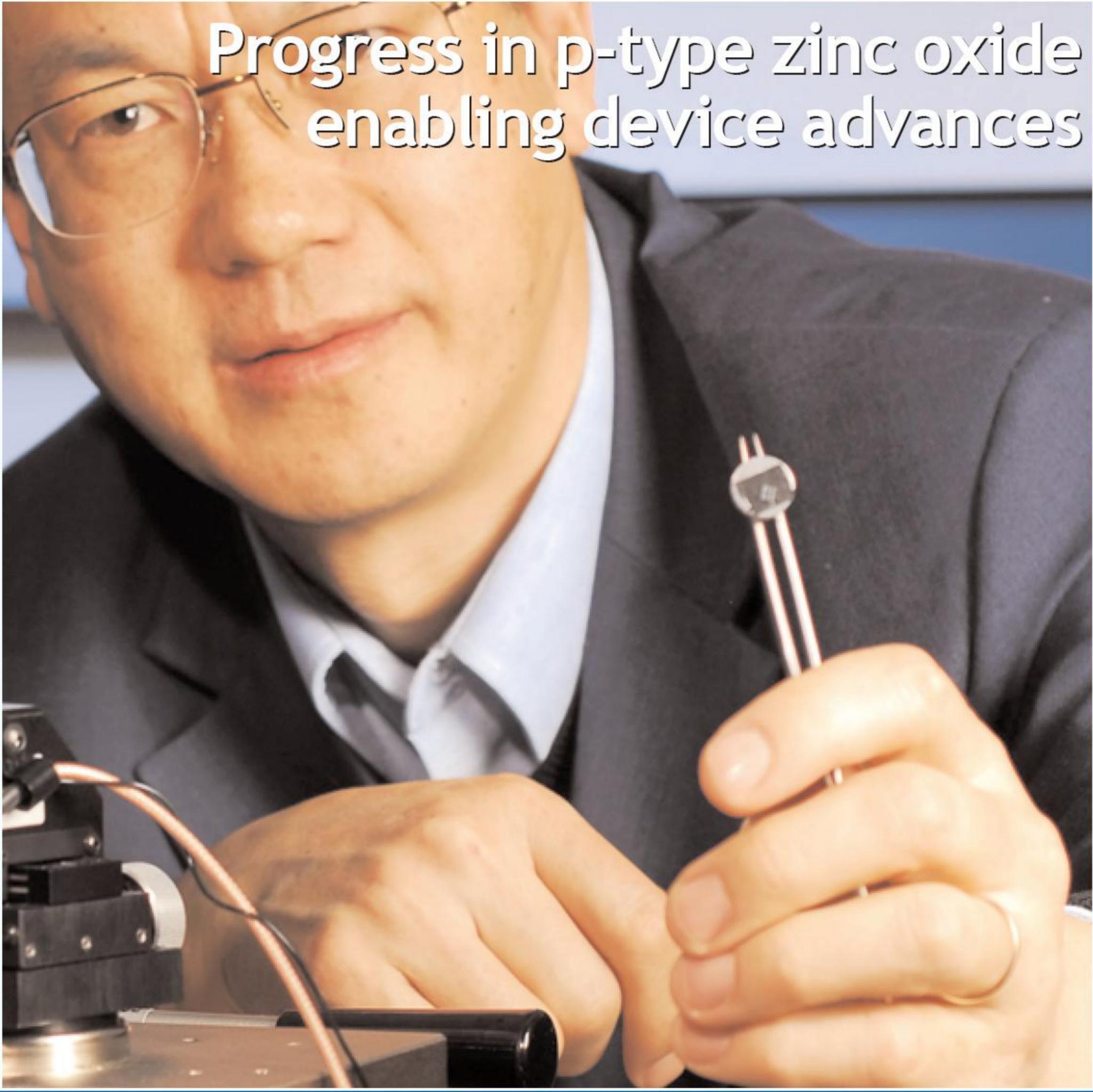


semiconductor **TODAY**

COMPOUNDS & ADVANCED SILICON

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A close-up photograph of a man with glasses, wearing a dark suit jacket over a light blue shirt and a grey tie. He is looking towards the camera with a slight smile. He is holding a metal probe in his right hand, which is positioned over a small, circular component on a device. His left hand is also visible, holding a copper wire. The background is a plain, light-colored wall.

