

Developments in III-V etch MiaSolé starts shipments



RFIC makers see early recovery • Backlights drive MOCVD boom
SemiLEDs & Cree plan China fabs • Rubicon doubling capacity

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COMPOUNDS & ADVANCED SILICON

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p13 Anadigics' new ACA2784 1GHz hybrid line amplifier for the recovering CATV market.



p36 A new converter mix being tested by Osram provides warm-white light.



p53 Artist's impression of NASA's COTS-CRS spacecraft, which will carry Emcore solar panels.



Cover: An installation of MiaSolé's CIGS (copper indium gallium diselenide) thin-film photovoltaic modules. MiaSolé has started commercial shipment of modules from its production facility in Santa Clara, CA, USA, shipping to 30 customer sites in Germany, Italy, Spain, France, Portugal and the USA. **p62**

LED lighting driving MOCVD order boom

Last issue we reported how, driven by booming demand for LEDs in the backlights of notebook PCs and TVs (as well as in solid-state lighting), Cree's third-quarter 2009 revenue was up a more-than-expected 14% on Q2/2009, as it announced an expansion in LED-making capacity (adding 575 staff in North Carolina by the end of 2012). This came after Cree had (in September) raised \$434m in a public offering of shares, for use in capital expenditure of about \$150m plus potential strategic investments.

Cree has since agreed to establish its first chip-fabrication plant outside North America by buying a facility in China, which is home already to more than half of the firm's staff (at its LED packaging plant) — see page 39.

Fellow US firm SemiLEDs (which has chip plants in Taiwan) also plans to establish a fab in China (see page 34), with a \$96m initial stage producing 20 million chips per month by next October. The aim is to supply the growing number of firms involved in solid-state lighting throughout China.

Meanwhile, as we went to press, Korea's Seoul Semiconductor (the world's fourth-biggest LED maker) said that it had raised \$248m from Singapore's sovereign wealth fund to enable it to address increased demand and market growth opportunities in lighting (see next issue for details).

The expansions are in response to the booming market adoption of LEDs in TFT LCD backlight units for notebook PC, monitor, and TV displays, rising from just 6.7% last year to 27.8% this year and 56.4% in 2011, according to market analyst firm DisplaySearch (see page 4).

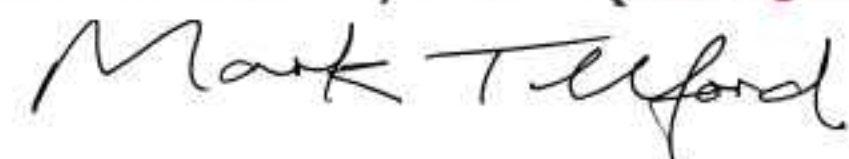
Strategy Analytics raises the prospect that such adoption for backlighting and early signs of the move toward solid-state lighting represent a 'tipping point'. It highlights the knock-on effect of booming orders for MOCVD reactors at suppliers Aixtron and Veeco, which collectively have a backlog of about 200 systems that are expected to come on-line during 2010 after order intake more than doubled from Q2 to Q3/2009 (see pages 24–27).

Veeco's CEO John Peeler cites "unprecedented demand from LED manufacturers in China, Korea and Taiwan as they ramp production for laptop and TV backlighting", adding that "Veeco is at the beginning of a multi-year MOCVD tool investment cycle". Analysts estimate the MOCVD market to be more than 350 tools in 2011. The firm is hence ramping up capacity to be able to ship more than 30 tools in Q4 and 45 in Q1/2010 (and more beyond that). Veeco says it is managing its slot plans and customer delivery schedules to ensure that lead times remain under six months. Meanwhile, in a public offering of shares on 26 October, Veeco raised \$130m (to be used partly for potential acquisitions).

Likewise, to meet accelerated demand (and shorter product cycles) over the next few years, Aixtron is issuing new shares to fund higher capital spending as well as potential strategic investments. It already reckons on being able to deliver up to 100 systems per quarter soon.

While Aixtron has started recruiting up to 100 new engineers in the next 12 months, Veeco uses outsourcing partners to scale capacity without adding direct costs, so it will be interesting to see how the two models cope.

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LED lighting nearing tipping point

The LED industry appears poised for a new phase of growth, with three companies alone raising close to \$800m in the past two months, according to the report 'Has LED Lighting Reached a Tipping Point?' from market research firm Strategy Analytics. The three public offerings indicate both the accelerated adoption of LED backlighting technology and some very early signs of the move toward solid-state lighting, the firm believes.

Within one week, Aixtron AG of Herzogenrath, Germany and Veeco Instruments Inc of Plainview, NY, USA, the two key manufacturers of MOCVD reactors for volume LED

production, raised a combined total of \$360m in public offerings and cited strong backlogs in orders for MOCVD equipment. The two offerings followed a similar move by LED chip maker Cree, which raised net proceeds of \$434m and in November announced its decision to build its first chip-fabrication plant outside North America (in Huizhou, Guangdong Province, southern China).

The backlog of Aixtron and Veeco represents orders for about 200 production reactors that can be expected to come on-line during 2010, says Asif Anwar, director of the Strategy Analytics GaAs and Compound Semiconductors Service.

"Both Aixtron and Veeco will need to add production capacity, and will have to invest in technology development for subsequent demand cycles," he adds.

"LED-based backlighting has reached a tipping point where we expect to see significant acceleration of the market for LED-backlit LCD TVs from 2010 on," comments Steve Entwistle, VP of Strategy Analytics' Strategic Technologies Practice. "The financial moves also indicate concrete plans for future growth phases of the LED market with solid-state lighting for general lighting applications."

www.strategyanalytics.com

LEDs to reach 56% of TFT LCD backlight market in 2011

LEDs will become the dominant large-area TFT LCD backlight unit light source by 2011 with a 56% market share as traditional backlights using fluorescent tubes — cold-cathode fluorescent lamps (CCFLs) and external-electrode fluorescent lamps (EEFLs) — for notebook PC, monitor, and TV displays drop to 44%, according to the most recent 'Quarterly LED & CCFL Backlight Report' from market research firm DisplaySearch. LED penetration will skyrocket to 78% in 2015, the firm adds.

With the transition to LEDs already taking place in the notebook PC segment, DisplaySearch forecasts that LED penetration in large-area TFT LCDs will reach 27.8% in 2009. As a result of the LCD TV supply chain's efforts to promote LED-backlit TVs, and the introduction of new LCD monitors with LED backlights, LED penetration in large-area TFT LCD is forecast to reach 44% in 2010. Traditional CCFL and EEFL backlights will fall from 72% in 2009 to 55% in 2011.



Penetration of LEDs into LCD backlighting market.

"LEDs have significant advantages over CCFL and EEFL backlights, such as power consumption, slim form-factor, enhanced performance and market differentiation," notes Yoshio Tamura, leader of DisplaySearch's materials and cost research team. "While there are still some technical and cost premium concerns about LED backlights, this is the first time the LCD TV supply chain (including backlight, display and consumer products) has joined forces to aggressively promote the benefits

of LED backlight products," he adds.

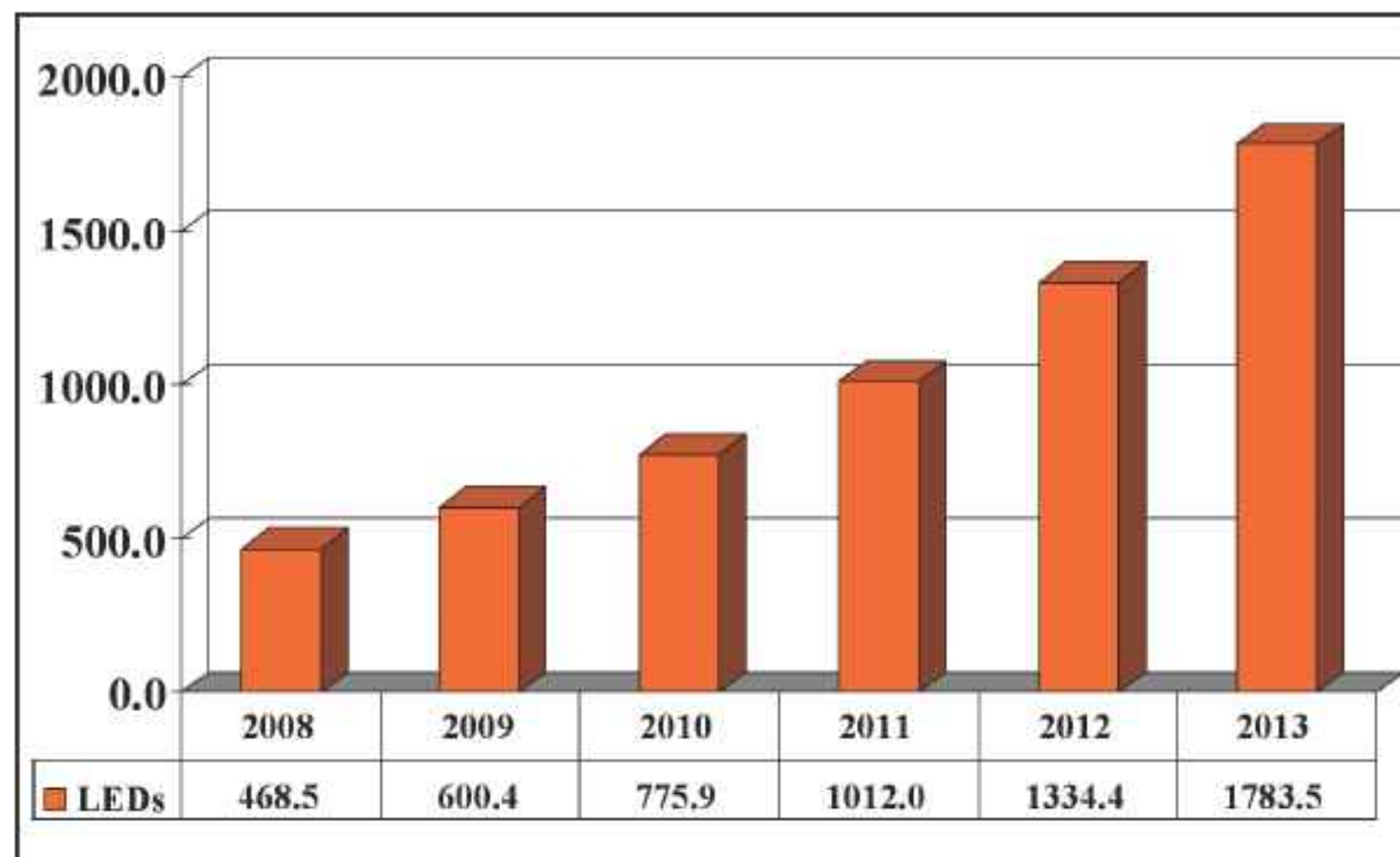
"We are seeing a tremendous LED backlight structure improvement, with cost reduction and supply chain revolution efforts, and this will only accelerate over the next five years," Tamura continues. "LED backlights will continue to drive momentum for continued growth in the TFT LCD industry. As LED backlights gain share in TFT LCD, pressure will be added on emerging display technologies such as PDP and OLED."

www.npd.com

LEDs used in test/measurement & medical science to grow at 30.7% to 1.8bn in 2012

The number of packaged LEDs used worldwide in test/measurement equipment & medical science (devices/equipment) reached 468.5 million in 2008 and is forecasted to rise at an annual growth rate of 30.7% to 1.783 billion in 2012 (see Figure), according to a new report from market research firm ElectroniCast Consultants.

"In terms of volume (quantity) the sensing/detection and analytical/monitoring applications, in 2008, represented nearly 60% share of worldwide consumption of LEDs used in the selected devices," says Stephen Montgomery, president of ElectroniCast – International Business. "This exciting market segment provides LEDs in advanced medical devices such as blood sensors to quality control in manufacturing processes to innovative technology for detection of



The number of packaged LEDs (in millions) used in test/measurement & medical science application/devices.

greenhouse gases," he adds.

"Another interesting market segment to watch is the use of LEDs in photodynamic therapy (PDT) devices, which are increasing at the fastest pace," he continues.

"The end-user devices range from small hand-held consumer products to large floor models used by dermatologists, dentists, cosmetologists and other professional disciplines. We see this particular market segment increasing 6x globally and at a multiple of nearly 8x in the American region over the next five-years."

www.electronicast.com

LED and HB-LED packaging challenges

The market for high-brightness LED (HB LED) and LED devices is currently \$5.56bn, according to the report 'HB LED & LED Packaging 2009' from Yole Développement.

Many firms are thinking packaging as a way of improving devices via new properties and low costs. In 2009, the material & equipment market should reach \$1.2bn (not including optics, leadframe etc).

The LED market is one of the semiconductor industry's high-growth sectors. The supply chain is filled with players from LED die makers (Epistar, Forepi), to LED assembly suppliers (Harvatek, Citizen, Liteon, Samsung) and fully integrated players (Lumileds, Osram, Toyoda Gosei).

In the wide range of LED packaging solutions, Yole presents the existing packaging process flow, materials and equipment and the main evolution in the coming years.

For the two categories of LEDs — (1) regular LEDs or LED lamps

(low-end products) and (2) added-value LEDs (high-brightness and ultra-high-brightness LEDs) — assembly is not the same, explains market analyst Cyrille Chemama.

There are two main processes:

- A standard process for low-cost LEDs (LED lamps): regular LED packaging process flow is based on the standard IC process and almost the same standard material, mainly due to cost, since regular LEDs are low-cost products (under \$0.10).
- A specific process for LEDs with high added-value: as a future lighting source, HB/UHB-LED packaging should have good optical properties, high thermal dissipation, and high reliability.

It is clear that it is now possible to make a perfect product, Chemama says, but the cost would be prohibitive. A choice must be made for each application, e.g. optical efficiency for LCD backlighting and thermal management for

automotive lighting.

Unlike regular LEDs, there are no standards for HB-LED packaging. Each LED vendor has their own proprietary design for most aspects of the assembly process flow. For this market, cost is the main driver: cheaper solutions with the best optical or thermal properties are under investigation. The main goals include a cut in the number parts and use of less costly materials.

Currently, a major issue is 2" or 3" wafers. If the LED manufacturing process were exclusively 2" or 3", this would cause wafer handling issues on equipment. The move to 4" and then 6" or 8" wafers will allow more standardized solutions using regular processes and equipment, says Yole.

There is also a big trend for wafer-level packaging of silicon LED modules, aimed at pushing LEDs to the general lighting market, says Yole.

www.yole.fr

Avago, Eudyna and WIN make gains in \$4bn GaAs device market

Avago Technologies, Eudyna Devices and Taiwan's WIN Semiconductor made impressive gains in market share in 2008, ascending the top-ten list in the annual ranking of the world's leading gallium arsenide device makers by market research firm Strategy Analytics.

RF Micro Devices remains the leading GaAs vendor by revenue, but its closest rivals — fellow US firms Skyworks Solutions and TriQuint Semiconductor — are pushing it hard.

In addition, Avago Technologies overtook Anadigics as the fourth-ranked supplier in 2008. Eudyna took Mitsubishi Electric's position as the leading Japanese GaAs vendor, as the structural change within the Japanese electronics industry is translating into an unprecedented rate of change in the ownership and management of firms running GaAs fabrication plants (with Eudyna, NEC, OKI, Renesas, Sony,

Toshiba, Panasonic and Sanyo all in the process of merging or major structural change).

Fast-growing WIN Semiconductor is neck-and-neck with TriQuint as the largest supplier of GaAs foundry services as the accelerating global trend towards outsourced and hybrid manufacturing has benefited WIN, establishing it as a top-ten player.

"Despite the onset of the global financial crisis, the GaAs industry grew 8%

to reach a total value of \$4bn," says Asif Anwar, director of the Strategy Analytics GaAs service. **The GaAs industry hit bottom during first-half 2009, and has since recovered its former momentum, with no major casualties resulting from the global recession**

Although the end of the year saw production slump to a near-standstill, Strategy Analytics believes that the GaAs industry hit bottom during first-half 2009, and has since recovered its former momentum, with no major casualties resulting from the global recession.

Other findings from Strategy Analytics' reports 'GaAs Device Vendor Market Share 2008: North America' and 'GaAs Device Vendor Market Share 2008: Asia Pacific and Europe' include that:

- M/A-COM will benefit from its ownership change, helping it to challenge competitors in the future;
- revenues at Japanese GaAs device makers rose sharply; and
- United Monolithic Semiconductors (UMS) cemented its place as Europe's leading GaAs device maker. However, Europe now houses just two primary GaAs device makers (UMS and OMMIC).

www.strategyanalytics.com

Power amplifier market on track to reach \$2.8bn from 4 billion units in 2014 despite dual-mode trend

The market for power amplifiers (PAs) in cell phones and related mobile devices will grow to \$2.8bn over the next five years, according to the report 'Cellular PA Forecast 2009-2014' from the Strategy Analytics RF & Wireless Component market research service.

Demand for cellular PAs declined in first-half 2009 due to the slowdown in handset shipments. However, cellular will continue to spread beyond conventional handsets into notebook and netbook computers as well as machine-to-machine systems such as automatic meter readers, says Strategy Analytics. At the same time, the number of bands used by the typical cellular terminal will continue to increase.

Together, these trends promise continued growth in shipments of cellular terminals and PAs, even as the conventional cell-phone market matures and growth slows.

"We estimate that the PA market will reach almost 4 billion units per year in 2014, even as dual-mode PAs begin to reduce the power amplifier count per cellular terminal," says Chris Taylor, director of Strategy Analytics' RF & Wireless Components market research service. **Cellular will continue to spread beyond conventional handsets into notebook and netbook computers**

"Shipments of CMOS PAs will increase over the next five years, but GaAs-based PA modules will continue to dominate the market as cellular moves beyond W-CDMA to LTE [long-term evolution]," comments Asif Anwar, who is the director of Strategy Analytics's Gallium Arsenide and Compound Semiconductor market research service.

The report covers shipments by power amplifier air interface (CDMA, GSM/GPRS, EDGE, and W-CDMA variants), the primary process technology (GaAs, LDMOS, CMOS, and SiGe BiCMOS) and the module type (basic module, PA-duplexer, and PA-switch).

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TriQuint's growth slows prior to expected Q4 pick-up

For third-quarter 2009, RF front-end product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported revenue of \$173m (63% from handsets, 25% from networks, and 12% from defense & aerospace; or 58% from Asia, 37% from Americas and 5% from Europe). This is down 7% on \$186.3m a year ago and up just 2% on last quarter's \$169.1m (compared with first-quarter 2009's sequential growth of 42%).

However, says president & CEO Ralph Quinsey, "TriQuint revenue in the last six months is up 28% compared with the previous six months, demonstrating a strong rebound from the economic slow-down [better than the industry as a whole]". Most recently, in Q3/2009, all three of the firm's markets grew sequentially.

Networks revenue grew the most (13%), driven by an 83% rise in wireless client revenue (due to increased demand in wireless LAN as excess inventory was cleared by a key customer). Transport revenue was down sequentially, with weakness in point-to-point radio, VSAT and cable, but this was offset by growth in optical markets and some growth in emerging markets (particularly automotive radar, due to the launch of a new program). However, general weakness persists in the transport submarket as carriers remain cautious on 2009 capital expenditure. "Networks revenue has been slower to recover than anticipated," comments chief financial officer Steve Buhaly.

Handset revenue was up only slightly sequentially, but up 11% on a year ago (EDGE up 136% and CDMA up 6% — wideband CDMA grew only slightly, but this was compared to an extraordinarily strong year-ago quarter, during

which TriQuint completed a major 3G program launch). GSM revenue fell 22% year-on-year, but this contributed to improved handset margins. While handset unit sales are down about 7% in 2009, TriQuint says that it is benefiting from healthy demand for 3G products (up 15-20%). Year-to-date, TriQuint's handset-related revenue is up about 30% (largely due to W-CDMA being up 60%, with CDMA up 10-12% and GSM down about 30%). "I see no significant inventory problems in the handset market, although inventory adjustments at specific customers happen regularly," says Quinsey.

Defense and aerospace revenue grew 40% on a year ago (due to radar programs such as the Joint Strike Fighter) but just 6% sequentially. "The long-anticipated flattening in the Department of Defense is certainly upon us, but TriQuint continues to benefit from new program ramps, our ability to attract new research revenue, and our investments in new technologies," says Quinsey. Highlights for the quarter include a new \$16.2m three-phase research contract (over four and a half years) from the US Defense Advanced Research Projects Agency (DARPA) for the Nitride Electrical NeXt-Generation Technology (NEXT) program, targeting 500GHz operation.

On a non-GAAP basis, Q3/2009 gross margin was 35%, up from 33.2% last quarter due to improved

factory utilization (75%, including 77% in Oregon and 39% in Texas) as well as eliminating inefficiencies associated with high sequential revenue growth in Q2/2009.

Non-GAAP net income was \$15.7m, down from \$17.1m a year ago but up from \$11.5m last quarter.

Cash flow from operations was \$45.7m. Primary uses of cash were \$14.8m in capital spending and \$8m for acquiring TriAccess Technologies of Santa Rosa, CA, a provider of cable TV (CATV) and fiber-to-the-home (FTTH) devices. Nevertheless, cash, cash equivalents, and investments still rose by \$35.2m to \$134.6m, and TriQuint has no debt.

For fourth-quarter 2009, TriQuint expects revenue of \$175-185m, representing growth of 20% year-on-year and 4% sequentially (due mainly to handsets growing 8-10%, despite a Korean customer making a demand adjustment to eliminate excess inventory). As of 21 October, TriQuint was 91% booked to the mid-point of the revenue guidance. The firm also expects non-GAAP gross margin of 35-37%.

Cash reserves are expected to rise by a further \$15m. "As we generate more cash, we'll look at our merger and acquisition opportunities, and other opportunities as well," says CFO Steve Buhaly

Cash reserves are expected to rise by a further \$15m. "As we generate more cash, we'll look at our merger and acquisition opportunities, and other opportunities as well," comments

chief financial officer Steve Buhaly. www.triquint.com

TriQuint recognized with supplier excellence award by Raytheon Space and Airborne Systems

RF front-end product maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA has been recognized by Raytheon Company for exceptional performance in supporting its Space and Airborne Systems (SAS) business during 2008. This is the second consecutive year that TriQuint has been honored with a Raytheon SAS Supplier Excellence Award (SEA).

TriQuint was one of five firms recognized by Raytheon at the four-star level. Winning suppliers represent less than 1% of the SAS supply base. Only 30 companies of the 3000 that supply Raytheon SAS received awards.

Winning firms were chosen by Raytheon for meeting demanding quality and delivery performance, customer satisfaction as well as total business and financial health standards. Evaluations from Raytheon buyers and material program managers who work with TriQuint every day were part of the selection process.

The recognition by Raytheon SAS spotlights TriQuint's service and

work on chipsets for phased array radar and other critical programs, comments vice president Tom Corder, who received the award along with Dr Gailon Brehm, TriQuint's Military Products marketing director. "It honors the TriQuint professionals who dedicate themselves to defense and aerospace products," remarks Brehm.

TriQuint manufactures integrated circuits for defense and aerospace applications including communications satellites, phased array radar, guidance, control and related systems. The firm's expertise in GaAs and GaN power technologies as well as packaged and custom products, including SAW and BAW filters, enables it to supply components to major defense and aerospace contractors. The firm's foundry is supported by the ISO/AS9100 Approved Quality System. Earlier this year, TriQuint was named by Strategy Analytics as the world's largest commercial GaAs foundry in 2009. TriQuint also became a Department of Defense (DoD) Category 1A 'Trusted Foundry' for GaAs devices in 2008.

IN BRIEF

Low-EIN amplifier for RFoG cable applications

In conjunction with the SCTE Cable Tec Expo '09 in Denver, CO, USA (28-30 October), TriQuint launched an RFoG (RF over glass) amplifier for optical receivers as part of its new TriAccess line. This follows TriQuint's acquisition in September of TriAccess Technologies of Santa Rosa, CA, a provider of cable TV (CATV) and fiber-to-the-premise (FTTP) RFIC components for the amplification of multimedia content.

TriQuint claims that its new TAT7457 amplifier performs with less than half the equivalent input noise (EIN) of existing RFoG/cable amplifier solutions.



"We believe TAT7457 will meet a critical need by enabling manufacturers to significantly extend the RFoG system link budget," says Brian Bauer, TriQuint's product marketing manager for Cable and FTTH devices.

www.triquint.com

TriQuint makes final of Oregon Manufacturing Company of the Year

At a luncheon at the Portland Art Museum on 29 October, TriQuint was named a finalist by the Portland Business Journal in the inaugural 'Oregon Manufacturing Company of the Year' awards, which recognize successful Oregon firms and their role in driving the regional economy through manufacturing and strategic innovation. The award criteria included company performance, overall business strategy and innovative approaches, such as excellence in internal operations and in manufacturing processes that involve customers, partners and suppliers.

TriQuint was a finalist in the Large Company category (for revenues of \$50m and above). The firm says that finalist designation acknowledges its success in a tough economic climate and in handling the ups and downs of dramatic changes in product demand, while avoiding layoffs and rebounding toward another record revenue year.

At the Oregon Manufacturing Awards luncheon, Intel's chief economist Paul Thomas gave the keynote address and noted the importance of continuing to invest and drive for results even in a challenging economic climate. He

commented that ongoing investment in technology innovation will be key to helping the region's economic recovery.

"By remaining focused on quality and customer service while experiencing a dramatic swing in demand and factory utilization, we've managed this phase while delivering results," says Steve Grant, TriQuint's VP of worldwide operations. The firm used the slower time in the factory to improve processes, fine tune procedures and find ways to increase factory efficiency, he adds.

<http://portland.bizjournals.com/portland/event/5513?mp=3>

RFMD's revenue grows 20%, boosted by CATV growth of 70%

For its fiscal second-quarter 2010 (ended 3 October 2009), RF Micro Devices Inc of Greensboro, NC, USA has reported revenue of \$254.8m, down 6.2% on \$271.7m a year ago but up 20% on \$212.5m last quarter.

The Multi-Market Products Group (MPG) comprised slightly less than 20% of revenue and the Cellular Products Group (CPG) just over 80% (up from 75% last quarter).

CPG grew significantly faster than its end markets, driven by new product cycles as diversification efforts yield results. The group launched nine new products during the quarter, and is on track to launch about 40 this fiscal year. While revenue grew sequentially at CPG's largest customer, total revenue at all other customers also grew, by about 50%. In particular, sales to Greater China rose 75% (to 10% of overall revenue).

Cellular product sales into 3G handsets increased by 50% year-on-year. CPG also broadened its customer base for its portfolio of power amplifiers and switch products for 4G LTE data cards and handsets.

In MPG, shipments of WiMAX components grew 40% sequentially, while CATV revenue grew by 70%. During the quarter, MPG added two new automatic meter reading (AMR)/smart-grid customers, and increased its electronic toll collection (ETC) customer base in China to seven (now covering all major population centers in China). MPG launched a record 100 new and derivative products, making 169 through fiscal first-half 2010 (and is on track to launch more than a product a day in full-year fiscal 2010). During the quarter, RFMD completed the transfer of production & test of MPG's integrated circuit (IC) and multi-chip module (MCM) products from Shanghai to its primary assembly facility in Beijing.

"RFMD's business model generated significant improvements in several key financial metrics," says chief financial officer Dean Priddy. Gross margin has risen from 28.3% a year ago and 34.8% last quarter to 35.9%.

Compared to an operating loss of \$19m a year ago, operating profit almost doubled from last quarter's \$12.1m to a record \$24.1m (operating margin of 9.5% of revenue).

However, excluding the impact of Polaris cellular transceivers (which have gross margin in the mid-teens and comprised 10–15% of total revenue), core business exceeded RFMD's target model of 40% gross margin and 15% operating margin.

Compared to net loss of \$14.2m a year ago, net income was \$14.6m, more than triple last quarter's \$4.8m.

Cash flow from operations rose from \$36.4m last quarter to \$47.2m. Subtracting capital expenditure of just \$1.4m, free cash flow was \$45.8m (up 33% sequentially). Total cash, cash equivalents, short-term investment and trading security investment therefore rose to \$357.8m.

RFMD believes its overall business environment is improving. The firm is experiencing continued strong demand from its cellular customers and much improved order visibility in MPG's main markets, including significant growth in CATV.

Adjusting for the 14-week September quarter, for the 13-week December quarter RFMD expects revenue to grow sequentially, and gross margin to be maintained.

Capital expenditure should be \$3m (tracking to the low-end of RFMD's forecast of \$10–20m for fiscal 2010). "It's likely we'll maintain at that level for the foreseeable future," says Priddy. "We are continuing to ramp our reduced-die-size products, resulting in meaningful and sustainable positive impact on manufacturing capacity. We are only in about the third innings for die-size reductions, so we are very optimistic that we can continue to grow revenues and improve the quality of profit without the need for significant gallium arsenide capital investments," he adds.

For the December quarter, RFMD therefore also expects strong cash flow and sequential growth in cash, cash equivalents and short-term investments. "Our expectations are for continued strong performance both in the December quarter and in calendar year 2010," adds president & CEO Bob Bruggeworth.

Also, despite Polaris transceivers maintaining a sizable low-margin contribution to revenue for roughly

We are very optimistic that we can continue to grow revenues and improve the quality of profit without the need for significant GaAs capital investments

three more quarters, in the longer term RFMD expects a substantial and sustainable improvement in gross margin, due to its customer diversification, the release of reduced-die-size products, the return of MPG's end markets, the transfer of MPG

test & assembly to Beijing, declines in depreciation, and increases in capacity utilization.

www.rfmd.com

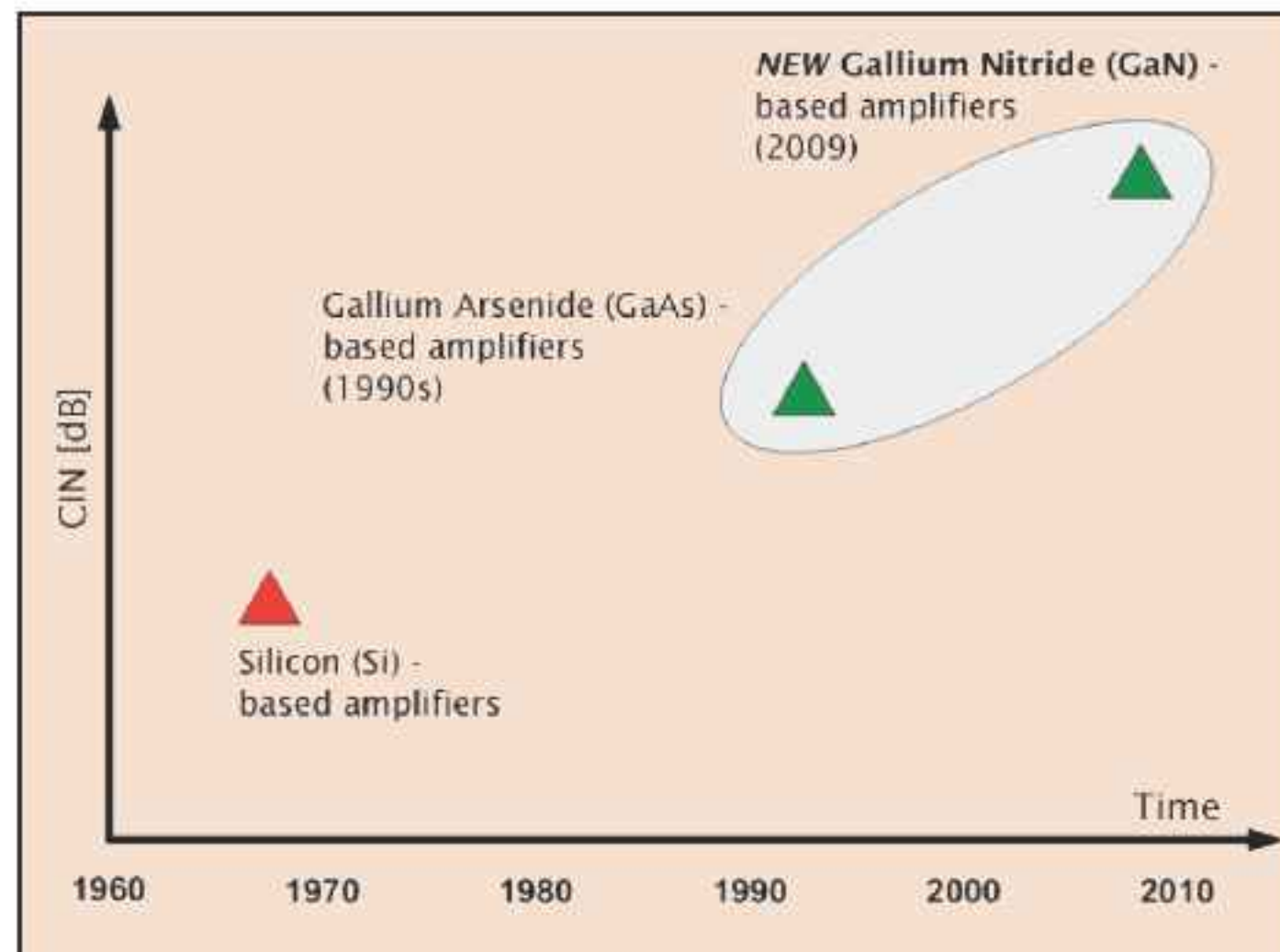
GaN hybrid power doubler amplifier modules for CATV

At the SCTE Cable-Tec Expo '09 in Denver (28–30 October), RF Micro Devices Inc of Greensboro, NC, USA launched what it claims is the industry's first 'green' gallium nitride (GaN) based CATV amplifier modules (D10040200PL1 and D10040230PL1), designed for use in current- and next-generation CATV infrastructure applications.

The hybrid power doubler amplifier modules are designed to provide the final amplifier stage for CATV trunk amplifiers, line extenders, and optical nodes. Operating at 45–1000MHz, the parts employ GaAs pHEMT and GaN HEMT die.

With low current and very low distortion, the D10040200PL1 and D10040230PL1 are stable under all terminations, says the firm.

Furthermore, the performance of the new amplifiers is said to be on a



Distortion performance of GaN amplifiers vs GaAs and Si.

par with RFMD's other GaAs CATV power doublers, but with 20% lower current consumption (24V/380mA). With these 'green' energy-saving benefits, the modules enable designers to fulfill growing requirements for lower energy consumption and to assist network operators in their drive to reduce the overall cost of operating

CATV networks. The D10040200PL1 and D10040230PL1 are the best-performing low-current CATV power doubler amplifiers on the market, claims RFMD.

"Network operators worldwide are increasingly focused on reducing the energy costs of operating their wireless and wireline networks," says Bob Van Buskirk, president of RFMD's Multi-Market Products Group (MPG). "RFMD's high-performance GaN technology satisfies the industry's drive for 'green technology' by

enabling advanced RF components and products that provide industry-leading power and operate at significantly lower power consumption levels."

RFMD claims it was first to launch GaN CATV amplifier modules: the D10040200PH1 and D10040230PH1 high-output power doubler CATV amplifier modules in June 2008.

Ultra-linear push-pull amplifiers for CATV infrastructure

RF Micro Devices has launched a portfolio of push-pull amplifiers designed for multiple cable TV (CATV) infrastructure applications. The CGA/CGR product portfolio includes the CGA-1518Z and CGA-7718Z amplifiers for forward path, downstream applications and the CGR-0118Z and CGR-0218Z amplifiers for return path, upstream applications.

Each amplifier leverages RFMD's proprietary HBT8D InGaP heterojunction bipolar transistor (HBT) process technology, combined with a 'push-pull' architecture, to deliver what is claimed to be best-in-class composite second order (CSO) distortion performance. The push-pull amplifiers are designed for ultra-linear amplification in current- and next-generation CATV applications, including multiple dwelling unit (MDU) amplifiers,

low-cost line extenders (LE), and customer premises equipment (CPE).

RFMD says that the CGA-1518Z matches the gain of competing +12Vdc push-pull amplifiers with lower multi-carrier distortion and a reduction of >1.5W in DC power consumption. The CGA-7718Z offers higher gain and lower multi-carrier distortion performance than the CGA-1518Z while consuming 1W less DC power than competing +12Vdc push-pull amplifiers, it is claimed. The CGA-1518Z and CGA-7718Z are suited to applications that require superior broadband amplification and must conserve DC power, such as CPE, MDUs and battery back-up cable and telephone networks carrying voice, data, and video.

The CGR-0118Z offers what is claimed to be the broadband industry's only 25dB gain surface

mount device (SMD) return path amplifier capable of ultra-linear +50dBmV RF output per channel performance from 5MHz to 65MHz combined with low multi-carrier distortion, excellent modulation error ratio (MER) and low DC power consumption. The CGR-0218Z provides what is claimed to be unmatched 5–210MHz bandwidth for ultra-linear return path applications requiring a SMD package, making it ready now for 'mid-split' return path architectures and 'future proof' for soon-to-be implemented DOCSIS 3.0 compliant 5–85MHz return path networks. The CGR-0118Z and CGR-0218Z meet the performance requirements demanded by channel bonding capable return path networks, MDU class return amplifiers, and CPE cable modems.

www.rfmd.com

IN BRIEF

RFMD cellular switch designed into CDMA smartphones for 2010

RF Micro Devices Inc of Greensboro, NC, USA has been selected by what it describes as a leading manufacturer of smartphones to supply its RF1130 single-pole 3-throw (SP3T) cellular switch for two upcoming CDMA models targeting the consumer smartphone market.

Shipments of the RF1130 are expected to start in the March quarter, for an expected launch of the first model in first-half 2010.

"We look forward to expanding our relationship through additional design opportunities across our RF components and switch & signal conditioning product portfolios," says Mike DeHaan, general manager of RFMD's Switch and Signal Conditioning business unit. "As new 3G/4G air interface standards are added and cellular devices increase in RF complexity, our expanding product portfolio and wide technology base enable RFMD to uniquely satisfy the technical requirements of tomorrow's smartphones and battery-powered multimedia devices," he adds.

The design win supports RFMD's diversification efforts across customers and air interface standards. The firm says that it is engaged at the smartphone maker to secure incremental business opportunities across 3G front ends, cellular switches, RF power management and WLAN components.

RFMD claims a leading market share in smartphones and expects its revenue growth in smartphones in 2010 to significantly exceed the handset market's growth rate.

www.rfmd.com

Anadigics upbeat on future wireless markets

GaAs-based broadband wireless and wireline communications component maker Anadigics Inc of Warren, NJ, USA has reported third-quarter 2009 net sales of \$36.7m, a decrease of 36.8% from third-quarter 2008. Not unusually, the company showed a 16.7% increase in net sales in a second to third quarter comparison. Furthermore, these results were better than Anadigics' expectation for the quarter of a sequential increase (third/second quarter) of just 5-10%.

The company saw an earlier-than-expected recovery in the broadband market (set-top boxes and wireless LAN). The 3G wireless market also made a good showing. Anadigics has LG, Samsung and Research In Motion (RIM) — the producer of the Blackberry communication device — as significant customers.

Net loss for the quarter was \$12.9m, or \$0.21 per share, as calculated according to US Generally Accepted Accounting Principles (GAAP). Removing non-recurring charges and a tax refund of \$0.3m gives a net loss \$6.4m, or \$0.10 per share. These non-GAAP figures exclude charges for a commercial dispute settlement with a customer (\$3.9m) and for stock-based compensation measures (\$2.9m).

Despite the negative figures, Anadigics' president & CEO Mario Rivas is upbeat: "Our positive third-quarter results are evidence of the successful execution on our stated business initiatives, resulting in revenue and non-GAAP loss per share exceeding our guidance. Our revenue during the quarter benefited from continued growth in our 3G wireless products as well as an earlier-than-expected recovery in both our cable TV and WLAN revenue."

The company is moving to a hybrid production strategy involving both its fab in Warren and a recent foundry agreement with WIN Semiconductors. The Taiwan-based foundry is expected to provide expanded production capabilities for Anadigics by fourth-quarter 2010. WIN has a range of gallium arsenide (GaAs) processes, including 1-2µm heterojunction bipolar transistors (HBTs), 0.1-0.5µm pseudomorphic high-electron-mobility transistors (PHEMTs), and combinations of the two (BiFET). WIN claims that these processes can cover frequency requirements from sub-1GHz up to 100GHz.

Utilization at Anadigics' 6-inch GaAs fab in Warren rose by 50% during the quarter, reaching 55%. Device types include InGaP HBT, GaAs MESFET, and GaAs pHEMT.

Anadigics has a large number of new products coming: power amplifiers (PAs) for wideband CDMA, HSPA and LTE cellular handsets; cable TV line amplifiers; PAs for mobile WiMAX (2.5GHz and 3.5GHz); and WiFi front-end modules and ICs for notebooks, netbooks, PCs and wireless handsets.

