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First Solar passes \$1 per Watt target Non-polar InGaN lasers hit 500nm



RFMD closing Shanghai plant • Anadigics cancels China fab
ST launches SiC Schottkys • NTT divests InP chip division

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p30 Infineon's new third-generation silicon carbide Schottky diodes, which are being supplied in both DPAK (left) and TO-220 (right) packages..



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p66 Amonix's new 7700 High Concentration Photovoltaic (HCPV) system.



Cover: Visualization of planned 30MW CdTe PV plant, consisting of about 500,000 2ft x 4ft panels, to be developed by First Solar as part of a 25-year power purchase agreement with Tri-State Generation and Transmission Association in Colorado, Nebraska, New Mexico and Wyoming. **p72**

LED and CPV growth to supplement GaAs recovery

After last issue reporting sequential revenue declines in fourth-quarter 2008 for GaAs RFIC makers ranging from 10% (Skyworks) through 20% (TriQuint) to 24% (RF Micro Devices), RFMD has since cut 100 jobs worldwide and announced the closure of its Shanghai test & assembly plant (page 10).

Anadigics has also since reported a 22% decline in revenue in Q4/2008 (with wireless sales in particular down 41% year-on-year) — see page 17. In addition, with utilization at its existing 6-inch GaAs wafer fab in Warren, NJ likely to dip towards as little as 30% in Q1/2009, the firm has finally decided to cancel its plan to build a \$60m 6-inch fab in Kunshan, China (announced in April 2007, but postponed indefinitely last August).

Also, after recruiting new president & CEO Mario Rivas (who has experience of overseeing outsourcing to foundries from both Motorola and Philips Semiconductors), Anadigics has now adopted a 'hybrid' manufacturing model, involving mixing in-house fab manufacturing with using foundries (with output from foundries ramping up in second-half 2009). Anadigics expects the move to improve operational efficiencies and responsiveness to customers, improving cycle times.

The silicon industry is already heavily outsourced to the likes of Taiwan's TSMC and UMC and Singapore's Chartered (which are hence suffering from the silicon slowdown). In contrast, increased outsourcing in the GaAs industry during cost-cutting times can still boost GaAs foundries.

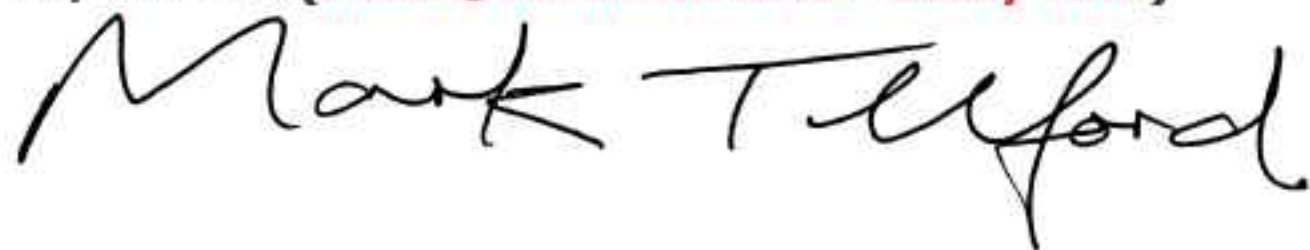
III-V product revenues for epiwafer foundry Kopin fell 8% in Q4 (page 22), not helped by its heavy dependence on Skyworks. Nevertheless, Skyworks has slowed its transition of in-house manufacturing from 4-inch to 6-inch, so Kopin stands to benefit from Skyworks outsourcing 6-inch manufacturing in the meantime.

In addition, despite a downturn in sales and job cuts in Q4/2008, epiwafer foundry IQE, which has a more diversified customer base, grew revenue 21% in 2008 (to be reported in detail next issue) and says that it sees an end to inventory reductions and a return to growth in Q2/2009 (driven by demand for 3G and smartphones).

This outlook concurs with RFMD saying that it is now seeing a broad-based improvement in order activity (see page 10). Meanwhile, several GaAs RFIC makers (including Anadigics) are expecting recent design-win activity (including for products launched at February's 2009 GSMA Mobile World Congress in Barcelona, Spain) to lead to production ramp up and revenue growth in second-half 2009.

In addition, for second-half 2009 IQE is expecting a boost from increased adoption of LED lighting as well as the emerging concentrating photovoltaic (CPV) sector, which is rapidly being adopted for projects that would formerly have used silicon (see page 66). Meanwhile, cadmium telluride PV maker First Solar is making inroads into utility-scale projects, and claims to have achieved manufacturing costs of \$1 per Watt (pages 70 & 72). Copper indium gallium diselenide (CIGS) PV news will be covered next issue.

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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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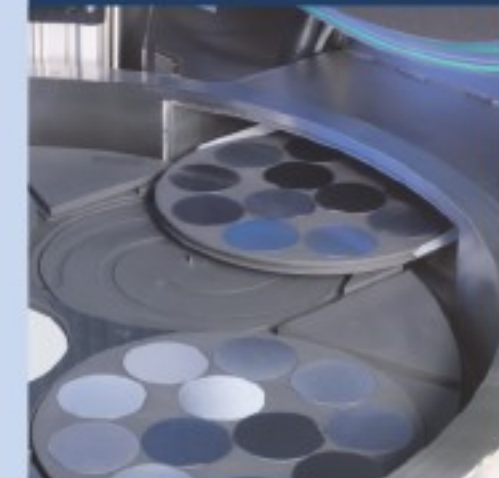
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Installed base for smart meters to reach 76 million in 2009

The number of 'smart' electricity meters installed worldwide was about 49 million in 2007, and will reach about 76 million this year, according to the new report 'Advanced Metering Infrastructure (AMM and AMI)' from ABI Research.

Smart (or remote) meters measure and automatically communicate detailed electrical (or gas or water) usage information to the utility and, in some cases, enable greater consumer awareness and control over consumption. The devices are being deployed at an increasing pace, especially in North America and Europe, including for 'home area networking' (HAN). Specific communications technologies involved include fixed RF, powerline, and cellular.

"Utilities need to move to smart metering as a way to address the growth in peak demand, operate more efficiently, provide customers with better service, and respond to environmental imperatives," says

senior analyst Sam Lucero. "Smart metering can help on all of these fronts," he adds. "They are encouraged in this by regulatory bodies, which use both the 'carrot' and the 'stick' to promote advances in energy distribution and conservation."

Current trends in AMI markets represent a continuation of the growth rates charted by ABI in recent years. "We don't think that the economic crisis is having a significant effect," says Lucero. "Utilities' smart metering deployments are typically multi-year plans developed in the context of regulated market environments, and not terribly susceptible to short-term economic fluctuations."

Indeed, there are elements in the economic stimulus packages of many countries that will boost smart metering. About \$4.5bn of the recently approved stimulus package in the US will go towards smart grid initiatives, Lucero notes.

www.abiresearch.com

Industry must not lose focus on innovation in 2009

The compound semiconductor industry is faced with tough choices to ensure some form of viability going into a very challenging 2009, says Strategy Analytics' GaAs and Compound Semiconductor Technologies (GaAs) service in its November 2008-January 2009 analysis of microelectronics, optoelectronics and materials/equipment markets.

Moving into 2009 the early emphasis was on workforce reductions and the streamlining of operations and manufacturing costs. Strategy Analytics believes that this emphasis will continue through the second quarter. Industry consolidation will also feature through the year, with Sumitomo Electric and Fujitsu com-

ing to an agreement related to Eudyna Devices, while Avanex and Bookham recently announced a merger of their operations.

"Early financial analysis shows the consistent trend of sequential drops in revenue for the final quarter of 2008 coupled with further downward adjustments in the first quarter of 2009," observes Asif Anwar of Strategy Analytics. "While streamlining operations and maximizing efficiency will be important, the industry should not lose its focus on innovation in 2009 if it is to capitalize on the emerging opportunities from next-generation devices and networks," he warns.

www.strategyanalytics.com

IN BRIEF

GaAs device market consolidates on top three after 9% growth in 2008

The gallium arsenide (GaAs) device market grew 9% from \$3.5bn in 2007 to \$3.9bn in 2008, according to a report from market research firm Strategy Analytics (confirming its forecast). Merchant demand for GaAs devices continues to be focussed on MMIC-based products targeted at the wireless sector.

The industry consolidated further around the leading players, with the top ten GaAs device makers (including Avago Technologies, M/A-COM and Mitsubishi Electric) accounting for up to 82% of the overall market. In particular, RF Micro Devices, Skyworks Solutions and TriQuint Semiconductor grew their collective market share from 53% to 59%, says Strategy Analytics. Although TriQuint and Skyworks closed the gap on RFMD through increased market share, RFMD held onto its place as the world's biggest supplier of GaAs-based RF components.

"Overall 2008 was a very good year, but growth in the GaAs industry hit a wall in the fourth quarter and 2009 will see industry revenues decline by 5-6%," notes Strategy Analytics' Asif Anwar. Previously, Strategy Analytics had expected market growth in 2009, before revising its forecast downwards in mid-December.

"However, we believe 2009 also presents an opportunity for the market leaders to squeeze out their competition, provided they can successfully leverage existing relationships while continuing to tap into adjacent markets and emerging opportunities," says Anwar.

www.strategyanalytics.com

Mobile shipments to fall 8.3% in 2009

The worldwide mobile phone market felt the full effects of the economic crisis in fourth-quarter 2008 as shipments fell 11.6% year over year, marking the first time the holiday quarter has not recorded double-digit growth in seven years, says market research firm IDC. This closed out a year that was dismal at best, yet overall 2008 managed to grow 4.3% on 2007. This has set the stage for what IDC predicts to be a very rough 2009, with shrinkage of 8.3% forecast for the year.

As consumer spending has dropped, handset makers and mobile operators have reduced supply on hand, which has left chip vendors with increased inventory. Inventory management has had a dramatic impact on shipments, but consumer demand is not falling as fast. Over the past couple of months, large chip vendors have been working to restructure inventory levels to deal with the expected downward year and should see some stabilization once inventories are reduced, says IDC.

Mature regions such as Japan, the USA, and Western Europe all face tough times, with forecast shipment declines ranging from -24.6% to -12.4% throughout 2009. In these markets, operators are struggling to find the right mix of marketing and device subsidy to entice consumers to spend while finances are tight.

The double-digit growth rates that the BRIC countries (Brazil, Russia, India, China) have seen in the past are also expected to slow to a collective growth rate of 0.3%. India remains the bright spot within that group, while Russia is experiencing a severe cut back in consumer spending and is predicted to drop significantly.

"Expectations for 2009 were negative going into the fourth quarter of 2008. However, worse-than-expected results and a steady flow of negative economic news are indicating that 2009 will be gloomier than predicted," says Ryan Reith, senior research analyst with IDC's Worldwide Mobile Phone Tracker. "Concern is understandable during this time, but note that the mobile phone market still has plenty of room to grow on a global scale and we expect recovery will begin in the first half of 2010," he adds.

Due to the industry's changing dynamics, the growth forecast for converged mobile devices (smartphones) has also been scaled back, from 8.7% to 3.4%, as IDC expects all segments to be effected. In the years to come, the industry will undoubtedly migrate more toward the converged device segment, yet in tough economic times the high price point that these devices carry can tend to stand out in the consumers eye. The notion that this segment will remain in positive growth while the industry expects an 8.3% downturn speaks volumes about the potential upside for these devices when the market turns, says the firm.

"The explosive growth of mobile applications adds a new dimension to converged mobile device growth, one that has resonated with users worldwide," says Ramon Llamas, senior research analyst with IDC's Mobile Devices Technology and Trends team. "The success of the Apple iPhone and App Store has shifted the paradigm for consumer behavior around this category, and new mobile applications pop up every day," he adds. "Now that other companies are poised to launch their own mobile application sites this

year, IDC expects continued growth for converged mobile devices in the face of a challenging market overall."

www.idc.com

Mobile WiMAX market grew 5% in Q4

The WiMAX equipment and device market held steady in Q4/2008 over Q3 at \$275m, as a slight dip in the 802.16d fixed WiMAX segment was countered by the 802.16e mobile WiMAX segment growing 5%, according to the Q4/2008 edition of Infonetics Research's market report 'WiMAX Equipment, Devices, and Subscribers'.

For 802.16e mobile WiMAX in 2008, equipment sales (ASN gateways, BTS, CPE) grew 188% and device sales (ultra-mobile PCs, phones, and external data cards) grew 121% (although the range of devices is still very limited). The number of fixed and mobile WiMAX subscribers grew 120% to 3.9m.

Alcatel-Lucent took the lead in mobile WiMAX revenue market share in 2008, pushing Motorola into second place, while Alvarion's strong second-half edged them past Samsung into third place. In a fierce vendor market share battle in the mobile WiMAX market, Alvarion consolidated its lead in WiMAX equipment revenue in Q4/2008.

While WiMAX infrastructure revenue is subdued by the economic climate, strong customer premise equipment (CPE) sales will drive mobile WiMAX market growth in 2009, as more services launch and new subscribers adopt them.

"The WiMAX market will be leaner in 2009, leading vendors to rationalize their strategies: Nortel has exited, Alcatel-Lucent has transitioned its mobility R&D to its LTE program, and others will have their commitment to WiMAX tested," says Richard Webb, directing analyst — WiMAX, Microwave, and Mobile Devices. "We will see more intense competition for the fewer new contracts, and a tight race for market leadership," he adds.

"Alvarion, Alcatel-Lucent and Motorola lead the field, but there is evidence to suggest that both Huawei and Cisco are coming up on the outside lane," Webb notes.

www.infonetics.com

Shipment growth (year-on-year) by device type.

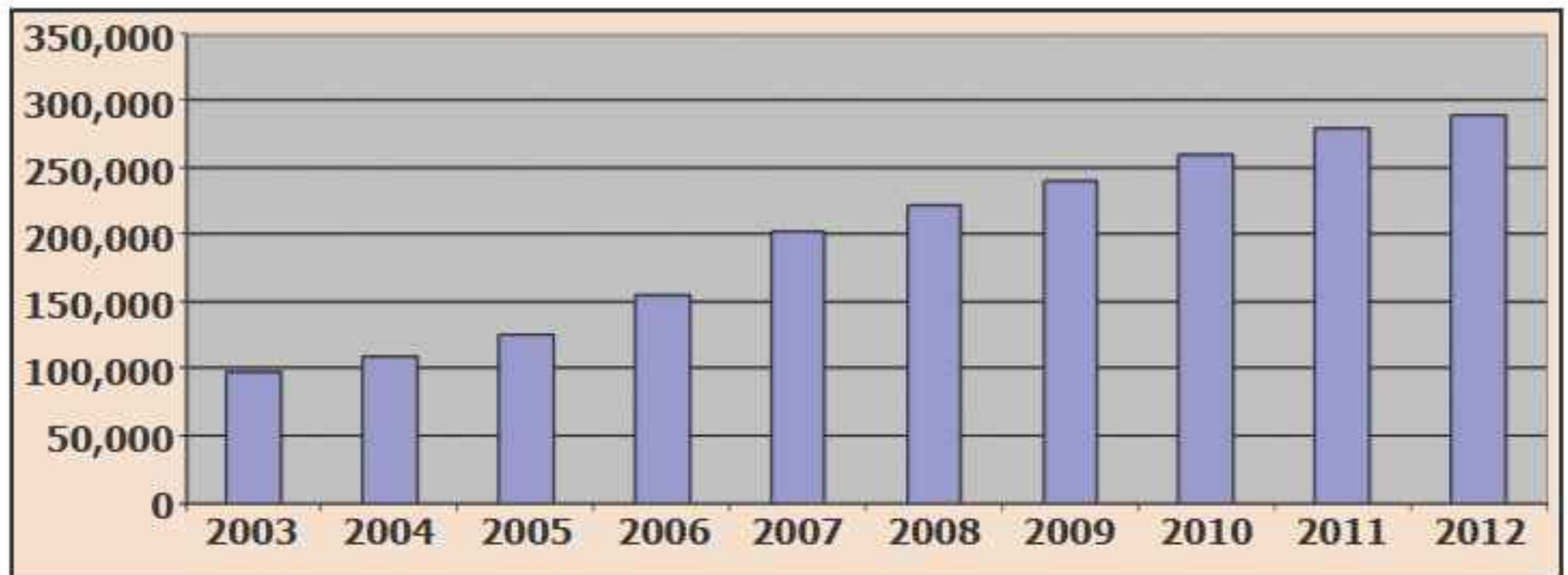
Device type	2008	2009	2010
Converged mobile device	21.9%	3.4%	22.2%
Traditional mobile phone	2.1%	-10.0%	7.4%
Total market	4.3%	-8.3%	9.5%

China handset market to grow 7.7% in 2009

Defying an expected 10.7% decline in global handset shipments, China's domestic wireless handset market is set to grow 7.7% from 222.1 million units in 2008 to 239.1 million in 2009, according to market research firm iSuppli.

"China's three wireless operators are attracting new subscribers by reducing service fees. This will greatly contribute to demand from first-time buyers," says Kevin Wang, senior manager of China research at iSuppli. "New subscribers are expected to exceed 90m in 2009. Furthermore, more existing mobile users will subscribe to a second number," he adds. "Beyond that, the government's broadened subsidy policy for consumer electronics purchases will stimulate demand in rural areas."

Domestic authorized handset market shipments surpassed 180 million units in 2008. Meanwhile, the domestic white-box handset market fell to about 40 million, down from more than 50 million in 2007. A number of white-box handset suppliers became authorized brand-name companies. Their business grew dramatically in tier-three and tier-four urban and rural markets.



China domestic mobile shipment forecast (thousands of units).

Foreign handset OEMs occupied 56% of China's handset market in 2008. Nokia was the largest supplier, with a 37% market share. At the same time, Samsung expanded its market share. In terms of domestic shipments, Tianyu will continue to be the leading Chinese brand.

There is no doubt that the China government finally will issue 3G licenses in 2009, says iSuppli. However, domestic 3G handset shipments will not increase dramatically during the year, the firm reckons.

The total domestic 3G handset market is expected to reach 8m units in 2009. Low-cost multimedia GSM and ultra-low-cost CDMA handsets should be among the best-selling products. However, smartphones

and handsets supporting 3G and the China Mobile Multimedia Broadcasting (CMMB) standard will also represent high-growth segments.

In terms of total unit shipments, Huawei and ZTE are likely to be the leaders in China's 3G handset market. Both were expected to ship more than 30 million units in 2008. Moreover, Huawei is now the largest 3G data-card supplier in the world, says iSuppli. China-based handset makers were collectively projected to ship more than 300 million handsets by the end of 2008. iSuppli forecasts that China-based handset makers will ship more than 360 million units in 2009, driven by both domestic and export markets.

www.isuppli.com

Automatic meter reading and smart energy to lead 802.15.4/ZigBee applications

Across nine primary application categories, automatic meter reading (AMR) and smart energy will be the leading applications for IEEE802.15.4 and ZigBee wireless sensor networks, forecasts In-Stat in its market report '802.15.4 — A New Sense of Energy'.

Other growing application segments include consumer electronics (via efforts by the RF4CE Radio Frequency for Consumer Electronics industry consortium), building control, industrial process control, and residential automation.

ZigBee, via its marketing efforts in the USA, has had the largest market share in the wireless sensor net-

working space for the past several years. However, a host of proprietary software stacks are being used in applications where ZigBee offers more than what is required by the specific applications, In-Stat says.

"A large number of technologies are being used for countless applications, with ZigBee usage becoming more focused on the fast-growing smart energy application," says analyst Brian O'Rourke. "On a global basis, utilities and governments are leveraging these technologies to provision, monitor, and bill customers more efficiently while also benefiting the environment," he adds.

In addition to proprietary standards, other consortia are building industry standards on 802.15.4 for other applications, including industrial, building, and home automation. These will help drive volume and lower chip costs for 802.15.4 parts.

In-Stat concludes that the number of 802.15.4 node and chipset units will reach 292 million in 2012, up from 7 million in 2007. However, currently only a third of 802.15.4 chips include a ZigBee stack, demonstrating the fragmentation among competing sensor network technologies and software stacks.

www.instat.com

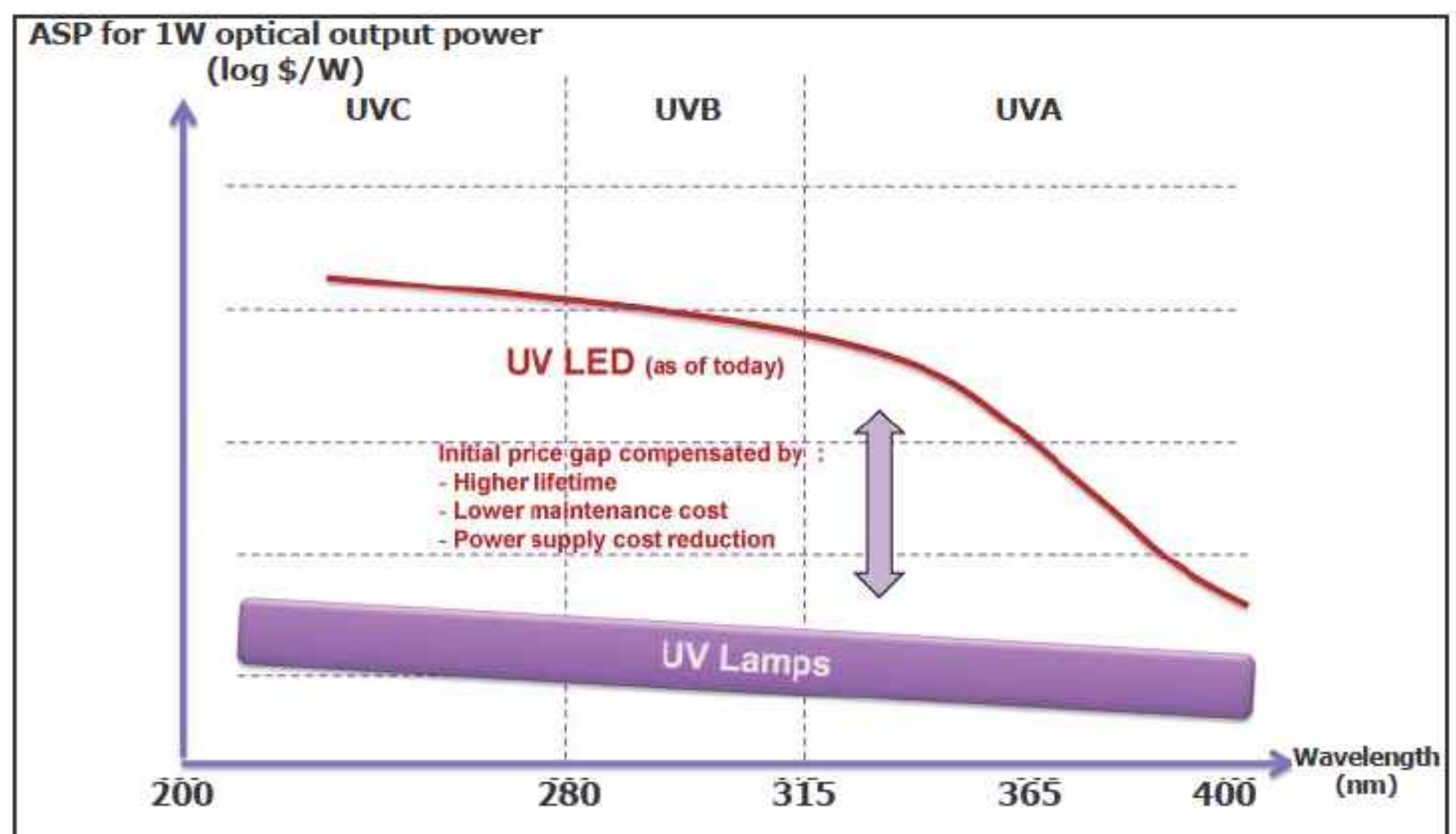
UV LED market to grow to \$250m in 2015

The annual market for traditional ultraviolet (UV) lamp technology is about \$500m. But, due to their compactness, lower cost of ownership and environmental friendly composition, UV LEDs will replace them and also open up many new applications (especially portable ones), forecasts consulting firm Yole Développement in its 'UV LED Market Report — 2009', which is dedicated to UV LEDs based on gallium nitride (GaN) and aluminum nitride (AlN) technologies.

In 2008, LEDs in the UV A/B spectrum were the dominant device in sub-400nm applications. More than 90% of the UV LED market (excluding R&D) consisted of UV curing, counterfeit detection, medical and instrumentation applications requiring UV A/B sources. The remaining 10% was for air and water purification, again consisting of a large portion of UV A-based LED sources for photocatalytic air purification.

Yole says that UVA (400–315nm light wavelengths) currently dominates the UV LED market (with a market share of about 90% in 2008) and will continue to do so for at least the next four years (with about 70% market share in 2012).

Key applications for UVA are UV curing, document/banknote verification, photocatalyst air purifier, and medical phototherapy. Among those, the most dynamic and important UVA lamp market is UV curing, where UV LEDs are definitely able to compete with traditional mercury lamps. The market is large (\$120m) and growing at about 10% annually due to the advantages of UV curing technology over traditional technology (e.g. speed). Consequently, many new players have emerged over the past five years at both the system and LED packaging levels. Also, the available power output



Traditional UV lamp pricing and current UV LED positioning in \$/Watt.

has greatly increased, and several Watts/cm² will be available in 2009–2010, says Yole.

Two years ago there were high hopes for UVC applications (e.g. disinfection, purification), but real applications have still not materialized due to the significant technical and economic challenges for UV LEDs, i.e. power output, efficiency, lifetime and cost. Players in UVC technology are hence now focusing on UVA instead.

Several players are expecting to provide AlN wafers in volume at the end of 2009... UVC LED applications based on AlN will probably reach the market in 2011–2012

The first UVC LED applications are mostly for scientific analytical instruments. It is expected that the first large-scale sales for the disinfection market will appear in 2010, for both existing markets and new point-of-use or portable applications (where compactness is a key issue).

UVC market growth is strongly connected to the availability of AlN bulk substrates, which could theoretically multiply by 100 the optical power output of the LED chip, says Yole. Several players are expecting to provide AlN wafers in volume at the end of 2009. Hence, UVC LED applications based on AlN will probably reach the market in 2011–2012, forecasts Yole.

"We also observe a strong trend where AlN companies are now extending their activities to UV LEDs to capture more added-value along the supply-chain," says the report's author, Yole project manager Dr Philippe Roussel. According to the large potential for UVA LED business in UV curing, augmented by growing market demand for water and air disinfection, Yole forecasts that the total UV LED market will be \$250m in 2015.

AlN companies are now extending their activities to UV LEDs to capture more added-value

www.yole.fr

LED market to exceed \$33bn by 2013

The overall solid-state lighting (SSL) market will exceed \$33bn by 2013, forecasts NextGen Research (the emerging technology arm of ABI Research) in its new report 'LEDs and Laser Diodes: Solid State Lighting Applications, Technologies, and Market Opportunities'.

Energized by improvements in the technologies that have produced dramatic increases in light output for both high brightness and color, and significant extensions of their life spans, LEDs have powerful and vocal proponents among local, state and federal governments, commercial industries and private citizens. These groups all are encouraging widespread acceptance and adoption of LEDs as a viable mainstream and green technology.

As a result, the LED market will experience robust growth over the next five years, fueled by increas-

ingly more-powerful and energy-efficient offerings that will help businesses and consumers lower their total cost of ownership, accelerate return on investment, and be more environmentally friendly, says the market research firm.

In particular, the illumination segment of the LED market will light the way with a compound annual growth rate (CAGR) of nearly 22% in 2009–2013 as cities shift their streetlights to more energy-efficient and ecologically friendly solutions. Also, the display portion of the market will experience a five-year CAGR of over 14%.

The market research firm says that a number of trends have intersected to make this one of the most dynamic periods in the history of LEDs. These include the bifurcation of the market between commoditized consumer LEDs and higher-end, leading-edge applications; the

transition of applications from incandescent to LED usage; standardization and green initiatives; consolidation within the industry; the emergence of new niche illumination applications, and new markets for mature applications.

Research analyst Laura DiDio identifies a number of factors spurring LED adoption, including: environmental and green energy initiatives; the need for more durable, longer-lasting and more-efficient lighting technologies; utility capacity shortages; and the need to reduce power consumption and costs.

On the other hand, the LED industry faces several challenges. "Vendors must work with legislators and industry groups to foster a smooth, orderly transition from incandescent bulbs to the more efficient LEDs," says DiDio.

www.ABIREsearch.com

LED lighting market to grow 28% annually to more than \$5bn by 2012

The LED lighting market will increase at a compound annual growth rate (CAGR) of 28% from 2008 to more than \$5bn in 2012 as it develops beyond single-color and color-changing applications into general illumination applications such as residential, commercial and off-grid applications, and ultimately into outdoor area applications, forecasts Strategies Unlimited in its report 'LED lighting Fixtures — Market Analysis and Forecast'.

But 2012 will only be the beginning for the ultimate replacement of conventional light sources, including high-efficiency fluorescent and HID fixtures, reckons the market research firm. However, many challenges face the LED industry to accomplish that goal.

Through 2007, LED lighting applications included niche markets

such as exit signs, architectural lighting, accent and decorative lighting, and entertainment lighting, many of which used red, green, and blue LEDs.

However, white LED fixtures have begun to capture a strong market position in selected applications such as consumer portable lighting (e.g. flashlights, headlamps) and solar landscape lighting, and more recently have begun to be used on a limited basis in applications such as retail display lighting, commercial and industrial lighting, and outdoor area lighting.

In 2008, white LED fixtures accounted for just over 50% of the total LED lighting fixture market. The penetration of white LED lighting fixtures into general illumination applications will accelerate when such fixtures offer

quantifiable energy and cost savings relative to the use of conventional light sources, says Strategies Unlimited.

In recent years, LED technology has made impressive performance gains, which in turn have improved the efficacy of LED lighting fixtures. During 2008–2012, white LED fixtures will make gains in market share as the best commercially available high-performance white LEDs move beyond luminous efficacies of 100lm/W.

Further improvements in designing fixtures that can optimize LED operation are expected to drive the growth in the LED lighting fixture market. Both recessionary pressures and mass manufacturing will further reduce the cost, adds the market research firm.

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IN BRIEF

Award from China's Semiconductor Industry Association

At the 2009 China Semiconductor Market Conference, officials of the country's Ministry of Industry and Information Technology and its Semiconductor Industry Association presented RFMD with an award for 'Successful Enterprises/Most Promising Enterprises In China's Semiconductor Market For 2009'. The award is in recognition of the firm's performance in 2008 (on the basis of analysis by Beijing-based CCID Consulting Co Ltd, an affiliate of the China Center for Information Industry Development).

The analysis scored semiconductor firms against six indicators: market competitiveness, corporate growth, cooperation in applications, market promotion, technical support, and growth potential.

RFMD's China operations include an assembly & test plant in Beijing, an R&D center in Shanghai, and sales and technical support offices in Beijing, Shanghai and Shenzhen. RFMD says it provides customers a total solution from design, sales and customer service support (field application engineering and failure/reliability analysis) to manufacturing and supply chain management. It claims that its broad presence in China enables shortened design and product introduction cycle times and rapid response to demand with localized supply chain management.

"We are sharply focused on servicing customers and platform providers in Greater China," says president & CEO Bob Bruggeworth.

CCID Consulting claims that success in the China market has become a decisive factor in measuring the business performance and growth potential of a semiconductor company. The Chinese semiconductor market is growing twice as rapidly as the global market, it is reckoned.

RFMD cutting 100 jobs and closing Shanghai plant

In a Form 8-K report filed with the US Securities and Exchange Commission (SEC) at the beginning of March, RF Micro Devices announced an operating expense restructuring (for completion by the end of the March quarter) that includes the elimination of about 100 jobs worldwide (about 2% of its workforce) — mainly in sales, administrative and R&D staff — along with cuts in supporting expenses. About half of the layoffs are in Greensboro, NC, USA.

The restructuring is expected to cut RFMD's expenses by \$12–15m on an annualized basis (starting from the June quarter), and result in aggregate pre-tax charges of about \$13m (\$2.5m related to one-time staff termination benefits, \$8m to impaired assets, and \$2.5m to lease and other contract termination costs). Of this, about \$8m relates to non-cash charges and \$5m to cash expenditures.

Also, previously, in a Form 8-K filing on 24 February, RFMD announced a restructuring to reduce manufacturing costs by consolidating its China back-end test & assembly operations from its Shanghai site into its primary facility in Beijing as well as outsourcing certain non-core



manufacturing operations.

The Shanghai closure (to be completed by the end of the September quarter) is expected to reduce RFMD's annualized manufacturing costs and operating expenses by \$4.5m (starting from the December 2009 quarter), and result in aggregate pre-tax charges of \$4.5m (\$1.4m related to one-time staff termination benefits, \$1.2m to impaired assets, and \$1.9m to lease and other contract termination costs). Of this, about \$1.2m relates to non-cash charges and \$3.3m to cash expenditures.

RFMD does not currently plan any further operating expense reductions. However, it adds that it will continue to evaluate the global macro-economic environment and pursue additional opportunities to cut costs and expenses as necessary.

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Broad-based improved order activity seen

At the Raymond James 30th Annual Institutional Investors Conference in Orlando, FL, USA on 10 March, chief financial officer & VP of administration Dean Priddy said that RFMD expected to generate cash in the March quarter, and to have reduced its net debt by about \$100m in the three quarters by the end of that quarter. He also reiterated the firm's free cash flow forecast of \$80–120m in fiscal 2010 (from 29 March 2009).

Priddy also said that RFMD has proactively responded to the reduced demand environment by

lowering breakeven points for cash generation and operating income.

RFMD's capital expenditure was about \$5m in the December 2008 quarter, and is expected to be less than \$20m in calendar 2009 (less than a quarter of 2008's \$81m).

Bob Van Buskirk, president of the Multi-Market Products Group (MPG), added that RFMD is experiencing improved order activity from customers across multiple industries. The firm expects significant leverage as demand continues to improve and as new product cycles continue to ramp.

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RFMD enters cellular switch filter module market

At the 2009 GSMA Mobile World Congress in Barcelona, Spain (16–19 February), RF Micro Devices announced its entry into the cellular switch filter module (SFM) market by making available samples of the RF1194 and RF1195 (in compact 4.5mm x 4.5mm x 1.2mm packages), designed for use in multi-band, multi-mode 3G handsets.

Both SFMs leverage RFMD's 3G front ends, as well as the high-volume cellular switch technology and filter integration capabilities demonstrated in the firm's Polaris radio solutions.

"RFMD's entry into the cellular switch filter module market supports our ongoing diversification efforts and leverages many of our core competitive strengths," says president & CEO Bob Bruggeworth. RFMD has shipped hundreds of millions of transmit modules featuring its GaAs pHEMT technology, and

has integrated hundreds of millions of filters into its POLARIS radios solutions.

"We expect meaningful growth in the SFM segment this year as our new products lower costs, reduce form factors, improve system performance, and ease the implementation of complex 3G front-end applications," Bruggeworth reckons.

The RF1194 integrates a single-pole nine throw (SP9T) pHEMT switch, quad-band GSM/GPRS/EDGE transmit low-pass filtering (LPF) and four

RFMD's entry into the cellular switch filter module market supports our ongoing diversification efforts and leverages many of our core competitive strengths

GSM/GPRS/EDGE receive (Rx) surface acoustic wave (SAW) filters, for implementation in a quad-band GSM/GPRS/EDGE, triple-band WCDMA/HSPA+ 3G multimode handset. With four symmetrical, low-insertion-loss GSM/GPRS/EDGE Rx ports and three symmetrical, high-linearity WCDMA/HSPA+ Tx/Rx ports, it simplifies the design of 3G multimode devices by providing a flexible, platform-capable front-end solution, RFMD says.

The pin-to-pin compatible RF1195 integrates a single-pole ten throw (SP10T) pHEMT switch and builds on the RF1194's architecture by providing an additional high-linearity port for a total of four symmetrical WCDMA/HSPA+ Tx/Rx ports.

Based on current design activity, RFMD anticipates first revenues from the RF1194 and RF1195 in fourth-quarter 2009.

www.rfmd.com

WCDMA/HSPA+ PA modules for 3G multi-band, multi-mode handsets

RFMD has announced the availability of samples and pre-production quantities of the RF720x family of WCDMA/HSPA+ power amplifiers (PAs), which consists of four PAs designed for 3G multi-mode devices implementing mode-specific, band-specific front-end architectures. The product family accommodates all major WCDMA/HSPA+ bands and band combinations and is optimized to mate with reference designs from the industry's leading open-market 3G chipset supplier.

The RF720x expands RFMD's customer footprint, particularly in Korea, China and Taiwan, by delivering compatibility with reference designs from the leading open-market 3G chipset supplier, says Paul Augustine, general manager of the Component Solutions business unit. RFMD continues to expect double-digit growth in 3G in 2009. "We are encouraged by ongoing favorable design activity in this growth market," he adds.

The RF7200 (band 1), RF7206 (band 2), RF7203 (band 3, 4, 9 or 10) and the RF7211 (band 11) are designed for single-band operation, while the RF7201 (band 1/8), RF7202 (band 2/5) and the RF7205 (band 1/5) feature two band-specific PAs integrated in a single module package. Each band of amplification in the RF720x product family is addressed with a band-specific, high-efficiency, linear power amplifier designed to lower current consumption as output power levels decrease. The improvement in low-power efficiency is enabled through the use of three digital power modes that adjust bias current and optimize the PA for the desired output power range while maintaining linearity, says RFMD.

Each PA in the RF720x product family includes an integrated output power coupler, which eliminates the need for external couplers in chipsets monitoring and adjusting

PA output power. The integrated power coupler also significantly reduces the board area required for front-end implementation and lowers mobile device bill-of-material (BOM) costs. The dual-band RF7201 and RF7202 further reduce board area and streamline implementation by combining the highest-volume WCDMA/HSPA+ 3G band combinations in one 4mm x 5mm x 1mm module (compared to the 3mm x 3mm x 1mm low-profile packages of the single-band RF7200, RF7206, RF7203 and RF7211).

RFMD says that, by combining multiple PAs from the RF720x family, handset makers and platform providers can accommodate most WCDMA/HSPA+ band combinations, including bands 1/8, bands 1/5, bands 2/5, bands 1/2/5 and bands 1/3/8.

Based on current design activity, RFMD expects shipments of RF720x PAs to start in Q4/2009.

RFMD claims first converged 3G/4G cellular front-end platform covering up to nine frequency bands

RF Micro Devices announced at the 2009 GSMA Mobile World Congress in Barcelona, Spain (16–19 February) that it is sampling its most highly integrated and scalable 3G/4G cellular front-end platform to lead customers and platform providers (with broad market availability expected in second-half 2009).

The RF6460 features an ultra-compact 'converged' multi-band, multi-mode architecture (2G/2.5G/3G/4G) that delivers what is claimed to be best-in-class efficiency, eases implementation, shrinks solution size and reduces component placements compared to mode-specific and band-specific architectures.

It is also claimed to be the only converged architecture capable of supporting up to nine cellular bands. The RF6460 hence simplifies the design, reduces the cost and accelerates the implementation of 3G and 4G multi-mode mobile devices, the firm says.

The converged front-end platform consists of the RF6260 multi-band, multi-mode power amplifier (PA) module, the RF6360 antenna switch module (ASM), and the

RF6560 front-end power management IC. With the broadband, multi-mode characteristics of the RF6260 and the flexibility of the RF6560, the RF6460 converged front-end platform delivers a scalable front-end solution that simultaneously supports the implementation of up to five WCDMA/HSPA+/LTE bands (three high bands and two low bands) and all four bands of GSM/GPRS/EDGE in 3G/4G multi-mode mobile devices. Mobile device makers can implement most 3G/4G band and mode combinations by selecting the appropriate band-specific duplexers to place with the RF6460. The RF6460 supports all major air interface standards in multi-mode devices, including GSM/GPRS, EDGE, CDMA, TD-SCDMA (3G), WCDMA/HSPA+ (3G), and LTE (4G).

The RF6460 streamlines the design of 3G/4G multimode handset platforms by shrinking the solution size, reducing overall component count, and optimizing efficiency for all modes and power levels, says Eric Creviston, president of RFMD's Cellular Products Group (CPG).

"This enables platform providers and phone manufacturers to accelerate time-to-market of next-generation 3G and 4G multi-mode devices that can deliver greater talk times at lower costs and in smaller form factors."

The RF6460 platform uses two quadrature (or 'balanced') amplification paths (one low-band and one high-band) capable of operating in bands 1–6 and 8–10 while in WCDMA/HSPA+/LTE mode. It also optimizes PA efficiency and linearity according to the needs of each mode of operation and uses patent-pending DC–DC conversion technology to intelligently and dynamically control PA operating conditions. The platform hence maximizes efficiency across power levels, across data rates (voice-only to LTE) and during non-ideal load conditions (i.e. antenna mismatch) by responding quickly to load and line transients. This helps extend battery life and significantly reduces average thermal dissipation, both of which are critical metrics to 3G/4G handset manufacturers, says RFMD.

www.rfmd.com

RFMD expands front-end module portfolio for mobile Wi-Fi

RFMD has expanded its Wi-Fi product portfolio by making available samples of three new highly integrated front-end modules (FEMs) designed to address the growing need for high performance and continued size reductions in 802.11b/g/n-enabled mobile devices, including handsets, personal navigation devices (PNDs), digital cameras and MP3 players.

Within their compact 3mm x 3mm x 0.5mm low-profile packages, the RF5325, RF5345, and RF5725 FEMs each contain a 2.4GHz power amplifier (PA) to optimize linearity (3.3% error vector magnitude) while minimizing current consumption.

Each integrates an output power coupler, transmit (Tx) low-pass filtering and a single-pole three-throw (SP3T) switch capable of switching between Wi-Fi receive (Rx), Wi-Fi Tx and Bluetooth Rx/Tx operations.

RFMD reckons that the integrated coupler significantly lowers bill-of-material (BOM) costs and reduces the board area necessary for front-end implementation in chipsets that use

These highly integrated FEMs offer mobile device designers a single-placement front-end

closed-loop power control to adjust output power. The RF5345 and RF5725 also integrate a low-noise amplifier (LNA) for RF architectures requiring additional Rx gain.

"These highly integrated FEMs offer mobile device designers a single-placement front-end solution that reduces footprint and minimizes component count while delivering an optimal blend of high linearity and low power consumption," says Rohan Houlden, general manager of RFMD's Wireless Connectivity business unit.

RFMD anticipates revenue generated by its Wi-Fi front-end portfolio to grow throughout 2009.

TriQuint and RFMD leading GaAs firms' development of dual-mode PAs

The forthcoming availability of dual-mode power amplifiers (PAs) was the most significant announcement from the GaAs industry at this year's GSMA Mobile World Congress (MWC) in Barcelona, Spain in mid-February, reckons Strategy Analytics' GaAs and Compound Semiconductor Technologies service report 'GaAs Device Suppliers Offer Dual-Mode Solutions at MWC'.

With a plethora of UMTS (Universal Mobile Telecommunications System) frequency bands, one of the challenges for the gallium arsenide industry is to supply solutions that provide the widest possible operational range while continuing to reduce size and cost.

To this end, at MWC both RF Micro Devices Inc of Greensboro, NC and TriQuint Semiconductor Inc of Hillsboro, OR announced the forthcoming availability of dual-mode power amplifier solutions.

"Dual-mode PA solutions offer the potential to reduce footprint and cost in W-EDGE cellphones by allowing a single amplification element to do the job of two," notes Asif Anwar at Strategy Analytics. "Based on the announcements at MWC, TriQuint and RFMD are leading the industry in the development of dual-mode solutions, with product shipments expected in 2010."

Other notable GaAs industry announcements analyzed in Strategy Analytics' report include:

- Anadigics Inc of Warren, NJ launched several PA modules for multimode 3G, LTE and WiMAX mobile devices;
- Avago Technologies of San Jose, CA launched a low-noise amplifier module for use in wireless infrastructure applications; and
- Skyworks Solutions Inc of Woburn, MA launched a portfolio of PAs and front-end modules for LTE (long-term evolution).

www.strategyanalytics.com

Low-cost 2G dual-band transmit modules for emerging markets

At the 2009 GSMA Mobile World Congress in Barcelona, Spain (16–19 February), RFMD launched the RF716x family of dual-band (EGSM900/DCS1800 or GSM850/PCS1900) GSM/GPRS transmit modules, designed to meet the front-end requirements of emerging markets handsets (including reduced solution size, improved efficiency and robust ESD protection) while satisfying the need for quality, reliability and reduced handset bill-of-material (BOM) costs.

Each compact, low-profile (6.63mm x 5.24mm x 1.00mm) transmit module (TxM) is class 12-compliant and features two symmetrical (interchangeable) receive (Rx) ports (with low insertion loss) for ease of routing during implementation.

The product family includes functionally identical transmit modules with 'mirrored' footprints (RF7166/RF7168 mirror for GSM900/DCS1800 and RF7167/RF7169 mirror for GSM850/PCS1900), maximizing layout design flexibility and easing implementation across handset platforms.

Each RF716x TxM leverages RFMD's GaAs pHEMT and patented PowerStar integrated power control technology while integrating transmit filtering for what is claimed to be best-in-class harmonic performance.