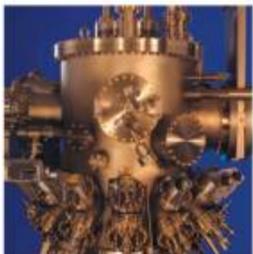
Progress in p-type zinc oxide
enabling device advances

RFMD adds R&D in Shanghai • Cree expands ZMP SiC to 4" LEDs driving MOCVD boom • Osram building Malaysia LED fab

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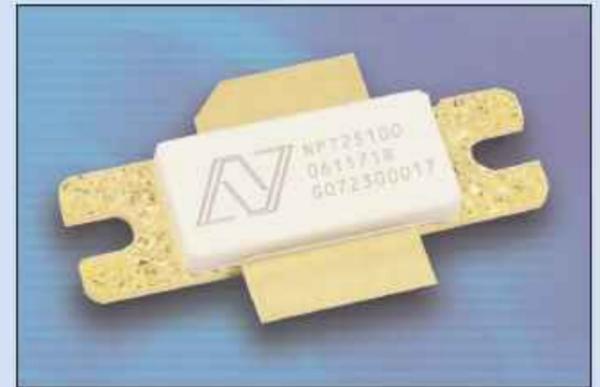
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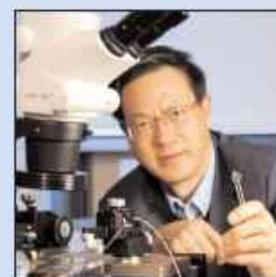
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Cover:

Zhong Lin Wang, a professor at the School of Materials Science and Engineering at the USA's Georgia Institute of Technology, holding

a prototype DC nanogenerator, which produces current through the bending of zinc oxide nanobelts and nanowires. (photos: Gary Meek). **p38**

Inventory correction and consolidation

This issue we report financial results for manufacturers of RFIC and optical communications devices, both of which are prone to current trends of consolidation and inventory correction in their respective markets.

Tallying approximately with data from Strategy Analytics (last issue, page 6), on page 5 IDC reports growth in mobile handset shipments slowing to 10% year-on-year, as well as the increasing consolidation of market share on the top five vendors (with other vendors down almost 12% collectively).

Such consolidation makes trends at the main handset makers increasingly influential for the main RFIC suppliers. So, in Q1/2007, whereas TriQuint and Anadigics continued their prolonged growth periods (thanks to rich product mixes), RFMD and Skyworks (which grew their collective share of the cellular power amplifier market to 71% in 2006) both reported dips in revenue compared to Q4/2006, largely due to inventory correction by Motorola (which comprises 20–30% of revenue for each company). Likewise, there were knock-on effects upstream at the likes of HBT epiwafer supplier Kopin and substrate supplier AXT (see pages 10 & 16, respectively). While all these firms are expecting recoveries in second-half 2007, RFMD and Skyworks are focusing on increasing design wins with new customers and ramping up manufacturing of new products.

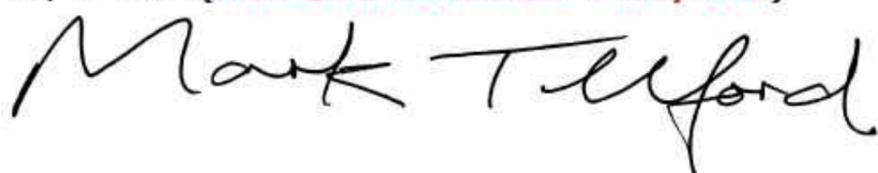
Likewise, in the fiber-optic communications sector, component makers JDSU, Bookham, Avanex, Finisar and Emcore all reported dips in optical communications-related revenues, with all blaming inventory correction and transitions to 'lean inventory' mode at major equipment manufacturing customers (after larger-than-expected inventories were built up in 2006) and, in the case of JDSU, consolidation activity at five of its key customers (see pages 30–33). Again, recoveries are expected in second-half 2007, helped in the case of Bookham by new product ramps, and in the case of Emcore by its diversified technology base (in high-growth broadband CATV and photovoltaic product sectors). In the meantime, all firms are focusing on cost reduction. In particular, joining Bookham (which has already closed or relocated facilities and laid off staff), JDSU has announced a restructuring of its Optical Communications segment, involving cutting 400 jobs.