Anadigics believes its net sales for fourth-quarter 2009 will increase by 5-8% over the most recent results, giving a GAAP net loss per share of \$0.16-0.18 and non-GAAP losses of \$0.08-0.10/share. This is despite some recent negative 'inventory adjustments'. Utilization is expected to fall as a result of a year-end two-week shutdown, negatively impacting gross margins in sequential quarter-to-quarter comparisons.

www.anadigics.com

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997

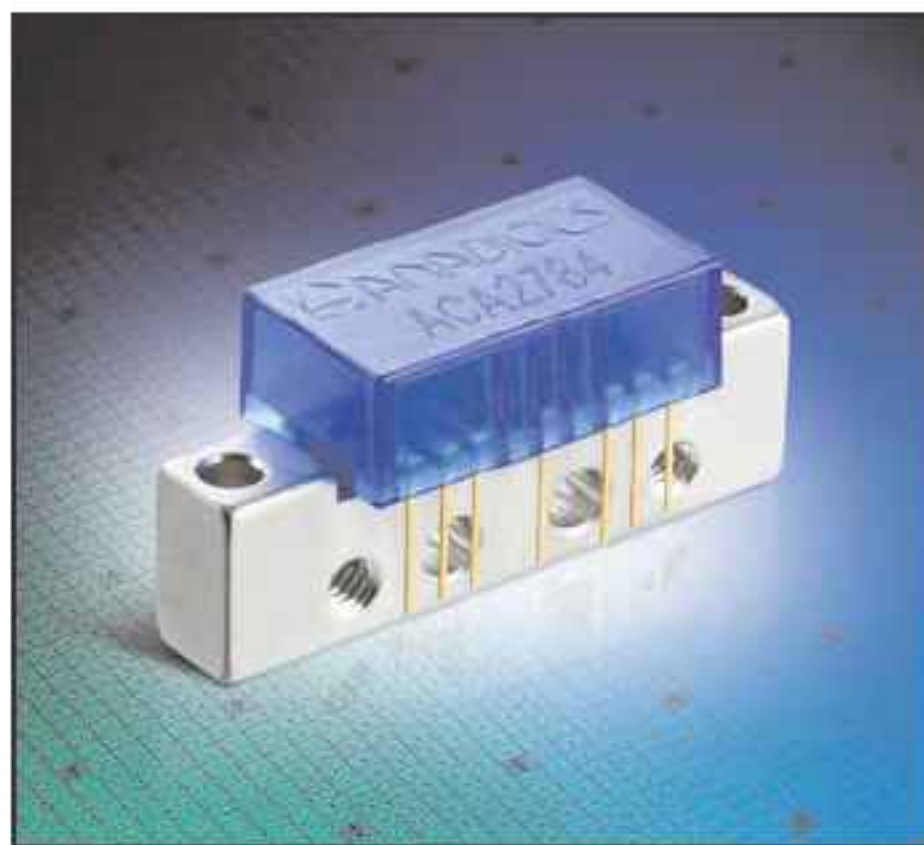
New family of 1GHz hybrid line amplifiers for CATV

GaAs-based wireless and broadband communications component maker Anadigics Inc of Warren, NJ, USA launched a new family of 1GHz hybrid line amplifiers that leverage the firm's CATV amplifier technology to provide what is claimed to be exceptional linearity and distortion performance in an industry-standard SOT115J package.

The ACA2764 is a push-pull amplifier that delivers 21.5dB gain and +40dBmV per channel linear output power. The ACA2782 and ACA2784 are power doublers that deliver 21.5dB gain and, respectively, +55dBmV and +58dBmV per channel linear output power. The ACA2786 is a power doubler that delivers 25dB gain and +58dBmV per channel linear output power.

The amplifiers deliver the additional channel spectrum required by multiple systems operators (MSOs) looking to upgrade infrastructure to support higher-throughput applications, such as high-definition video, VOD, and high-data-rate internet.

Over the past 15 years Anadigics has shipped over 20 million line



Anadigics' new ACA2784 1GHz hybrid line amplifier.

amplifiers in surface-mount packages. Based on this experience, the firm has developed new 1GHz hybrid devices that deliver what is claimed to be unmatched levels of linearity and exceptional return loss, while providing high tolerance to electro-static discharge (ESD), enhancing ruggedness for outdoor operation.

"Our new 1GHz line amplifiers provide MSOs with valuable added spectrum," says senior product marketing manager Ray Aubert.

"With today's compression

technology, some MSOs are maxing out their spectrum as they add more standard and HD channels to their lineup. And as new bandwidth-intensive, high-data-rate technologies such as DOCSIS 3.0 gain momentum, spectrum expansion to 1GHz will become more prevalent."

Another trend in the CATV industry is to push the fiber content of hybrid fiber-coax networks deeper towards the subscriber terminal. MSOs now have the chance to provide systems that will support growing bandwidth demands by incorporating the latest 1GHz devices when performing node splits, or when installing new fiber nodes and system amplifiers in greenfield deployments.

"We have leveraged our vast experience in GaAs MESFET processes to deliver industry-leading performance," says Doug Johnson, VP of CATV products. "To assure field ruggedness, our parts have been tested to ESD levels which far exceed any other hybrid available."

www.anadigics.com

Anadigics launches 4G power amplifier for mobile WiMAX

Anadigics has made available samples of a 4G power amplifier (PA) that delivers typical error vector magnitude (EVM) of 2.5% at +25dBm linear output power and typical power-added efficiency of 24% for mobile WiMAX applications in the 2.3–2.7GHz spectrum. RF gain is 30dB.

Developed for use in handsets, PC cards/dongles and embedded WiMAX modules, the AWT6264 enables high-performance mobile devices that conform to the IEEE802.16e standard and maximizes battery life for mobile WiMAX applications.

As the first mobile broadband wireless standard to be made available commercially, WiMAX technology is currently the corner-

stone of networks serving mobile subscribers worldwide, says Anadigics. In a recent research report, Maravedis Inc estimated that the number of WiMAX subscribers will exceed 75 million by 2014, when more than 100 million mobile WiMAX-enabled devices will be shipped.

"Global WiMAX roll-outs will dramatically increase the demand for broadband wireless subscriber products, with battery life being a key differentiator," says Glenn Eswein, Anadigics' director of product marketing.

The AWT6264's wide 2.3–2.7GHz operating bandwidth enables OEMs to serve multiple geographies [USA, Russia, Taiwan, Japan, South Korea and Malaysia] with a

single device. In addition, the 4mm x 4mm x 1mm device — which incorporates fully matched RF ports, an output power detector and a step attenuator — supports faster product development cycles and requires less PC board space than more discrete solutions.

"This new power amplifier module offers +25dBm output power, together with the linearity and spectrum mask performance required by service providers operating in the 2.5GHz spectrum," says Joe Cozzarelli, director of Wireless Infrastructure and WiMAX product development. "The performance of the AWT6264 enables a class of mobile devices that will provide the consumer with a rich wireless broadband experience."

Skyworks' recovery strengthens, boosted by diversification, market-share gains and content growth

For its fiscal fourth-quarter 2009 (to end September), Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions for handset and infrastructure equipment, has reported revenue of \$228.1m (80% from handsets and 20% from linear products).

Though down 2% on \$232.6m a year ago, this is up 19% on the June quarter's \$191.2m (which itself was up 11% on the March quarter's low of \$173m). It also exceeds the revenue guidance of \$220–225m (which had been raised from \$210m on 9 September).

Nevertheless, full-year fiscal 2009 revenue of \$802.6m was still down 7% on fiscal 2008's \$860m (following the 10% and 18% sequential slumps in the December 2008 and March 2009 quarters).

After cutting staffing by 4% (150 employees) in the March quarter, operating expenses have been cut from \$65.8m a year ago to \$59.6m in fiscal Q4. Subsequently, on a non-GAAP basis, operating margin has risen from 15% last quarter to 18.6% and gross margin from 40.5% to 40.9% (up slightly on 40.8% a year ago). Skyworks attributes the increase to continued factory process and productivity enhancements, product and yield improvements, and double-digit year-on-year material cost reductions. Non-GAAP net income has hence risen from \$27m last quarter to \$41.8m (above \$35.3m a year ago).

Skyworks says that a fab-lite manufacturing approach and leaner cost structure yielded full-year fiscal 2009 operating margin of 15.1% (exceeding 2008's 14.1%) and net income of \$116.5m (remarkably almost equaling 2008's \$117.4m).

Hence, despite the worst industry downturn in recent memory, cash flow from operations was \$210m,

including \$70m in fiscal Q4. During the quarter, despite \$15m in capital expenditure and retiring \$17.4m of the \$50m in 2010 convertible debt due on 1 March, cash and equivalents rose from \$308m to \$370m.

"Skyworks' improving financial performance reflects the growing momentum of the mobile internet and increasing demand for always-on connectivity, particularly given the ubiquity of social networking applications and the proliferation of smart phones, notebooks, netbooks and embedded wireless devices," says president & CEO David J. Aldrich. "We believe we are at the beginning of three powerful, multi-year waves including broadband access growth, infrastructure capacity expansion and smart grid implementations"

During fiscal Q4, Skyworks supported the launch of a number of Android-based smart phones; started production in support of Intel wireless local-area networking (WLAN) reference designs for notebook and netbook devices; launched network infrastructure digital attenuators, voltage-controlled oscillators, synthesizers and mixers at Huawei, ZTE, Ericsson, Alcatel-Lucent and Nokia-Siemens; and ramped smart-grid solutions at Itron, ESCO, Neptune, Landis + Gyr and Sensus leveraging new ZigBee architectures. "We are entering a new and exciting growth phase which is positioning Skyworks to further differentiate and demonstrate even greater operating leverage," adds Aldrich.

"Although we continue to remain cautious on the broader economy, based on our improving order visibility and backlog strength, we anticipate 13–15% year-over-year revenue growth for the first fiscal quarter of 2010 [to \$238–242m] driven by mobile internet, energy management and diversified analog applications," says VP & chief financial officer Donald W. Palette.

Assuming \$240m in revenue, Skyworks expects non-GAAP gross margin to rise to 41.5–42%, and operating expenses of \$51.5m, yielding operating margin of 20%. This achieves Skyworks' previous targeted financial model of \$240m in quarterly revenue, 42% gross margin and 20% operating margin.

Given its future product mix, gross margin improvements, and operating expense leverage,

Skyworks has been ramping up its 6-inch GaAs production line for several quarters... the firm plans full conversion from 4-inch wafers in mid-2010, boosting margins in second-half 2010

Skyworks says that it now sees a path to a new target operating margin in the mid-20s. "We believe this longer-term model is highly achievable and strikes the right balance between gaining market share, enhancing margins and, most impor-

tantly, maximizing free cash flow," concludes Palette. In particular, Skyworks has been ramping up its 6-inch GaAs production line for several quarters, but Palette says that the firm plans full conversion from 4-inch wafers in mid-2010, boosting margins in second-half 2010.

www.skyworksinc.com

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Kopin's III-V revenues rise 37% due to smartphones/3G

For third-quarter 2009, GaAs epi-wafer foundry Kopin Corp of Taunton, MA, USA, which makes III-V hetero-junction bipolar transistor (HBT) epiwafers and CyberDisplay LCDs, has reported record revenue of \$32m, up 4% on \$30.7m a year ago and 13% on \$28.2m last quarter.

In contrast to CyberDisplay revenue of \$17.7m (down 4% on \$18.9m a year ago and roughly flat on last quarter), III-Vs revenue of \$14.3m was up 21% on \$11.8m a year ago and 37% on last quarter's \$10.4m.

"Smartphones and other 3G devices fueled robust demand for our III-V products," says president & CEO Dr John C.C. Fan. "Many of these new products require complex circuitry and triple the number of power amplifiers as a standard wireless handset, a technology evolution that only strengthens our position as the world's leading III-V merchant supplier," he claims. "We have invested strategically to increase our 6" wafer capacity and capability, and we expect to further build our 6" infrastructure in the coming year."

While down on 33.8% a year ago, gross margin has recovered from a low of 26% last quarter to 32.6%, reflecting variations in sales mix between CyberDisplay and III-V

products (for which fab utilization was high).

Net income has risen from \$1.5m a year ago and \$3.7m last quarter to \$8.5m. "Despite this challenging economic period, we are delighted that we reported our fifth consecutive profitable quarter," says Fan.

As of 26 September, Kopin had cash and marketable securities of \$107.5m, up from \$105.8m at the end of June and \$100m at the end of 2008. Year-to-date capital expenditure was just \$2.2m.

However, during the quarter, Kopin invested a further \$6.3m in its Asian foundry subsidiary Kopin Taiwan Corp (KTC), raising its stake from 34% to 87%. The firm is hence now consolidating KTC (which contributed \$500,000 of Kopin's Q3/2009 revenue). The additional investment is designed to provide capacity to capitalize on the demand for Taiwan's fast-growing foundry services, fueled by the expanding telecoms and wireless markets. Specifically, it enables KTC to meet customers' demands as they transition from using 4" to using 6" GaAs wafers.

"While the fourth quarter historically has been our seasonally weak quarter, based on discussions with our customers and the expected

continued strong momentum of our military display program and III-V products we expect to achieve the top end of the full-year 2009 revenue guidance of \$90-110m that we issued in April [nearer to 2008's revenue of \$114.8m]," says Fan.

"With our good financial and operational results through the first nine months of the year, we are poised to complete a strong 2009 performance despite the challenges created by the economic recession," Fan continues. "Although visibility into 2010 is still somewhat limited by the economic climate, we plan to continue to aggressively leverage our Wafer Engineering and AMLCD technologies to develop transformative applications for high-growth markets," he adds.

"Kopin is anchored by a strong balance sheet, which has enabled us to invest strategically in advanced research and production equipment and processes in the past few years [CapEx is expected to increase to \$6-10m for the next 12 months]. Exciting new products and technology platforms are coming on line, and we are continuing our active patent filing of new technologies and products."

www.kopin.com

Sumika boosts epi capacity to meet GaAs HBT demand

III-V epiwafer foundry Sumika Electronic Materials Inc of Phoenix, AZ, USA (a subsidiary of Japan's Sumitomo Chemical Co Ltd) says that it is installing an additional Aixtron 2600 G3 MOCVD epi reactor to address growing demand for its compound semiconductor epitaxial deposition services (mainly for high-frequency ICs for wireless communications).

"Our capacity expansion is in response to the steadily increasing demand we're seeing for our GaAs epi wafer services from producers of HBT devices and other microelectronics requiring compound semiconductor materials," says

Ken Campman, general manager of Sumika Electronic Materials' epi operations. "These customers are ramping up their orders for epi wafers that meet their needs for repeatability and stability, especially in terms of gain performance — a key requirement in processing advanced HBT devices."

Market research firm Strategy Analytics estimates that the global semi-insulating GaAs epitaxial substrate market (merchant & captive) will be 21.1 million square inches in 2009, and will grow at a projected compound annual growth rate (CAGR) of 6% to 26.6 million square inches in 2013.

Sumika says that the Aixtron reactor can be easily integrated into its existing installed base, which includes several other 2600 G3 systems as well as other epi reactors from multiple equipment suppliers.

The firm's 150mm epi foundry in Phoenix has been in operation since the its formation when Sumitomo Chemical Co Ltd acquired ATMI's GaAs epiwafer business in 2003. The foundry also provides III-V epi services to manufacturers of discrete semiconductor components, pHEMTs, LEDs, and solar cells for CPV (concentrated photovoltaic) systems.

www.sumikamaterials.com



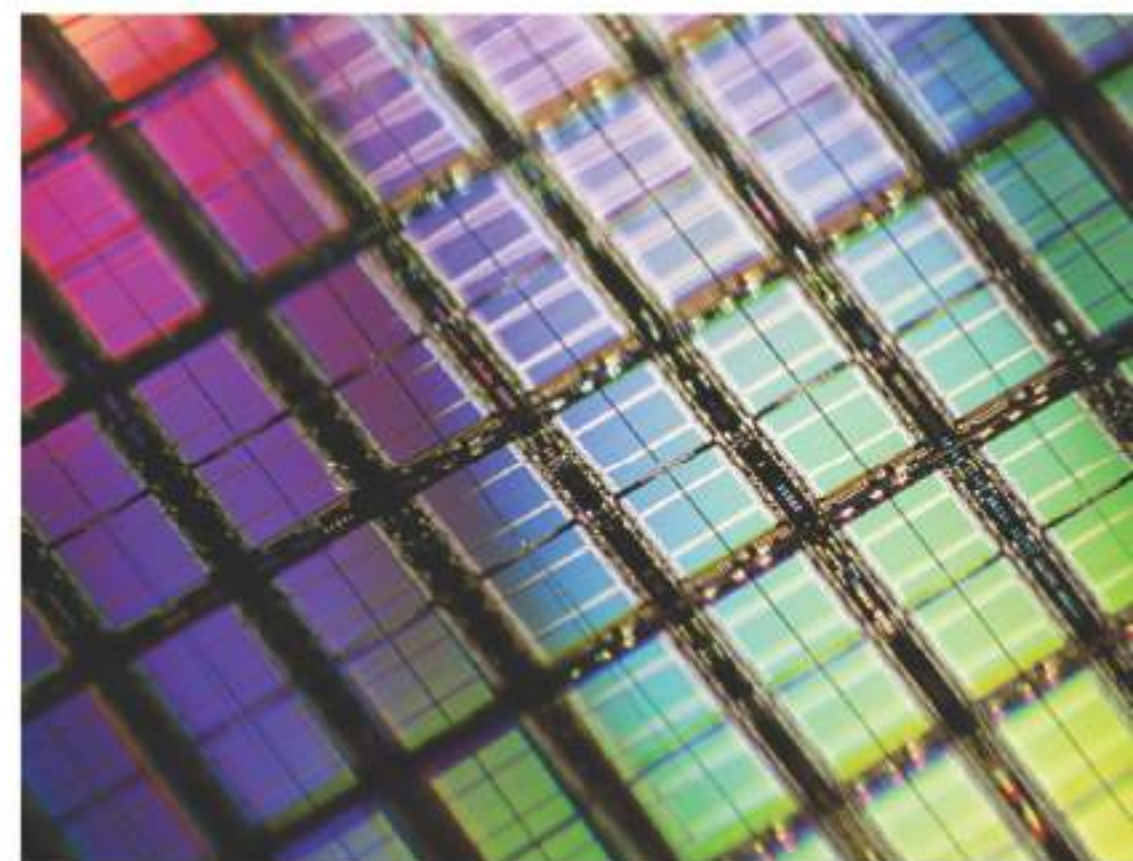
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IN BRIEF

M/A-COM Tech recruits ex-TriQuint engineering exec as VP of engineering

M/A-COM Technology Solutions Inc of Lowell, MA, USA, which provides semiconductors, active and passive components and subassemblies for RF, microwave and millimeter-wave applications, has recruited Mike Murphy as VP of engineering, reporting to CEO Joseph G. Thomas.

Murphy will lead new technology and product development efforts for the firm, taking the lead in setting policy in many areas as well as R&D project tracking and reporting. M/A-COM says that he will play a key role in developing and executing on its new product growth strategy.

Most recently, Murphy served as VP of engineering of the Networks and Standard Products business unit of TriQuint Semiconductor Inc of Hillsboro, OR. Prior to that, he led TriQuint's New England Design Center, which he initially launched for Infineon Technologies in 1999 (before TriQuint purchased Infineon's GaAs IC business unit in 2002). His early career included 13 years with M/A-COM where, as product line manager in the late 1990s, he led an embryonic business and technical team in the development of RFICs for handset and wireless local-area network (WLAN) applications that grew to more than \$45m in revenue in just a few years.

"This senior staff position is one of our most critical as we kick off our new strategic growth plan," says Thomas. "Mike is an accomplished and recognized technical leader in our industry, having led many game-changing technical and product line teams throughout his career."

www.macomtech.com

Hittite's recovery continues

For third-quarter 2009, 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 revenue of \$41.5m, down 8.9% on \$45.5m a year ago but up 4.5% on \$39.7m last quarter (and above July's \$40–41m forecast).

Compared to 36% and 64% in Q2, 43% of revenue (\$17.8m) came from customers in the USA and 57% (\$23.7m) from outside the USA following a slowing in China 3G infrastructure business. However, this is expected to return to a more typical 40:60 split in future.

Revenue distribution across Hittite's target eight markets was slightly less concentrated, with 78% of revenue being accounted for by three markets (cellular infrastructure, microwave & millimeter-wave communications, and military) versus 82% in Q2.

Automotive, broadband, fiber-optic, space, and test & measurement markets accounted for the remaining 22% (up from 18%). Six of the eight end-markets grew sequentially (compared to just four in Q2). The strongest growth came from test & measurement, followed by (in descending order) military, automotive, microwave communications, broadband and space.

Cellular infrastructure revenue fell due mainly to the exceptionally strong Q2 related to the 3G rollout in China. Fiber-optic revenue also fell due to the timing of orders. However, chairman, president & CEO Stephen G. Daly stresses that such decreases are normal short-term variations, and long-term growth prospects remain strong. The underlying favorable trend of the increased loading of existing infrastructure networks and the need to expand connectivity worldwide represents a significant growth opportunity, he adds.

Although still down slightly on 72.5% a year ago, gross margin has bounced back from a low of 70.4% last quarter to 72% (due to

price, production cost, and mix). Net income was \$12m, down from \$13.7m a year ago but up from \$10.6m last quarter (and above the forecast \$10–10.9m, due to the higher revenue, improved gross margin, and lower operating expenses). Operating cash flow was \$17.9m. During the quarter, total cash and cash equivalents rose from \$197.9m to \$215.2m.

Capital spending was \$1.8m (and \$6.2m year to date), focused on production test & assembly equipment and production mass tooling. "We maintain a high focus of constantly improving our internal manufacturing processes, supply chain management and factory efficiencies," says Daly. "During 2009 we have more than doubled our automated die-attach and wire-bonding assembly capability. This new automation will lower the manufacturing costs for many of our products by improving throughput," he adds. "Automated assembly also improves our product quality, which has a positive effect on production test yield, part-to-part variation and long-term reliability."

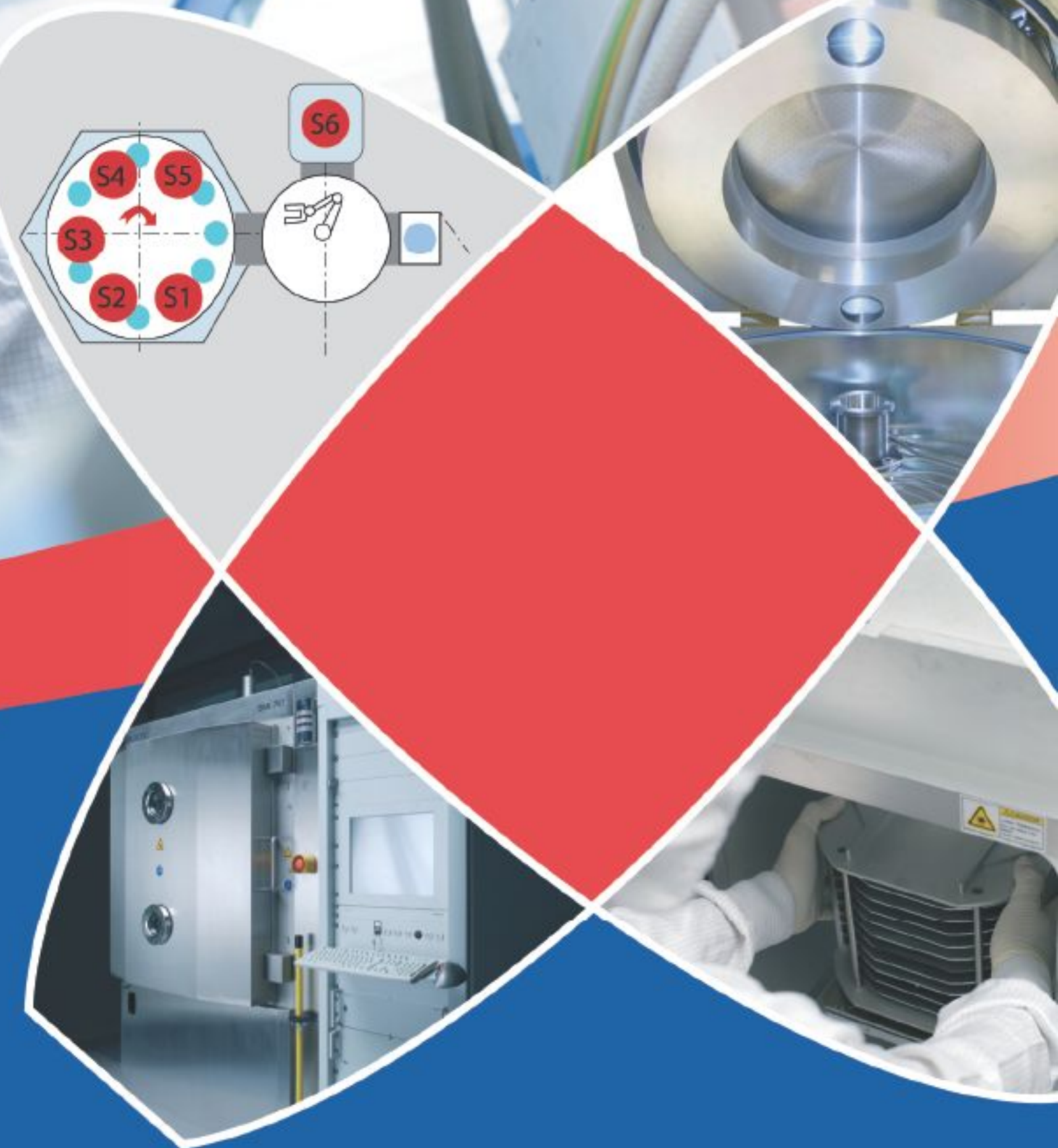
"We introduced 21 new products and recently launched two new product lines," Daly says. "The product line expansion and the continued growth of our product portfolio will enhance our ability to penetrate our target markets." Hittite has over 3000 customers and expects this to rise again in 2009.

With order backlog stronger than at the beginning of Q3, for Q4/2009 Hittite expects revenue to rise by up to 5% to \$42.5–43.5m and net income to be flat at \$11.3–12.3m.

Daly describes military, space, and fiber markets as strong, microwave communications in broadband markets as neutral, and the cellular infrastructure and automotive markets as weak. However, in terms of the long-term growth prospects for infrastructure, he notes that the upcoming release of 3G licenses in India should provide a lot of activity over the next year or so.

www.hittite.com

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RFMD's first GaN order from tier-1 base-station maker

RF Micro Devices Inc of Greensboro, NC, USA has won its first purchase order from a tier-one wireless base-station original equipment manufacturer (OEM) for a product featuring its gallium nitride process technology. The order is for the RFG1M09180 180W GaN broadband power transistor (BPT) and is in support of the global expansion of 4G wireless networks.

The RFG1M09180 BPT supports LTE (long-term evolution) at 750–800MHz, 3GPP/IS95 at 865–895MHz and multi-carrier GSM at 930–960MHz, enabling cost-effective and energy-efficient support of multi-standard base-stations. The product is part of the RFG1M power device family, which addresses power requirements from 30W to 360W, offers wider bandwidth than incumbent LDMOS technology, and supports wireless communication bands from 0.7GHz to 3.8GHz. The RFG1M family also features internal matching and is

optimized for high-efficiency techniques, such as Doherty and envelope tracking.

"We are actively targeting the base-station HPA market, which we expect will represent approximately half of the high-power RF market within the next three years," says Bob Van Buskirk, president of RFMD's Multi-Market Products Group (MPG).

RFMD claims that, compared with existing semiconductor technologies, its GaN process technology delivers superior RF power per square milli-meter and superior RF conversion efficiency. The firm also claims that, in wireless base-station applications, GaN HPAs deliver industry-leading power performance at significantly reduced energy requirements. This satisfies the increasing focus on 'green' technologies by enabling more efficient operation of network equipment and by reducing network-related energy costs, RFMD adds.

● RFMD says that its high-power GaN HEMT process technology has demonstrated what it claims is record reliability performance for operation at a bias of $V_{ds}=48V$ and a power density of $7.5W/mm$: at a channel temperature of $200^{\circ}C$, mean time to failure (MTTF) is 30 million hours. The activation energy for the process was $E_a=2.3eV$.

In June, RFMD completed the process qualification of its high-power GaN HEMT and announced the formation of its GaN Foundry Services business unit in order to supply its GaN technology into multiple RF power markets. RFMD says that several leading customers are preparing designs using its GaN process design kit (PDK) in anticipation of initial multi-project GaN wafer runs, scheduled for October.

RFMD has also scheduled subsequent multi-project GaN wafer runs on a monthly basis to meet what it says is increasing customer demand.

www.rfmd.com/foundry

RFMD ships first GaN product to achieve full qualification

RFMD has qualified and released the RF3931, a 48V, 30W GaN unmatched transistor optimized for high-power commercial and defense applications. The RF3931 is RFMD's first GaN product to achieve full qualification and be released for mass production. Shipments have commenced to multiple high power amplifier (HPA) manufacturers, and should increase significantly as new GaN products are introduced.

"RFMD's GaN process technology will play a central role in our corporate mission to extend and leverage our leadership in RF components and compound semiconductor technologies into multiple industries," says president & CEO Bob Bruggeworth. "The unique physical properties of RFMD's GaN technology deliver performance that is unattainable by current competing technologies," he adds. RFMD's GaN technology is manufactured

in the same high-volume manufacturing facility as its GaAs products, which RFMD reckons provides a competitive advantage. "Accordingly, we believe our GaN technology will become a disruptive technology across a broad range of commercial and defense markets."

"These achievements are major milestones for RFMD as we drive adoption of our GaN technology, increase our presence in the high-power RF market, and satisfy our customers' increasing emphasis on 'green' technologies," says Jeff Shealy, VP & general manager of RFMD's Defense and Power business unit. RFMD's GaN process technology delivers better RF power per square millimeter and better RF conversion efficiency compared to existing semiconductor technologies, he adds.

The 30W RF3931 is part of a family of five RFMD GaN unmatched

power transistors to be released for mass production over the next two quarters. Ranging from 10W to 120W, the wide-bandwidth, unmatched power transistors enable the development of high-efficiency HPAs for a broad range of applications, including cellular and WiMAX infrastructure, CATV, military communications, public mobile radio, radar and radar jammers. In wireless and wireline applications, the transistors enable 'green' architectures that can cut energy costs and improve network efficiency for operators.

The RF3931 achieves high efficiency and flat gain over a broad frequency range in a single amplifier design, RFMD says. It is packaged in a hermetic, flanged ceramic package, providing thermal stability through the use of advanced heat sink and power dissipation technologies.

Nitronex adds director of sales & business development for Asia-Pacific, targeting expansion into new markets

Nitronex Corp of Durham, NC, USA, which designs and manufactures gallium nitride on silicon (GaN-on-Si) RF power transistors for defense, communications, and industrial & scientific markets, has named Edwin Chen as director of sales & business development for the Asia-Pacific (APAC) region.

Chen has over 15 years experience in mobile and broadband communications, as well as in infrastructure base-station sales and business development. He also has 10 years of experience in leading field sales, technical resources and channel partner teams in the Asia-Pacific region, as well as a Bachelors Degree in Electronics Engineering from the University of Melbourne, Australia and an executive MBA from the University of Southern California.

Nitronex aims to expand existing business and enter into new markets

in the Asia-Pacific. Chen highlights partnering with the Asia-Pacific teams of distributor Richardson Electronics Ltd of La Fox

near Chicago, IL, USA (in October 2007, Nitronex expanded its distribution partnership with Richardson to include the Americas and all of Asia). "Nitronex will leverage their local expertise, market knowledge and established account relationships to continue Nitronex business growth in the Asia-Pacific region."

Chen was most recently senior director at Pulse~LINK, where he managed the sales & business development activities in introducing Pulse~LINK CWave high-definition TV home-networking solutions to the Korean and Chinese markets. He has also held senior sales & business development positions at



Cygnus Communications and Conexant Systems.

"Edwin has a proven track record of developing strategic sales strategies and delivering results in the Asia-Pacific geography," Gary Blackington, Nitronex's VP of sales. "His experience in developing business and building strong channel partner organizations will help Nitronex drive its market share and build strong customer relationships," he believes.

● According to a regulatory filing in October Nitronex raised \$3.68m of the \$4m sought by selling promissory notes and stock purchase warrants.

Nitronex raised \$4m in debt financing in April. Since being founded in 1999, it has garnered at least \$46.6m from Alloy Ventures, ARCH, Intersouth Partners, Diamondhead Ventures, VantagePoint Venture Partners and Contender Capital.

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AXT grows 28% as end markets continue recovery

For third-quarter 2009, AXT Inc of Fremont, CA, USA has reported revenue of \$16.8m. Although down 6% on \$17.9m a year ago, this is up 28% on \$13.1m last quarter due to the continued recovery in end markets, coupled with ramping volumes for newer qualifications.

Specifically, gallium arsenide (GaAs) substrate revenue was \$13.3m, down 2% on \$13.6m a year ago but up 32% on last quarter's \$10.1m due mainly to the overall increased demand in all diameters (particularly 6-inch).

Raw materials sales of \$1m were flat on last quarter and down from \$3m a year ago, as excess inventories are not expected to clear until late 2009. Indium phosphide substrate revenue of \$688,000 was also level with last quarter (\$684,000), but up 42% on \$484,000 a year ago. Germanium substrate revenue of

\$1.8m is up 50% on last quarter's \$1.2m and more than double \$795,000 a year ago.

Gross margin has continued its recovery, up further from 19.3% last quarter to 32.9% (and above 25.4% a year ago). Operating expenses of \$3.7m were roughly level with last quarter's \$3.8m, after being cut from \$5.5m a year ago.

"Improved margin performance, manufacturing efficiency and cost control allowed us to exceed our earnings expectations and return the company to profitability," says

Improved margin performance, manufacturing efficiency and cost control allowed us to exceed our earnings expectations

CEO Dr Morris Young. Compared with an operating loss of \$0.9m a year ago and \$1.3m last quarter, income from operations was \$1.9m. Net income was \$2.1m, compared with a net loss of \$1.3m last quarter and \$1m a year ago. During the quarter, cash and equivalents (including restricted deposits) rose from \$33.6m to \$37.8m.

"We are very pleased to see continued diversification of our customer and revenue base as well as many positive trends in our markets that highlight our competitive advantages and are likely to provide further growth opportunities in the quarters ahead," says Young.

For fourth-quarter 2009, AXT expects revenue to rise to \$17-17.5m and net income per share to be \$0.03-0.05.

www.axt.com

AXT announces executive promotions

Substrate maker AXT has announced three executive promotions.

Raymond Low, former VP, corporate controller & acting chief financial officer, has been appointed VP & chief financial officer.

AXT co-founder Davis Zhang, formerly president of joint venture operations, has been appointed president of AXT China Operations, with responsibility for managing and developing AXT's joint venture operations, as well as assisting Young with the management of AXT's manufacturing facilities in China.

Bob Ochrym, formerly VP of business development, has been appointed VP of business development, strategic sales & marketing, with responsibilities including sales for the North American East Coast, as well as for Europe. He will continue to work closely with John Cerilli, VP of global sales and

marketing, to maximize customer support around the world. He will also be responsible for developing sales and marketing strategies, major sale contract negotiations, major market identification and other strategic sales and marketing functions.

"Each of these individuals has made significant contributions to AXT, and I am looking forward to further leveraging their talents in expanded roles," says Young.

"Davis has been instrumental in the success of our joint venture program and his knowledge of our business and customer needs make this new position a natural fit," Young says. "By bringing together two critical functions of manufacturing and joint venture operations, we can better plan and respond to the present and future needs of our customers," he adds.

"Bob has a wealth of contacts and experience in our industry and we are excited to leverage his knowledge to further enhance the reach and success of our sales and marketing efforts," Young says. "We have great opportunities to grow our market share with a number of the customers that we currently serve as well as with new customers that we do not presently supply. Further, we are continuing to explore new applications for our products in wireless devices, LEDs and photovoltaics that expand our addressable market and provide further opportunity for growth."

"Raymond has a strong financial background and a deep understanding of our financial structure, which has allowed him to transition smoothly into his permanent role as our chief financial officer," concludes Young.

Marktech and Optrans launch 4-inch InP wafers in North American and European markets

In collaboration with Marktech Optoelectronics of Latham, NY, USA (its exclusive North American and European sales & marketing partner), Optrans Corp of Kawasaki, Japan, which specializes in visible and infrared emitters, sensors and assemblies, has introduced high-purity, high-speed indium phosphide wafers to the North American and European markets.

The Optrans R&D team has developed a new MOCVD process that produces multiple 4" wafers simultaneously, significantly reducing the processing time required. The firm says the Closed Coupled Showerhead (CCS) technology from Aixtron that is used in the MOCVD reactors results in increased production capacity and greater cost savings. Optrans ordered an Aixtron CRIUS CCS reactor in multi 4" wafer configuration in fourth-quarter 2008 for the production of InP-based

optoelectronic devices including photodiodes and LEDs. More recently, in March, Optrans acquired part of the InP microchip division of long-term Aixtron customer NTT-AT of Japan. The firm's target is to produce 12,500 wafers annually by 2010.

Optrans says that, since InP material enables high operating speeds, low noise, low voltage and high reliability, the industry is shifting from traditional materials such as gallium arsenide to next-generation high-speed circuits using InP. Also, since InP is used in both photonic and electronic applications, typical photonic device types include lasers, photo-detectors, avalanche photo-diodes, optical modulators and amplifiers, waveguide-based devices, quantum photonic devices, and both optoelectronic and photonic integrated circuits as well as new devices for optical communica-

tions, switching, networking, signal processing and leading-edge material for solar cells.

In particular, InP-based high-electron-mobility transistors (HEMTs) allow low-noise operation and are the best choice for optoelectronic applications that require compatibility with InP-based optical devices and speeds of 40Gb/s or above, while InP heterojunction bipolar transistors (HBTs) are the preferred solution for future generations of fiber-optic transmission systems envisioning speeds of up to 80Gb/s.

Optrans says that it is poised to meet the growing demand for InP wafers in the microelectronics and telecoms industries. The firm's 4" InP wafers are in full production, and are available through Marktech Optoelectronics with lead times of 8-10 weeks.

www.marktechopto.com

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Aixtron's 45% quarterly growth driven by TV backlighting

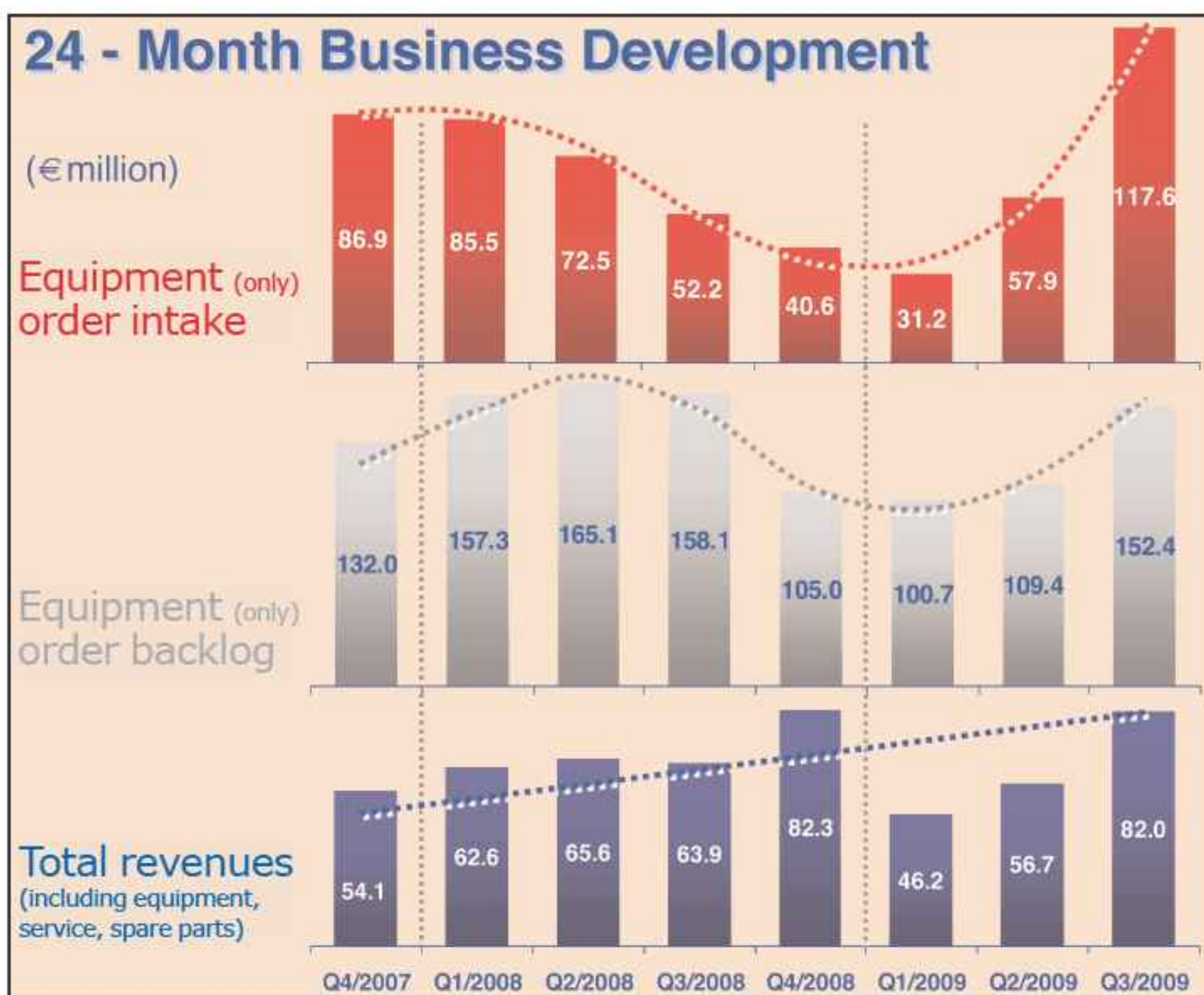
For third-quarter 2009, deposition equipment maker Aixtron AG of Herzogenrath, Germany reported revenue of €82m, up 45% on €56.7m last quarter and 28% on €63.9m a year ago (and just less than Q4/2008's record of €82.3m).