"The RF716x family of high performance transmit modules helps manufacturers of emerging market handsets lower their bill of material (BOM) costs, reduce size and accelerate product time-to-market without sacrificing the quality and reliability," says Paul Augustine, general manager of RFMD's Components Solutions business unit. "The RF7168 is achieving very favorable design activity among both handset manufacturers and platform providers in Korea, Taiwan and China," he adds.

All RF716x TxMs include an electrostatic discharge (ESD) filter to provide antenna port ESD protection at a rating of 8kV contact discharge (CD) — twice the integrated protection offered by competing products, it is claimed. The ESD protection is integrated to help handset makers prevent ESD failures during handset production while minimizing signal loss, providing maximum efficiency at rated output power (P_{out}) and consistent reliability.

The RF7168 (EGSM900/DCS1800) TxM is the first available product in the RF716x family. Samples of the RF7166, RF7167 and RF7169 were due to be available in the March quarter. Each TxM is priced under \$1 in quantities of 10,000.

Based on design activity, RFMD expects revenue from the RF716x family to begin in first-half 2009.

www.rfmd.com

MediaTek selects RF7168 for GSM/GPRS

RFMD says that its RF7168 dual-band GSM/GPRS transmit module (TxM) has been selected to support multiple upcoming MediaTek GSM/GPRS handset platforms based on MediaTek's MT6139 and Othello-G transceivers. MediaTek is a provider of GSM/GPRS cellular platforms and accounts for most GSM/GPRS handsets produced by handset makers in China.

"Our participation on these cellular handset platforms highlights the positive design activity for our industry-leading TxM portfolio and underscores our commitment to supporting MediaTek's continued success, both in Greater China and elsewhere," says Eric Creviston, president of RFMD's Cellular Products Group.

www.mediatek.com



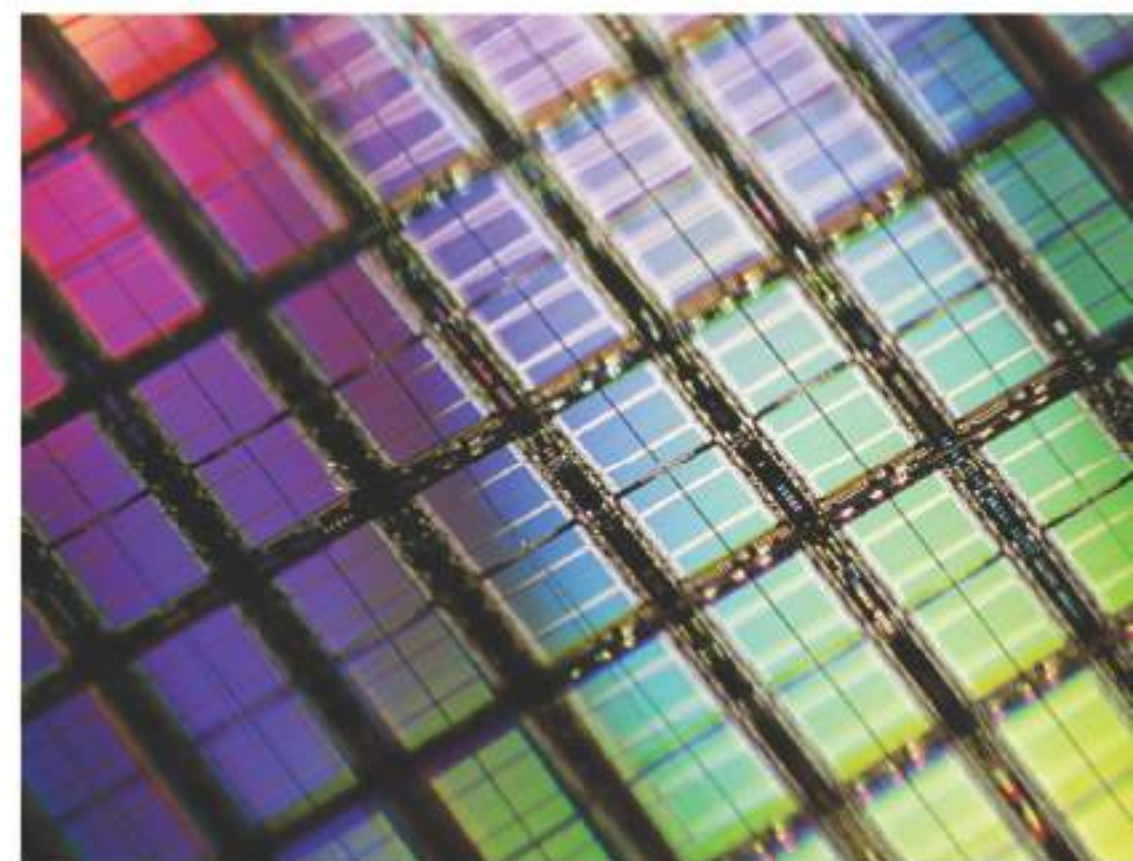
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Anadigics launches 4G and 3G power amplifiers

WiMAX 4G PA for 2.3–2.7GHz

At the 2009 GSMA Mobile World Congress in Barcelona, Spain, Anadigics launched the AWM6424, a worldwide WiMAX 4G power amplifier (PA) operating at 2.3–2.7GHz.

With the same package footprint and pin-out as the AWM6422 and AWM6423 WiMAX PAs, the device's wideband capability simplifies the design of broadband mobile wireless equipment intended to operate in multiple international destinations.

Designed to support the current IEEE 802.16 and future 4G mobile wireless standards, the AWM6424 provides a solution for subscriber products that connect to broadband wireless services in South Korea and Malaysia (2.3–2.4GHz band) and the USA, Taiwan, Russia and Japan (2.5–2.7GHz band). It complies with recommended ETSI and WiMAX Forum spectrum mask limits at +23.5dBm output power with a 3.3V supply. Under these operating conditions, power efficiency exceeds 20%. An increase in voltage to 4.2V produces a boost to the maximum linear output power, supporting systems that require slightly higher subscriber transmit power levels.

The AWM6424 includes an integrated 25dB step attenuator, output power detector, and input and output RF impedance matching circuits in a 4.5mm x 4.5mm x 1mm low-profile module, minimizing board layout space and enabling RF front-ends for size-constrained applications.

"With commercial WiMAX services now available in two major US cities and further roll-outs expected in 2009 across other parts of North America, Taiwan and Japan, it's clear that there will be a mounting demand for high-performance WiMAX PAs," says Glenn Eswein, director of product marketing for Broadband Business. "The wideband performance and integrated features of the AWM6424 simplify radio designs, accelerate product development cycles, and enable equipment manufacturers to reduce external component costs and minimize inventories," he claims.



4G PAM for band 1 femtocells

Anadigics launched its AWB7226 PA, a highly isolated, fully matched, multi-chip module (MCM) designed for the 2.1–2.7GHz band and engineered for use in femtocell and customer premises equipment (CPE) that operate in UMTS band 1.

"The AWB7226 enables connectivity in the most popular 3G band worldwide," says Joe Cozzarelli, director, Wireless Infrastructure and 4G Products. "Its balanced design delivers exceptional linearity, high power, optimized performance and integrated functionality to simplify femtocell designs and assure reliable, high-speed connectivity."

The femtocell market represents a new market opportunity for Anadigics' power amplifiers, says Dr Ali Khatibzadeh, senior VP & general manager, Wireless Products. "The tough macro-economic conditions are putting pressure on capital expenditure by major wireless operators, making femtocells a very attractive, low-cost path to increased capacity and data ARPU [average revenue per user]," he adds. "Our technology and product differentiation position Anadigics well to gain share in this emerging market."

The 4.2V module operates at UMTS band 1 downlink frequencies of 2.11–2.17GHz. It has been designed to handle WCDMA, HSPA and LTE waveforms with a P1dB of 34dBm and 30dB of gain. With a WCDMA waveform, the module delivers 25.5dBm of rated power.

The AWB7226's self-contained 7mm x 7mm x 1mm surface-mount package incorporates matching networks optimized for output power, efficiency and linearity in a 50Ω system.

Small-form-factor linear EDGE PA module

Anadigics has also made available samples of its AWE6157 quad-band linear EDGE PA module for 3G wireless handsets and equipment.

Designed to meet requirements for GSMK and linear EDGE modes in multi-mode devices, the AWE6157's 5mm x 5mm package is 30% smaller than typical EDGE PA modules and includes separate amplifier chains for GSM850/900 and for DCS/PCS band operation, each optimized for efficiency, power, gain, and linearity. An integrated power control scheme makes production calibration faster and easier, and a multi-function CMOS controller integrates several functions designed to drive performance including: voltage tracking for 3GPP compliance at low battery voltage conditions; analog power control for GSMK mode; digital bias control for EDGE mode; a regulated voltage supply; and a DAC RC filter for analog power control.

"The AWE6157 is a highly integrated solution for EDGE and WCDMA/HSPA phones and data devices which incorporate linear EDGE chipset architecture," says EDGE product line director Joe DeMoura. "The smaller package and integrated functionality simplify RF design and board layout, while also assuring spec-compliant performance under extremes of low battery voltage," he adds.

"Due to the migration of 2G networks to 2.5G and 3G technologies, EDGE power amplifiers represent a large segment of the wireless power amplifier market," says Khatibzadeh. "Several 2.5G/3G chipset vendors employ linear front-end architecture for their solutions, and AWE6157 presents them with an optimized solution in terms of performance, size and flexibility," he claims.

Anadigics' new products are manufactured using the firm's proprietary InGaP-Plus technology.

www.anadigics.com

Anadigics' China plant cancelled and cost cutting planned as sales drop 22% and fab utilization heads towards 30%

GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported revenue for 2008 of \$258.2m, up 12% on 2007. However, fourth-quarter revenue of \$45.2m was down 22% sequentially and 33% on a year ago (and approaching half of Q2/2008's \$80.5m record). Top customers in Q4 were LG, Motorola and Cisco.

In 2008, wireless sales grew 19.9% to \$154.7m, including \$24.8m in Q4 (down 15% sequentially and 41% on a year ago). Broadband sales grew 2% to \$103.5m, including \$20.3m in Q4 (down 29% on Q3, with a decline for wireless LAN outweighing growth of \$2.4m in cable business).

"We had a very strong first half due to the success of our products," says chairman Gilles Delfassy. "However, we weren't able to completely satisfy the high product demand at that time, which resulted in a loss of market share at certain customers in the second half," he adds. This was followed by the resignation of former CEO Bami Bastani.

Consequently, Anadigics' \$50m plan to construct a 6-inch GaAs wafer fabrication plant in Kunshan, China (announced in April 2007, and subsequently postponed indefinitely last August) has now been cancelled.

"The most effective and efficient way to augment our existing capacity is actually with foundry suppliers," says Delfassy who, along with new president & CEO Mario Rivas (former head of wireless semiconductor business at both Motorola and Philips Semiconductors, where he was responsible for overseeing foundries), has experience of such a hybrid manufacturing model.

Anadigics should start seeing output and revenue from foundry suppliers in second-half 2009. After capital expenditure of \$4.4m in Q4/2008, CapEx should consequently be no more than \$5-10m in 2009.

Net loss for 2008 was \$41.9m, driven by a loss of \$36.4m in Q4. However, this included charges of \$31.4m (including \$13m for China fab contract termination and \$2.1m from staff reductions). Excluding such charges, non-GAAP Q4 net loss was \$4.9m. For full-year 2008, non-GAAP net income fell from \$23.1m in 2007 to \$15.8m.

Anadigics' loss of market share in second-half 2008 has been compounded by the recent economic slowdown, with customers delaying orders to reduce their exposure in the weak and continuingly uncertain economic environment, Delfassy says. For first-quarter 2009, Anadigics hence expects revenue to fall 35% from Q4/2008.

After falling from more than 90% in Q2 to about 70% in Q4, fab utilization should bottom out at about 30% in Q1 before rebounding due to the burn off in inventory. "Although we are aggressively managing expenses, the under-utilization of our fab will continue to put pressure on gross margins [forecast to be below 10% in Q1] until supply and demand are better aligned," says Delfassy.

Previously, on 5 November, Anadigics announced cost-cutting initiatives including about 100 job cuts (15% of the workforce), costing \$2.1m but expected to realize benefits of \$15-20m.

Also, during Q1/2009 Anadigics has taken additional measures (costing a further \$1m) to contain cost and conserve cash. These include voluntary redundancies and retirement, mandatory furlough arrangements with all US staff, and the suspension of certain benefit programs. Savings for Q1 are estimated at \$1.2m. "These actions

are prudent in light of the change in quarterly revenue while preserving our capabilities to meet future customer demand and maintain a strong balance sheet," says chief financial officer Thomas Shields. "We will continue to evaluate our cost structure relative to demand," he adds.

"The plan we put in place to improve operational efficiencies and responsiveness to customers is producing results," says Delfassy. "We are achieving dramatic improvements in cycle times, yields and delivery of new product samples. More importantly, these improvements, along with the technical advantages of our products, have resulted in renewed traction with our customers as we are engaged in many of their new programs," he adds.

"Customer wins that were announced in the fall of 2008 are now ramping in production, resulting in market share gains at those customers," says Rivas (who replaced interim CEO Delfassy at the beginning of February).

Also, in mid February, Anadigics announced availability of a network interface module (NIM) reference design for CATV set-top boxes and other home gateway subsystems, expanded its 4G power amplifier portfolio with a new Band 1 femto-cell module, and also launched new products including the AWE6157 quad-band linear EDGE power amplifier (PA) module for 3G wireless handsets and equipment and the AWM6424 worldwide WiMAX 4G power amplifier (PA) for the 2.3-2.7GHz frequency range. "With the new designs scheduled to ramp in the second half of 2009, we believe we are well positioned to resume growth during the next product cycle," Rivas says. "I am encouraged that Anadigics can emerge out of this downturn a stronger company."

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Fab utilization should bottom out at about 30% in Q1 before rebounding

Module shipments reach half billion

TriQuint has now shipped more than a half billion RF modules to manufacturers of mobile devices, and is continuing to expand its module line by introducing a new Tritium III PA-Duplexer module for band 8 and a new QUANTUM II Tx module for GSM/GPRS/EDGE.

TriQuint says that its modules provide the RF functionality in hundreds of millions of phones and data cards, including smartphone and 3G WCDMA phones. Also, its Tritium PA-Duplexer Module family experienced record growth in 2008 and secured numerous design wins for future production volume.

According to TriQuint, the Tritium and Quantum families provide a scalable 3G RF solution easily configurable for different handset segments, ranging from basic single-band 3G to premium quad-band WCDMA/HSUPA.

"Providing unmatched RF performance in a compact package enables manufacturers to rapidly develop full-featured mobile devices," said Tim Dunn, VP of Handsets. "We are also utilizing our module expertise to expand into products for value-added services such as GPS LNA-Filter modules, and an 802.11 b/g/n + Bluetooth front-end module."

With the launch of the Tritium III PA-Duplexer module (TQM626028) and the Quantum II Tx module (TQM6M9014), TriQuint adds support for an additional 3G band to its WCDMA/HSUPA solution. Specifically, the TQM626028 adds support for WCDMA/HSUPA Band 8. Previously announced members of the Tritium PA-Duplexer family (the TQM616021, TQM666022, and TQM676025) provide support for Bands 1, 2, 5/6, respectively. The TQM6M9014 Quantum module includes linear switch support for WCDMA/HSUPA Band 8 in addition to Bands 1, 2, 5/6.

Samples of both products are available from April.

TriQuint launches module for converged 3G/4G RF devices

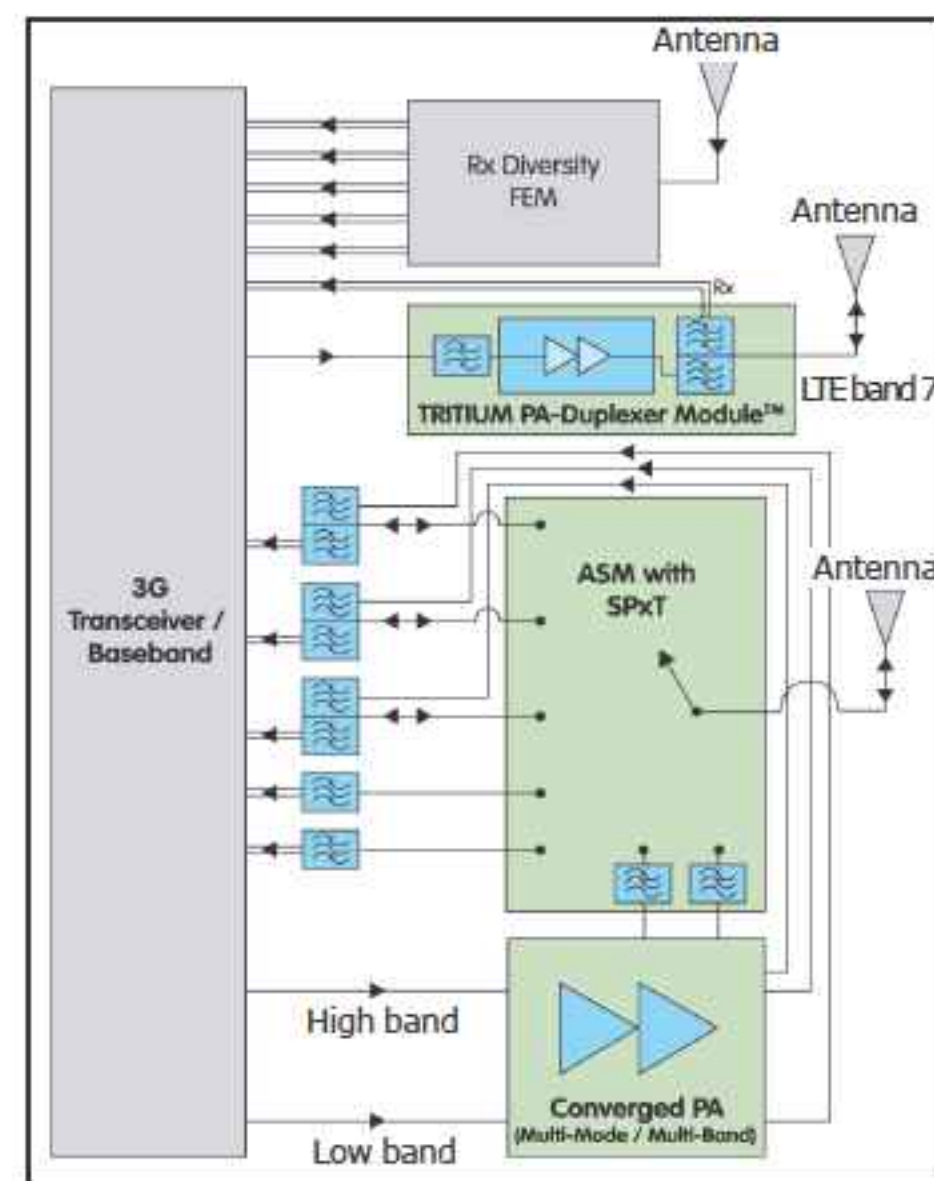
RF front-end product manufacturer TriQuint Semiconductor Inc of Hillsboro, OR, USA has launched its TRIUMF (TriQuint Unified Mobile Front-end) Module family, a convergence architecture for mobile device manufacturers designing next-generation 3G/4G products.

Multi-mode capability includes support for GSM/GPRS/EDGE for voice and lower-rate data and WCDMA/HSPA/LTE for high-speed data. Multi-band capability features the traditional quad-band GSM850/900/DCS1800/PCS1900 bands 'unified' with options for the 3GPP designated bands 1 through 17 enabling worldwide WCDMA/HSPA/LTE coverage.

The module family will therefore offer manufacturers a streamlined radio frequency footprint combining GSM, EDGE, WCDMA and HSPA transmit functionality into one module. This convergence of functionality into one power amplifier module should offer a size reduction of up to 50% over existing multi-band module solutions, TriQuint reckons.

TriQuint says that the TRIUMF module architecture will enable manufacturers to use the converged module in place of multiple discrete modules. A single converged PA module coupled with antenna switching, mode/band switch and duplexers can therefore reduce front-end board area, making board space for features such as Wi-Fi, GPS, Bluetooth, cameras, and FM radios. Combining four separate PA modules into one lowers inventory and centralizes sourcing with one preferred vendor, while cutting handset assembly cost (reducing the bill-of-materials), says TriQuint.

Also, scalability means that the module will work seamlessly in a variety of board configurations, including 3G low-cost, middle-tier and high-end smartphones, as well as 3G/4G data-cards.



The TriQuint Unified Mobile Front-end of the TRIUMF module family.

"TriQuint set the industry standard for size and performance with its highly integrated TRITIUM and QUANTUM Module families for 3G devices," says Andreas Nitschke, product marketing manager for mobile handsets. "We are using this expertise and ability to design both active and passive RF elements into one elegant RF system solution," he adds. TRIUMF will combine support

TRIUMF will combine support for multiple frequency bands

for multiple frequency bands and modes into a single converged solution. "We are working closely with our chipset partners

and customers to implement the architecture for next-generation 3G and 4G devices [including for long-term evolution (LTE) standards]."

TriQuint says that the TRIUMF Module family will be designed in close alignment with industry-leading 3G chipset solutions and optimized towards FTA readiness.

● TriQuint discussed its full range of RF solutions at the 2009 GSMA Mobile World Congress in Barcelona, Spain (16-19 February).

www.triquint.com

Intel Preferred Quality Supplier award to be presented to TriQuint

TriQuint Semiconductor Inc of Hillsboro, OR, USA is one of 26 firms to receive Intel Corp's Preferred Quality Supplier (PQS) award, recognizing its contributions to Intel in 2008. TriQuint supplies Intel with amplifiers, RF switches and a front-end module for wireless local-area network (WLAN) products, which are deemed essential to Intel's success. Celebrations to honor the PQS award winners were held in March in Tokyo, Japan and Santa Clara, CA.

"TriQuint has worked closely with Intel on a range of significant programs enabling the RF evolution of MIMO-based WLAN and WiMAX solutions," says Brian Balut, VP Networks for TriQuint. "TriQuint's focus on integrated semiconductor technologies as well as customer service and quality has enabled us to improve performance and lower overall system costs for our customer," he claims.

"This achievement is a tribute to TriQuint's strong commitment and execution in support of RF components for Intel's wireless products," says Leif Stavig, Materials Manager, Integrated Circuit Sourcing and Enabling Manager for Intel.

The award is part of Intel's Supplier Continuous Quality Improvement (SCQI) program, which encourages suppliers to strive for excellence and continuous improvement. To qualify for PQS status, suppliers must score 80% on a report card that assesses performance and ability to meet cost, quality, availability, delivery, technology and responsiveness goals. Suppliers must also manage and deliver on a challenging improvement plan and a quality/business systems assessment. Furthermore, the 2008 awardees had to demonstrate basic compliance to the Electronic Industry Code of Conduct and to Intel's Green Sustainability Program.

<https://supplier.intel.com/static/Q>

IN BRIEF

Technology Exec of Year award for CEO

TriQuint's president & CEO Ralph Quinsey has been selected by the Oregon Council of AeA (formerly the American Electronics Association) to receive its 2009 Technology Executive of the Year award (to be presented at the Oregon Technology Awards program at the Portland Art Museum on 7 May).

Quinsey was selected for his leadership shown in TriQuint, the greater Oregon community, and the technology industry, as his results- and employee-oriented approach has contributed to the firm's year-on-year growth over the past three years during a challenging period for much of the semiconductor industry. Quinsey is recognized for streamlining operations and focusing the market direction of the firm since he joined it in July 2002.

www.oregontechawards.com

TriQuint fulfills Northrop's initial production orders for JSF

RF product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has fulfilled initial production orders from Northrop Grumman Corp to support the fire-control active electronically scanned array (AESA) radar system for the F-35 Lightning II aircraft.

The new stealth-capable, supersonic, multi-role Joint Strike Fighter (JSF), which will replace fighter and strike aircraft including the F-16 and its variants, is being developed by Lockheed Martin Corp with primary partners Northrop Grumman and BAE Systems. The F-35/JSF program is a multi-nation effort, with participants including Australia, Canada, Denmark, Italy, the Netherlands, Norway, Turkey, the UK and the USA. Israel and Singapore are also engaged as part of a Security

Cooperative Participation (SCP) approach. Several thousand aircraft are expected to be delivered by the mid-2030s.

TriQuint has fabricated, tested and delivered power amplifiers, other gallium arsenide devices and bulk acoustic wave (BAW) filters for the aircraft's phased array radar system. The products support Northrop's role in developing radar and other systems for the JSF.

The JSF program is past the midpoint of a 12-year-long system development and demonstration (SDD) phase that includes a variety of application and flight-readiness tests. The products supplied by TriQuint are part of the overall program's low-rate initial production (LRIP) phase, which is being run in concurrence with the SDD phase; TriQuint has shipped an assortment of GaAs ICs for LRIP Phases I and II.

TriQuint applied some of its latest foundry processes to support Northrop Grumman design objectives for the JSF fire control system, says Dr Gailon Brehm, TriQuint's director of Defense and Aerospace products marketing. The new processes will play an important role in manufacturing and deploying the phased array radar. "TriQuint shipped a variety of production devices in 2008 and remains actively engaged in meeting our customer's needs for high-quality components," adds Brehm. "As we ship devices and as the program moves closer to full production, we expect multi-million dollar revenues."

● TriQuint exhibited and presented four papers at the GOMACTech Conference and Exhibition in Orlando, FL, USA (16-19 March). www.gomactech.net/2009

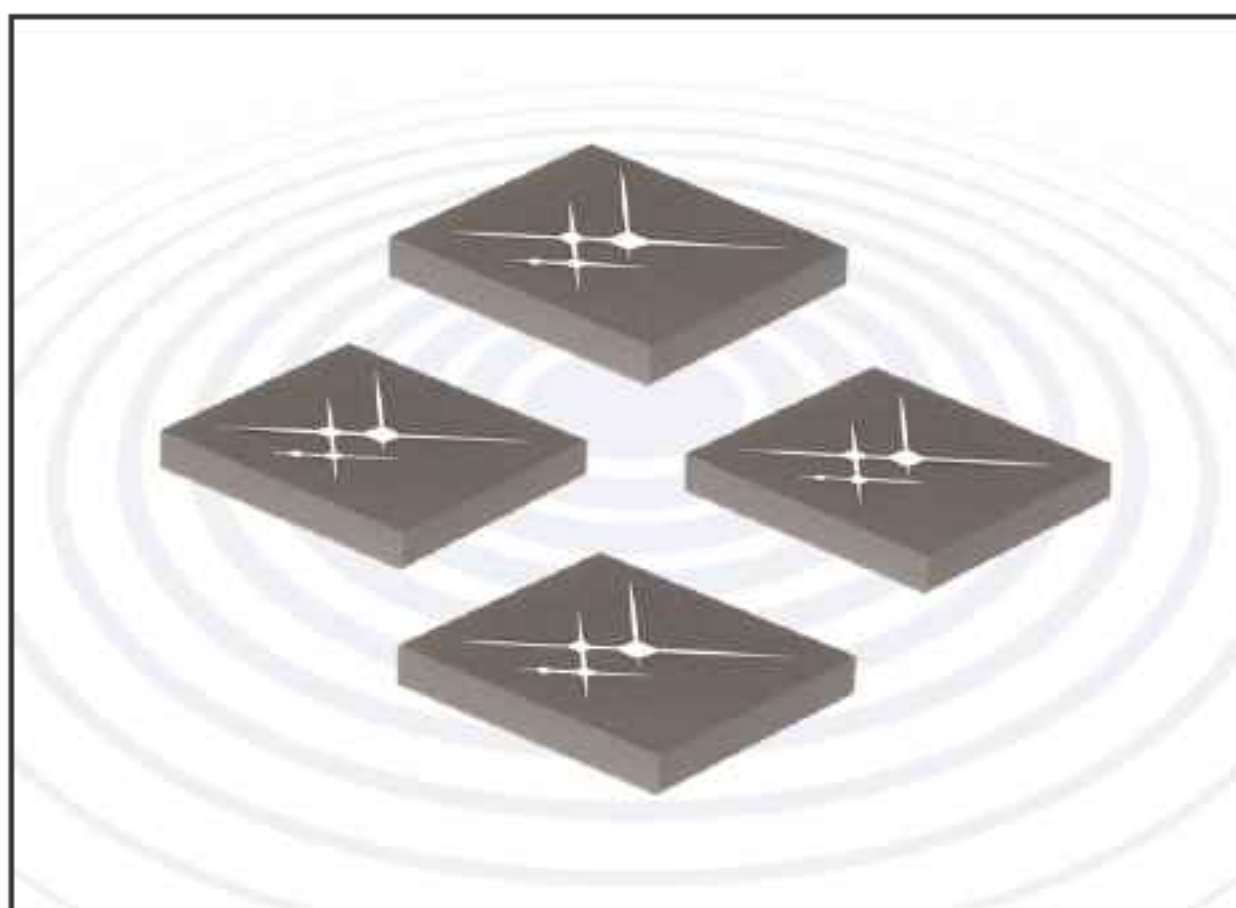
Skyworks introduces front-end modules with integrated power control scheme for quad-band handsets

Skyworks Solutions Inc of Woburn, MA, USA has launched a suite of highly integrated GSM, GPRS and EDGE front-end modules (FEM) with a small footprint and a unique power control scheme (based on a coupler detector) that greatly enhances the total radiated power (TRP) performance for quad-band cellular handsets. Different FEMs in the new family support the 2.5G and 3G platforms of baseband suppliers Broadcom, Infineon and MediaTek.

"Our complete transmission-to-antenna solution with integrated electrostatic discharge network is the perfect combination for today's mobile handset manufacturers as they look to reduce bill-of-materials and printed circuit board footprint," claims Thomas Richter, director of product marketing for front-end solutions.

The SKY77527 (8mm x 6mm x 1.12mm) — optimized for Infineon's reference designs — and the SKY77528 (8mm x 6mm x 1.1mm) — supporting Broadcom's platform — consist of a GSM850/900 and DCS1800/PCS1900 PA block, impedance-matching circuitry for 50Ω input and output impedances, a multi-function power amplifier (PA) control (MFC) block, low-pass harmonic rejection filters, and a single-pole six-throw (SP6T) antenna transmit/receive (T/R) switch.

The MFC in the SKY77527 provides 'pin-out' for interoperation with an external power control loop. The external circuit uses the linear detector output to provide closed-loop power control in EDGE and gaussian minimum shift keying (GMSK) modes of operation. With an integrated saturation, detection and correction circuit, the SKY77528 also improves phone reliability with output radio frequency spectrum (ORFS) performance in voltage standing wave ratio (VSWR) and low-battery condition.



Skyworks' new FEMs for quad-band handsets.

The SKY77529 (7.5mm x 7mm x 1.1mm) — optimized for Infineon's reference designs — consists of a GSM850/900 PA block and a DCS1800/PCS1900 PA block, a printed directional coupler for each block, impedance-matching circuitry for 50Ω input and output impedances, an MFC block, low-pass harmonic rejection filters, and a SP8T antenna T/R switch. The FEM, with an antenna that connects to any one of two reception (Rx) or four wideband code division multiple access (WCDMA) Rx/Tx ports, incorporates full support for a serial peripheral interface (SPI) bus function.

The SPI controller, which offers convenient digital control, accepts SPI telegrams with data fields that support PA and switchplexer-related functions. All FEM operating modes

and switch states shall be determined by the SPI telegram. The MFC provides pin-out for interoperation with a specified transceiver that will establish a closed-loop power control mechanism. The external circuit uses the linear detector output to set a fixed bias point for 8PSK (EDGE) mode and a variable bias point for GMSK (GSM) mode, which allows easy-to-implement

timing and calibration.

Finally, the SKY77546 (7mm x 6mm x 1.0mm) consists of an extended global system for mobile communications (EGSM900) PA block and a DCS1800 PA block, impedance-matching circuitry for 50Ω inputs and outputs, a multi-function PA control block, low-pass harmonic rejection filter, and a Tx/Rx antenna switch. Supporting MediaTek's low-cost EDGE platform, the module contains a diplexer filter which provides what are claimed to be excellent harmonics and electrostatic discharge (ESD) performance.

The SKY77527 and SKY77528 are already in volume production, while the SKY77529 is sampling now, and the SKY77546 will sample in second-quarter 2009.

www.skyworksinc.com

Low-noise amplifier for 250MHz–6GHz

Skyworks has launched a low-noise amplifier (LNA) that operates in the 250MHz to 6GHz range.

The SKY65038-70LF is a general-purpose, broadband amplifier fabricated from Skyworks' pHEMT process and packaged in a miniature SOT-89 package. With a low noise figure of 2dB and high output IP3 of 40dBm at 1.0GHz, the devices are suited to

transmit/receive applications. In addition, an output impedance of 50Ω enables the devices to be easily cascaded with a simple input impedance matching network, says the firm.

The new LNA is lead-free, RoHS-compliant, and contains no antimony or halogens.

A populated evaluation board is available upon request.

WCDMA PAs with integrated directional couplers

Skyworks has made available samples of a family of single- and dual-band WCDMA power amplifiers (PA) for universal mobile telecoms system (UMTS) applications that integrate the directional coupler, reducing the phone board footprint and bill-of-material costs. Volume production was due to start in first-quarter 2008.

The firm's expanded Intera portfolio of front-end solutions now includes five of the what are claimed to be the smallest and highest-performance UMTS PAs that support bands I, II, IV, V and VIII:

- SKY77186 for band I (1920–1980MHz);
 - SKY77187 for band II (1850–1910MHz);
 - SKY77188 for bands V & VI (824–849MHz);
 - SKY77189 for band VIII (880–915MHz);
 - SKY77191 for bands IV, IX & X (1710–1785MHz);
- plus two dual-band PAs that support the most popular band combinations (bands I/VIII and II/V):
- SKY77195 for bands I & VIII

(1920–1980MHz and 880–915MHz);

- SKY77196 for bands II & V (1850–1910MHz and 824–849MHz).

"Our newest family of power amplifiers offers significant benefits to handset OEMs who must constantly address size, cost and performance issues across a broad range of frequencies," says Gregory L. Waters, executive VP & general manager, front-end solutions. The compact solutions provide seamless operation and offer high power-added efficiency (PAE) at mid and low powers, increasing talk times, the firm says.

The five 3mm x 3mm solutions are fully matched, 10-pad surface-mount modules. High efficiencies attained throughout the entire power range deliver talk-time advantages. The modules also meet stringent spectral linearity requirements of high-speed down-link packet access (HSDPA) data transmission with high PAE.

The two 4mm x 5mm dual-band PA modules provide solutions for these increasingly popular phone models. Skyworks' integration techniques

pack most of the external passive components into the modules, requiring only two external bypassing capacitors for the two bands compared to 10–14 passives typically required with two single-band PA modules. This results in bill-of-materials count savings as well as up to 40–50% board area savings, claims Skyworks, enabling OEMs to devote more functionality to the phone without increasing its size.

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

The PA modules are manufactured with Skyworks' InGaP heterojunction bipolar transistor (HBT) bipolar field-effect transistor (BiFET) process, which provides for all positive voltage DC supply operation while maintaining high efficiency and good linearity.

LTE power amplifiers and front-end modules

Skyworks has made available samples of what it claims is the broadest family of power amplifiers (PAs) and front-end modules (FEMs) for long-term evolution (LTE) applications.

LTE has emerged as the dominant 4G standard with all major handset OEMs, infrastructure suppliers, and operators worldwide. According to Strategy Analytics, the LTE handset market alone is expected to reach 150 million units by 2013.

Skyworks' multi-band and multi-mode product family, which now includes two new PA modules and four new FEMs, supports 13 frequency bands and provides a flexible set of options for developing and building 4G-enabled handsets, infrastructure base-stations, wireless PC cards, and other embedded solutions. The portfolio includes what are said to be the first PA modules

supporting LTE-FDD for the USA (the SKY77449 and SKY77453) and LTE-TDD for China (the SKY77441), and the first LTE front-end module for band VII.

The SKY77455, SKY77456, SKY77457 and SKY77458 (compact FEMs that support bands I, IV/X, V/VI and VIII, respectively) are fully matched and completely compliant for LTE, as well as HSDPA and WCDMA standards. These FEMs integrate the PA, inter-stage filter, input/output matching, power detection, and duplexer functionality in a small 4mm x 7mm form factor.

The SKY77449 for bands XIII and XIV and the SKY77453 for bands XII and XVII are both fully matched PA modules developed for 4G LTE/EUTRAN standards. They integrate all active RF circuitry (including the input, inter-stage

and output matching circuits and power detector functionality) within a single 4mm x 4mm x 0.85 mm low-profile package.

Using Skyworks' InGaP BiFET design, which provides bias and detection architecture implementation, the new range also supports low operating voltage down to 3V with high power-added efficiency (PAE). It also delivers high linear power under quadrature phase-shift keying (QPSK), 16 quadrature amplitude modulations (QAM), and wideband code division multiple access (WCDMA) modulation, with up to 20MHz in bandwidth and partial or full resource block allocation.

The SKY77445 PA module for band VII and the SKY77441 FEM for bands 38 and 40 were launched in 2008. Volume production of all new devices should start this year.

IN BRIEF

Avago adds low-noise, high-gain, high-linearity balanced amplifier module

Avago Technologies of San Jose, CA, USA has added to its ALM-1x22 family of fully matched GaAs amplifiers by launching a new low-noise, high-gain and high-linearity two-stage balanced amplifier module for use in tower mounted amplifiers, low-noise amplifier (LNA) modules and cellular base-station applications. The new ALM-1522 is suited to major 800/900MHz cellular bands such as GSM, CDMA, UMTS and next-generation long-term evolution (LTE) applications that operate in the 700MHz band.

By using Avago's proprietary 0.25µm GaAs enhancement-mode pHEMT process, the 5V ALM-1522 offers a low noise figure of 0.6dB, high gain of 31dB, and high linearity performance, which helps to improve the sensitivity and dynamic range of cellular base-station receivers. Housed in a miniature 5mm x 6mm x 1mm surface-mount molded chip-on-board package, the balanced amplifier module allows the development of smaller or more compact base-station products such as pico and femto base-station receivers that do not require as much board space as typical discrete solutions, Avago says.

The ALM-1522 has no external RF matching components, aiding design simplification and shortening the design-to-market cycle. The module also replaces the four discrete transistors typically found in the traditional TMA, LNA/filter combiner and LNA products used in base-station front-end receivers.

The ALM-1522 is priced at \$8.56 each in 10,000 piece quantities.

www.avagotech.com

Kopin grows profit in Q4 despite 8% drop in III-Vs revenues

Kopin Corp of Taunton, MA, USA, which makes III-V heterojunction bipolar transistor (HBT) epiwafers and CyberDisplay LCDs, has reported revenue growth of 17% from \$98.1m in 2007 to a record \$114.8m in 2008 (with GaAs RFIC maker Skyworks Solutions Inc of Woburn, MA comprising 29% of revenue). Fourth-quarter revenue of \$29.1m was down 5% on \$30.7m last quarter but still up 1% on \$28.9m a year ago.

"We posted record top-line results in 2008, paced by strong sales of military display products," says president & CEO Dr John C.C. Fan. Displays revenue grew 24% from \$54.6m in 2007 to \$67.8m in 2008, including \$18.2m in Q4 (down 4% on \$18.9m last quarter but up 9% on \$16.7m a year ago), with reduced revenue from lower-margin consumer electronics applications such as low- and mid-range digital still cameras and camcorders compensated by increased revenue from higher-margin military and certain consumer electronic applications.

III-V product revenue grew 8% from \$43.6m in 2007 to \$47m in 2008. "Our III-V product line grew modestly in 2008, despite the effects of the economic downturn on the wireless handset market," Fan says. However, Q4 revenue of \$10.9m is down 8% on \$11.8m last quarter and 11% on \$12.2m a year ago, reflecting the deteriorating macroeconomic conditions.

"Despite the global economic slowdown, we are delighted that we achieved many of our 2008 objectives," says Fan. Gross margin grew from 16.5% in 2007 to 27.5% in 2008, including 27.8% for Q4/2008 (up from 20% a year ago), reflecting the higher sales of military displays.

Compared with a net loss of \$6.6m for 2007, net income in 2008 was \$2.6m. This included \$1.8m in Q4, up from \$0.3m a year ago and \$1.5m last quarter. This

was despite R&D expenses rising from \$11.5m in 2007 to \$16m in 2008 from developing high-resolution displays and new III-V products.

During 2008, Kopin's cash and marketable securities grew by \$6.7m to \$100m. "Our strong cash position is key to our competitive advantage," says Fan. With no long-term debt, in December the firm's board of directors approved a program to re-purchase up to \$15m of its common stock.

In 2009, Kopin expects revenues from military display products to continue to grow as part of its strategy of focusing on higher-margin products. However, the global economic slowdown is expected to result in lower revenue for commercial and industrial products.

"Coming off a year of record revenue, we remain optimistic about the opportunities ahead, despite the challenging environment," says Fan. "During this economic slowdown, we observed a very strong shift to more advanced handsets — 3G and even 4G handsets, especially in China," he adds.

"We continue to believe that our unrivaled wafer and manufacturing experience and strong experience

Our III-V product line grew modestly in 2008, despite the effects of the economic downturn

and expertise with III-V technology such as indium gallium phosphide (InGaP) represent important advantages for Kopin as new handset standards are being installed worldwide," says Fan. "We are confident that we can use our established manufacturing expertise, solid base of top-tier customers, strong cash position, and relentless technology and product innovation to emerge from this downturn as an even stronger leader in the markets we serve."

www.kopin.com

AWR acquires STAAR for parallelized 3D FEM electromagnetic technology

AWR of El Segundo, CA, USA, which provides high-frequency electronic design automation (EDA) software, has acquired Simulation Technology and Applied Research Inc (STAAR) of Mequon, WI, a developer of three-dimensional (3D) parallelized FEM (finite-element model) tools for electromagnetic (EM) simulation of components and subsystems operating at RF and microwave frequencies.

STAAR is now a subsidiary of AWR Corp, but retains its operations and facilities in Wisconsin under the continued guidance of founder Dr John DeFord.

AWR says that it chose STAAR after spending much of 2008 evaluating 3D EM technologies and firms in response to customer demand for a seamlessly integrated 3D FEM tool within the AWR Design Environment.

STAAR, a profitable company that was launched in 1997, has developed proprietary parallelized 3D FEM EM simulation and analysis capability, embodied in its Analyst software. Analyst software is the result of more than a decade of development at STAAR in collaboration with the US Department of Defense and the Department of Energy, and has been employed to analyze extremely complex RF and microwave structures at the Fermi National Accelerator Laboratory, Stanford Linear Accelerator Center, and Naval Research Laboratory.

"The entire team at STAAR is delighted that our Analyst technology was found to be the most compelling 3D FEM EM software for AWR to offer to its customer base," says DeFord. "STAAR's product line, corporate philosophy of simulation accuracy and scalability, along with excellent customer service, aligns well with AWR's corporate culture," he adds. "Analyst software is a natural complement to AWR's existing product portfolio, and we're excited by the prospect of taking the Analyst solution global via

AWR's worldwide sales, marketing, and support organization."

Analysis of EM fields in complex structures such as complete monolithic microwave integrated circuits (MMICs), densely populated RF circuit boards, and multifunction modules frequently requires large amounts of memory and processing power

Analysis of EM fields in complex structures such as complete MMICs frequently requires large amounts of memory and processing power

that can overburden even the most capable existing 'high-end' workstations. Many of these problems can be solved, but with limited accuracy for want of greater system resources. Analyst software addresses this deficiency by employing scalable decomposition algorithms to optimize cluster computing resources, resulting in much reduced computation times, improved accuracy, and a greater return on investment in computer hardware, it is claimed. By supporting both shared- and distributed-memory systems, Analyst can be easily configured to work with common computing architectures.

AWR's VP of marketing Sherry Hess says that STAAR's 3D FEM EM analysis technologies complement AWR's existing EM solutions such as the award-winning AXIEM 3D planar EM simulator (strong demand for which drove AWR's 2008 revenue up by more than 22% on 2007). "Analyst's novel parallelized 3D FEM technologies provide exceptional power and scalability beyond anything available on the market today, and alongside AXIEM 3D planar EM software gives designers the ability to solve a wide range of designs," she claims.

www.awrcorp.com

IN BRIEF

Mimix launches 34-37GHz GaAs MMIC high-power amplifiers

Mimix Broadband Inc of Houston, TX, USA has launched two GaAs MMIC high-power amplifiers (HPAs) covering the frequencies 34-37GHz and suiting millimeter-wave military, radar, satellite and weather applications.

The XP1072-BD achieves power-added efficiency (PAE) of 25%, with +35dBm pulsed saturated output power and 22dB of large-signal gain.

"This XP1072-BD multi-stage amplifier delivers industry-leading power and efficiency for Ka-band applications, with a saturated output power of nearly 4W, providing a boost to applications that require both high power and efficiency in a small area," claims product manager Jeff Kovitz.

In conjunction with Mimix Broadband's existing XP1017-BD driver amplifier, the XP1072-BD provides an excellent solution for many Ka-band high-power amplifier requirements, says Kovitz.

The XP1072-BD also serves as the foundation for the balanced XP1073-BD device, which achieves power-added efficiency of 24%, with +37dBm pulsed saturated output power and 22dB of large-signal gain.

"The XP1073-BD is a balanced high-power amplifier and, with saturated output power of nearly 6W, it rises well above anything available in the marketplace," claims Kovitz.