In contrast, the LED market continues to boom, especially for GaN-based blue LED chip making in Asia. This is driving growth for MOCVD system makers Aixtron and Veeco (see pages 18–19) and expansion by suppliers of both sapphire substrates (Rubicon) and dicing equipment (JPSA) to 4" diameter (pages 21–22).

Likewise, the photovoltaic sector continues to grow rapidly, for example driving growth in AXT's germanium substrate sales for GaAs solar cells (page 16) and attracting continuing investment in development firms developing CIGS-based solar cells (to be covered next issue).

● Also in the next issue, we will return our focus to technology and research, including reporting from May's CS MANTECH conference.

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Regular issues contain:

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 **Thomas Swan**

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Japan & Taiwan LED revenue to slow as China, Korea & Europe speed up

Global blue LED chip capacity rose 8.6% to 3.79bn units in 2006, according to Taiwan's Photonics Industry Technology & Development Association (PIDA) at April's 'Blue 2007 — The Solid State Lighting Suppliers Conference' in Hsinchu Taiwan, reports DigiTimes. Taiwan had the largest blue LED chip capacity (and the greatest growth), followed by Japan, South Korea, China, the US and Europe.

However, in terms of packaged LED value, Japan is largest (\$3.3bn) with Taiwan a distant second

(\$1.3bn) being caught by Europe (after growth of 66% to \$1.1bn), followed by Korea (growing at 22.3%), overtaking the USA (dipping 16%) and China (growing most, at 25.6%).

By 2009, this order will remain, but China will be growing the most year-on-year (27.7%), with the USA second (22.4%), followed by Korea and Europe (15.4% and 14.5%, respectively), while growth in Taiwan and Japan slows (9% and 8%, respectively).

www.pida.org.tw

Packaged LED value, 2005–2009 (\$m) and year-on-year growth.

	2005	2006	2007	2008	2009	2006y/y	2009y/y
China	425	534	695	853	1089	25.6%	27.7%
Taiwan	1164	1313	1445	1589	1732	12.8%	9.0%
Korea	613	750	931	1111	1282	22.3%	15.4%
Europe	666	1106	1181	1350	1546	66.1%	14.5%
USA	845	709	851	1002	1226	-16.1%	22.4%
Japan	2987	3337	3637	3964	4281	11.7%	8.0%
Total	6700	7749	8740	9869	11,156	15.7%	13.0%

Sharp now 6th in handsets

In the April issue (page 6), we reported Strategy Analytics' initial figures for global handset shipments in Q1/2007 growing 12% year-on-year to 252 million units. The market research firm has since revised these figures to 11% growth to 247m units.

While demand was robust in Asia Pacific, Africa and South America, shipments fell across North America, Western Europe, and Central and East Europe. Nokia was top in four out of six regions. Motorola held firm in North and South America. Meanwhile, Sony Ericsson remained a clear number two in Eastern Europe.

Nokia reached its highest ever market share. Motorola remained weak in 3G. Sony Ericsson continued to outgrow all its major rivals, while LG returned to the top slot in CDMA. Among second-tier players, Sharp crept into 6th position for the first time, says Strategy Analytics.

www.strategyanalytics.net

Decline in handset LED market due to backlights to be mitigated by camera flash LED revenue growing at 23%

The market for LEDs in camera flashes will grow at a compound average annual growth rate (CAAGR) of 23% through 2011, forecasts Strategy Analytics in its report 'LED Demand from Cellular Handsets: 2006–2011'. However, overall LED revenues for cellular handsets will decline due to falling average selling prices (ASPs) of LEDs shrinking revenue from backlights from \$1.3bn in 2006 to just over \$984m in 2011 (producing only 63% of total LED revenue from handsets).