"We continue to see very healthy demand for our systems, driven by an exceptionally positive response by consumers to the introduction of TV LED backlighting," says president & CEO Paul Hyland.

Earnings before interest and taxes (EBIT) more than doubled to €16.7m (a 20% margin), rising 255% from €4.7m (8% margin) last quarter. Net profit was €11.6m, up from €3.3m last quarter. With free cash flow up from just €8m last quarter to €27.3m, cash & cash equivalents (including cash deposits) rose from €84.4m to €111.1m.

In Q3, equipment order intake more than doubled last quarter's €57.9m to a record €117.6m, boosting backlog from €109.4m to €152.4m. Of this, 98% is for compound semiconductor systems (as the ongoing memory market slump led to silicon system order intake remaining very low). Aixtron expects about €88m to be shipable for conversion into revenue by the end of fourth-quarter 2009, adding to expected spares & non-equipment revenue of €7m in Q4.

Together with €184.9m in total revenue from Q1-Q3/2009 (down just 4% year-on-year, despite the intervening economic turmoil), Aixtron has therefore raised its full-year 2009 revenue guidance for the second time this year, from €230-250m to €280m (up 27-40% on the initial guidance, given in May, of €200-220m, and outstripping 2008's revenue of €274.4m). EBIT margin guidance has been raised from 12-13% to 18% (compared to the initial guidance of 10-11%).



Aixtron's equipment order intake (top), backlog (middle) and total revenue (bottom) over the last 24 months, showing Q1/2009 dip and then upturn.

Compared to 2008 (in which 53% of revenue came from the second half), 60% of 2009's revenue will come from the second half. "Encouragingly, order and quotation activities are still continuing at a very high level, and this trend seems set to continue into 2010,"

Aixtron has raised its full-year 2009 revenue guidance for the second time this year

says Hyland.

Aixtron believes that, to fund accelerated growth over the next few years, a further strengthening of its capital base is essential. The executive board has therefore agreed, with the consent of the supervisory board, to issue up to 8,979,937 new shares (9.8% of the firm's current share capital). The proceeds will be used to:

strengthen the balance sheet; support higher capital spending and additional working capital in an accelerated growth market with shorter product cycles; consider potential strategic investments; and accelerate the adoption of HB-LED applications.

Aixtron has already confirmed its capability of delivering up to 100 deposition systems per quarter soon. Hyland adds that, to prepare for its

The firm has already started recruiting what is expected to be a total of up to 100 new engineers within the next 12 months

next stage of development, the firm has started recruiting what is expected to be a total of up to 100 new engineers within the next 12 months.

www.aixtron.com

Tokuyama expands UV-LED capacity with Aixtron MOCVD reactor

Aixtron says that a further AIX 200/4 RF-S MOCVD system has been installed and has started operation at Tokuyama R&D center in Tsukuba, Japan. The reactor was shipped in fourth-quarter 2008 and is being used for the development of AlGaIn-based ultra-violet LEDs.

The UV-LED market is currently worth about \$100m per year, with the potential to more than double in the next few years. Motivated by the need to replace existing UV light sources, the market could reach \$250m in 2015, according to a recent report. In addition, the availability of compact solid-state UV sources with well-defined wavelength ranges could enable many new applications, including solutions for the medical sector.

Higher-power devices will also create opportunities for industrial applications such as the hardening or curing of resins, says Aixtron. However, the most prominent opportunity is the desire to replace costly traditional mercury lamps,

which are not only fragile and short-lived but also present an environmental hazard.

The realization of this market potential will be conditional on specific technical advances, especially in the cost-effective growth of AlN-based substrates and epitaxial layers, hence the need for precision MOCVD equipment, says Aixtron. Since it has the widest direct energy bandgap of all semiconductors (about 6.2eV), AlN suits the development of UV devices (as well as being effective for high-temperature components such as power LEDs and laser diodes for DVD recorders and fiber optics). Moreover, using MOCVD, bandgap engineering can create the optimum alloys and heterostructures for UV-LED applications.

As well as manufacturing chemical products such as ultrapure polysilicon for the electronics industry, Tokuyama Corp also has the world's largest aluminum nitride (AlN) plant. www.tokuyama.co.jp/eng/research

Changelight receives Aixtron reactor for GaAs LED production

Aixtron says that in third-quarter 2009 it delivered an AIX 2600G3 Planetary Reactor deposition system in 49x2" wafer configuration to the new facilities of Changelight Co Ltd in Xiamen Torch Industry Park of Fujian Province, China for the production of gallium arsenide LEDs.

"The AIX 2600G3 system is well known for its capabilities in respect to the mass production of GaAs LED," says Changelight's CEO Deng Dian Ming. "We have been working closely with the local Aixtron support team before, and they have always been very responsive, thus we are looking forward to further good cooperation," he adds.

Changelight is developing mass production of III-V-based optoelec-

tronic devices. As well as acquiring the new equipment, the firm says that its technical team will be supported by new staff members from the USA and Taiwan.

Founded in February 2006, Changelight started mass production of red HB-LEDs after installation was completed in late 2006 for its first two AIX 2600G3 reactors (in 49x2" and 12x4" configurations). A third AIX 2600G3 system was delivered early in Q2/2007. Subsequently, in second-quarter 2008, Aixtron shipped two more AIX 2600G3 systems to Changelight for large-scale manufacturing of red, orange and yellow (ROY) ultra-high-brightness LEDs.

www.aixtron.com

IN BRIEF

IQE appoints new group business development director

IQE plc, which supplies compound semiconductor substrates and epitaxial wafer growth services for the wireless, optoelectronic, solar, and solid-state lighting industries, has appointed Adrian Meldrum as group business development director, based at its headquarters in Cardiff, UK.

Meldrum has more than 15 years of experience in the optoelectronics market sector, having held technical and commercial roles with JDSU and, more recently, business development and sales & marketing roles at Bookham (now Oclaro), where he was general manager of the Telecom Division until joining IQE.

IQE says that the appointment complements and further strengthens its management team following the recently announced appointments of professor Wang Nang Wang as chief scientific adviser (formerly CEO of gallium nitride substrate firm NanoGaN Ltd of Bath, UK, acquired in October), Walt Wohlmuth as New Technology director in the US, Kent Wardley as US wireless sales director, and Brian VanOrsdel as US opto sales director.

IQE's portfolio includes III-V PHEMT, HBT, and BiFET epiwafers as well as lasers, detectors, vertical-cavity surface-emitting lasers (VCSELs), ultra-high-brightness LEDs and multi-junction solar cells for concentrated photovoltaic (CPV) applications. IQE's products are grown by MBE, MOCVD and CVD at the firm's six manufacturing facilities in the US, UK, and Singapore.

www.iqep.com



LED backlighting drives Veeco's return to profit

For third-quarter 2009, epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview NY, USA has reported revenue of \$98.9m. This is down 15% on \$115.7m a year ago but up on \$72m last quarter (and well above July's guidance of \$80-88m).

LED & Solar process equipment revenue was \$53m (up 66% from \$31.9m last quarter, due mainly to an increase in demand for high-brightness LEDs for backlighting applications). Data storage process equipment was \$21.5m (down 22% on last quarter, due to customers continuing to tightly control capital spending). Metrology was \$24m (down 7% on last quarter, due to the slowdown in data storage, semiconductor and industrial markets).

"Our third quarter performance exceeded guidance on every metric," says CEO John R. Peeler. "Veeco has quickly returned to profitability [following four consecutive quarters of losses]."

Veeco's restructuring actions have cut operating expenses by 19% from \$46m a year ago to \$37.4m. "We completed our factory consolidations ahead of plan and achieved our \$80m breakeven target [after generating cash through the down-cycle]," says Peeler.

Compared to 39.8% a year ago and 33.9% last quarter, gross margin has rebounded to 41.4%. This is attributed to material cost savings, manufacturing and overhead cost reductions from staff cuts and outsourcing, and a favorable product mix. In particular, LED & Solar gross margin has risen from 36% a year ago to 41.7% (due to increased sales volumes, better product pricing, and improved product costs from outsourcing and improved purchasing related to the MOCVD high-brightness LED tools).

Compared with a loss of \$2.4m a year ago and \$14.7m last quarter, in Q3 Veeco reported net income of \$1.3m, due to the higher-than-forecast sales.

During the quarter, Veeco's cash balance grew by \$12m to \$109.4m. Capital expenditure was just \$1.5m.

In Q3, orders were a quarterly record of \$225.6m (up 150% on \$90m a year ago and 129% on \$99m last quarter). Of total bookings, 80% were for LED & Solar (\$179.2m, more than triple \$57m last quarter and a seven-fold increase on just \$25.8m a year ago, and above the forecasted \$125-175m). "We are proud of the progress we are making winning important business in MOCVD, CIGS solar and in MBE systems," says Peeler.

"We have seen an unprecedented demand from LED manufacturers in China, Korea and Taiwan for our TurboDisc MOCVD systems as they

We have seen an unprecedented demand from LED manufacturers in China, Korea and Taiwan... as they ramp production for laptop and TV backlighting

ramp production for laptop and TV backlighting," says Peeler. In MOCVD, Veeco has been chosen as the supplier of choice for an important Korean TV maker.

Meanwhile, the firm's MOCVD systems have also been selected by two leading US LED makers (Philips Lumileds and Bridgelux) to ramp production for general illumination. In total, Veeco received multi-unit orders from eight LED makers.

"We believe Veeco is gaining share [reckoned to be about 30%] by penetrating key accounts around the world, particularly in China and Korea," says Peeler.

Also, momentum has continued in Veeco's CIGS PV business, with a second key customer win from China worth \$15m for the FastFlex web coating system and a repeat multi-million dollar order from a leading US CIGS PV maker for thermal deposition components. Also, a

27% sequential improvement in Metrology orders was driven by new product success and a modest pick-up in activity from both research and industrial customers.

Order backlog has hence risen from \$160m to \$286.5m (including \$239m in LED & Solar). "We continue to experience positive business trends in our MOCVD business, with a high level of demand for our K465 MOCVD system," says Peeler. "While it is challenging to predict quarterly bookings trends in this dynamic environment [given the large number of potential MOCVD multi-tool orders], it is clear to us that MOCVD quoting activity remains well above historic levels [with a large number of customers evaluating the purchase of multiple systems]," he adds.

"We are also seeing strong interest in our thermal deposition systems for manufacturing of CIGS solar cells, and believe that Veeco is well positioned to capture share in this market [which is reckoned to be worth more than \$600m in 2011]," says Peeler. "Our thermal co-evaporation approach for the CIGS absorber layer will help drive lower materials costs and reduced capital costs for CIGS manufacturers."

In addition, overall business conditions in Data Storage and Metrology

Veeco is at the beginning of a multi-year MOCVD tool investment cycle as LEDs increase their penetration in laptop and TV backlighting and gain momentum for general illumination

appear to be improving from the trough levels experienced earlier this year.

For fourth-quarter 2009, Veeco therefore expects revenue to rise 33-44% to \$120-130m and bookings to be more than

\$130m (a positive book-to-bill ratio). Also, as a result of the increased

sales volume and improved mix, gross margin should rise to 43–44% (approaching Veeco's longer-term goal of 45–46%).

Veeco has hence raised its full-year 2009 revenue guidance from \$310–\$325m to \$353–\$363m. This is still down 18% on 2008, but a "very respectable performance" during an unprecedented economic downturn, believes Peeler.

"Veeco is at the beginning of a multi-year MOCVD tool investment cycle as LEDs increase their penetration in laptop and TV back-lighting and gain momentum for general illumination," he comments. To satisfy demand, the firm is hence ramping up manufacturing capacity to be able to ship more than 30 tools in Q4 and more than 45 in Q1/2010 (and more beyond that). The average analyst estimate for the MOCVD market is more

than 350 tools in 2011 (worth nearly \$1bn), says Veeco. "With our customer list including over 80% of the world's key LED makers, Veeco is extremely well positioned to capitalize on this sizeable growth opportunity," believes Peeler.

"We are managing our slot plans and customer delivery schedules to ensure that our lead times remain under six months and we have sufficient capacity coming on line to keep them within this timeframe," he says. "We have 100% on-time systems delivery for MOCVD systems on a year-to-date basis," Peeler adds. "The variable model we have designed with two out-sourced partners gives us a lot of flexibility to scale manufacturing up and down as required by the market without bringing a lot of additional cost directly to Veeco."

www.veeco.com

Exercising of over-allotment option boosts Veeco stock offering proceeds to \$130m

Veeco has closed its public offering of common stock (announced on 26 October).

Veeco sold 5,750,000 shares (including 750,000 representing full exercise of the underwriters' 30-day over-allotment option) at an offering price of \$23.75 per share.

After deducting offering expenses, underwriting discounts and commissions payable by Veeco, the net proceeds are \$130.1m.

These will be used for general corporate purposes, including potential acquisitions.

Entegris ships gas purification systems to Taiwan LED maker Lextar

Entegris Inc of Billerica, MA, USA, which provides products for purifying, protecting and transporting materials used in semiconductor processing and manufacturing, says that it has shipped multiple Aeronex gas purification systems to Lextar Electronics Corp, which is a Taiwan-based manufacturer of high-brightness LED (HB-LED) products. Lextar Electronics is also one of the world's top three manufacturers of thin-film transistor liquid crystal display (TFT-LCD) panels.

Lextar has bought separate Aeronex gas purification systems for purifying nitrogen, hydrogen and ammonia used in the gallium nitride-based LED manufacturing process. The systems remove a variety of contaminants (including moisture and oxygen down to the parts-per-billion level) from the process gases used during metal-organic chemical vapor deposition (MOCVD). Removal of such contaminants enhances the photoluminescence of LED devices, says Entegris.

www.entegris.com

IN BRIEF

Sanan expands HB-LED capacity with Veeco MOCVD reactors

Sanan OptoElectronics Co Ltd of Xiamen, China, which designs and manufactures full-color high-brightness (HB) LEDs, epitaxial wafers, photo-diode detectors and compound semiconductor solar cells, has placed multiple tool orders for TurboDisc metal organic chemical vapor deposition (MOCVD) systems from epitaxial deposition, process, and metrology equipment maker Veeco Instruments Inc of Plainview NY, USA in order to expand its HB-LED manufacturing capacity. Sanan is already said to be China's largest manufacturer of full-color LEDs.

"The addition of Veeco's high-productivity MOCVD systems to our manufacturing facilities in Xiamen and Tianjin, China ensures that we can continue to increase output," says Sanan's CEO Simon Lin. "We are seeing increased demand for LEDs in such applications as general illumination, TV backlight and outdoor display," he adds.

"We are looking forward to partnering with Sanan as they increase their high-volume production of HB-LED devices," says Bill Miller, senior VP & general manager of Veeco's MOCVD operations.

Veeco claims that its TurboDisc K465 GaN MOCVD system delivers the industry's highest throughput available for high-volume production of GaN-based blue and green HB-LEDs, while its TurboDisc E475 As/P MOCVD system is engineered for high-volume production of red, orange and yellow HB-LEDs.

www.veeco.com

www.sanan-e.com/en

IN BRIEF

France's STnano research center orders OIPT plasma etching & dep tool

UK-based etch and deposition equipment maker Oxford Instruments Plasma Technology (OIPT) has won a contract to supply a Plasmalab System80 Plus ICP system to the research center STnano in Strasbourg, France.

STnano is the new Strasbourg nanofabrication platform, established jointly by IPCMS (a CNRS lab) and the University of Strasbourg (UdS), and has expertise in the design of nanostructures through top-down methods as well as in the study of their magnetic properties.

Oxford Instruments says that its Plasmalab System80Plus is a flexible and compact system for plasma etching and deposition. STnano has purchased the inductively coupled plasma (ICP) configuration, in order to process multiple materials including silicon etch. The System80Plus is also available configured for etching and deposition (ICP-PECVD), reactive ion etching (RIE), plasma etching (PE) or plasma-enhanced chemical vapour deposition (PECVD).

"We demanded the highest-specification system we could find to fit the specifications for the work we are undertaking," says STnano's nanofabrication manager Dr Hicham Majjad. "The Plasmalab80 Plus open load design allows for fast loading and unloading, ideal for prototyping and low-volume production environments such as ours."

The system has been bought as part of the STnano's program to equip its cleanroom for nano- and micro-scale fabrication in the fields of molecular electronics, spintronics, and polymers.

www.oxford-instruments.com

NCKU collaborates with Taiwan Nitride Material

Taiwan's National Cheng Kung University (NCKU) has signed an agreement with privately owned Taiwan Nitride Material Inc to create Taiwan's first joint venture for the production of aluminum nitride (AlN). Both parties agreed to invest a total of NT\$30m (US\$932,000) for R&D on AlN, which is widely used for heat radiation and insulation in microelectronics and optoelectronics.

The AlN production technique was developed by professor Shyan-Lung Chung of NCKU's Department of Chemical Engineering. Chung has been dedicated to researching AlN for many years and has developed various techniques (such as sintering and composite materials) for its efficient production. A number of manufacturers have collaborated closely with his lab in order to develop or test downstream AlN products. Since they can reduce production costs, AlN products are becoming increasingly prevalent. Furthermore, such innovations have been protected under various issued patents. As a result of technology transfer, NCKU will have an 18% stake in the venture, and expects revenue of at least NT\$100m (US\$3.1m) over the next 10 years.

The venture has support from Taiwan's National Science Council (NSC) via an umbrella project 'A Study of Interdisciplinary Platform for New Technology Commercialization, Academic-Enterprise Collaboration, and Entrepreneurship', supervised by principal investigator Hwung-Hweng Hwung (a senior executive vice president of NCKU). Six sub-projects include 'aluminum nitride production and development of innovative technologies' and 'aluminum nitride electrical substrate metallization'.

Hwung says that technology transfer in Taiwan has often led to

failure in the past, since no continuous R&D creation has been contributed from the university. In contrast, the project's new model of academia-industry collaboration aims to provide continued support. In particular, the project aims to integrate relevant academia-industry resources, including the NCKU Research and Service Headquarter (RSH) and the NCKU Technology Licensing and Business Incubation Center (TLBIC). NCKU and Taiwan Nitride Material Inc will therefore remain close partners, even after completing technology transfer.

"Taiwan is known for its volume production of LED," says Taiwan Nitride Material Inc's chairman H.H. Chang. The coverage and luminescence intensity of LED lighting is increasing, and LED-

based backlight modules for LCD displays are prevailing, he adds. "LED lighting is replacing iridescent bulbs," says Chang.

However, LED lifetime is still a grave concern, resulting from overheating of the device. Chang says that work by Chung on developing AlN products could help to solve the problem of heat dissipation, which is frequently encountered in LED devices and is the main cause of their failure, especially in lighting and large-size TVs. Chang says that AlN can also help to enhance the competitive advantage of Taiwan's high-power LED lighting industry (e.g. in street lamps and backlight modules). "There will be more collaborative opportunities [with NCKU] in the future," he adds.

<http://english.web.ncku.edu.tw>

Work by Chung on developing AlN products could help to solve the problem of heat dissipation in LED devices

Tyndall buys Cambridge NanoTech plasma ALD system

To enhance its atomic layer deposition (ALD) research capabilities, Tyndall National Institute in Cork, Ireland has purchased a Fiji Plasma ALD system from Cambridge NanoTech Inc of Cambridge, MA, USA, which was spun off from Harvard University's Gordon Lab in 2003.

"The Tyndall Institute [which has CMOS, III-V and MEMS wafer fabrication capabilities] is the largest micro/nano-electronics, photonics and microsystems research institute in Ireland," says Cambridge NanoTech's European sales director Jeremy Davis. The Fiji system complements the institute's materials research efforts to support the introduction of new materials into its device fabrication process, he adds.

"The dual chamber system provides excellent process versatility, more functionality, and fits in a

very small footprint," says Tyndall process engineer Alan Blake. Cambridge NanoTech also provided support during the start-up phase as well as training, and continues to provide follow-up support as needed.

The Fiji system delivers versatility for both plasma and thermal ALD deposition, Cambridge NanoTech claims. Its flexible system design, which includes a dual-chamber configuration, is customizable for optimum experimental efficiency, says the firm. With very low precursor consumption, a fully integrated ALD Shield vapor trap, and off-the-shelf replacement costs, the Fiji system reduces operating costs and simplifies system maintenance, the firm claims.

www.cambridgenanotech.com

www.tyndall.ie

IN BRIEF

Plasma-Therm sells multi-module ICP tool to III-V foundry

Plasma-Therm LLC of St Petersburg, FL, USA has sold a multi-module VERSALINE ICP production etch system to a major III-V foundry.

The system is configured with three chambers for GaAs via etch processing. The modules feature actively controlled source heating (which enables a stable process environment and cuts downtime for maintenance) and incorporate fully integrated EndpointWorks for accurate and repeatable endpoint process control.

"The VERSALINE platform offers versatility that meets customer requirements from R&D through high-volume production," says Ed Ostan, executive VP of sales & marketing.

www.PlasmaTherm.com

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Solar Metrology launches line-mountable XRF tool for atmospheric CIGS composition & thickness measurement

X-ray fluorescence (XRF) analysis system maker Solar Metrology of Holbrook, NY, USA has expanded its SMX XRF tool portfolio for film composition and thickness measurement of copper indium gallium diselenide (CIGS) photovoltaic deposition with the addition of the System SMX-Remote static head ILH.

Solar Metrology says that its SMX metrology tool platform provides a production-ready suite of film thickness and composition measurement tools for research and process development, in-process monitoring and post-process quality control. The firm adds that XRF is an enabling technology for CIGS manufacture, delivering yield management and improvement by allowing in-situ process control.

The SMX-ILH in particular is an atmospheric in-line XRF metrology



Solar Metrology's SMX x-ray fluorescence (XRF) system.

tool platform that provides composition and thickness measurements for thin-film solar PV metal film stacks on flexible roll-to-roll substrates such as stainless steel, aluminum and polyimide or rigid substrates such as float glass.

The system is designed to perform measurements in an atmospheric

environment, either near-line or in-line. Remote SMX-ILH tool platform models are designed to measure in either one static location or across the gradient (points on a line perpendicular to motion) of the flexible or rigid glass substrates. Typical measurement applications include Mo (molybdenum) thickness and all CIGS combinations (including all CIG alloys and/or film combinations and final CIGS formulations).

The ILH platform includes both fully integrated, stand-alone tools and remote configurations that can be incorporated directly into a tool or line, providing the versatility and adaptability needed to match custom requirements at each XRF measurement point in the process, says the firm.

www.solarmetrology.com

Camtek closes acquisition of Israeli TEM and SEM sample preparation system maker SELA

Following an agreement announced on 24 September, Camtek Ltd of Migdal Ha'Emek, Israel, which makes automatic optical inspection (AOI) systems for printed circuit boards, high-density interconnect substrates, and semiconductor manufacturing and packaging, has completed its acquisition of Semiconductor Engineering Laboratories Ltd (SELA), for which it will pay SELA's shareholders future payments of up to \$9.5m (contingent upon SELA's revenues).

Founded in 1992 in Yokneam, Israel, SELA develops and manufactures automated scanning electron microscope (SEM) and transmission electron microscope (TEM) sample preparation equipment for the semiconductor and optical components industries. With 26 staff and revenues of \$3.8m and \$4.4m in 2008 and 2007 respectively, SELA has more than 275 systems installed worldwide.

SELA recently introduced the Xact, the first TEM/STEM sample preparation system using adaptive ion milling (AIM) technology, which is said to enhance traditional focused ion beam (FIB) technology by reducing the sample thickness to below 30nm over a large area with high precision and throughput and with superior image quality.

Camtek says that these attributes are essential for meeting the growing market requirements for nano-scale material analysis, including much reduced turn-around times and enhanced productivity. The trend for continuous device shrinks and material complexity increases utilization of TEM and hence the

SELA will function as a business division of Camtek, led by former CEO & president Colin Smith

served available market for Xact, it is reckoned.

"SELA is a significant addition to our technological assets, and we are eager to leverage Camtek's global infrastructure, sales and support teams, manufacturing and facilities, to continue to service SELA's existing customer base, while targeting new customers," says Camtek's CEO Rafi Amit. "This acquisition of SELA is directly aligned with our strategy of further enhancing Camtek's position and presence in the semiconductor market, enabling us to further expand our offering to this market," said Amit at the time of the acquisition's announcement.

SELA will function as a business division of Camtek, led by former CEO & president Colin Smith, who will assume the position of VP at Camtek and SELA Division manager.

www.camtek.co.il

Nanometrics receives metrology orders for HB-LEDs

Nanometrics Inc of Milpitas, CA, USA, a supplier of process control metrology systems primarily for manufacturing semiconductors, solar cells and high-brightness LEDs, says that it has received multiple orders from new and existing HB-LED customers for RPMBlue and IVS185 metrology systems (for delivery and qualification in fourth-quarter 2009) to be used for photoluminescence (PL) mapping and critical dimension and overlay control, respectively.

"Customers in Asia are adopting the high-productivity RPMBlue to support the rapidly growing application of HB-LEDs for backlighting of notebook and LCD televisions," says Tom Ryan, director of the Materials Characterization business unit. The latest round of RPMBlue orders comes from end-device manufacturers as well as a leading MOCVD reactor supplier. "As the HB-LED process flow becomes

increasingly complex, it drives the requirement for improved control of overlay and critical dimensions in the patterning process," he adds. "Our IVS185 system, shipping for the first time to an HB-LED customer, is a cost-effective solution that incorporates both overlay and CD control in a single tool, with extendibility across multiple substrate sizes."

Nanometrics has a range of products and technologies for HB-LED metrology and process control, including the RPMBlue for high-volume production of LEDs used in LCD backlighting, the Vertex PL mapping system to support HB-LED process development, and the IVS185 overlay and CD system for LED patterning process control. Nanometrics claims that the systems are used by over 90% of top-tier HB-LED makers in development and production.

www.nanometrics.com

LayTec ranked 30th out of Germany's top 50 fastest-growing companies

Berlin-based LayTec GmbH, which provides in-situ thin-film monitoring systems, has been ranked 30th among the 50 fastest-growing companies in Germany, at Deloitte's Technology Fast 50 award ceremony in Hamburg on 21 October. Deloitte provides audit, tax, consulting, and financial advisory services to public and private clients.

"This award recognises LayTec's extraordinary work in both its innovative development of metrology products and its successful organic growth strategy," says LayTec's president & founder Dr Thomas Zettler. "We owe this success to the high commitment and dedication of the company's employees and to the close collaboration with customers and business partners worldwide," he adds.

Founded in October 1999 as a spin-off of the Technical University Berlin, LayTec says it quickly became a market leader in compound semiconductor process monitoring instrumentation, especially for LED production. Between 2004 and 2008 the firm increased its turnover by 378%.

In 2007, LayTec recognized the strong potential for its products among thin-film solar cell producers and, after less than a year of engineering and testing, launched its first in-line monitoring system for photovoltaic thin-film applications. LayTec is now cooperating with numerous partners to further develop in-situ and in-line metrology solutions for the complete range of photovoltaic thin-film processes.

www.laytec.de

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Rubicon to double sapphire capacity

For third-quarter 2009, Rubicon Technology Inc of Franklin Park, IL, USA, which makes monocrystalline sapphire substrates and products for the LED, RFIC, semiconductor and optical industries, has reported revenue of \$5.7m.

This is higher than the expected \$4.5m, but still less than half \$11.8m a year ago, due to declines of \$1.3m in R&D revenue and \$2.4m in silicon-on-sapphire (SoS) revenue. In particular, SoS has dropped from \$2.9m a year ago to \$479,000 in Q3, due to the high level of inventory at key RFIC-making customer Peregrine Semiconductor Inc of San Diego, CA.

However, total revenue is up from \$3.2m in Q2 and a low of \$2.3m in Q1/2009, driven by increased sales into the LED market as inventory cleared. In addition to demand for other LED applications beginning to improve, the main driver remains the rapid adoption of LED backlighting units (BLUs) for notebook/netbook PCs as well as LCD TVs, as the price differential with fluorescent backlighting has become negligible.

LED applications represented 83% of Q3 revenue after more than doubling from \$2.2m last quarter to \$4.7m. However, while this is also up on a year ago in terms of unit volume, it is down on Q3/2008's \$6.7m due to declining average selling prices (ASPs) as well as the product mix.

Most chips for LED BLUs are made in Taiwan, mostly still on 2" wafers. Taiwanese LED chip makers now represent 60% of Rubicon's revenue. The proportion of total revenue from such low-margin 2" substrates has therefore risen from 53% a year ago to 67%, with just 33% from higher-margin large-diameter (4–6") substrates, presenting a 'short-term margin challenge'. Operating results were hence still impacted by product mix and weak pricing, plus under-utilization of Rubicon's slicing and polishing infrastructure due to the low SoS sales.

Despite operating expenses being cut from \$3m a year ago to \$1.8m, net loss was \$2.1m compared to net income of \$1.6m a year ago. Nevertheless, net loss was cut from \$2.9m last quarter, and is better than the expected \$2.5m. So, including \$1.6m in capital expenditure in Q3, cash, cash equivalents and short-term investments fell by just \$2.1m, from \$47.5m to \$45.4m.

In addition, as the LED market continued to strengthen during Q3, substrate pricing stabilized as global sapphire production capacity began to tighten, says president & CEO Raja Parvez.

Due to the improving demand, Rubicon expects pricing to begin to rise in Q4/2009 (by 7% overall, and 10% for certain products).

Also, as a result of the current high level of investment by LED chip makers worldwide in processing equipment for large-diameter substrates (as well as in R&D on migrating from smaller diameters), in Q3 Rubicon saw a corresponding increase in orders. The firm hence expects the proportion of its revenue from such higher-margin large-diameter substrates to rise, starting in Q4/2009 and reaching about 50% of revenue next year as demand grows steadily through 2010 and 2011.

For Q4/2009, Rubicon expects its total revenue to grow further, by 23% to \$7m. "Based on the expected pricing and product mix, gross margin should turn positive," says chief financial officer William Weissman.

"We are at the beginning of a long-term growth cycle in the LED industry," believes Parvez. In addition to automotive and signage applications strengthening as the economy improves, he cites forecasts that the penetration of LED backlighting into TVs will grow rapidly from less than 3% this year to more than 40% in 2013 (as adoption spreads next year beyond early-adopter Korean TV makers and Taiwanese BLU chip makers, as well

as penetrating the desktop PC market from 2010). He also cites the progress in adoption for illumination applications such as street-lighting.

In addition, Rubicon expects qualifications with new SoS customers to be completed within 6–9 months, leading to extra orders by mid-2010. This should drive demand for 6" and 8" substrates and provide a further boost to ASPs as well as utilization of Rubicon's substrate polishing equipment.

Rubicon is already ramping crystal growth capacity at its existing facilities, building out the remaining furnaces over the next few months to reach a maximum annual revenue-generating capacity of \$30–35m in Q1/2010.

The firm is therefore now also in the process of finalizing a two-part expansion plan:

- a new second-generation crystal growth facility (near its existing plant in Bensenville, IL), with larger furnaces able to service the demand for larger-diameter substrates (as well as providing extra annual revenue-generating capacity of \$35m);
- a new plant in Asia to expand post-crystal-growth processing operations including slicing and polishing (for which land has already been bought).

"These expansion initiatives would be designed to ensure Rubicon maintains its global leadership in high-quality, large-diameter sapphire substrates and ensure our pricing remains competitive while maximizing our revenue and margins generated from our existing and new manufacturing facilities," says Parvez.

The firm's most recent crystal growth facility cost \$25m and was opened in July 2007 just 6–9 months after deciding its location (more than doubling the firm's capacity at that time). Rubicon is hence confident that both new plants will open within 12 months and be fully operational within 24 months.

www.rubicon-es2.com

Momentive wins \$4.5m ARPA-E grant for LED lighting

Specialty materials firm Momentive Performance Materials Inc of Albany, NY, USA is to receive \$4.5m in funding from the Department of Energy (DOE) to continue the development of technology for low-cost production of LEDs used in solid-state lighting (SSL) as well as for increased LED light source performance. Although LED-based lighting can consume 75% less energy and have a longer lifetime than common lighting options, it is currently more expensive to produce than conventional lighting. Momentive will add about 20% of its own money to the DOE's funding for the project.

Momentive's proposal is one of only 37 research projects selected (out of almost 3700 submissions) to receive a total of \$151m in a first round of funding awarded on 26 October through the DOE's Advanced Research Projects Agency-Energy. ARPA-E was established under the America Competes Act of 2007, and in April President Obama announced \$400m in initial funding through the American Recovery and Reinvestment Act.

"We are honored to be among the first recipients of this innovative funding program and its inspiring mission of working toward a low-cost, secure and low-carbon energy future for the US," says chief technology officer Eric Thaler. The DOE has estimated that by 2025, with appropriate R&D funding, the displacement of incandescent and fluorescent lighting sources with SSL could result in a 29% cut in US energy consumption for lighting. LED-based lighting is also more versatile than conventional lighting, as it can be integrated into a variety of structures, components and design elements for widespread use.

Based on Momentive's platform technology and initiated by the firm, the two-year energy research project brings together a team of companies specializing in ammonothermal bulk gallium nitride crystal growth technology, high-pressure/high-temperature reactor development, and LED device testing and development to produce a high-pressure ammonothermal process for the inexpensive production of high-

quality, single-crystal GaN substrates at high growth rates.

Collaborating with Momentive on the project are Soraa Inc of Goleta, CA and Advanced Photonic Crystals LLC of Fort Mill, SC. Solid-state lighting startup Soraa was founded by GaN materials and device researchers at University of California Santa Barbara (UCSB) including Steve DenBaars and Shuji Nakamura, and in February 2008 raised investment from Khosla Ventures. Advanced Photonic Crystals is a manufacturer of solid-state crystals for laser, photonics and optoelectronics applications, with proprietary technology licensed exclusively from Clemson University and expertise in high-pressure autoclave engineering and crystal growth.

"The grant will allow us to help develop the commercial-scale technology, processes and equipment needed for the cost-effective, mass production of energy-efficient LEDs," says Thaler. "This, in turn, should help facilitate a game-changing transition from current lighting technology to solid-state lighting."

www.momentive.com

LED expert joins BluGlass's board as non-exec director

BluGlass Ltd of Sydney, Australia, which has developed GaN-on-glass technology, says that Dr Alan Li has joined it as a non-executive director.

Li has 15 years experience in the LED industry, holding senior posts in semiconductor lighting and optoelectronics materials in China and Taiwan. He is currently general manager & chief technology officer of Rainbow Optoelectronics Materials (Shanghai) Co Ltd and is co-inventor of over 37 optoelectronics patents. Li has also been a board member of FangDa Guoke Optronics (part of Chinese listed firm FangDa Group) and is on the advisory board of the Solid State Lighting and Energy Centre (SSLEC) at University of California Santa Barbara (UCSB).

As well as completing a PhD at the Australian National University in

Canberra, Li also received an Innovation Award from China's Ministry of Science and Technology in 2006, the ShenZhen Innovation Award of Science and Technology for the Key Technology for Fabrication of High Power LED Chips in 2007, and the Guangdong Science and Technology Award for the Key Technology for Fabrication of High Power LED Chips in 2008. He is also principal researcher in an R&D project (funded by the Scientific Board of Shanghai City) to design new MOCVD reactors.

"His vast industry, commercial and academic experience will be of significant value," believes BluGlass's chairman Dr Mike Taverner. "Alan will immediately become an important part in directing the development and commercialization of our technology, with his keen interest

in low-temperature nitride growth."

Spun off from Macquarie University in 2005, BluGlass has developed a low-temperature process using remote-plasma chemical vapor deposition (RPCVD) to grow materials including GaN and InGaN for the production of high-efficiency devices such as LEDs with what is reckoned to be significant low-cost potential and inherent scalability. In May, BluGlass said it intended to develop high-efficiency group III nitride solar cells. Via its subsidiary BluSolar, it is now exploring the process' viability in PV applications.

"The company has developed cutting-edge technology which has huge market potential in both the solid-state lighting and solar cell industries," comments Li.

www.bluglass.com.au

IN BRIEF

SemiLEDs adds MOCVD capacity to meet demand for high-end lighting applications

LED maker SemiLEDs Corp of Boise, ID, USA says that it has added an Aixtron Close Coupled Showerhead CRIUS MOCVD system (with 7x4-inch wafer configuration) into its 4-inch fabrication plant in Hsinchu Science Park, Taiwan.

SemiLEDs has shifted its mass-production high-power vertical LED (VLED) from 2.5-inch wafers to 4-inch wafers, boosting production capacity to keep pace with strong demand for high-end applications such as street light and home lighting, as well as shortening lead times for customers. The 4-inch LED fab should be able to produce 10 million VLEDs per month when running at full capacity.

SemiLEDs' blue (white), green and ultraviolet high-brightness LED chips are manufactured using a unique, proprietary 'metal vertical photon' (Mvp) process that provides a patented flexible copper alloy base, enabling what is claimed to be the best thermal resistance on the market (0.4°C/W) as well as providing electrical and optical advantages such as longer lumen maintenance.

● As announced at the 6th China International Forum on Solid State Lighting (China SSL 2009, 14-16 October), using I-core MvpLED chips (subsequently launched commercially in early November — see the story to the left), SemiLEDs' packaging customers have achieved cool-white LED luminous efficacy of 120lm/watt running at 350mA.

www.semileds.com

SemiLEDs plans China LED wafer and chip fab

High-brightness LED chip maker SemiLEDs Corp of Boise, ID, USA (which has chip fabrication facilities in Hsinchu Science Park, Taiwan) plans to establish a new LED wafer and high-power LED chip fabrication plant in Foshan, Guangdong Province, China.

The plant will be developed in three stages, with the initial stage seeing an investment of \$96m and set to be ready for full-scale production by October 2010. Initial monthly production capacity will be 20 million 1mm x 1mm LED chips per month, with investment and production expected to grow three-fold within three years.

"Developing a fabrication facility in the NanHai Economic Development Zone will allow SemiLEDs to be in

the center of the LED industry in China," says chairman & CEO Trung Doan. "NanHai has invested RMB\$2bn to support the industry's development. The government provides great support and, combined with the local industry, it makes a perfect match," he adds.

SemiLEDs reckons that the China plant will enable it to provide further service and support to the growing number of firms involved in solid-state lighting throughout China while boosting production to meet rapidly growing global demand.

SemiLEDs supplies LED chips to many packaging firms in China focusing on solid-state lighting such as street lights, commercial and residential lighting.

First I-core LED chip launched

SemiLEDs has launched the I-core (IC) LED, a new chip that will be featured in the firm's blue (white), green and ultraviolet ultra-high-brightness LED product portfolio. The IC is the first product released in SemiLEDs' I-core series of LEDs, which are designed to provide further improvements in brightness, reliability and overall efficiency.

The I-core is designed with new electrodes that are convenient for wire bonding. SemiLEDs says that advantages include improved reliability, delivered through the optimization of stress management for the chip at high-current operation. The firm claims that the IC LED is also significantly brighter, as its robust design results in much improved light extraction. An optimized white-light I-core LED chip in a 40 mil package can deliver 120lm/W, which is a significant improvement over the previous version.

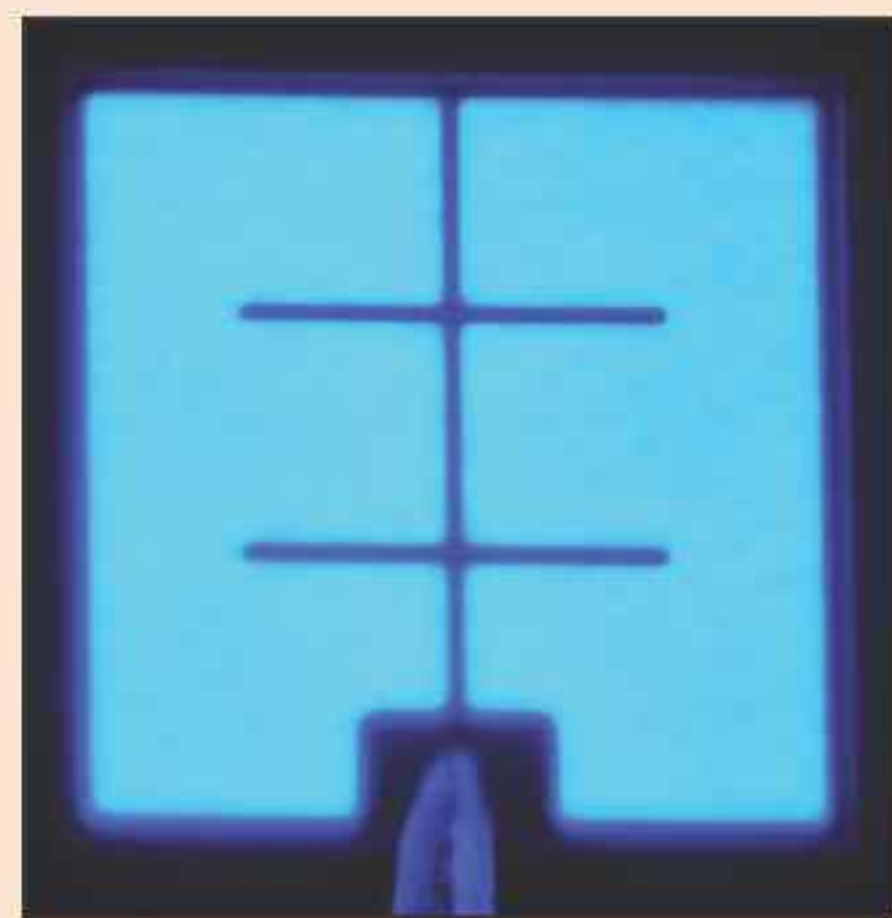


Photo showing the chip of SemiLEDs' new I-core LED.

