies small quantities of metals and materials for research, development, prototyping and specialised manufacturing operations.

**TECDIA Inc**
(see section 16 for full contact details)

## 10 Gas and liquid handling equipment

**Air Products and Chemicals Inc**
(see section 7 for full contact details)

**Cambridge Fluid Systems**
12 Trafalgar Way, Bar Hill,
Cambridge CB3 8SQ,
UK
Tel: +44 (0)1954 786800
Fax: +44 (0)1954 786818
www.cambridge-fluid.com

**CS CLEAN SYSTEMS AG**
Fraunhoferstrasse 4,
Ismaning, 85737,
Germany
Tel: +49 89 96 24 00 0
Fax: +49 89 96 24 00 122
www.cscleansystems.com

**EMF Semiconductor Systems Ltd**
(see section 6 for full contact details)

**IEM Technologies Ltd**
Fothergill House, Colley Lane,
Bridgwater, Somerset TA6 5JJ,
UK
Tel: +44 (0)1278 420555
Fax: +44 (0)1278 420666
www.iemtec.com

**Power + Energy Inc**
106 Railroad Drive,
Ivyland, PA 18974,
USA
Tel: +1 215 942-4600
Fax: +1 215 942-9300
www.powerandenergy.com

**SAES Pure Gas Inc**
4175 Santa Fe Road,
San Luis Obispo, CA 93401,
USA
Tel: +1 805 541 9299
Fax: +1 805 541 9399
www.saesgetters.com

## 11 Process monitoring and control

**EMF Semiconductor Systems Ltd**
(see section 6 for full contact details)

**k-Space Associates Inc**
3626 W. Liberty Rd.,
Ann Arbor, MI 48103,
USA
Tel: +1 734 668 4644
Fax: +1 734 668 4663
www.k-space.com
k-Space Associates Inc specializes in in-situ, real-time thin-film process monitoring tools for MBE, MOCVD, PVD, and thermal evaporation. Applications and materials include the research and production line monitoring of compound semiconductor-based electronic, optoelectronic, and photovoltaic devices.

**LayTec GmbH**
Seesener Str.
10–13, 10709
Berlin, Germany
Tel: +49 30 39 800 80 0
Fax: +49 30 3180 8237
www.laytec.de
LayTec develops and manufactures optical in-situ and in-line metrology systems for thin-film processes with particular focus on compound semiconductor and photovoltaic applications. Its know-how is based on optical techniques: reflectometry, emissivity corrected pyrometry, curvature measurements and reflectance anisotropy spectroscopy.

**Optical Reference Systems Ltd**
OpTIC Technium, St Asaph
Business Park, St Asaph, LL17 0JD,
UK
Tel: +44 (0)1745 535 188
Fax: +44 (0)1745 535 186
www.ors-ltd.com

**WEP (Ingenieurbüro Wolff für Elektronik- und Programmentwicklungen)**
Bregstrasse 90, D-78120
Furtwangen im Schwarzwald,
Germany
Tel: +49 7723 9197 0
Fax: +49 7723 9197 22
www.wepcontrol.com

## 12 Inspection equipment

**Bruker AXS GmbH**
Oestliche Rheinbrueckenstrasse 49,
Karlsruhe, 76187,
Germany
Tel: +49 (0)721 595 2888
Fax: +49 (0)721 595 4587
www.bruker-axs.de

**KLA-Tencor**
160 Rio Robles, Suite 103D,
San Jose,
CA 94538-7306,
USA
Tel: +1 408 875 3000
Fax: +1 510 456 2498
www.kla-tencor.com

## 13 Characterization equipment

**J.A. Woollam Co. Inc.**
645 M Street Suite 102,
Lincoln, NE 68508,
USA
Tel: +1 402 477 7501
Fax: +1 402 477 8214
www.jawoollam.com

**Lake Shore Cryotronics Inc**
575 McCorkle Boulevard,
Westerville, OH 43082,
USA
Tel: +1 614 891 2244
Fax: +1 614 818 1600
www.lakeshore.com

## 14 Chip test equipment

**Keithley Instruments Inc**
28775 Aurora Road,
Cleveland, OH 44139,
USA
Tel: +1 440.248.0400
Fax: +1 440.248.6168
www.keithley.com

**SUSS MicroTec Test Systems**
228 Suss Drive,
Waterbury Center,
VT 05677,
USA
Tel: +1 800 685 7877
Fax: +1 802 244 7853
www.suss.com

## 15 Assembly/packaging materials

**ePAK International Inc**
4926 Spicewood Springs Road,
Austin, TX 78759, USA
Tel: +1 512 231 8083
Fax: +1 512 231 8183
www.epak.com

**Gel-Pak**
31398 Huntwood Avenue,
Hayward, CA 94544, USA
Tel: +1 510 576 2220
Fax: +1 510 576 2282
www.gelpak.com

**Williams Advanced Materials**
2978 Main Street, Buffalo, NY 14214,
USA
Tel: +1 716 837 1000
Fax: +1 716 833 2926
www.williams-adv.com