"By 2011, 82% of all handsets shipped will include a camera," notes Asif Anwar, director of the Strategy Analytics GaAs service.

"This will drive LED demand for the camera flash function, which will be the only growth market for LED manufacturers [through 2011] — especially as the standard resolution for camera phones will feature 2 megapixel and above:

2 megapixel and higher resolutions will feature in 68% of all camera phones shipped in 2011, driving LED flash demand," adds Stuart Robinson, director of Strategy Analytics' handset component technologies (HCT) service.

However, as camera phone resolutions increase, LED-based flash will face growing competition from Xenon-based flash technology,

which Strategy Analytics estimates had 4% penetration of the market in 2006 in camera phones with a resolution of greater than 2 megapixels.

Strategy Analytics also predicts that there will be an increasing number of LEDs going into handsets for other applications, including indicators for Bluetooth functionality, call alert and personalization. However, the commodity pricing will offset volume demand. Overall LED revenues from the cellular handset market will decline at a negative CAAGR of -1% through 2011.

www.strategyanalytics.net

Handset shipment growth slows to 10% year-on-year, says IDC

IDC's Worldwide Quarterly Mobile Phone Tracker has reported cell-phone shipments of 256.4m units in Q1/2007, down 13.8% on the previous quarter's record shipments (although the decline was expected due to market seasonality).

However, it is also the first quarter of slower year-on-year growth in the mobile phone market: just 10% up on Q1/2006's 233m units (much lower than year-on-year growth of over 20% in each quarter of 2006). This reflects IDC's expectation that, as more subscribers are added to the network, fewer new subscribers are left to be added. So, shipments are increasingly moving from being new handsets for first-time users to replacements for seasoned users; overall growth will continue, but at a slower rate.

"The increase in worldwide phone shipments was driven, in part, by new subscribers in emerging markets and, in part, by replacement sales in mature markets," says Ramon Llamas, research analyst with IDC's Mobile Devices Technology and Trends group. "Since basic voice connectivity and affordability are often the key components of demand in emerging markets, device vendors, appropriately, seek to supply low-cost handsets in these markets, which, in turn, has the unfortunate effect of dragging down device average selling prices (ASPs)," he adds. "To stem the decline in ASPs, device vendors are taking steps to rationalize platforms, improve supply chain logistics, and relocate production to low-cost regions."

Rankings did not change among the top five vendors, but some trends have begun to unfold, says Ryan Reith, research analyst for IDC's Worldwide Mobile Phone Tracker. "Samsung was able to benefit from Motorola's misfortunes by recording a positive sequential

growth in the first quarter, which is uncommon given the effects of seasonality on this industry. While Motorola announced plans to revamp growth, the sudden shift in momentum demonstrates how competitive this industry is and how innovation on product development is essential."

Shipment figures for top-five mobile phone vendors are as below:

- Nokia shipped 91.1m units in Q1/2007 (up 21.3% year-on-year). Shipments into the Middle East, Africa and China were up from the holiday quarter, while Asia/Pacific held steady. Nokia's device ASPs held at €89, stemming the decline it saw in 2006. In the converged mobile device space, Nokia reported record shipments of 11.8m units, citing the success of the N73, N70 and the newly launched E65.
- Motorola shipped 45.4m units (down 1.5% year-on-year) and reported operating losses. The firm is now focusing on recovery. With a restructured management team and new objectives in place, Motorola's mobile device team aims to reverse its fortunes by year end. Motorola hopes its new devices announced or launched during the quarter will drive recovery.
- Samsung bucked the trend by posting shipment growth not only year-on-year (20%) but also sequentially (record 34.8m units).

Fueling this was strong sales of its 'Ultra Edition' handsets, particularly its D900 model and E250 handset. Like other vendors, Samsung is focused on maintaining its double-digit profitability, while becoming more active in emerging markets.

- Sony Ericsson registered the largest year-on-year growth (63.9%, to 21.8m units), citing improvement in Europe, Asia/Pacific and Latin America with its low- and mid-tier portfolio. While it enjoyed double-digit profitability, its strategy to move into lower-tier devices depressed ASPs. To address emerging markets, Sony Ericsson has partnerships with Asian manufacturers Foxconn and Flextronics, as well as an agreement with France's Sagem to provide entry-level devices.