SemiLEDs says that these advantages are further emphasized through its patented and proprietary 'metal vertical photon' (Mvp) LED chip technology, which features a vertical structure with a flexible copper alloy base to enable effective thermal dissipation.

www.semileds.com

Lumileds launches white automotive-rated LUXEON Rebel LEDs

Philips Lumileds of San Jose, CA, USA has announced the broad release of its white automotive-rated LUXEON Rebel LEDs.

Intended for use in automotive applications such as daytime running lamps, position lamps, backup lamps and interior lighting, the LEDs provide greater design flexibility and are engineered and tested to exceed automotive requirements for reliability, performance, and lifetime. Each part conforms to both the SAE and ECE color specifications and has complete PPAP documentation.

"The auto industry is under continuous pressure to innovate, inspire and develop more sustainable solutions, and vehicle lighting is one of those applications where the latest LUXEON LEDs can positively contribute to how people feel about their cars and how they see others on the road," says Steve Barlow, executive VP of sales & marketing.

"LUXEON Rebel enables new, unique design possibilities because of its small size and high output," he adds. "The low power consumption contributes to saving millions of litres of fuel. And the rugged package is designed to function for the life of the vehicle, eliminating the need to change bulbs."

The firm claims that benefits to automotive lighting engineers include:

- simplified secondary optic design and integration;
- reduced thermal management engineering; and
- easier assembly and integration for reduced manufacturing costs.

LUXEON Rebel white LEDs for automotive applications are the most recent addition to a portfolio of products for the automotive industry that includes LUXEON Altilon, SuperFlux and SnapLED.

www.philipslumileds.com

AZZURRO unveils technology transfer and license to Osram

Epiwafer foundry AZZURRO Semiconductors AG of Magdeburg, Germany, which provides gallium nitride on large-diameter (100 and 150mm) silicon substrates for LED and high-voltage applications, has made public that, a year ago, it agreed to license and transfer its GaN-on-Si process technology to Germany's Osram Opto Semiconductors for the growth of GaN-based LED structures.

Although the technology transfer is exclusive to Osram Opto until 7 November 2010, the licence is non-exclusive (allowing AZZURRO to still supply GaN-on-Si-wafers to both the LED market and the market for high-voltage applications).

Developed by AZZURRO over the last six years, the proprietary GaN-on-Si technology enables the growth of thick and crack-free GaN layers on silicon substrates with high

crystal quality and minimum bow.

"The license and transfer agreement is a big step for the commercialization of LEDs produced on silicon substrates," says CEO Erwin Wolf. "Our technology will enable manufacturers to use silicon fabs to produce LEDs on 150mm and in future also on 200mm silicon substrates."

Executive VP of sales & CFO Alexander Loesing adds that, although AZZURRO's current reactor accommodates only 150mm wafers, next year the firm will have MOCVD reactors capable of deposition on 200mm wafers. The industry will ultimately transition to 200mm wafers, he believes, as — besides the inherent efficiency of using a greater proportion of the reactor area — this will allow the economies of scale of using silicon foundries.

www.azzurro-semiconductors.com

Blue LED pioneer Akasaki receives Kyoto Prize

In early November, the Inamori Foundation presented its 25th annual Kyoto Prize to four recipients, including Dr Isamu Akasaki in the category 'Advanced Technology' (which this year focuses on electronics). Akasaki (a professor at both Nagoya University and Meijo University in Japan) receives the award for pioneering work that led to the development of the blue LED.

The Kyoto Prize is Japan's highest private award for global achievement, honoring contributions to the scientific, cultural and spiritual betterment of humankind. Laureates received a diploma, a 20-karat-gold Kyoto Prize medal, and a cash gift of 50m yen (US\$550,000) per prize category.

After decades of research on gallium nitride, Akasaki created GaN-based positive-negative (p-n) junctions, making the blue LED practically possible. This stimulated research on blue LEDs worldwide, and served as the first step toward their eventual commercialization in the 1990s.

Applications now include displays for mobile electronic devices; large outdoor display equipment and signage; railway and road traffic signals; and vehicle lamps. Also, with the advent of blue semiconductor lasers, the capacity of optical recording media such as Blu-ray discs has been increased.

The award citation also says that Akasaki's research has not only led to diverse new applications in electronic equipment but also offers promise for protecting the global environment as blue LEDs are adopted for energy-conserving general-purpose lighting.

The 2009 laureates will reconvene on 20–22 April 2010 for the ninth annual Kyoto Prize Symposium at San Diego State University; University of California, San Diego; and University of San Diego.

www.kyotoprize.org

Osram prototypes LED with warm-white light, high efficiency, and true colors

Osram Opto Semiconductors GmbH of Regensburg, Germany has developed a prototype LED that, it claims, is the first to offer the three key properties that, together, are essential for widespread adoption for general illumination: high luminous efficiency of 104lm/W, a high color rendering index (CRI) of 82, and a warm-white color temperature of 3000K (since warm-white light is targeted specifically at the residential sector).

At 3000K, the LED's light color is similar to that of a halogen lamp. Its color location is precisely on the Planckian curve, and the light is exactly white, showing no shift to the green spectral region. With an operating current of 350mA and a



A new converter mix being tested in Osram's development lab provides warm-white light.

chip surface of 1mm², the prototype of the new single-chip LED achieves a brightness of 124lm, corresponding to an efficiency of 104lm/W.

Up to now, efficiencies exceeding 100lm/W have been achieved

only in the cold-white spectrum. "The successful combination of high quality of light and excellent energy efficiency will bring the commercial breakthrough for LED technology even closer," reckons Dr Frank Baumann, project manager for the development of warm-white LEDs.

Osram says that the record results are based on its expertise in providing a new chip architecture in conjunction with improvements in silicon crystal growth technology, improvements in the converter mix, and a high-efficiency package.

Osram aims to gradually integrate the new technologies into production.

www.osram-os.com

Osram Opto LEDs used in 3M's micro-projectors

LEDs made by Osram Opto Semiconductors are being incorporated by diversified technology company 3M in its new micro-projectors.

3M's MPro120 PocketProjector is about the size of a mobile phone, and enables viewing of photos or videos by projection onto a wall. The light source has been adapted specifically to 3M's requirements based on Osram's OSTAR SMT LED. Depending on lighting conditions, the LEDs project images of more than a meter in size diagonally. The MPro120 can also connect to other devices (mobile phones, digital cameras or laptops) via an AV-input.

"Thin-film chip technology and a specially developed LED enclosure make powerful light possible in the smallest spaces," says Osram Opto Semiconductors' marketing manager Wolfgang Schnabel.

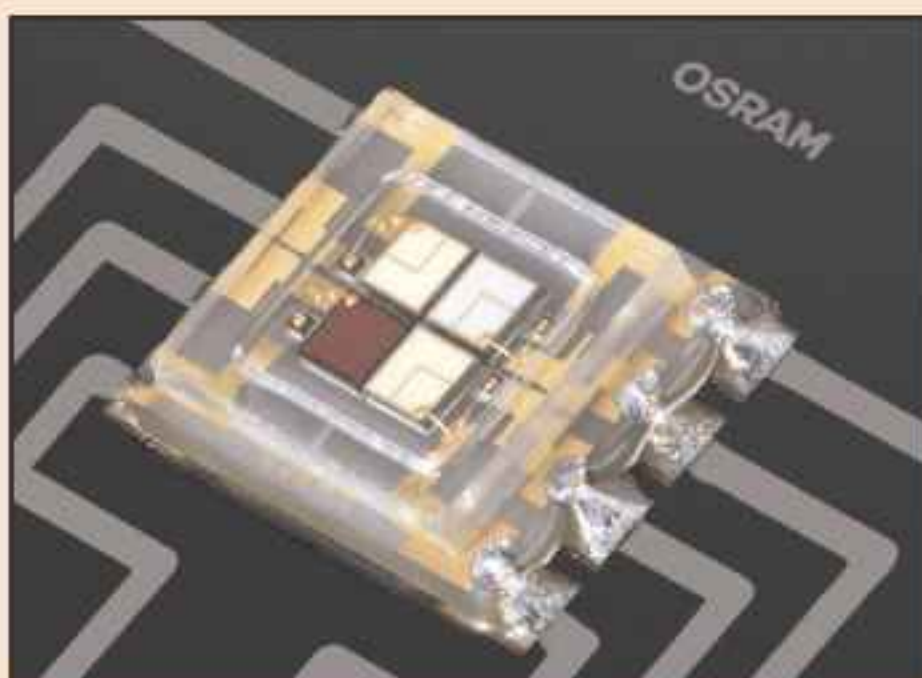
"The LED's low energy consumption also conserves the projector's battery and, therefore, ensures longer operating times — the crucial aspect for mobile applications."

By coordinating 3M's Light Engine with the LED, the projector has a



3M's new MPro120 PocketProjector.

luminous efficiency of more than 10lm/W. As it works with a multi-chip LED (comprising two green chips, one red chip and one blue chip), the unit achieves excellent color rendering, claims Osram.



Osram's OSTAR SMT LED.

"Last year, 3M was the first company to launch a micro-projection unit with LED technology," says Kay-Uwe Schenke, market development manager at 3M Deutschland GmbH. "3M's new MPro120 PocketProjector has been developed with user needs and requirements in mind. Besides full VGA resolution, its distinctive features are market-leading brightness, integrated speakers and a projection area of 20–127cm (depending on lighting conditions). This makes projection on the move possible instantly and easily with a laptop or multimedia mobile phone."

Osram Opto Semiconductors says that it offers a wide range of LEDs for all types of projection applications. The OSTAR Compact has been developed for use in small devices such as mobile phones, PDAs or music players. OSTAR Power Projection is aimed at high-performance projection applications such as home theatre systems. Projection system requirements from 1W to 300W can therefore be covered.

New MULTILED boosts homogeneity for video displays

Osram Opto Semiconductors GmbH of Regensburg, Germany has launched a new MULTILED product, the LRTB GFTM, developed specifically for the video display market. The new MULTILED provides homogeneous display results and high color fidelity across the entire viewing angle required by the video display market, while its black surface enables good contrast in both indoor and outdoor environments, claims the firm.

As a further extension of Osram Opto Semiconductors' black product series, the LRTB GFTM provides what is claimed to be excellent contrast and depth of color. "Because the RGB chips in the MULTILED series are arranged in a straight line, the displays look the same no matter from which angle they are viewed," says KC Cheng, marketing director of Asia Pacific at Hong Kong-based subsidiary Osram Opto Semiconductors Asia



High homogeneity over the viewing angle in all colors due to MULTILED's in-line arrangement of the chips.

Ltd. The high homogeneity suits application to video walls and displays.

Osram Opto says that homogeneous display results are also achieved by using its latest high-power Thinfilm and ThinGaN technologies. By supplying in very narrow distributions in terms of brightness and color location, the display colors remain constant from all viewing angles.

Osram Opto Semiconductors claims that the new MULTILED also provides value for money, especially for volume markets in Asia. According to market research firm Strategies Unlimited, large full-color sign applications accounted for 9.3% of the high-brightness LED market in 2008. Also, according to iSuppli, China and Asia-Pacific will become the biggest signage and professional display markets by 2011.

LED benefits have accelerated the adoption of LED displays, since the light sources contain no lead or mercury and offer much longer life time with less maintenance. In addition, like other members of the MULTILED family, the LRTB GFTM enables reduced maintenance costs, as its six-lead package delivers improved thermal management and increased reliability, it is claimed.

www.osram-os.com

BMW motorbike fog lights to use Osram LED modules

Developed jointly by Osram's Automotive Lighting division and LED maker Osram Opto Semiconductors GmbH of Regensburg, Germany, the Joule JFLCF2 LED module (a version of its JFL2 and in series production since November) is being used in fog lights on BMW motorcycles, replacing conventional halogen-based technology. The motorcycle fog lights were developed as part of a joint BMW and Osram project.

Since the modules are highly resistant to shocks and vibrations, the lifespan usually exceeds that of the motorcycle, reckons Osram, so headlamps with LEDs need to be maintained far less often than conventional halogen-based lamps. With just 14W of power input per fog light, the LED module is also much more efficient than the halogen version's 55W.

As they already include lenses, which meet the requirements of



Osram's Joule JFLCF2 LED module for BMW motorcycle fog headlamps.

the new EU directive ECE R19 F3, the JFLCF2 modules can be integrated into fog lights easily and inexpensively. The fog lamps can be customised with heat sinks or assembly fixtures and offer the possibility of adjusting the design to specific needs.

Due to the integrated lenses, Osram claims that the JFLCF2

module ensures ideal fog-light distribution, yielding relatively good vision even in thick fog and hence improving safety for motorcyclists. The area in front of the bike and the edge of the road are illuminated better, and other road users can see the motorcyclist better.

Also, even motorcycles that were unsuitable for conventional halogen fog lamps due to their battery or wiring can be fitted with the Joule JFLCF2 LED module.

"By using LEDs, customers can develop new and innovative fog lamps within a very short time, which definitely enhance rider safety and are environmentally friendly, as they reduce energy consumption by more than 80W per bike compared with the current halogen technology", says Christian Meier, product manager of Joule LED systems.

www.osram.com

IN BRIEF

LED light bulb with 969lm output and 102lm/W efficacy

At the annual shareholder meeting of LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA, chairman & CEO Chuck Swoboda demonstrated an A-lamp LED light bulb with what is claimed to be the industry's highest reported lumen output and efficacy.

The bulb produces 969 lumens at an efficacy of 102 lumens per watt. This is the light output equivalent to a 65W incandescent bulb, yet the LED uses only 9.5W.

The demonstration A-19-style bulb features Cree's latest production XLamp XP-G LEDs and TrueWhite Technology, a patented method of delivering warm-white light (with a correlated color temperature of 2800K) with improved efficiency and color rendering index (a CRI of 91). All data was verified by third-party testing under steady-state operating conditions.

"We are pushing the industry by demonstrating what's possible," says Swoboda. "With every improvement in LED components, new applications become achievable," he adds.

www.cree.com

Cree CEO joins US Energy Secretary to discuss energy efficiency

On 28 October, Cree's chairman & CEO Chuck Swoboda joined US Energy Secretary Steven Chu at the Clean Energy Economy Forum in Washington DC to discuss science, innovation and job creation in the new clean economy.

Swoboda was one of four CEOs invited to participate in a panel discussion and question-and-answer session on energy efficiency and the creation of new jobs in clean technology that aims to help drive US energy independence.

Other featured speakers at the event included Valerie Jarrett (senior advisor to the President), Carol Browner (assistant to the President for Energy and Climate Change) and Cathy Zoi (Department of Energy assistant secretary for Energy Efficiency and Renewable Energy).

"The clean economy won't happen by talking about it. Real, sustained job growth will only follow the creation of a viable market for clean products and technologies," said Swoboda.

Founded in 1987 by graduates from North Carolina State University, Cree has more than 3200 staff and, in October, announced the creation of 575 new jobs to be filled over the next few years in North Carolina.



Speakers at the Clean Energy Economy Forum.

"LED lighting is all about energy efficiency, and I believe it is the single most important thing we can do to impact the energy equation in the next 20 years," said Swoboda. "LED lighting costs more upfront, but the benefit is that it pays for itself in energy savings and lower maintenance costs," he adds. "To those that say we can't afford to do this, I tell you that we cannot afford not to do this. The cleanest, cheapest energy is the energy we don't use."



Steven Chu

Swoboda previously met with President Obama in July as part of a roundtable discussion on US innovation and clean energy technology.

Cree LED lamps to provide lighting for 650 Walmart stores

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has been selected to provide LED lighting to US-based retailer Walmart for new stores and renovations.

Walmart plans to install Cree's LRP-38 LED light bulbs in 650 stores during the first year, replacing ceramic metal halide in the produce and electronics departments. Cree's LR6 recessed LED downlights are also being used in new construction applications.

Cree says that its LRP-38, a PAR38-style LED lamp, was selected for its energy efficiency, long lifetime, controlled beam and high color-rendition. Designed to last 50,000 hours, it is said to consume 82% less energy than the 70W ceramic metal halide bulbs it replaces and can last more than five years in a 24/7 operating environment. Its design also reduces glare for customers, focusing attention on the merchandise and not the lighting,

it is reckoned.

"Cree TrueWhite technology delivers high-quality light — making food and merchandise attractive," says Cree LED Lighting president Neal Hunter. "We're able to do all this while reducing energy consumption and eliminating toxic mercury," he adds. "The selection of Cree's lamp followed a thorough analysis of performance, in-store evaluations and return on investment."

www.CreeLEDLighting.com

China gets Cree's first non-US chip fab

LED chip, lamp and lighting fixture maker Cree Inc of Durham, NC, USA has agreed to buy a 592,000ft² facility in Huizhou, Guangdong Province in southern China. It will become Cree's first chip-fabrication plant outside North America and is targeted to also house future expansion of components manufacturing.

Already, more than half of Cree's 3172 staff work in China, mostly at its existing packaged high-brightness LED manufacturing plant in Huizhou, which it gained with the \$207m acquisition in 2007 of Hong Kong-based COTCO Luminant Device Ltd.

"This investment enables us to expand our presence in China and demonstrates our commitment to serving the growing demands of both our local and global LED customers," says chairman & CEO Chuck Swoboda. "We are building on a solid foundation in Huizhou with a strong local management team and a history of manufacturing excellence."

Cree recognizes the support of Huizhou's party secretary YeBin Huang and mayor RuQiu Li during site selection. "Solid-state lighting is a key strategic green industry for China," says Huang. "From the government's perspective, we will do our best to support Cree through government projects as well as government policies," he adds. "This investment will be a win-win project for Cree and China's SSL industry."

Previously, in September, Cree raised \$434m in a public offering of common stock, for use for potential strategic investments as well as anticipated capital expenditures of about \$150m in fiscal 2010 (to end-June 2010). Subsequently, in early October, Cree announced plans to add 575 jobs: 275 at its existing chip fab in Durham by the end of 2009 and a further 300 in North Carolina by the end of 2012.

Also, Huizhou is joining the Cree LED City program, an international community of government and industry parties initiated in December 2006 to evaluate, deploy and promote LED lighting for municipal infrastructure. The existing program members are Raleigh, NC, Ann Arbor, MI, Austin, TX, Anchorage, AK, Indian Wells, CA, Fairview, TX and Danville, VI in the US; Toronto and Welland in Canada; Tianjin in China; Gwangju in South Korea; and Torraca and Apecchio in Italy.

Huizhou has already completed several trials of LED streetlights and is deploying LED streetlights in the ZhongKai Hightech Industrial Zone.

"We are very proud to be the first city in southern China to join the Cree LED City program," says RuQiu Li. "Energy saving and emission reduction are our city's priorities for sustainable development; we will continue to drive the adoption of the SSL products through government initiatives."

Lighting-class XP-C LEDs exceed 100 lumens

Cree has added to its XLamp range with new 100+ lumen XP-C LEDs. This addition shifts Cree's entire XLamp portfolio of lighting-class LEDs into the 100+ lumen range, at a drive current of 350mA.

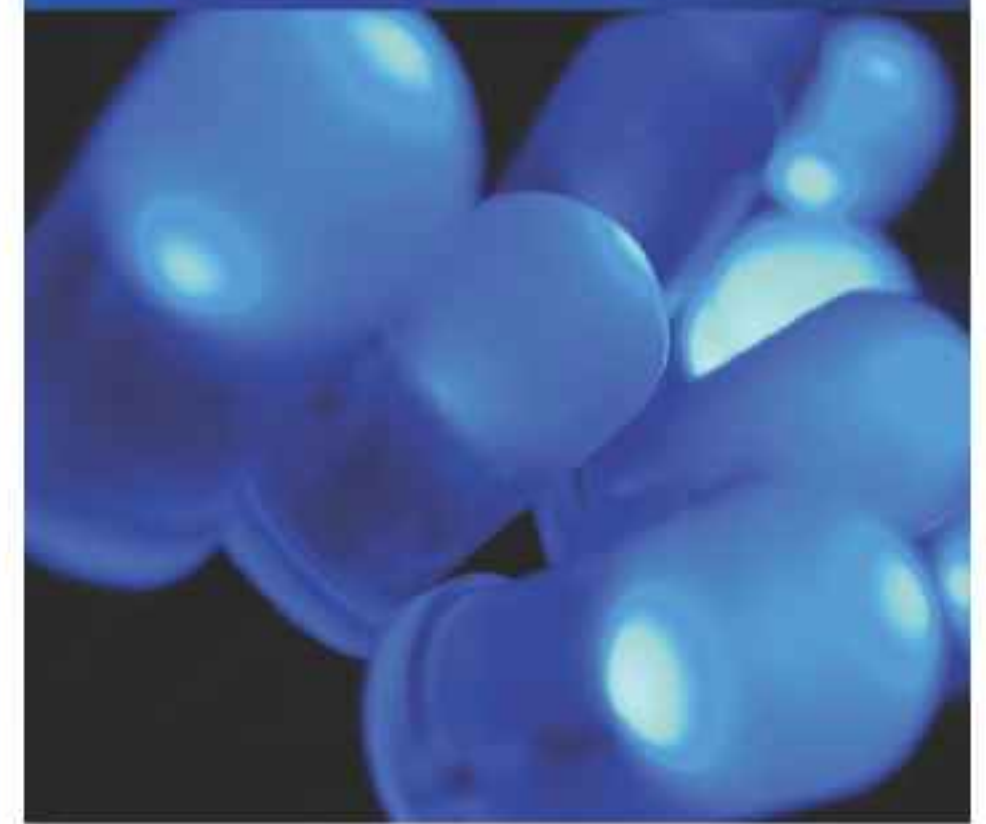
"Customers now expect high-volume 100 lumen parts, and the Cree XLamp family delivers more than 100 lumens at 350mA with the addition of these new XLamp XP-C LEDs," says Paul Thieken, Cree's marketing director, LED components.

Originally launched in August 2008, XP-C LEDs are now available in cool white with up to 107lm at 350mA. Warm-white XP-C LEDs are available up to 80lm at 350mA. Cree says that XP-C LEDs suit applications needing high-performance, lower-priced lighting-class LEDs. They are available in ANSI-compatible chromaticity bins for cool- and neutral-white and in the industry's smallest ANSI-compatible warm-white bins.

www.cree.com

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Sharp's AlInN route to inner-stripe blue-violet laser power

Researchers at Sharp Corp's Advanced Technology Research Laboratories in Japan and Sharp Laboratories of Europe Ltd in the UK have used lattice-matched aluminum indium nitride (AlInN) to improve blue-violet laser output power [Wei-Sin Tan et al, Appl. Phys. Express, vol2, p112101, 2009]. The AlInN material is used as a current-confinement layer for inner-stripe lasers (Figure 1).

The researchers are targeting emission wavelengths of around 405nm, as used for high-density optical storage such as Blu-ray and high-definition DVD (HD-DVD). Higher-power laser diodes would be advantageous for optical storage, as they give the possibility for increased data transfer rates. The researchers also see opportunities for high-brightness light sources and laser projector systems.

Presently, lasers constructed using ridge structures have low wall-plug efficiency (WPE), resulting in heat generation at high operating powers. Heat degrades laser operation and can lead to catastrophic failure.

By using an inner stripe, one can mitigate the poor conductivity of top p-type aluminum gallium nitride (p-AlGaN) cladding and p-type gallium nitride (p-GaN) contact layers by allowing the current to flow across a wider area. It is these layers that in a narrow ridge structure have high resistance and hence generate heat under high voltages.

Prior work with inner stripe laser diodes has used aluminum nitride (AlN) as the current-blocking layer. Sharp used undoped lattice-matched AlInN (with an indium composition of 17%), since this should reduce strain build-up and hence tendencies towards cracking and defects. These factors are expected to improve the quality of subsequent layers.

Sharp's devices were grown on n-type (0001)-face GaN substrates from Japan's Sumitomo Electric Industries Ltd. Initial layers to the lower part of the p-type cladding were grown by MOCVD. These were:

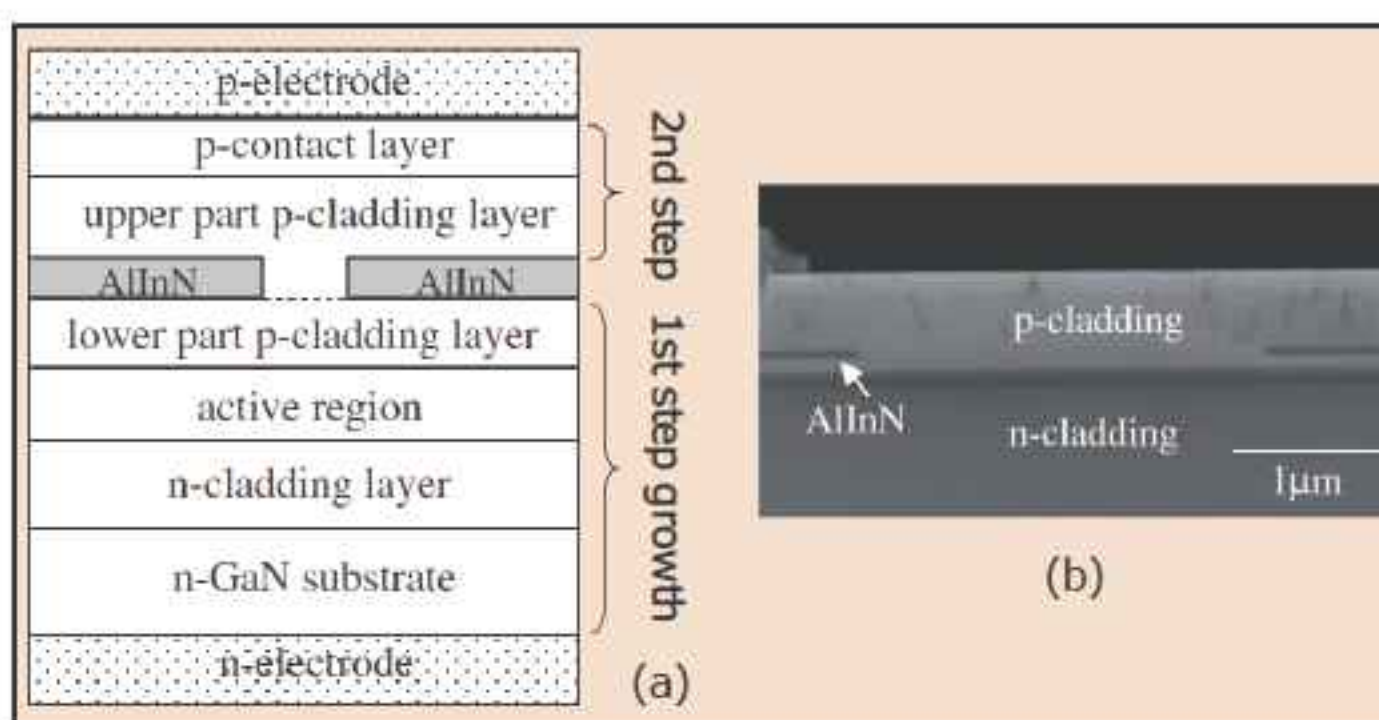


Figure 1. Sharp's inner-stripe laser structure (a) and cross-sectional SEM of grown device (b).

n-Al_{0.06}Ga_{0.94}N cladding, n-GaN waveguide, a triple InGaN quantum-well active region, p-Al_{0.30}Ga_{0.70}N to prevent evaporation, and the lower p-Al_{0.06}Ga_{0.94}N cladding.

Plasma-assisted molecular beam epitaxy (MBE) was then used to deposit a 50nm Al_{0.83}In_{0.17}N layer. The laser stripe aperture (2–6µm wide) was then created using lift-off techniques with a silicon dioxide sacrificial layer. This MBE process creates resistive AlInN material (10³Ω-cm) rather than the usual n-type material that results from undoped AlInN grown by MOCVD. The usual n-type characteristic of AlInN has been attributed to nitrogen vacancies or oxygen impurities. Sharp says that it sees further application potential for its resistive MBE-grown AlInN.

The wafer was then returned to MOCVD layer growth of the upper cladding, ensuring optimal conditions for a smooth interface between the upper and lower parts of the cladding.

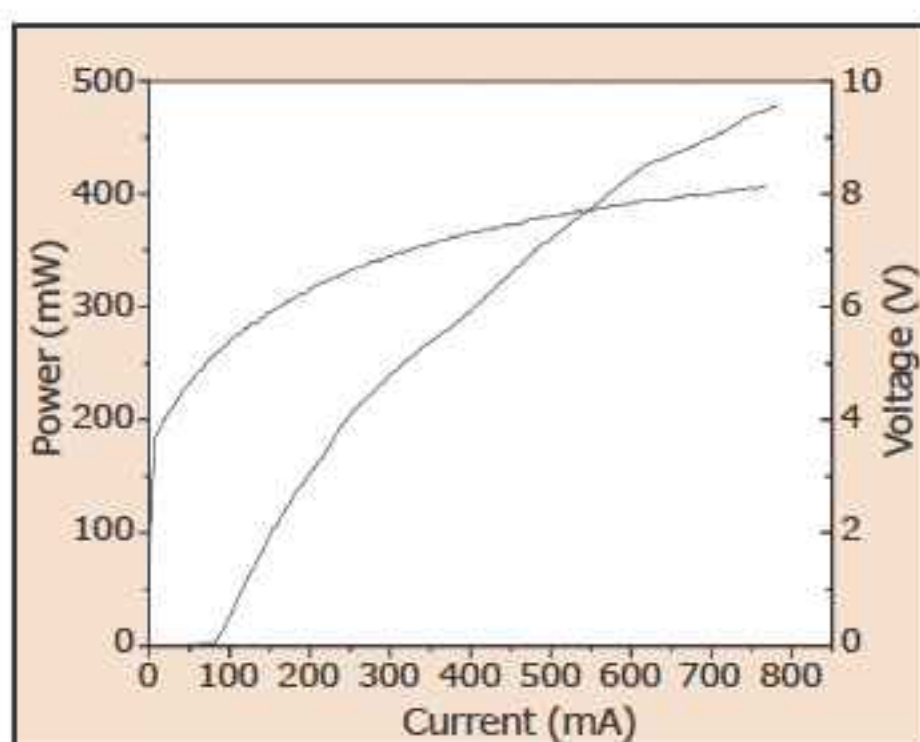


Figure 2. Pulsed output power-current-voltage (L-I-V) plot for 4.3x600µm² device (p-side up) at 25°C.

The p- and n-metal contacts consisted of palladium/gold (Pd/Au) and titanium/aluminum/gold (Ti/Al/Au), respectively.

Typical uncoated devices achieved continuous-wave (CW) lasing at a threshold current density of 3.3–3.5kA/cm² and

a slope efficiency of 0.8–0.9W/A. The researchers note that these values are comparable to those of ridge laser diodes. A 4.3x600µm² device achieved a peak slope efficiency of 1.6W/A and could be operated at up to 800mA under a 0.1% duty cycle of pulsed power (Figure 2).

Kinks in the optical power-current (L-I) plot are attributed to multi-mode laser generation effects, which could be eliminated by using narrower stripes of 1.0–1.5µm width.

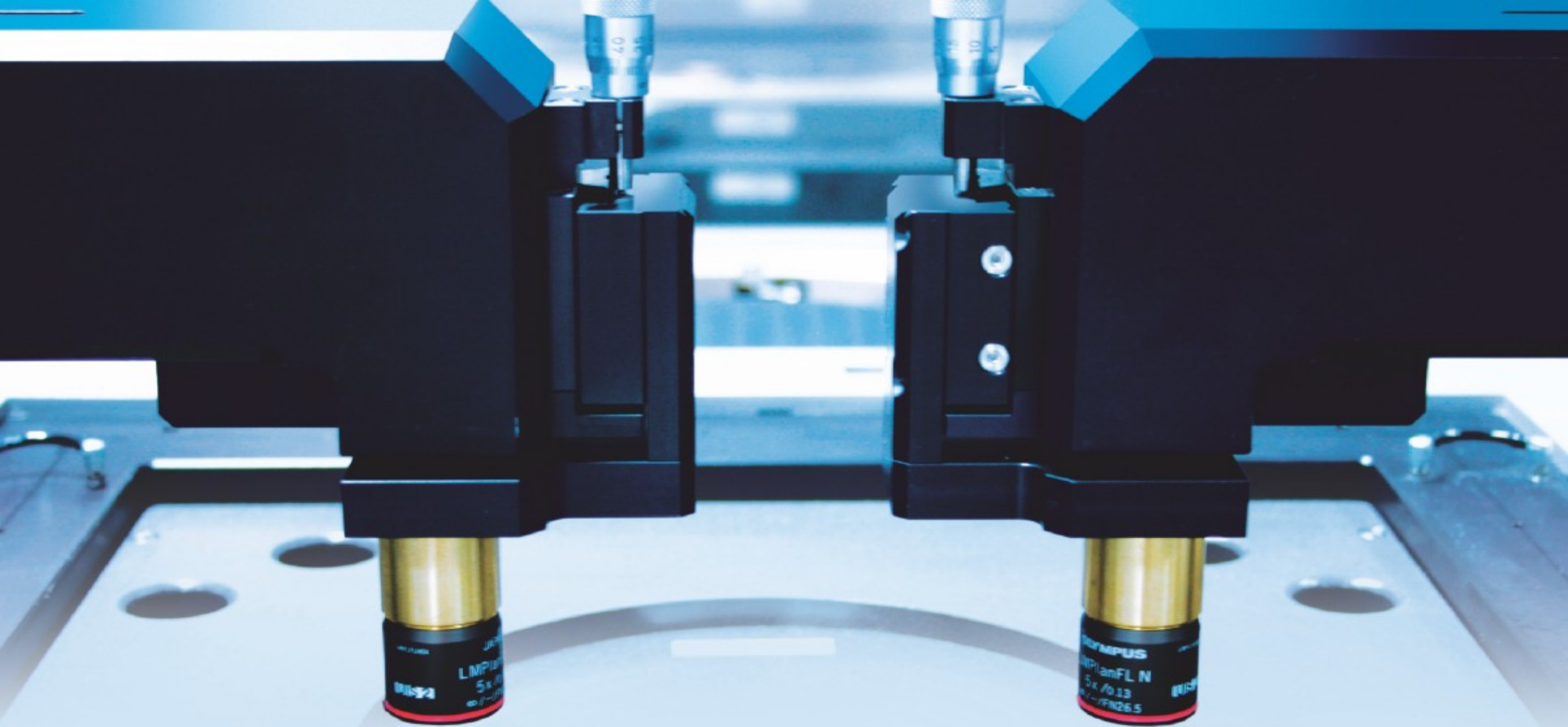
Reliability tests were carried out for a 2.8µm-width device operated under CW conditions at 25°C. The current was increased over time to maintain a constant output power of 50mW. Extrapolating from 400 hour operation, the researchers give a lifetime (to 1.3x the initial operating current) of 1000 hours. The researchers note that scanning electron microscope (SEM) investigations showed no obvious damage to the re-growth interface resulting from the testing.

Simulations suggest that reducing the stripe width could give further benefits over equivalent ridge structures. So, the researchers are working toward achieving these benefits experimentally, particularly to lower operating voltage and reduce thermal roll-over effects.

Sharp does not supply components commercially, but Nichia laser diode engineering samples are listed at up to 500mW output power, and up to 200mW for marketed products.

<http://apex.ipap.jp/link?APEX/2/112101>
<http://sharp-world.com>

Author: Mike Cooke



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IN BRIEF

DILAS extends diode laser system to 300W (200µm fiber) and 400W (300µm fiber)

At Productronica 2009 in Munich, Germany (10–13 November), DILAS Industrial Laser Systems of Mainz, Germany (a division of high-power diode laser maker DILAS Diodenlaser GmbH) announced that it has extended the power range of its COMPACT series of diode laser systems to 300W out of a 200µm fiber and 400W out of a 300µm fiber at 9xxnm. The fiber-coupled, turnkey diode laser systems are based on conduction-cooled diode laser bars.

Along with the COMPACT 500W, 400µm (launched a year ago), the COMPACT 300W, 200µm and 400W, 300µm systems complete the product portfolio. The systems are available with an industrial water-to-air chiller, power supply and an integrated control unit. The systems' features are controllable via 24V interface signals. Also, the 19-inch rack mount for laser and cooling unit make them easy to integrate for OEM integrators, says the firm.

COMPACT diode laser systems can be combined with a range of accessories for process control, including laser processing heads, cameras, pyrometer, galvo scanner and galvo scanner with integrated pyrometer.

In combination with a galvo scanner, the systems are suitable as a source for quasi-simultaneous plastics welding. DILAS says that the new extended beam properties provide advantages such as increased working fields and larger working distances as well as smaller focal diameters, enabling greater flexibility as well as productivity.

www.DILAS.com

Advanced Photonix maintains gross margin despite slump

For its fiscal second-quarter 2010 (ended 25 September 2009), Advanced Photonix Inc of Ann Arbor, MI, USA (which designs and makes silicon, InP- and GaAs-based photodetectors, high-speed optical receivers, and terahertz instrumentation) has reported sales of \$5.4m. This is down 34% on \$8.2m a year ago and 8% on \$5.9m on last quarter due to a broad-based decline across four of the firm's five markets.

"The first half of the year was negatively impacted by the recessionary environment, and this quarter was in line with our expectations," says chairman & CEO Richard Kurtz. "We have taken the necessary cost-reduction steps to minimize the impact of the revenue shortfall in the first half of the year," he adds.

Hence, for fiscal first-half 2010, gross margin was 45%, down only slightly on 46% a year ago despite the 29% drop from what had been record half-year revenue, reflecting cost-reduction initiatives and the prior year's facilities consolidation. The latter involved consolidation of the wafer fabs in Camarillo, CA and Dodgeville, WI into Ann Arbor in

mid-2007 and closure of the silicon photodiode assembly facility in Dodgeville in late 2007.

On a non-GAAP basis, net loss was \$452,000, compared to net income of \$315,000 last quarter and \$306,000 a year ago.

EBITDA (earnings before interest, taxes, depreciation, and amortization) was minus \$220,000, compared to positive EBITDA of \$554,000 last quarter and \$557,000 a year ago.

"We anticipate second-half revenue to show a return to growth, driven mainly by our HSOR [high-speed optical receivers] and Terahertz product platforms," says Kurtz. "While we do not anticipate top-line revenue to meet [fiscal] 2009 numbers, predominantly due to the industrial product market being closely tied to the overall economy, we do expect the second half of the year to show growth over the first six months and, with the reduced cost structure, a return to GAAP profitability," he adds. "We continue to invest in our product platforms that position us for additional future growth as the overall economy improves."

www.advancedphotonix.com

Opnext to supply Microvision with red lasers for mobile pico-projectors

Optical component, module and subsystem maker Opnext Inc of Fremont, CA, USA has begun shipping its red laser diodes to Microvision of Redmond, WA, USA for its PicoP laser projection display engine.

Microvision's PicoP display technology platform is designed to enable next-generation display and imaging products for potential applications including ultra-miniature pico projector displays for embedded or accessory applications for mobile phones,

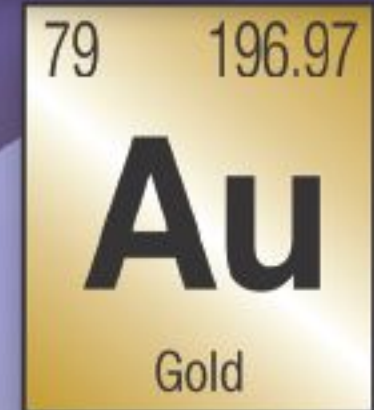
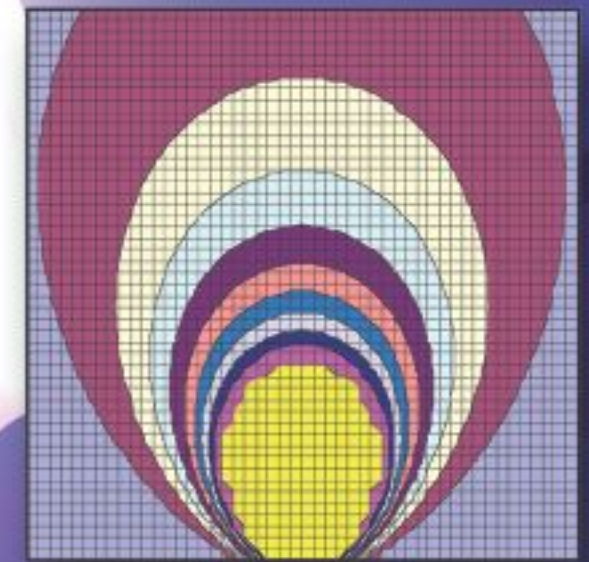
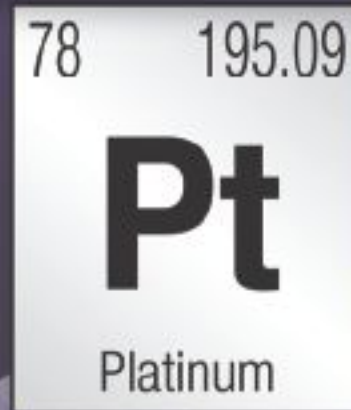
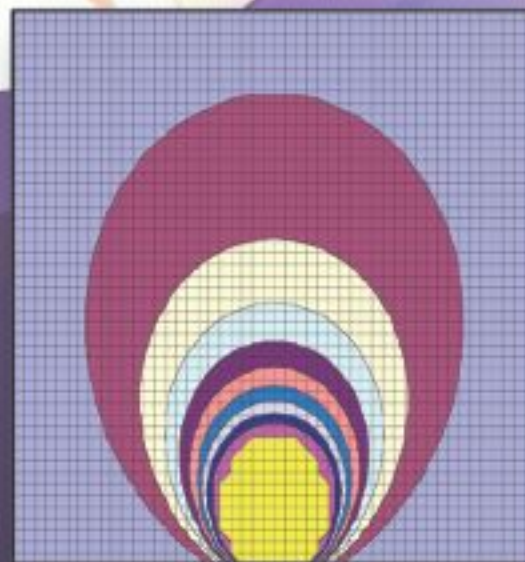
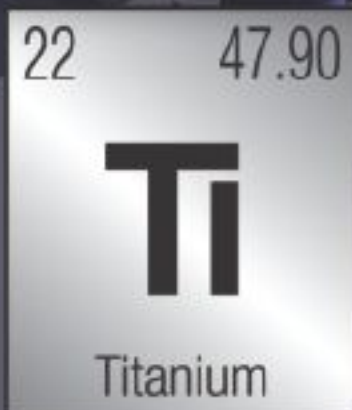
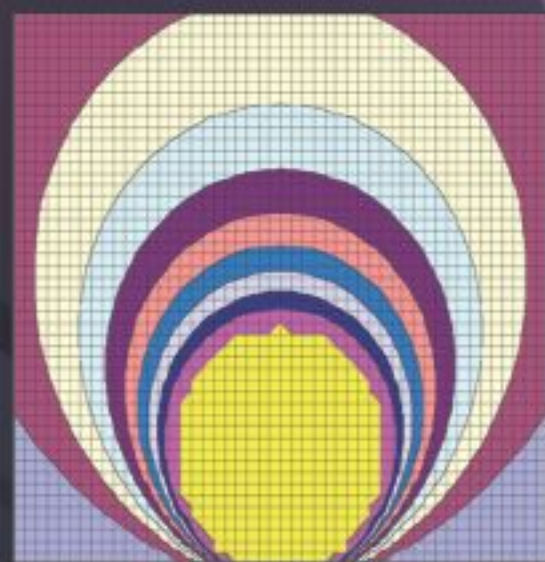
personal media players, laptops, vehicle displays, and future wearable display devices.