Also, by balancing two XP1072-BD devices using a fairly unique Lange coupler network, the XP1073-BD provides a well matched HPA solution for many Ka-Band applications, he adds.

www.mimixbroadband.com

Hittite grows in Q4, but expects 20% revenue drop in Q1

For full-year 2008, Hittite Microwave Corp of Chelmsford, MA, USA, which designs and supplies analog and mixed-signal RF, microwave and millimeter-wave ICs, modules and subsystems, has reported a rise in net income from 2007's \$51.2m to \$53.8m. Revenue rose 15.2% from 2007's \$156.4m to \$180.3m.

In particular, fourth-quarter revenue was \$46.4m, including \$19.1m (41%) from the USA (after 7.6% year-on-year growth) and \$27.3m (59%) from outside the USA (after 21.2% growth).

This is up 9.2% on \$42.5m a year ago and up 1.9% on Q3/2008's \$45.5m, aided by the launch of new products and increased market penetration with new and existing customers. "Our fourth quarter was an excellent finish to the year," says chairman & CEO Stephen Daly.

The revenue distribution across Hittite's eight target markets was more concentrated in Q4/2008. Apart from automotive, broadband, fiber optic, space, and test & measurement, three markets (cellular infrastructure, microwave and millimeter-wave communications, and military) accounted for 82% of total revenue (up from 76% last quarter), reflecting strong sequential growth in military business in particular.

Broadband revenue fell by 15% year-on-year (due to reduced shipments to certain direct broadcast satellite receiver customers, where Hittite exited low-margin business). However, the other seven markets grew between 12% and 97% year-on-year. "In light of the difficult economic conditions of 2008, we believe these growth rates confirm we are taking market share," says Daly.

Q4 gross margin rose from 70.8% a year ago to 72%, but this is down slightly from Q3/2008's 72.5% due to product mix, production costs, and non-standard manufacturing costs.

Net income was \$13.6m, down slightly from Q3's \$13.7m. Total cash and cash equivalents fell during the quarter by \$4.8m to \$180.9m.

Starting in May, Hittite repurchased 1,317,000 shares of its stock for \$41.6m during 2008 (including 679,000 shares for \$19.4m in Q4), and completed the planned buy-back of 1.7 million shares (for a total of \$52.1m) on 17 February 2009.

Net bookings rose by 15.9% from 2007's \$158.3m to \$183.4m for full-year 2008, boosting order backlog from \$36.5m to \$39.6m. In particular, Q4 orders included \$2.7m from a \$35m multi-year defense production contract received in December for microwave subsystems to be used in a US military weapon system. "Moving to the production phase of this project marks the successful completion of several years of effort by our advanced subsystems development team," says Daly. Deliveries and related revenue are expected to start in first-half 2010 and be completed by the end of 2011 (with 20% of the revenue recognized in 2010 and the remainder in 2011), although further orders are anticipated.

However, in the meantime (particularly in January), reflecting greater-than-normal uncertainty in the markets that it serves, Hittite experienced an abrupt slowdown in orders across all markets, mostly from the Americas (followed by Europe then Asia) and mainly from the microwave and millimeter-wave communications markets (due to inventory correction).

Consequently, for first-quarter 2009 Hittite expects revenue of just \$36-38m (down 18-22% sequentially and 11-15% year-on-year). Net income will fall to \$8.3-10.2m.

The firm attributes the decline to the likely impact of the current global economic downturn and related disruption in credit markets

on the firm's target markets (rather than any loss of market share in any one industry, the effect of any one competitor, or the loss of any one significant customer).

"While we cannot predict the length or severity of the recession, we will establish a range of plans which will protect the company's long-term position in the multi-billion dollar markets we serve," says Daly.

Consequently, for 2009, Hittite will remain focused on expanding its technology portfolio, gaining market share, managing expenses, and positioning the company for growth, he adds.

Cost-cutting actions that have been taken include implementing activities to preserve cash, eliminating the use of all contractors and temporary staff, reducing or eliminating all overtime, managing R&D expenses to ensure that the firm invests in priority programs, reducing sales & marketing expenses by

50%, and reducing or eliminating discretionary spending and benefits.

"Hittite's profitable business, cash position and proprietary technology give me great confidence we will maximize our opportunities during this recession," says Daly. "In these difficult times, customers tend to select best-in-breed suppliers that are profitable and have experience managing through downturns. Hittite is in this category and we are in a great position to service our industry and push out financially weak competitors that are just looking to survive," Daly reckons.

www.hittite.com

Particularly in January, Hittite experienced an abrupt slowdown in orders across all markets, mostly from the Americas

We are in a great position to service our industry and push out financially weak competitors that are just looking to survive, says Daly

TriAccess introduces RFICs for CATV hybrid applications

TriAccess Technologies of Santa Rosa, CA, USA, a fabless semiconductor company that provides CATV (cable TV) and FTTH (fiber-to-the-home) RFICs for amplifying high-quality multimedia content, has launched a series of RFICs that feature its patent-pending on-chip linearization for use in CATV hybrids.

The TAT8807 and TAT8857 are 75Ω RFIC amplifiers that work for applications operating at 50–1000MHz and 24V. Gain can be adjusted easily by varying external components. This flexibility enables CATV hybrid module makers to develop entire families of efficient modules around a single RFIC, says the firm.

TriAccess claims that its RFICs are the first to apply on-chip linearization fabricated in a single-die GaAs IC developed specifically for CATV networks. By incorporating on-chip linearization, the TAT8807 and TAT8857 yield higher gain (25dB) and consume very little power

(350mA from a 24V supply) compared with other currently available products, it is claimed. The result is a compact, reliable, high-performance RFIC that takes up to one-third less power while maintaining high RF output. TriAccess says that it has developed this use of on-chip linearization for cable television applications in direct response to requests from key CATV customers for greater power efficiency.

"Both international cable operators and MSOs (multi-system operators) are looking to extend their existing infrastructures and increase the available services to their CATV subscribers," says president and chief technology officer Chris Day. "Boosting the RF signal enables cable operators to carry more bandwidth-consuming services on their existing networks," he adds. "Boosting an entire distribution node, especially those with long trunk cabling and a large number of subscribers, can be very expensive,

and our lead customers for the TAT8807 and TAT8857 RFIC amplifiers recognize the value of these products for delivering higher performance at lower cost and lower power."

Designed for use in CATV line amplifiers and CATV system amplifiers and distribution nodes, the new TAT8800 family of RFICs is fabricated using the commercial foundry GaAs process of TriQuint Semiconductor Inc of Hillsboro, OR, USA. By integrating amplifier and linearization functions, the TAT8800 family achieves both excellent 2nd- and 3rd-order distortion performance, TriAccess claims.

The new RFICs were debuted and exhibited — along with TriAccess' complete portfolio of products and solutions — by sales representative WaiTat Electronics Ltd and Mitron at the China Content Broadcasting Network (CCBN) conference in Beijing (21–23 March).

www.triacesstech.com

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SIA's University Researcher Award for UCLA's Kang Wang

At its annual conference in Washington DC on 12 March, the Semiconductor Industry Association (SIA) presented its 2009 University Researcher Awards to Dr Kang Wang of University of California, Los Angeles (UCLA) and Dr Anantha Chandrakasan of Massachusetts Institute of Technology (MIT).

"Each year, the SIA recognizes university researchers who have made significant contributions to solving the obstacles that must be overcome to continue on our technology roadmap," says SIA chairman Hector Ruiz.

Kang Wang has been a professor in the Electrical Engineering Department at UCLA since 1979, and was chair of the department from 1993 to 1996. He is a Fellow of the IEEE, and a member of the American Physical Society and the Materials Research Society. He has directed projects on silicon carbide nano devices, self-assembly of quantum structures, spintronics materials and devices, and other basic research to develop technologies that should enable continued progress in semiconductor technology when the limits of conventional microelectronics technology are reached. His current research focuses on nanoelectronics and optoelectronics, MBE and superlattices, micro-wave and millimeter electronics/optoelectronics, and quantum computing.

Dr Anantha Chandrakasan is the Joseph F. and Nancy Keithley professor of Electrical Engineering at MIT. He has performed research in micro-power design, wireless micro-sensor arrays, and ultra-wideband radios. A recent joint project with Texas Instruments developed a microcontroller that cuts power consumption by 90% compared to conventional devices.

www.sia-online.org



Eco-friendly chip-making collaboration

University-research consortium Semiconductor Research Corp (SRC) of Research Triangle Park, NC, USA and nanoelectronics research center IMEC in Leuven, Belgium have agreed to establish an international collaboration aimed at creating novel processes and materials for advanced semiconductor manufacturing. The memorandum of understanding (MOU) calls for the consortia to apply their more than 50 years of combined expertise to finding more environmentally friendly chip manufacturing methods.

The effort will bring together SRC's university research for sustainable high-performance materials and processes with IMEC's expertise in research of deep-submicron IC process technologies and devices. The work will be conducted among IMEC and the joint SRC/SEMATECH Center for Environmentally Benign Semiconductor Manufacturing (CEBSM).

What was formerly the NSF/SRC Engineering Research Center (ERC) for Environmentally Benign Semiconductor Manufacturing (until 2006) was established in 1996 by SRC and the US National Science Foundation (NSF) as a university/industry consortium together with the University of Arizona, Massachusetts Institute of Technology, Stanford University, and the University of California-Berkeley (joined in 1998 by Cornell University, Arizona State University and MIT Lincoln Laboratory, and in 1999 by the University of Maryland). CEBSM's expertise focuses on addressing strategic environment, safety & health (ESH)-related research challenges.

The new IMEC-CEBSM collaboration's cooperative work targets two objectives: creating leading-edge technologies that protect the environment, and more effective processes for lowering the costs of chip manufacturing.

SRC, IMEC, and CEBSM intend to start the first phase of the joint initiative with an emphasis in two areas.

The first area focuses on sustainable cleaning and surface preparation of new materials and nano-structures, including the timely integration of new channel and gate materials such as germanium (Ge) and III/V compounds. The research will establish options for minimizing emissions and decreasing the usage of chemicals (including deposition precursors, etch chemicals and cleaning agents), water and energy during processing. The joint initiative will also explore novel in-line and real-time approaches for monitoring the efficacy of nano-structure cleaning processes.

The second area aims to explore sustainable high-performance material planarization processes. This research will advance the design and feasibility of process options that eliminate the release and discharge of nanoparticles in the manufacturing waste streams.

"Semiconductors have made enormous progress in speed, performance, and miniaturization, which places greater demand on the environmental aspects required," says SRC's president & CEO Larry Sumney. "Joining the considerable talents of SRC and IMEC with the CEBSM's proven track record for high-impact ESH research demonstrates the commitment of the chip industry to stewardship of the global environment," he adds.

"By joining forces with CEBSM's experts, we will be able to complement our advanced semiconductor scaling research with ESH aspects already at a very early stage of researching new processes and materials for next-generation IC technologies," says IMEC's president & CEO Gilbert Declerck. "Such collaboration will offer our partners an added value towards future volume manufacturing."

Details of the R&D plans covered by the MOU were presented at CEBSM's annual meeting in February at the University of Arizona in Tucson.

www.src.org

www.imec.be

Fujitsu launches long-term evolution base-station incorporating gallium nitride HEMTs

Fujitsu Network Communications Inc, a supplier of optical and wireless networking solutions, has launched its new BroadOne LS LTE eNodeB base-station portfolio, which aims to address the power and implementation cost requirements of wireless operators as they expand existing networks to include fourth-generation (4G) mobile services.

The new base-stations feature simple maintenance, easy customization, and are among the smallest and most power efficient in the industry, resulting in lower implementation and operational costs, the firm claims. Mobile service providers should be able to build 4G wireless broadband infrastructure at a lower cost and offer end-users 4G mobile service at more reasonable rates.

The LS LTE eNodeB family is based on a new architectural concept and will be available in distributed and all-in-one versions. The eNodeBs include antenna technologies comprising digital signal processors (DSPs) to augment advanced RF technology.

The BroadOne LS LTE series employs a distributed architecture, consisting of a remote radio head (RRH) and a base band unit (BBU). The BBU comes in both indoor and outdoor models to meet the diverse deployment environments of existing networks. The RRH is designed to take advantage of the lower operational cost of an all-outdoor deployment.

The eNodeB's RRH incorporates a high-output amplifier, which uses a gallium nitride high-electron mobility transistor (HEMT) device that was developed based on transistor technology patented by Fujitsu. The device is coupled with Fujitsu digital pre-distortion technology, which already has a proven track record in 3G systems, to create two high-output power transceivers packaged in a single unit. These technologies allow for efficiencies



Fujitsu Network Communications' new BroadOne LS LTE eNodeB base-station.

that halve power consumption over current technologies, the firm claims.

"Carriers who purchased AWS and 700MHz spectrum at record pricing levels want to get the most out of their investment and satisfy consumers who continue to devour more bandwidth," says principal network architect Jim Orr. "Our LTE solution will allow carriers to make the most efficient use of their spectrum while offering the performance that an increasingly savvy public demands," he adds. "Fujitsu pioneered GaN HEMT-based amplifiers, so we're able to deliver a whole new level of efficiency and operational simplicity that has not been available before to North America wireless operators."

The eNodeB's RRH incorporates a high-output amplifier, which uses a gallium nitride high-electron mobility transistor (HEMT) device that was developed based on transistor technology patented by Fujitsu

The RRH is compact and light-weight, enabling installation anywhere there is fiber, up to 20km from the RRH. The efficient design provides low operating costs as less heat translates to no fans, no filters, or any other moving parts. By combining energy efficiency and world-class design, Fujitsu claims to have significantly reduced the costs associated with installing and operating base-stations.

"Fujitsu is also a leader in orthogonal frequency division multiplexing (OFDM) and multiple input multiple output (MIMO) technologies that are fundamental for LTE systems," Orr claims. "With such expertise, we can provide network operators with end-to-end LTE solutions for network infrastructure in a variety of applications and services."

Fujitsu has developed a 3GPP-compliant LTE system for the global market. The firm was chosen by NTT DOCOMO to be a supplier for its LTE eNodeB in 2006 as well as its LTE core network system in 2008, and is now taking the technology worldwide. In a joint demonstration with NTT DOCOMO, performance of more than 250Mb/s was exhibited in an outdoor environment over the LTE eNodeB (also demonstrated at both CEATEC Japan 2008 and CTIA Wireless 2008 in Las Vegas, NV, USA).

Fujitsu offers a full portfolio of products and solutions for the mobile network, providing terminals, radio access network equipment and core network equipment in addition to a full suite of engineering and civil services.

Carriers can create and extend their LS LTE eNodeB footprint by using Fujitsu's Network Life Cycle Services for next-generation wireless networks (wireless solutions for every life-cycle phase, including: RF planning & design, network deployment, network integration & testing, NOC services, and knowledge transfer).

Element Six provides CVD diamond for MORGaN program

Element Six Ltd of Ascot, UK, which supplies CVD diamond and diamond-like materials, says it is involved in a project to develop new materials for electronic devices and sensors.

Funded under the Nanosciences, nanotechnologies, materials & new production technologies (NMP) theme of the European Union's Seventh Framework Programme, the three-year Materials for Robust Gallium Nitride (MORGaN) project will cost €9.2m and gather groups of specialists in materials, electronics and metallization for processing, through to device design modelling and packaging at 23 companies and universities in 11 countries.

One of the project's main aims will be to combine synthetic diamond with gallium nitride (GaN) to create next-generation, high-performance sensors and electronic devices that can operate in extreme conditions and harsh environments, especially high temperatures and high internal device electric fields.

Diamond's excellent thermal conductivity (reaching $2400\text{Wm}^{-1}\text{K}^{-1}$ for single-crystal diamond, the highest of any solid material) makes it useful as a heat spreader in these new device designs, so one area of study

will be the use of III-nitride materials together with polycrystalline diamond-based substrates to act as heat spreading layers.

"Diamond is potentially the ultimate substrate for many high-temperature or extreme-power applications," says Geoffrey Scarsbrook, R&D operations manager for Element Six Technologies.

Element Six says it is a pioneer in the development of CVD diamond technology and that its research laboratory in the UK was the first to demonstrate the synthesis of electronic-device-quality, single-crystal CVD diamond. One of the firm's key roles in the MORGaN project will be to supply the consortium with diamond-based wafers suitable for III-N epitaxy.

"Element Six will use its expertise to further develop and optimize the synthesis and primary processing of silicon/polycrystalline diamond

composite wafers," says Steve Coe, general manager of Element Six Technologies.

In addition, Element Six will develop and supply specially prepared polycrystalline and single-crystal diamond surfaces to aid III-N epitaxial growth. New electronic sensors and devices arising from MORGaN are expected to function under harsh conditions that cannot be tolerated by conventional silicon-based devices. Harsh environments can be external ones such as high temperature or pressure, or they can be internal to the device, as a consequence of power dissipation under high current flow at high bias. These environments need new semiconductor materials that are stable, especially at high temperature, and have substrate and package combinations that enable rapid heat extraction or capability to withstand high temperature.

The hope is that the project will lead to the demonstration of innovative composite substrates combining the excellent thermal behaviours of polycrystalline diamond with the electrical efficiency of GaN compounds.

www.morganproject.eu
www.e6.com

One of the firm's key roles in the MORGaN project will be to supply the consortium with diamond-based wafers suitable for III-N epitaxy

Raytheon wins phase 2 DoD contract to develop GaN solid-state sources for non-lethal weapons

The US Department of Defense's Joint Non-Lethal Weapons Directorate (JNLWD) has awarded Raytheon Company's Integrated Defense Systems (IDS) business of Tewksbury, MA, USA a phase-two contract to develop a gallium nitride (GaN) solid-state source for use in non-lethal weapons.

Raytheon claims that its gallium nitride technology enables revolutionary performance and functionality for a wide range of Department of Defense systems including radar, electronic warfare and communications.

"Our support of the JNLWD is for very high-frequency, millimeter-wave GaN to provide the warfighter with a lower-cost, lighter-weight, non-lethal engagement alternative," says IDS' VP of engineering Michael Del Checcolo.

Our support of the JNLWD is for very high-frequency, mm-wave GaN to provide the warfighter with a lower-cost, lighter-weight, non-lethal engagement alternative

Work on the contract will be conducted at IDS' semiconductor foundry at the Integrated Air Defense Center in Andover, MA. IDS provides compound semiconductor technology development, products and services for military and homeland security applications. Foundry capabilities include design, development and manufacturing of gallium arsenide and GaN monolithic microwave integrated circuits (MMICs) and modules for advanced radar, electronic warfare, communications and weapon systems.

www.raytheon.com/businesses/rids

First production-ready DC test system for power devices

Reedholm Instruments of Georgetown, TX, USA has launched what it claims is the first DC test system for testing and characterizing high-power devices at the wafer level in a production environment.

High-power devices built on SiC or other substrates achieve maximum performance with vertical structures connecting the drain or collector to the wafer backside. Testing devices on manual probers with a collection of instruments is satisfactory during early development, but low yields require reliable, high-throughput testing when getting ready for market introduction, says the firm.

The fully integrated RI-2kV/5A DC test system is configured for high-volume testing. Contact to the wafer backside is through Kelvin sensing leads capable of +2kV and 5A. Instrumentation is built into the base of a lost-cost, high-speed prober that has been altered to be insensitive to catastrophic device breakdown. A data-driven applications environment eliminates programming. Also, a test controller mounted inside the prober table provides real-time control. The system is accessed via a Windows computer running a test intranet application.

"The main thing customers have asked for is a simple tool that quickly tests large sample sizes of product die in one probe pass [to show customers that they can deliver in high volumes]," says applications engineer Bill Trimble.

Key features include:

- Rugged rectangular probe card interface that does not require a bulky and complicated test head.
- Bipolar, FET, capacitor, & resistance device parameters and characterization, not just pass/fail.
- 0 to 2kV in <10ms with no overshoot and pulsed 5A tests in 30–300µs.

The RI-2kV/5A can be ordered integrated with an EG 2001 prober or in a separate cabinet for use with another prober.

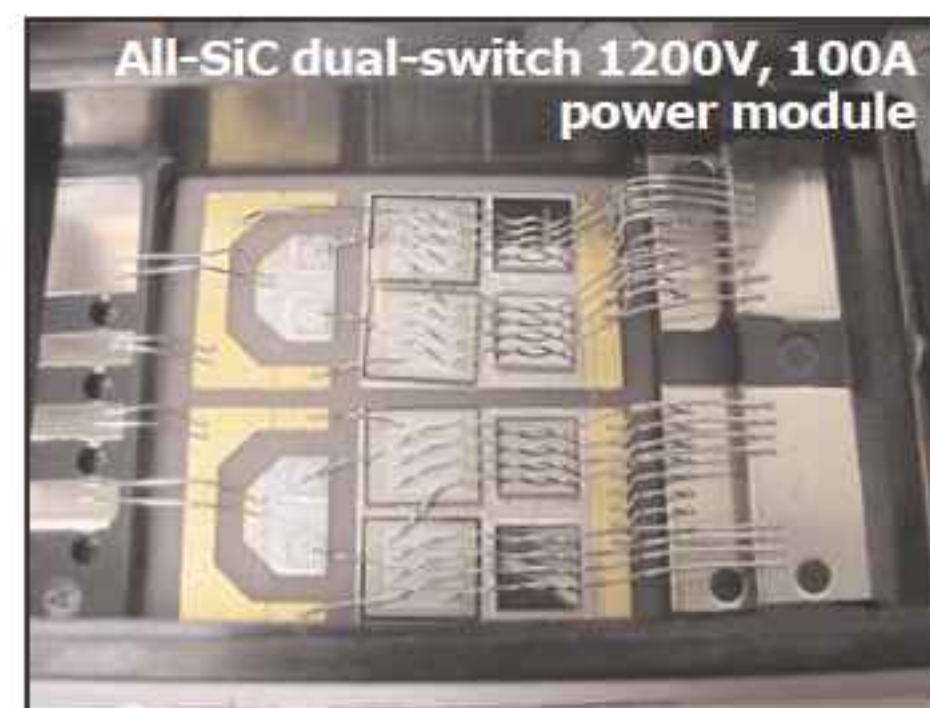
www.reedholm.com

Cree and Powerex develop 1200V, 100A SiC MOSFET power switch modules

Working with both the US Air Force Research Laboratory (AFRL) Propulsion Directorate and Powerex Inc of Youngwood, PA, USA (which supplies discrete, modular and integrated high-power semiconductor solutions), Cree Inc of Durham, NC, USA has developed a demonstration dual-switch 1200V, 100A power module featuring all-SiC semiconductors and capable of operating at junction temperatures up to 200°C. The combination of SiC devices and innovative package design allows the module to operate at temperatures beyond those achievable with a module based on silicon insulated-gate bipolar transistor (IGBT) technology.

Development of the power module was funded by AFRL. It features Cree's high-current SiC MOSFETs and Schottky diodes, developed under contracts from the US Army Research Laboratory (ARL). The SiC MOSFETs are normally-off devices and have drive requirements equivalent to the silicon IGBTs they replace, making the module a potential drop-in replacement for most applications. The all-SiC power switch module can be an enabling technology for next-generation military aircraft and future army combat systems, Cree says. It adds that the combination of its SiC devices and Powerex packaging technology could also lead to smaller, lighter-weight systems with reduced cooling requirements, while offering increased reliability and overload capacity due to its high-temperature operation capability.

Compared to a silicon IGBT module of equal rating, and operating at a junction temperature of 150°C, the SiC MOSFET-based module has 38% lower conduction losses and 60% lower switching losses for a total power-loss reduction of 54% when operated at 20kHz, Cree says. Combining both low conduction and switching losses suits application where high efficiency is critical, such as solar energy power inverters and



electric drives, and power conversion for hybrid and electric vehicles.

The all-SiC module has been developed using materials and assembly processes common in the industry, offering a clear path to volume production. It can also be easily scaled for higher currents, and the layout can be modified for other switch configurations.

"These 1200V, 100A SiC MOSFET modules represent the next level of integration for SiC power devices... a critical milestone in the technology progression toward high-reliability, energy-efficient power conditioning and control," claims Dr John Palmour, Cree's chief technology officer, power components and RF devices. "The component-efficiency advantage of this technology is highly relevant in the current energy-conscious environment and could translate to significant energy savings for hybrid and electric vehicles, solar power inverters, and industrial motor drive systems," he adds.

"As we have seen in the initial reliability-evaluation and electrical-testing of these modules, the practical realization of the SiC high-temperature, power, and frequency performance entitlement, on a pervasive scale, is coming to fruition," says Dr James Scofield, the power electronics section lead for AFRL's Propulsion Directorate. "With its inherent high-temperature operational capability, this technology will be widely applicable to high-reliability military and commercial-system power conversion applications."

www.cree.com

Infineon launches third-generation SiC Schottky diodes

At the Applied Power Electronics Conference and Exhibition (APEC) in Washington DC in February, German power semiconductor maker Infineon Technologies launched its third-generation thinQ! silicon carbide (SiC) Schottky diodes. Sampling started in January, with series production scheduled for early spring.

Infineon claims that, with its third-generation, it provides the industry's broadest SiC Schottky diode portfolio, which not only includes the TO-220 package (two-pin version) but also the DPAK package for high-power-density surface-mount designs.

Third-generation thinQ! SiC Schottkys are available in 600V (3, 4, 5, 6, 8, 9, 10 and 12A) versions in both TO-220 and DPAK packages, and in 1200V (2, 5, 8, 10 and 15A) versions in TO-220 packages.

Featuring what it claims is the industry's lowest device capacitance for any given current rating (which enhances overall system efficiency at higher switching frequencies and under light load conditions), the new thinQ! diodes help to reduce overall power converter system costs.

The main application areas for SiC Schottky diodes are active power factor correction (CCM PFC) in



Infineon's third-generation Schottkys, in DPAK and TO-220 packages.

switched-mode power supplies (SMPS) and other AC/DC and DC/DC power conversion applications such as solar inverters and motor drives.

Compared to Infineon's second-generation SiC Schottky diodes, the third generation's device capacitances are about 40% lower, reducing switching losses (e.g. improving overall efficiency by 0.4% under 20% load conditions in a 1kW PFC stage operating at 250kHz).

Higher switching frequencies allow the use of smaller and lower-cost passive components (inductors and capacitors), resulting in higher-power-density designs. Reduced power losses result in benefits including reduced cooling requirements in terms of the size and

number of heatsinks and fans (enabling system cost reduction and increased reliability levels). This also contributes to reduced system-level energy requirements to provide an appropriate cooling environment. Infineon expects system cost reductions in some SMPS applications of up to 20%.

Infineon was the world's first provider of SiC Schottky diodes, introducing its first products in 2001. "During the last eight years, Infineon has made a number of significant improvements to its SiC Schottky diode technology in areas such as surge current stability, switching performance and in product cost, extending the benefits of SiC technology," says Andreas Urschitz, VP & general manager Power Semiconductor Discretes. SiC helps to drive new markets such as solar energy and high-efficiency lighting systems, he adds.

In quantities of 10,000 pieces, third-generation SiC Schottky diodes with a blocking voltage of 600V (3A) are priced at €0.61 (\$0.85) per unit. The 4A version is priced at €0.85 (\$1.19) per unit, the 8A version at €1.89 (\$2.65) per unit.

www.infineon.com/sic

SemiSouth's new 1200V SiC Schottkys include 30A diode

SemiSouth Laboratories Inc of Austin, TX, USA has launched a complete line of silicon carbide (SiC) Schottky diodes to fill what it claims is a 'critical void' in the market for high-performance power semiconductors. Rated at 1200V, initial devices will be available at 5, 10, 20 and 30A. The 30A diode will be the largest SiC Schottky ever commercialized, claims the firm.

Growing demand for high-performance and high-efficiency power electronics has resulted in an expanding

need for SiC JFETs and diodes, says CEO Kenney Roberts. "As we have visited customers around the world, we continue to see strong acceptance of our high-performance and high-efficiency devices. Customers also realize that upgrading to SemiSouth's SiC Schottky diodes is not only the fastest way to improve efficiency and performance, but the lowest cost as well," he claims.

"In addition to performance enhancement through a simple drop-in replacement, designers are

now also experiencing the benefits of new power topologies and architectures that were not achievable without the high-speed and low-loss nature of silicon carbide," says chief technology officer Jeff Casady. "The 1200V Schottky diodes are avalanche capable and have zero-recovery loss. This now enables power supplies and solar inverters to have the highest possible levels of efficiency, reliability, and power density."

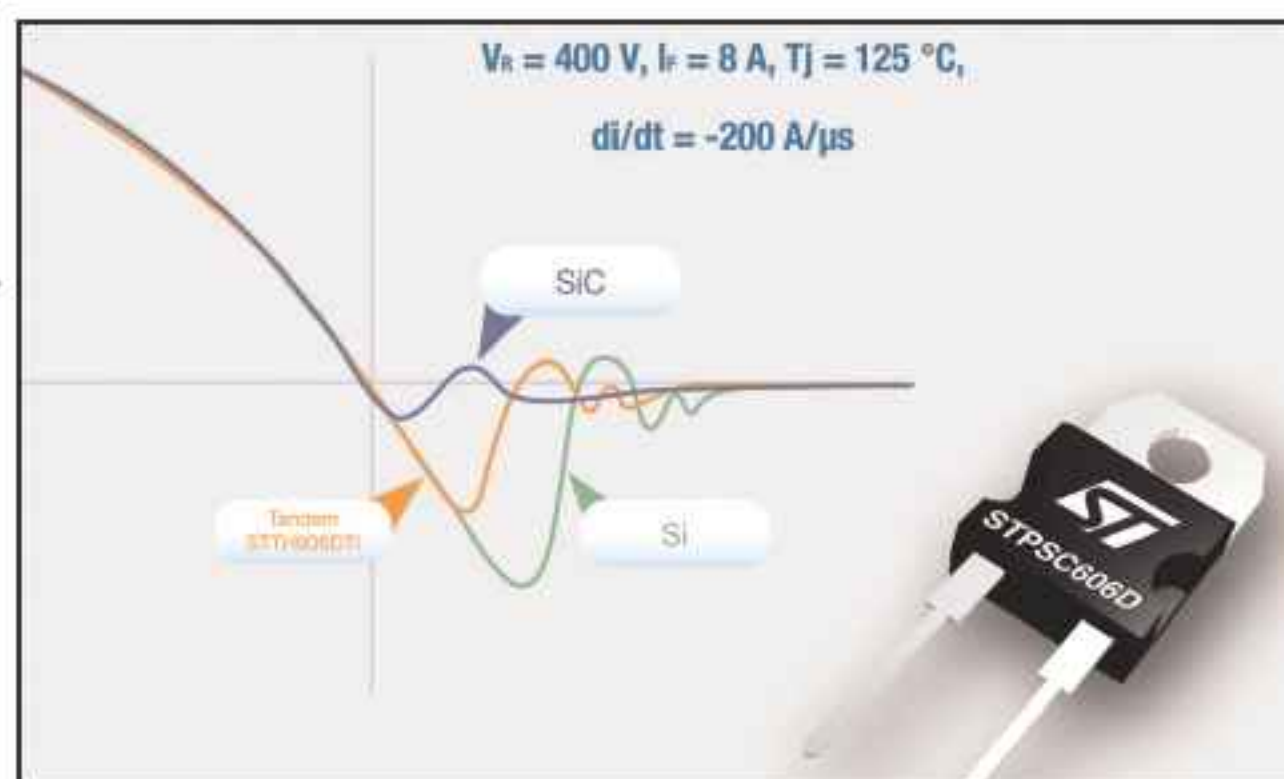
www.semisouth.com

ST targets new SiC Schottky diodes at switching losses

Power semiconductor maker STMicroelectronics of Geneva, Switzerland has launched silicon carbide (SiC) Schottky diodes, targeting the saving of the energy normally lost during switching (since ordinary silicon diodes used in switched-mode power supplies lose up to 1% efficiency by not turning off immediately).

The firm says that the STPSC806D and STPSC1006D SiC Schottky diodes are especially useful in converters for solar power systems, where every fractional efficiency percentage is valuable. Power supplies for servers and telecom systems, which are operational around the clock, can also benefit from the cumulative savings of the apparently small improvement in efficiency. The diodes can also be used in motor controllers, which are deployed in large numbers, saving the environmental impact of many thousands of Watts of generated energy.

Also, by saving energy normally dissipated as heat by the silicon diode, SiC technology allows a lower



Comparison of reverse recovery between SiC, Si, and ST's tandem STTH806DTI boost diode.

maximum current rating for the diode, enabling smaller components to be used without sacrificing usable power. In high-power applications where heat-sinks are normally used, these can also be made smaller, leading to more compact power supplies delivering higher power density.

A further benefit for switched-mode power supply (SMPS) designers is that SiC diodes allow higher switching frequencies, which enable other components such as filtering capacitors and inductors to become smaller and less expensive, as well as consuming less power.

SiC technology can deliver these benefits because no reverse recovery charge accumulates during the diode's normal conduction period. When a conventional bipolar silicon diode is turned off, this charge must be dispelled by recombination between groups of charge carriers close to the diode junction. The current flowing during this recombination period is called the reverse recovery current. This undesired current, when combined

with the voltage across associated semiconductor power switches, generates heat that is dissipated by the switches. By eliminating this reverse recovery charge, SiC Schottky diodes have much lower switching losses across the board, leading to higher efficiency and lower heat dissipation.

The 8A-rated STPSC806D and 10A-rated STPSC1006D, for 600V applications, are in production in the industry-standard TO-220AC package, available at \$3.90 and \$4.90, respectively, in quantities of 10,000.

www.st.com

Tankeblue cuts SiC prices by 60%

Tankeblue Semiconductors Co Ltd of Beijing, China, which manufactures silicon carbide (SiC) wafers based on physical vapor transport (PVT) growth technology from the Chinese Academy of Sciences' Institute of Physics, is cutting the prices of its 2" conductive n-type 6H-SiC and 4H-SiC wafers by 60% to \$150 and \$250 each, respectively.

Tankeblue expects its new pricing strategy to speed the development of SiC-based devices such as LEDs, Schottky diodes, converters used in hybrid automobiles, etc. In addition, its semi-insulating SiC wafers (for fabricating power devices) will be launched on the market in the near future.

The SiC wafer market is forecast to reach about \$400m by 2012,

with 3", 4" and larger SiC wafers being mainstream products, according to a 2008 survey by Yole Developpement.

The main substrate manufacturers (Cree and II-VI Inc in the USA, SiCrystal and Norstel in Europe, and Tankeblue and Nippon Steel in Asia) have been striving to improve crystal quality and increase size. Cree has a dominant market share of 60-70%. However, the technical gap between Cree and its rivals is said to be gradually narrowing.

Also, although a variety of SiC-based devices has been developed in recent decades, substrate price is still a barrier for the widespread adoption of these devices, says Yole.

www.tankeblue.com

UCSB's Mishra made member of NAE

The US National Academy of Engineering (NAE) has elected 65 new members and nine foreign associates, bringing the US membership to 2246 and the foreign associates to 197.

New members include professor Umesh K. Mishra of University of California, Santa Barbara's department of electrical and computer engineering, for "contributions to the development of gallium nitride electronics and other high-speed, high-power semiconductor electronic devices".

<http://National-Academies.org>



AXT's revenue falls 13%, as GaAs sales drop by a third

AXT Inc of Fremont, CA, USA has reported revenue of \$73.1m for 2008, up 26% on 2007's \$58.2m. Most recently, for fourth-quarter 2008, revenue was \$15.6m, down 11% on \$17.6m a year ago and 13% on \$17.9m last quarter. As a proportion of total revenue, North America fell from 28% to 24% and Asia-Pacific from 56% to 45%, while Europe rose from 16% to 31%.

In particular, gallium arsenide substrate revenue was \$9.1m, down 25% on \$12.2m a year ago and as much as 33% on \$13.6m last quarter. The decline was due mainly to an overall market slowdown, with lower-than-expected demand from customers and some push-out of scheduled shipments to first- and second-quarter 2009, which also resulted in lower production levels. Semi-insulating (6 inch) wafers (e.g. for handset applications) fell to just 48% of GaAs revenue, versus 52% for semiconducting (2-3 inch) wafers (e.g. for LED applications). This contrasts with AXT's normal 55:45 semi-insulating/semiconducting split for GaAs.

Indium phosphide (InP) substrate revenue was \$473,000, down slightly on \$484,000 last quarter but up 43% on \$330,000 a year ago.

Germanium (Ge) substrate revenue was \$684,000, down 16% on \$795,000 last quarter and 9% on \$746,000 a year ago.

Raw materials sales (mainly 99.99%-pure gallium) were \$5.3m, up 77% on \$3m last quarter (which had been restricted due to the Olympics and Paralympics) and 23% on \$4.3m a year ago.

Gross margin has fallen from 30.1% a year ago and 25.4% last quarter to 4.8%. This was due mainly to the following factors:

- The gallium joint venture Ji Ya Semiconductor in China ceased production for five weeks as a result of a supply shortage of raw materials from the affiliated aluminum plant in which it is housed (which had reduced production and halted operations due to falling aluminum prices in second-half 2008). To meet customer supply obligations, 99.99%-pure (4N) gallium had to be sourced from an inde-

The gallium joint venture Ji Ya Semiconductor in China ceased production for five weeks as a result of a supply shortage

pendent third-party supplier, lowering gross margin. The JV has also used this supplier when demand has exceeded capacity, and will continue to source finished products from it, despite lower gross margins, if it again experiences power and supply shortages or if customer demand again exceeds its capacity.

- Gross margin was also negatively impacted by AXT's lower production volume (less overhead recoveries), higher warranty expense as a result of warranty reserves from certain customers due to failure to meet specification requirements, and higher unfavorable variances due to lower yields from the GaAs production line.

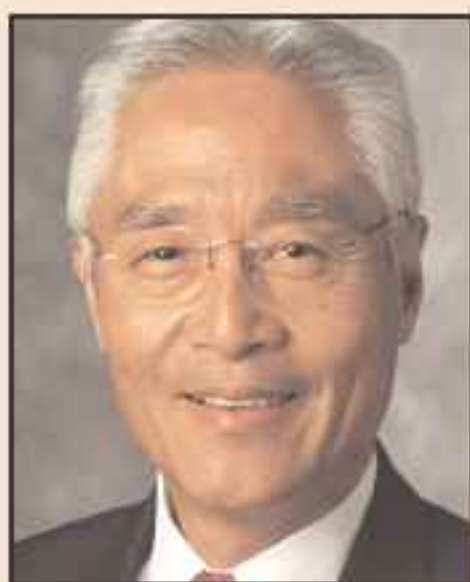
Q4/2008 hence contributed to full-year 2008 gross margin falling from 34.8% in 2007 to 24.6%.

Q4 net loss grew to \$2.4m (\$0.08 per diluted share), compared with \$1m (\$0.03 per diluted share) last quarter and net income of \$1.9m (\$0.06 per diluted share) a year ago. This contributed to full-year 2008 net loss of \$689,000 (\$0.03 per diluted share), compared with net income of \$5.3m (\$0.16 per diluted share) for 2007. Nevertheless, AXT generated cash flow of

Chairman & CEO steps down; CFO made principal executive officer

AXT says that Dr Philip C. S. Yin has resigned as chairman & CEO in order to pursue other opportunities. He has also resigned as a member of the board of directors.

Jesse Chen, a director since 1998 and lead independent director, has become non-executive chairman. Chief financial officer Wilson W. Cheung is now also responsible for administering day-to-day operations (supported by Raymond A. Low, VP corporate controller). Cheung will function as principal executive officer pending the appointment of an interim CEO to serve until a successor CEO can be named.



AXT's Phil Yin.

2007. "We thank him for his dedication and the many contributions that he has made," adds Chen.

From a low of just \$26.5m in 2005, under Yin's guidance AXT's annual revenue rose to a high of \$73.1m in 2008.

"We appreciate the contributions that Phil has made to the company since his appointment as CEO in 2005," says Chen.

Yin also replaced Chen as chairman in October

From 2003 to February 2005, Yin was general manager for North America of Aixtron Inc, and from 2002 to 2003 he was sole proprietor of Philip S. Yin Consulting (consulting on semiconductor materials in epitaxial deposition, silicon wafers and strategic business development). From 1999 to 2002, he was president of ATMI Epitaxial Services.

Prior to that, he held positions as senior VP sales & marketing of Crysteco, and director of sales for Mitsubishi Silicon America. He also held positions with Monsanto Electronic Materials and IBM Thomas J. Watson Research Center.

\$2.7m from operations in Q4/2008, helped by capital expenditure of just \$1.4m.

"2008 was a challenging but productive year for AXT," says chairman & CEO Phil Yin. "We successfully negotiated a new 2009 contract worth nearly \$15m with one of our largest customers [IQE], concluded a major qualification with a leading germanium substrate customer, expanded our customer base to include several top tier companies and laid important groundwork for growth when the macro-environment strengthens. Still, the economic downturn in 2008, coupled with the inventory overhang in our industry and customer-specific issues that we continue to work through, put pressure on our financial performance and will have a significant impact on our first-quarter 2009 results," says Yin.

For first-quarter 2009, AXT expects revenue to almost halve to \$7-8m. Half of the revenue drop is expected to be due to 6 inch semi-insulating GaAs (mainly from one customer). A request for a major order push-out in Q1 is being addressed in order to help the customer to digest inventory and prevent a further build-up. Also, gross margin should bounce back to more normal levels, helped by Ji Ya getting up to full capacity (allowing it to build inventory, minimizing the impact of potential future shutdowns). Net loss per diluted share should be \$0.05-0.08.

However, most excess inventory at customers should be consumed in Q1/2009, which will represent the bottom of the slump in demand (for semi-insulating GaAs substrates for handset applications), believes AXT. This will be followed by the start of a slow ramp up from Q2 (driven by demand for WCDMA and CDMA2000 3G standards, especially in China, for which handsets have greater GaAs content). "As we look beyond the first quarter, we believe that the business will begin to improve as a result of pockets of strength in our GaAs business, new qualifications of

customers in the LED and photovoltaics market, and our improved cost structure as a result of efforts to streamline our business in relation to the current demand environment," says Yin.

Cost cutting includes reducing headcount by 70 (mainly in production) to 1120. This should help to reduce operating expenditure from \$4-4.5m in 2008 to \$3.5-3.7m in 2009. Meanwhile, capital expenditure is expected to shrink to less than \$4m in 2009. Gross margin is expected to rebound to the low to mid 20% level (assuming revenue of \$15m per quarter). Also, cash flow is expected to improve in 2009.

In addition, for concentrating photovoltaic (CPV) technology, AXT's germanium substrates have now been qualified with a large European solar cell manufacturer for space applications (with a first order received, for shipment in Q2/2009), while further qualifications are underway for terrestrial application. Additional qualifications with two more European manufacturers are underway, for completion this year. After moderate growth in Q1, germanium revenue should ramp up from Q2/2009. Yin also highlights that NREL's 40.8% efficient triple-junction solar cells late last year were grown on GaAs substrates, opening up a potential new market. Also, in February, at the first annual meeting of the CPV Consortium, Yin was elected to its board of directors.

"We remain encouraged by the overall trends in our industry and believe that we will successfully leverage our competitive advantages for growth and market share gains as the economy improves," says Yin.

www.axt.com

IN BRIEF

SOITEC's ISO 9001 certification expanded worldwide

After being audited by the Lloyd's Register Quality Assurance (LRQA) organization, Soitec, which manufactures engineered substrates including 80% of all silicon-on-insulator (SOI) wafers as well as III-V epiwafers through its Picogiga International division, has been awarded International Standards Organization (ISO) 9001 certification for quality assurance, both for a renewal at its headquarters in Bernin, France (first certified in 1998) and a first certification for its new production facility in Singapore (which is in the process of customer qualifications).

To ensure global standardization, all group activities will now be managed through a corporate quality management system. Soitec says that its compliance with internationally recognized quality management practices underscores its continued efforts to increase efficiency and alignment across its operating sites. "We rely on strong internal processes to drive our business," says Jean-Luc Ledys, VP of corporate quality for the Soitec Group.

The entire Soitec group is now certified for having established a high-level process and system-oriented quality management (QM) based on ISO 9001 standards. The site of Soitec's Picogiga International division in Les Ulis, which provides substrates including III-V epiwafers and gallium nitride (GaN)-based wafers for manufacturing high-frequency electronics and optoelectronic devices, currently holds its own ISO certification and will be integrated into the certification group subsequently.

www.soitec.com

IN BRIEF

GaN-on-Si epi foundry Azzurro appoints CEO

Epiwafer foundry Azzurro Semiconductors AG of Magdeburg, Germany, which provides GaN on large-diameter (50–150mm) substrates (including silicon) for LED, high-voltage and high-frequency applications, says that Erwin Wolf has joined its executive board as CEO.

Wolf has held various executive posts in the semiconductor industry (predominantly in optoelectronics and power semiconductors) over the last 30 years. Before joining Azzurro, Wolf was managing director of Infineon Fiber Optik GmbH and then VP technology for power semiconductor production at Infineon Technologies. Furthermore, he was also CEO of Osram Opto Semiconductors Inc USA and general manager & VP of the Opto Components business unit (for LEDs, infrared diodes, detectors, sensors and lasers) at Siemens AG.

"Erwin's wide experience in the semiconductor industry

will be a strong addition to Azzurro's competence in accelerating the usage of GaN-on-Si," says chairman of the board Christian Kruber. "With him on board, we will drive our further expansion," he adds.