## 16 Assembly/packaging equipment

**Ismeca Europe Semiconductor SA**
Helvetie 283,
La Chaux-de-Fonds, 2301,
Switzerland
Tel: +41 329257111
Fax: +41 329257115
www.ismeca.com

**J P Sercel Associates Inc**
220 Hackett Hill Road,
Manchester, NH 03102,
USA
Tel: +1 603 518 3200
Fax: +1 603 518 3298
www.jpsalaser.com

**Kulicke & Soffa Industries**
1005 Virginia Drive,
Fort Washington, PA 19034,
USA
Tel: +1 215 784 6000
Fax: +1 215 784 6001
www.kns.com

**Palomar Technologies Inc**
2728 Loker Avenue West,
Carlsbad, CA 92010, USA
Tel: +1 760 931 3600
Fax: +1 760 931 5191
www.PalomarTechnologies.com

**TECDIA Inc**
2700 Augustine Drive, Suite 110,
Santa Clara, CA 95054,
USA
Tel: +1 408 748 0100
Fax: +1 408 748 0111
www.tecdia.com
Tecdia is a manufacturer of single-layer chip capacitors, chip resistors, DC boards, bias-Ts, diamond scribing tools and dispensing nozzles.

## 17 Assembly/packaging foundry

**Quik-Pak**
10987 Via Frontera,
San Diego, CA 92127,
USA
Tel: +1 858 674 4676
Fax: +1 8586 74 4681
www.quikicpak.com

## 18 Chip foundry

**Compound Semiconductor Technologies Ltd**
Block 7, Kelvin Campus,
West of Scotland, Glasgow,
Scotland G20 0TH,
UK
Tel: +44 141 579 3000
Fax: +44 141 579 3040
www.compoundsemi.co.uk

**United Monolithic Semiconductors**
Route departementale 128,
BP46, Orsay, 91401,
France
Tel: +33 1 69 33 04 72
Fax: +33 169 33 02 92
www.ums-gaas.com

## 19 Facility equipment

**MEI, LLC**
3474 18th Avenue SE,
Albany, OR 97322-7014, USA
Tel: +1 541 917 3626
Fax: +1 541 917 3623
www.marlerenterprises.net

## 20 Facility consumables

**W.L. Gore & Associates**
401 Airport Rd,
Elkton, MD 21921-4236,
USA
Tel: +1 410 392 4440
Fax: +1 410 506 8749
www.gore.com

## 21 Computer hardware & software

**Ansoft Corp**
4 Station Square, Suite 200,
Pittsburgh, PA 15219, USA
Tel: +1 412 261 3200
Fax: +1 412 471 9427
www.ansoft.com

**Crosslight Software Inc**
121-3989 Henning Dr.,
Burnaby, BC, V5C 6P8,
Canada
Tel: +1 604 320 1704
Fax: +1 604 320 1734
www.crosslight.com

**Semiconductor Technology Research Inc**
10404 Patterson Ave., Suite 108,
Richmond, VA 23238,
USA
Tel: +1 804 740 8314
Fax: +1 804 740 3814
www.semitech.us

## 22 Used equipment

**Class One Equipment Inc**
5302 Snapfinger Woods Drive,
Decatur, GA 30035,
USA
Tel: +1 770 808 8708
Fax: +1 770 808 8308
www.ClassOneEquipment.com

## 23 Services

**Henry Butcher International**
Brownlow House, 50–51
High Holborn,
London WC1V 6EG,
UK
Tel: +44 (0)20 7405 8411
Fax: +44 (0)20 7405 9772
www.henrybutcher.com

**M+W Zander Holding AG**
Lotterbergstrasse 30,
Stuttgart,
Germany
Tel: +49 711 8804 1141
Fax: +49 711 8804 1950
www.mw-zander.com

**TECDIA Inc**
(see section 16 for full contact details)

## 24 Consulting

**WSR Optical Device Solutions**
P.O. Box 248, Flemington,
NJ 08822,
USA
Tel: +1 908 428 4986
www.wsr-ods.com

## 25 Resources

**SEMI Global Headquarters**
3081 Zanker Road,
San Jose, CA 95134,
USA
Tel: +1 408 943 6900
Fax: +1 408 428 9600
www.semi.org

**Yole Développement**
45 rue Sainte Geneviève,
69006 Lyon, France
Tel: +33 472 83 01 86
www.yole.fr

# event calendar

**If you would like your event listed in *Semiconductor Today*'s Event Calendar, then please e-mail all details to the Editor at mark@semiconductor-today.com**

**5–9 April 2010**
**2010 MRS Spring Meeting**
San Francisco, CA, USA
**E-mail**: info@mrs.org
**www.mrs.org**

**7–9 April 2010**
**CPV-6: the Sixth International Conference on Concentrating Photovoltaic Systems**
Fraunhofer ISE, Freiburg, Germany
**E-mail**: info@cpv-conference.org
**www.cpv-conference.org**