Laser-based microprojectors are said to have a unique combination of features that are optimal for mobile device users, including infinite focus, rich color, and high contrast and resolution. Opnext claims that its family of red laser diodes are playing a key role in this rapidly emerging mobile-display market.

www.opnext.com

www.microvision.com

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GigOptix buys ASIC firm ChipX to complement opto ICs

GigOptix Inc of Palo Alto, CA, which designs modulator and laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials as well as polymer electro-optic modulators, has acquired Santa Clara-based ChipX Inc, a privately held fabless supplier of analog and mixed-signal custom application-specific integrated circuits (ASICs) including standard cell, structured ASIC and hybrid ASIC technology.

ChipX's investors (which include Elron Electronic Industries Ltd, Wasserstein Venture Capital, UMC and Needham Capital Partners) will receive 3.5 million common shares of GigOptix (about 26% of its fully diluted share count). The acquisition is expected to broaden the ownership of GigOptix's common stock with the addition of new strategic and institutional investors.

In parallel, GigOptix has entered into a new commercial banking relationship with Bridge Bank N.A. of San Jose, CA (a full-service professional business bank) that includes a \$4m asset-based line of credit.

The existing GigOptix management will continue to lead the firm (with Dr Avi Katz as CEO & chairman) and the new ChipX (CX) product line will be jointly managed in the interim by ChipX executives Ophir Nadir as VP engineering and Elie Massabki as VP sales & marketing.

Combined revenues for the first nine months of 2009 would have been more than \$25m. GigOptix expects the scaled-up firm to be better positioned financially to mitigate the infrastructure cost of being a publicly traded small-cap company.

Both firms are in Silicon Valley and, for organization and financial benefit, will be consolidated into GigOptix's HQ in Palo Alto (ChipX's lease in Santa Clara expires in two months). GigOptix and its subsidiaries will have about 95 staff (down from 115 pre-merger), of which 40% are in R&D and 15% in sales & marketing.

The firm believes that, as with its previous three acquisitions — iTerra Communications LLC (a maker of

amplifiers and modulator driver ICs) in July 2007, Helix Semiconductors of Zurich, Switzerland (a maker of transimpedance amplifiers, limiting amplifiers, and VCSEL drivers) in January 2008, and Lumera Corp of Bothell, WA, USA (a maker of polymer electro-optic modulators) in December 2008 — it will achieve financial efficiencies after consolidation. Cost synergies should contribute to improving the bottom line as soon as first-quarter 2010.

GigOptix plans to boost the annual revenue per employee from about \$230,000 prior to the acquisition to more than \$300,000 in 2010.

Katz says the acquisition of ChipX continues GigOptix's vision of gathering complementary technologies so it can enrich the features offered while reducing the cost to customers. "ChipX brings a loyal portfolio of tier-1 customers who use the first class design services and IP of ChipX to create their own truly differentiated custom products," he adds. "We will bring our own IP together with that of ChipX to bring new standard products to market faster, and at a lower investment by leveraging their excellent design capability... This acquisition fits into our continuous rollup and consolidation growth strategy."

Expected benefits of ChipX include:

- A revenue stream from more than 60 active customers, and over 100 custom mixed-signal ASIC products in production and five in development.
- Strong customer relationships due to the level of engagement required during joint development of custom ASICs (focused on the vertical markets of defense & aerospace, industrial, communications, medical and test & measurement, where GigOptix offers complementary products).
- A portfolio of IP and complementary skills that will enable GigOptix to develop new products for the optically connected market (alternatively, organically developing and building such a portfolio of about 70 silicon-proven IP cores would take several years and millions of dollars).

- Increased presence in defense and instrumentation markets, supported by ChipX's ITAR certification and its R&D subsidiary in Haifa, Israel (facilitating the expansion of sales to the defense market).

- As a fabless high-volume silicon IC supplier, ChipX brings strong relationships with foundries and sub-contractors and increased purchasing power (which can boost operating margins and enhance supply chain accessibility).

- Continuing the roll-up of firms that have invested millions of dollars in developing sophisticated technology and products for a fraction of their investment, to support GigOptix's build up of technology and products.

With the acquisition, GigOptix gains high-volume silicon design expertise to complement its III-Vs, silicon-germanium and electro-optic (EO) polymer technologies. This will support its move into higher levels of integration of analog and mixed-signal system-on-chip products, e.g. clock & data recovery (CDR) ICs and serializer/de-serializers (SerDes). Similar to the acquisition of Helix, ChipX supports GigOptix's aim to expand into high-volume optically connected markets such as consumer electronics, data centers, and high-performance computing, as well as to cut the time and cost of developing products, customer relationships and vertical markets. The deal also delivers greater scale, with an existing revenue stream from complementary product sales.

"The combination of standard products and custom ASICs is an effective model in many successful semiconductor companies due to the ability to leverage the valuable customer channel and investment in IP across a larger number of products," says Nadir. "It makes sense to add new IP to the custom ASIC tool kit from the GigOptix product base," he adds. "ChipX has a healthy pipeline of new customer designs ongoing and expects to see growth in ASIC sales in 2010."

www.chipx.com/homepage.html

GigOptix diversifying to mitigate dependence on major telecom clients

For third-quarter 2009, GigOptix Inc of Palo Alto, CA, which designs modulator and laser drivers and transimpedance amplifier (TIA) ICs based on III-V materials as well as polymer electro-optic modulators, has reported revenue of \$3.1m, up 28% on \$2.5m a year ago but down 31% on \$4.5m last quarter.

Revenue was lower than expected as two large clients reduced their product order due to the economic environment. "The third quarter was our most financially challenging as a public company as two of our major telecom clients unexpectedly reduced their product orders," explains chairman & CEO Dr Avi Katz.

However, the new GX product line is experiencing strong market acceptance and helping to diversify the client base, making GigOptix less reliant on large accounts. Management says that, overall, it is encouraged by the new business development trends of its expanding product lines, as well as new clients, which should mitigate the risk of being so heavily dependent on any one client in the future.

"We are managing our risk profile by broadening our customer base in Asia and the US, both within the US government and through the expansion of our Fortune 500 customer base," says VP of marketing Julie Tipton.

Katz says that each product line saw significant achievements: the HX4 series of ultra-low-power multi-channel 10G drivers and receivers was demonstrated at data-center system customer locations (gaining traction, with multiple module active optical customer developments progressing well); the GX line launched the GX3 series (a range of TIA receivers co-developed by the Zurich and Palo Alto offices for 10, 40 and 100Gb/s networks); and the LX line introduced the LX8 series (the first polymer-

based modulators for 40Gb/s and 100Gb/s operation). GigOptix is continuing with its aim of establishing itself with a highly diverse and complete portfolio of electronic devices for optically connected applications with a fast-growing list of customers worldwide now moving to production with its products.

"The investment in new products was supported by our strong cash position as we continued with product development and market penetration activities in spite of the challenging quarter in order to ensure our future market position," says Katz.

Net loss has been cut from \$1.6m a year ago to \$1.2m. However, this is up from \$609,000 last quarter due to higher R&D expenses as the firm continues product development. On a non-GAAP basis, net loss has been cut from \$1.7m a year ago to \$609,000.

Though down on \$6.9m a year ago, cash reserves rose during the quarter, from \$2.1m to \$2.8m.

"In addition to our product launches, we continued to attract new opportunities to serve the US

The investment in new products was supported by our strong cash position as we continued with product development

Government and military with our technology, including moving one step further in securing a \$5m government funding to develop faster and more integrated polymer modulator technology and products," says Katz. Additionally, GigOptix expects to complete Phase II project milestones of an SBIR contract for the US Defense Advanced Research Projects Agency (DARPA), which could yield revenue of about \$750,000 by end-2009.

"New contracts and other meaningful product developments are not yet reflected in our financial results due to the continued economic pressures experienced in the semiconductor space," Katz comments. "We have also seen

We are at a critical inflection point as we transition to a much more broadly diversified company

extended design times from some customers as they push out projects to manage costs, resulting in a delay in revenues

from product launched at the beginning of this year," he adds.

"We are at a critical inflection point as we transition to a much more broadly diversified company, with many new products that are now qualified and will be sold to existing and new clients in 2010," Katz continues. "Analysts predict that the market segments addressed by GigOptix will grow robustly in 2010 after a tough 2009," he notes.

"We will still look to consolidate further all of the transactions we have made during the past couple of years," Katz says. Integration of ChipX (acquired in early November) should allow improved cost structure and efficiency, particularly via the consolidation of operations and management teams.

GigOptix believes that the current economic climate has created some unique opportunities to help GigOptix to continue growth via acquisitions of synergistic businesses and assets. "Finding superior M&A candidates and continuing to seek acceptance by major datacom customers to support our growth efforts, while progressing toward sustainable profitability, will be our main priorities," says Katz.

www.GigOptix.com

Infinera named America's 2nd fastest-growing tech firm

Infinera of Sunnyvale, CA, USA, a vertically integrated manufacturer of digital optical network systems incorporating its own indium phosphide-based photonic integrated circuits (PICs), has been placed second in the Technology Fast 500, which is accounting and consulting firm Deloitte LLP's ranking of the fastest-growing technology, media, telecoms, life sciences and clean technology firms in North America. Rankings are based on fiscal-year revenue growth during the five-year period from 2004 to 2008.

"Technology Fast 500 recognizes innovative companies that have broken down barriers to success and defied the odds with their remarkable five-year revenue growth," says Phil Asmundson, vice chairman & US Technology, Media and Telecommunications leader at Deloitte.

Infinera's DTN digital optical network system is a digital ROADM (reconfigurable optical add-drop multiplexer) for long-haul and metro core networks, combining high-capacity dense wavelength division multiplexing (DWDM) transport, integrated digital bandwidth management, and GMPLS-powered service intelligence in a single platform.

Infinera says that the DTN has achieved significant milestones showing worldwide acceptance as a highly reliable platform carrying voice, video, and data traffic for a broad range of telecom operators. The firm's PICs have now surpassed a cumulative total of 200 million hours of operation in live networks worldwide with no chip failures. Infinera says that this reliability rate for the PIC (with more than 50 devices) is equivalent to or better than the reliability of a single telecom-grade laser, evidence of the high reliability of the firm's photonic integration technology and indicating significant benefits to overall network reliability.

In Q3/2009, Infinera surpassed the \$1bn mark in cumulative revenue for its flagship product (the DTN), which it says signifies the commercial success of the industry's first optical networking platform based on large-scale PICs. The DTN has now been deployed on network routes spanning more than 500,000 fiber route-kilometers.

"When we introduced the digital paradigm to optical networks in 2004, it ran counter to the all-optical paradigm then prevailing, and still prevailing, among our

competitors," claims CEO Jagdeep Singh. "These gratifying indicators of our success show that our customers have recognized the value that PIC-based digital optical networks can bring to their networks and their businesses," he adds.

"We are working hard to bring this new paradigm to our forthcoming next-generation products and new segments of the optical networking market," Singh continues.

Infinera's current PICs integrate 60 optical elements including lasers, modulators, and other optical devices onto a pair of monolithic chips with a total capacity per chip of 100Gb/s. Its next-generation PICs will be designed to integrate more than 400 optical elements onto a pair of chips with a total capacity of 400Gb/s. The high level of integration enables its optical systems to deliver advantages in scalability, cost, space consumption, power consumption, and reliability, the firm claims. Infinera says that it achieved high PIC reliability through an early focus on design for manufacturability and carrier-grade reliability.

www.infinera.com

Infinera DTN earns Department of Defense JITC approval

Infinera's DTN has been approved for US Department of Defense (DoD) network deployments after passing extensive conformance and interoperability tests with the Defense Information Systems Agency's (DISA) Joint Interoperability Test Command (JITC). The JITC certification supports potential DTN deployments with the DoD and related agencies.

The DTN is the first DWDM system to be certified by JITC for carrying 40Gb/s services. Infinera says its Bandwidth Virtualization enables it to carry 40Gb/s services over any optical infrastructure capable of transporting 10Gb/s services.

The system was tested and certified as a 'DISN Terrestrial Transport' device in accordance with JITC's Unified Capabilities Requirements (UCR) 2008 and has now achieved Unified Capabilities (UC) Approved Products List (APL) status.

JITC testing provides a thorough assessment of a product's ability to provide security, protocol compliance, stability, scalability, interoperability, and management for potential DoD network configurations. The DTN was installed and tested in the JITC Advanced Technologies Testbed at Indian Head, MD. The tests replicated potential DoD network configurations, and

confirmed the DTN's capability to interoperate within various configurations and protect sensitive information.

Infinera's certifications also include approval by the US Army Test Integration Center (TIC) at Ft. Huachuca, AZ, as well as the US Department of Agriculture's Rural Development Program for deployment by telecom companies using USDA Rural Utilities Service (RUS) funding to build networks. The DTN has been deployed in public sector networks including the New Mexico state network, and the Internet2 backbone network (the world's largest research network).

Oplink's recovery continues from March-quarter low

For its fiscal first-quarter 2010 (to end-September 2009), photonic component, module and subsystem maker Oplink Communications Inc of Fremont, CA, USA has reported revenue of \$33.6m. This is down 22% on \$43m a year ago but up 4% on \$32.4m last quarter (following 5% growth that quarter, as recovery continues from the March-quarter low of \$30.8m).

Gross margin doubled from 14.4% a year ago to 28.6% last quarter, and now gross margin has risen again slightly to 29.3% (after expecting it to be level on last quarter).

Compared to a net loss of \$3.4m a year ago, the return to profit last quarter with net income of \$249,000 was followed by net income rising more than forecast, to \$1.8m.

During the quarter, Oplink generated \$9.1m in cash from operations (up from \$1.4m last quarter and \$4.3m a year ago), helping to boost cash, cash equivalents and short-term investments from \$166m to \$178.7m.

We are winning more advanced OMS business, in part based on our component expertise

"We are winning more advanced OMS [optical manufacturing solutions] business, in part based on our component expertise," says president & CEO Joe Liu. "Oplink has become one of the leading providers of advanced photonic sub-systems product engineering and manufacturing solutions for global long-haul, metro-core and edge equipment companies," he claims. "Our reputation for executing customer needs positions us to benefit as telecom spending resumes."

For its fiscal second-quarter 2010 (to end-December 2009), Oplink expects revenue of \$31–35m.

www.oplink.com

Avago adds short- and long-range 10/1Gbps dual-rate SFP+ transceivers for 10 Gigabit Ethernet

Avago Technologies of San Jose, CA, USA has expanded its family of SFP+ optical transceiver modules for next-generation 10 Gigabit Ethernet (GbE) equipment designs. The new additions to the series include the 10/1Gbps dual-rate AFCT-701SDDZ 10GBASE-Long Range (LR) single-mode and AFBR-703SDDZ 10GBASE-Short Range (SR) multi-mode fiber transceivers for enterprise and data center applications. Dual-rate operation allows flexibility in data rate control through hardware or software control.

Both transceivers are halogen-free and in compliance with the International Electrochemical Commission (IEC) 61249-2-21 specifications aimed at protecting the environment. They are also compliant with the halogen-free specifications defined by industry organizations such as JPCA, IPC, iNEMI. Avago claims to be one of the first optical transceiver vendors to announce the shift to delivering halogen-free transceiver products.

The AFCT-701SDDZ is for operation in single-mode fiber link applications at distances of up to 10km. It complies with the optical interface specification per IEEE 802.3ae 10GBASE-LR standards and with the transmitter extinction ratio and receiver sensitivity specifications at 1.25Gbps per 1000BASE-LX. The transceiver incorporates Avago's 1310nm distributed feedback (DFB) laser and PIN detector technology. Moreover, the AFCT-701SDDZ is an addition to the 10Gbps AFCT-701SDZ (launched at ECOC 2008), which operates at case temperatures in the commercial range 0–70°C while maintaining maximum power dissipation of less than 1W.

The AFBR-703SDDZ is for operation in OM3 multi-mode fiber link applications at distances of up to 300m. It incorporates Avago's 850nm vertical-cavity surface-emitting laser (VCSEL) and PIN detector technology to provide an IEEE 10 Gigabit Ethernet design that is compliant

with the 10GBASE-SR standard, and with the transmitter extinction ratio and receiver sensitivity specifications at 1.25Gbps per 1000BASE-SX. The transceiver is an addition to the 10Gbps AFBR-703SDZ (launched at March's OFC 2009) and is designed to operate at case temperatures of 0–70°C to enable 10 GbE equipment designs with high port density.

Avago's 10 Gigabit Ethernet SFP+ transceiver series includes products for 10GBASE-SR, -LR, and -LRM IEEE-compliant optical performance. The transceivers also comply with the electrical interface specifications from SFF-8431 for enhanced 10Gbps SFP+, as well as the SFF-8472 specification for DMI in optical transceivers. All of Avago's 10Gbps SFP+ transceiver products are RoHS 6 compliant.

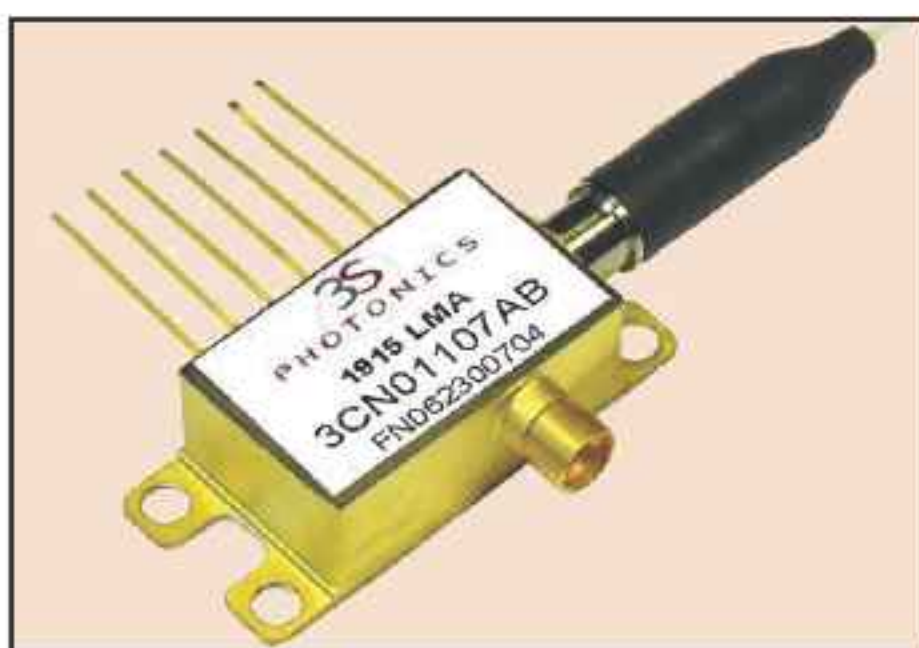
Prices for the AFCT-701SDDZ and AFBR-703SDDZ 10/1Gb SFP+ optical transceivers are \$380 and \$250, respectively, in minimum quantities of 10.

www.avagotech.com

3S Photonics' directly modulated analog laser transmits at 19Gb/s over 25km of single-mode fiber

3S Photonics of Nozay, France says that a prototype of its 1915 LMA Series of directly modulated 1550nm high-bandwidth analog laser modules — launched at the 35th European Conference and Exhibition on Optical Communication (ECOC 2009) in Vienna, Austria (21–23 September) — has been successfully tested at 19Gb/s over 25km of single-mode fiber (SMF) without any chromatic dispersion compensation, and using the OFDM (orthogonal frequency division multiplexing) modulation format.

The prototype, presenting a 7GHz bandwidth and a +7dBm output power, was tested by Orange Labs in Lannion, France within the telecom project EPOD — Enhanced PON (passive optical networks) using OFDM — which is sponsored by France's National Research Agency (ANR) and is planned to last 24 months (after beginning in



3S Photonics' new 1915 LMA directly modulated 1550nm high-bandwidth analog laser module.

early February 2009). EPOD is led by Orange Labs (the R&D division of the French telecom provider) and, as well as 3S, also embraces academic partners including LISIF (Laboratories of Electronics and Electromagnetism – L2E of the Paris region) and a research team from XLIM (a research institute held jointly between the University of Limoges and CNRS).

3S says that a fully satisfactory 19Gbit/s transmission over a 25km single-mode optical fiber link was experimentally demonstrated using the discrete multi-tone (DMT) modulation format, which is already widely deployed for xDSL-type copper lines (digital subscriber line). The DMT signal contains 255 sub-carriers spread over 5GHz. Transmission was achieved without any chromatic dispersion compensation and with a 8.5GHz-bandwidth APD-based receiver module.

3S says that the promising experimental results reinforce the credibility of using OFDM modulation applied on a directly modulated analog laser module to design the next-generation of low-cost broadband optical access networks.

Additional tests are underway to demonstrate the 1915 LMA analog laser module's transmission capability at 40Gb/s.

3S maintains positive cash flow despite 10% annual revenue drop

For its fiscal year 2008/2009 (ended June 2009), 3S Photonics of Nozay, France, which manufactures laser chips, optical discrete modules and passive components for telecom networks, has reported revenue of €23.04m.

Despite the challenging worldwide economic and financial environment, this is down just 10% on fiscal 2008, compared to declines of about 30% for the firm's main competitors, it is claimed.

Operating expenses were lower, in line with turnover. "Great efforts have been made to reduce our operating expenditure," says chairman, president & CEO Alexandre Krivine. "At the end of the first quarter of our fiscal year 2010, our expenses are fully in line with our budget," he adds.

Net income and cash flow has remained positive in 2009, without

taking into account the funds raised in July from three investment funds (Fonds Stratégique d'Investissement, Alto Invest and Midi Capital), which are being devoted mainly to supporting the firm's acquisition strategy. Equity capital has risen from €12m to €20m.

"Despite adverse economic conditions, we are pleased to sustain a healthy financial position with positive operating profit and a stable debt [which has been reduced in 2009]," says Krivine.

3S was deep in debt when, in April 2007, Alexandre Krivine and Didier Sauvage acquired what was Avanex France SA from optical communications component and module maker Avanex Corp of Fremont, CA, USA (which in 2003 had acquired what was then Alcatel Optronics). In two years, 3S recovered its financial stability

by leveraging its existing product portfolio as well as diversifying to new segments of the telecoms market such as pump modules for terrestrial applications or transmission lasers for FTTH (fiber-to-the-home) and PON (passive optical networks).

3S Photonics says that it is resilient to the current economic situation due to its positioning in niche markets with strong added value or growth markets such as wavelength division multiplexing (WDM), long-term projects, and R&D activities partly financed by industrial partners.

In addition to demand provided by the market, 3S Photonics says that growth over the next few years will depend on merger & acquisition activities, facilitated by the funding from the firm's new shareholders.

www.3Sphotonics.com

Oclaro's first quarter since merger sees underlying operating profit

For its fiscal first-quarter 2010 (ended 26 September 2009), optical component, module and subsystem maker Oclaro Inc of San Jose, CA, USA has reported revenue of \$85.1m. This is up 27% on \$66.9m last quarter (excluding \$5.1m from the New Focus business, which was transferred to Newport Corp on 4 July in exchange for their Spectra-Physics laser diode business plus \$3m in cash).

Non-GAAP gross margin rose more than expected to 26.2%, up from 25.4% last quarter (or just 21%, including Avanex's results for the entire quarter rather than only two months). Oclaro was formed on 27 April through a merger that combined the optical component expertise of San Jose-based Bookham Inc with the module and subsystem expertise of Avanex Corp of Fremont, CA.

Net loss has been cut from \$14.6m last quarter to just \$0.5m (though this is still down on a profit of \$2.2m a year ago). Also, says president & CEO Alain Couder, "in the first full quarter after our merger with Avanex we have generated positive non-GAAP operating profit [\$1.3m, compared to a loss of \$2m last quarter and \$0.8m a year ago]... This was driven by increasing revenues and improving our gross margins." In addition, adjusted earnings before interest, taxes, depreciation and amortization (EBITDA) rose from \$0.7m last quarter to \$3.8m.

As a result, Oclaro was cash-flow positive in the September quarter. Nevertheless, including \$6.5m of net deal-related expenditures, cash, cash equivalents, restricted cash and short-term investments fell from \$58m to \$52.5m.

"We are moving beyond the integration phase of Oclaro, and we still have more synergies to come," says Couder. "While visibility still remains fairly short term, our pipeline suggests the extent of our December revenue growth opportunities may be supply constrained, which is reflected in our guidance range."

For its fiscal second-quarter 2010 (ending 2 January), Oclaro expects revenue of \$87–92m (up 5%). Non-GAAP gross margin should be 25–28%, and adjusted EBITDA \$3–7m. "By delivering on this guidance we believe we have a reasonable chance of generating cash in the December quarter," says Couder. ● On 30 September, Oclaro regained compliance with NASDAQ listing rule 5450(a)(1) after the closing price of its common stock exceeded \$1 for 10 consecutive business days.

www.oclaro.com

Oclaro launches VCSEL for Intel Light Peak interconnects in computing and consumer electronics applications

Oclaro has launched a vertical-cavity surface-emitting laser (VCSEL) for the fast-developing Intel Light Peak market, which leverages optical technology to connect electronic devices such as peripherals, workstations, displays, disk drives, and docking stations. Intel's Light Peak technology is bringing optical technology to the mainstream, and offers Oclaro the opportunity to further expand the applicability of its products into new markets such as computing and consumer electronics devices.

Optical technology promises to overcome the practical limitations on speed and length being approached by existing electrical cable technology in mainstream computing devices. Intel's Light Peak platform is designed to deliver high bandwidth, starting at

10Gb/s (enabling a full-length Blu-Ray movie to be transmitted in less than 30 seconds). The technology has the potential to scale to 100Gb/s over the next decade.

"A core part of Oclaro's strategy is to expand into adjacent markets where we can leverage our optical technology and solutions to deliver value for customers," says Yves Le Maitre, executive VP & division manager of Oclaro's Advanced Photonics Solutions division.

"Oclaro has already ramped very high-volume production of similar VCSEL lasers in another consumer application and, as a result, has the technology and manufacturing scale necessary to effectively serve the Light Peak market," he adds.

Light Peak consists of a controller chip (from Intel) plus an optical module (containing lasers and

photo-detectors) for inclusion in platforms supporting the technology.

Intel's Light Peak transport technology uses fiber optics instead of copper wires and supports protocols such as USB, HDMI, DisplayPort, PCIe and others. It is designed from the ground up to be inexpensive and small, and supports a wide range of devices (such as handhelds, laptops, PCs and consumer electronics). "Light Peak has high bandwidth and the ability to run multiple I/O protocols over a single cable, enabling the technology to connect to many devices such as displays, disk drives, peripherals and docking stations," says Jason Ziller, director of Intel's Optical I/O Program Office.

Intel is working with Oclaro to make Light Peak optical components ready to ship in 2010, he adds.

Rebound in demand returns JDSU to underlying profit

For its fiscal first-quarter 2010 (ended 3 October 2009), JDSU of Milpitas, CA, USA has reported revenue of \$297.8m. This is down 21% from \$377.2m a year ago but up 9% on \$273.1m last quarter and at the high end of the guidance (given in August) of \$283–300m. The Americas represented 51% of revenue, Europe 27% and Asia-Pacific 22%, with growth in all three regions.

“Results represent growth across all of our business segments, providing clear evidence of improving demand,” says president & CEO Tom Waechter.

Advanced Optical Technologies revenue was \$54.1m (18% of total revenue), up 6.5% on last quarter and up 1.1% on a year ago. Communications Test & Measurement revenue was \$143.4m (48% of total revenue), down 11.4% on a year ago but up 8.1% on last quarter (the second consecutive quarter of growth), although this was mainly due to \$7.5m from the Storage Network Tools (SNT) business acquired in July.

Communications and Commercial Optical Products (CCOP) revenue was \$101.1m (34% of total revenue), down 38% on \$162m a year ago but up 12% on last quarter’s \$90.7m. Of this, Commercial Lasers revenue was \$15.1m, down 30% on a year ago but up 32.4% on last quarter. Optical Communications revenue was \$86m (64% from transport; 36% from transmission, boosted by datacom products). This is down 38.8% on \$140.6m a year ago but up 8.6% on last quarter’s \$79.2m (as eight out of 11 product lines grew sequentially, particularly transmission products such as pluggable transceivers, tunables, and modulators). However, revenue for reconfigurable optical add-drop multiplexer (ROADMs) continued to fall (to less than 20% of optical communications revenue), as a major customer continued to burn off excess inventory.

“The leverage in our operating model and balance sheet will become increasingly evident as our top line grows,” says Waechter.

Non-GAAP gross margin has risen from 42.2% last quarter to 44%. This is due to continued benefits from lean initiatives and the transition to a variable-cost manufacturing model in the CommTest and CCOP segments (e.g. the transfer of JDSU’s optical communications assembly & test plant in Shenzhen, China to the contract manufacturer Sanmina-SCI Corp in April).

In particular, optical communications gross margin was 19.7%, up on last quarter’s 17%. This is due mainly to the favorable product mix (led by the pluggables, tunables and amplifier product lines), as well as April’s closure of the ex-Picolight fab in Louisville, CO (and consolidation of its GaAs chip manufacturing under one roof in JDSU’s GaAs and InP fab in San Jose, CA), plus closure of the firm’s submarine product assembly plant in San Jose (by transferring its operations to Shenzhen).

Operating expenses have hence been cut by about \$20m from a year ago. Including about 100 new staff from the SNT acquisition, headcount is 3982 (cut from 6714 before April’s consolidation). Operating loss for CCOP in particular has been cut from \$7.8m last quarter to \$1.5m. Overall operating loss has risen from \$16.2m to \$27.5m.

On a non-GAAP basis, overall operating margin was 3%, down on 6% a year ago but an improvement on last quarter’s operating loss of 1%.

Non-GAAP net income was \$9m, still down on net income of \$23.9m a year ago but an improvement on net loss of \$1.6m last quarter. Free cash flow was \$11.2m.

Fiscal Q1 was the first time in the last five quarters that JDSU’s book-to-bill ratio for optical communications was more than one. In particular, the firm believes that the decline in its ROADM revenue has bottomed, as orders rose more than 30% on last quarter (with shipments expected to start in the December quarter).

Also, in September JDSU’s tunable XFP product (the first tunable available in an XFP form factor, it is claimed) was released for production. To date, the firm has engaged with 20 customers, up on 12 last quarter. In addition, the unique architecture of JDSU’s new Super Transport Blade provides substantial footprint savings, it is claimed, and is hence generating traction with network equipment manufacturer (NEM) customers (with significant orders already received from one customer — for production volumes in the December quarter — while JDSU is also working with most remaining customers). Total revenue from products less than two years old rose to about 30% in fiscal Q1, but JDSU aims to boost this to more than 50% over the next three years.

For fiscal Q2/2010 (to 2 January), JDSU expects rises in revenue to \$320–345m and in non-GAAP operating margin to 5–8%. The full benefit of closing the San Jose plant won’t be realized until the March quarter, says chief financial officer Dave Vellequette. The near-term optical communications goal is for sustainable gross margin of 25–30%. “We can operate in this range by the end of fiscal 2010,” he believes. The recovery in ROADMs should boost gross margin, and JDSU is now beta sampling next-generation 50GHz ROADMs for qualification at eight customers, with production volumes in fiscal Q3 expected to boost ROADM market share.

JDSU believes quarterly revenue of \$150m for CCOP and \$375–385m overall would yield operating margin of 10–15% and gross margin of 46%.

www.jdsu.com

Fiscal Q1 was the first time in the last five quarters that JDSU’s book-to-bill ratio for optical communications was more than one

Opnext's revenues depressed by 40G slowdown in US

For its fiscal second-quarter 2010 (ended 30 September 2009), Opnext has reported revenue of \$81m, at the low end of August's forecast of \$80–90m. Despite including \$24.3m from the former StrataLight Communications Inc (acquired on 9 January), this is up only 1% on \$80.2m a year ago and down 5% on \$85.3m last quarter.

For 10Gb/s and below products, revenue has fallen 26.2% from \$67.6m a year ago to \$49.9m (down in most major product categories except XFP and SFP+ modules). However, it has rebounded by 4% from \$48m last quarter. An 8% rise in 10Gb/s revenue (mainly from higher sales of XFP and SFP+ products as sales continue to recover from a March-quarter low) was partially offset by reduced revenue from less than 10Gb/s SFP products (as Opnext continued to be selective in this highly price sensitive market).

Revenue from 40Gb/s products is up fourfold from \$7m a year ago to \$28m, but mainly due to StrataLight. Compared to last quarter, 40Gb/s has fallen by a more-than-expected 20.1% (from \$35m) due to customers' inventory reductions and deferred spending. Although down 44.6% from \$5.6m a year ago, revenue from industrial & commercial products rebounded by 34.8% from \$2.3m last quarter to \$3.1m.

Opnext signed advanced technology development contracts with several customers worth \$7m. During the quarter, \$2m was received but this revenue has been deferred pending the achievement of milestones leading to delivery of final products.

"We were pleased with the growth in our 10G product sales," says CEO Gilles Bouchard. "However, we experienced a slowdown in the 40G US backbone market segment due to customer inventory builds and cautious spending tied to the global economic uncertainty. The 40G market is going through the same adjustments and gyrations that the 10G market went through a couple of quarters ago."

Continued progress in cutting costs (including shedding about 10% of its staff by year-end, announced in April) contributed to improved gross margin. Though down on 30.6% a year ago, non-GAAP gross margin rose from 23.2% last quarter to 24.2%, due mainly to the higher 10Gb/s and industrial & commercial sales, and lower material and outsourcing costs (more than offsetting the impact of lower average selling prices and lower 40G sales).

Compared to a net profit of \$3m a year ago, non-GAAP net loss was \$9.2m, level with last quarter despite the lower revenue and unfavorable dollar-to-Yen exchange rates.

During the quarter, cash and cash equivalents fell from \$165.3m to \$155m, reflecting \$1.1m of CapEx, \$2.7m of capital lease payments, \$7.7m of cash used in operations, and a \$1.2m benefit from foreign currency exchange fluctuations.

"Looking forward to the December quarter, we expect to see bifurcation in our markets, with continuing growth in 10G, while our 40G business will remain affected by customer inventory adjustments," says Bouchard.

In response to slowing 40G sales and challenging yen exchange rates, Opnext took further initiatives in the second week of October to cut annual operating expenditure by \$3.5m. "We expect our streamlined cost structure to provide operating leverage as demand recovers and growth resumes," says Bouchard.

While business has stabilized at lower levels, the potential market continues to recover. After growing almost 10% in the October quarter, 10G telecom product sales are pushing pre-downturn levels on the strength of SFP modules, while 10G datacom products continue to rebound (after growing more than 10%), Bouchard says. "This portion of our business decreased more

dramatically during the downturn and has more upside potential." Opnext also expects industrial & commercial revenue to continue to recover after having bottomed in the June quarter.

But, while recent customer engagements have been positive and suggest an improving tone (with continuing growth in 10G), Bouchard expects 40G business to continue to be challenging, leading to a further drop in revenue in fiscal Q3/2010 (to end-December 2009) to \$75–80m.

Despite benefits from the higher volume of 10G and industrial communications products as well as continued efforts on cost reduction, chief financial officer Robert Nobile expects margins to also decline.

Nevertheless, Nobile expects 40G sales will bottom before starting to recover in Q4. In particular, in the October quarter, of nine new qualifications, six were 40G design wins. "We are present in just about every design win in 40G," claims Bouchard.

At ECOC 2009 in Vienna, Austria in September, Opnext launched its 40Gb/s DQPSK modules for DWDM transmission as well as its compact VSR module for high-density 40Gb/s platforms. It also demonstrated its CFP MSA-compliant module for 100GBASE-LR4 (100GbE), which was debuted at March's OFC/NFOEC 2009 in San Diego. Bouchard says DQPSK is in qualification stages at most customers, with final design wins due in the next few quarters.

Investment in next-generation products and technology (especially 100G and 40G transport) will capture market share in the future, Bouchard believes. While Opnext has reduced all other expenditure, R&D spending was up \$7.5m on a year ago to \$18.7m in the October quarter and should be at the high end of the \$16–18m range in the December quarter. Opnext could be profitable today if it was spending as little on R&D as its competitors, but the firm made the conscious decision not to do this, he comments.

www.opnext.com

40G sales will bottom before starting to recover in [fiscal] Q4

Sharp hits 35.8% efficiency for triple-junction solar cell

Japan's Sharp Corp is claiming an efficiency record with its report of a triple-junction compound semiconductor device that boasts a 35.8% efficiency in tests performed in September by Japan's National Institute of Advanced Industrial Science and Technology (AIST) on a 1cm² cell (Figure 1).

The device structure consists of an indium gallium arsenide (InGaAs) bottom layer, a GaAs middle layer and an indium gallium phosphide (InGaP) top layer (Figure 2). This differs from the usual range of triple-junction devices, mainly in having InGaAs rather than germanium for the bottom layer.

Although germanium is easier to manufacture and can generate a large amount of current, much of the power is wasted. InGaAs has high light-utilization efficiency, but is much more difficult to produce with the high level of crystallinity that is needed.

Sharp says that it has developed a 'proprietary' technology to produce much better InGaAs layers, increasing the resulting triple-junction cell from the company's previous effort of 31.5% to 35.8% in the latest announcement.

This record for monolithic, unconcentrated cells should be distinguished from other recent record announcements for triple-junction cells using concentrator systems. The latter class includes Boeing's Spectrolab Inc with 41.6% (August 2009), Fraunhofer-Institut für Solare Energiesysteme (ISE) with 41.1% (January 2009), and the US Department of Energy's National Renewable Energy Laboratory (NREL) with 40.8% (August 2008). The Fraunhofer ISE efficiency was achieved at a light intensity of 454 suns over a 5mm² area; NREL's with the equivalent of 326 suns.

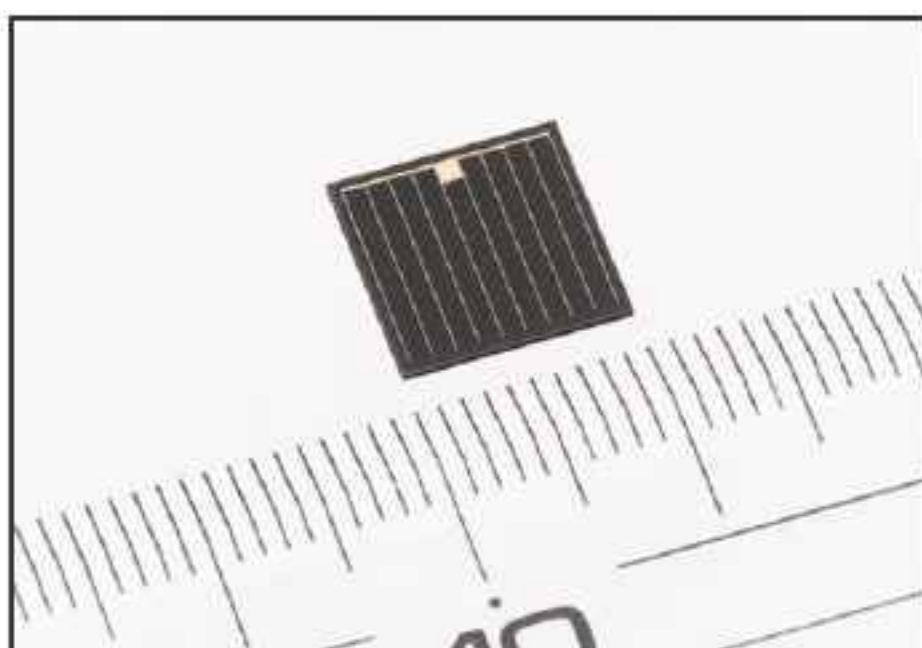


Figure 1. Sharp's triple-junction solar cell.