The existing members of Azzurro's executive board will remain in place, with Alexander Lösing continuing to be in charge for sales & finance and Dr Armin Dadgar remaining responsible for production and development as chief technology officer.

www.azzurro-semiconductors.com



CEO Erwin Wolf.

Riber returns operating profit in 2008

After reporting preliminary revenues in mid-January, Riber S.A. of Bezons, France, which manufactures molecular beam epitaxy (MBE) systems as well as evaporation sources and effusion cells, has confirmed healthy revenue growth of 13% from 2007's €17m to €19.3m in 2008.

An 11% decline in European revenue was offset by strong growth in Asia (up 33%) and the USA (up 175%). Nevertheless, Europe still represented 47% of total revenue, Asia 42%, and the USA 11%.

Growth was driven by sustained MBE system sales to both research centers and device manufacturers (€13.3, up 4.7% on 2007's €12.7m). This was supplemented by strong organic growth of 39.5% (from €4.3m to €6m) in sales of component and

after-sales services for installed machines (technical support, system upgrades, sales of improved cells, etc). This included the take-off of sales of evaporation sources for new applications (e.g. organic LED screens and solar cells).

Component and services sales should continue to expand following the acquisition of OIPT's MBE operation

The acquisition of Oxford Instruments Plasma Technology's MBE unit (formerly VG Semicon) in late Sep-

tember is a significant new growth driver for component and services sales, consolidating Riber's dominant position in the market (with about 60% of all installed machines).

Riber has now also reported that an increase in productivity and cost control led to gross profit rising from €1.07m (just 6.3% of sales) in 2007 to €5.85m (30.4% of sales) in 2008.

Operating income was €0.27m in 2008, compared to 2007's loss of €6.16m. Net loss also improved from €9.73m to just €1.02m (taking into account non-recurring exceptional expenses of €1.2m).

Demonstrating confidence in its future, at the annual general meeting on 14 May Riber's management board aims to propose the payment of a first dividend of €0.02 per share, while fully preserving the firm's development capacity.

Riber comments that, during the highly unstable economic and financial environment at the start of 2009, the market for research center and university-dedicated systems continued to perform well, whereas systems dedicated to compound semiconductor manufacturers provided less visibility.

However, component and services sales should continue to expand, in particular following the acquisition of OIPT's MBE operation and the introduction of new products dedicated to OLED screens and solar cells.

Riber appoints chairman of executive board

Riber says its supervisory board has appointed Frédéric Goutard as chairman of the firm's executive board. He replaces Jean-Pierre Régner, who has held the position on an interim basis since last May after the resignation of previous chairman Michel Picault.

Goutard is a graduate of the Pierre et Marie Curie and Orsay universities, the Reims ESC, and holds an MBA from the University of Toronto. In London, after acting

as senior consultant for PricewaterhouseCoopers in the telecoms sector, Goutard joined telecommunications firm BT Group in 2000, where he headed service and equipment operations.

In Paris since 2006, Goutard was appointed managing director of the family owned financial holding company NG Investments (Riber's leading shareholder), in charge in particular of its industrial interests.

www.riber.com

Edwards sells 1000th iXH vacuum pump

Vacuum and exhaust-management equipment maker Edwards of Crawley, West Sussex, UK says that it has now sold 1000 iXH harsh-process vacuum pumps to semiconductor and solar manufacturers since the product was introduced just a year ago, in February 2008.

Solar and semiconductor manufacturing processes such as gallium arsenide compound semiconductors require vacuum technology capable of handling high hydrogen gas flows, says CEO Nigel Hunton. "The iXH series was specifically designed to address these challenges, while reducing cost of ownership with longer pump life and lower utility costs," he adds. "The rapid industry adoption of iXH technology is a testament to its success in meeting these challenges."

Hydrogen is a difficult gas to pump due to its small molecular size and low viscosity, so the iXH pumping system uses a series of large-capacity pumps and boosters



Edwards' iXH vacuum pumps.

to attain the optimum compression ratio required to pump hydrogen efficiently.

The system is modular and highly configurable, making it easy to meet the site installation and performance requirements for a variety of solar and semiconductor manufacturing processes, says Edwards. The components can also be stacked on top of each other to achieve what is claimed to be the

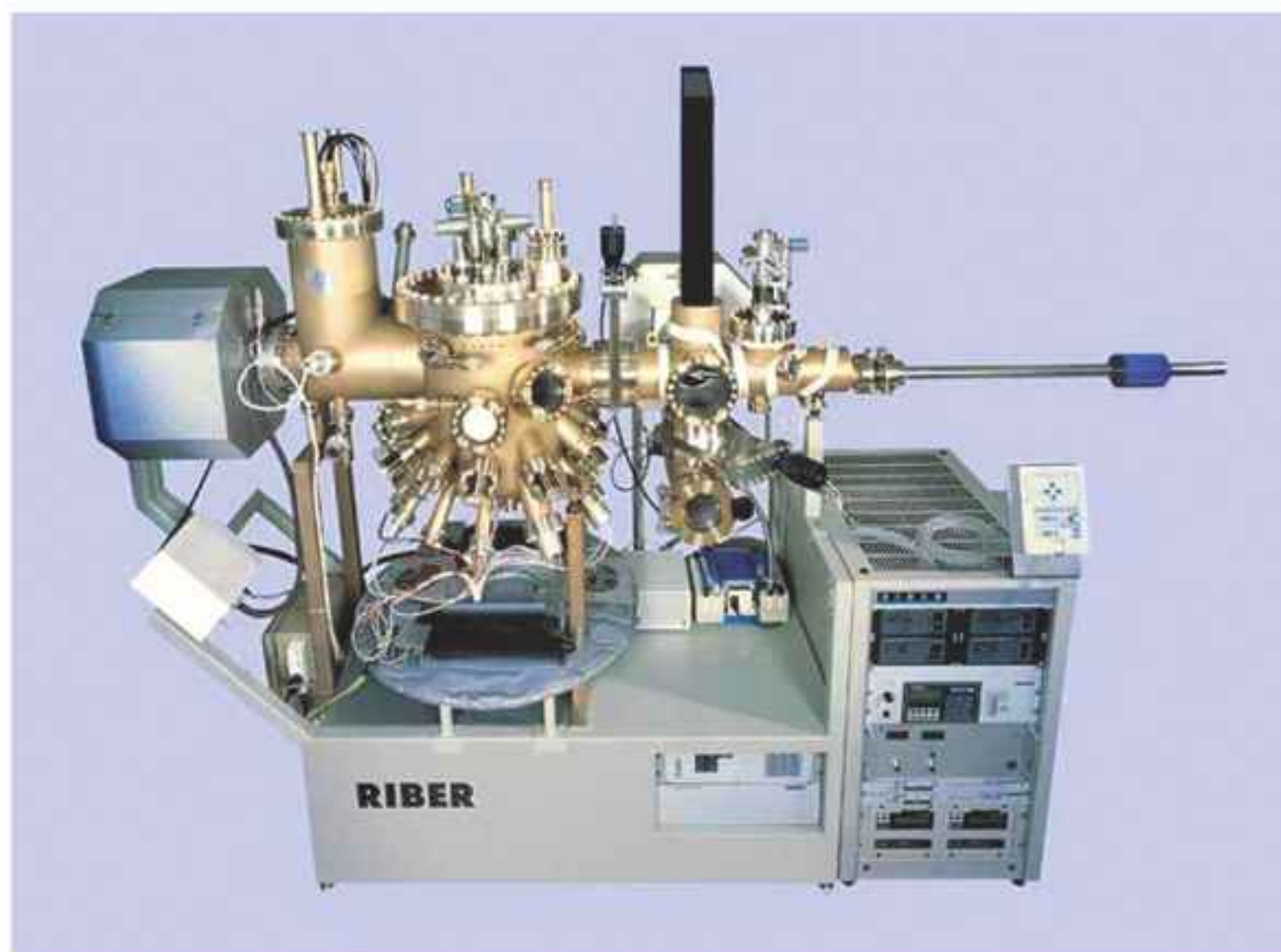
smallest footprint in the industry. Multiple iXH modules, configured to meet application-specific requirements and managed by a single controller, appear to the operator as an easy-to-use, seamlessly integrated vacuum system.

The iXH series of dry pumps for harsh processes offer greater process capability and reduced cost of ownership (CoO) compared to previous-generation Edwards pumps. Reduced CoO is achieved through a 10% reduction in energy consumption, longer overhaul intervals, and reduced unscheduled downtime. They also feature a wide temperature range (which helps to minimize by-product accumulation), greatly increased powder-handling capabilities, and unique Gas Buster technology, as well as innovative pump seal technology that helps to lengthen process life and reduce leakage risks, adds Edwards.

www.edwardsvacuum.com

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RIBER

Veeco expects 36–46% dip in sales in Q1 /2009, despite record MBE reactor orders for solar applications

Veeco Instruments Inc of Plainview, NY, USA says its revenues grew 10% on 2007's \$402m to \$443m in 2008. LED & Solar became the largest unit, growing 43% from \$116m to \$166m (37% of total revenue), including more than \$40m for solar.

Data Storage grew 10% from \$136m to \$149m (34% of revenue) while Metrology shrank 15% from \$150m to \$128m (29% of revenue).

However, Q4/2008 revenue was \$110.3m, up 3% on \$106.8m a year ago but down 4.7% on Q3's \$115.7m.

LED & Solar process equipment contributed 34% of Q4 revenue (\$38m, down 8% on Q3's \$41m). This included \$7.9m for solar web coaters and 50% growth for MBE products. Data Storage contributed 41% (\$45m, up 40% from \$32m), while Metrology contributed 25% (\$28m, down 13% from \$32m).

Gross margin of 40% is up on 38% a year ago but down from Q3's 40.6%. In particular, LED & Solar margin fell from 39.8% a year ago to 35%, due partly to a 33% drop in MOCVD sales.

Excluding charges of \$80.1m (including \$73m in asset impairment, following a decline in market capitalization), earnings before interest, taxes and amortization (EBITA) were \$6.2m, down on Q3's \$8.3m.

During Q4, Veeco generated \$19m in free cash flow and retired \$37m of convertible debt. Over the year, net debt has been cut from \$26m to just \$5m, while the cash balance has fallen from \$117m to a still healthy \$104m (despite acquiring Mill Lane Engineering for \$11m).

Q4 bookings were \$89m, flat on Q3 despite a 57% drop in Data Storage bookings to a historical low of \$14m. LED & Solar orders grew 69% to \$44m due to record orders for MBE systems for emerging applications (e.g. solar), orders for thermal sources from six solar firms, and two large orders for MOCVD systems from LED and concentrator photovoltaic (CPV) customers. Metrology bookings were down 4% to \$31m.

However, Veeco expects a weak start to 2009. In Q4/2008, order backlog fell from \$176m to \$147.2m (after adjustments of \$6.9m, including \$4.9m from the cancellation of a couple of LED systems and \$2m from changes in foreign currency rates). Also, due to industry overcapacity, financing constraints and weak business outlook, some key LED and Data Storage customers have pushed out \$30m of equipment deliveries scheduled for Q1/2009. Hence, nearly half the order backlog is forecasted for revenue only in second-half 2009.

For Q1, Veeco expects revenue of \$60–70m (down 36–46%), gross margin of just 33–36%, and EBITA of minus \$7.3–11.5m. Bookings are expected to be down on Q4/2008.

Due to deteriorating business conditions, in Q4/2008 Veeco initiated a restructuring program, including a 26% cut in staffing, by 340 from 1318 at the end of September to under 1000 (with 70% of cuts to be completed by Q2/2009 and the rest by the end of 2009).

The cut is being achieved by centralizing the firm's supply chain and operations, consolidating business units, increasing outsourced manufacturing (to lower expenses and improve the variable cost structure), and cutting the number of manufacturing sites from eight to four.

In particular, Veeco aims to fully outsource MOCVD system manufacturing in Somerset, NJ by Q4/09 (compared to outsourcing about 60% of the product line a year ago). It also aims to move the CIGS (copper indium gallium diselenide) web-coater plant in Lowell, MA (formerly Mill Lane Engineering, bought in Q2/2008) to outsourced manufacturing (while retaining a focus on prototypes).

Other cost-cutting actions include senior management pay cuts, a reduction in board of directors compensation, a staff wage freeze, and a cut in discretionary spending.

"We have moved swiftly to restructure Veeco to lower our quarterly breakeven level to \$80m [with gross margin rebounding to 41–42%], with a goal to return to EBITA profitability by Q4/2009," says CEO John R. Peeler. Restructuring should yield annualized savings of \$36m, including \$20m in manufacturing labor and overhead and service costs which are included in cost of goods sold, plus \$16m in operating spending (including travel, IT, telecoms, supplies, and consultants).

However, Veeco is still investing in R&D for high-growth opportunities, with an emphasis on LED & Solar and new applications in Metrology, says Peeler. In particular, in tune with the end-market growth rates of 20% for LEDs and 50% for solar, the LED & Solar business will more than double from 20% of total R&D spending in 2007 to 44% (while silicon chip-related R&D spending will drop from 16% to 7%).

"Despite the current pause in capacity spending, we anticipate strong multi-year LED industry growth tied to further adoption in applications such as TVs and laptops," Peeler adds. Veeco's solar strategy is based on building an integrated equipment offering for CIGS thin-film solar cells. In first-half 2009, Veeco aims to expand its CIGS range to include a new glass deposition system (anticipating a several hundred million dollar equipment opportunity for vacuum deposition).

"It is our goal to emerge from this downturn with a strong product portfolio well aligned to our customers' technology needs; a solid balance sheet; and a leaner, more cost-effective organizational structure that can achieve 15% EBITA when end-market conditions improve," says Peeler. The 'end-market recovery model' is for quarterly revenue of \$110–120m and gross margin of 45–46% (up on Q3/08's \$116m and 41%).

www.veeco.com

Settlement agreed on Dow's acquisition of Rohm and Haas

The acquisition of Rohm and Haas Company of Philadelphia, PA by Dow Chemical Company of Midland, MI (announced last July) has been agreed for 1 April, resolving litigation initiated by Rohm and Haas against Dow on 26 January.

Dow (with sales of \$58bn in 2008 and 46,000 staff) reckons that the acquisition of Rohm and Haas (which had sales of \$9.6bn in 2008) will make it the world's leading specialty chemical and advanced materials company, combining the two organizations' technologies, geographic reach and industry channels. "Rohm and Haas is a strong operational and strategic fit for Dow and is a critical component of the company's long-term transformational strategy," says Dow chairman & CEO Andrew N. Liveris. Dow reckons that Rohm and Haas provides a good position in industry segments that are poised for significant growth given long-term market trends,

notably in electronic materials. Rohm and Haas' Electronic Materials division, in particular, includes microelectronics technologies such as providing precursors for MOCVD.

Rohm and Haas' two main shareholders have agreed to buy \$2.5bn of perpetual preferred equity issued by Dow. Also, one (the Haas Family Trusts) has agreed, at Dow's option, to invest in an extra \$500m of Dow's equity. These investments substantially reduce the debt financing required to fund the acquisition. Dow has hence restructured the deal to pay the equivalent of \$63 per share in cash and \$15 per share in face value of preferred equity securities.

"Dow has taken the time and steps necessary to close this transaction on substantially improved financial terms to the company, despite the continuing financial and economic uncertainty," says Liveris. "The restructuring of the terms of the transaction allows Dow to maintain

financial flexibility as we proceed to implement our strategy in a way that realizes the original promise of this acquisition... The strategic benefits of the acquisition of Rohm and Haas have never been in question; just the path to completing the deal."

Dow has also put in place an even more aggressive plan to realize combined synergies of \$1.3bn, up from the originally outlined \$910m. Cost savings should come from increased purchasing power for raw materials for the combined firm; manufacturing and supply-chain work process improvements; office consolidations; and the elimination of redundant corporate overhead for shared services and governance. Also, as part of Dow's plans to improve its financial position, it has started an aggressive asset divestment program (involving a number of Dow and Rohm and Haas business units) expected to yield about \$4bn.

www.dow.com

VaporStation central delivery system installed at Aixtron

Rohm and Haas Electronic Materials of North Andover, MA, USA says one of its VaporStation central delivery systems has been installed and is now operational at the Applications and Demonstration Center of Aixtron AG in Aachen, Germany.

MOCVD equipment maker Aixtron is using the VaporStation central delivery system to deliver TMGa (trimethylgallium) to a CRIUS MOCVD reactor and a Planetary MOCVD reactor. More reactors are expected to be connected to the system.

The VaporStation is designed to deliver TMGa and other metalorganic precursors to multiple MOCVD reactors from a central supply source cabinet using a high-purity carrier gas. The firm says that the delivery technology improves the economy and the safety of the MOCVD process (through the reduction of cylinder changes and handling) as well as enabling manufacturers of compound semiconductor devices

such as LEDs, solar cells and laser diodes to further reduce production costs. In the case of LEDs, the VaporStation can help manufacturers to more quickly reach cost parity with conventional general lighting production, it is claimed.

"The delivery of TMGa from a central unit reduces the footprint of our systems, and this is an important consideration for our customers using expensive cleanroom space," says Aixtron's VP of technology Johannes Kaeppler. "The performance of the system met with our expectations right from the first run. Without a single calibration run, gallium nitride films made using the central delivery system could not be distinguished from the films made using the conventional onboard delivery method," he adds.

"Delivery to multiple reactors using large-scale cylinders with 20kg or more of content eliminates a number of costly inefficiencies, such as

calibration runs, cylinder change outs, and residual 'heels' associated with on-board cylinders," says Joe Reiser, general manager for Rohm and Haas Electronic Materials' Metalorganics business. "Additionally, the VaporStation central delivery system significantly increases reactor up time," he reckons.

The VaporStation debuted in 2004, and recent installations at LED and solar cell manufacturers have proven its production worthiness, the firm says. The system can deliver a stable MO precursor concentration at a precisely controlled flow rate to up to 10 MOCVD reactors from a single 20kg supply cylinder. The delivery system has shown improved performance and economy over the traditional on-board MO source approach (in which each MOCVD reactor requires its own cylinder), it is claimed.

www.rohmhaas.com

Aixtron's Q4/08 growth driven by Asian LED makers, but continued drop in orders points to down year in '09

Deposition equipment maker Aixtron AG of Aachen, Germany has reported revenue of €274.4m for full-year 2008, up 28% on 2007's €214.8m (and the third consecutive year of growth). This was despite a weaker dollar/euro exchange rate and the general slowdown in semiconductor equipment spending.

The rise is due mainly to sales of compound semiconductor equipment rising 62% from €145.2m to €235.7m, driven by rising demand for LED end-market applications (especially the increasing adoption of LEDs in lighting and backlight units for LCD displays). In particular, revenue for LED applications grew by 82% year-on-year.

"Despite the currently volatile environment, we have been able to deliver a result within the range we gave as far back as March 2008," says president & CEO Paul Hyland.

Of total revenues, 86% came from compound semiconductor equipment and just 4% from silicon equipment (the remaining 10% came from spare part and services). By application, 84% came from LED manufacturing (up from 61% in 2007) and just 6% from silicon (with memory device makers especially hard hit by pricing pressures). Correspondingly, 87% came from Asia (up from 81% in 2007), just 7% from Europe (down from 9%) and 6% from the USA (down from 10%).

Aixtron estimates its share of the MOCVD market to be 60–70%.

Gross margin improved by 1 percentage point to 41%, reflecting new common platform systems rising from 72% of total revenue to 88%, coupled with a favorable product mix and cost cutting (offsetting the effect of the weaker \$/€ exchange rate). "Against softening demand and US dollar weakness, we were able to hold the gross margin improvements made earlier in the year and finish it with a gross margin performance in excess of our target of 40%," says Hyland.

Scale effects and further enhancements of internal operating efficiency boosted EBIT (operating income) by 58% from €20.6m to €32.5m, representing an improved EBIT margin of 12%. Net income rose by 33% from €17.3m to €23m.

Fourth-quarter revenue was exceptionally high at €82.3m, up 29% on Q3's €63.9m. However, "The extraordinary financial and economic turmoil has already firmly focused our minds on 2009 and beyond," says Hyland. Together with a few order push-outs, order intake fell for a second consecutive

Order intake fell for a second consecutive quarter... most customers are reporting very limited visibility in the currently unsettled environment

quarter to €40.6m (down on Q3's €52.2m and Q2's €72.5m) while previous equipment orders are digested by customers. Capacities built up over recent years now need to be fully commissioned and tuned, and customers are focused on increasing their utilization rates, says Aixtron. Total orders in 2008 of €250.8m were roughly level on 2007. However, the proportion of orders that were for silicon manufacturing has fallen from 16% to just 5%.

In addition to the predicted down-cycle in LED-equipment demand and suppressed silicon industry capital spending, most customers are reporting very limited visibility in the currently unsettled environment. Many are unable to see beyond one month ahead and consequently are more reluctant to make longer-term purchasing commitments, says Aixtron. This lack of visibility is impairing Aixtron's ability to give comprehensive guidance for 2009 revenues and EBIT.

The opening order backlog for fiscal 2009 (adjusted for risk) is down 20% on €132m a year ago to €105m (€98.2m for compound semiconductors and €6.8m for silicon). Aixtron adds that it expects revenue to fall in 2009. However, it also expects to maintain a share of more than 60% of the MOCVD market, which is forecast to fall from €464m in 2008 to €438.4m in 2009, according to market research firm VLSI.

Also, Aixtron aims to remain profitable at an EBIT level, which will be achieved once revenues reach €170m for the year. Management says that it will elaborate on this guidance as soon as visibility improves.

"Looking into 2009, we start what will be a challenging year for all industries with many of the key boxes ticked," says Hyland.

"We have a very strong market share position. We have a full product development pipeline. We have a good cash position, carry no debt, and our balance sheet and our operational flexibility give us the exceptional resilience needed in these circumstances," he adds.

"We are confident of achieving our 2009 objective to come out of this turbulent

period stronger than we went into it... this crisis offers many opportunities for Aixtron if we can retain a positive and proactive attitude to the challenges ahead," Hyland reckons.

www.aixtron.com

Chinese LED makers order reactors

In the last few quarters, Aixtron has received several orders from Chinese LED makers, including recent start-ups ramping production.

Aqualite using CCS MOCVD reactors for LED chip production

In second-half 2008 Aixtron delivered three Close Coupled Showerhead (CCS) CRIUS MOCVD reactors, in 31x2"-wafer configuration, for the development and production of GaN-based blue, green and white LED chips by Aqualite Co Ltd of Wuhan, China.

"Features that we particularly favor include the process versatility, reproducibility and the wafer-to-wafer and run-to-run uniformity," says Aqualite's CEO James Dong. "We look forward to once again working closely with our local Aixtron team."

Aqualite was founded in 2006 and holds several US and Chinese patents, based on proprietary technology for the mass production of epitaxial wafers and power chips. Sponsored by the Chinese Hi-Tech '863' programs and the National Torch Plan and with investment from Wuhan Hi-Tech Group, TianDi Growth Capital and InfoTech Ventures, Aqualite undertakes both R&D and high-volume production of GaN-based LED power chips for solid-state lighting applications in China. Its roadmap targeted an annual capacity of 3.6bn chips from its 55000m² plant by the end of 2008.

Electro Scientific Industries Inc of Portland, OR, USA says Aqualite is using its AccuScribe 2112 wafer scribing system (delivered last September) to help it ramp production.

Tonghui entering LED market with Aixtron MOCVD reactors

Aixtron has announced a triple order for MOCVD systems from China-based start-up Tonghui Electronics Corp: an AIX 2800G4 HT IC planetary reactor (Aixtron's flagship for large-scale manufacturing of LEDs and other advanced devices) and two AIX 2600G3 IC reactors.

The 2800G4 HT IC (configured for 42x2"-wafer capacity) and the two G3 systems (in 49x2" configuration)

were delivered in Q1 and Q3/2008, respectively. All three will be used for the development and manufacturing of power LED chips.

"We have used their [Aixtron's] tools and, based on this good experience, we have decided to place with them our first major order for LED equipment," says Tonghui Electronics' professor Liu. "The large-scale reactors underpin our present and future production plans."

Tonghui Electronics aims to supply high-performance optoelectronic devices, starting with power LEDs, and perhaps also adding III-V concentrator photovoltaics (CPVs) to its range in future.

"For power chip LEDs it is crucial that we have the best uniformity," Liu says. "In addition we will need superb production efficiency in terms of uptime, maintenance and precursor efficiency."

CRIUS system for Yangzhou Zhongke Semiconductor Lighting Center

In Q2/2008 Aixtron received an order for a CCS CRIUS system from new customer Yangzhou Zhongke Semiconductor Lighting Center Co Ltd. The 31x2"-wafer system was delivered to the firm's facility in China's Yangzhou High-Tech Venture Services Center in Q4/2008, for use in the development and volume production of ultra-high-brightness (UHB) blue/green LEDs.

"Our goal is to promote the LED-based solid-state lighting industry in China," says the firm's CEO Dr Guohong Wang. "I have long-time familiarity with Aixtron MOCVD systems such as the AIX 200 and AIX 2400G3 15x2" AlInGaP system used for diode laser applications at the Institute of Semiconductors at the Chinese Academy of Sciences (ISCAS)."

Yangzhou Zhongke Semiconductor Lighting Center was established by ISCAS and Yangzhou New Light Source Technical Development Co Ltd in October 2007. Its plan is to develop processes for the mass production of technology such as UHB LEDs.

IN BRIEF

NTU orders reactor for white LEDs

Aixtron says that in Q4/2008 the National Taiwan University (NTU) in Taipei City ordered a Close Coupled Showerhead 3x2"-wafer Research Platform MOCVD reactor (for delivery in Q3/2009) to be used for R&D on gallium nitride and related materials and devices. The Institute of Photonics and Optoelectronics' main research topics include InGaN nanostructures, and the growth and fabrication of all-InGaN white-light and polarized LEDs.

"We have been researching on nitride-based alloy semiconductors for a number of years," says professor Chih-Chung (C. C.) Yang of the Institute of Photonics and Optoelectronics. "Our experiments require a stable and reliable system with commonality and compatibility with Taiwan's popular production technologies. Not only does Aixtron's CCS Research Platform suit this task very well but it also has a high degree of versatility," he adds.

In particular, the researchers aim to use the Dynamic Reactor Height Adjustment option for growth at various reactor pressures. Yang expects this to enable more rapid implementation of their process development program.

The Aixtron Taiwan team also aims to continue its role in the project. R&D and process manager Dr Joe Yang (who graduated from NTU in 2003) adds: "Our process team is naturally keen to ensure that the very best efforts go into this project so we can provide NTU with a parameter set to form an excellent base for their advanced R&D."

● Yang is organizing December's international conference 'White LED 2009' in Taipei.

www.ntu.edu.tw/engv4

<http://conference.ipon.ntu.edu.tw/icwledssl2009>

LayTec enters thin-film photovoltaic market with SolR in-line monitoring systems for CIGS, CdTe solar cells

LayTec GmbH of Berlin, Germany has launched what it says are the first in-line monitoring systems commercially available for thin-film photovoltaic (PV) applications. The new SolR product line will be available in various editions for copper indium gallium diselenide (CIGS) and cadmium telluride (CdTe) thin-film solar cell processes, and enables the monitoring of the film thickness of all layers, including transparent conducting oxide (TCO), absorber and buffer layers.

The main challenge was to obtain an accurate film thickness measurement, despite the reduced reflectance due to absorber layers (CdTe or CIGS) that are intentionally designed to be rough in order to maximize internal reflections of sunlight in the cell and hence enhance its efficiency. However, reflectance measurements work better with smooth layers, so LayTec developed a robust method to establish film-thickness measurements under challenging conditions.

Currently, measurements in thin-film PV processes are mainly performed off-line and not on each batch. "SolR will help thin-film PV producers to control their production on-line and thereby enhance their yield," says CEO Thomas Zettler. "Besides, it will accelerate development cycles and help to transfer established processes to new lines, an important feature in times when thin-film PV industry grows rapidly," he adds.

The main challenge was to obtain an accurate film thickness measurement, despite the reduced reflectance due to absorber layers that are intentionally designed to be rough in order to maximize internal reflections



Figure 1: SolR optical head.

"We realized a strong demand from CIS- and CdTe-based solar cell producers in discussions with researchers of big thin-film PV players at several conferences," says Zettler. Now, after less than a year of engineering and testing works, LayTec has signed its first order contracts, and in May will ship the first SolR system to a thin-film PV manufacturer. Many further systems are expected to follow.

SolR is designed to be compatible with typical in-line and roll-to-roll processes, and to work for all substrates and existing PV cell design.

www.laytec.de

First results of in-line monitoring of photovoltaic processes with SolR

At the 18th International PVSEC conference in Kolkata, India in January, Dr Steffen Uredat of LayTec reported the first results of in-line monitoring with LayTec's new SolR system. The measurements were obtained during CIGS, CIS and CdTe-based solar cell processes. SolR monitored the film thickness of all layers throughout the thin-film PV processes: transparent conducting oxide (TCO), absorber and buffer layers. Furthermore, the measurement results on conductivity quality of the TCO layer material, the optical band-gap of the absorber material, the texture,

and surface roughness were presented in the talk.

Fig. 2 shows typical reflectance spectra from a CIGS solar cell process. Reflectance measurements after each deposition step allowed the thickness determination for each layer in the whole process. The position and number of interference fringes measured by the interferometer were automatically analyzed in order to determine the film thickness.

Further results on SolR's performance were presented at the Photovoltaic Technology Show 2009 Europe in Munich (4-6 March).

www.photon-expo.com

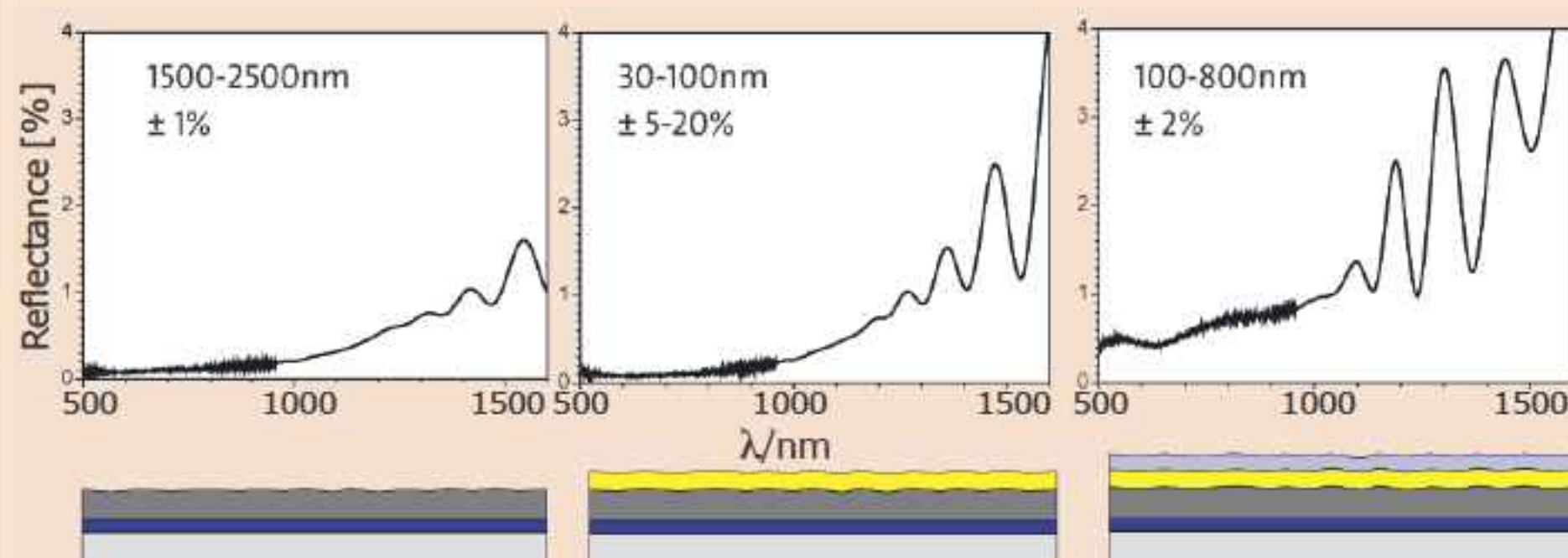


Figure 2: Layer-by-layer monitoring: reflectance spectra for thickness determination of the absorber CIGS (left), CdS buffer layer thickness (middle) and TCO layer thickness (right).

Direct in-situ monitoring for concentrating photovoltaic cells development at Fraunhofer ISE

LayTec has presented the first results from the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, Germany using its EpiCurveTT system for direct in-situ monitoring of the strain occurring in the epilayer structure of the new types of triple-junction concentrating photovoltaic (CPV) solar cells that ISE is developing.

Figure 1 shows the shift in room-temperature bandgap energy that is targeted by use of the solar cell's metamorphic epilayer structure. Three differently grown GaInAs buffer layers were used to shift the bandgaps of the middle cell and top cell down to about 1.2eV and 1.7eV, respectively.

Figure 2 shows in-situ curvature measurements used to minimize the residual strain and wafer bowing after the growth of the buffer.

The grading rate and grading profile of the InGaAs composition were tuned during the buffer growth. The curves in Figure 2 start to fall (increasing curvature) during the strained growth of the lattice-mismatched InGaAs buffer layers. After a certain critical thickness the crystal starts to relax through the formation of dislocations. The final curvature is an important measure

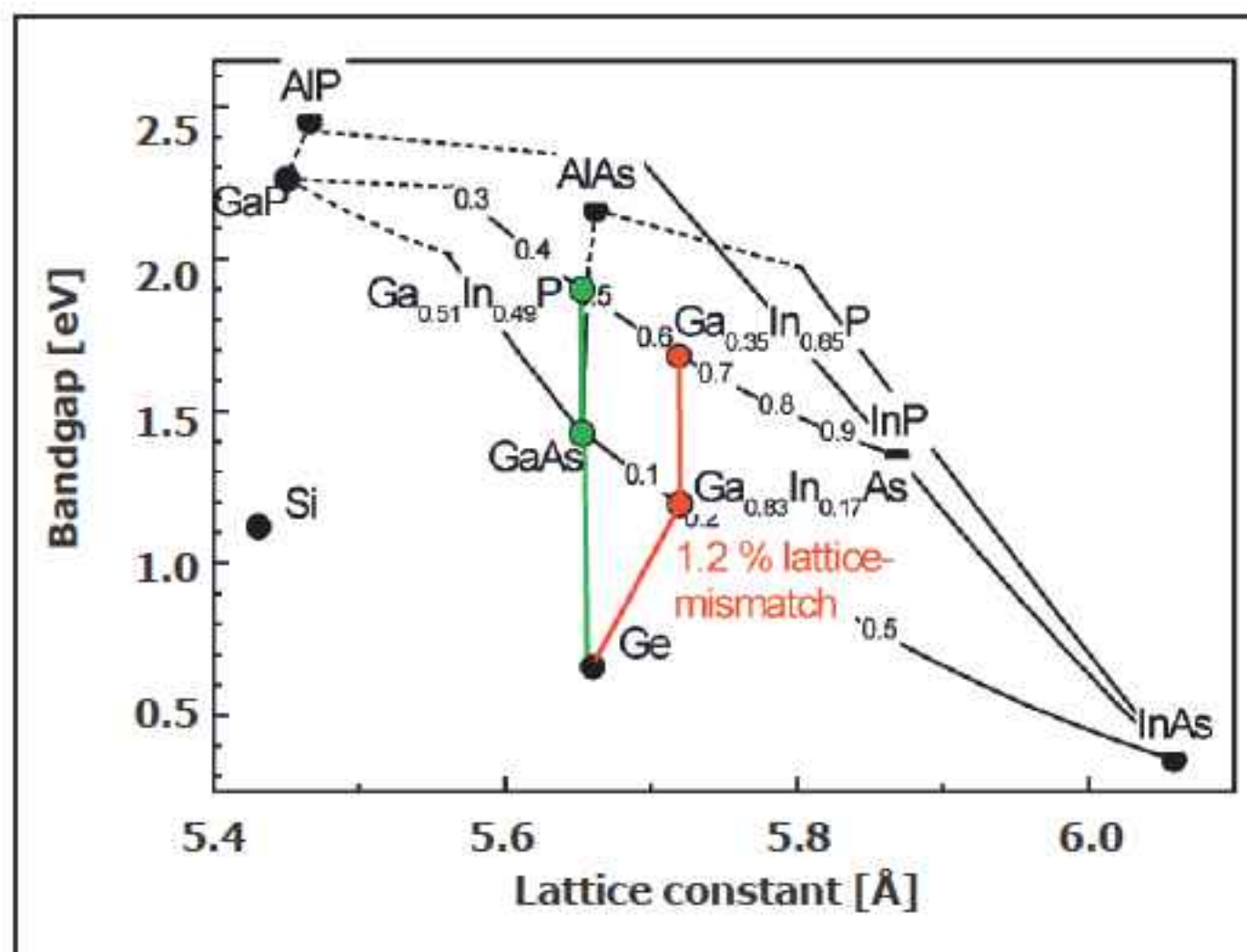


Figure 1: Diagram of room-temperature bandgap versus lattice constant, illustrating lattice-matched (green) and metamorphic (red) triple-junction solar cell growth.

for the relaxation of the metamorphic buffer structure during the lattice-mismatched growth, showing the differences for the differently grown GaInAs buffer layers.

LayTec's EpiCurveTT is being further developed to achieve an even higher resolution and to better understand the formation of dislocations and the effect of strain within the layers.

www.ise.fraunhofer.de

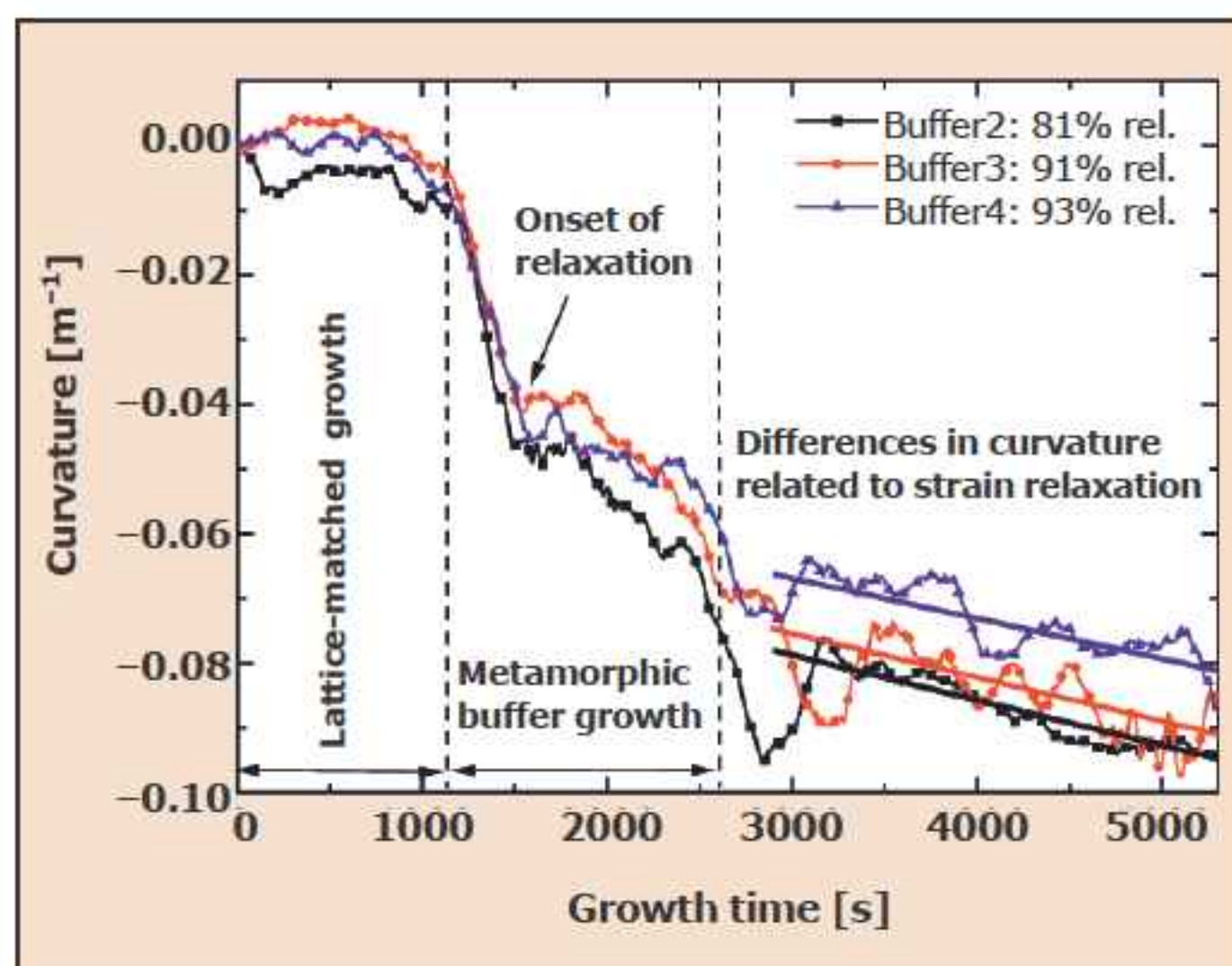
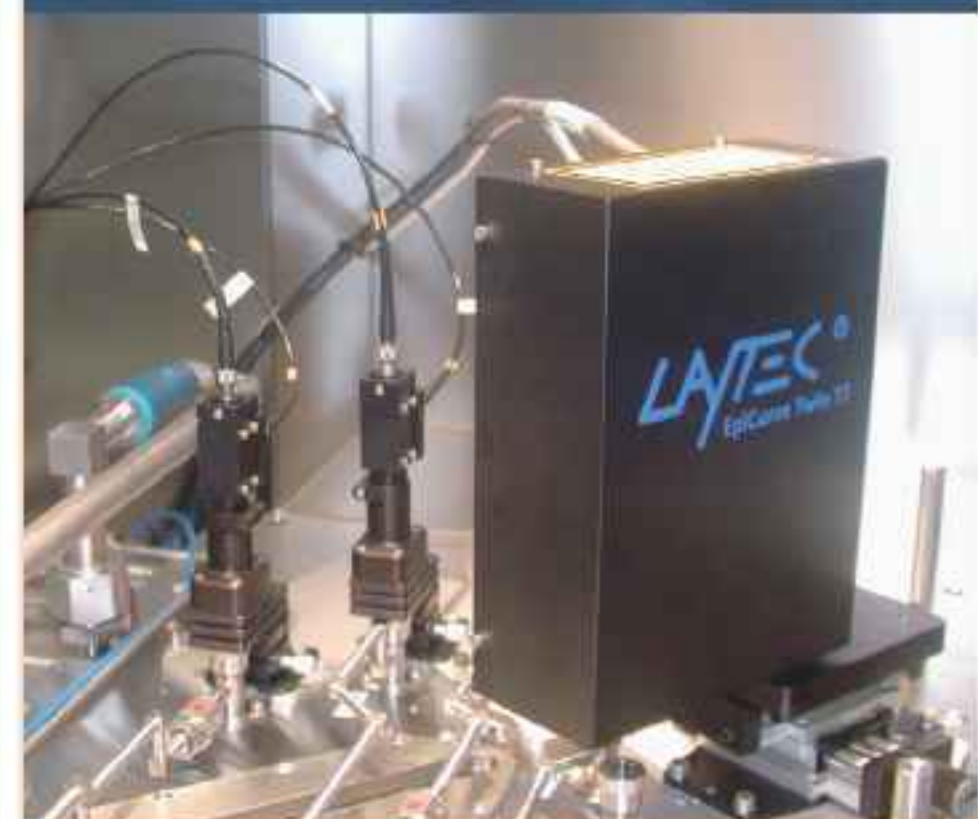


Figure 2: Curvature data for the three differently optimized InGaAs buffer layers.

Every move you make

LayTec's uniquely flexible EpiTT in-situ sensor system is adaptable to every MOCVD growth environment. Additional twin head and bowing measurement options enhance standard growth rate and true temperature parameters, allowing you to create the ideal sensing system for your specific production or R&D application.



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CVD Equipment range extended to solar applications

CVD Equipment Corp of Ronkonkoma, NY, USA has expanded its product line of EasyTube chemical vapor deposition systems to focus on quality control and R&D for next-generation process development in solar applications.

The EasyTube platform provides a framework of solutions that can be quickly and cost-efficiently customized to a wide variety of thin-film process requirements needed to accelerate the commercialization of next-generation solar cell/modules and smart windows.

As well as being used for quality control of polysilicon precursors in solar cell manufacturing, EasyTube research systems can be used for depositing other films, including amorphous silicon, polysilicon, silicon nitride, high- or low-temperature silicon dioxide, silicon and silicon-germanium epitaxy, transparent conductive oxides (SnO_2 , ZnO , etc), sulfurization, selenization, rapid thermal annealing, POCl_3 and other related diffusion-driven processes needed for next-generation silicon and copper indium gallium diselenide

(CIGS) solar cell process optimization.

The EasyTube system can be equipped with a variety of options, including a load-lock, operation at high or low pressures, substrate rotation for deposition and composition uniformity, and rapid heating. The process gas handling system accommodates pyrophoric, flammable, corrosive, toxic, solid and liquid source materials. Optional gas-, liquid- or solid-source delivery and process gas exhaust treatment allow turn-key process solutions.

www.cvdequipment.com

Laser edge deletion system for thin-film PV panels

At the Photon Technology Show in Munich, Germany (4–6 March), Newport Corp of Irvine, CA, USA launched the SolaryX Edge, a laser edge deletion system that uses high-power, pulsed lasers to enable effective and efficient removal of all coatings — including amorphous silicon (a-Si), cadmium telluride (CdTe), copper indium diselenide (CIS) or copper indium gallium diselenide (CIGS) — around the perimeter of thin-film solar panels.