- LG posted an expected seasonal sequential decline in shipments (to 15.8m units) as well as flat growth on a year ago. Improvements in its product mix and WCDMA growth helped boost operating margins (compared to negative profitability a year ago). After success with its Black Label Chocolate series, LG aims for success with more premium devices, including its Shine and digital multimedia broadcast devices.

Other vendors totalled 47.5m shipments, down 11.9% year-on-year, evidencing the increased consolidation of the handset market.

www.idc.com

Shipments (in millions) and market shares for Q1/2007 vs 2006.

Vendor	Q1/06		Q1/07		Change
Nokia	75.1	32.2%	91.1	35.5%	21.3%
Motorola	46.1	19.8%	45.4	17.7%	-1.5%
Samsung	29.0	12.4%	34.8	13.6%	20%
Sony Ericsson	13.3	5.7%	21.8	8.5%	63.9%
LG Electronics	15.6	6.7%	15.8	6.2%	1.3%
Others	53.9	23.1%	47.5	18.5%	-11.9%
Total	233.0		256.4		10%

Vendor shipments are branded shipments, excluding OEM sales.

Anadigics launches Linear EDGE PA

Anadigics has launched the AWT6172 quad-band GPRS/EDGE power amplifier module designed for the Linear EDGE architecture adopted by several base-band chipset suppliers (for 2.75G and 3G cell phones, PDAs, and wireless PC cards that use the global GSM/EDGE cellular standard).

Anadigics has also launched products for the Polar EDGE architecture adopted by top-tier 3G chipset suppliers. But the new Linear EDGE PA extends Anadigics' reach beyond Polar EDGE and WEDGE markets, says Dr Ali Khatibzadeh, general manager of Wireless Products. "It will also enable us to participate in the other segment of the 3G market served by chipset suppliers using the linear EDGE architecture." The EDGE standard has been adopted by most GSM operators either in combination with UMTS WCDMA (3G) or as a stand-alone upgrade (2.75G) to the GSM/GRPS (2.5G) system, and there are two predominant hardware architectures adopted by base-band chipset suppliers serving the EDGE market: Polar and Linear.

Fabricated using InGaP-Plus HBT technology, the AWT6172 has a 6mm x 6mm x 1.1mm package, is enhanced GPRS capable (class 12) and supports operation in the GSM850, GSM900, DCS and PCS bands. It delivers efficiencies of up to 55% in GMSK mode for longer talk-time, with a linearity of 64dBc adjacent channel power ratio (ACPR) at 28.5dBm output power level. Saturated output power in GMSK mode is rated at +35dBm in GSM850/900 bands and +33dBm in DCS/PCS bands, with efficiencies of 55% and 50%, respectively, for the two bands. Comparable numbers for EDGE linear power are +28.5dBm and +27.5dBm for GSM850/900 and DCS bands, respectively.

www.anadigics.com

GaAs devices to grow to \$5bn by 2011, driven by cellular handset and Wi-Fi

In its annual five-year outlook for the GaAs microelectronics industry "GaAs Industry Forecast: 2006-2011", market research firm Strategy Analytics forecasts a compound annual growth rate (CAAGR) of 12%, from \$3bn in 2006 to over \$5bn by 2011.

The main driver will be wireless applications, comprising 79% of total GaAs MMIC demand in 2011. Cellular handsets will remain the largest market for GaAs devices, while Wi-Fi will emerge as the second largest from 2007.

"We are seeing a variety of power amplifier (PA) approaches applied in the cellular handset front-end, ranging from PA, PA-switch and PA-filter modules," says Asif Anwar, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies service. "Regardless of approach, we believe that GaAs HBTs will rule the PA, with silicon LDMOS continuing to lose market share."

"GaAs device demand from the Wi-Fi market will grow at a CAAGR of 28% through 2011," adds Stephen Entwistle, VP of the Strategic Technologies Practice at Strategy Analytics. "GaAs will govern PA functions as the market moves to 802.11n. GaAs HBT PAs and GaAs pHEMT switches will also dominate Wi-Fi PA-switch modules."