The US Defense Advanced Research Projects Agency (DARPA) project, led by the University of Delaware, also claimed a record with 42.8% (July 2007). However, this result has not been

This record for monolithic, unconcentrated cells should be distinguished from other recent record announcements for triple-junction cells using concentrator systems. The latter includes Spectrolab Inc with 41.6%

accepted by NREL, which claims that it is one of only three labs in the world that can validate cell efficiencies. The other labs are based in Germany and Japan. In fact, these other labs are Fraunhofer ISE and AIST.

The DARPA device was tested with "sunlight at standard terrestrial conditions" but, on reading the small print, one finds that it is also a concentrating system and, further, it is non-monolithic, splitting the solar light into three different energy bins (high, medium and low) and directing them onto cells of various light-sensitive materials to cover the solar spectrum.

A more recent announcement (September 2009) says: "DARPA recently began the second two-year phase of a four-year program with the VHESC Consortium to raise the system power efficiency of a new class of solar modules to 40% and deliver manufacturable engineering prototype modules."

<http://sharp-world.com>

The author Mike Cooke is a freelance technology journalist who has worked in the semiconductor and advanced technology sectors since 1997.

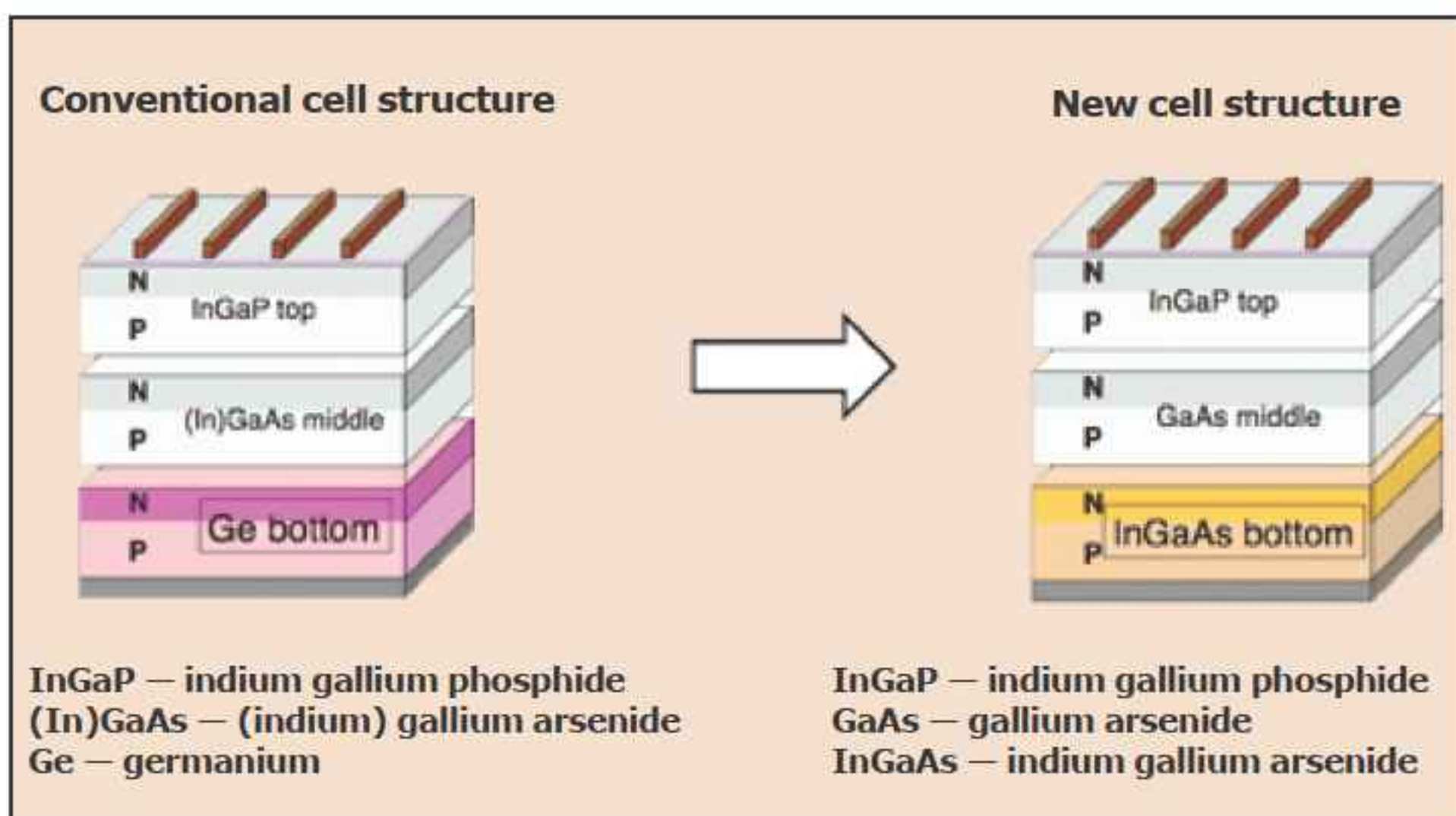


Figure 2. Schematic of Sharp's device structure (right) compared with traditional set-up (left).

Emcore wins Dutch Space PV contract for NASA's Cygnus resupply spacecraft

Emcore Corp of Albuquerque, NM, USA, which manufactures components and subsystems for the broadband, fiber-optic, and solar power markets, has won a contract from Dutch Space of Leiden, The Netherlands to manufacture, test, and deliver the solar panels to power the Cygnus spacecraft being developed by Orbital Sciences Corp for NASA's Commercial Resupply Service (CRS) project. With all options exercised, the total value of the contract would be in excess of \$15m.

Under the CRS project, Orbital will carry out eight pressurized space cargo missions from early 2011 through 2015 to provide a US-produced and operated automated cargo delivery service to the International Space Station (ISS). An initial demonstration flight will be part of NASA's Commercial Orbital Transportation Services (COTS) project, which provided NASA incentives to the developing commercial launch services industry.

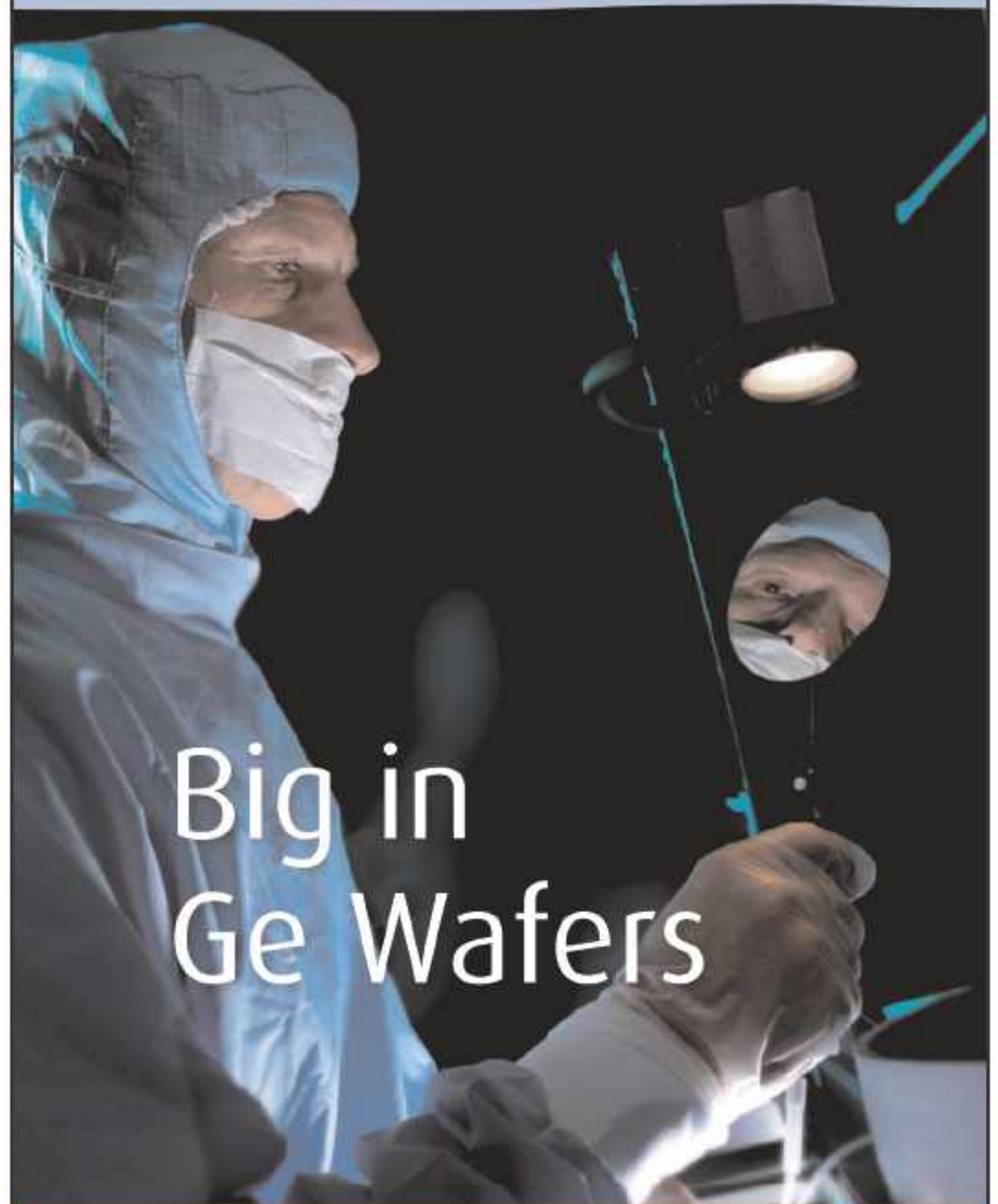
The solar panels for Dutch Space will use Emcore's ZTJ solar cells which, with a conversion efficiency of 30%, are claimed to be the highest-performance space-qualified multi-junction solar cell available.

"From our joint experience on NASA's Dawn interplanetary project, which included Orbital as the prime contractor, we know that collaborating with Emcore results in first-class technology tailored to specific needs," says Dutch Space's CEO Bart Reijnen. "Their contribution to the solar arrays for the Cygnus spacecrafts will provide the highest available efficiency, optimized for the mission."

"This is a reformation of the team that successfully collaborated on NASA's DAWN mission, which is currently powering the spacecraft on its voyage to the Asteroid Belt," says Emcore's CEO Christopher Larocca. The latest award paves the way for more future partnerships with Dutch Space, he reckons.

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CPV system maker OPEL Solar awarded \$179,000 by US Treasury under American Recovery & Reinvestment Act

OPEL Solar Inc, a subsidiary of OPEL International Inc of Shelton, CT, USA and Toronto, Canada, which makes high-concentration photovoltaic (HCPV) panels, has been awarded \$179,000 as part of the US Department of Energy (DoE) and Treasury Department program, under the American Recovery & Reinvestment Act (ARRA), which aims to provide up to \$3bn in direct payments to companies that create and place in service renewable energy facilities.

The award is in recognition of the development and installation of one of Connecticut's first rooftop tracking solar power systems, completed by OPEL Solar in March. The patent-pending Sequoia solar tracker system (inspired by the roots of the Sequoia tree) is a

non-penetrating roof design that allows simple installation and easy disassembly for necessary maintenance, says OPEL Solar. The installation generates 131kW of power, supplying up to 20% of the electricity needs of the Linden Elementary School in Plainville, CT. OPEL Solar has also been awarded a grant by the Connecticut Clean Energy Fund (CCEF) for the installation.

"The direct payment by the US Treasury Department broadens OPEL Solar's ability to fund new solar projects that will create new jobs and will make inroads for clean solar energy," says OPEL Solar's chief financial officer Mike McCoy.

www.opelinc.com
www.ctcleanenergy.com

● John Rieger has joined OPEL Solar in the new role of director of regional sales, responsible for business development and sales in the USA and Canada.

Based in Massachusetts, Rieger is handling dealer network expansion and project sales. Frank Middleton, VP marketing, reckons that, by having him cover the eastern regions of the USA and Canada, OPEL Solar can boost responsiveness to customers and capitalize on the rapid growth of business in the Eastern US spurred by Department of Energy grants to states and other solar incentive programs.

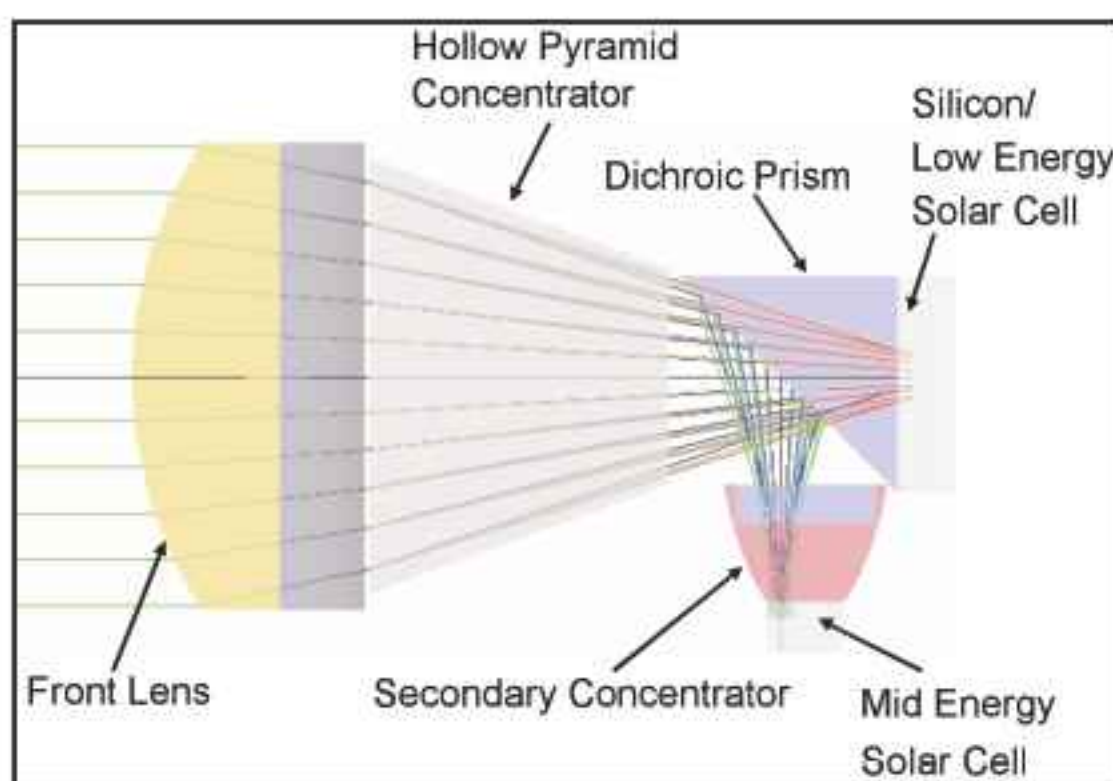
"The expansion of our solar sales force in the US is in response to an increase in solar quoting activity," says OPEL International's CEO Robert Pico.

VHESC awards Energy Focus extra \$100,000 to develop spectrum-splitting solar module

Energy Focus Inc of Solon, OH, USA, which provides LED lighting and fiber-optic products, has entered into a \$100,000, 12-month contract with the DuPont-University of Delaware Very High Efficiency Solar Cell (VHESC) consortium as part of solar research funded by the US Defense Advanced Research Projects Agency (DARPA) to enable low-cost photovoltaics. This follows an initial \$3.1m, two-year contract announced just on 24 September (see October issue, page 50).

"The added effort will be directed toward utilizing our photovoltaic coating technologies to achieve low-cost efficient 'spectrum splitting,'" says Energy Focus' chief technology officer Roger Buelow.

"This brings this phase of our solar program funding to \$3.2m," says CEO Joe Kaveski. "We are pleased with both DARPA's and the VHESC consortium's confidence in us to deliver," he adds. "We are proud to



Solar module using the VHESC optical spectrum-splitting approach.

be part of the team that we believe will make efficient, affordable solar panels a reality for the military and for all Americans."

DARPA recently began the second two-year phase of a four-year program with the VHESC consortium to raise the system power efficiency of a new class of solar modules to 40% and to deliver manufacturable engineering

prototype modules.

The modules under development by the VHESC team use an optical spectrum splitting system that directs light from the sun into different paths corresponding to the color of the light, and concentrates the light onto photovoltaic cells that cover different segments of the solar spectrum. The technology could boost rooftop power three-fold over silicon, it is said.

DARPA is developing the VHESC solar module technology for compact renewable energy to power both permanent and mobile bases, as well as to reduce the considerable logistical burden of supplying energy (e.g. batteries and fuel) to the US military in the field.

www.energyfocusinc.com
www.darpa.mil/STO/smallunitops/vhesc.html



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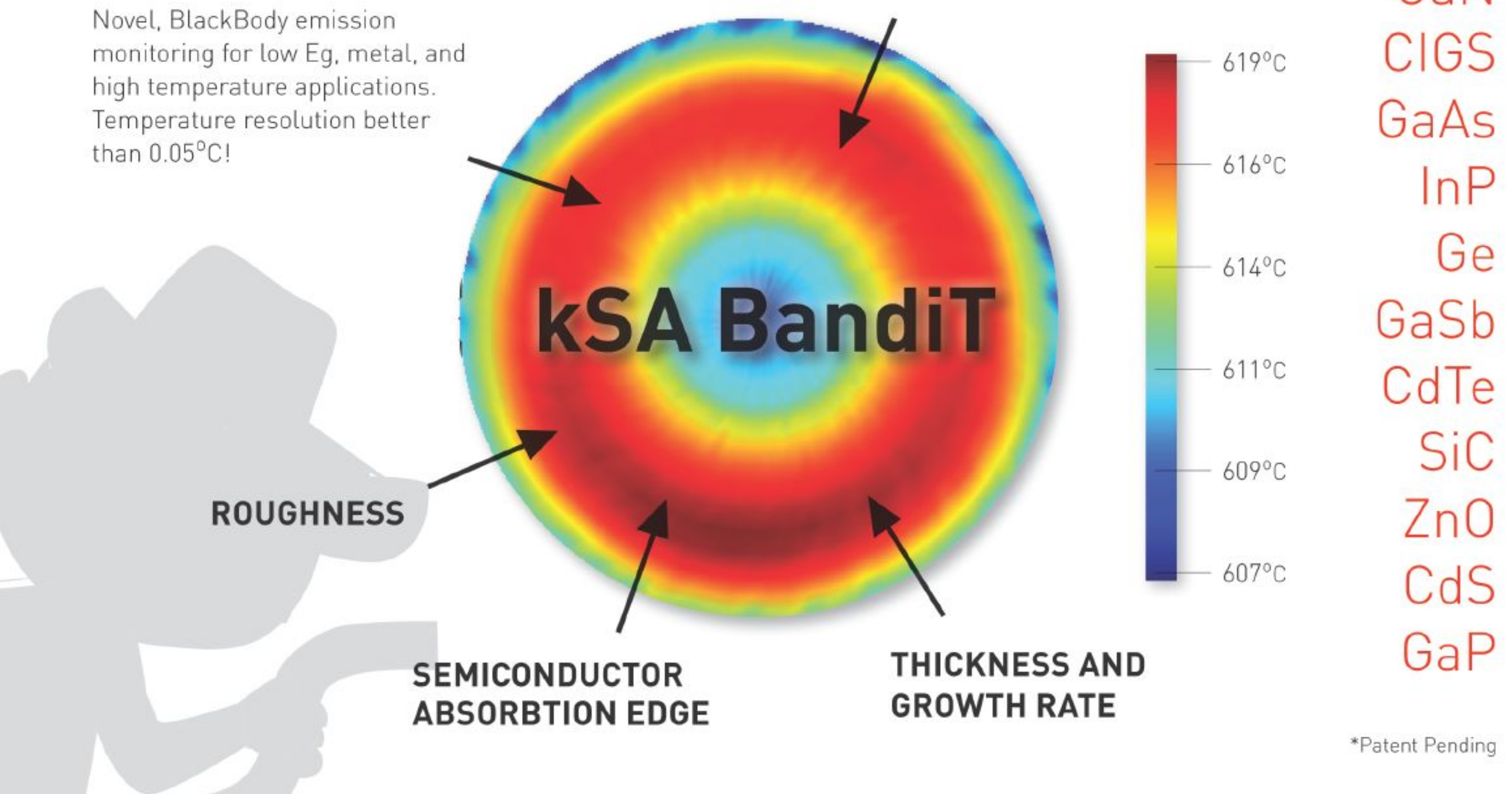
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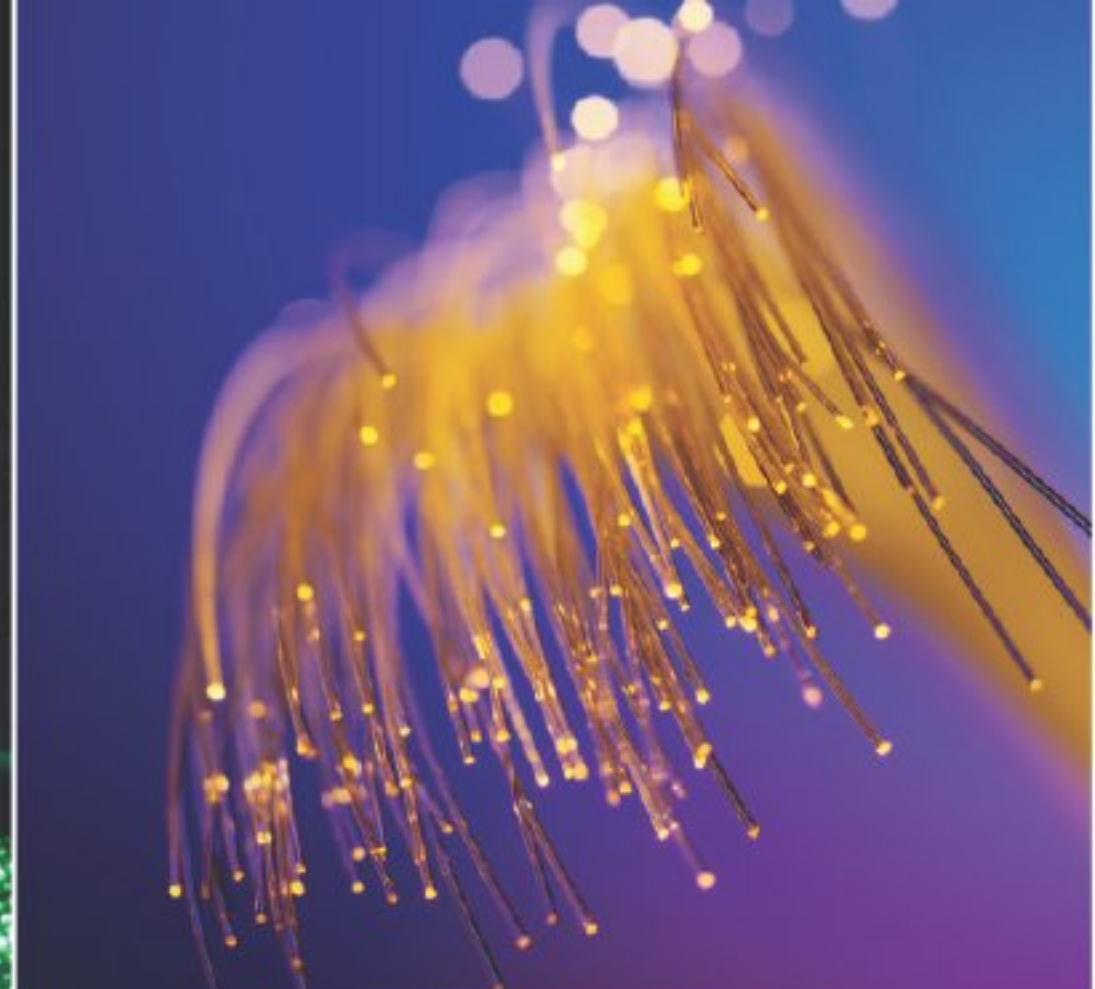
Single port designs for Aixtron, Veeco, Taiyo Nissan

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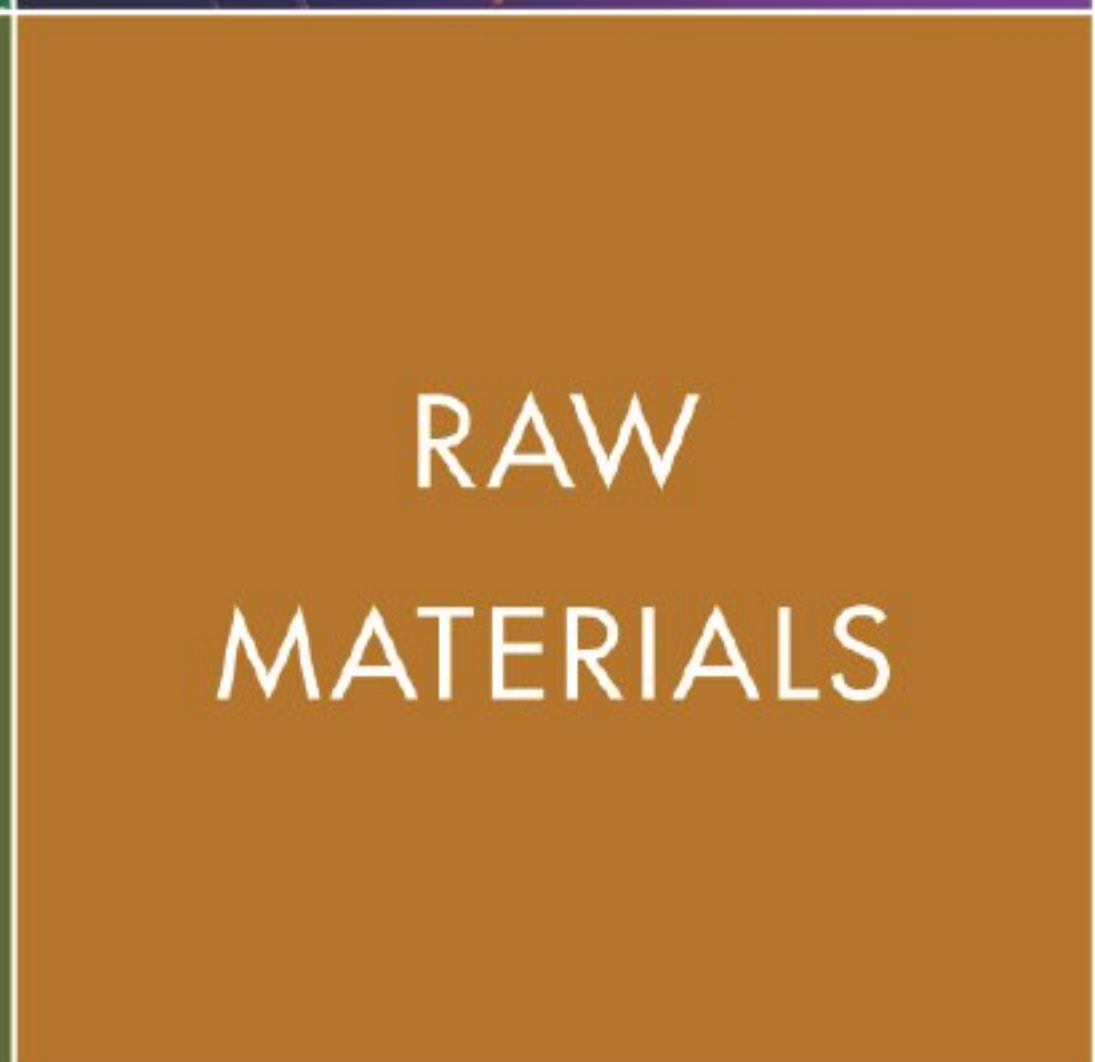
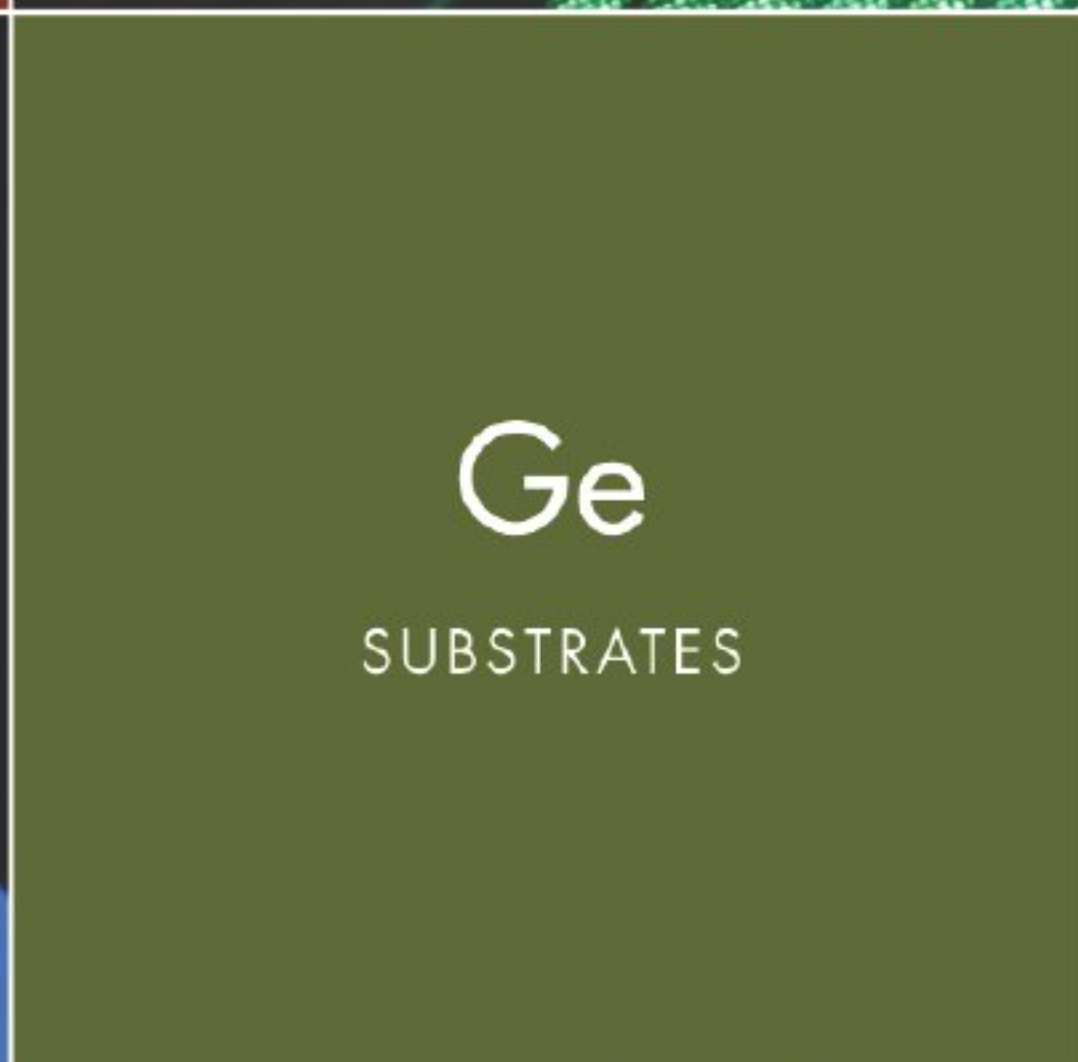
Fiber optic integration for difficult deposition chamber geometries



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IN BRIEF

Abound's modules get UL certification

Underwriters Laboratories has certified the AB1 series modules of Abound Solar of Loveland, CO, USA (formerly AVA Solar). Abound is the second CdTe PV panel maker to pass the UL 1703 Third Edition standard.

Based on 15 years of research at Colorado State University (supported by the National Renewable Energy Laboratory), AVA was founded in early 2007. An initial 3MW pilot line in Fort Collins, CO was joined this April by a commercial-scale plant in Longmont, CO (with annual capacity of 65MW, and 200MW ultimately).

UL certification requires electrical and mechanical testing of the modules (under the UL Witness program) over several months at both Abound's internal compliance lab and UL's PV Lab in San Jose, CA. The modules were exposed to accelerated stress testing under various climate conditions, mechanical impact tests, wind and snow load, fire test, rain, and arcing. Certification also included on-site inspection of Abound's Longmont plant.

"UL Certification is an important milestone for Abound Solar modules and for the company itself," says senior VP of sales & marketing Julian Hawkins. "As we continue to reduce production costs, this certification gets us one step closer to meeting the demands of consumers," he adds.

Abound Solar's modules are already labeled with the CE mark, certifying that the product has met European consumer safety and health requirements. The firm is also in the process of testing according to IEC certification through independent testing, assessment and certification company TÜV Rheinland.

www.abound.com "

First Solar raises 2009 guidance

For third-quarter 2009, First Solar Inc of Tempe, AZ, USA, which manufactures thin-film photovoltaic modules based on cadmium telluride (CdTe), has reported revenue of \$480.9m. This is up 38% on \$348.7m a year ago but down 8.6% from \$525.9m last quarter, despite shipping all modules that were produced.

This is because, in contrast to Q2 being boosted by \$27m deferred from Q1 (for the 53MW Lieberose project with renewable energy firm juwi near Cottbus, Germany), First Solar was unable to recognize \$58m of revenue shipped to its 20MW project near Sarnia, Ontario, Canada (which was two-thirds completed at quarter end, and should be completed in December), since the contract for the project's sale to Toronto-based energy distributor Enbridge Inc was not signed until early Q4. Sarnia is the first Canadian project from First Solar's acquisition in April of the project development business of OptiSolar Inc of Hayward, CA (a pipeline of more than 1GW of projects).

First Solar's 22 production lines produced 292.4MW in Q3, up 1% on last quarter. Annualized capacity per production line was 53MW, up 2.5% due to not only improved throughput but also conversion efficiency (11%, up from 10.9% last quarter and 10.7% a year ago). This brings total annual capacity (existing and announced) to 1.4GW. Manufacturing cost was \$0.85/Watt, down from \$0.87/W last quarter and \$1.08/W a year ago, driven by the higher throughput and efficiency as well as lower material costs.

"We expect continued throughput and conversion efficiencies and material cost improvement, in line with our long-term cost roadmap, partially offset by near-term ramp cost associated with the Perrysburg expansion," says chief financial officer Jens Meyerhoff. During the quarter, First Solar started to decommission its original line 1 in Perrysburg, OH as it transitions the site to a four-line

configuration. The expansion is on track to ramp up in Q1/2010.

Despite the reduced manufacturing and materials costs, gross margin was 50.9% in Q3, down from 56.7% last quarter due to the effect of a more competitive pricing environment, customer mix and foreign exchange rates.

Net income was \$153.3m, down from \$180.6m last quarter but up from \$99.3m a year ago.

Operating cash flow of \$179m minus capital expenditure of \$65m yielded free cash flow of \$114m (compared to minus \$41m in Q2). Total cash has hence risen from \$777m to \$830m (offset by debt repayment of \$49m for the financing of First Solar's manufacturing site in Frankfurt/Oder, Germany).

"We made significant progress in Q3 building our pipeline of business for the future in new markets," says executive chairman Michael Ahearn. During the quarter, First Solar signed power purchase agreements (PPAs) totaling 550MW with Southern California Edison (300MW at Stateline, 250MW at Sunlight) and a 55MW PPA with Los Angeles Department of Water and Power (in Niland). It also signed a memorandum of understanding with China's Ordos City in Inner Mongolia to develop a 2GW solar power plant (by 2020) and was selected by Juwi for 27MW of US installations (in Florida and Ohio). In addition, Enbridge is a major player in the natural gas business in Canada and the USA and will be a significant ongoing customer, believes First Solar.

For Q4/2009, First Solar expects revenue of \$550-600m and positive free cash flow after CapEx of \$50-65m.

For full-year 2009, the firm now expects revenue of \$1.975-2.025bn (at the high end of the previous guidance range of \$1.9-2bn), CapEx of \$260-275m (down from guidance of \$270-300m) and plant start-up costs of \$14m (up from the prior estimate of \$10m).

www.firstsolar.com

Cooperation framework agreement signed for 2GW Ordos City project

In mid-November, in the presence of Chinese vice premier Li Keqiang, National Energy Administration vice minister Liu Qi and US Secretary of Energy Steven Chu, First Solar's president Bruce Sohn and mayor Yun Guangzhong of the Ordos City Government signed a cooperation framework agreement with the Chinese government that represents another step towards realizing the world's largest solar power plant.

In September, First Solar signed a memorandum of understanding (MOU) with the Chinese government to build a 2GW solar power plant over a multi-phase period in Ordos City in the autonomous region of Inner Mongolia, China. Phase 1 is to be a 30MW demonstration project. Phases 2, 3 and 4 will be 100MW, 870MW and 1000MW, respectively. Phases 2 and 3 will be completed in 2014 and Phase 4 will be completed by 2019.

The new agreement outlines additional project details and local support, and confirms the expected construction start date of 1 June 2010 for Phase 1. First Solar and Ordos also agreed to establish two committees to ensure execution of the project and to develop a new energy industry in Ordos.

"This Cooperation Framework Agreement and its recognition by the National Energy Administration mark a critical step forward in the approval process for the Ordos project," said First Solar's CEO Rob Gillette. "It reinforces the commitment of First Solar, the Chinese government, and the Ordos local government to make an immediate contribution to the development of a healthy solar industry in China," he added.

The signing ceremony took place as part of the US-China Summit where US President Barack Obama and Chinese President Hu Jintao met to discuss topics including upcoming global climate change negotiations and clean energy.

"President Obama's trip to Beijing is a significant step forward in further solidifying bilateral relations with China," said Gillette. "First Solar is enthusiastic in contributing to the commercial relations of our two countries through this cooperative framework agreement," he added.

"Solar energy will play a significant role in achieving China's low-carbon future," says Ordos City's mayor Yun Guangzhong. The First Solar project is part of Ordos City's planned 11.95GW New Energy Industry Demonstration Zone, which is expected to combine solar, wind, hydroelectric and biomass power sources to provide a steady supply of renewable energy to the region that includes the Chinese capital.

Sohn also participated in a Clean Energy Roundtable with Liu Qi and Steven Chu as well as US Secretary of Commerce Gary Locke, US Trade

Projects such as Ordos will enable significant cost reductions through scale, and make solar a truly sustainable energy source in the near future

Representative Ron Kirk and a small group of senior US and Chinese business executives. "Projects such as Ordos will enable significant cost reductions through scale, and make solar a truly sustainable energy source in the near future," said Sohn. "First Solar is committed to helping build a sustainable solar industry and low-carbon economy in China by bringing advanced solar PV technology, global experience, and a focus on cost reduction and environmental sustainability."

Final agreement between the parties involved in the Ordos City project is subject to the negotiation and execution of definitive agreements.

www.firstsolar.com

IN BRIEF

First Solar sells California's largest PV plant to NRG

First Solar says that power generation firm NRG Energy Inc of Princeton, NJ has bought the 21MW AC solar energy project that it has developed and constructed in Blythe, CA.

Located in Riverside County about 200 miles east of Los Angeles, Blythe is California's first and largest utility-scale photovoltaic power generation facility, and among the largest in North America. Construction (which created 175 jobs) began in September and is expected to be completed by the end of this year. Electricity from the plant will be sold to electric utility firm Southern California Edison under a 20-year power purchase agreement with First Solar that was approved by the California Public Utilities Commission (CPUC) in July 2008. First Solar will provide operations and maintenance services at Blythe under a long-term contract with NRG.

"First Solar is very pleased that the first of our utility-scale solar projects in California will be coming on line with a leading power producer like NRG," says First Solar's president Bruce Sohn. "This clean, affordable, and sustainable energy will help California meet the goals of its Renewable Portfolio Standard."

The Blythe plant will use First Solar's CdTe thin-film PV panels to generate over 45,000MW-hours of electricity per year, displacing more than 12,000 tons of carbon dioxide emissions per year (equivalent to taking 2200 cars off the road), it is reckoned.

First Solar is currently developing a total of 1300MW of PV projects under contracts with utilities in California and the Southwest USA.

www.nrgenergy.com

IN BRIEF

DayStar appoints directors to board

DayStar Technologies Inc of Santa Clara, CA, USA, which is developing copper indium gallium diselenide (CIGS) thin-film PV products, has appointed Dr Kang Sun as an independent director.

Sun is president & CEO of PV tracking system maker RayTracker. He was previously president, chief operating officer and director of China-based PV product maker JA Solar Holdings Co (responsible for securing \$620m in equity funding in 2007 and 2008 and growing revenue from \$90m in 2006 to \$800m in 2008).

Prior to JA, Sun was managing director, new business development & chief strategy officer of semiconductor equipment maker Applied Materials' New Business and New Products Group.

"His experience in technology companies will be of great value as we move forward to commercialize DayStar's CIGS thin-film technology," says chairman Peter Lacey.

DayStar has also appointed Jonathan Fitzgerald (an investment banker providing advisory services to early- and growth-stage technology firms) as an independent director on its board.

Previously, he was a managing director and senior investment banker with Morgan Joseph & Co Inc, leading its cleantech investment banking practice.