Newport claims that a unique optical design makes the SolaryX Edge a lower-cost, higher-throughput

product while occupying a significantly smaller footprint than competing laser-based systems. It also eliminates the consumables that are required for other methods (e.g. sandblasting), suiting the global thin-film solar panel manufacturing market.

The rugged system is designed for maximum reliability in 24/7 industrial environments. "The SolaryX Edge provides superior performance, combining extremely fast coating removal rates for takt times down to 22 seconds, high reliability, and significantly lower cost of own-

ership than other solutions," claims Ron Hartmayer, Newport's director of marketing, Photovoltaic Systems.

As the latest addition to Newport's portfolio of photovoltaic manufacturing and test solutions, the new system joins the SolaryX family of laser scribe tools, lasers for thin-film scribing and patterning, automated PV I-V test stations, and solar simulators. SolaryX Edge systems have already shipped to customers in the USA and are currently operational in plants manufacturing thin-film solar panels.

www.newport.com

Shin-Etsu launches ultra-thick photoresist for bump processing, GaAs and MEMS applications

Tokyo's Shin-Etsu Chemical Co Ltd has introduced the SIPR-7126 positive-tone, chemically amplified ultra-thick photoresist, developed for thick plating applications of high-aspect-ratio features, such as those used in copper pillar bump processing in advanced packaging, as well as GaAs devices.

Such applications need an ultra-thick layer of photoresist to cover the topography on the integrated circuit and to plate very high-aspect-ratio features (up to 100 μm thick). The plating chemistries are complex

and varied, so the resist must also be robust to the different plating environments.

SIPR-7126 is also applicable to etch applications, such as MEMS and through-silicon vias (TSVs), where the entire thickness of silicon must be etched to build circuitry.

The flexible i-line photoresist can be developed by standard TMAH solutions; can be exposed by multiple exposure tools, such as steppers and aligners; and can plate up to 100 μm in a single coat with vertical profiles.

The latest version in the 7100 series, SIPR-7126 is optimized to reduce processing steps and improve removability. Features include: flexibility to different plating chemistries; easy rework; and no need for a post-exposure bake.

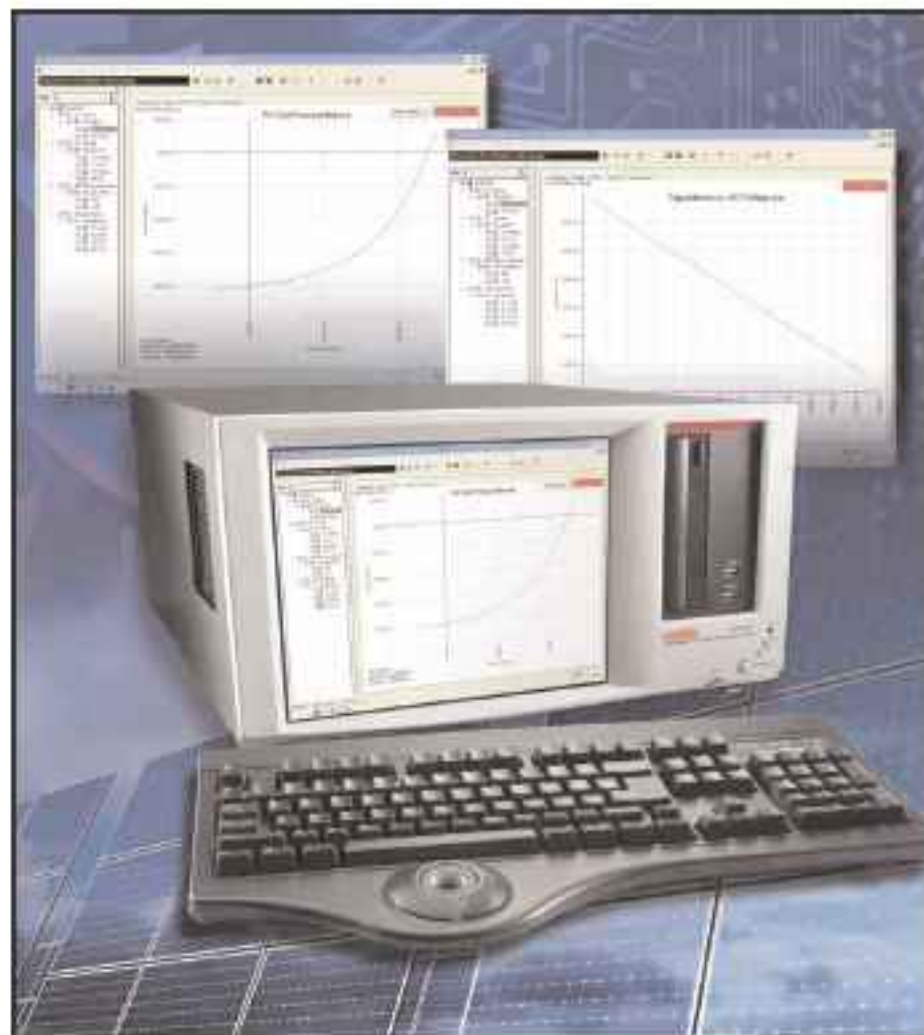
The new photoresist, along with the photolithography, packaging and flexible printed circuit materials of subsidiary Shin-Etsu MicroSi Inc of Phoenix, AZ, USA, was displayed at SPIE's Advanced Lithography 2009 event (24–25 February) in San Jose.

www.shinetsu.co.jp

Keithley upgrades semiconductor characterization system for testing solar cells

Keithley Instruments Inc of Cleveland, OH, USA, which provides electrical test instruments and systems, has introduced hardware, firmware, and software enhancements to its Model 4200-SCS semiconductor characterization system. The Keithley Test Environment Interactive (KTEI) V7.2 upgrade includes nine new solar cell test libraries, an expanded frequency range for the system's capacitance-voltage (C-V) measurement capability, and support for the new nine-slot Model 4200-SCS instrument chassis.

The new test libraries included in KTEI V7.2 expand the Model 4200-SCS's capabilities for solar cell I-V, C-V, and resistivity testing applications, says Keithley. The software upgrade also supports drive-level capacitance profiling (DLCP), a new solar cell testing technique that was difficult to perform accurately using earlier test solutions, adds the firm. DLCP provides defect density information on thin-film solar cells. In addition, existing Model 4200-CVU capacitance-voltage unit cards (introduced in November 2007) can be readily modified to support this



Keithley's KTEI V7.2 upgrade.

testing technique.

To support DLCP testing, the Model 4200-CVU's frequency range has been expanded from 10kHz-10Mz to 1kHz-10MHz. This extended frequency range also expands the system's applications, providing support for the testing of flat panel LCDs and organic semiconductors such as OLEDs. Keithley's V7.2 upgrade also provides support for a nine-slot instrument chassis. Previously, the Model 4200-SCS had just eight

slots to hold a growing array of source-measure units (SMUs), pulse generation and scope cards, and capacitance-voltage cards. Existing Model 4200-SCS systems can be upgraded to support nine slots; all new mainframes will have nine slots.

Version 7.2 of KTEI is available at no cost to existing Model 4200-SCS users. However, Keithley adds that there is a charge to calibrate the upgraded 4210-CVU and to upgrade existing Model 4200-SCS systems to support nine instruments.

In support of the V7.2 upgrade, Keithley has also introduced a new high-performance triaxial cable kit for connecting the Model 4200-SCS to a prober, designed to simplify the process of switching between DC I-V, C-V, and pulse testing configurations. According to the firm, the cable kit eliminates the need for recabling, as well as eliminating the measurement errors that often result from cabling errors. Two versions of the cable kit are available, one for Cascade Microtech probers and the other for SUSS MicroTec probers.

www.keithley.com

CIGS/CdTe XRF tool expanded to full-panel analysis

X-ray fluorescence (XRF) analysis system maker Solar Metrology of Hollbrook, NY, USA says that it has expanded its SMX product range, which provides a production-ready suite of thin-film thickness and composition measurement systems for research and process development, in-process monitoring and post-process quality control.

The new SMX-FPV (full panel view) model is designed for near-line film composition and thickness control of copper indium gallium diselenide (CIGS) and cadmium telluride (CdTe) film stacks in finished photovoltaic (PV) panels, says Solar Metrology.



Solar Metrology's SMX XRF system.

The new model joins the range's existing models: the SMX-BEN (for benchtop process development and failure analysis), the SMX-ISI (for in-situ deposition monitoring and control) and the SMX-ILH (for

in-line post-deposition control, introduced last November).

The new SMX-FPV has a full 600mm x 1200mm lateral xy range and is designed for the measurement of rigid glass substrates. The FPV provides process control of active, contact and TCO (transparent conductive oxide) layers. Detailed analysis of full photovoltaic panels is possible, including fast and repeatable copper and gallium ratio determination, and panel gradient analysis allows for yield improvement and management and conversion efficiency gains in production.

www.solarmetrology.com

ESI scribe enables GaN LED power chip production ramp at China's Aqualite

Electro Scientific Industries Inc (ESI) of Portland, OR, USA, which provides photonic and laser systems for microengineering applications, says that its AccuScribe 2112 wafer scribing system has helped to enable the aggressive production ramp at Aqualite Co Ltd of Wuhan, China.

Aqualite was founded in 2006 and holds several US and Chinese patents, based on proprietary technology for the mass production of epitaxial wafers and power chips. Sponsored by the Chinese Hi-Tech '863' programs and the National Torch Plan and with investment from Wuhan Hi-Tech Group, TianDi Growth Capital and InfoTech Ventures, Aqualite undertakes both R&D and high-volume production of gallium nitride (GaN)-based LED power chips for solid-state lighting

applications in China. The firm's roadmap targeted an annual capacity of 3600 millions chips from its 55000m² plant by the end of 2008.

Delivered last September, the AccuScribe 2112 system has met AquaLite's stringent production ramp requirements on schedule, says ESI. The AccuScribe 21xx series is the latest system in ESI's range of scribing solutions, which is reckoned to provide the greatest improvements in high-brightness LED (HB-LED) scribing since the inception of the firm's Titan laser scribe. Using high-efficiency, high-stability UV DPSS (diode-pumped solid-state) laser technology, the production-worthy platform supports 100mm wafer capability.

"The decision to choose ESI's AccuScribe 2112 system was supported by their continued roadmap

developments and support for our fast-paced production ramp schedules," says Mr Dong, president of Aqualite. "With a strong supplier record and innovative designs that continue to deliver systems with the lowest cost-of-ownership in the industry, ESI is the right choice for the LED market," he adds.

"Our close customer relationships allow us to develop innovative solutions to meet aggressive production ramps, and further our customers' product and technology roadmaps," says Michael Stubelt, marketing director of ESI's New Wave Research division. "Aqualite is a valued partner and we will continue to develop solutions with significant cost-of-ownership advantages to meet our global customers' manufacturing needs," he adds.

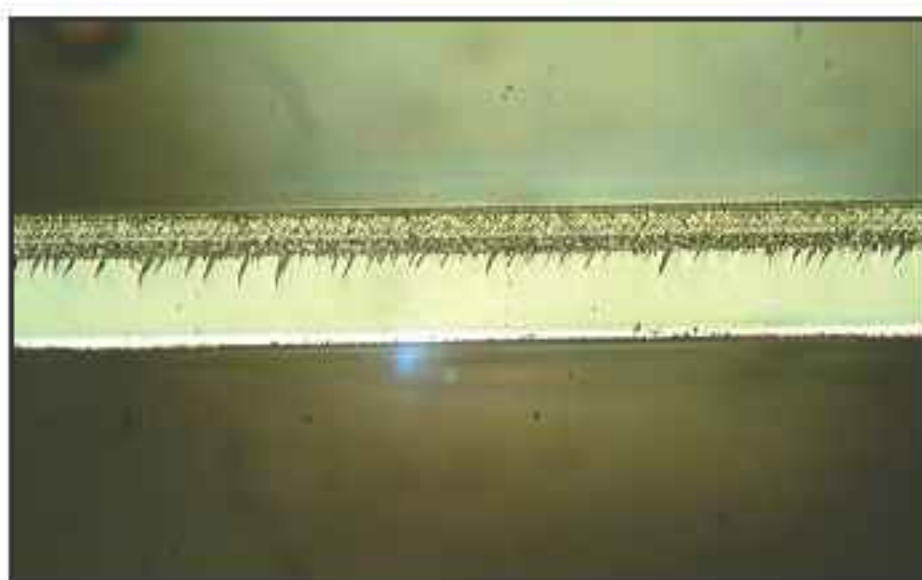
www.esi.com

JPSA introduces dual side scribe (DSS) capability for laser systems

At the SEMICON Shanghai 2009 event in China (19-20 March), JP Sercel Associates Inc (JPSA) of Manchester, NH, USA is introducing new dual side scribe (DSS) processing capability on its laser wafer scribing systems, for performing both front-side and back-side scribing for LED, sapphire, GaAs, silicon, and metal wafers (depending on wafer processing requirements).

JPSA's proprietary back-side camera technology provides high accuracy with fast alignment times for the DSS systems. The firm has achieved high-throughput back-side scribing at speeds of up to 150mm per second with no debris or damage to the epitaxial layer.

The DSS capability is also available as a field upgrade to all existing JPSA scribing systems, such as the IX 210, IX 300 and IX 6100. DSS also allows for easy conversion from front-side to back-side scribing.



LED backside scribing: a 30µm deep scribe in sapphire at 130mm/s, showing the unaffected epi-layer.

"For many years, JPSA has been at the forefront of advanced deep UV front-side laser scribing," claims president Charlie Cuneo. "With our recent advances in back-side scribing, namely a new laser absorption enhancement technique, we are able to offer our customers their choice of highly efficient scribing processes that best meets their production requirements," he adds.

www.jpsalaser.com

OIPT announces 2009 seminar series

Etch and deposition equipment maker Oxford Instruments Plasma Technology of Yatton, Bristol, UK says that in 2009 it is holding several seminars on a variety of topics.

Speakers from host universities will be supplemented by guest speakers from other institutes and industry, in addition to process and applications experts from OIPT.

- 2 July — 'Innovation in Processing at the Nanoscale', hosted by the University of Southampton, UK;
- 16-17 July (during Semicon West week) — 'Plasma Etch Tech 2009: Pushing the Limits', hosted by The Molecular Foundry, Lawrence Berkeley National Laboratory, CA, USA;
- 27-28 August — 'Dry processing for microelectronics, growth, deposition and etching', hosted by TU Eindhoven, The Netherlands.

To register, contact:
process.news@oxinst.com

www.oxford-instruments.com



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Rubicon's revenue falls by two thirds

For 2008, Rubicon Technology Inc of Franklin Park, IL, USA, which makes sapphire substrates and products for the LED, RFIC, semiconductor and optical industries, has reported revenue of \$37.8m (up 11% on 2007's \$34.1m, driven by sales of larger-diameter wafers). Net income was \$4.3m, compared to 2007's loss of \$2.9m.

However, fourth-quarter 2008 revenue was \$4m, down 58% on \$9.5m a year ago and 66% on last quarter's \$11.8m. The sudden drop is attributed to the slowdown in consumer spending, particularly in electronics (where much of Rubicon's products are used). "The LED market continued to soften throughout the fourth quarter," says CEO Raja Parvez. Net loss was \$1.8m, a slight improvement on \$2m a year ago.

Previously, in mid-September, Rubicon had announced that, due to the slowdown in handheld device and small-display markets affecting both LED-making customers of its small-diameter (2") LED wafers as well as its main silicon-on-sapphire (SoS) customer (RF communications IC maker Peregrine Semicon-

ductor Corp of San Diego, CA, USA), it had executed contract modifications that shifted delivery of nearly \$7m of product scheduled for 2008 into first-half 2009.

Subsequently, in early December, Peregrine's obligation to purchase material from Rubicon in 2008 and first-half 2009 was replaced by a multi-year agreement under which Peregrine committed to source at least 50% of its sapphire purchases from Rubicon through 2011. "This amendment to our agreement provides some relief to our customer as they work through their inventory," said Parvez at the time.

During Q4/2008, Rubicon not only repurchased about 731,000 shares under its share repurchase program (at a total cost of \$3.1m) but also purchased \$2m in preferred equity in Peregrine. Year-end cash and investments totaled \$58m, and Rubicon has no debt.

"It may take another quarter or two for inventory levels throughout the supply chain to realign and for orders to pick up again," says Parvez. "The first quarter will be challenging, with reduced LED

orders as inventory levels come down." For Q1/2009, Rubicon expects a net loss of \$3-4m on revenue down 25-50% on Q4/2008 to \$2-3m.

"Rubicon's products are integral to several emerging technologies and demand will resume when supply chain inventory levels are reduced," says Parvez. "We also believe we can build on the success of our growing optical business with new applications in new market segments that require high-quality sapphire in large diameters," he adds.

"In the meantime we continue to monitor costs very closely and have adjusted staffing levels and production schedules accordingly," says Parvez. "Our strong balance sheet allows us to continue to invest in advancing our technology, in projects that will lower our costs, and in improving our capital structure through our share repurchase program," he adds. "Until we have further clarity on the longer-term outlook for our product sales, we believe it's prudent to refrain from giving full year estimates."

www.rubicon-es2.com

CrystalQ appoints ex-Philips lighting execs as supervisory board member and chairman

Sapphire substrate maker CrystalQ Group B.V. of Stadskanaal, The Netherlands has appointed Dr Peter Stormberg to its supervisory board and Peter W van Strijp as the supervisory board's chairman.

van Strijp has extensive expertise from a long-standing career in the lighting industry (both conventional and solid-state lighting), including as executive VP of Philips Lighting. Until his retirement in early 2008, he was CEO of Philips Lighting's Solid State Lighting business unit, including acting as a board member at LED maker Lumileds and being directly involved in several of Philips Lighting's LED-related acqui-

sitions. He currently serves on the boards of several companies in the LED value chain.

van Strijp has a Master's degree in Business Administration from the University of Eindhoven as well as a Bachelor's degree in Economics from the University of Rotterdam, The Netherlands.

Stormberg has more than 30 years experience in R&D in various lighting technologies and, until his recent retirement, was chief technology officer of Philips Lighting, responsible for the R&D strategy for both conventional and solid-state lighting technologies.

He was also involved in Philips

Lighting's acquisitions and the definition of its Intellectual Property strategy. He represented Philips Lighting on several standardization committees and on the board of the European technology platform Photonics21, where he chaired the working group 'Lighting & Displays'. Stormberg has a Master's degree in Physics and a Ph.D. in Physical Chemistry, both from the Technical University Aachen, Germany.

The extensive knowledge of the LED market and the industry connections of both Stormberg and van Strijp will add great value to CrystalQ, reckons CEO Joris Barendregt.

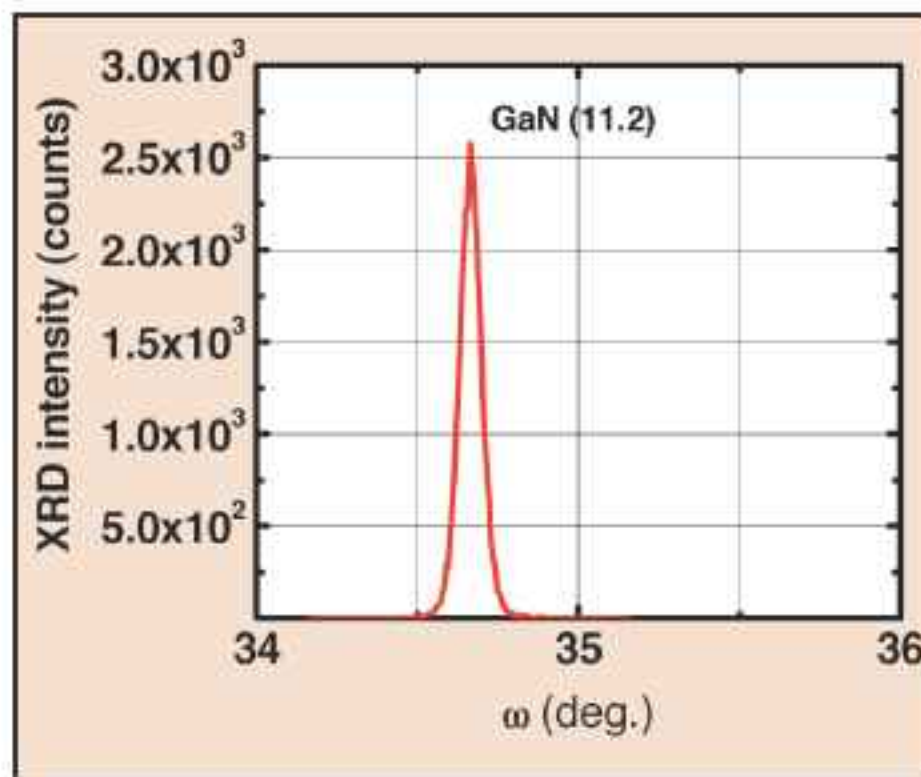
www.crystalq.nl

HVPE of semi-polar GaN on m-plane sapphire

Oxford Instruments-TDI's technical team, led by Dr Alexander Usikov, says that it has made significant progress in fabricating semi-polar gallium nitride layers for optoelectronic devices (which should boost radiative recombination efficiency and device performance), and is working with a leading LED maker.

In the past decade, group III-nitride materials have been widely used for visible and ultraviolet LEDs and blue-violet laser diodes. Most of these optoelectronic devices are typically fabricated on conventional polar (0001) c-plane oriented substrate materials.

However, devices grown on a polar substrate orientation suffer undesirable spontaneous and piezoelectric polarization, leading to significant bending of the energy bands in the quantum well layers of the structure. This reduces radiative recombination efficiency, limiting the light-emission performance.



XRD ω -scan rocking curve of symmetric (11.2) reflex for a 2" (11.2) GaN/m-plane sapphire wafer. GaN layer thickness is about 25nm. The XRD spectrum has a record full width at half maximum (FWHM) of 286 arc-sec, showing high crystalline quality. The GaN layer also has smooth surface morphology with some macroscopic surface

To reduce the polarization effects, the growth of GaN-related devices along semi-polar and non-polar

directions has been studied. Using hydride vapour phase epitaxy (HVPE), Oxford Instruments-TDI has grown high-quality, semi-polar (11.2) oriented GaN on (10.0) m-plane sapphire with an intermediate layer between the sapphire substrate and the GaN layer.

The semi-polar (11.2) GaN layers were grown at 930–1050°C in an inert argon ambient at atmospheric pressure. Gallium and aluminum were used as metallic source materials and hydrogen chloride (HCl) and ammonia (NH₃) as the active gases for the HVPE process. Epitaxial growth of GaN was performed at a high rate of about 60µm/hr (about the same as on c-plane sapphire) using a thin intermediate layer deposited on m-plane sapphire followed by an undoped GaN layer.

This growth procedure results in a high-quality, semi-polar GaN layer with a thickness of up to 30µm.

www.oxford-instruments.com

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Golden Dragon Plus LEDs installed in Korean street lamps

Osram Opto Semiconductors GmbH of Regensburg, Germany says that its Golden Dragon Plus LEDs are being used in PRAUS streetlights from GALED Co, a Korean lighting manufacturer established in 2007.

The LED street lamps have been erected since mid-2008 as prototypes in several high-profile locations in Korea in response to the government's call for energy efficiency. Korea's President Lee Myung-bak has stressed the need to save energy to overcome the current economic downturn, instructing local government chiefs to focus on ways to reduce energy consumption in their regions.

The LED-based 80W/150W PRAUS street-lighting prototype projects have replaced metal halide lamps and sodium lamps in four locations, including the roads near Wonju city hall in Kang-Won province, at the Halla University campus in Won-ju, in front of the Nam-gu government office in Gwang-ju, and at the Dae Won Science College campus in Je-cheon. GALED expects the average annual energy savings of the installations to be over 55%.



Street lamps with Golden Dragon Plus LEDs erected in front of the Nam-gu government office in Gwang-ju.

Nam-Gu_govt_office_in_Gwang.jpg With the Golden Dragon Plus LEDs' color temperature of 6500K, the roadway luminaires can also provide higher-quality white light through an optimized color rendering index (CRI), says Osram Opto: the increase in CRI from about 30 to over 65 can improve night visibility.

Osram Opto says its Golden Dragon LEDs offer full-color spectrum brightness, consume 80% less electricity than incandescent lamps, and can last for up to 50,000 hours. The longer service intervals and the robust nature can also reduce street-lighting maintenance costs. Furthermore, the availability of

cool- and warm-white LEDs with high CRI offers the flexibility to adjust the color temperature to the specific street-lighting application.

The Korean government further plans to use more energy-efficient LED bulbs to replace all incandescent light bulbs at public facilities by 2012. "As a Korean company, we are proud to help move forward the energy-efficiency initiatives by developing LED-based street lighting in various cities throughout the country," says GALED's CEO Seok-Hoon Kang. "We continue to work with local governments to drive installations, which will in the short and long run provide immediate benefits for the communities. We are confident that our products can meet the stringent street-lighting standard which will be announced by the government in April," he adds.

"We applaud the commitment from the Korean Government to make energy efficiency a priority for the country," comments Dr Alfred Felder, president & CEO of Hong Kong-based subsidiary Osram Opto Semiconductors Asia Ltd.

www.galed.co.kr

Golden Dragon LEDs in first LED street-lighting in Finland

After extensive testing, the Levi ski resort in Kittilä will be Finland's first district to install LED street-lighting.

The system comprises 64 Starium Dragon 60 luminaires from EasyLed Oy, each equipped with 60 Osram Opto Semiconductors Golden Dragon LEDs fitted with oval lenses (3840 LEDs in total). The LED street-lamps consume just 41W, cutting energy costs for the local authority and, together with minimal maintenance requirements, leading to a payback period of just 4.5 years, it is reckoned.

"We were particularly persuaded by the excellent color rendering [with a color temperature of 5600K, similar to natural light], the vibration resistance of the light sources, and the freedom to create



EasyLed's low-profile Starium Dragon 60 luminaires, each equipped with 60 Golden Dragon LEDs and oval lenses from Osram Opto. Source: EasyLed.

any luminaire designs thanks to the small size of the LEDs," says EasyLed's product development director Mika Nummenpalo.

"The stability of the luminous flux and the ideal distribution of light with no scatter — and therefore no light pollution — were key factors in the decision to install LEDs," adds Ari Tiilikainen, a lighting designer at Lite-Design. "Thanks to sophisticated thermal management, we were able to give the luminaires a modern low-profile design, as requested by the local authority."

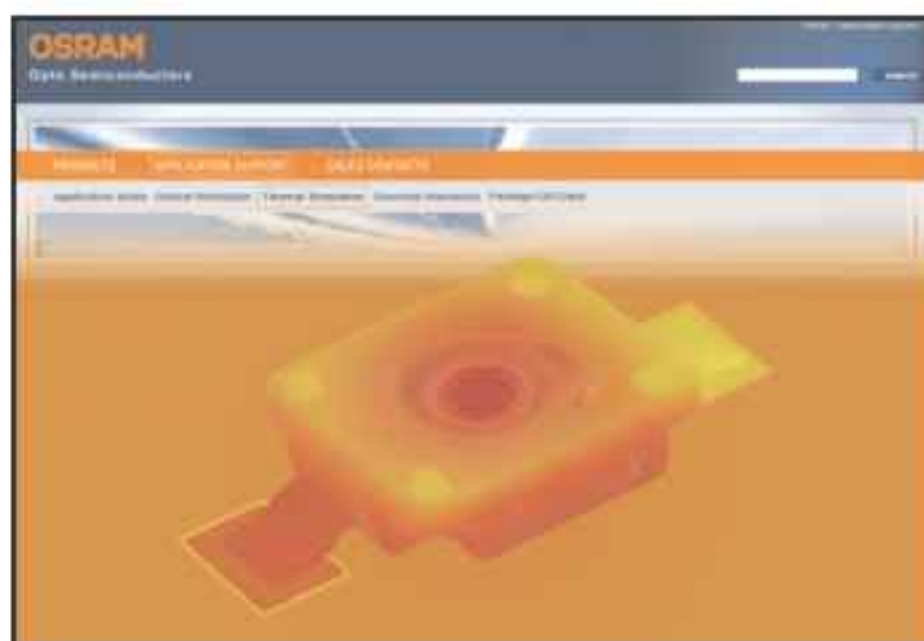
"The Starium Dragon 60 offers the best luminous efficacy and therefore the greatest potential savings," reckons Jari Kinnunen from the Technical Department in the Kittilä authority.

Online thermal models for LEDs

Osram Opto Semiconductors has provided thermal models for computing different LED designs as downloads for the first time. In addition to electrical, mechanical and optical data, a compact model for Flotherm software is now permanently available online for calculating thermal behavior.

Different designs can be tested without having to build costly prototypes or carry out time-consuming measurements. "This significantly shortens the design phases and drastically reduces development costs," says Joachim Reill, director LED Applications Engineering. The data is available for standard high-power LEDs in the visible range, particularly for the Dragon family, the Advanced Power TOPLED range, the Power TOPLED range, and some OSTAR versions.

The compact model available on the website is a simplified thermal geometry model that can be integ-



Thermal simulation web page.

rated in Flotherm software and can be used for customer-specific calculations. It is suitable, for example, for calculating the temperature distribution in a planned system. With extended application support it is possible to design all end-applications, including display backlighting, in terms of thermal criteria. "Customers can use simulations to see which LEDs are suitable for which boards and then check the thermal behavior of the overall design," says Reill.

www.osram-os.com/thermal-files

Osram LEDs light up Jing Jiang City

Osram Opto Semiconductors says that its Golden DRAGON LEDs are lighting up a major thoroughfare of Jing Jiang City in the Jiangsu province of China.

Jiangsu Hua Jing Photoelectronics has installed fourteen 8m-high prototype 180W LED streetlights containing Golden DRAGON LEDs in a pilot project to replace traditional 250W HID (high-intensity discharge) lamps. Based on Hua Jing's tests, the Golden DRAGON based-street lamps offer energy savings of more than 37%, together with an improvement in night visibility.

Currently, there are about 8000 street-lights in Jing Jiang city and its development zone. Getting the new LED lamps approved in Jing Jiang will be a combined effort of the government and the local community, working closely with Jiangsu Hua Jing. China's Ministry

Prototype LED streetlights in Jing Jiang City.



of Science and Technology is pushing to replace traditional incandescent lighting with more energy-efficient LEDs, and targets RMB260bn in energy savings by 2015.

"China is leading the way with its commitment to energy-efficient lighting solutions, and LEDs are increasingly recognized as the best light source to meet this commitment," says Dr Alfred Felder, president & CEO of Hong Kong-based Osram Opto Semiconductors Asia Ltd.

Cree launches product characterization tool to speed LED system design

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has launched the Product Characterization Tool (PCT), an interactive LED design tool that simplifies the task of translating nominal LED performance to real-world conditions.

The online tool allows users to characterize any XLamp LED over a wide range of operating conditions, including drive current, flux bin, price and junction temperature. It also calculates metrics such as lumen output, lumens per watt, and lumens per dollar.

Cree claims that the PCT introduces functionality not offered commercially by any other LED supplier. It can perform simple LED system design on the basis of a target total lumen output, calculating parameters such as the number of LEDs required and the total system efficacy. The calculated system parameters take into account electrical, optical and thermal losses associated with LED system performance. In addition, the PCT allows users to compare up to three different XLamp LED configurations at once, enabling the best choice between the XLamp XR, MC and XP package families.

"The Product Characterization Tool acts like an interactive data sheet, giving users a more intuitive way to design LED systems using XLamp LEDs," says Paul Thieken, marketing director for LED components. "Determining even basic LED system parameters like efficacy with only data sheet graphs and characteristics used to be a time-consuming process," he adds. "Cree is moving the LED lighting industry forward by simplifying the process to just a few clicks of the mouse."

www.cree.com/pct

Lumileds joins California Lighting Technology Center affiliate program

LED maker Philips Lumileds of San Jose, CA, USA has become an affiliate member of the California Lighting Technology Center (CLTC), which is based at University of California at Davis.

As a member, Philips Lumileds is working with luminaire makers to develop market-ready applications (based on the firm's Luxeon LEDs) that meet the energy efficiency and lighting quality levels required by EnergyStar and other similar regional and national guidelines.

"Our affiliation with the CLTC supports the development of specification and architectural-grade solutions using our LUXEON Rebel and LUXEON K2 power LEDs," says Jay Shuler, Lumileds' regional marketing manager for the Americas.

"By working with the CLTC, our customers will gain access to new opportunities with state agencies, utilities and businesses eager to adopt solid-state lighting solutions."

Established through a collaborative effort between the Public Interest Energy Research (PIER) program of the California Energy Commission (CEC) and

University of California at Davis with support from the US Department of Energy and the

National Electrical Manufacturers Association, the CLTC is a research and education facility that focuses

Customers will gain access to new opportunities with state agencies, utilities and businesses

on the application of energy-efficient lighting and daylighting technologies through research, development, demonstration, outreach and education in partnership with utilities, manufacturers, end-users, builders, designers, and governmental agencies. The center conducts both cooperative and independent activities with lighting manufacturers, electrical utilities and the design and engineering professional communities.

These partnerships facilitate the commercialization of products developed at CLTC in accordance with its mission to bring viable research-based projects to the commercial marketplace in two years or less.

<http://cltc.ucdavis.edu>

Lumileds' Luxeon LEDs light Osaka street lamps

Reflecting the emergence of solid-state lighting as an energy-efficient alternative to street lamps using standard light sources, Philips Lumileds of San Jose, CA, USA has announced the installation of the first street lights using its Luxeon power LEDs in Osaka Prefecture in Japan.

The fixtures, developed by Osaka-based Three Force, are contributing to an overall saving of 88% in electricity bills over the older high-pressure mercury lamps used elsewhere in the region. "Our new street lamps in Osaka are saving a tremendous amount of energy and pedestrians really enjoy the quality of light that we get from the Luxeon LEDs," says Three Force's CEO & president Kazuaki Ueshima.

Installed in a park on the Kizu River, each LED-based street lamp uses 36 cool-white Luxeon LEDs. The LED array generates 30 lux at a pole height of 4.5m, comparable



Street-lights in Osaka, Japan, each containing 36 cool-white Luxeon

to the brightness of mercury lamps, while using just 25W of power per fixture. Three Force worked with Future Lighting Solutions to ensure that system design and bin selection enabled it to meet the solution specifications.

In addition to energy savings, Luxeon LEDs offer a 60,000-hour lifetime (5-10 times longer than

mercury vapour), mercury-free construction, and the ability to achieve uniform light distribution with minimal glare in street-lamp applications because of the greater control over light direction enabled by Luxeon's small form factor. Light can be precisely targeted through LED placement and optics optimization.

"This initial installation in Osaka Prefecture is part of an emerging movement to bring LED illumination to streets and sidewalks," says Norihide Yamada, general manager Japan for Philips Lumileds. "We are seeing growing interest in solid-state street lamps from partners and cities around the globe and certainly here in Japan," he adds. "Municipalities are familiar with the energy and maintenance benefits of LEDs, and street lighting promises to be the next big wave of LED adoption at the municipal level."

www.philipslumileds.com

Samsung setting up LED JV to expand to applications

According to a regulatory filing, South Korea's Samsung Electronics and its component manufacturing affiliate Samsung Electro-Mechanics Co have agreed that in April they will launch a new 50:50 joint venture (tentatively named Samsung LED) dedicated to producing LEDs, as reported by news agency Reuters and Korean newspaper Chosun Ilbo.

Samsung Electro-Mechanics currently runs a business that focuses on producing white LEDs for mobile phone backlighting. The new venture should be able to use parent

firm Samsung Electronics' cash reserves and technology to further expand LED business.

In particular, it aims to grow business for applications such as backlight units (BLUs) for display, especially in large flat-screen LCD TVs.

The new venture also aims to boost the firm's presence in the rapidly growing market for energy-efficient lighting technology

The venture will help to support Samsung Electronics' LED-backlit TV business.

The new venture also aims to boost the firm's presence in the rapidly growing market for energy-efficient lighting technology. The South Korean government has announced support for the use of LED lighting, and plans to replace 30% of all bulbs at public facilities with LEDs by 2012. Korea aims to capture a 26% share of the global LED market within nine years.

www.sem.samsung.com

Bridgelux signs exclusive global franchise agreement with distributor Premier Farnell

Bridgelux Inc of Sunnyvale, CA, USA, which designs and makes power LED chips based on ITO/InGaN (indium tin oxide/indium gallium nitride), has signed a new global franchise agreement with distributor Premier Farnell plc.

Premier Farnell will carry Bridgelux's new LED Array products, which have been developed specially to provide lamp and luminaire manufacturers with a solution for simplified system-level integration. Available product options deliver between 400 and 2000 lumens under application conditions in cool-, neutral- and warm-white colours. The high-lumen-output integrated sources reduce system design complexity, enabling miniaturized cost-effective lamp and luminaire designs. Applications include down-lights, task and accent, track, hospitality, architectural, street, wide area, and security lighting.

"This new global franchise agreement with Bridgelux will continue to strengthen our SSL [solid-state lighting] product offerings for our worldwide design engineering cus-

tomers base," says David Shen, Premier Farnell's head of Global Technology Marketing. "We are pleased to be working with a company that has a variety of LED technologies which produce the highest luminosity on the market, with a special process to reduce heat," he adds. Bridgelux controls all of the core technologies, from the epitaxial process to packaging, enabling it to manufacture both high-power LED chips and LED Arrays.

"Bridgelux LED Array products are ideal for Premier Farnell's high-service multi-channel marketing capabilities, which offers great support to our design engineering customers as they strive to bring their latest products to market as quickly, cost effectively and efficiently as possible," says Shen. He adds that Premier Farnell continues to invest in and drive its own technical support programmes to ensure that electronic design engineers worldwide receive the support, information and data on the latest technologies and products from suppliers like Bridgelux as

quickly and effectively as possible. This scheme provides designers with immediate web access to data and support, as well as reduced delivery lead times, Shen claims.

"Premier Farnell has the extensive global market reach and an excellent reputation for customer service, and we are confident that they will support Bridgelux's customers by providing the very latest in high-power, high-quality LED light source technology," says David Barnby, Bridgelux VP of sales & general manager of EMEA. "We believe that our recently launched LED Arrays will significantly reduce the cost of light by simplifying LED lamp and luminaire designs, thereby reducing manufacturing costs," he adds. "Distributing our products through Premier Farnell complements our global sales network and our capabilities to service the fast-growing SSL market." The Next Generation Lighting Industry Alliance (NGLIA) estimates the global lighting market to be about \$40bn.

www.premierfarnell.com

www.bridgelux.com

IN BRIEF

SemiLEDs and Nichia settle LED patent dispute

Japanese LED maker Nichia Corp and Semi-Photonics Co Ltd of Boise, ID (a subsidiary of SemiLEDs Corp USA) say that they have settled their patent case before the Osaka District Court.

SemiLEDs' 'metal vertical photon' (Mvp) products are manufactured using what it claims is unique, patent-protected technology that provides a flexible copper alloy base for thermal and electrical conduction.

As a result of the settlement, Semi-Photonics Co Ltd has withdrawn the lawsuit against Nichia.

www.semiphotonics.com

www.nichia.com

FOREPI to set up China subsidiary

Taiwan-based LED epiwafer and chip maker Formosa Epitaxy (FOREPI) plans to invest US\$150m to establish a subsidiary in Rushan, Shandong province, east China, according to a report in Digitimes.

Sited in the Rushan Taiwan Industrial Complex (a 7.5km² area for Taiwan-invested projects), the new firm will focus on R&D and manufacturing of LED epitaxial wafers, chips and related semiconductor lighting products, says FOREPI's chairman Chien Fen-ren. Production will initially focus on blue/green gallium nitride (GaN) LEDs.

FOREPI targets the LED street-lamp market in China. The firm is currently working with China packaging houses to ship to the domestic market. Revenues from LED chips for general lighting applications accounted for 10–15% of FOREPI's total revenues in 2008.

www.forepi.com.tw

www.digitimes.com/news/a2009

Rothschild files LED patent complaint with ITC against firms in Taiwan and China

On 27 February, Gertrude Neumark Rothschild (professor emerita of Materials Science and Engineering at Columbia University in New York) filed a complaint requesting that the US International Trade Commission (ITC) initiate an investigation against China's Xiamen Sanan Optoelectronics Technology Co Ltd and Taiwan's Chi Mei Lighting Technology Corp, Tekcore Co Ltd, Toyolite Technologies Corp, Tyntek Corp and Visual Photonics Epitaxy Co Ltd.

Citing Section 337 of the Tariff Act of 1930, the complaint alleges unlawful importation into the USA and sale of certain LED chips, laser diode chips and products containing them that infringe US patent no. 5,252,499 ('Wide Band-Gap Semiconductors Having Low Bipolar Resistivity and Method of Formation', issued in 1993, covering a method of producing gallium nitride-based semiconductors for LEDs and laser diodes emitting in the blue, green, violet and ultraviolet end of the spectrum).

Rothschild further asserts that the patent is the subject of a number of licenses, following litigation in the US District Court for the Southern District of New York (filed in 2005 and settled last March by LED maker Philips Lumileds of San Jose, CA, USA) and a pending investigation before the ITC, 'Certain Short-Wavelength Light Emitting Diodes, Laser Diodes and Products Containing Same' (investigation no. 337-TA-640, following a complaint filed against more than 30 firms in February 2008). None of the defendants in the district court actions or respondents in the pending ITC investigation are named as a proposed respondent in the latest ITC complaint.

The complaint also alleges that domestic industry exists "as a

result of Professor Rothschild's substantial investment in the exploitation of the '499 patent through enforcement and licensing." Specifically, Rothschild "has vigorously enforced her rights with regard to the patent as a part of her licensing efforts" and such efforts have resulted in license grants under the patent to several firms, including LED makers Nichia Chemical Industries Ltd, Toyoda Gosei Co Ltd and Seoul Semiconductor Co Ltd as well as Taiwan's Epistar Corp and Everlight Electronics Co Ltd.

Rothschild began her research career in private industry, working with Sylvania Research Laboratories in Bayside, NY in the 1950s and later at Philips Laboratories in Briarcliff Manor, NY before joining Columbia as a professor of materials science in 1985. She conducted research in the 1980s and '90s into the electrical and optical properties of wide-bandgap semiconductors that is claimed to have been pivotal in the development of short-wavelength emitting (blue, green, violet and ultraviolet) diodes now used in consumer electronics. Recognized by the American Physical Society as a Notable Woman Physicist in 1998, Rothschild was elected as a Fellow of the American Physical Society in 1982.

Rothschild is represented by intellectual property attorneys Albert Jacobs and Daniel Ladow of Dreier LLP.

www.dreierllp.com

www.usitc.gov

www.usitc.gov

Epistar to ship AC-LED products in Q2 using technology licensed from ITRI

Taiwanese LED chip maker Epistar says it expects to be the first firm in the world to make volume shipments of alternate-current LED (AC-LED) chips to packaging houses, starting in second-quarter 2009 (shipping to clients in Taiwan, China and Malaysia). Lighting products using the chips are expected to be available on the market as early Q3/2009.

Epistar has been developing AC-LED chips since 2004 and has filed more than 10 patent applications in related fields. In February 2008, the firm also licensed a patent for AC-LED technology from Taiwan's government-funded Industrial Technology Research Institute (ITRI), which has established a patent portfolio that includes design, processing, packaging and applications for AC-LEDs. On 3 October, ITRI teamed with 19 Taiwanese firms to create an 'AC LED Application Research Alliance', with the aim to "expedite new product development and promote this burgeoning market". Alliance members now number 22: Epistar, I-Chiun, China Electric, Kingbright, Lite-On Technology, Elsa, Keepertech, Chroma, Intematix, Neo-Neon, Upkey, Liquidleds, SCI, Lei Yueh, Tyntek, Forward Electronics, Lustrous, Everlight Electronics, Crystotech, Formosa Epitaxy, and Lastertech.

Epistar says that it is aware of the lighting industry's desire for a 'two-wire solution', i.e. a light engine without complicated electronics. The AC-LED concept simplifies system design by making the AC-DC converter redundant. For a conventional DC-driven LED design, the AC-DC converter introduces a conversion loss typically of 15-30%. Any reliability issues with the converter are also eliminated.

Epistar acknowledges that the luminous efficacy of an AC-LED is lower than that of a DC-LED at the same chip size. However, based on the cost saving from eliminating the AC-DC converter, Epistar is working

with a larger chip size, currently 55 mil per side (about 1.4mm). Many '1 watt class' DC-driven LEDs measure 1mm (40 mil) per side.

Epistar says that its AC-LED chip, when driven at 1W, has an efficacy of up to 70lm/W at a color temperature of 5700K. This is equivalent to a DC-driven LED with 85lm/W efficacy and a converter with 15% conversion loss, claims Epistar.

The company believes that both AC-LED and DC-LED technologies have their unique characteristics, and each will be suitable for different applications; AC-LED is best suited for LED spot lights with less than 10W power, such as MR16 or AR111 replacements. Meanwhile, DC-LEDs are suitable for high-brightness applications such as street lamps or automotive headlights.