**8–10 April 2010**
**PV America Expo**
Washington DC, USA
**E-mail**: swatson@seia.org
**www.pvamericaexpo.com**

**12–16 April 2010**
**SPIE Photonics Europe 2010**
Brussels, Belgium
**E-mail**: CustomerService@spie.org
**http://spie.org/photonics-europe.xml**

**13–14 April 2010**
**Photovoltaics Europe 2010**
Dresden, Germany
**E-mail**: sales@idtechex.com
**www.idtechex.com/printedelectronicseurope10**

**14–16 April 2010**
**Lighting Japan: the 2nd LED/OLED Lighting Technology Expo**
Tokyo Big Sight, Japan
**E-mail**: light@reedexpo.co.jp
**www.lightingjapan.jp/english**

**19–22 April 2010**
**Photonica: Lasers, Optics & Application 2010**
ZAO Expocentr, Moscow, Russia
**E-mail**: es@expocentr.ru
**www.photonics-expo.ru/en**

**20–24 April 2010**
**2nd Photovoltaics Thin-Film Week including:**
**— International Workshop on CIGS Solar Cell Technology**
**— 2nd Thin-Film Industry Forum 2010**
Berlin, Germany
**E-mail**: info@solarpraxis.de
**www.helmholtz-berlin.de/projects/pvcomb/thin-film-week/index_en.html**

**21–22 April 2010**
**2010 DOE Solid-State Lighting Manufacturing R&D Workshop**
San Jose, CA, USA
**E-mail**: solidstate@courtesyassoc.com
**www.ssl.energy.gov**

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**25–30 April 2010**
## 217th Electrochemical Society Conference (Spring 2010 ECS)
Vancouver, Canada
**E-mail**: meetings@electrochem.org
www.electrochem.org/meetings/biannual/217/217.htm

**27–29 April 2010**
## PHOTON's 6th Photovoltaic Technology Show 2010 Europe
Stuttgart, Germany
**E-mail**: info@photon-expo.com
www.photon-expo.com/en/pts_2010_europe/pts_2010.htm

**5–7 May 2010**
## SNEC 4th International Photovoltaic Power Generation Conference & Exhibition
Shanghai International Convention Center, China
**E-mail**: teresawen@sneia.org
www.snec.org.cn

**10–14 May 2010**
## LightFair International 2010
Las Vegas Convention Center, NV, USA
**E-mail**: info@lightfair.com
www.lightfair.com

**16–21 May 2010**
## 8th International Symposium on Semiconductor Light Emitting Devices (ISSLED2010)
Peking University, Beijing, China
**E-mail**: issled2010@pku.edu.cn
www.issled2010.com.cn

**17–20 May 2010**
## 2010 CS MANTECH (International Conference on Compound Semiconductor Manufacturing Technology)
Portland Marriott Downtown Waterfront, OR, USA
**E-mail**: csmantech@csmantech.org
www.csmantech.org

**19–21 May 2010**
## SEMICON Singapore 2010
Suntec, Singapore
**E-mail**: cchan@semi.org
www.semiconsingapore.org

**21 May 2010**
## LED Lighting 2010
University of Naples 'Federico II', Naples, Italy
**E-mail**: info@led-lighting.it
www.led-lighting.it/english

**23–28 May 2010**
## 15th International Conference on Metal Organic Vapor Phase Epitaxy
Hyatt Regency, Lake Tahoe, NV, USA
**E-mail**: mtgserv@tms.org
www.tms.org/Meetings/Specialty/icmovpe-xv

**23–28 May 2010**
## IEEE Microwave Theory and Techniques Society (MTT-S) International Microwave Symposium (IMS 2010)
Anaheim Convention Center, CA, USA
**E-mail**: aw@ee.ucr.edu
www.ims2010.org

**31 May – 4 June 2010**
## Compound Semiconductor Week 2010: IPRM 2010 (22nd International Conference on Indium Phosphide and Related Materials) ISCS 2010 (37th International Symposium on Compound Semiconductors)
Takamatsu Symbol Tower, Kagawa, Japan
**E-mail**: iprm2010@ech.co.jp
www.iprm.jp

**1–2 June 2010**
## S2K 2010
City Hall, Cardiff, Wales, UK
**E-mail**: jemi@ee.ed.ac.uk
www.semiconductor2k.com/default1.htm

**6–10 June 2010**
## 22nd International Symposium on Power Semiconductor Devices and ICs (ISPSD '10)
Hiroshima, Japan
**E-mail**: ispsd10@ics-inc.co.jp
www.ispsd2010.com

**8 June 2010**
## The Solar Future strategy conference
Munich, Germany
**E-mail**: e.koot@solarplaza.com
www.thesolarfuture.com

**9–10 June 2010**
## euroLED 2010
Ricoh Arena, Coventry, West Midlands, UK
**E-mail**: eveg@bsp-a.com
www.euroled.org.uk

**9–11 June 2010**
## Intersolar 2010
New Munich Trade Fair Center, Germany
**E-mail**: dsartiaux@semi.org
www.pvgroup.org/intersolareu



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