Due to increased R&D spending, DayStar's net loss grew to \$7.7m in Q1/2009, making it cut staffing by 30% in Q2 and divest its Halfmoon, NY operation to Veeco. Cash and cash equivalents fell from \$17.1m at the end of 2008 to \$1.3m at the end of Q2. However, despite expecting further losses as it builds out of its module manufacturing line, this has since recovered to \$1.7m at the end of September due to cost cutting.

www.daystartech.com

Caltech and Dow Chemical agree four-year, \$4.2m project to seek more abundant, efficient PV materials

California Institute of Technology (Caltech) of Pasadena, CA, USA and Dow Chemical Company have agreed to jointly develop lower-cost semiconductor materials for solar cells in a four-year, \$4.2m effort.

The research will initially focus on direct-bandgap materials incorporating elements that are less expensive and more commonly available than those used in today's thin-film photovoltaic semiconductors. In particular, the researchers will investigate the use of earth-abundant elements.

Although most solar cells today are constructed from silicon (an abundant low-cost material), silicon has an indirect energy bandgap. This means that, in absorbing photons to create a voltage, more energy is eventually lost as heat. More efficient cells can be made by using direct-bandgap materials, but unfortunately such materials usually contain less abundant and more costly elements including gallium (Ga) and indium (In).

To make up for its inadequacies, high-efficiency silicon solar cells need to use high-quality crystal substrates, which are relatively expensive compared with thin-film solar technology using direct-bandgap materials such as cadmium telluride (CdTe) and copper indium gallium diselenide (CIGS). Dow has previously developed CIGS for use in thin-film solar cells.

However, today's direct-bandgap semiconductors contain elements too scarce (In, Ga, Te) to ultimately meet the demands of full-scale solar-energy technologies.

The Caltech/Dow project is led by applied physicist professor Harry Atwater and chemist professor Nate Lewis. Atwater's research in PVs has previously concentrated on achieving high cell efficiency in Si or GaAs by growing very large-grain semiconductor films in low-temperature growth processes. Lewis has



Lewis (left) and Atwater (right).

researched the photo-electrochemistry of semiconductor/liquid junctions as a means to store electrical energy produced by sunlight.

"Development of materials that are abundant in the earth's crust will enable solar-energy technologies to ultimately scale to large volumes at low cost without concern about the materials' availability," says Atwater.

Dow recently announced its first building-integrated photovoltaic product, the POWERHOUSE Solar Shingle, which is designed to provide a product with lower cost, easier installation and improved aesthetics for integration into rooftops with standard asphalt shingle materials. The product incorporates thin films of CIGS that can be incorporated into flexible products. However, the company remarks that some of the elements in CIGS and other thin-film semiconductors are in great demand and are expensive and scarce.

Dow is concerned that increased material costs could threaten the expanded adoption of PV as part of a comprehensive energy policy.

The new Dow/Caltech solar-research initiative is one of the company's largest externally funded research agreements. A Dow Chemical Company Graduate Fellowship in Chemical Sciences and Engineering is also to be created at Caltech.

www.dow.com

www.caltech.edu

Author: Mike Cooke.

Odersun and AT&M form copper indium disulfide photovoltaic cell and module joint venture in China

Advanced Technology & Materials Co Ltd (AT&M) of Zhongguancun Science & Technology Park, Beijing, China and Odersun AG of Frankfurt (Oder), Germany plan to form a joint venture in Beijing for the production and sale of flexible solar cells and modules based on Odersun's thin-film technology, which uses proprietary CISCuT (copper indium disulfide on copper tape) reel-to-reel manufacturing.

Odersun and AT&M established their relationship in 2004, when AT&M became an early investor in Odersun (which was founded in 2002) and a strategic partner in a number of joint research projects, including solar modules for a building-integrated photovoltaic (BIPV) project located at the visitor center of the Olympic Park in Beijing.

Odersun and AT&M say that, as recent renewable energy support schemes are driving significant growth in the photovoltaic sector in China, they are now joining forces to address the fast-growing market.

"Our joint venture is the result of long-term cooperation and trust between Odersun and AT&M," says AT&M's president Dr Zhao Pei.

AT&M's expertise in material science and technologies and Odersun's solar technology and market experi-

As recent renewable energy support schemes are driving significant growth in the PV sector in China, they are now joining forces to address the fast-growing market

ence form a mutually beneficial foundation to the collaboration, it is believed. "Here we have the unique opportunity to address the Chinese market and at the same time to further accelerate innovation at Odersun in cooperation with a highly competent partner," says Odersun's CEO Dr Hein van der Zeeuw.

"While we continue with our current expansion plans in Germany, our future technology development will benefit from AT&M's expertise and long-time experience in material technology and manufacturing," he adds.

The construction of the joint venture's manufacturing facilities in China is expected to commence during 2010.

www.atm.cn/en
www.odersun.com

Atlumin establishes thin-film photovoltaic materials manufacturing in California

Renewal energy materials manufacturer Atlumin Energy Inc of New Hartford, NY, USA (a subsidiary of metals supplier MCP-Group) has established a 55,000 square-foot plant in Sunnyvale, CA to support renewable energy manufacturers (initially solar module makers).

The new plant should ship its first product (customer-specific rotary sputtering targets for solar module manufacturing) in January 2010, but will ultimately manufacture a full range of products for solar module manufacturers. The metals tellurium, selenium, indium, gallium, copper, and cadmium are the basis of most of Atlumin products.

"We are putting manufacturing roots in California to be local to many of our key thin-film customers' manufacturing sites and development locations," says VP of sales David Preische. "Close

proximity is a component of our strategy to be super-responsive," he adds. "Our new facility is within 10-20 minutes of many local customers. This proximity dramatically compresses response time and development cycles — speed counts in solar."

At the new facility, Atlumin will provide metals, chemicals, and fabricated products (including specialized sputtering targets) as well as reclaim services (since some materials used in thin-film photovoltaics, such as indium and gallium, are valuable enough to support reclaim).

The plant will be equipped with the Atlumin Material Loop for the materials that it manufactures: a closed-loop system will link customer facilities to the plant in order to compress cycle time, reduce loss, minimize waste, and be environment friendly.

"We drive efficiency along several dimensions, such as, administrative, yield management, cycle time, and minimal process steps," says VP of operations Tim Starkey.

"The goal is to deliver consistently high-quality products via a just-in-time philosophy to help our customers continue to reduce their cost structure and accelerate their own ramp-up," he adds. "Speed and quality drive their system costs down, enabling customer cost control: the same lessons that we learned in the hard-disc drive industry."

The new plant will also provide a central location structure, housing product development, process engineering, application engineering, and sales administration (with the aim of enabling Atlumin to be efficient and responsive to customer needs).

www.atlumin.com

MiaSolé starts commercial shipments of CIGS PV modules

MiaSolé, which manufactures copper indium gallium diselenide (CIGS) thin-film photovoltaic modules, has started commercial shipments of its CIGS thin-film modules from its production facility in Santa Clara, CA, USA.

"We have now shipped modules to 30 customer sites in Germany, Italy, Spain, France, Portugal and various locations in the USA; we now have commercial projects in the ground, under development and on the drawing board," said CEO Dr Joseph Laia.



An installation of MiaSolé's modules.

In September 2006, MiaSolé had promised full production as long ago as 2007. However, the firm suffered delays, leading to founder & former CEO David Pearce that

September becoming chairman and being superseded by Laia. More recently, the firm has made significant progress towards commercial manufacturing.

"With complete UL/IEC certification and long-standing customer partnerships, we are now ramping our factory output and production capacity for 2010," says Laia. "We are confident our cost structure and manufacturing efficiencies will enable us to compete effectively in the large and growing solar energy market."

www.miasole.com

IN BRIEF

IEC certification for Shurjo Energy's CIGS PV modules

PAE Ltd subsidiary Shurjo Energy of Kolkata, India says that Euro Test Laboratory S.r.l. has awarded it International Electrotechnical Commission (IEC) certification for its solar panels, which incorporate copper indium gallium diselenide (CIGS) thin-film photovoltaic cells that have been sourced from an unnamed US-based manufacturer.

Shurjo Energy says that the IEC 61646 and IEC 61730 certification confirms that its module adheres to the stringent requirements for functional, mechanical and safety capabilities for long-term operation and open air environments.

The firm adds that the IEC certification is also a requirement for photovoltaic modules used in solar power plants in most markets worldwide.

www.shurjo-energy.com

VP of manufacturing & operations recruited

MiaSolé has recruited Kevin Eassa as VP for manufacturing & operations.

Eassa has more than 26 years of manufacturing experience in the disc-drive industry with Seagate, responsible for the rapid global expansion of its manufacturing and operations in five countries and on three continents.

"He brings the experience he has gained from leading Seagate's global manufacturing operations," says CEO Dr Joseph Laia. "Kevin joins us at a critical time," he adds.



On 30 October, MiaSolé received certification of its 100W and 107W CIGS PV modules to UL 1703 and IEC 61646 and 61730 standards,

and it is now ramping up its production lines. "He brings a wealth of experience in building organizations that can drive scale rapidly, and is a perfect fit for our environment of low-cost and high-volume manufacturing," Laia concludes.

Modules receive UL and IEC certifications

On 30 October, MiaSolé received simultaneous certification of its 100W and 107W CIGS PV modules to UL 1703 and IEC 61646 & 61730 standards (the first CIGS modules to be certified by Underwriters Laboratories Inc to the three most critical certification standards).

"We are delighted to have this third-party validation of the safety and reliability of our products from such a well respected certification body such as UL," says CEO Joseph Laia. The certification represents the culmination of MiaSolé's in-

house testing capability and the last two years of focused work. The firm's reliability and testing team has tested the modules extensively well beyond the current industry standards, says Laia. "Anything that we can envision having an impact on safety, quality or reliability has been thoroughly tested."

Miasolé was verified by the US Department of Energy's National Renewable Energy Laboratory (NREL) in July last year as producing modules with solar energy conversion efficiency of 10.2%.

Ascent reaches 14% cell efficiency in commercial production

Ascent Solar Technologies Inc of Thornton, CO, USA says it has achieved a solar energy conversion efficiency of 14% for its copper indium gallium diselenide (CIGS) thin-film photovoltaic cells on flexible plastic substrate produced at its 1.5MW-capacity Fab1 commercial production line at its former headquarters in Littleton, CO.

The US Department of Energy's National Renewable Energy Laboratory (NREL) measured 14.01% cell efficiency for the CIGS material (up from just 11% for an Ascent champion cell measured last November).

Ascent has also raised efficiency for its monolithically integrated CIGS

modules (manufactured at Fab1) from 10.5% up to a peak of 11.7%. NREL verified module efficiency of 10.4% as recently as July (up on the 9.64% verified last December).

"This is a significant breakthrough in demonstrating our ability to achieve thin-film CIGS cells with 14% efficiency from regular production machines," says president & CEO Dr Farhad Moghadam.

"Ascent Solar's ability to manufacturer monolithically integrated modules with efficiency as high as 11.7% in regular production serves as a vital element to our low-cost per watt manufacturing goal."

www.ascentsolar.com

Ascent to supply FTL for NYSERDA

Ascent Solar is to provide modules to New York-based FTL Solar for their R&D contract with New York State Energy Research and Development Authority (NYSERDA). The parties will collaborate on developing light-weight flexible structures that incorporate solar electric modules produced by Ascent Solar.

FTL claims that its patent-pending products are the first pre-fabricated, mass-produced photovoltaic tensile structures to integrate thin-film PVs with strong fabric to create solar canopies, arrays and enclosures. "We are confident their light-weight flexible high-power modules will work well with our existing products as well as future products currently in our product development pipeline," says FTL's chief technology officer Robert Lerner.

NYSERDA is investing \$250,000 towards the \$500,000 FTL project, which is developing a "unique product with so many real-world, right-now applications," says NYSERDA president & CEO Francis J. Murray Jr. "Because of its physical attributes and application flexibility, shade and electricity can be realized just about anywhere," he adds. "From a

New York perspective, the potential for this firm [FTL] to bring product development and manufacturing to the Empire State is very encouraging and supports Governor Paterson's goal to attract clean energy efficiency manufacturing jobs to our state."

Development work will be under a \$22,500 collaborative agreement between FTL and the Center for Autonomous Solar at Binghamton University and Binghamton's Center for Advanced Microelectronic Manufacturing at Endicott Interconnect Technologies Inc in Endicott, NY.

"FTL Solar has developed a variety of multi-purpose solar-integrated flexible tensile structures," says Ascent's president & CEO Farhad Moghadam. "These structures are ideally suited for the incorporation of Ascent Solar's high-energy, flexible and light-weight photovoltaic modules." The relationship with FTL and NYSERDA presents a chance to embed Ascent's modules into a range of structures serving various market segments, he adds. "FTL Solar has the expertise and deep history in developing these unique products."

www.ftlsolar.com

CIGS PV maker Ascent Solar unveils FlexPower module product line

At Solar Power International 09 in Anaheim, CA (27-29 October), Ascent Solar launched its FlexPower line of CIGS PV products.

Ascent claims that the FlexPower class of modules, which includes Light, Mobile and Extreme, has an industry-leading power-to-weight ratio, achieves the highest power density of any flexible product on the market, and provides a unique form-fit capability.

FlexPower Light modules are manufactured for the building-integrated photovoltaic (BIPV) market. The range features a 5m-long product that delivers power of 123W and is claimed to be the world's largest monolithically interconnected flexible module. Manufacturers of building materials and BIPV systems can use the FlexPower Light class for large-area BIPV installations and seamless integration into building surfaces.

FlexPower Mobile is designed for the electronic-integrated photovoltaic (EIPV) market. The modules are optimized for 12V battery-charging applications, allow integration into consumer electronics, and are available encapsulated or unencapsulated as a build-to-suit solution.

FlexPower Extreme is a durable and deployable photovoltaic solution for defense applications, and is designed to provide excellent power density and to match existing battery-recharging ecosystems (allowing for more supply-line independence).

"Our ability to manufacture monolithically integrated flexible CIGS modules provides a unique and enabling solution to various premium market opportunities," says Ascent Solar's president & CEO Farhad Moghadam. "FlexPower is not only a brand name, but it also best represents our manufacturing capability," he adds.

www.solarpowerinternational.com

DARPA awards HRL, TriQuint and Northrop Grumman NEXt contracts for GaN ICs

DARPA has kicked off research aimed at yielding 'revolutionary' advances in gallium nitride electronic device integration and performance with awards to three multi-year projects led by HRL Labs, TriQuint and Northrop Grumman.

In the last few months, the US Defense Advanced Research Projects Agency (DARPA) has awarded three contracts worth a total of \$61.1m for its 'Nitride Electrical NeXt-Generation Technology' (NEXt) program, which is focused on research on nitride-based electronic devices and ICs for use in tactical radio systems, phased array radar, and satellite communication.

NEXt is designed to enable what is described as revolutionary advances in nitride electronic devices and ICs, resulting in their ability to operate at very high frequencies while maintaining extremely favorable voltage breakdown characteristics. "Specifically excluded is research that primarily results in evolutionary improvements to the existing state of practice," emphasizes DARPA.

HRL: \$16m over 54 months

On 4 September, HRL Laboratories of Malibu, CA, USA (a corporate R&D lab owned by The Boeing Company and General Motors) received a \$16m NEXt contract over four and a half years to conduct advanced nitride electronics research.

Among HRL's previously reported successes in millimeter-wave GaN-based monolithic microwave integrated circuits (MMICs) is 500mW of output power at 95GHz for a GaN MMIC, as presented at the 2008 IEEE Compound Semiconductor IC Symposium (CSIC) in Monterey, CA, USA.

To boost its GaN HEMT capabilities, in third-quarter 2009 HRL ordered an Aixtron Close Coupled Showerhead (CCS) MOCVD reactor (in 6x2-inch configuration), for delivery in first-quarter 2010.

The system will be used to support HRL's work on GaN, including the growth of GaN high-electron-mobility transistors (HEMTs) for millimeter-wave power applications and high-voltage GaN transistors for high-efficiency power switching applications.

The Aixtron system will enable fabrication of more sophisticated GaN HEMT structures, as well as addressing the need for higher process throughput, says HRL.

**TriQuint Wins New
DARPA \$16.2M
GaN R&D Contract.**



TriQuint's NEXt program targets 500GHz operation of GaN ICs (as well as increased yield and circuit size) for defense and aerospace applications.

Northrop Grumman: \$28.9m over 60 months

On 14 September, Northrop Grumman Space & Mission Systems of Redondo Beach, CA, USA received a \$12.4m contract for the two-year first phase of a five-year \$28.9m NEXt project, with an estimated completion date of 13 September 2011. Work will support defense communications, aircraft and space systems through the development of next-generation GaN IC technology.

"New GaN transistors and integrated circuit technology developed under this program will enable high-performance analog-to-digital converters for future advanced electronic systems," says Dwight Streit, VP of Electronics and Sensors at Northrop Grumman Aerospace Systems.

"The goal of the NEXt program is to increase the operating frequency of GaN devices to 500GHz while maintaining its high breakdown voltage in a large-scale integration process [in circuits of at least 1000 transistors]," says Northrop Grumman Aerospace Systems' NEXt program manager Mike Wojtowicz. "This will enable the next-generation, high-dynamic-range mixed-signal technology and high-frequency RF power sources," he adds. "NEXt technology will provide

significant improvements in performance and functionality for US military and space systems.”

Partners on the project include the University of California Santa Barbara (UCSB), Arizona State University and Pennsylvania State University.

Northrop Grumman's NEXT program builds on another DARPA initiative involving GaN technology — the Wide Bandgap Semiconductors for RF Application (WBGS-RF) program, which is developing high-power, high-efficiency wideband GaN circuits for defense and aerospace applications.

TriQuint: \$16.2m over 54 months

Most recently, on 12 October, RF device maker and foundry services provider TriQuint Semiconductor Inc of Hillsboro, OR, USA received a \$16.2m four-and-a-half-year R&D contract to create complex, high-dynamic-range GaN circuits for future defense and aerospace applications.

TriQuint's principal investigator, senior fellow Dr Paul Saunier, reckons that achieving NEXT program goals could lead to GaN circuits as radically different as existing computers are compared to those of the 1980s.

“GaN is already recognized for its ability to handle more power per square millimeter than other semiconductor technologies like gallium arsenide, and much more so than silicon. Yet even with the advances TriQuint has pioneered, today's analog GaN technology has frequency and power limits,” Saunier stresses.

“NEXT circuits will be ‘game-changing’ technology that could radically improve performance in defense and aerospace applications like phased array radar and communications,” claims Saunier. “NEXT calls for complex digital GaN circuits that also have very high breakdown voltages — something that silicon can't do, and that is also beyond the scope of today's other semiconductor processes,” he adds.

NEXT's initial Phase I will run for two years, pursuing devices that can operate at 300GHz with essential yield levels of a small circuit. The 18-month Phase II program will raise the operating frequency to 400GHz while increasing yield and circuit size. The third and final 12-month Phase III targets 500GHz while also substantially increasing yield and circuit size.

Another key aspect of NEXT will be to develop enhancement-depletion (E/D) mode GaN circuits, similar to the E/D circuits that TriQuint uses for greater functionality and power handling in its GaAs devices, says Dr David Fanning, TriQuint's program manager for NEXT.

TriQuint will also team with University of Notre Dame professors Patrick Fay, Debdeep Jena, Greg Snider and Huili Xing to explore alternative wafer materials and circuit designs. University of Illinois professor Ilesanmi Adesida will assist with work to develop fabrication processes.

NEXT contractors, awards and project durations (all in three phases).

TriQuint	54 Months	\$16.2m
HRL	54 months	\$16m
Northrop Grumman	60 months	\$28.9m

TriQuint has researched GaN for both defense and civilian applications since 1999. In addition to defense products, the firm has launched GaN amplifiers for civilian applications and has provided commercial GaN foundry services since 2008. Previously, this June, TriQuint was also selected by the Army Research Laboratory (ARL) in Adelphi, MD to lead the two-year \$16.5m Phase III of the DARPA-funded Wide Bandgap Semiconductors for RF Applications (WBGS-RF) R&D program. TriQuint previously began execution of the \$15.8m Phase II WBGS-RF program in 2005. Phase III aims to extend device reliability for 48V operation while increasing operational lifetime and extending performance to cover the high end of frequency ranges.

IQE wins TriQuint subcontract for NEXT

As with TriQuint's WBGS-RF project, its NEXT project team will also include the Somerset, New Jersey operation of epiwafer foundry and substrate maker IQE plc of Cardiff, Wales, UK as a subcontractor. At the end of October, IQE said that it had been sub-contracted to provide GaN wafer products to TriQuint as part of its NEXT GaN R&D contract.

“IQE and TriQuint have enjoyed a close relationship over many years,” says Alex Ceruzzi, VP & general manager of IQE's New Jersey facility. The TriQuint NEXT program will utilize IQE's GaN wafer product expertise, he adds.

IQE's GaN HEMT epiwafer foundry at its New Jersey facility provides a complete portfolio of RF products, ranging from high-volume HEMTs, HBTs and BiFETs to advanced GaN-based products. The firm's GaN production capability was increased on 8 October through the acquisition of gallium nitride substrate firm NanoGaN Ltd of Bath, UK.

● As for DARPA's WBGS-RF program, its NEXT program is also under the supervision of Mark Rosker in the DARPA Microsystems Technology Office (MTO), which is responsible for enabling new platform capabilities by exploiting breakthroughs in circuits, devices, materials, and mathematics for beyond-leading-edge components with revolutionary performance for the US Department of Defense (DOD). ■

www.darpa.mil/MTO

www.as.northropgrumman.com

www.hrl.com

www.triquint.com

Management of arsenic-rich waste streams in III-V foundries

Keith Torrance and **Helen Keenan** of the University of Strathclyde discuss safe practices for waste management associated with the grinding, lapping and polishing of gallium arsenide in the wafer thinning process.

Backside processing of gallium arsenide and other III-V semiconductors dictates that fabricated wafers are thinned from 625 μm to less than 100 μm to improve heat dissipation of the diced and packaged device.

Wafer grinding, lapping, polishing or a combination of processing methods is most commonly used in the fab to mechanically abrade material from the backside of the wafer. Grinding using a resin-bonded fixed diamond wheel is the preferred method for 100mm and larger substrates, but lapping is still used for lower-volume operations. The resulting waste stream is in the form of slurry, with solid GaAs and abrasive particles mixed with coolant that contains dissolved arsenic. In the USA, the State of California has recently classified GaAs as a known carcinogen and, under most legislative regimes, the waste streams from backthinning are classified as hazardous waste. This article seeks to explain the chemical and physical characteristics of this

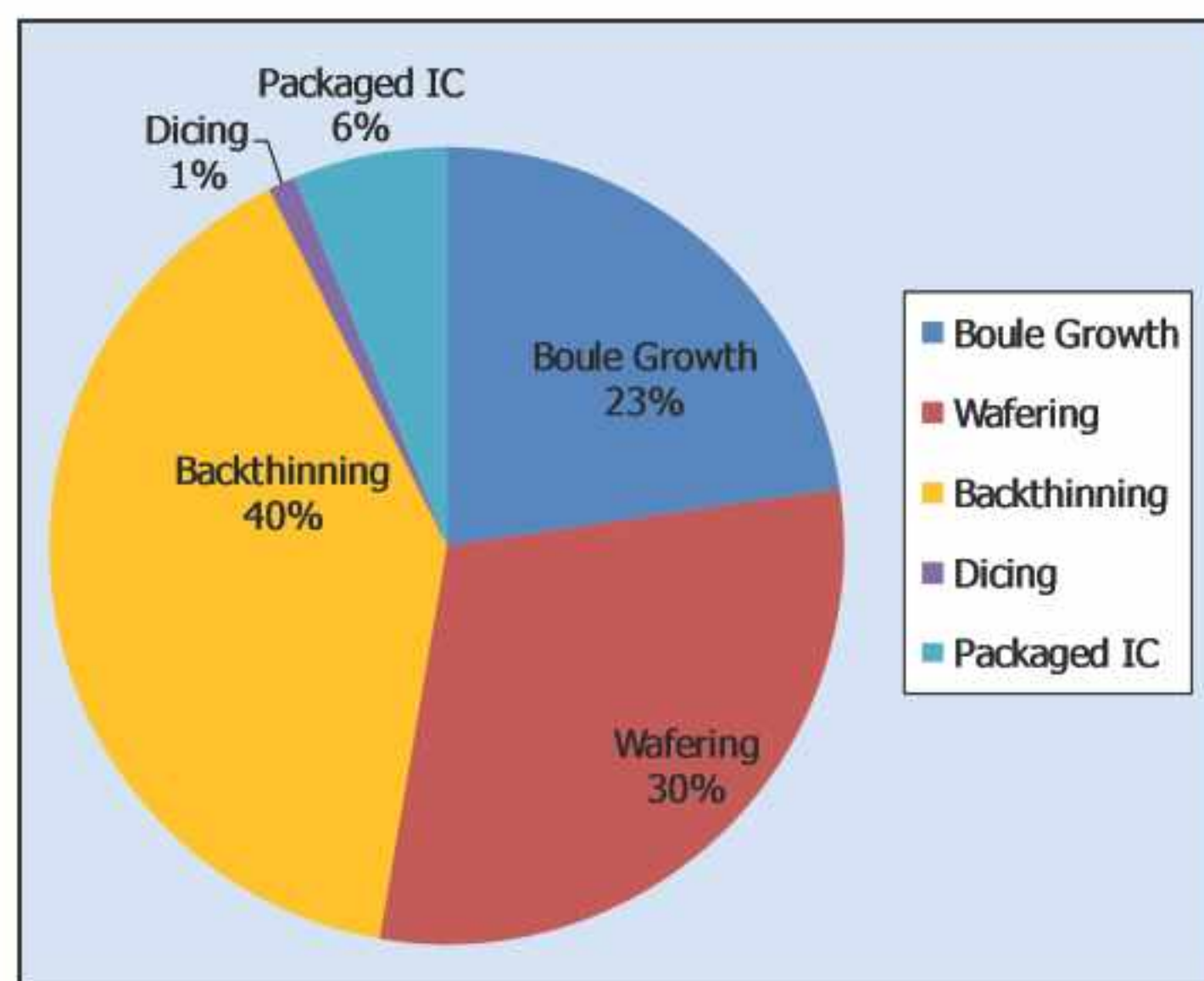


Figure 1. Material losses during processing from boule to packaged IC (without recycling).

Table 1. Characteristics of GaAs processing waste streams.

Type	Source	Characteristics	pH	Total GaAs* (gl^{-1})	Dissolved As (mg^{-1})
Grinding slurry	Grinding of boules, wafering and dicing	Slurry with visible GaAs particles and surfactant	7.0	20–75	10
Lapping slurry	Wafer back lapping	Grey slurry of alumina and fine GaAs particles	8.0	20–30	20–90
Polishing slurry	Prime wafer polishing & backside polishing	Clear solution with alumina & SiO_2 particles. May be alkaline or acidic	10–11 6.0	3–5	1800–2400

* Solid GaAs particulates and dissolved material.

waste, the legislation that covers its safe disposal and to provide some guidance on safe practices for handling waste.

GaAs wafer processing is very inefficient in its use of substrate material. It can be calculated that up to 94% of a grown GaAs boule is potentially discarded during wafering and subsequent backthinning operations (Figure 1).

Although some recycling of substrate material is possible, e.g. during boule growth, it is only economical to recover certain metals, such as gallium, from the waste. The residue is therefore further enriched in arsenic, and must be disposed of as hazardous waste, as there are limited uses for arsenic. Further, during thinning, a significant proportion of arsenic becomes soluble, so that any water used as a coolant or for cleaning is potentially contaminated.

Arise

is recognised as both a chronic and acute toxin; as little as 100mg of arsenic trioxide can be fatal.

Arise can exist in several valence states, with the As^{-3} state (i.e. arsine gas) considered to be the most toxic [1], followed by As^{+3} valence state; inorganic arsenic compounds are more toxic than organic arsenic compounds. Millions of people worldwide, especially in West Bengal and Bangladesh, are at risk from chronic health problems associated with the consumption of groundwater that is naturally high in arsenic.

Prolonged ingestion of arsenic results in higher incidences of keratosis, skin and bladder cancers. The World Health Organisation (WHO) has set a target maximum permissible level of $10\mu g l^{-1}$ arsenic in drinking water, although this level is exceeded in many parts of the world from natural sources.

The chemistry and physical characteristics of the main waste streams are shown in Table 1. Arsenic content is best determined using inductively coupled plasma mass spectrometry (ICP-MS), although there are a number of simple colourimetric test kits that can be used to monitor the arsenic content of waste waters inexpensively.

Slurries from wafer grinding and dicing are most amenable to recycling as the solids can be removed by recirculating the coolant through a filter. Based on

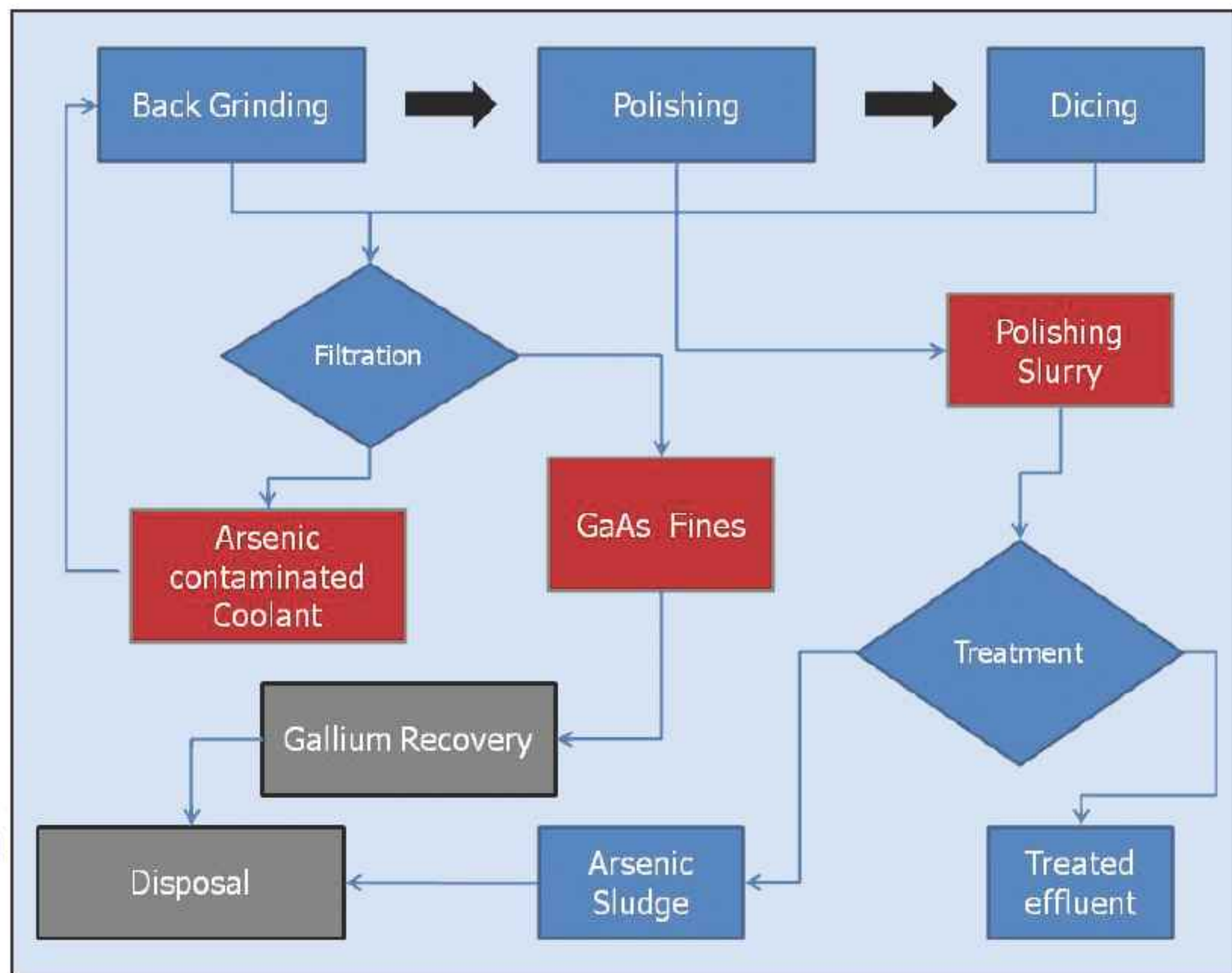


Figure 2. Gallium arsenide waste stream flow chart within a fab.

laboratory studies, typical arsenic concentrations in the coolant are less than $10mg l^{-1}$, although this is still above most permissible discharge standards. Lapping slurries have a higher dissolved arsenic content (up to $100mg l^{-1}$). Recycling of these slurries is complicated by the presence of aluminum oxide abrasive, reducing the average gallium content to about 5% (on a dry basis), which is close to the economical threshold for gallium recovery. Several firms (including Recapture Metals Ltd of Peterborough, Ontario, Canada) can reclaim gallium metal from waste slurries. Polishing slurries have a dissolved As content of about $2000mg l^{-1}$, as all the GaAs that is removed will be in soluble form from the strong oxidizing nature of GaAs polishing solutions.

In the European Union, disposal of hazardous waste is covered by the Waste Framework Directive (2006/12/EC) [2]. Arsenic-containing waste is considered hazardous above $5mg kg^{-1}$ and must be disposed of in solid form in a licensed hazardous landfill. It is no longer acceptable to co-dispose hazardous and non-hazardous waste in the EU, and there are a diminishing number of compliant landfills, which adds to the cost of disposal. Water is removed from the slurry by the waste contractor, usually by incineration. One further consideration is that the transport of hazardous waste to destinations outside the EU is tightly regulated, making shipment of waste to North America for recycling problematic.

Table 2. Hazards associated with GaAs processing waste streams.

Waste stream	Possible hazards	Hazard minimization
Solid particles as dust	Inhalation of dust.	Minimize dust generation, through wet processing. Ventilation and extraction of working area of grinders and saws. Store waste in liquid slurry form in a closed container. Wear protective clothing, mask and gloves.
Grinding, cutting and lapping waste slurries	Ingestion of GaAs. Dermal contact. Contamination of groundwater through improper disposal.	Treat waste streams as hazardous waste and dispose of according to local and national regulations. Wear protective clothing and gloves.
	Generation of arsine gas in waste container.	Avoid creating a reducing environment in waste slurry tank. Maintain low pH in waste slurry tank to avert microbial activity.
Polishing slurries.	Ingestion of arsenic.	Wear protective clothing and gloves.

In the USA, arsenic is one of eight metals regulated under the Resource Conservation and Recovery Act (RCRA), and waste with a leachable content — as determined by the Toxicity Characteristic Leaching Procedure (TCLP) [3] — of more than 5.0mg l^{-1} is considered hazardous. Although this is a less onerous standard than the EU definition, most waste slurries from GaAs lapping and grinding are still classified as hazardous. The US Environmental Protection Agency (EPA) has set effluent discharge standards for the semiconductor industry, including a peak limit of 2.09mg l^{-1} for arsenic and an average of 0.83mg l^{-1} over 24 hours.

On 1 August 2008, GaAs was classed by the State of California as a material that is a known carcinogen (California Proposition, 65 OEHHA) [4]. It is also toxic by inhalation and ingestion [5]. Consequently, sludge that contains GaAs particulates must be treated as hazardous waste and semiconductor workers must be protected from exposure. The primary concern is the inhalation of particulates; a ceiling value of $2\mu\text{g m}^{-3}$ is recommended by the US National Institute for Occupational Safety and Health (NIOSH)[6].

Table 2 summarizes the potential hazards associated with the different waste streams, together with some handling recommendations. There are a number of

treatment options to remove soluble arsenic from waste water and bring it within discharge limits.

Most importantly, waste should only be transported and disposed of by a contractor licensed to handle hazardous waste. Under the 'polluter pays' principle that underlies EU regulation, the generator of waste retains a responsibility for the final disposition of the waste and is responsible for ensuring that the contractor is in compliance with all pertinent regulation.

Although there have been only a few reported instances of arsenic pollution resulting from semiconductor manufacture[7], the onus is on semiconductor foundries to properly manage waste streams and ensure compliance with local and national legislation. ■

Authors: Keith W. Torrance and Helen E. Keenan, David Livingstone Centre for Sustainability, University of Strathclyde, Glasgow, UK.

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TECDIA's Scribing Tool Selection

							
							
TD-3YGP For sapphire, GaN or SiC wafers	TD-3P Mostly for InP wafers	TD-4PB Toe-cut type, used mostly for silicon wafers	TD-420 Heel-cut type, used primarily for GaAs or glass wafers	TD-4L Mostly for silicon, GaAs, or glass wafers	TD-2P Custom made, for semiconductor wafers or thin film photovoltaic modules	TD-8P Custom made, for R&D use (both toe and heel cut types)	TD-8D Mostly for silicon, GaAs, or glass wafers

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Progressing etch techniques for compound semiconductors

Mike Cooke reports on some recent developments in using various etch processes on compound semiconductors.

It is often surprising to the newcomer to compound semiconductor production how little etch figures in the description of device construction. The focus tends to be on improved crystal growing and epitaxial layer growth. Etch only appears late on in the production process to create gross structures such as ridges for laser microcavities, mesas and waveguides, along with the creation of contact areas and wiring.

Here we look at developments over the past year where etch is used in a non-standard format. We also consider one area where an etching action occurs where one would prefer it didn't.

Selective boost to nitride light emission

Zhilai Fang at Xiamen University in China has been exploring the use of etch techniques to improve nitride light emission [1]. The aim was to reduce the negative effects of threading dislocations and indium-rich clusters in indium gallium nitride (InGaN) layers. However, one has also to recognize that the light-emission processes in InGaN are not properly understood.

The consensus is that light emission is actually enhanced by a variety of imperfections leading to nano-scale indium content fluctuations, creating localized energy states. Among these imperfections are: spinodal decomposition in which components separate into regions with different chemical and physical properties; phase separation; and, the tendency of indium to aggregate. At too high indium concentration, surface pitting occurs, reducing crystallinity and therefore hitting quantum efficiency of light-emitting structures.

Some recent studies suggest another explanation in terms of inhomogeneous strain effects. These effects can influence the growth modes of the layers (islands that coalesce or complete layers) and can create anomalous light-emission effects.

To study some of these questions, Fang intentionally etched threading dislocation (TD) sites using an in-situ selective process. Fang attributes increased light emission resulting from this process to the suppression of non-radiative recombination near the TD sites.

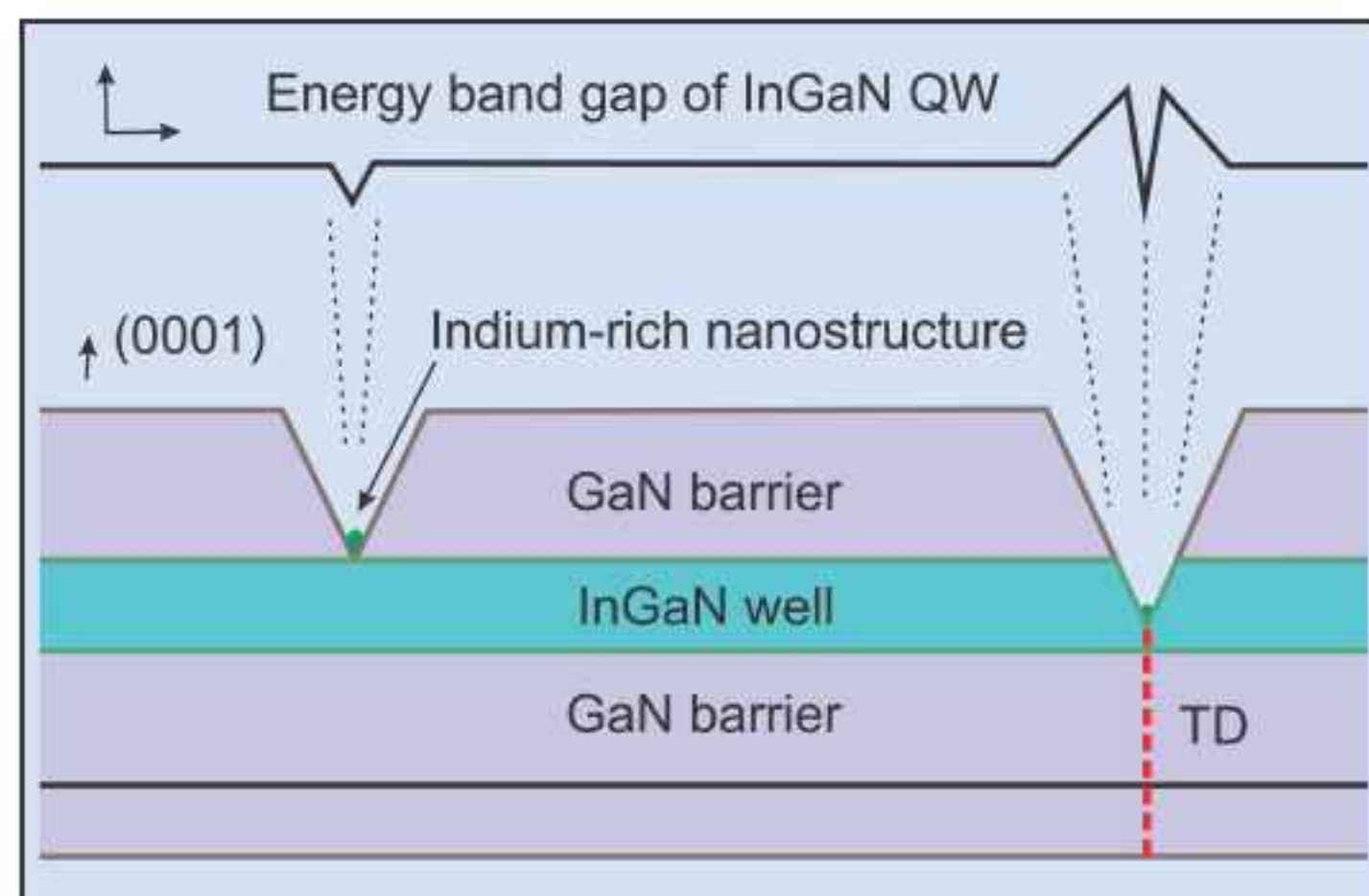


Figure 1. Schematic for the formation of V-shaped pits and the effect on the energy band gap of the InGaN active layers around the threading dislocations.