Firms that are already supplying AC-LED products include, notably, Korea's Seoul Semiconductor, which makes power LEDs that can be connected directly to an AC source, and Lynk Labs, which makes AC-driven modules and light engines.

The AC LED technology developed by ITRI and Epistar appears to be superficially similar to that used by Seoul Semiconductor in its Acriche AC LED products. The chip is divided into a number of "micro-diodes", which are connected into two parallel strings. Current flowing in one direction illuminates the micro-diodes in one of the strings. When the current changes direction, the other string is illuminated.

Seoul Semiconductor has a large number of patents and more than 200 products in the field of AC LED technology, and may act to prevent other LED makers from entering the market. When Nichia and Seoul reached a cross-licensing agreement earlier this year, Seoul said the deal would allow it greater freedom to pursue other infringing firms, since its resources were no longer being diverted by its battle with Nichia.

www.itri.org.tw

IN BRIEF

PerkinElmer buys Opto Technology

PerkinElmer Inc of Waltham, MA, whose PerkinElmer Optoelectronics business unit supplies LEDs under its LED Solutions brand, has acquired Opto Technology Inc of Wheeling, IL, a supplier of LED-based lighting components and subsystems.

The acquisition adds optical subsystems to PerkinElmer's portfolio of high-brightness LED components for OEMs serving the health, safety and security markets. PerkinElmer's LED solutions are part of the company's Environmental Health business.

"The addition of Opto Technology expands PerkinElmer's presence in the solid-state specialty lighting market," says David Nislick, president of PerkinElmer's Illumination and Detection Solutions business.

www.perkinelmer.com

Harvatek boosting high-power LEDs

Taiwan-based LED packaging firm Harvatek plans to double its monthly capacity of high-power LEDs from the current level of 1.5 million units to 3 million units, according to Digitimes.

The proportion of Harvatek's revenues that consists of high-power LEDs is forecast to rise from 2% in 2008 to 8-10% in 2009. In both January and February the firm received orders of NT\$8-9m for LED lighting products, and orders for LED lightbars from European vendors are expected to be the main growth driver in 2009.

Harvatek has entered the supply chain of Apple and two Taiwan notebook vendors for side-view LEDs used in keyboard backlighting. The firm expects to start volume shipments in June.

www.harvatek.com

UK funds Cambridge–UCSB GaN LED lighting and photovoltaic development

Research Councils UK (RCUK) has announced £12m of new funding for the expanded Science Bridge Awards scheme.

The first Science Bridges awards were funded by the UK Government in 2006 to support existing collaborations between the UK and the USA by taking research results towards commercialization and undertaking proof-of-concept studies.

The latest funding is designed to foster research collaborations between 16 UK universities and leading academic and industrial institutions in not only the USA but also the emerging super-economies of China and India.

The ten RCUK Science Bridges awards approved this year include a £1.48m award over three years (from 1 March) for a project 'Harnessing Materials for Energy' between the UK's University of Cambridge and the University of California at Santa Barbara (UCSB). Colin Humphreys (professor of Materials Science at the University of Cambridge) is the project's principal investigator, while UCSB professor Tony Cheetham and the University of Cambridge's professor Sir Richard Friend, professor Ian White and Dr V Deshpande are the project's other investigators.

The aim is to progress existing research in the field of energy-related materials (from existing collaboration between the University of Cambridge and UCSB) through to prototype products and devices.

The multi-faceted collaboration involves developing new prototype products and devices including the following:

- high-efficiency organic and inorganic solar cells, including multi-layer stacks based on GaN/InGaN/Si for concentrating photovoltaic systems (with the GaN layer absorbing the ultraviolet part of the spectrum, the InGaN layer the blue and green, and the silicon layer the yellow, red and near-infrared, giving a theoretical efficiency of more than 60%).
- gallium nitride (GaN) white LEDs grown on 6-inch silicon wafers (instead of 2-inch sapphire wafers) in order to reduce costs by a factor of 10 for lighting applications (as well as researching ways to increase luminous efficiency) — the University of Cambridge will grow the LED structures, while UCSB will process the LED structures into lamps;
- novel phosphors with better color rendering for more natural-looking solid-state lighting, so that skin tones, the colour of clothes etc, look the same indoors and out (compared with existing blue LEDs coated with a yellow phosphor, which gives poor-quality cold-white artificial light that may be detrimental to health);
- organic light emitting diodes (OLEDs) for large-area applications in both displays and lighting;
- the low-cost integration of both LEDs and OLEDs onto printed circuit boards, reducing the cost of using LEDs and OLEDs; and
- ultralight cellular materials and structures (like a honeycomb or three-dimensional lattice) using both polymers and metals as well as composites (aiming to save energy when used in transportation systems such as cars, buses, lorries, trains and planes).

RCUK funding for the projects is being boosted by additional backing from the three partner countries involved, provided by the Indian Department of Science and Technology, the FCO Science and Innovation Network in the USA, and the Ministry of Science and Technology (MOST) in China.

"By working with international partners we can benefit from their expertise and get more value from our investment in the UK's world-class research community," says Lord Drayson, Minister of State for Science and Innovation. "The RCUK Science Bridges Awards are an

The ten RCUK Science Bridges awards approved this year include a £1.48m award over three years for a project 'Harnessing Materials for Energy' between Cambridge and UCSB

excellent example of how the UK is encouraging research which has both strong international collaborations and close links with business," he adds.

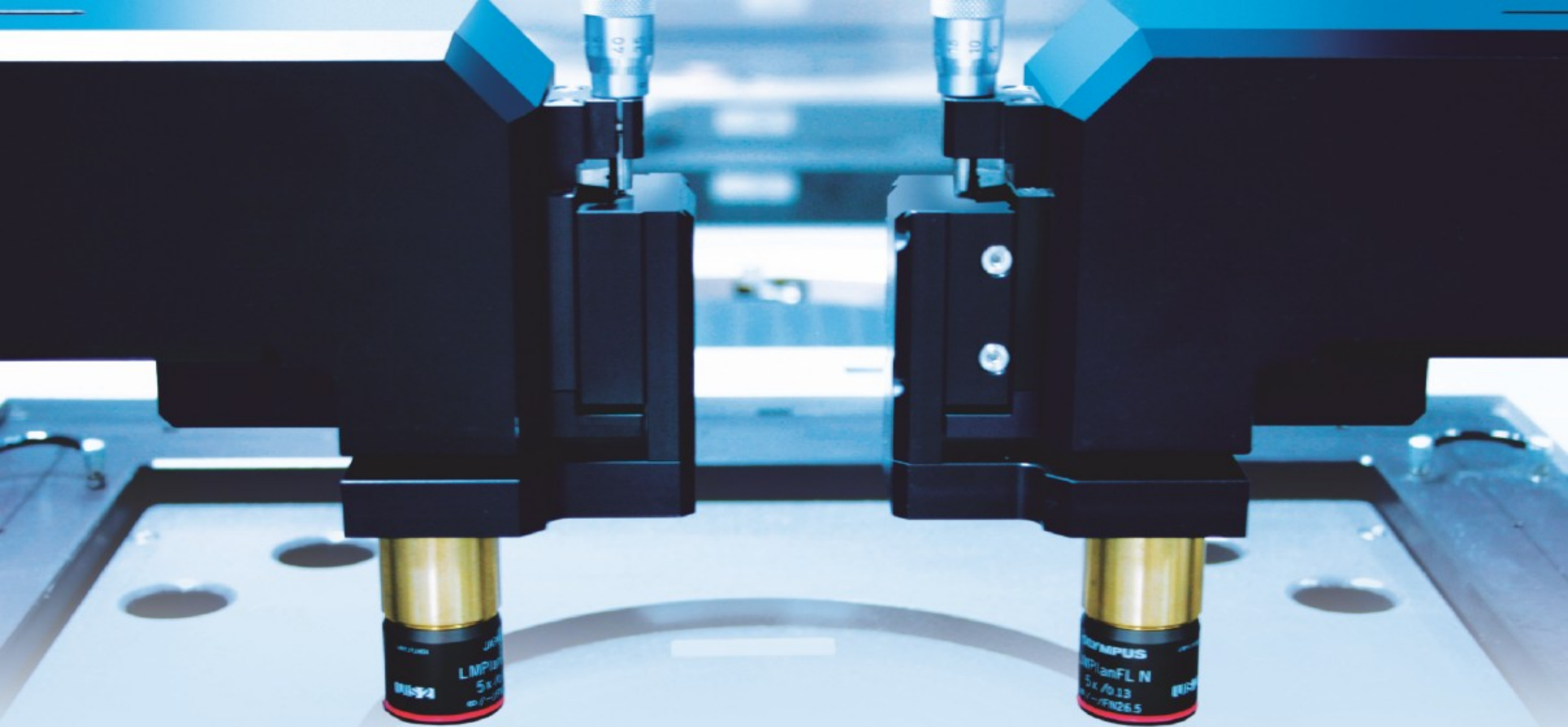
"The UK already participates in a huge amount of collaborative research globally, and we hope UK

businesses and the wider global community will reap the economic and environmental benefits arising from these research partnerships," comments RCUK's chair, professor Ian Diamond.

www.rcuk.ac.uk

<http://gow.epsrc.ac.uk>

www.msm.cam.ac.uk/GaN



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The key to your success

Multi-color LEDs for entertainment and architectural use

Luminus Devices Inc of Billerica, MA, USA is sampling two new PhlatLight LED modules, for volume shipment from second-quarter 2009. The four-color CBM-380-RGBW and three-color CBM-290-RGB modules are designed to enable next-generation solid-state lighting fixtures for entertainment and architectural lighting applications that require ultra-high lumens and dynamic color-changing.

Based on the PhlatLight (Photonic Lattice) LED large-chip architecture, the firm claims that the new modules are the industry's first multi-color LEDs with individually controllable color channels that can deliver light levels exceeding 2500 total lumens from a compact 6mm x 8mm optical footprint.

"The PhlatLight LED large-chip architecture shatters the current brightness limitations of solid-state lighting for the entertainment and architectural markets," says Dave Sciabica, general manager of Luminus Devices' Lighting Business Group. "For the first time, fixture manufacturers can provide lighting designers intense high-quality, well-mixed digital light without the annoying

color shadows that result from using hundreds of lumen-starved LEDs in over-sized fixtures."

The CBM-380-RGBW produces up to 2500 lumens from a light-emitting surface area of 38mm². With individual monolithic red, green, blue, and white die, it suits applications where a broad color gamut and superior color rendering are key, the firm says. The 6mm x 8mm optical source window allows the use of simple optics to eliminate the color shadowing and color mixing challenges that lighting designers typically face. The mechanical form factor is designed to support an array of tiled, replaceable modules, enabling fixture designers to scale the light output of their systems beyond 10,000–15,000 lumens.

The CBM-290-RGB has a total emitting surface area of 29mm², producing up to 1500 lumens of total output from a 6mm x 8mm optical source. With individual large red, green, and blue die, it suits applications that require dynamic color changing and homogeneous color mixing, but with slightly lower lumen output and color rendering index (CRI). It also eliminates the

color shadowing typically seen with multi-color, multi-LED arrays. The CBM-290-RGB has the same form factor as the CBM-380-RGBW, allowing for an array of tiled, replaceable modules and scalable system output.

Both the CBM-380 and CBM-290 come in a connectorized, thermally efficient package with standard mounting features that simplifies system design by eliminating the added cost of PCB design and assembly of LED arrays. Luminus Devices claims that both modules are simple to service and upgrade, even after the fixture has been installed. Compared to the alternative of using hundreds of smaller LEDs, their high single-source output increases system reliability and results in faster design and manufacturing cycles, it is reckoned. The additive color mixing characteristics of multi-color LED lighting systems also contributes to higher overall system efficiencies, translating into energy savings. PhlatLight LEDs are also mercury-free, highly reliable, and have a lifetime of 60,000 hours with lumen maintenance of greater than 70%.

www.luminus.com

Luminus launches 9mm² white LEDs emitting 1000lm at 10W

Luminus Devices has added the large-chip CST-90 white LED to its PhlatLight family of LED products, developed for fixture manufacturers in the general lighting industry.

The CST-90 comes in a connectorized chip-on-board package with standard mounting features (making it easy to integrate) and is simple to service and upgrade (even after the fixture has been installed).

"In a direct response to the growing needs of lighting fixture designers, the CST-90 white PhlatLight LED offers excellent system flexibility, reliability and efficiency," claims Dave Sciabica, head of Luminus Devices' Lighting Business Group.

Luminus has also launched the SST-90, a large-chip white PhlatLight LED in a new surface-mount (SMT) package designed for standard SMT assembly processes. "The SST-90 is a surface-mount package in a form factor that OEMs are familiar with and use regularly," says Sciabica.

Both the CST-90 and SST-90 are intended to enable lighting fixture OEMs to replace bulbs and LED arrays with a single large LED, resulting in simplified designs, lower costs and faster time-to-market.

The light-emitting surface of both the CST-90 and SST-90 is a single, monolithic die that is 9mm² in size. Also, a lens-based design allows for improved light extraction and

easy integration with standard optics, Luminus Devices says. Both LEDs produce 1000 lumens with 10W input (at 6500K), while at their maximum rated drive current the CST-90 produces 2750lm and the SST-90 produces 2250lm.

With a lifetime of 60,000 hours with lumen maintenance of greater than 70%, the LEDs are suited to general lighting applications, including architectural, retail and residential lighting as well as wide-area street and parking lot lighting.

Both the CST-90 and SST-90 will be available for sampling at the beginning of March, with production volume shipments starting in second-quarter 2009.

PhlatLight LEDs power Acer pocket projector and Chi Lin and Delta HD home theater projectors

Luminus also announced that ODM/OEM manufacturer Chi Lin Technology (a subsidiary of Taiwan's Chi-Mei Group) is bringing to market a new home theater projector that combines its PhlatLight LED PT-120 chipset and Texas Instruments' DLP technology to offer an expanded color gamut, high color and brightness stability, and what is claimed to be best-in-class reliability. Designed specifically for home theater projectors, the PT-120 chipset light source is expected to never need replacement.

Luminus also announced that its PT-120 chipset is the solid-state light source inside Delta Electronics Inc's HT-8000 — the industry's first full high-definition (HD) LED-based DLP projector for the consumer market (available in Q1/2009), which combines PhlatLight LEDs, Delta's optical engine technology and Texas Instruments' DLP capability.

"This new brightness breakthrough allows us to create lamp-free projectors delivering dramatically improved picture quality and superior reliability," claims Jeff Fu, director for Projection Display at Delta's Display Solutions business unit. "With this product, we believe the era of the HD LED



Acer's K10 pocket projector, incorporating a PhlatLight PT-39 chipset.

home theater projector has arrived. PhlatLight LEDs will continue to be a key component of our DLP product line."

Luminus also says that it has achieved brightness levels with its PhlatLight LED PT-39 chipset to power the Acer Inc's new K10 lightweight pocket projector. PhlatLight LEDs offer high levels of brightness and performance not available today in pocket projectors using traditional lamp technologies.

The PT-39 chipset is designed specifically for projection systems that use micro-displays ranging from 0.4" to 0.55" with individual red, green and blue LEDs and work in conjunction with Texas Instruments' digital light processing technology. The combined technologies enable PhlatLight LEDs to work

more efficiently in the Acer K10, suiting a mobile projector.

The K10 is Acer's first projector to use PhlatLight LED technology, and emits a high brightness of up to 100 ANSI lumens, says Victor Chien, director of Acer's Digital Display business unit. "As part of Acer's continued drive to offer greener and more environmentally friendly products, LED lamp technology is free from hazardous substances such as mercury or halogen gases and consumes less power than traditional lamps," he adds.

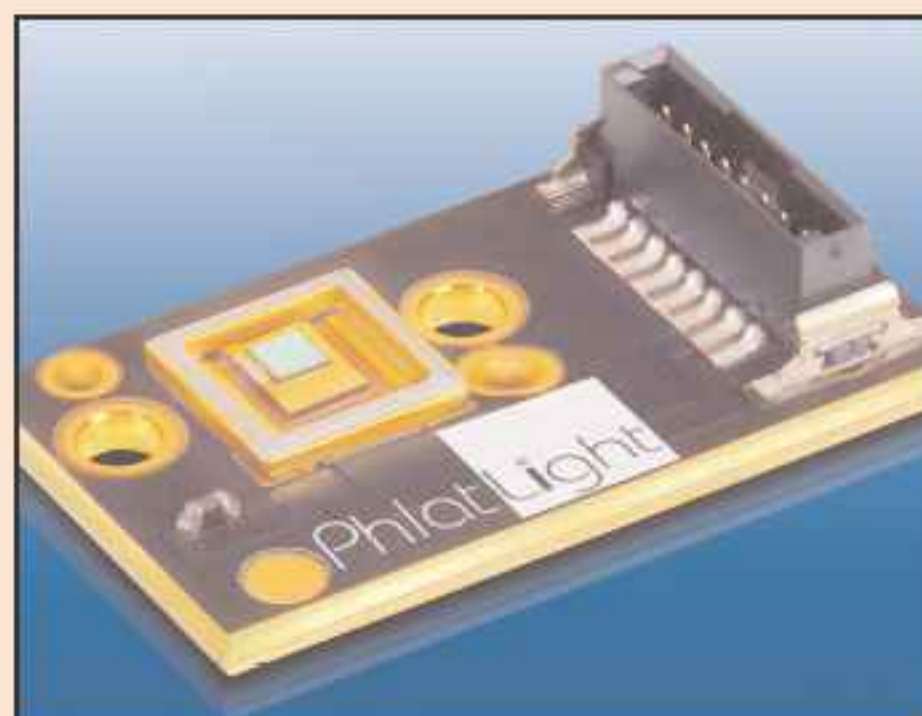
Luminus displayed the Acer K10 at January's CES'09 Consumer Electronics Show in Las Vegas, NV, USA, together with the new Delta Electronics HT-8000 and Chi Lin home theater projectors.

www.luminus.com

PhlatLight LEDs being used in BenQ pocket projector

Luminus Devices says that BenQ's new GP1 versatile and lightweight pocket projector is powered by its high-brightness PhlatLight LED PT-39 chipset. The firm claims that its PhlatLight (Photonic Lattice) LEDs offer high levels of brightness and performance that are currently not available in pocket projectors using traditional lamp technologies.

PhlatLight LEDs work in conjunction with Texas Instruments' digital light processing (DLP) technology, and the combined technologies enable PhlatLight to work more efficiently, making the projector



Luminus' PhlatLight PT-39 chipset.

suitable for business travelers and other mobile system users (e.g. gamers). The PT-39 chipset is

designed specifically for projection systems that use micro-displays ranging from 0.4" to 0.55" with individual red, green and blue LEDs.

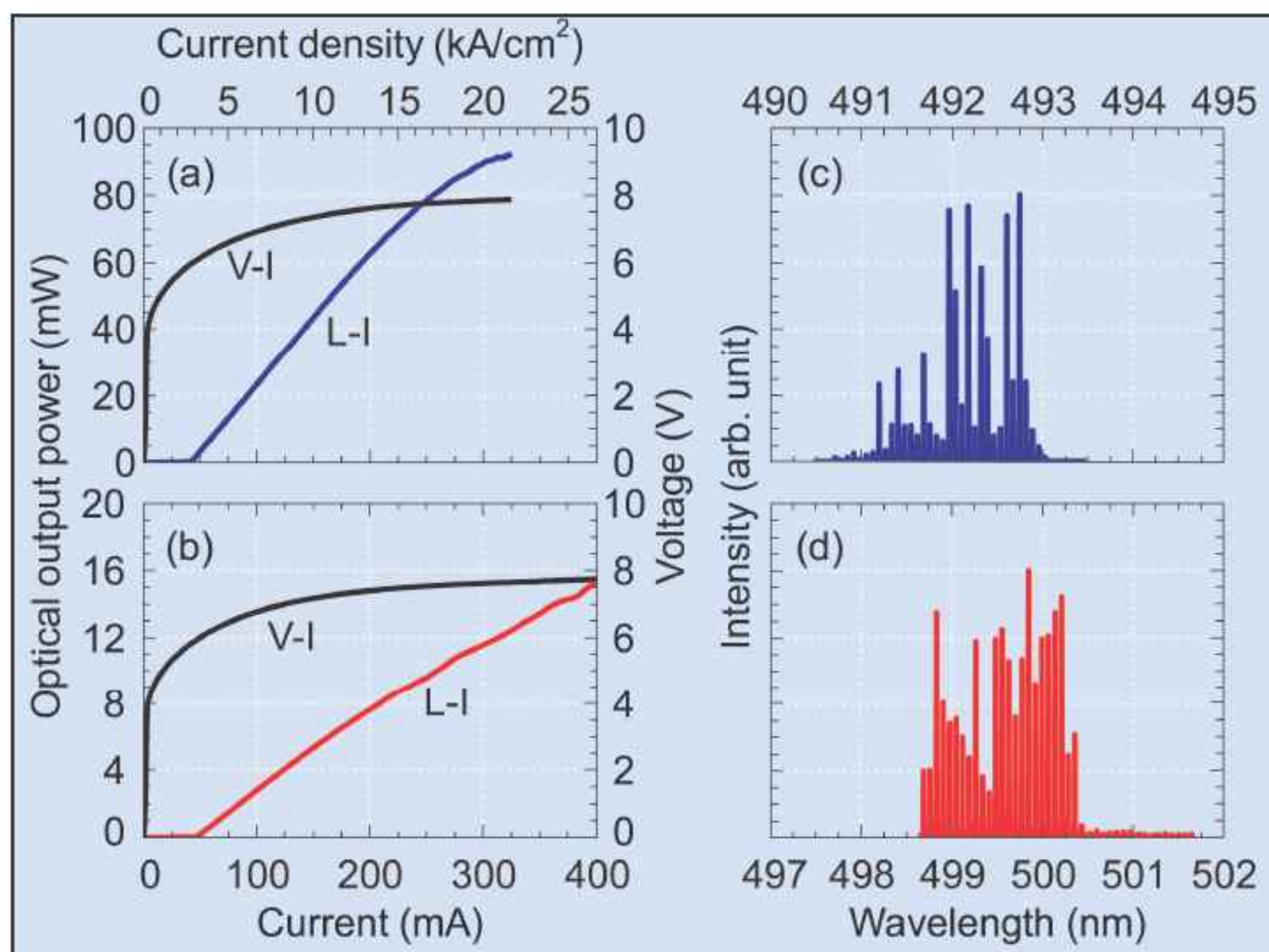
"BenQ is revolutionizing the pocket projector industry, and award-winning PhlatLight LEDs are a key in providing our customers with the industry's best products," says Po Su, marketing director at BenQ America. "Our next-generation pocket projectors are flexible, making them ideal for multiple applications like home movies and gaming, as well as meeting room demos and mobile business presentations."

Non-polar InGaN lasers near green light

Scientists at Rohm Co Ltd's R&D headquarters in Kyoto, Japan have extended the wavelength for continuous wave (CW) operation of indium gallium nitride (InGaN) laser diodes (LDs) [Okamoto et al, *App. Phys. Lett.*, vol.94, p071105, 2009]. The researchers claim that the 499.8nm (near-green) CW lasing wavelength is the longest reported for such devices. Previously, Rohm reported a 481nm blue-green laser last June followed by a 488nm laser in October, while Japan's Nichia Corp had reported a 488nm blue-green laser in January 2008. Among the possible applications of laser diodes emitting at green wavelengths (i.e. 490–560nm), when commercialized, could be full-color displays and mobile projectors.

The Rohm team grew the laser diodes on free-standing m-plane wurtzite GaN substrates (supplied by Mitsubishi Chemical) using low-pressure metal-organic chemical vapor deposition (MOCVD). By growing in the m-plane direction, rather than the more usual c-plane, the devices avoid the large polarization electric fields that arise from the different effective charges (ionicity) of the group III elements (Ga, Al, In) and nitrogen in the wurtzite lattice. Such large polarization fields shift the energy band levels of the carriers in heterostructures through quantum-confined Stark effects (QCSEs). Such fields also make it difficult to set up the electrical conditions needed for lasing.

The Rohm laser diode structures consisted of a sequence of layers of n-type GaN, n-type AlGaIn (cladding), n-type InGaIn (waveguide), a two-period InGaIn multi-quantum well (active), p-type AlGaIn (electron blocking), p-type InGaIn (waveguide), p-type AlGaIn (cladding), and p-type GaN (contact). Ridged stripes were etched out to form the laser structures (bottom width: 2.5µm). A ZrO₂ insulator was used. The cavities were 600µm in length. Cleaving



Output power (L-I, left scale) and voltage (V-I, right) performance with respect to current for the two Rohm InGaN devices — LD70 (a) and LD97 (b) — with respective spectra (c and d).

along the c-plane was used to form the mirror facets. A sputtered dielectric was used to create front and back mirrors. The back mirror was 99% reflective but two different reflectivities were used for the front mirror (70% and 97%) to investigate the role of self-heating in LD performance.

For comparison, devices with similar threshold currents were chosen for detailed testing. The device with a 70% front mirror (LD70) had a threshold current of 42mA (density 2.8kA/cm²), threshold voltage of 5.9V, and a slope efficiency for producing

Previously, Rohm reported a 481nm blue-green laser last June followed by a 488nm laser in October, while Japan's Nichia Corp had reported a 488nm blue-green laser in January 2008

laser emission of 0.4W/A. The figures for LD97 were 46mA (3.1kA/cm²), 5.9V, and 0.05W/A, respectively. The maximum output powers for LD70 and LD97 were 92mW and 15mW, respectively. These come in well above the 5mW output of c-plane blue-green LDs. Spectral measurements showed the peak wavelengths of LD70 (operated at 30mW) and LD97 (15mW) to be 492.8nm and 499.8nm, respectively. Many sharp peaks are seen in the spectrum.

By comparing the wavelength shift from CW and pulsed operation, the researchers determined that self-heating effects lead to a red-shift of the emission. Band-filling effects — where as the numbers of carriers in the active region increase they become effectively more separated in energy — would lead to higher-energy photons, and hence to a blue-shift in the spectrum.

Author: Mike Cooke
<http://apl.aip.org>
www.rohm.com

Osram claims first 500nm InGaN laser

Osram Opto Semiconductors GmbH of Regensburg, Germany has demonstrated what is reckoned to be the world's first indium gallium nitride (InGaN) laser with an emission wavelength of 500nm (blue-green) — the longest wavelength reported for a GaN-based laser diode in pulsed operation (Queren et al, '500nm electrically driven InGaN based laser diodes', Appl. Phys. Lett. 94 (2009), 081119).

Osram Opto's latest laser structure was grown on a c-plane GaN substrate. By comparison, the longest reported emission wavelengths for InGaN lasers grown on non-polar (m-plane) GaN substrates are about 490nm in pulsed operation and 499.8nm in cw (continuous wave) operation with a high junction

temperature (reported by Japan's Rohm Co Ltd in February).

Osram Opto has been working since 2006 on developing blue InGaN laser diodes with high wall-plug efficiencies. At the Photonics West 2009 event in late January, the firm announced its first blue InGaN laser product (emitting at a wavelength of 450nm with a power output of 50mW and efficiency of 0.9W/A, and to be launched commercially in April for consumer applications such as mobile miniature projectors).

The 500nm lasers have been achieved through recent improvements in the growth of indium-rich InGaN quantum wells

The latest development is based on Osram Opto's efforts to further improve the performance of its blue laser diodes and to tune the InGaN-based devices to emit at longer, blue-green wavelengths. Specifically, the 500nm lasers have been achieved through recent improvements in the growth of indium-rich InGaN quantum wells with low defect densities. Also, the devices were processed as broad oxide-insulated stripe laser diodes. The consequent combination of low threshold current density and high slope efficiency enables high output powers of up to 70mW, says Osram.

The latest research has been funded partly by the German Federal Ministry for Education and Research (BMBF).

www.osram-os.com

Lumics launches 300W laser for industrial applications

Lumics GmbH of Berlin, Germany has launched a 300W laser emitting at 9xx nm wavelengths, with a robust laser head designed to provide flexibility for various heavy-duty industrial applications such as welding, soldering or cutting.

The laser is based on individual, hermetically sealed, single-emitter diode lasers packed in an industrial sealed housing on a small footprint, for integrated systems or machines. The overall design is fiber based, involving no free-space optics. Besides the benefit of the ultra-long diode lifetime, there are no epoxy-glued elements to degrade laser performance.

The laser is actively cooled by tap water. No micro-channels (for deionized water) are necessary. A red pilot beam, monitor diodes and thermistors provide all necessary process feedback information. The output fiber is 800µm in diameter and terminated by a high-power connector.

www.lumics.com

Lumics extends medical laser module family to 30W and 40W

Lumics, which manufactures single-emitter diode lasers (single- and multi-mode) as well as systems for the telecom, materials processing and medical markets, has followed last November's launch of its 10W 808nm and 980nm Med-Laser with a second wave of medical laser modules with power outputs of 30W and 40W at wavelengths of 808, 940 and 980nm.

The firm says that the new lasers should open up new opportunities for OEM clients and their customers in dental, dermatological, veterinary, and health applications.

As in the medical laser module, the new higher-power lasers are fully equipped with a thermistor, monitor photodiodes, output fiber detector, and red pilot beam (as required by law).



Lumics' 30–40W medical laser module.

The form factor is small (fitting into portable units) and hermetically sealed.

The fiber output can be chosen between 200µm and 400µm, with a connector of the customer's choice.

Lumics also plans to introduce a 70W version of the laser module later this year.

OneChip secures \$19.5m in VC funding for InP PICs

The privately held firm OneChip Photonics of Ottawa, Canada has secured \$19.5m in venture capital financing from Canadian and US investors, including BDC Venture Capital, DCM, GrowthWorks Canadian Fund and Morgenthaler Ventures. The funding should enable the firm to expand its operations globally and deliver what it aims to be the only fully integrated fiber-to-the-home (FTTH) transceiver technology on the market (providing higher performance than competing solutions at significantly lower cost).

OneChip develops and makes optical transceivers based on monolithic photonic integrated circuits (PICs) fabricated in indium phosphide (InP) for access networks and other mass-market broadband applications. The firm reckons that its technology can remove cost and performance barriers that have been impeding the ubiquitous deployment of FTTH and enable new business and consumer broadband applications. OneChip is developing transceivers for optical network terminals (ONTs) and optical line terminals (OLTs) in Ethernet passive optical networks (EPONs) and Gigabit passive optical networks (GPONs).

"OneChip is well positioned to help system providers and carriers deploy FTTH more cost-effectively than ever before — and meet consumer and business demand for high-bandwidth voice, data and video services," reckons CEO Jim Hjartarson.

"OneChip is one of only a few companies with new core intellectual property and advanced technology in the optical transceiver business that can sustain a competitive advantage over other optical component providers, which rely on conventional technology and assembly processes," he adds.

Most current FTTH transceiver providers base their transceivers on either discrete optics or planar light-wave circuit (PLC) designs, which offer low levels of integration and require assembly from multiple parts. There is little technical differentia-

tion among them, says OneChip. Rather, vendors must compete on the basis of who can assemble the parts in a slightly cheaper fashion, and there is little opportunity to further reduce such costs.

"Carriers and system providers recognize that an approach that would eliminate assembly from multiple parts is needed to lower the cost and improve the performance of transceivers and ONTs in optical access networks," says Dr Lynn Hutcheson, VP of communication components at analyst & consulting firm Ovum.

OneChip's PIC technology monolithically integrates all the functions required for an optical transceiver onto a single InP-based chip. All active and passive components of the chip — including the distributed-feedback (DFB) laser, optically pre-amplified detector (OPAD), wavelength splitter (WS), spot-size converter (SSC), and various elements of passive waveguide circuitry — are, uniquely (it is claimed), integrated in one epitaxial growth step, without re-growth or post-growth modification of the epitaxial material.

With respect to transmit performance, the single-frequency DFB lasers can offer performance that is more suitable for longer-reach and higher-bit-rate applications than competing Fabry-Perot (FP) lasers, it is claimed. With respect to receive performance, the OPAD design is a higher gain-bandwidth solution than competing avalanche photodiode (APD) solutions, as well as being lower cost (as it does not require a high-voltage power source), the firm claims.

As well as its monolithic PICs having a small footprint, OneChip says that the optical parts are aligned for life and are highly robust

(resistant to vibration and other outside elements). Further, the PICs are designed for automated mounting on a silicon optical bench, without requiring active alignment, using industry-standard, automated assembly processes — resulting in high yields of good devices.

In addition, the firm says that, by using automated production processes, it can maintain high production scalability and respond rapidly to demand. Standard production processes also provide reliable supply, it adds.

"OneChip's fully integrated technology can help unleash the potential of FTTH and other mass-market optical communications applications," says Hutcheson.

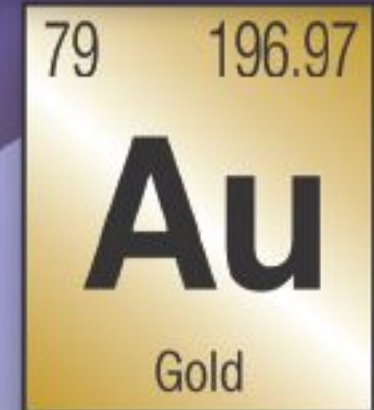
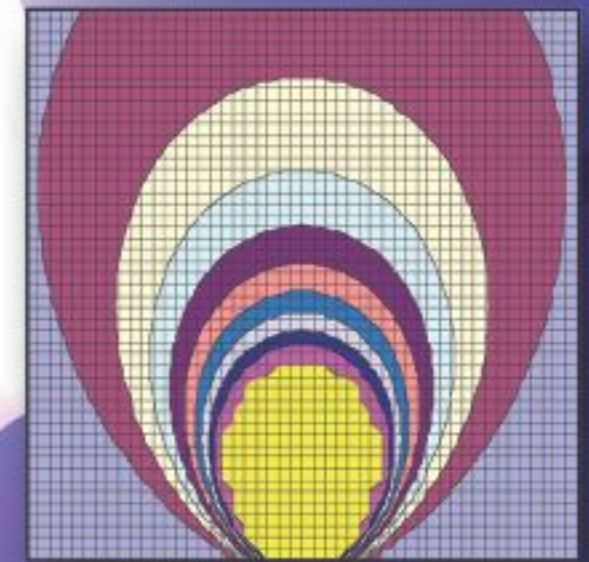
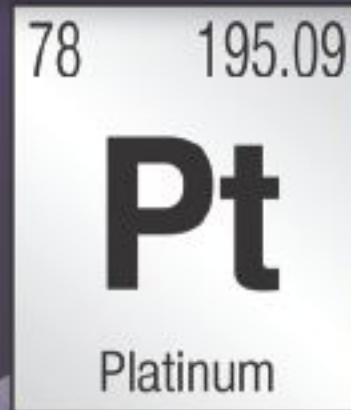
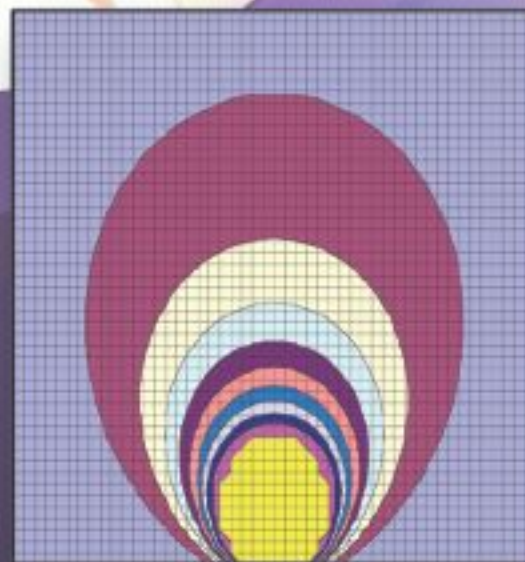
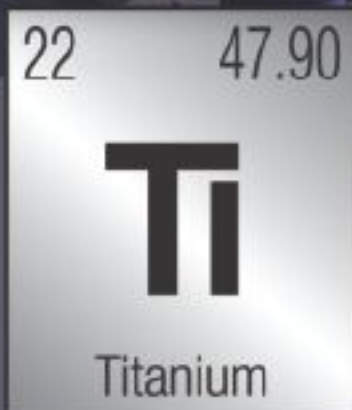
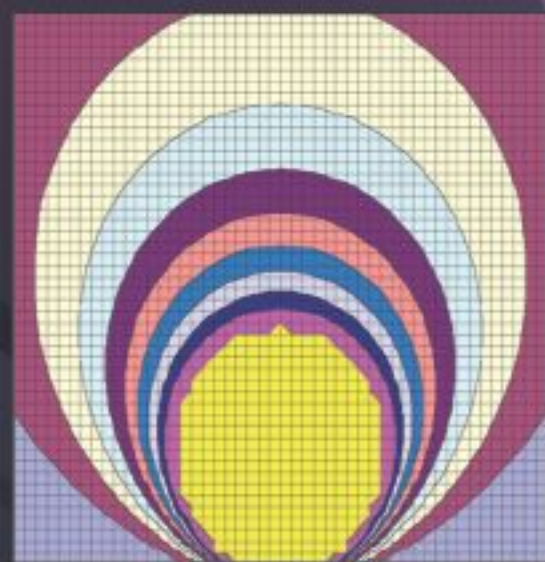
There is tremendous potential for FTTH to become widespread in access networks in the next three years, reckons Ovum. It forecasts that the number of FTTx subscribers — including fiber-to-the-home (FTTH) and fiber-to-the-building (FTTB) subscribers — will increase from about 48 million by the end of 2009 to more than 100 million by the end of 2012. FTTx broadband users comprise about 8% of all broadband users currently, and should rise to about 16% by 2012, forecasts Ovum. OneChip believes that its technology will strengthen the business case for broader deployment of FTTH worldwide, and enable it to claim a significant share of the FTTx optical transceiver market, which Ovum estimates will grow from \$387m by the end of 2009 to \$594m by the end of 2013.

OneChip says that it also recognizes that optical communications are becoming economically and technologically mandatory in areas outside traditional telecommunications. The firm is therefore poised to introduce photonics integration into other high-volume business and consumer markets, reckoning that its PIC technology can also reduce costs and improve performance in those domains.

www.onechipphotonics.com

OneChip's PIC technology monolithically integrates all the functions required for an optical transceiver

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Finisar's sales fall 14.5% after December's drop in orders

After reporting preliminary results on 4 February, fiber-optic subsystem and network test system maker Finisar Corp of Sunnyvale, CA, USA has confirmed revenue for its fiscal third-quarter 2009 (ended 1 February) of \$136.4m. Though up 20.9% on \$112.7m a year ago, this is due mainly to the merger of optical subsystem maker Optium Corp of Horsham, PA (completed on 29 August); excluding Optium, revenue from traditional Finisar products was down only 5% on a year ago. Total revenue is down 14.5% on \$159.5m last quarter. In particular, Optium revenues have fallen from \$41.5m to about \$30m.

The impact of the recession has been greatest in telecoms, says chairman, president & CEO Jerry Rawls. After record revenue for both Finisar and Optium for the quarter to end-July 2008 before the firms' merger (\$176m collectively), fiscal Q3's \$136.4m is down 22.5% in just two quarters, with IT enterprise-related revenues down 17% and telecom-related revenue down 37%.

Of total revenue, Network Test tool sales of \$10.3m were up 5% on \$9.8m a year ago but down 12.6% on \$11.8m last quarter.

Optics revenues of \$126.1m were up 22.5% on \$103m a year ago (due mainly to the Optium merger), but down 14.7% from \$147.7m last quarter. In particular, analog and cable TV revenues were \$3.3m (level with last quarter, albeit down 53% on revenues realized by Optium a year ago). Metro and telecom revenues of \$69.4m are down 14.4% on last quarter. Even the data storage sector saw weakness in the midst of a 'deer in headlights' response by many IT departments as they seek to recalibrate their plans for investment this year, says Rawls. Local-area network (LAN) and storage-area network (SAN) revenues of \$53.4m are down 15.7% on last quarter (with a 19% drop for sub-10Gb/s applications

offset by slight growth for 10Gb/s applications).

Almost half of the \$21.6m drop in Optics revenue (\$10.3m) was due to lower revenues for short-reach sub-10Gb/s LAN and SAN applications. Though up 68.5% on \$29.1m a year ago, sales of products for 10–40Gb/s applications fell by 9% (\$5m) to \$49.1m. Sales of reconfigurable optical add-drop multiplexer (ROADM) products declined by \$2.6m. The remaining \$3.7m drop was due to metro, telecom and CATV products. In contrast, revenue from 10 Gigabit Ethernet LAN and 4 Gigabit SAN applications actually rose sequentially.

Following a charge of \$178.8m last quarter for the impairment of goodwill (related mainly to the Optium merger), Finisar recognized a further goodwill write-down of \$46.5m (in conjunction with the continued deterioration in the macroeconomic environment and a consequent reduction in the firm's market capitalization).

Excluding such charges, non-GAAP net income was \$2.3m, down from \$10.3m last quarter. During the quarter, cash and short-term investments (plus other long-term investments that can be readily converted into cash) fell from \$51.9m to \$35.3m.

Finisar says that demand is being impacted by some customers reducing their inventory levels on top of a decline in end-user demand. For its fiscal fourth-quarter 2009 (ending 30 April), continuing softness in orders will most likely result in a further 6–15% drop in revenue to \$115–128m (\$9m for Network Test tools and \$106–119m for Optics, again down mainly due to sub-10Gb/s LAN and SAN applications).

However, the weakness appears to be concentrated at a small number of customers, says Rawls. In particular, revenue for 10Gb/s applications will be down only about 5% as demand continues to

be more robust than for other segments, while revenue for short-reach 10 Gigabit Ethernet applications should actually rise for a second consecutive quarter. "Many of the postponed IT projects will get started in the next couple of quarters, as the underlying premise for making that investment is mostly unchanged," Rawls says.

He adds that, after the tech bubble burst in the previous telecoms slump of first-quarter 2001, Finisar's revenue fell by 47% in two quarters (much more rapid than the current slump) and then began to rise again shortly afterwards (before growing 20% annually through fiscal 2008). "It takes at least two quarters before you can touch the bottom and any sort of correction," he reckons. "Given that the economic downturn didn't become visible to us until the very end of our second quarter, which ended in October, we think the upcoming quarter ended 30 April probably marks the low point of this correction... We saw orders at a much diminished rate in December. They came back a little bit in January, but have recovered quite nicely in February and even this week," he adds.

Also, Finisar is more highly diversified than it was in 2001 and the industry supply chain carries less inventory thanks to the proliferation of adjusting time inventory hubs at many customers, notes Rawls. "In some ways, we think that we're better off this time around." Rawls expects a return to revenue growth in the quarter to end-July 2009.

Furthermore, despite the difficult economic environment, Finisar has made progress in qualifying new products at a number of customers. In the 4 February revenue announcement, Finisar noted that it continues to make progress with respect to customer qualifications of new products. In addition to those mentioned on 4 February, these also include:

- wavelength-selectable switch (WSS) 50GHz and 100GHz products with four customers;
- a pluggable tunable 10Gb/s transponder with two customers; and
- a cable TV (CATV) low-cost 1310nm transmission product with one customer.

In addition, Finisar is pushing hard to get new products developed and qualified, says Rawls. At the Optical Fiber Communication event (OFC 2009) in San Diego in late March, the firm demonstrated a new 120Gb/s parallel optical solution (while starting to deliver samples to customers) as well as a new 100 Gigabit Ethernet optical link, 16 Gigabit Fiber Channel link, and a 43Gb/s DQPSK transponder for telecom applications.

"We continue to make progress in terms of reducing costs," says CEO Eitan Gertel. On 4 February, Finisar reported cost-reduction actions that are expected to yield annual savings of \$44m. About \$24m has now been realized, including: staff reductions of about 200 (17% of the workforce, excluding operations in Malaysia and Shanghai); salary

reductions of 10% for officers, directors and most staff, starting in February; and a suspension of 401(k) matching company contributions. "With the reductions we have already realized, our non-GAAP EBITDA [earnings before interest, taxes, depreciation and amortization] exceeded \$11m in the most recent quarter [down

We are already evaluating additional savings that will accrue as a result of a number of R&D projects

from \$20m last quarter, but still in excess of capital expenditure requirements, which fell to \$5.1m]," he adds. CapEx should continue to fall over the next couple of quarters. In fiscal Q4, EBITDA should be \$7-8m (still in excess of CapEx requirements, which should fall to \$4m or less).

"Combined with the additional cost reductions that we have put in place for the fourth quarter [yielding \$8m in annualized OpEx savings], we should be in a good position to weather any near-term

weakness in our top line," says Gertel. Combined with a further reduction in inventory, the cash position at the end of the current quarter should stay level or even rise.

Other cost-reduction actions that should benefit the firm starting in fiscal first-quarter 2010 (ending 2 August 2009) include the transfer of certain product manufacturing to the firm's lower-cost off-shore locations. "We see a lot of what used to be Optium products made in the West going into our locations overseas," says Gertel (long term, most, if not all, manufacturing is going to be in Malaysia and China, he adds). Hence the remaining \$12m of the \$44m in annual savings should be realized by the fiscal second-quarter 2010 (ending 1 November 2009).

"We are already evaluating additional savings that will accrue as a result of a number of R&D projects that will enable us to manufacture certain components internally versus paying a higher price for those components in the merchant market," says chief financial officer Stephen Workman.

www.finisar.com

NTT divests InP chip division to Optrans Japan

Kawasaki-based Optrans Japan Corp, which makes optoelectronic assemblies and components (including LEDs and photodetectors), has acquired the operations and patented technology of the specialty microchip division of Nippon Telegraph and Telephone Advanced Technology (NTT-AT). The move comes as a result of NTT-AT (a subsidiary of NTT, the largest telecoms company in Asia) opting to focus on its software segment.