GaAs device demand from non-wireless applications, including consumer (CATV and DBS), millimeter-wave and fiber-optic markets, will also grow, at CAAGRs ranging from 6% to 11% through 2011.

Strategy Analytics also reckons that the market for GaAs substrates is expected to grow to \$480m by 2011. The vertical gradient freeze (VGF) growth method will be the main technology for manufacturing bulk substrates, while epiwafer growth will remain evenly split between MOCVD and MBE technologies.

www.strategyanalytics.com

RFMD and Skyworks gain share in handset PAs: consolidation likely

RF Micro Devices and Skyworks increased their combined share of the cellular terminal power amplifier (PA) market from an estimated 65% share in 2005 to 71% in 2006, reckons market research firm Strategy Analytics.

According to Chris Taylor, director of its RF & Wireless Component service, "The move to multi-band, multi-mode EDGE and 3G handsets has accelerated the pace of product development for PA suppliers, who now have to have expertise in linearization and system optimization, RF switching, filters, power conditioning and packaging — as well as power amplification — to play in this market."

Below the top two, TriQuint and Anadigics gained share, while most

of the other players either maintained or lost ground. Asif Anwar, director of the Strategy Analytics GaAs and Compound Semiconductor service, adds that the market share growth of the top players came at the expense of several lower-share players, at least three of which withdrew from the PA market from late 2005 through 2006.

The PA vendor population has dropped from 24 suppliers in 2002 to about 16 in 2006. It appears likely that slim margins and the torrid pace of product development will force several more lower-share suppliers to strike deals with competitors or withdraw from the PA market entirely over the next two to three years, reckons Strategy Analytics.

www.strategyanalytics.com

WJ loss prolonged by late fab closure & product qualification

For Q1/2007, WJ Communications Inc of San Jose, CA, USA, which designs and supplies wireless infrastructure RFICs and multi-chip modules as well as RFID reader modules, has reported revenue of \$10.8m. This is down from \$11.3m in Q4/2006 and \$12.3m a year ago.

Operating expenses have risen from \$8.2m in Q4/2006 to \$9.5m due to increased R&D spending related to the acceleration of new product introductions and the operation of WJ's 4" GaAs fab in Milpitas, CA being extended longer than originally planned before its eventual closure at the end of March (completing WJ's transition to a fabless business model). WJ acquired the fab in its June 2004 acquisition of EiC Corp's wireless infrastructure business, and had at one stage planned to close it by mid-January.

Correspondingly, net loss has risen from \$2.9m in Q4/2006 to \$4.6m in Q1/2007 (including \$0.9m of stock compensation expenses). Gross margin has fallen from 50.2% a year ago and 45.0% in Q4/2006 to 42.7% in Q1/2007. However, this was due to the reduced utilization of the fab during the close-down process and the delayed qualification by a customer for cost-reduced parts that were originally anticipated in the quarter.

"The closure of our wafer manufacturing facility [which should yield annualized cost savings of \$4-5m] represented an end to a period of transition for WJ that began in late 2005," says president and CEO Bruce Diamond. "With the last step in that process now complete, we are able to further focus our resources on our core competencies, including the aggressive introduction of new products and technologies in each of our target markets."

WJ is on schedule to launch 15 new products in first-half 2007, with eight sampled during Q1.

"Following the successful implementation of a number of key initiatives over the last 18

months, we believe our business is at a positive inflection point," says Diamond. "We enter the second quarter with our highest ever OEM backlog, solid traction and a strong pipeline of business, and we expect revenue for the second quarter to increase sequentially 7-11%."

● WJ has added Angelos J. Dassios, a principal of San Francisco-based private equity firm Fox Paine

We are able to further focus our resources on our core competencies, including the aggressive introduction of new products

Management III LLC, to its board of directors.

Dassios was previously with Goldman, Sachs & Co in the Investment Banking Division and the Principal Investment Area. He is a graduate of Dartmouth College and was formerly on the board of directors of United America Indemnity Ltd. "His familiarity with WJ's business, coupled with his strong experience in business and finance, will assist WJ in further improving the company's growth and profitability," says Diamond.