Fang grew his InGaN layers using metal-organic chemical vapor deposition (MOCVD) on c-sapphire substrates, using tri-methyl gallium (TMGa), tri-methyl indium (TMIn) and ammonia (NH₃) as precursors. Silane (SiH₄) was used as n-type dopant. GaN nucleation and buffer layers were grown using traditional methods. This was followed by a surface treatment using a droplet homoepitaxy technique developed by Fang and his colleagues to improve the surface/interface with subsequent layers, enhancing the quantum well properties. Ga droplets deposited in this process are designed to serve as both nuclei for subsequent growth and as a surfactant. The resulting layers have been found to have increased photoluminescence (PL), and can be arranged to have narrower line-width [2].

The InGaN/GaN interface was treated with indium by varying the TMIn flow rate for a few seconds. An ultrathin GaN layer was used to protect the well (WPL = well protection layer) from indium losses during thermal processes and for strain pre-relaxation to improve surface smoothness. The indium treatment results in In-rich nanostructures and V-shaped pits. The treatment resulted in some improvement in surface

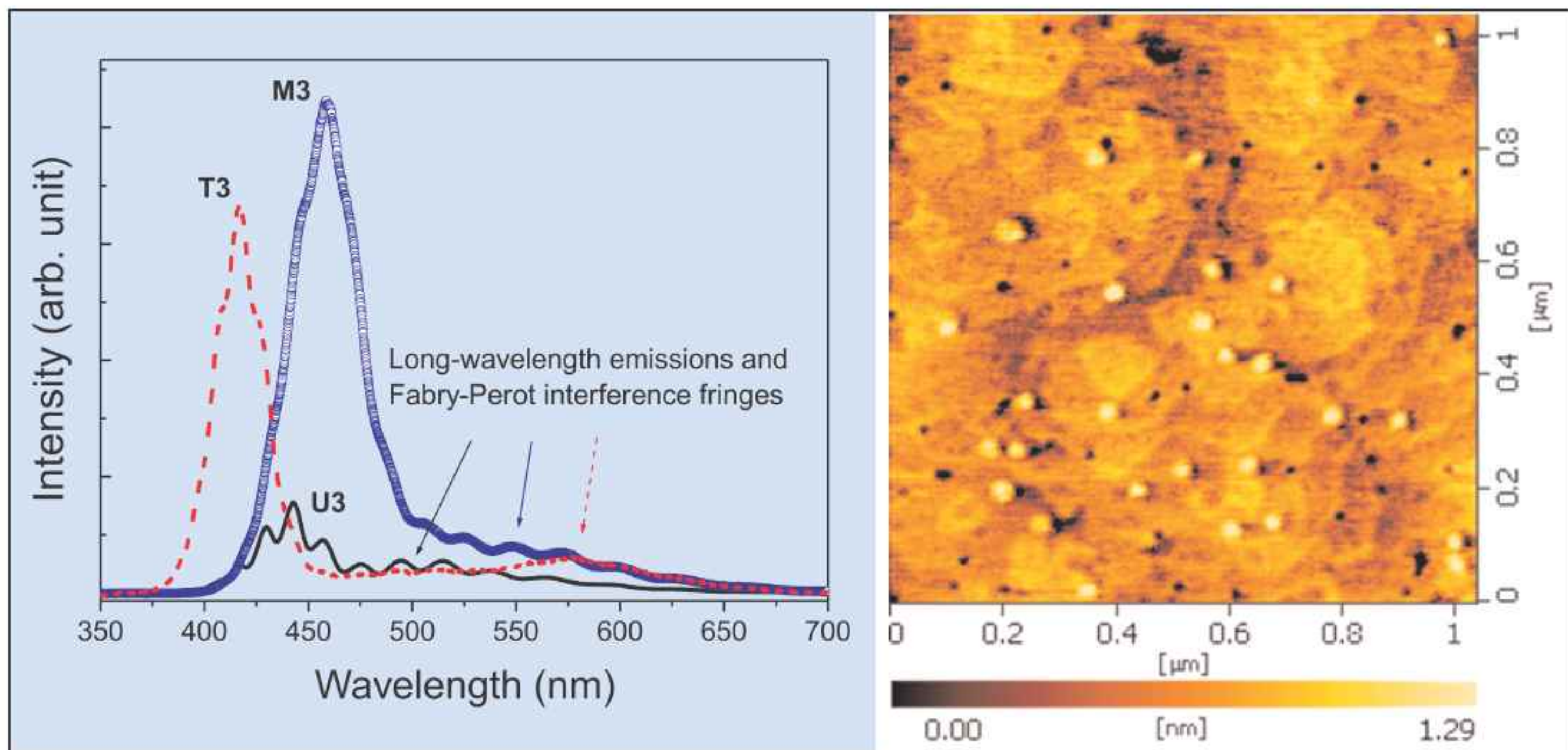


Figure 2. Photoluminescence spectra at 300K for untreated (U3) and treated (T3) quantum wells, and a modified treatment (M3) to reduce phase separation effects. The long-wavelength tail shows emissions from In-rich nanostructures and interference fringes from Fabry-Perot reflections. Also shown is the surface morphology of bare InGaN epilayers with a moderate indium post-treatment using a TMIIn flow rate of 40sccm (M1), as revealed by atomic force microscopy.

smoothness: the root-mean-square (RMS) roughness was 0.5nm for untreated samples, but was reduced to 0.4nm in treated samples.

Fang believes that some of the V-shaped pits are the result of selective etching of TDs by the indium flow where the screw and mixed dislocations in such regions become chemically active (Figure 1). Other pits may result from In-rich nanostructures that form on the well during the subsequent GaN barrier growth. The size of typical pits was around 20nm, with a depth of 0.7nm. The density of pits was around $4 \times 10^9/\text{cm}^2$. Since the etching of these pits removed some active InGaN material around TDs, it was expected that a potential barrier would be raised to electrons and holes, increasing the bandgap.

Photoluminescence characterization (Figure 2) revealed a double peak that Fang attributes to the separate emissions from the quantum well (QW) and In-rich nanostructures. The spectra also reveal Fabry-Perot interference fringes from interface reflections, indicating the smoothness of the surfaces. The QW peak for the untreated sample (U3) was 442nm, while the longer-wavelength peak from the nanostructures was around 510nm. For the treated sample (T3), the peaks were 417nm and 574nm, respectively. The treatment therefore blue-shifts QW emissions while red-shifting nanostructure peaks (from green to yellow). U3 had a nanostructure/QW peak intensity ratio of 0.38, while for T3 this was reduced to 0.09. The QW emission for T3 was approximately four times that for U3.

The large blue-shift of the T3 QW peak suggests phase-separation effects from the strong indium treatment. Fang therefore tried a modified TMIIn flow of 40 cubic centimeter per minute at standard temperature and pressure (sccm), instead of the original 160sccm. The QW peak was then 459nm and the long wavelength was 537nm, indicating successful suppression of phase separation.

Although the Xiamen University group has presently only applied these techniques to undoped structures in photoluminescence studies, Fang believes that the technique should also apply for electroluminescence measurements with appropriate doping to achieve p-GaN and n-GaN layers for diode action.

Light-enhanced wet etch eats into nitrides

Researchers based in Crete, Greece, have been developing photo-enhanced wet etch techniques for use with nitride-based semiconductors. Illumination with ultraviolet light of a well-defined wavelength enables selection of some III-nitride materials and not others to etch into with an electrochemical solution of potassium hydroxide (KOH) in water.

Normally, group III-nitrides such as GaN are highly resistant to wet chemical etching methods therefore plasma techniques have to be used. However, plasma processing tends to leave ion-induced damage and rough sidewalls in its wake. For optoelectronic devices, such as lasers, smooth sidewalls for cavities can be extremely important. ▶

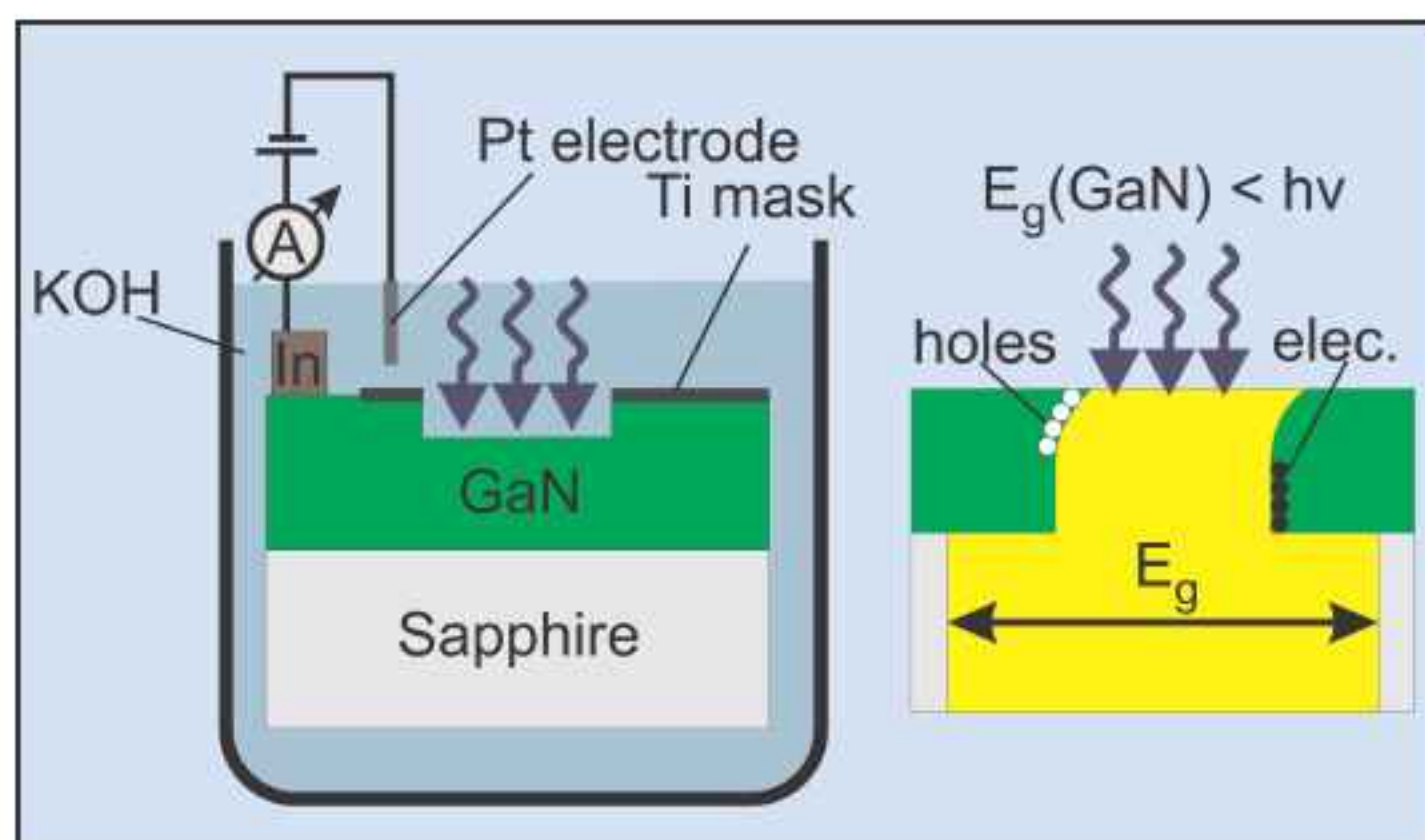


Figure 3. Schematic of photo-etch set-up (left) and band diagram of semiconductor structure under bias producing holes near the surface.

In recent work [3], GaN vs AlGaIn selective etch has been studied by the researchers from the University of Crete and the Greek Foundation for Research and Technology Institute of Electronic Structure & Laser (FORTH/IESL). The samples were put in an electrochemical cell where a bias can be applied between an anode formed by an indium contact on the GaN film surface and a cathode made of platinum (see Figure 3, left). A 100nm-thick titanium layer patterned with square holes was used as the etch mask.

A Ti:sapphire laser was used to produce 150 femto-second pulses with a wavelength tuning range of 670–760nm. The nonlinear photonic crystal beta barium borate (BBO) was used to double the frequency of the radiation to the range of GaN's bandgap ($\sim 3.4\text{eV}$).

The researchers measured the photocurrent at various excitation energies and found a resonance around 3.43eV associated with exciton absorption. Excitons are electron-hole bound states that, in PL measurements, produce lines below the main bandgap edge. The exciton enhancement has not been seen before by other groups exploring photochemical etching. The Crete scientists believe that this is due to the

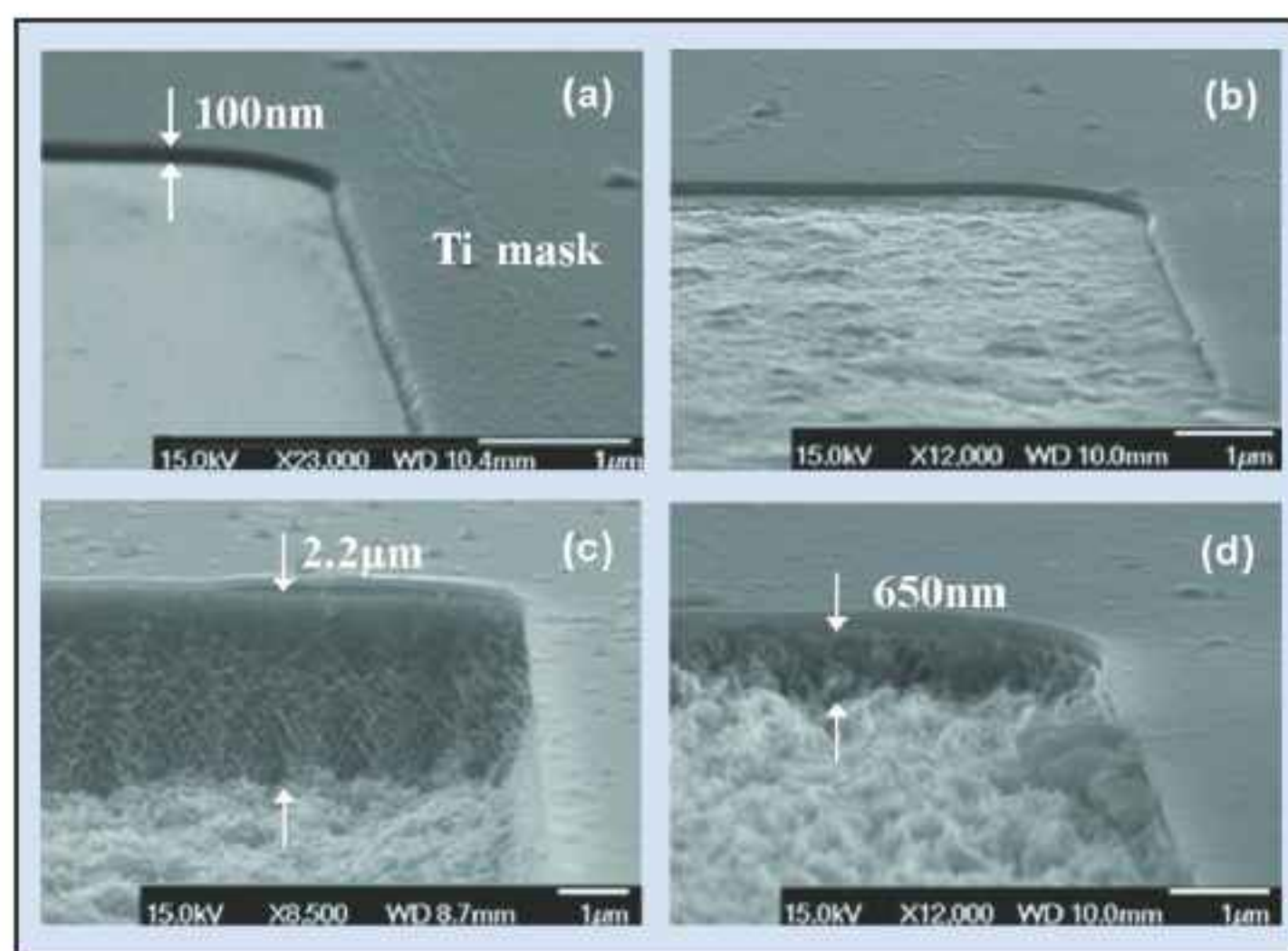


Figure 4. SEM pictures of result of photo-etch process at various stages and under different conditions: Ti patterned GaN sample before etch (a), and when electrochemically etched under illumination at 3.36eV (b), 3.43eV (c), and 3.54eV (d).

excitation sources in these other experiments being more broadband.

The wet etch process actually occurs under a reverse bias that confines holes to the GaN surface where they enable the oxidation of the Ga from the GaN film (Figure 3, right).

Scanning electron microscope (SEM) characterization of the etch results for various frequencies of excitation followed cleaning with a strong KOH solution to remove oxide by-products (Figure 4). The greatest etch depth of 2μm occurred at 3.43eV, while at 3.36eV there was a small amount of roughening of the surface and at 3.54eV the etch process reached down only 650nm.

The researchers investigated the same process with an $\text{Al}_{0.32}\text{Ga}_{0.68}\text{N}$ film with a wider bandgap and found no etching at all at 3.43eV. This selectivity opens up the hope that the process could be useful for processing nitride semiconductors, particularly those requiring optical flatness.

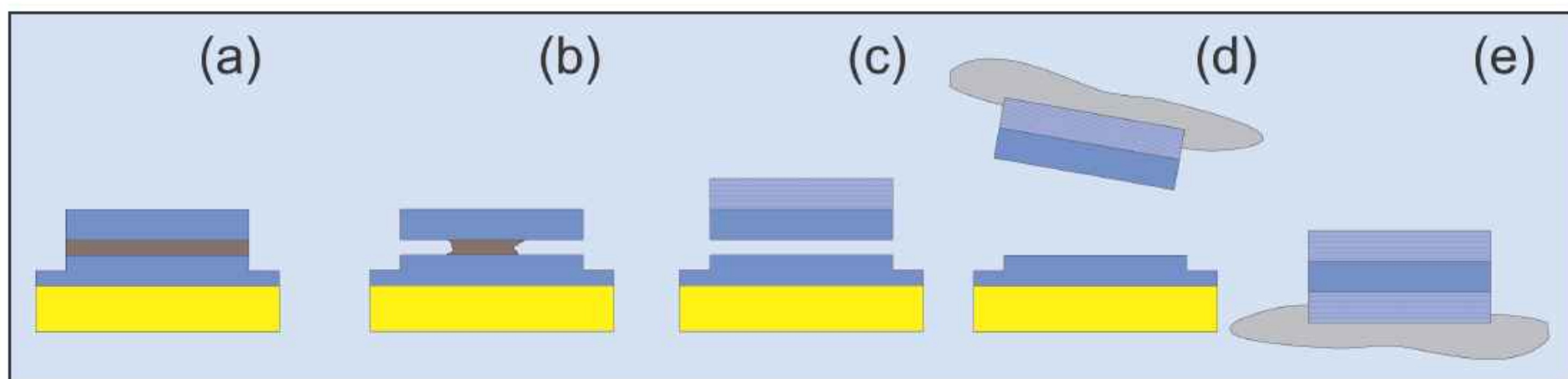


Figure 5. Proposed method for producing distributed Bragg reflectors (DBRs) on a GaN membrane: a mesa is formed using reactive ion etch (a), then an InGaN layer is etched under the top GaN layer using photo-electrochemical method (b), one DBR is then deposited on top of the GaN membrane (c), that is then transferred to carbon tape (d), and flipped to create back-side DBR (e).

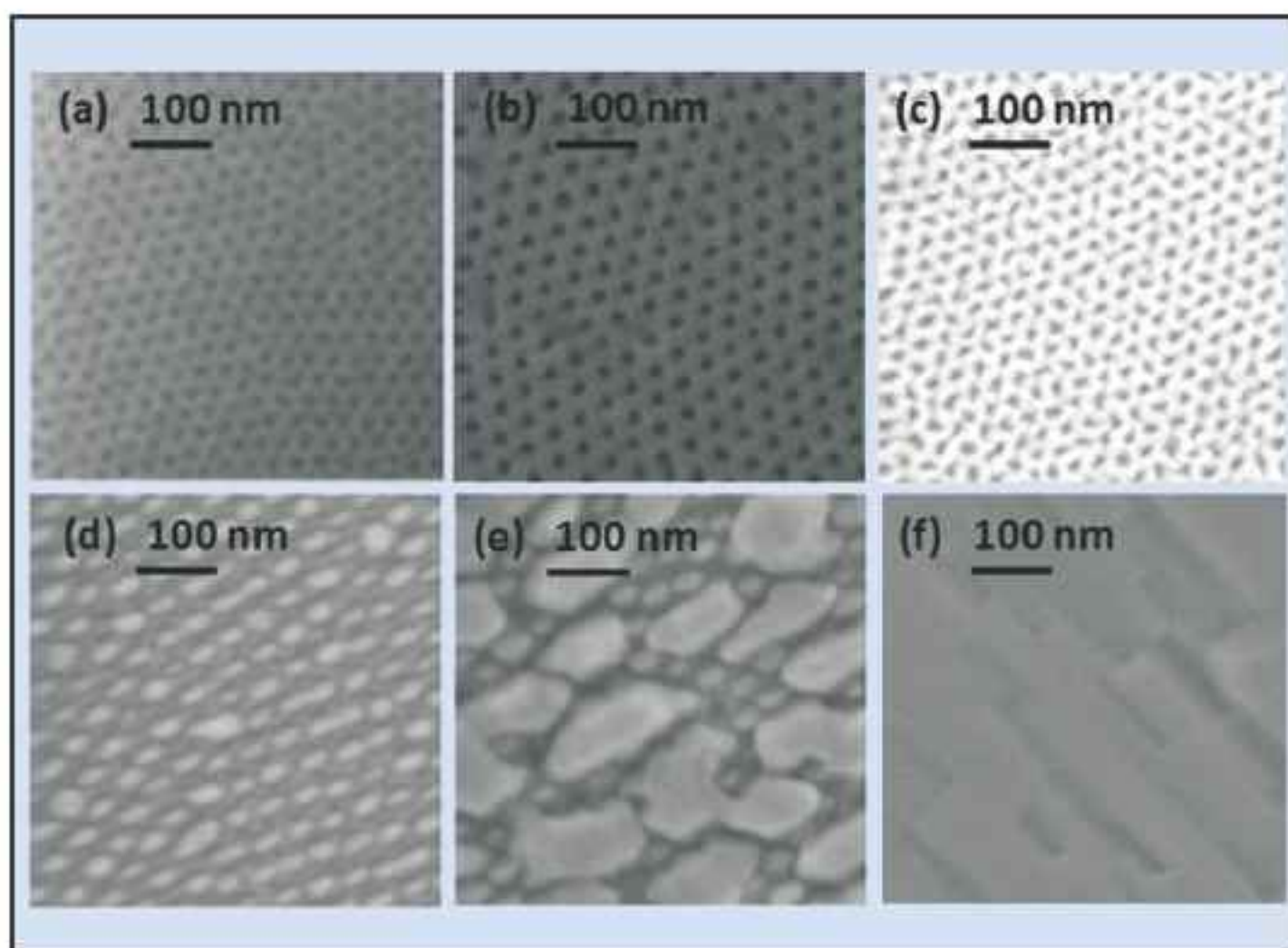


Figure 6. Different stages of using hydroxy-terminated random polystyrene-poly-methyl-meth-acrylate (PS-r-PMMA) copolymer brush material to form hexagonal SiO_2 mask over GaAs substrate (a–c) and then grow 200nm GaSb layer with improved crystal structure (d–f).

A final experiment looked at structures that combined layers of pure GaN with AlGaIn. In particular, GaN was deposited on a 100nm layer of $\text{Al}_{0.2}\text{Ga}_{0.8}\text{N}$. The wet etch with $\sim 3.4\text{eV}$ illumination consumed the GaN layer but stopped when it reached the AlGaIn. Again, a Ti patterned mask was used.

The Crete researchers are also investigating the possibility of creating high quality factor (Q) nitride microcavities using GaN membranes created from etching away narrower-bandgap InGaIn material (Figure 5). It is proposed to form the membranes by etching laterally under mesa structures previously formed by a reactive ion etch. A distributed Bragg reflector would then be deposited on the GaN membrane before transfer to carbon tape. The structure would then be flipped and a second DBR deposited on the other surface of the GaN. A journal article is in preparation describing the formation of the GaN membranes.

The researchers in Crete have been developing the photochemical etch for a while. Last year, they studied the etch technique on separate samples of GaN and AlGaIn [4].

Patterns of development

In mainstream semiconductor production on silicon, etch is used to transfer patterns to the growing layers of device structures. This is less common in compound semiconductor growth, where layer structures are built up using MOCVD or MBE. Device structures (LEDs, lasers, transistors, etc.) are then formed only after all the compound semiconductor layers have been deposited. Even where nanostructures are desired, such as quantum dots, dashes or wires, one generally depends on 'self assembly' to create different regions.

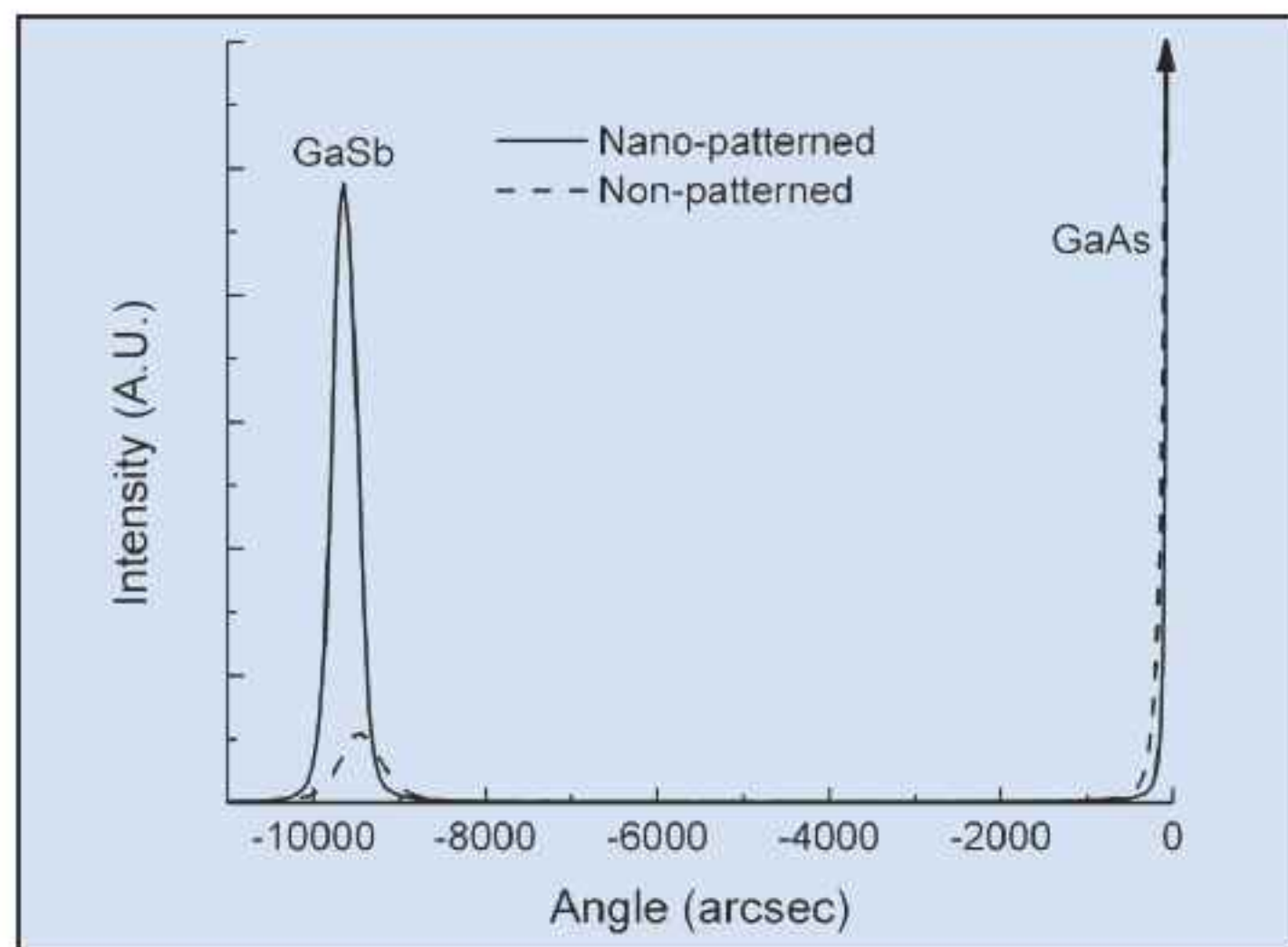


Figure 7. High-resolution x-ray diffraction plot for non-patterned and nano-patterned 200nm GaSb layers grown at 530°C on GaAs substrate. Plots are normalized to give equal peak height for the GaAs signal. The nano-patterned sample shows a higher, narrower peak, indicating better crystal quality.

For example, InAs quantum dots form naturally on a GaAs surface under the correct growth conditions.

One reason for the continuous growth methodology is that it is time consuming (and, in production, costly) to interrupt growth processes for patterning steps. A good reason is therefore needed before a patterning step is considered. Epitaxial lateral overgrowth (ELOG) techniques use windows etched in a layer of material used to block dislocations in nitride semiconductor material from continuing their growth upwards. The dislocations result from the large lattice mismatches ($\sim 15\%$) between sapphire and silicon substrates and the nitride semiconductor material system. GaN material grown from the semiconductor layer exposed by the windows generally exhibits lower dislocation densities.

Researchers at the University of Wisconsin at Madison (UW-Madison) have also used patterning to improve crystal structure for GaSb/GaAs with a poor lattice match ($\sim 8\%$) [5]. These researchers used directed self-assembly of a block copolymer to form a polystyrene mask of $\sim 40\text{nm}$ -pitch hexagonally structured $\sim 20\text{nm}$ holes on silicon dioxide layer on a GaAs wafer (Figure 6). A reactive ion etch using CHF_3/Ar is then used to cut through to the GaAs substrate. The polystyrene was removed using an oxygen plasma. GaSb films grown using tri-ethyl-Ga (TEG) and TE-Sb (TES) on patterned wafers showed improved crystallinity over GaSb films grown using the same process on unpatterned wafers, as shown by high-resolution x-ray diffraction (Figure 7).

UW-Madison has previously used a similar copolymer technique to grow quantum dot structures on InP [6]. Another structuring technique being explored by UW-Madison is to etch through an active layer to create quantum 'boxes' of InGaAs/AlInAs [7].

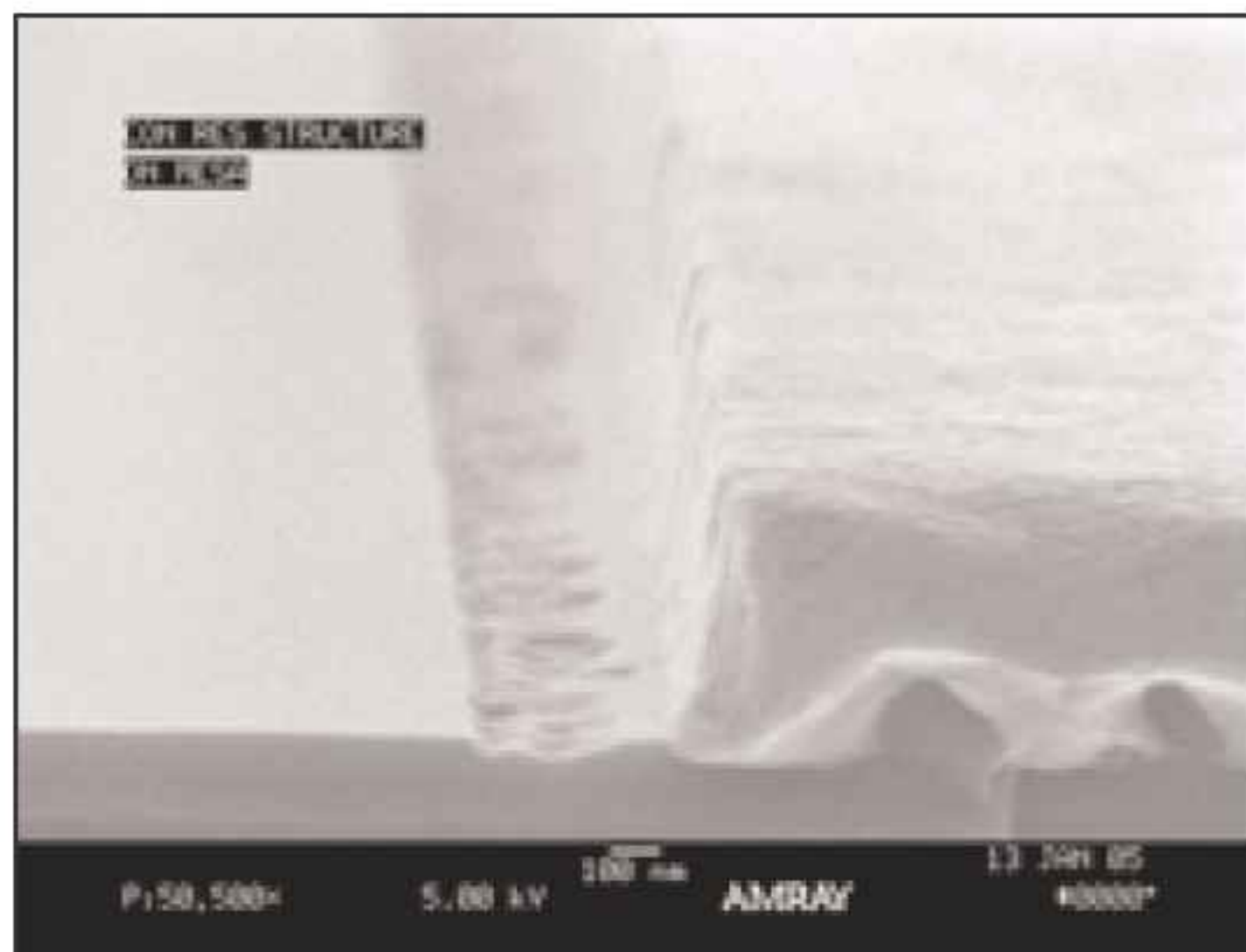


Figure 8. Erosion of n-doped GaAs next to ohmic metal as a result of wet cleaning processes.

Etch not wanted here

Some wet processes cause etching that is not required. Kezia Cheng of Skyworks recently investigated an erosion effect that can occur in producing ohmic contacts (Figure 8) during GaAs transistor production [8]. It is thought that an electrochemical (galvanic) etch effect during wet cleaning processes is the cause. The effect is believed to result from the combination of metals in the contact stack. The erosion tends to cause an increase in contact resistance. In some cases, a two-fold increase in resistance is observed.

Such contacts are typically formed by evaporation of metals onto the wafer, a lift-off process of the excess material, and alloying into the semiconductor material in a thermal process. Cheng carried out tests on three contact recipes: a standard Ni/Au/Ge/Au and a new combination of Ni/Ge/Au that is thermally annealed for alloying in two different ways (Table 1). The wafers used contained AlGaAs/InGaAs/AlGaAs pseudomorphic high-

electron-mobility transistor (pHEMT) device structures.

Apart from the metal deposition and thermal annealing, the wafers were subjected to the same processing steps including three treatments with N-methyl-pyrrolidone (NMP) and deionized water rinse, and one ammonium hydroxide (NH₄OH) dip. NMP is an electrolytic solution with potential for electrochemical action, depending on differences in work function between the metal and semiconductor layers. It is after the wet processes that the lightly annealed group of new ohmic metal showed a two-fold increase in contact resistance (post-gate column, Table 2). SEM inspection indicated that trenching had occurred in this group.

A further round of NMP and ammonium hydroxide processing, before process control monitoring (PCM) resistance measurements, created additional contact resistance degradation for the lightly annealed group A and in addition a significant increase for the traditional metal combination of group C. Meanwhile, the more aggressively annealed group B, showed only a small increase in contact resistance through the process.

Cheng performed various focused ion-beam, scanning transmission electron microscope (STEM) and energy-dispersive X-ray (EDX) inspections to analyze the contacts. A high proportion of NiGeAs grains were observed in the group B samples. The other wafers had large gold grains with a larger work function between the noble metal and GaAs, increasing the erosion effect. Cheng believes that the potential difference between adjacent gold and NiGeAs grains also creates an electrochemical action, reducing the rate of reaction on the GaAs surface. The doping level also has an effect, due to a shift of work function, so that on-mesa (highly doped) erosion is less than that off-mesa (lightly doped).

An unwanted side-effect of the reduced contact resistance was a 29% increase in gate leakage in transistors with the new ohmic metal formulation.

Skyworks is exploring the causes of the higher leakage currents. However, the on-resistance and third-harmonic over control were improved compared to the traditional metal scheme. ■

The author Mike Cooke is a freelance technology journalist.

Table 1. Contact stack alloying conditions and resistivity measurements at various stages of production process.

Group	Alloying		Pre-gate R_{cont} Ω -mm	Post-gate R_{cont} Ω -mm	PCM R_{cont} Ω -mm
	Temp °C	Time sec			
A, new ohmic	380	10	0.21	0.47	0.76
B, new ohmic	420	45	0.18	0.23	0.25
C, control	415	200	0.17	0.27	0.4

Table 2. DC and RF test data on contact stacks.

	R_{on} W	Leakage (I_g) mA	Third harmonic dBc
Control	4.6	0.67	67.53
New ohmic	4.3	0.86	70.29

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(see section 8 for full contact details)

Praxair Electronics

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11 Process monitoring and control

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18 Chip foundry

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United Monolithic Semiconductors

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www.ums-gaas.com

19 Facility equipment

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www.ieee.org/conference/iedm

8-9 December 2009

Solar Turkey

Istanbul, Turkey

E-mail: william.t@greenpowerconferences.com

www.greenpowerconferences.com

10-14 January 2010

IEEE Radio & Wireless Symposium (RWS 2010)

New Orleans, LA, USA

<http://rawcon.org>

20-22 January 2010

10th Fiber Optics Expo (FOE 2010)

Tokyo Big Sight, Japan

E-mail: foe@reedexpo.co.jp

www.foe.jp/en

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E-mail: heidi@newsolartoday.com

www.cpvtoday.com/usa

2-4 February 2010

PHOTON's 5th Photovoltaic Technology Show 2010 USA

San Francisco, CA, USA

E-mail: info@photon-expo.com

www.photon-expo.com

3-5 February 2010

SOLARCON Korea

COEX, Seoul, Korea

E-mail: julee@semi.org

www.solarconkorea.org/SOLARKOREA-EN

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Dublin, Ireland

E-mail: clee@semi.org

www.semi.org/isseurope

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www.ledchina-gz.com/english/syly.asp

3–5 March 2010

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E-mail: pv@reedexpo.co.jp

www.pvexpo.jp

7–9 March 2010

Photovoltaic Fab Manager's Forum

Berlin, Germany

E-mail: semieurope@semi.org

www.semi.org/pvfmf

16–18 March 2010

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http://semiconchina.semi.org/scchina-en

16–18 March 2010

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E-mail: laser@mami-shanghai.com

www.world-of-photonics.net/en/laser-china/start

21–25 March 2010

Optical Fiber Communication Conference and Exposition and National Fiber Optic Engineers Conference (OFC/NFOEC 2010)

San Diego Convention Center, CA, USA

E-mail: info@ofcconference.org

www.ofcnfoec.org

22–24 March 2010

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Austin, TX, USA

E-mail: erica.mcgill@sematech.org

www.sematech.org/meetings/spcc

24–26 March 2010

6th Photovoltaic Science Application and Technology (PVSAT-6) Conference and Exhibition

University of Southampton, UK

E-mail: info@uk-ises.org

www.pvsat.org.uk

29–31 March 2010

Semiconductor and Integrated Opto-Electronics Conference (SIOE'10)

Cardiff University, Wales, UK

E-mail: K.A.Shore@bangor.ac.uk

www.astro.cardiff.ac.uk/research/pm/events/?page=sioe

5–9 April 2010

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Orlando, FL, USA

E-mail: customerservice@spie.org

http://spie.org

5–9 April 2010

2010 MRS Spring Meeting

San Francisco, CA, USA

E-mail: info@mrs.org

www.mrs.org

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Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany

E-mail: info@cpv-conference.org

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8–10 April 2010

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Washington DC, USA

E-mail: swatson@seia.org

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ZAO Expocentr, Moscow, Russia

E-mail: es@expocentr.ru

www.photonics-expo.ru/en

22–23 April 2010

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