Supported by Japan's New Energy and Industrial Technology Development Organization (NEDO), NTT-AT has developed epitaxial crystal manufacturing growth technology, and has been researching the feasibility of manufacturing ultra-high-speed indium phosphide (InP) microchips in volume, with the goal

of reducing the price and broadening applications for the technology.

Founded in 1987 by president Katsuya Homma, Optrans Japan says that it was chosen to acquire the specialty microchip division on the basis of its manufacturing expertise, R&D, and possession of a key patent required for the mass-production process that would hasten its commercialization. NTT-AT has transferred the division to Optrans together with its research, prototypes, patents, laboratory staff, and customers. Initial production will begin in Japan as early as spring 2009, says Homma.

The InP chips being manufactured by Optrans have a wide range of applications, particularly in telecoms and satellites. To date, InP

microchips have been used primarily in the defense industry, where price is less of a limitation. However, Optrans' target is to manufacture 12,500 wafers annually by 2010. Such a mass-production level is projected to reduce costs by two-thirds, opening up new applications in telecoms, transportation and other industries.

The firm says that, compared to lower-cost microchips currently in use, InP chips can dramatically increase the reliability and speed of fiber-optic networks and satellite-to-ground transmission, improve the accuracy and speed of light-sensor reaction, and have other potential applications including rear collision sensors in automobiles.

www.ntt-at.com

www.optrans.com/english

Bookham launches 600mW pump laser module in 80% smaller package

Optical component and module maker Bookham Inc of San Jose, CA, USA has made available samples of what it claims is the first cooled small-form-factor, Mini-DIL pump laser module for network amplifiers, as well as the most powerful wavelength-locked single-mode Mini-DIL pump laser available (capable of delivering over 600mW of power). The module will reach full qualification by the end of Q1/2009.

The module delivers all the performance and functionality of a 14-pin butterfly pump in a package that is 80% smaller, while also reducing power consumption by 10%. The new product enables amplifier designers to reduce the size of low-noise EDFAs, DWDM amplifiers, amplifier modules and cable TV (CATV) amplifiers. Bookham says that the 600mW Mini-DIL module also helps telecom equipment vendors to lower overall system energy consumption and to reduce running costs in the face of rising utility prices and increased environmental pressures.

"Similar pump modules that compete with this product are in 14-pin butterfly packages that are five times the size of this new high power module," claims Mark Ives, director of product management. "This major size reduction allows telecom equipment vendors to save real estate within amplifiers and linecards, and to reduce the size and running costs of the facilities that house them," he adds. "The potential energy and cost savings enabled by this development will be hugely disruptive."

The module has a wide operating temperature of -20° to $+75^{\circ}$, is Telcordia and RoHS compliant, and uses the same scalable and proven base alignment technology as other Bookham telecom pump lasers, including the 750mW Ultra high-power single-mode pump laser module, and the OceanBright submarine pump laser module. The 600mW Mini-DIL pump laser module incorporates the Bookham G08 chip, which has now achieved a combined total of over 300 million field hours.

www.bookham.com

Avanex discloses going concern qualification

Optical communications component and module maker Avanex Corp of Fremont, CA, USA says that its financial statements for the fiscal year ended 30 June 2008 (included in the registration statement of proposed merger partner Bookham filed with the Securities and Exchange Commission on 26 February) contain a going concern qualification from its independent registered public accounting firm.

However, this does not change the firm's financial statements or its most recent annual and quarterly reports.

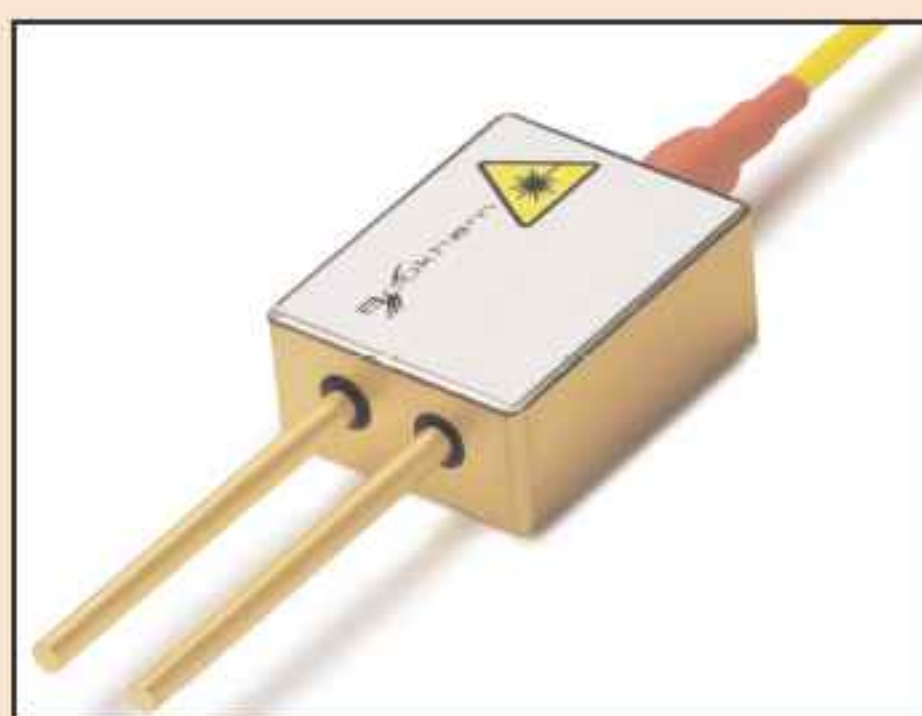
In its fiscal second-quarter 2009 (to end-December 2008), Avanex made a net loss of \$16.8m (on revenues down 16% sequentially from \$45.3m to \$38m) and cash reserves and investments fell by \$12.4m to \$37.3m. For fiscal Q3/2009 (ending 31 March), the firm expects revenue to fall an even greater 18-37% to just \$24-31m. The targeted breakeven run rate is \$46-48m in quarterly revenue.

www.avanex.com

Bookham launches 6 Watt 808nm single-emitter module

Bookham has expanded its portfolio of 808nm single-emitter products with the launch of a module that delivers a minimum of 6W from a 200 μ m core fiber. The new module is designed to provide the power and reliability required for all solid-state and direct diode laser systems, particularly Nd:YAG pumping and medical, analytical and printing applications.

The new product is built on Bookham's proven platform for single-emitter fiber-laser pump modules, enabling high-volume, cost-effective manufacturing. Devices are available as a chip-on-submount or chip-on-C-Mount. The 808nm single-emitter chip can also be integrated into the multi-emitter package to achieve further



Bookham's new 6 Watt 808nm single-emitter module.

increased power output levels.

The RoHS-compliant module is hermetically sealed and incorporates a floating anode and cathode. It includes a multimode laser diode chip with E2 front-mirror passivation to prevent catastrophic optical

damage (COD) to the laser diode facet even at very high power levels. The coupling process allows for high output powers that are very stable with both time and temperature.

"The continued progression in power output and reliability of our 808nm single-emitter portfolio increases the number of markets that we can target, without needing to introduce new manufacturing processes," says Gunnar Stolze, director of High Power Laser marketing & sales. "As photonic technologies continue to grow in importance across a wide range of applications and industries, we are positioning ourselves to meet the varied demands of many customers while ensuring that we are competing on cost."

ITC to probe Avago allegation of patent infringement by Emcore

The US International Trade Commission (ITC) has voted to institute an investigation based on a complaint filed on 3 February by Avago Technologies of San Jose, CA against Emcore Corp of Albuquerque, NM, USA.

The complaint alleges violations of Section 337 of the Tariff Act of 1930 in the importation into the USA and sale of certain optoelectronic devices, components, and products containing them that infringe Avago's US patent numbers 5,359,447 and 5,761,229. Avago requests that the ITC issues Emcore with an exclusion order and a cease and desist order.

The ITC has not yet made any decision on the merits of the case. The ITC's chief administrative law judge will assign the case to one of

its six administrative law judges (ALJs), who will schedule and hold an evidentiary hearing. The ALJ will then make an initial determination as to whether there is a violation of Section 337; that initial determination is subject to review by the ITC.

Within 45 days after instituting the investigation, the ITC will set a target date for completing the investigation. It aims to make a

Avago requests that the ITC issues Emcore with an exclusion order and a cease and desist order

final determination in the investigation 'at the earliest practicable time'.

ITC remedial orders in Section 337 cases are effective when issued and become final

60 days after issuance, unless disapproved for policy reasons by the US Trade Representative within that 60-day period.

Prior to this latest complaint against Emcore, a lawsuit regarding these patents had previously been filed by Avago in the Delaware district court in 2006 against Finisar Corp.

In addition, before that (in 2000), Avago's predecessor Agilent Technologies filed lawsuits in the Delaware district court against both 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.usitc.gov

Emcore awarded patent for active optical cable technology

Emcore Corp of Albuquerque, NM, USA, which manufactures components and subsystems for the broadband, fiber-optic, and solar power markets, has received a patent award for its active optical cable technology. US patent no. 7,494,287 B2 covers all fiber-optic active cable applications and is believed to be fundamental to current and future market segments and platforms related to data communications links between information systems, says the firm.

Existing high-speed data communications networks use optical fiber cables for data transmission between information system units such as computer clusters, mass data storage devices, and routers. Typical systems communicate via electrical host adapters that, when connected to electro-optical transceivers mated with an optical fiber cable, enable high bandwidth, low latency, lightweight and improved airflow data networks.

According to the Active Optical Cables Market Study 2009 by Information Gatekeepers Inc, overall cumulative cable revenue from 2009 through 2013 is expected to exceed \$8.5bn, representing a cumulative total of 1040 million meters of cables for the five years.

"Emcore previously announced supporting IBM's use of 55 miles of our active optical fiber for the world's first petaflop super-computer," says Stephen Krasulick, executive VP & general manager of Emcore's Fiber Optics Products division.

For next-generation 40Gb/s and greater bandwidth applications we expect active optical cables to replace copper cables and become the dominate connect solution

"For next-generation 40Gb/s and greater bandwidth applications we expect active optical cables to replace copper cables and become the dominate connect solution," Krasulick adds.

The firm currently sells in high volume the Emcore Connects Cables (ECC) product platform for high-performance InfiniBand interconnects that operate at high-speed 20Gb/s data rates. Emcore is also sampling next-generation 40Gb/s data rate cables to major OEMs.

Emcore demonstrated the new 40Gb/s ECC at the Optical Fiber Communication Conference and Exposition/National Fiber Optic Engineers Conference (OFC/NFOEC 2009) in San Diego, (24-26 March). Emcore Connects Cables currently support 40Gb/s quad data rate (QDR), 20Gb/s double data rate (DDR) and 10Gb/s single data rate (SDR) and are available in lengths of 1-100m.

www.emcoreconnects.com

Amonix replaces silicon with III-Vs for new CPV system

At the Renewable Energy World Conference and Exposition in Las Vegas, NV (10–12 March), Amonix of Torrance, CA, USA demonstrated its latest concentrating photovoltaic (CPV) system, which has replaced the 27.6%-efficient silicon cells in the firm's previous-generation systems with 37%-efficient III-V-based multi-junction cells, yielding 30% module efficiency. This has produced what is claimed to be the first CPV system with a solar energy conversion efficiency of 25% (AC, post-inverter).

The Amonix 7700 High Concentration Photovoltaic (HCPV) system consists of seven proprietary MegaModules. Each MegaModule contains 36 receiver plates, each having its own matching sheet of 30 inexpensive plastic Fresnel lenses (which concentrates sunlight to 500 times its usual intensity). Integration of the lens, mounting structure and solar cell into a single unit eliminates over 75% of the parts and costs associated with other concentrator designs while providing advantages in ease of manufacturing, installation and maintenance, the firm claims.



Amonix 7700 High Concentration Photovoltaic system. Also, by incorporating Amonix's patented

Each MegaModule is factory assembled and aligned to a maximum transportable size (48ft x 72ft) before shipping to the field for rapid and cost-effective deployment within days. This reduces construction time, the firm says. With a nominal rated power output of 53kW per unit and a design lifetime of 40 years, the Amonix 7700 is designed for utility-scale deployment (applicable to both distributed generation and centralized solar farms).

"The Amonix 7700 is the largest and most powerful high-concentration photovoltaic power generator in the world and leverages our 15 years of field experience to reliably produce

cost-competitive and emissions-free renewable energy," says CEO Vahan Garboushian. Founded in 1989, Amonix has almost 13MW of silicon-based HCPV technology installed worldwide, and the 7700 is its seventh-generation commercial system.

'built-in' dual-axis tracker, the 7700 generates over 40% more energy in sunny climates than conventional fixed solar panels, better matching utility demand curves, claims the firm.

As well as having lower installed costs, the system also requires less land (just 5–6 acres per MW of installed capacity) than competing systems, it is reckoned.

In addition, due to the 7700 system's modular design, individual solar cells are field replaceable and easily upgradeable as higher-efficiency multi-junction solar cells become available, Amonix adds.

www.amonix.com

SolFocus & Samaras expand Greek CPV project to 10MW

Concentrator photovoltaic (CPV) system maker SolFocus Inc of Mountain View, CA, USA is to expand its installation of CPV technology in Greece (announced last November as a co-development with engineering company Concept, a division of renewable energy firm Samaras Group of Thessaloniki) from the originally agreed 1.6MWp to 10MWp. Over the past four months, the partners have investigated several sites and begun engineering plans for the installation.

"The swift expansion of this project resulted from the favorable political, economic, and energy generation environment that exists in Greece for commercial solar technologies," says SolFocus'

CEO & president Mark Crowley.

Spanning multiple sites in Greece, installation will begin this summer (using the SolFocus 1100S systems), with the first delivery of power expected in the fall. Launched last November, the SF-1100S uses III-V-based solar cells to achieve panel efficiencies that are typically 30–50% greater than traditional PV panels, it is claimed, providing the highest energy generation potential per area of land. The Greek installation's first year of production alone should prevent the release of 17,500 tons of CO₂ emissions into the environment, it is reckoned.

"The Samaras Group is confident that we can accomplish such a sig-

nificant project expansion with the continued partnership of SolFocus," says Samaras Group's president Dimitrios Samaras. "SolFocus systems are easy to scale, reliable in the field, and amazingly efficient," he adds. In a solar-rich country like Greece, such efficiency can accelerate the trajectory for solar energy to reach cost parity with fossil fuels, SolFocus adds.

"2009 is truly the beginning of CPV commercialization, and Greece is a front-runner," says Crowley. "We expect that CPV will follow a similar growth path in other high-sun regions over the next several years."

www.solfocus.com

www.e-concept.gr

GreenVolts to commercialize NREL's IMM solar cell design

Concentrating photovoltaic (CPV) system maker GreenVolts of San Francisco, CA has entered into a development relationship to commercialize the inverted metamorphic (IMM) multi-junction solar cell design of the National Renewable Energy Laboratory (NREL) of Golden, CO, USA.

The US Department of Energy (DoE), which oversees NREL, has committed \$500,000 for GreenVolts to co-develop NREL's patents and bring the technology to market. GreenVolts has also signed a licensing agreement with NREL to commercialize their patents.

Founded in 2005, GreenVolts' CPV technology integrates optics (an off-axis micro-dish aluminum reflector mirror) as well as solar tracking together with GaAs-based multi-junction solar cells into a system that aims to produce the lowest-cost utility-scale solar energy for wholesale distributed generation.

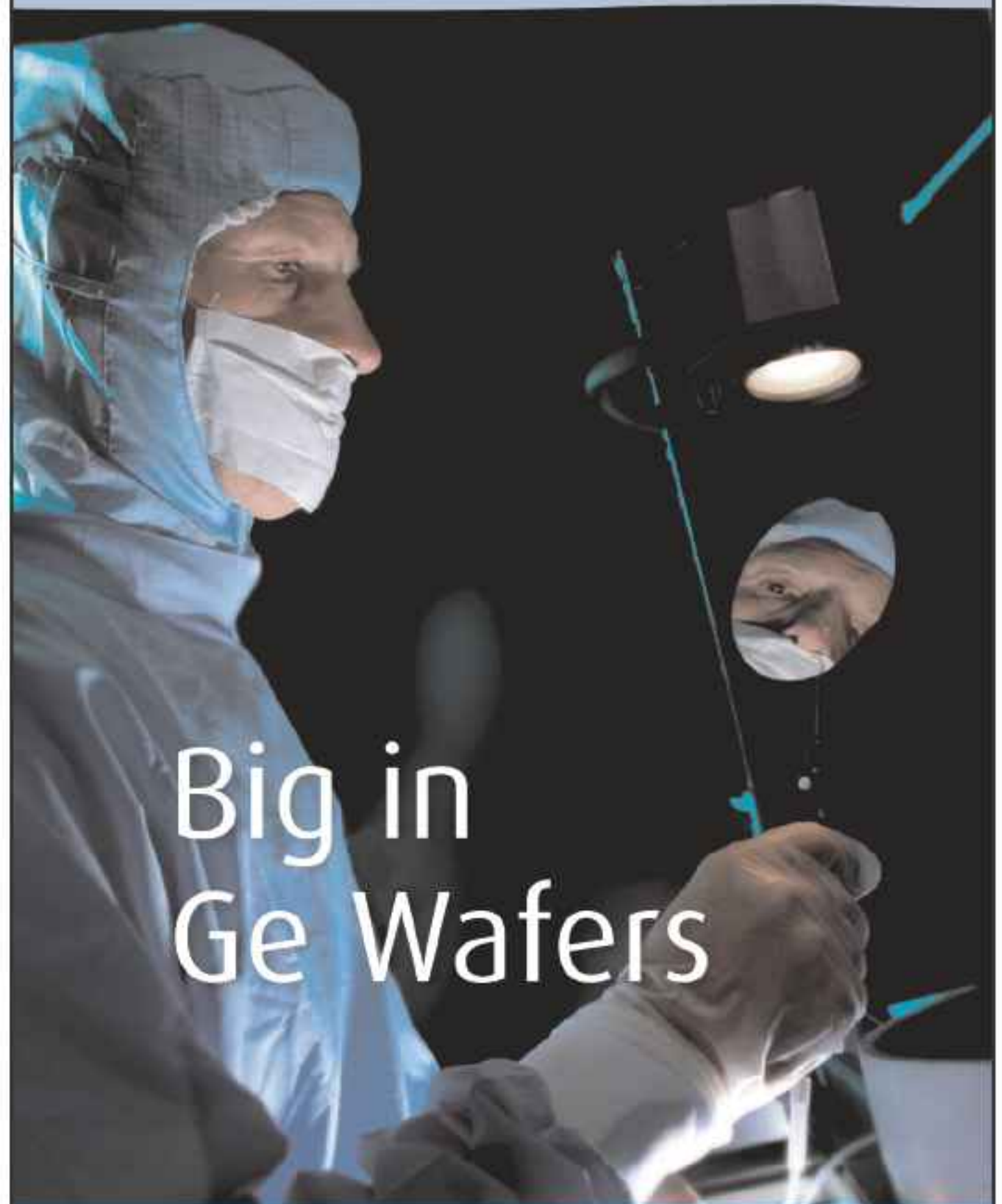
The two-year agreement aims to transfer NREL's IMM solar cell technology to GreenVolts so that the firm can develop a customized cell tailored to its optical system, and to accelerate the widespread commercialization of the technology through its high-volume manufacturing partners. The development agreement will be completed in multiple phases, each of which will build towards GreenVolts delivering a customized, reliable IMM device cost effectively fabricated at high volume.

"This new IMM technology is key to a tremendous leap forward in solar cell efficiency," claims NREL director Dan Arvizu. "We are pleased to be working with GreenVolts to both refine these advancements and provide for a viable way to bring them to market."

NREL's IMM technology last August reported record solar cell efficiency of 40.8% at 326x concentration (since exceeded by Fraunhofer ISE's 41.1%, although NREL reckons its technology promises further increases). GreenVolts says a customized solar cell should enable it to optimize its CPV system by increasing efficiency and reliability while reducing the overall cost of energy. "We look forward to working closely with NREL to develop a quality high-volume, low-cost manufacturing process to ensure that this next-generation technology will be readily available," says founder & CEO Bob Cart.

Under a Cooperative Research and Development Agreement (CRADA), technical representatives from both parties cooperate to make technical advances. Throughout the CRADA, NREL will provide necessary technology specifications and process information as well as advice and assistance in device optimization and technology transfer. NREL will also provide test and measurement services to qualify the results of the transfer process, including reliability.

www.greenvolts.com



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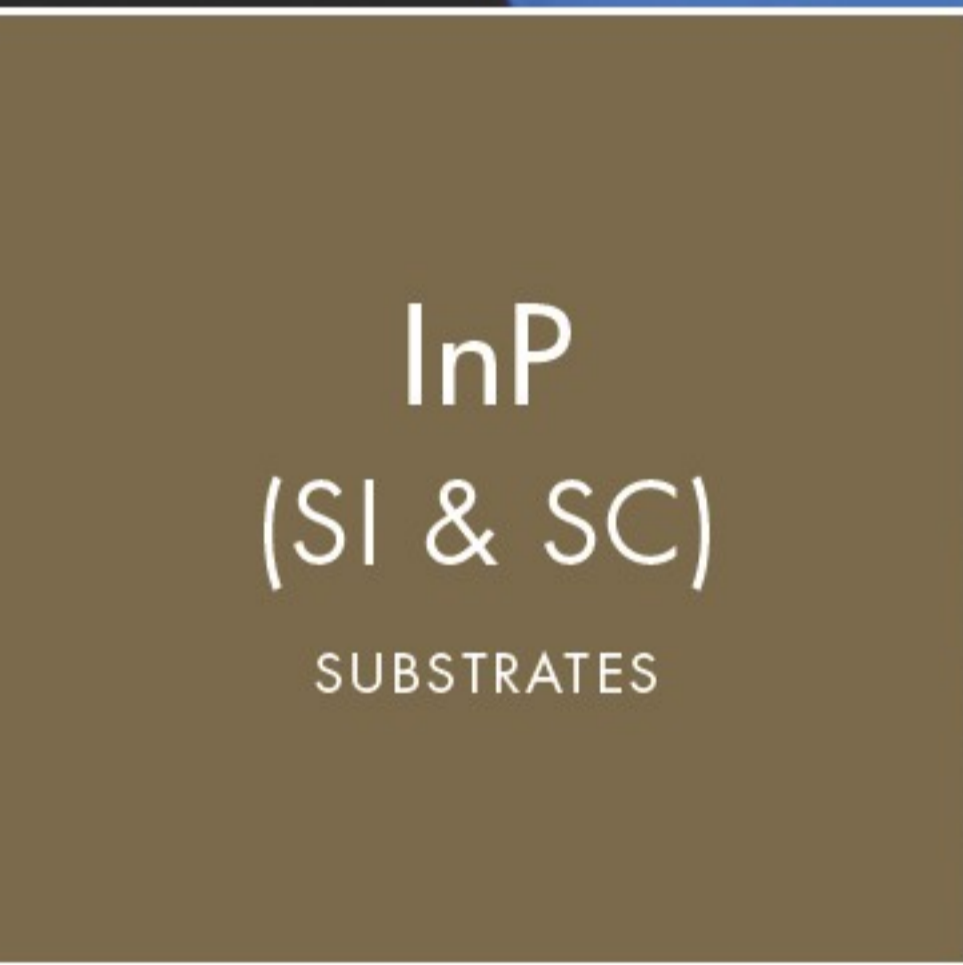
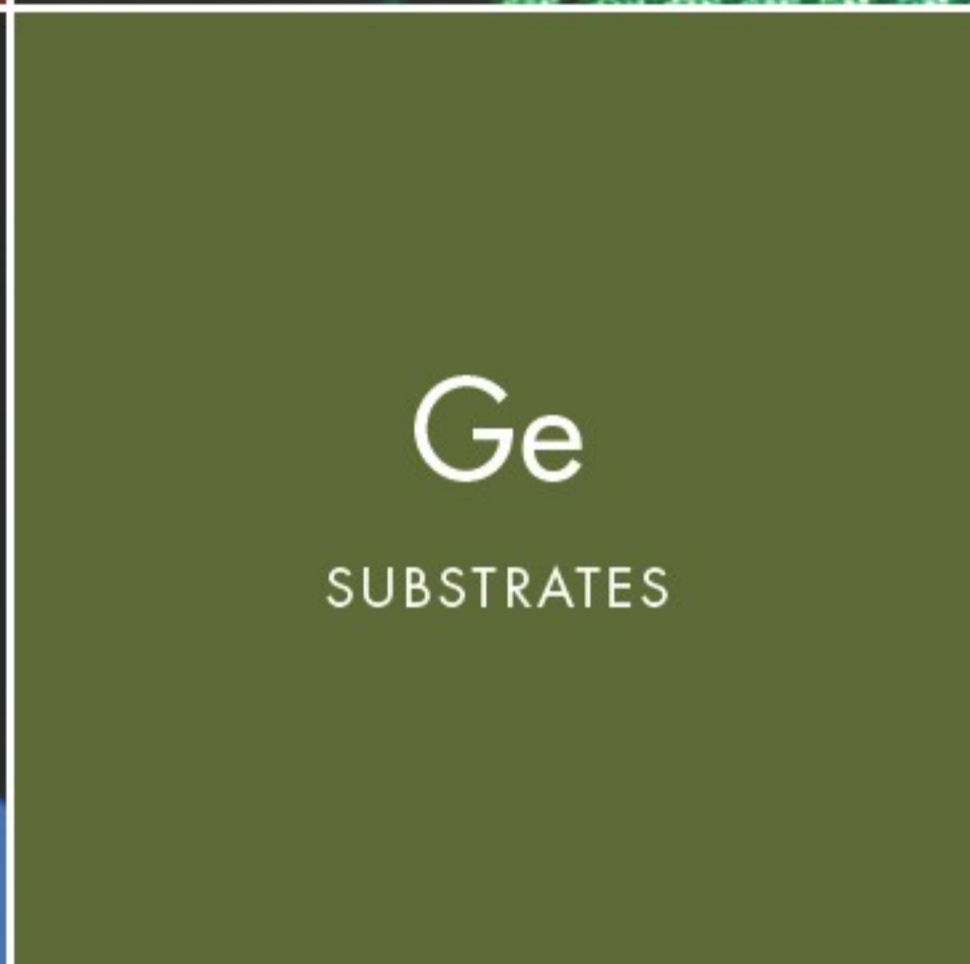
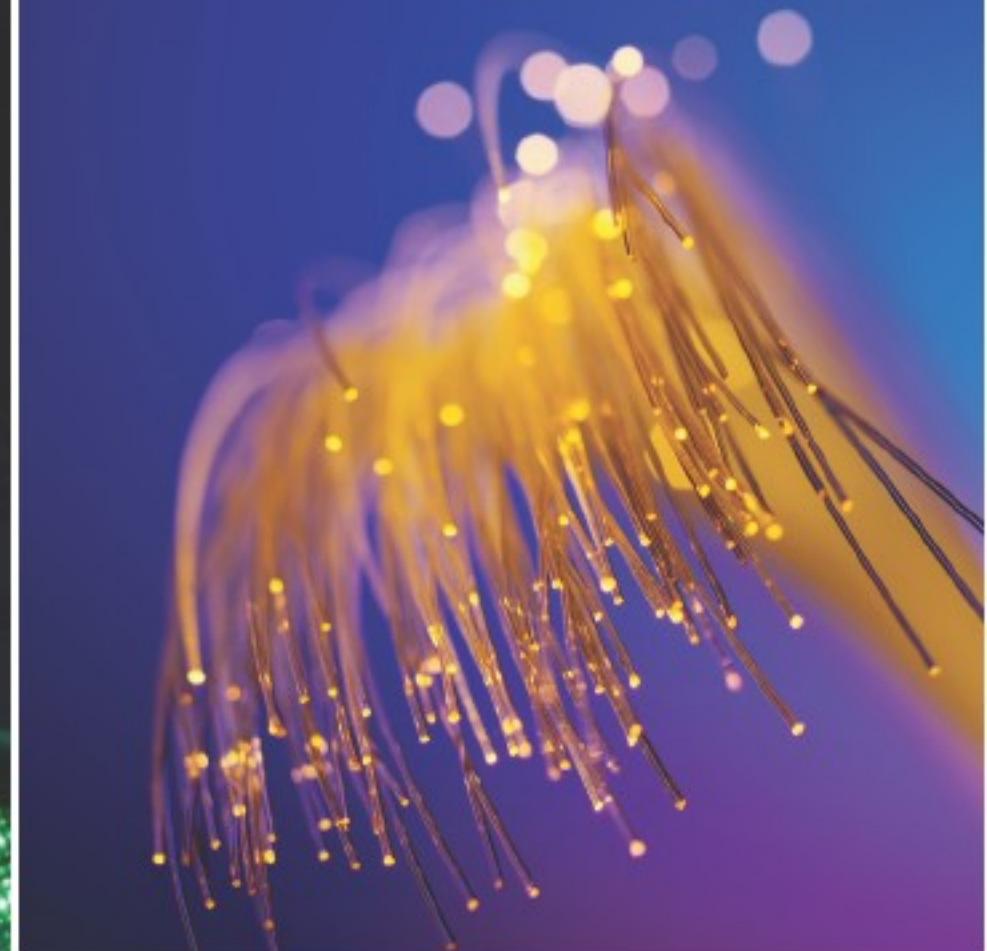
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First Solar acquiring multi-Gigawatt utility-scale PV project business

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe), has entered into an agreement to acquire the photovoltaic project development business of OptiSolar Inc of Hayward, CA (which makes thin-film PV modules and produces power from its own large-scale solar farms) for about \$400m in stock.

The transaction is expected to be completed in second-quarter 2009, and should significantly expand the firm's penetration within the US utility solar power market.

The acquisition includes:

- a 550MW AC Topaz Solar Farm development project in San Luis Obispo County, CA under a power purchase agreement announced last August with PG&E;
- A project pipeline of an additional 1300MW AC that is in negotiation with Western region utilities for solar development projects;
- strategic land rights of about 136,000 acres (210 square miles) with the potential to deploy up to 19GW AC of utility-scale solar power projects.

In addition, the core development team responsible for assembling and executing on the pipeline of solar projects will join the First Solar development team.

First Solar expects to construct solar power plants developed under the acquired solar power project pipeline over the next several years and sell them to a combination of regulated utilities, diversified energy companies, and other independent power producers.

The firm says that its investment in the development pipeline and planned projects ensures that at least 400 new 'green-collar' jobs will be created in California. Project development is planned to begin as early as 2010.

The transaction represents another key step in First Solar's US utility expansion. In November 2007, the firm acquired Turner Renewable Energy in order to obtain engineering, procurement and construction (EPC) capabilities of utility-scale solar plants in the USA. First Solar has since expanded its EPC function and demonstrated its capabilities by constructing a 10MW AC plant in El Dorado, NV with Sempra Generation. In addition, last October, it entered into a strategic agreement with Edison Mission Energy to develop and construct utility-scale solar generation in California. First Solar was awarded the first three projects in Southern California Edison's utility-owned generation program. The new agreement expands on First Solar's development capabilities and greatly adds to its generation project pipeline.

"OptiSolar has created an impressive and well-designed development pipeline," says CEO Mike Ahearn. "Adding these resources, along with their development team, to First Solar is our next logical step to delivering multi-GW of solar power

The new agreement expands on First Solar's development capabilities

to US utilities over the next several years," he adds. "As First Solar continues to drive down its manufacturing and EPC costs, OptiSolar's project pipeline and the ability of our team to continually expand our existing pipeline will enable us to bring solar energy on-line quickly."

First Solar, which recently announced that it had broken the \$1 per watt price barrier, has steadily lowered its cost and expanded its manufacturing capacity since 2005. This year the firm will reach a manufacturing capacity of 1100MW. First Solar's strategy is to reduce the cost of solar electricity by driving higher throughput deployment of utility-scale projects, which in turn enables economies of scale and rapid learning cycles.

"The State of California has been a leader in solar technology and the Topaz project will be an important aspect of meeting the state's renewable goals," says Ahearn.

"Combining the solar industry's cost-performance leader with a multi-gigawatt solar power project portfolio and the expertise of a world-class development team is a tremendous step forward for utility-scale PV solar generation," believes OptiSolar's CEO Randy Goldstein.

www.optisolar.com

www.firstsolar.com

First Solar surpasses 1GW of production

First Solar says that it has produced 1GW of its CdTe PV modules since beginning commercial production in early 2002 with a single manufacturing line in Perrysburg, OH and about 150 associates.

It took more than six years to produce its first 500MW, but just eight months to produce its second. By the end of 2009, the firm's PV modules will come from 23 manufacturing lines employing more

than 4000 associates on three continents (in the USA, Germany and Malaysia), giving the capacity to produce more than 1GW per year (equivalent to an average-sized nuclear power plant).

"This volume allows us to rapidly reduce manufacturing costs, thereby furthering our mission of making solar power an affordable alternative to conventional energy sources," says president Bruce Sohn.

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\$1 per Watt milestone claimed

First Solar Inc of Tempe, AZ, USA, which makes thin-film photovoltaic modules based on cadmium telluride (CdTe), says that in fourth-quarter 2008 it cut its manufacturing cost to 98 cents per Watt, breaking the \$1 per Watt price barrier. "This achievement marks a milestone in the solar industry's evolution toward providing truly sustainable energy solutions," claims CEO Mike Ahearn.

First Solar began full commercial operation of its initial manufacturing line in late 2004. Annual production capacity has since grown 2500% to more than 500MW in 2008, and should double in 2009 to more than 1GW (the equivalent of an average-sized nuclear power plant). In addition, manufacturing costs have fallen by two-thirds, from over \$3 per Watt to less than \$1 per Watt. The firm says that it is confident that further significant cost reductions

are possible based on the yet untapped potential of its technology and manufacturing process.

"Without forward-looking government programs supporting solar electricity [naming Germany in particular], we would not have been able to invest in the capacity expansion which gives us the scale to bring costs down," Ahearn says. "First Solar's ongoing focus on cost reduction enables continued growth even as subsidies decline," he adds.

"To address climate change in a meaningful way, we need energy technologies that are affordable, scalable and have a low environmental impact on a life-cycle basis," says Ken Zweibel, director of the Institute for the Analysis of Solar Energy at The George Washington University and former program leader for the Thin Film Partnership Program at the National Renewable

Energy Laboratory (NREL) in Golden, CO, USA. "With this announcement, First Solar continues to demonstrate the ability of thin-film PV technology to provide an alternative to traditional fossil fuels and for solar power to provide a meaningful contribution in addressing climate change," he adds.

● First Solar's revenue more than doubled from \$504m in 2007 to \$1,246.3m in 2008. Despite operating expenses rising from \$114m to \$240m, net income more than doubled from \$158.4m to \$348.3m. Cash reserves rose from \$404m to \$716m.

In particular, Q4/2008 revenue was \$433.7m, up 24% on Q3's \$348.7m and more than double \$200.8m a year ago. Net income has risen from \$62.9m a year ago and \$99.3m in Q3/2008 to \$132.8m.

www.firstsolar.com

30MW CdTe PV plant to be developed for Tri-State

First Solar has entered into a 25-year power purchase agreement with Tri-State Generation and Transmission Association Inc, a wholesale electric power supplier serving more than 1.4 million consumers through 44 electric cooperatives and public power districts in Colorado, Nebraska, New Mexico and Wyoming.

The agreement, which represents the largest PV contract by an electric cooperative in the USA, calls for First Solar to engineer, procure and construct (EPC) a 30MW AC ground-mounted photovoltaic power plant (the 'Cimarron I Solar Project', consisting of about 500,000 2ft x 4ft panels) on a 250-acre site in Colfax County, between the towns of Cimarron and Springer in north-eastern New Mexico.

"This photovoltaic power plant is another demonstration of our ability to provide affordable, utility-scale solar solutions," says John Carrington, executive VP of marketing & busi-



Visualization of planned PV plant.

ness development. "In addition to being cost-effective, the plant will create 120-140 construction jobs, significantly reduce greenhouse gas emissions, and provide enough power to serve the equivalent of about 9000 homes," he adds.

"Our partnership with First Solar further diversifies our resource mix and brings value to our member cooperatives across our four-state service territory," says Tri-State's executive VP & general manager Ken Anderson. "This project in New Mexico demonstrates how

electric cooperatives can effectively bring utility-scale solar projects to the rural areas they serve," he adds. "Tri-State's first utility-scale renewable energy project will be among the largest solar photovoltaic projects in the world."

The project will be the first utility-scale solar power plant in the region. Construction should start in April 2010, with the first part of the plant producing energy by August and the remainder to be fully operational by the end of 2010. First Solar will provide monitoring and maintenance services for the plant over its lifetime. The firm expects that, upon the plant's completion, it will have transferred substantially all of its equity interest in the project.

"This first-of-its-kind initiative is further evidence that New Mexico is a national leader in renewable energy production," claims Senator Jeff Bingaman (chair of the Energy and Natural Resources Committee).

www.tristategt.org

Heterostructuring for high speed, power and light

Last month we reported on developments presented at December 2008's International Electron Devices Meeting (IEDM) towards III-V MOSFETs for use in mainstream high-performance microelectronics. Here **Mike Cooke** looks at progress with the wider variety of heterostructure materials (III-nitride, III-arsenide, III-phosphide) for power, light and high speed applications.

Nitride semiconductors are best known for their ability to produce higher-frequency light (green to ultraviolet) both in normal LEDs and laser diodes. In recent years, the material system's ability to handle higher critical fields has spawned a new area of development — power devices. At IEDM 2008 last December, this new focus was expressed with most nitride papers being concerned with developing the new power capability. Meanwhile, the more traditional arsenide and phosphide semiconductors have been pushed in speed for microwave applications (GHz–THz), often with an eye to combination with silicon technology.

Nitride power

One group at Hong Kong University of Science and Technology (HKUST) reported on using industry-standard AlGaIn/GaN-on-Si epitaxial wafers from Nitronex to develop low-cost AlGaIn/GaN devices for switched-mode power supply (SMPS) converters [1]. The integrated devices consisted of high-performance lateral field-effect rectifiers (L-FER) and normally-off HEMTs (Figure 1). The rectifier had a 470V breakdown and $2.04\text{m}\Omega\text{cm}^2$ specific on-resistance. A boost converter proof-of-concept with 1MHz switching frequency was also produced based on the integrated device.

The normally-off HEMT makes the power switch fail-safe with low circuit complexity and higher noise margin. The normally-off nature of both the L-FER and HEMT is achieved using a CF_4 plasma treatment. Fluorine atoms from the plasma deplete the two-dimensional electron gas (2DEG) channels of the HEMT and L-FER, shifting the threshold from -2.1V to $+0.9\text{V}$. Schottky contacts are then made for the HEMT gate and L-FER anode (shorted with an Ohmic contact).

The drift length between the anode and cathode regions of the L-FER can be varied to trade-off breakdown voltage (BV) with specific on-resistance (R_{on}). A longer drift region offers a higher BV at the cost of higher R_{on} . The researchers point out that the forward turn-on voltage at forward current densities of $100\text{A}/\text{cm}^2$ for their device

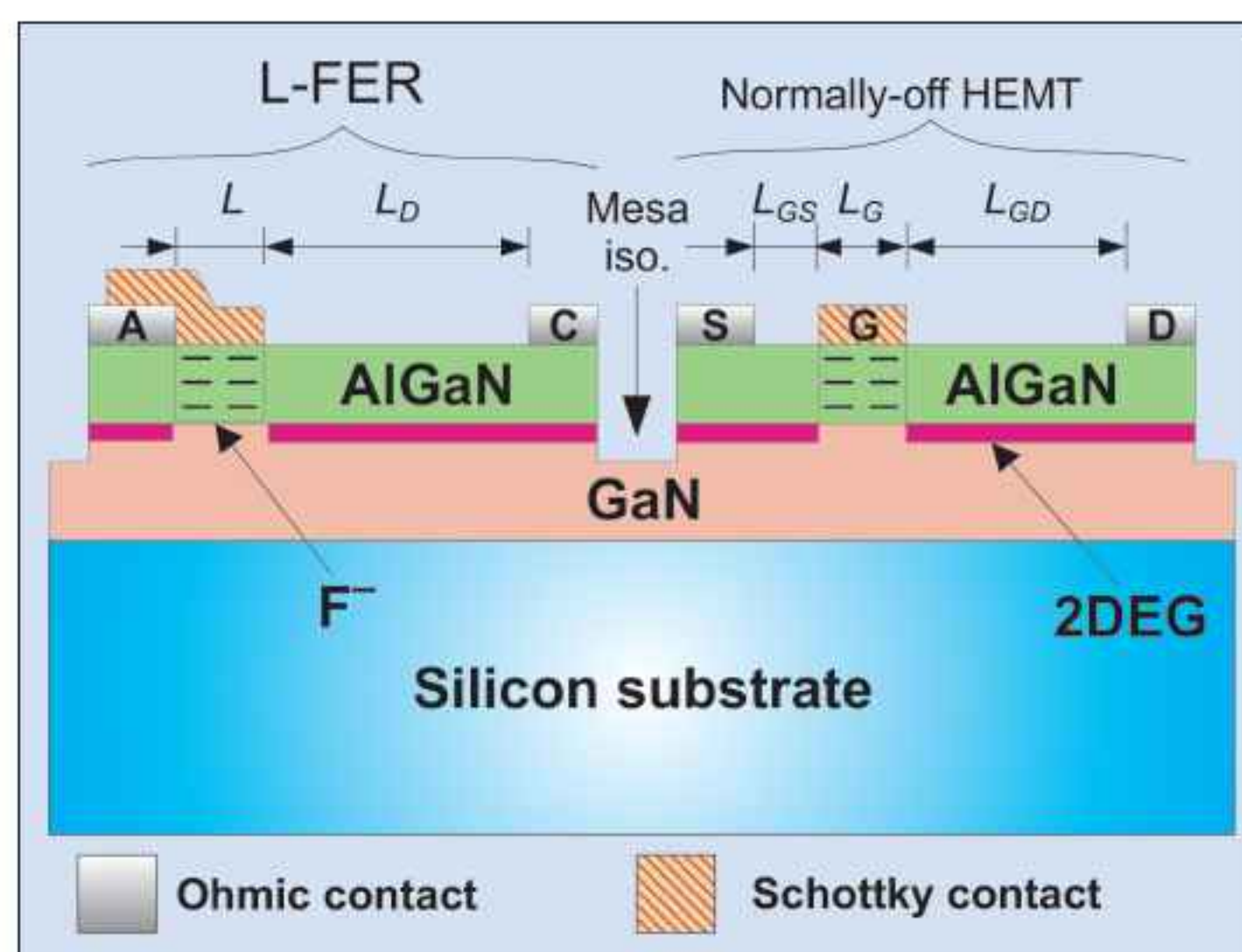


Figure 1. Schematic cross-sectional diagram of a lateral field-effect rectifier (L-FER) with normally-off HEMT. L_D is the drift length of the L-FER.

with various drift lengths is significantly lower than that achieved for silicon p-i-n and SiC Schottky barrier (SBD) diodes that are currently used for these types of application. This is attributed to the turn-on control offered by the field-effect mechanism compared with p-i-n or Schottky junctions. High 2DEG densities and mobilities also play a role. The voltage performance is little affected by temperatures up to 250°C , although the current decreases somewhat as a result of phonon scattering.

The monolithic boost converter was constructed from an L-FER with $15\mu\text{m}$ drift region and $1.5\mu\text{m}$ gate HEMT (gate-source distance $1.5\mu\text{m}$, gate-drain distance $12\mu\text{m}$). The width of the device was 2mm for the HEMT gate and 1mm for the anode of the L-FER. The chip area was 0.36mm^2 , with the active region being 0.0625mm^2 . With a 1MHz switching speed, 55% duty cycle and 10V input, an output voltage of 21V with 84% efficiency is obtained. At lower voltages the power efficiency decreases due to the increased R_{on} of the component devices. The main reason for this is given as being due

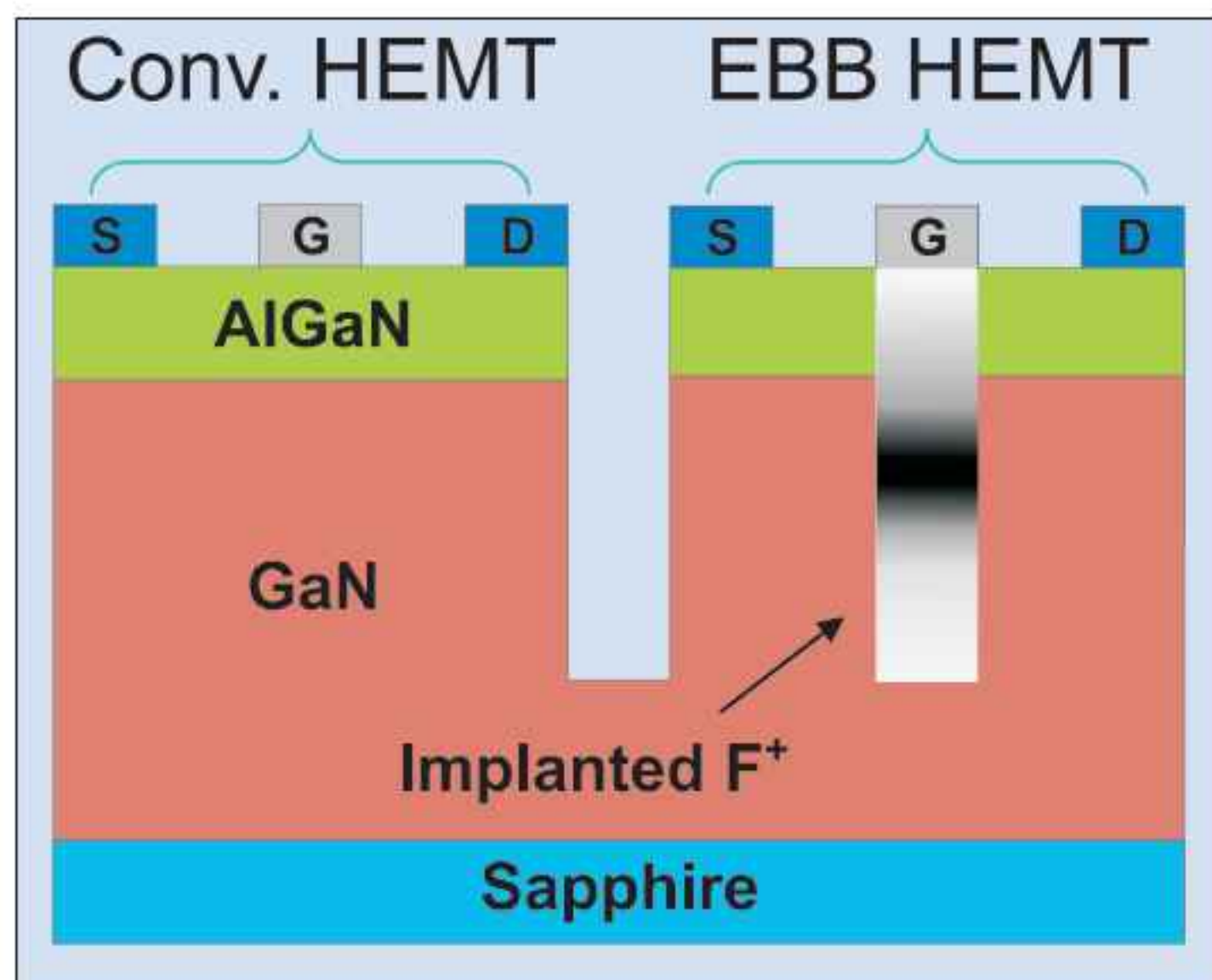


Figure 2. Schematics of conventional HEMT and HKUST's HEMT with fluorine implanted enhanced back barrier to block unwanted off-state current flow.

to increased dynamic resistance related to current collapse at higher switching amplitudes and frequencies. Current collapse can be ameliorated using passivation and field-plates.

Further study of the use of fluorine in improving source injection induced off-state breakdown in AlGaN/GaN HEMTs was the subject of another HKUST presentation [2]. Drain-injection techniques were used to study both source and gate injection induced impact ionization. Source injection was identified as the culprit in leading to premature three-terminal breakdown of the device.

The researchers found that a 35% increase in breakdown performance could be achieved in enhanced back-barrier (EBB) HEMTs with a fluorine implant (Figure 2). Fluorine ions beneath the channel were found to be an effective blocker of source injection through the buffer layer. The effect of the negatively charged fluorine in the GaN is to modulate the band structure, raising the conduction band in the buffer by about 1eV and thus reducing the source current injected into the high-field region of the channel. The HEMTs were produced on sapphire substrates using MOCVD.

Panasonic's Semiconductor Device Research Center in Kyoto has developed what it calls 'Natural Super Junctions' (NSJ) using GaN technology [3]. Diodes produced from the structure (Figure 3) achieve extremely high breakdown voltages of 9300V, while the specific on-resistance ($R_{on,A}$) remains low ($176\text{m}\Omega\text{cm}^2$). These parameters are claimed to be records over GaN-based Schottky barrier diodes (SBDs).

Traditional super junctions consist of alternating layers of p- and n-type material. This structure enables higher levels of breakdown voltage but is difficult to grow with sufficient accuracy. The voltage is applied along the layers rather than across, as is more usual in

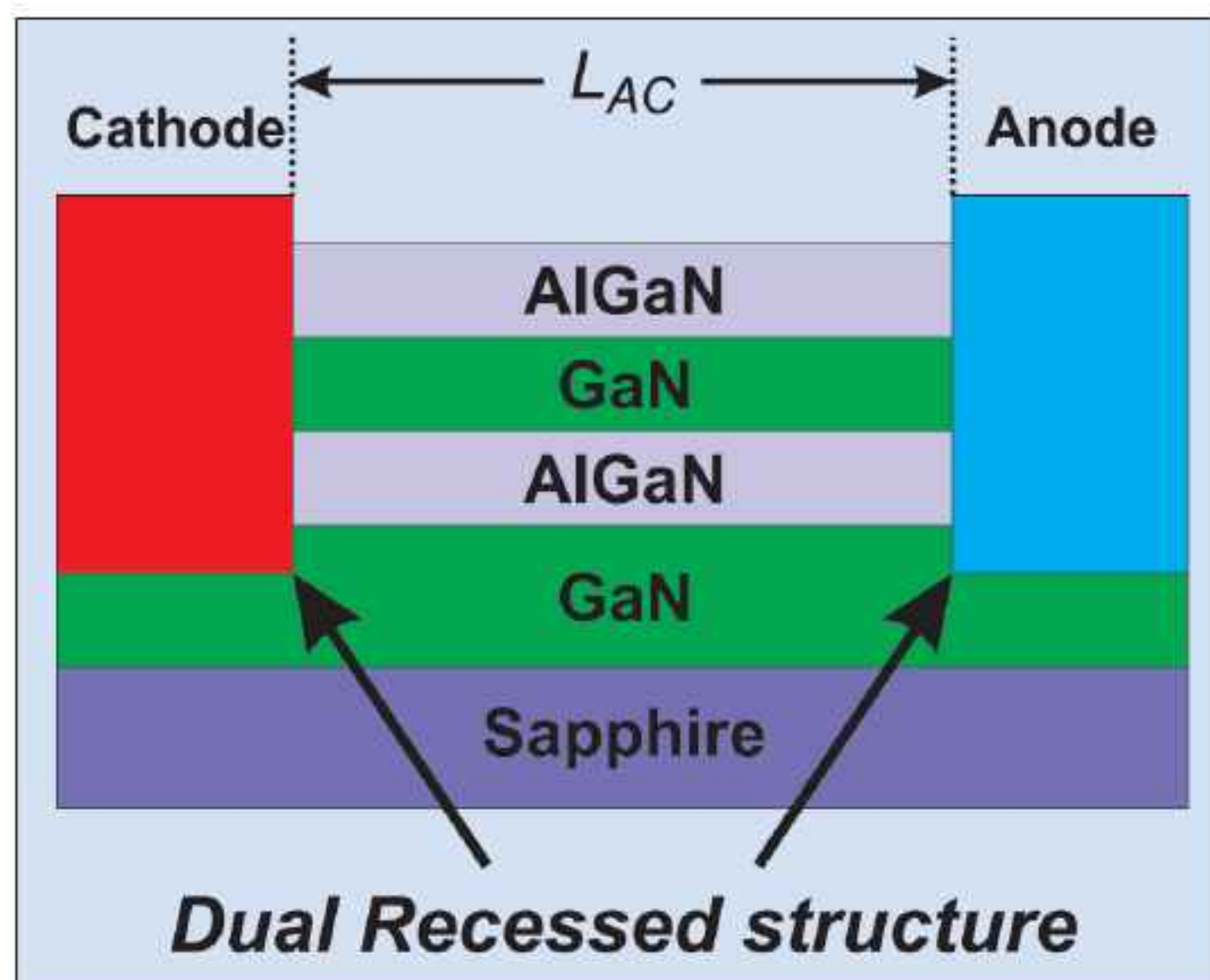


Figure 3. Schematic of Panasonic's natural superjunction diode with double channel and dual-recess structure.

single pn-junction diodes. The structure reduces the peak field that arises for a given applied potential. This increases the breakdown voltage that is achievable. Complete balance between the n- and p-type regions is hard to achieve due to the difficulties of controlling film thicknesses and impurity concentrations.

The Panasonic team believes that junctions of undoped GaN with AlGaN can behave like a natural super-junction due to the polar nature of the material where the Ga ion in the lattice tends to have a positive charge and the N ion tends to have a negative charge. Two-dimensional numerical simulations based on charge continuity and on Poisson's equation were carried out to model an AlGaN/GaN structure with p-GaN at one end (anode) and n-GaN at the other (cathode). The AlGaN and GaN layers were both $1\mu\text{m}$ long and 50nm thick. At equilibrium, an electron gas is formed in the GaN material while a hole gas forms on the AlGaN surface opposite the AlGaN/GaN junction. At reverse bias these carriers disappear. These simulations were then confirmed by producing single- and dual-channel diodes with and without recessing. Dual-recessing increases the forward current and thus lowers the specific on-resistance.

Joh and Del Alamo of MIT have worked on charge trapping in GaN HEMT devices [4], targeting high-power RF and high-voltage applications. Excessive charge trapping and detrapping (Figure 4) in such devices degrade the performance and lead to current collapse effects.

Joh and Del Alamo have found that when GaN HEMTs are stressed beyond a critical voltage, the trapping behavior is significantly enhanced inside the AlGaN barrier layer or at the surface. The buffer layer, however, has the same trapping properties as before the degradation event.

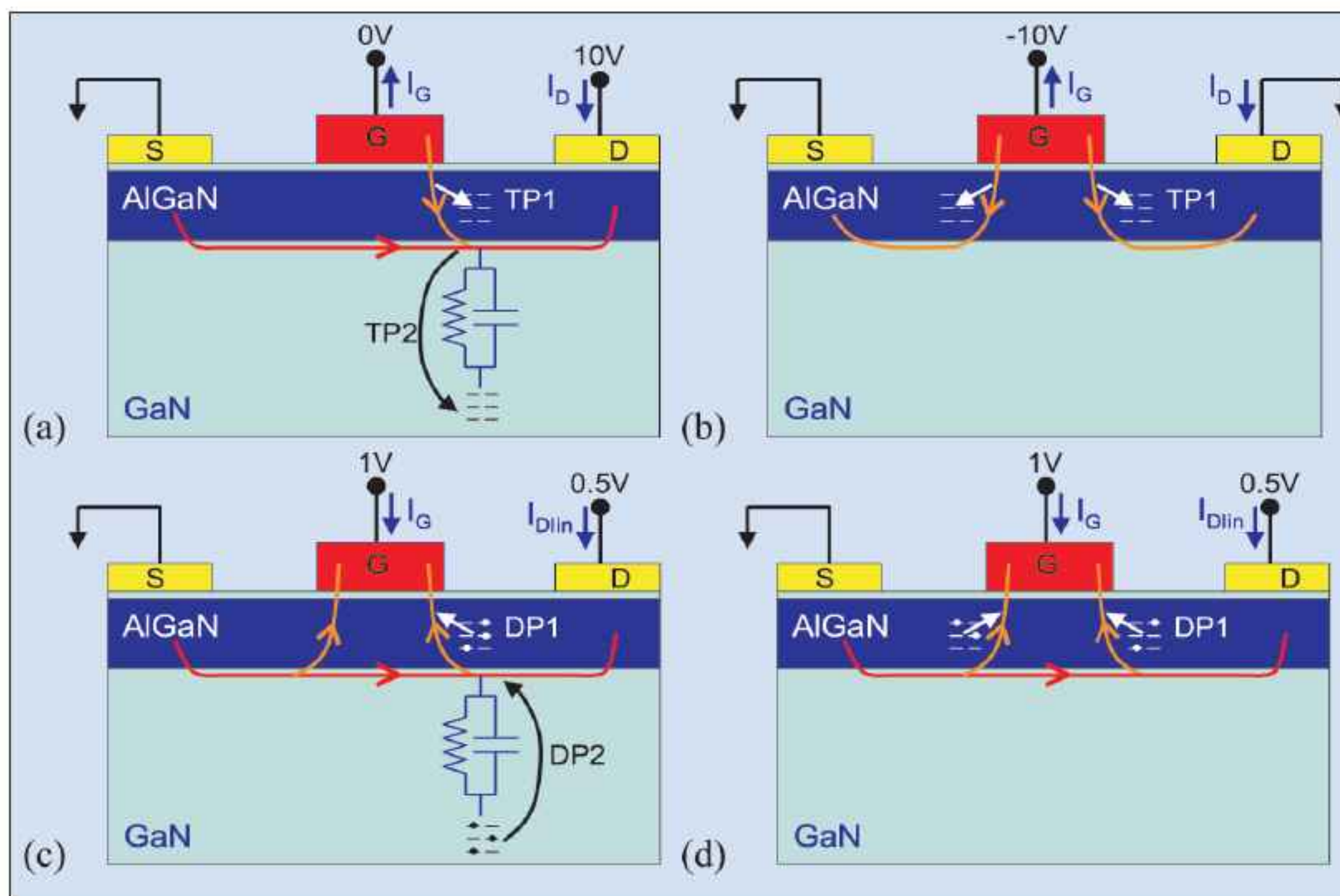


Figure 4. Different trapping and detrapping mechanisms. (a) On-state trapping. (b) Trapping with $V_{DS} = 0$. (c) Detrapping after on-state pulse. (d) Detrapping after $V_{DS} = 0$ pulse.

These insights are the result of a newly developed current transient analysis methodology. This reveals traps in the GaN buffer and also at the surface or in the AlGaN barrier in fresh devices. Degradation introduces new traps with a broad spectrum of detrapping time constants on the drain side of the device.

The technique was demonstrated on a $0.25\mu\text{m}$ -gate millimeter-wave GaN HEMT with a source field plate. The device width was $2 \times 25\mu\text{m}$. The performance could be restored from the stressed condition to the initial condition by shining a microscope light on the device for 30s.

The researchers believe that the results are consistent with their previous findings that suggest that deep trap states result from an inverse piezoelectric effect where the electric field physically stresses the material to the point where defects are introduced.

Researchers from the University of Padova and Matsushita Electric Industries (now officially Panasonic) have studied the degradation of InGaN laser diodes designed for use with BluRay optical disk storage [5]. The nature of the current through the device is found to be a major driver towards degradation of such devices.

The work was carried out on low-dislocation-density ($10^6/\text{cm}^2$) LDs with a threshold current density of $3.2\text{kA}/\text{cm}^2$ (29mA) and a slope efficiency of $1.6\text{W}/\text{A}$. The case temperature of the devices was raised to 70°C to accelerate the degradation process. Stressing the devices at constant current levels shifts the threshold upwards. Degradation occurred at currents as low

as $200\mu\text{A}$, suggesting that the role of the optical field in the degeneration process is small. It was also found that current stress reduced the sub-threshold emission.

These facts have led the researchers to propose that the degradation is due to a shortening of the non-radiative recombination lifetime so that its importance increases relative to the radiative recombination, reducing the effectiveness of the device. This was confirmed by extracting the non-radiative recombination lifetime from plots comparing efficiency with output power. The researchers believe that the increase in non-radiative recombination is correlated with an increase in the concentra-

tion of defects in the active layer.

Arsenide speed

Another Hong Kong University of Science and Technology (HKUST) group, Lau et al [6], described the production of AlInAs/GaInAs metamorphic HEMTs (mHEMTs) on silicon wafers 'for the first time'. The researchers see this approach as being attractive to the development and integration of monolithic microwave ICs (MMICs) and high-speed logic with more mature silicon technology.

In 2007, AlInAs/GaInAs HEMTs were grown on silicon using molecular beam epitaxy (MBE). However, for integration with silicon CMOS technologies, an MOCVD approach is preferred, and this was the growth method used by HKUST. A composite series of buffer layers was grown on the silicon before the undoped $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ channel (Figure 5, Table 1). The recessed gate consisted of a Ti/Pt/Au Schottky contact. The source/drain contacts consisted of a six-layer metal system of Ni/Ge/Au/Ge/Ni/Au.

The Hall mobility of the two-dimensional electron gas (2DEG) was measured at $4540\text{cm}^2/\text{Vs}$ at 300K. The sheet carrier density was $8 \times 10^{12}/\text{cm}^2$. The mobility increased to $14,000\text{cm}^2/\text{Vs}$ and the sheet carrier density fell to $5 \times 10^{12}/\text{cm}^2$ at 77K.

X-ray diffraction rocking curves revealed that the GaAs and InP buffer layers were fully relaxed and that the other layers were compositionally lattice-matched to the InP layers. Transmission electron micrographs (TEMs) showed misfit and threading dislocations in the compositional buffer. The final two buffer layers were

found to effectively terminate the threading dislocations, leaving the active layers with no significant threading dislocations. This is necessary for the formation of a 2DEG with high mobility.

Transistors with $1.0\mu\text{m}$ gates had cut-off frequencies of 32GHz and 44GHz for f_T and f_{max} , respectively. The peak extrinsic transconductance (G_m) was 587mS/mm. The reverse gate leakage was somewhat higher than desirable

for applications, but the researchers point out that no passivation or plasma treatment had been performed. Such treatment is a normal part of commercial production to reduce gate leakage.

Rochester Institute of Technology, University of Notre Dame and Amberwave Systems are claiming a record peak-to-valley current ratio (PVCR) of 56 for GaAs-based Esaki inter-band tunnel diodes grown on silicon [7]. Normal GaAs tunnel diodes have PVCRs in the range 21–25, while Si-based devices have PVCRs of 6 at best. Only tunnel diodes grown on indium phosphide substrates show better performance (a PVCR of up to 144 for a resonant inter-band device, Table 2).

The researchers see their achievement of higher-performance tunnel diodes on silicon as a spur to further exploration of new tunneling-based circuit architectures to extend and enhance CMOS, such as for static random access memory and field-effect transistors.

The deposition of GaAs on silicon has to deal with the large lattice mismatch as well as coefficient of thermal expansion differences between the two materials.

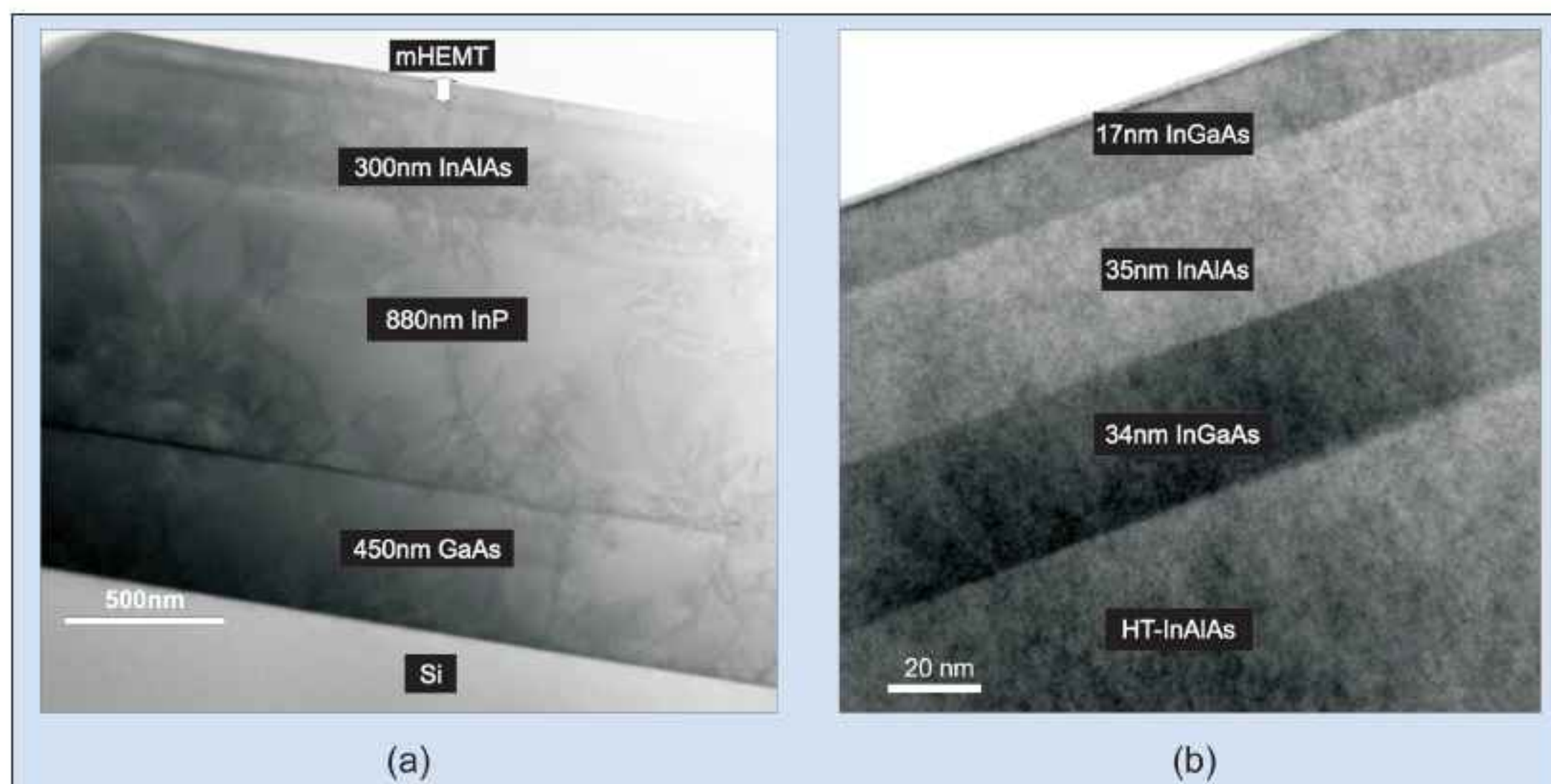


Figure 5. TEM cross-section of an mHEMT structure.

Table 1. Nominal layered structure of mHEMT device grown by MOCVD.

$\text{In}_{0.53}\text{Ga}_{0.47}\text{As}:\text{Si}$	15nm	Cap layer
Undoped $\text{In}_{0.50}\text{Al}_{0.50}\text{As}$	30nm	Barrier
Si	$(4-8)\times 10^{12}\text{cm}^{-2}$	δ -doping
Undoped $\text{In}_{0.50}\text{Al}_{0.50}\text{As}$	5nm	Spacer
Undoped $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$	32nm	Channel
Undoped HT- $\text{In}_{0.50}\text{Al}_{0.50}\text{As}$	180nm	Buffer 5
Undoped LT- $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$	180nm	Buffer 4
Undoped HT-InP	730nm	Buffer 3
Undoped LT-InP	150nm	Buffer 2
Undoped HT-GaAs	450nm	Buffer 1
Undoped LT-GaAs	10nm	Nucleation
n-type Silicon	(100)	Substrate

The team implemented a new technique called aspect ratio trapping (ART), which uses patterned, sub-micron-wide trench features and epitaxy of germanium, which is closer to GaAs in terms of lattice matching (Figure 6).

Table 2. Comparison of Rochester Institute of Technology's Esaki diode on silicon with similar devices.

Type	Substrate	Tunnel diode	Growth technique	$J_p(\text{A}/\text{cm}^2)$	PVCR	Study
RITD	Si	Si/SiGe	MBE	5000	6	Eberl, 2001
RTD	Si	AlAs/InGaAs	MBE/Wafer Bond	30000	27	Evers, 1996
Esaki	GaAs	P+/N+ GaAs	Alloy	N/A	25	Holonyak, 1960
Esaki	GaAs	GaAs/ $\text{In}_{0.1}\text{Ga}_{0.9}\text{As}$	MOCVD	1500	22	Richard, 1993
RTD	InP	AllnAsSb/InGaAs	MOCVD	22000	46	Su, 2002
RTD	InP	AlAs/InGaAs/InAs	MBE	3000	51	Smet, 1993
RITD	InP	InGaAs/InAlAs	MBE	200	104	Day, 1993
RITD	InP	InGaAs/InAlAs	MBE	200	144	Tsai, 1994
Esaki	Si	GaAs/P+/N+ $\text{In}_{0.1}\text{Ga}_{0.9}\text{As}$	UHVCVD/MOCVD	9	27	IEDM 2008 (TD 1)
Esaki	Si	GaAs/P+/N+ $\text{In}_{0.2}\text{Ga}_{0.9}\text{As}$	UHVCVD/MOCVD	1000	43	IEDM 2008 (TD 2)
Esaki	Si	P+/N+ $\text{In}_{0.1}\text{Ga}_{0.9}\text{AsAs}$	UHVCVD/MOCVD	250	56	IEDM 2008 (TD 3)
Esaki	Si	P+/N+ $\text{In}_{0.1}\text{Ga}_{0.9}\text{As}$ graded	UHVCVD/MOCVD	65	8	IEDM 2008 (TD 4)

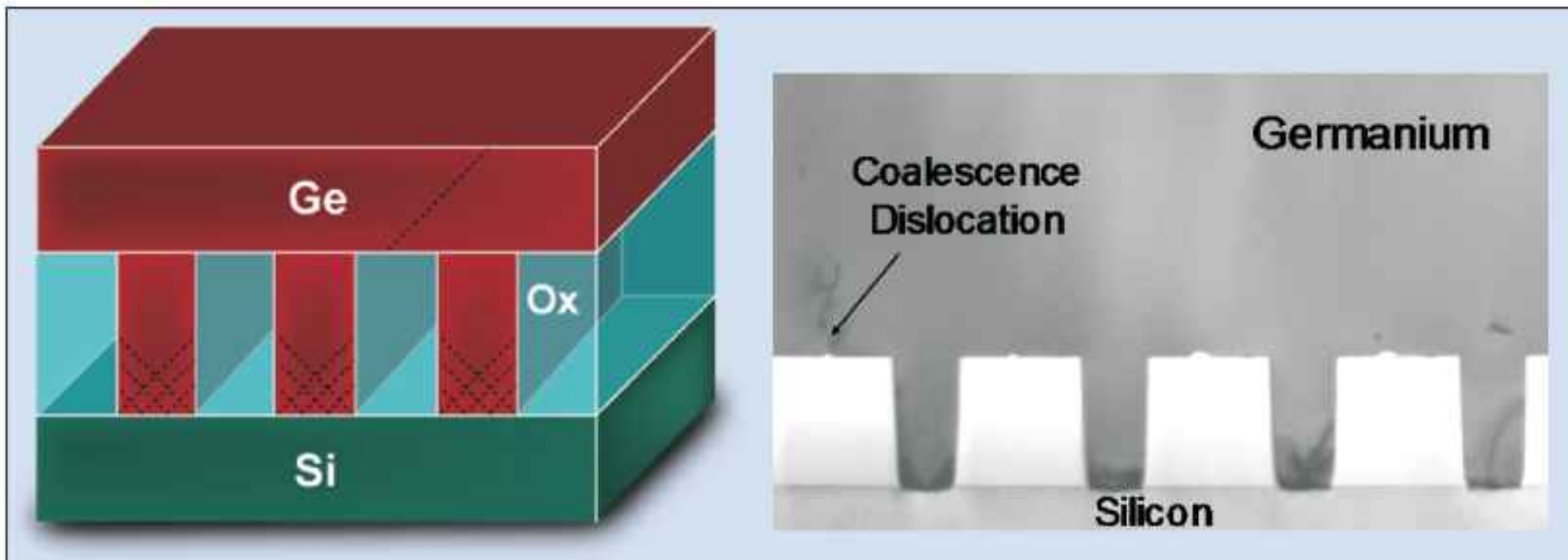


Figure 6. Aspect ratio trapping — dislocation densities in germanium on silicon can be reduced with trench structures that trap the faults.

The trenches used were 250nm wide, made in a 490nm layer of thermal oxide grown on the silicon wafer. Reduced-pressure chemical vapor deposition (RPCVD) was then used to grow a germanium layer. Defects caused by the Si/Ge lattice mismatch are trapped by the oxide trench side walls. The final Ge layer is relatively thin (825nm) compared with the microns of Ge resulting from techniques normally used to deposit Ge on Si. The rough surface resulting from the coalescence of the Ge from the various trenches is planarized using chemical mechanical polishing (CMP), a standard technique in CMOS processing.

The GaAs/InGaAs deposition used by the team was metal-organic chemical vapor deposition (MOCVD) rather than the molecular beam epitaxy (MBE) more commonly used for Esaki diodes. Unlike CVD, MBE processes are rare in mainstream CMOS production. The layer structure of the Esaki diodes reported was n⁺GaAs/n⁺InGaAs/p⁺GaAs with different combinations

of parameters. A structure of 50nm n-GaAs (Si-doped > 9x10¹⁸/cm³), 10nm n-In_{0.1}Ga_{0.9}As (Si 9x10¹⁸/cm³) and, finally, 80nm of p-In_{0.1}Ga_{0.9}As (carbon-doped 5x10¹⁸/cm³) gave the 56 PVCR and a peak current of 250A/cm² (Figure 7). An alternative structure — 50nm n-GaAs (Si > 9x10¹⁸/cm³), 10nm n-In_{0.2}Ga_{0.8}As (Si 9x10¹⁸/cm³) and, finally, 80nm p-GaAs (C 5x10¹⁸/cm³) gave a higher peak current of 1000A/cm² but with a lower PVCR of 43.

Kim and Del Alamo of MIT have pushed InAs pseudo-morphic HEMT (pHEMT) performance to more than 600GHz, which is usually the territory of InP or SiGe HBTs [8]. The 30nm device (Figure 8) operates in enhancement mode (normally-off). A gate sinking process effectively thins the barrier layer, which consists of In_{0.52}Al_{0.48}As material. The gate length is scalable from 130nm down to 30nm.

The f_T/f_{max} combination of 601/609GHz is said to be record breaking (V_{DS} = 0.5V). The source injection velocity is estimated at 2.5x10⁷cm/s, a factor of two higher than state-of-the-art Si MOSFETs. This velocity

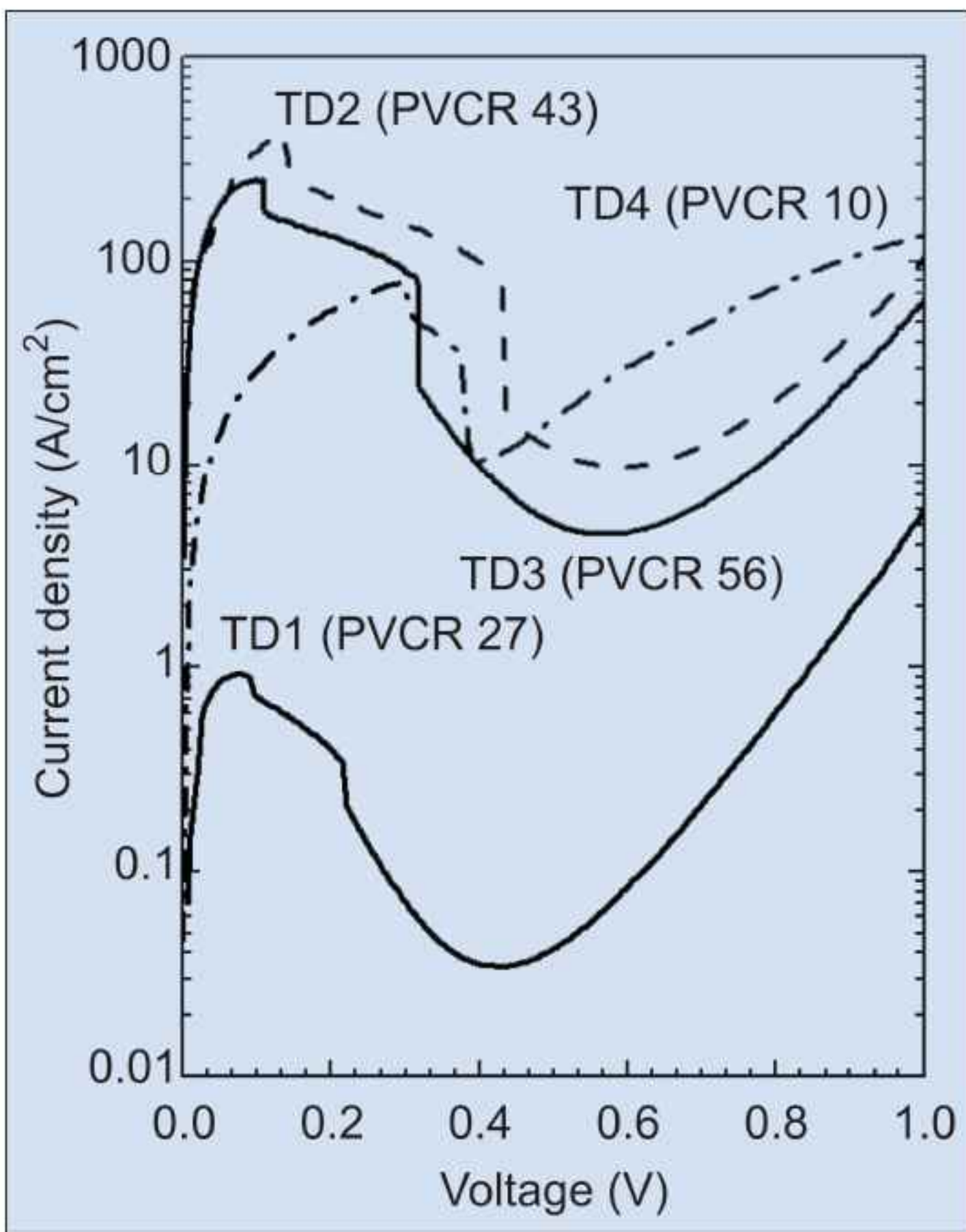


Figure 7. I-V characteristics for different InGaAs Esaki diodes built on ART germanium on silicon substrate. TD3 has the highest PVCR of 56.

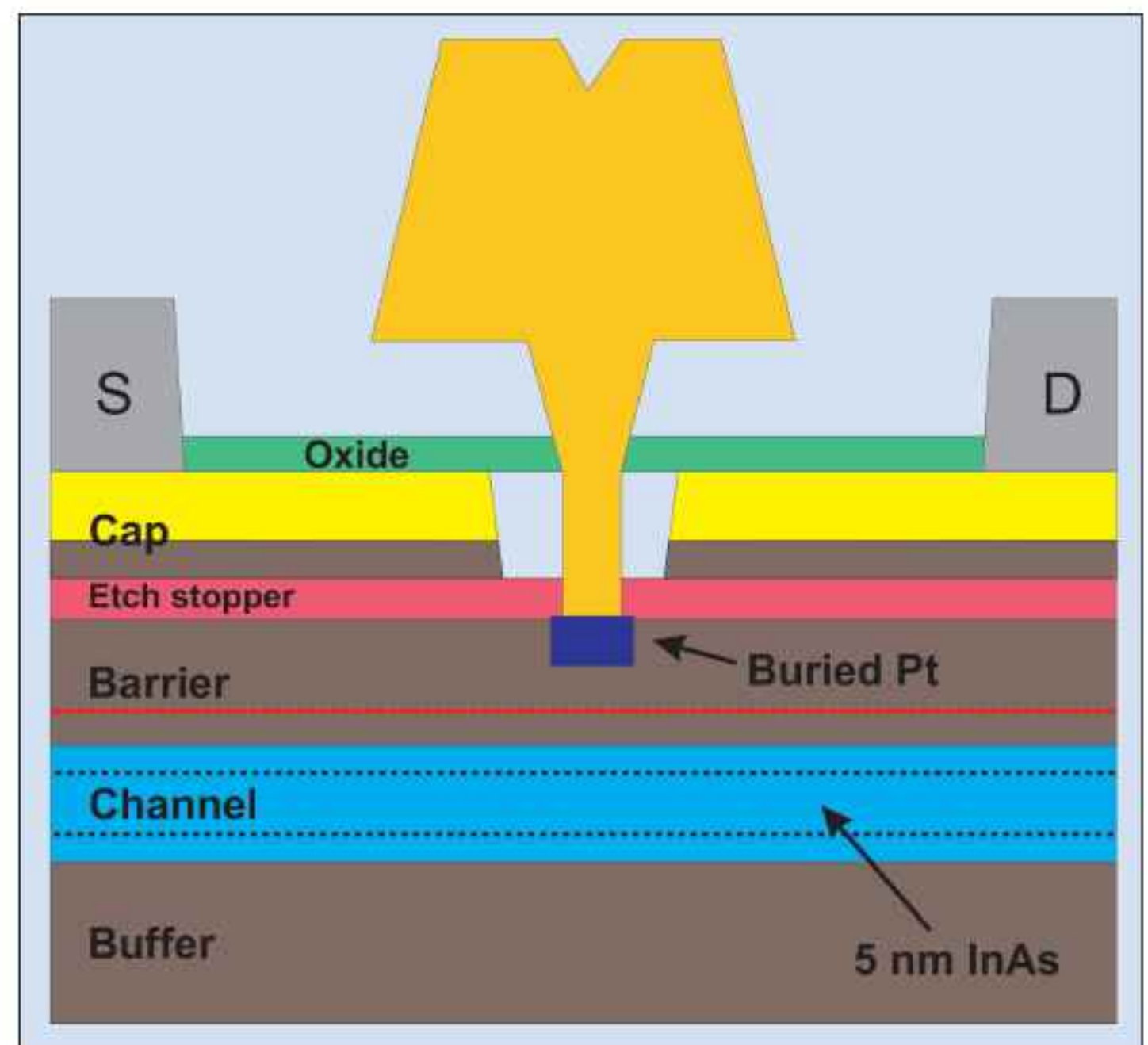


Figure 8. Schematic of MIT's InAs pHEMT.

meets the requirements of the International Technology Roadmap for Semiconductors (ITRS) for devices at 10nm. The device has been carefully designed to deliver 'outstanding' THz frequency and logic performance at short channel lengths.

InP on Si RF-CMOS fusion

Finally, researchers from HRL Laboratories have integrated entire wafers of high-performance 250nm, 300GHz f_T/f_{max} InP double-heterostructure bipolar transistors (DHBTs) with wafers from IBM's CMRF8SF 130nm RF-CMOS technology [9]. For handling purposes, the full-thickness InP 76.2mm or 100mm epitaxial wafer is first temporarily bonded to a handle wafer. This allows the InP growth substrate and etch-stop layers to be removed. An aluminum heat-spreader layer is deposited as a blanket film. The InP DHBT layers are then permanently bonded to the IBM CMOS wafer's top surface. In tests, the CMOS transistors showed no sign of degradation, while the InP transistors showed only minor performance impacts. ■

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7 Wafer processing materials

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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,
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Austria

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Oerlikon Wafer Processing

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St. Petersburg, FL 33716, USA

Tel: +1 727 577 4999

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www.oerlikonoc.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

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USA

Tel: +1 408 734 0459

Fax: +1 408 734 0961

www.samcointl.com

Surface Technology Systems plc

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www.synova.ch

TECDIA Inc

(see section 16 for full contact details)

Tegal Corp

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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

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Fax: +44 (0) 1480 424900

www.goodfellow.com



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10 Gas and liquid handling equipment

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12 Trafalgar Way, Bar Hill,
Cambridge
CB3 8SQ,
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Tel: +44 (0)1954 786800

Fax: +44 (0)1954 786818

www.cambridge-fluid.com

CS CLEAN SYSTEMS AG

Fraunhoferstrasse 4,
Ismaning, 85737,
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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

LayTec GmbH
Helmholtzstr. 13-14,
Berlin, 10587
Germany
Tel: +49 30 39 800 80 0
Fax: +49 30 3180 8237
www.laytec.de

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.
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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,
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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.jp-salaser.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

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www.tecdia.com

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CA 92127,
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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
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**United Monolithic
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Route departementale 128,
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Fax: +33 169 33 02 92
www.ums-gaas.com

19 Facility equipment**MEI, LLC**

3474 18th Avenue SE,
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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
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Fax: +1 604 320 1734
www.crosslight.com

**Semiconductor Technology
Research Inc**

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USA
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Fax: +1 804 740 3814
www.semitech.us

22 Used equipment**Class One Equipment Inc**

5302 Snapfinger Woods Drive,
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USA
Tel: +1 770 808 8708
Fax: +1 770 808 8308
www.ClassOneEquipment.com

23 Services**Henry Butcher International**

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Fax: +44 (0)20 7405 9772
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Germany
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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

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13–15 April 2009

6th China International Solar PV Exhibition

Shanghai International Exhibition Center, China

E-mail: nuogaisi2004@126.com

www.ch-solar.com

14–16 April 2009

2009 MRS Spring Meeting

Moscone West and San Francisco Marriott, CA, USA

E-mail: info@mrs.org

www.mrs.org

20–23 April 2009

SPIE Europe Optics + Optoelectronics 2009

Prague Congress Centre, Czech Republic

E-mail: info@SPIEeurope.org

<http://spie.org/x25077.xml>

20–23 April 2009

Photonics '09: 4th International Specialized Exhibition for Laser, Optical and Optoelectronic Technologies

Moscow, Russia

E-mail: es@expocentr.ru

www.photonics-expo.ru

21–22 April 2009

US Department of Energy Solid-State Lighting Manufacturing Workshop

Fairfax, VA, USA

E-mail: SSLWorkshop@akoyaonline.com

www1.eere.energy.gov/buildings/ssl/fairfax09.html

26–30 April 2009

IEEE International Reliability Physics Symposium (2009 IRPS)

Montreal, Canada

E-mail: phyllism@widerkehr.com

www.irps.org

28–29 April 2009

2nd Concentrated Photovoltaic Summit

Toledo, Spain

E-mail: belen@cpvtoday.com

www.cpvtoday.com/eu09

3–7 May 2009

LightFair International 2009

New York, NY, USA

E-mail: info@lightfair.com

www.lightfair.com

10–14 May 2009

IPRM'09: 21st Annual IEEE Conference on Indium Phosphide and Related Materials

Marriott Hotel & Spa, Newport Beach, CA, USA

E-mail: s.blodgett@ieee.org

www.ieee.org/organizations/society/leos/LEOSCONF/IPRM2009

17–20 May 2009

WOCSDICE 2009: 33rd Workshop on Compound Semiconductor Devices and Integrated Circuits

Málaga, Spain

E-mail: wocsdice2009@die.upm.es

www.wocsdice2009.org

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17–22 May 2009

**ICSI-6:
6th International Conference on Silicon
Epitaxy and Heterostructures**

Los Angeles, CA, USA

E-mail: organizers@icsi-6.org

www.icsi-6.org

18–19 May 2009

4G World Summit 2009

Boston Park Plaza Hotel, MA, USA

E-mail: info@trendsmia.com

www.4gworldsummit.com

18–20 May 2009

**OPTOmism:
Photonics for the Green Revolution**

Santa Clara, CA, USA

E-mail: OPTOmismAbstract@oida.org

<http://opt09.events.pennnet.com>

18–20 May 2009

**European Workshop on Photonic Solutions
for Wireless, Access, and In-House
Networks**

University Campus, Duisburg, Germany

www.ist-iphobac.org/workshop

18–21 May 2009

**CS MANTECH (2009 International
Conference on Compound Semiconductor
Manufacturing Technology)**

Tampa, FL, USA

E-mail: csmantech@csmantech.org

www.gaasmantech.org

19–20 May 2009

The Thin Film Solar Summit Europe

Berlin, Germany

E-mail: josh@thinfilmtoday.com

www.thinfilmtoday.com/eu

20–23 May 2009

**LED & Solid State Lighting EXPO 2009
(LED EXPO 2009)**

KINTEX, Seoul, South Korea

E-mail: led@exponu.com

www.ledexpo.com

24–28 May 2009

**APWS 2009:
4th Asia-Pacific Workshop on Wide gap
Semiconductors**

Zhang Jia Jie, Hunan, China

E-mail: Apws2009@pku.edu.cn

www.apws2009.com.cn

24–29 May 2009

**215th Electrochemical Society Conference
(Spring 2009 ECS)**

San Francisco, CA, USA

E-mail: meetings@electrochem.org

www.electrochem.org/meetings/biannual/215/215.htm

27–29 May 2009

**PHOTON's 5th Photovoltaic Technology
Show 2009 Asia**

Shenzhen, China

E-mail: ticket@photon-expo.com

www.photon-expo.com/en/pts_2009_asia/pts_2009.htm

31 May – 5 June 2009

**CLEO/IQEC '09:
29th Conference on Lasers and Electro-Optics
and 27th International Quantum Electronics
Conference**

Baltimore, MD, USA

E-mail: custserv@osa.org

www.cleoconference.org

1–3 June 2009

Photovoltaics Summit 2009

Hotel Kabuki, San Francisco, CA, USA

E-mail: jeremy.powell@pira-international.com

www.photovoltaicssummit.com

1–3 June 2009

SEMICON Russia 2009

Moscow, Russia

E-mail: ovyshkvarkov@semi.org

www.semiconrussia.org

2–4 June 2009

euroLED 2009

Ricoh Arena, West Midlands, UK

E-mail: eveg@astonsciencepark.co.uk

www.euroled.org.uk

3–4 June 2009

**S2K 2009:
semiconductor conference and networking
exhibition**

City Hall, Cardiff, Wales, UK

E-mail: jemi-enquiries@see.ed.ac.uk

www.semiconductor2k.com

7–10 June 2009

**13th European Workshop on Metalorganic
Vapor Phase Epitaxy (EWMOVPE XIII)**

Neu-Ulm, Germany

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www.uni-ulm.de/opto/EWMOVPE2009



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