● WJ has launched the WJA family of InGaP/GaAs HBT-based active-bias broadband amplifiers. Operating frequencies of 50-4000MHz and a mix of power gain (up to 20dB), high linearity (output IP3 of 35-43dBm) and low current consumption (60-90mA) from a +5V supply suits next-generation cellular (CDMA, GSM/GPRS/EDGE, W-CDMA, and WiMAX) infrastructure and CATV applications.

The first RF (WJA10xx) and IF (WJA15xx) series are available in a small SOT-89 surface-mount (SMT) package. The 50Ω internally matched amplifiers minimize the use of external components, simplifying system integration. Integrated active bias circuitry minimizes variations in linearity and current draw due to temperature.

www.wj.com

Fabless Hittite continues growth and product launches

Fabless firm Hittite Microwave Corp of Chelmsford, MA, USA, which designs ICs, modules and subsystems for RF, microwave and millimeter-wave applications, has reported Q1/2007 revenue of \$36.3m, up 2.6% on Q4/2006's \$35.4m and 30.4% on \$27.9m a year ago.

Gross margin has risen from 70.8% in Q4/2006 to 71.3%.

Net income was \$12.0m, roughly level with \$12.1m in Q4/2006 but up 36% on \$8.8m a year ago. Cash reserves have risen from \$83.8m to \$127.7m.

"We see expanding customer acceptance of our existing and new products in all our target markets," says chairman and CEO Stephen Daly. "Our product development

team continues to execute, and during the quarter we introduced 21 new products, including our first pure silicon CMOS product for the broadband market."

For Q2, Hittite expects sales to rise slightly again, to \$36.5-37.5m, and net income to be \$11.9-12.5m (roughly level with Q1).

www.hittite.com

Motorola inventory correction hits RFMD and Skyworks; TriQuint and Anadigics make gains due to product mix

Motorola inventory correction hits RFMD's March/June quarters

For its fiscal 2007 (to end-March), RF Micro Devices Inc of Greensboro, NC, USA reported record revenue of \$1.023bn (up 33% on fiscal 2006) and income of \$83m (up from \$16m) reflecting 'unit volume strength at leading handset makers'.

However, fiscal Q4 revenue was 'just' \$257.3m (down 8.5% on Q3's \$281m). Net income was \$30.1m (down from a profit of \$59.3m).

A downturn in orders at Motorola's handset division and a build-up of excess component inventories (coupled with high per-unit dollar content) are impacting RFMD's near-term results. But, longer term, RFMD says it will benefit as handset inventories are reduced and as forecasts and shipments increase.

RFMD forecasts June-quarter sales of \$215-230m (down 9-16%), due to a volume reduction at its lead POLARIS RF solution customer. However, follow-on, multi-year platform opportunities have been won with this customer, for which growth should return in the September quarter. Also, RFMD's next-generation POLARIS 3 RF solution is on track to ramp in second-half 2007, which should expand the customer base and transition an additional top-tier handset customer into a 'higher-dollar-content status'.

Also, RFMD expects to increase its dollar content at customers other than Motorola [particularly Nokia] through increased sales of not only complete RF solutions but also complementary components for cellular front ends and other high-growth markets.

"RFMD is winning opportunities to grow its dollar content in mobile devices as they increase in complexity and require

additional high-performance RF content," says president and CEO Bob Bruggeworth. In the June quarter RFMD expects a growth in sales of GaAs pHEMT cellular switches, as well as the product launch of its GaAs pHEMT multi-market low-noise amplifiers (LNAs). Bruggeworth claims that RFMD's investments in transceivers, pHEMT switches, filters, DC-to-DC converters, integrated shielding, MEMS switches, module assembly, wafer manufacturing and systems-level expertise have positioned the firm to help its customers and channel partners to eliminate complexity, improve performance, reduce costs and speed time to market.

RFMD expects growth in fiscal 2008, driven by sales of GaN devices, wireless LAN front ends, and GPS solutions

RFMD expects modest sequential quarterly revenue growth to resume in the September quarter and to continue through the remainder of 2007, followed by an acceleration of growth in 2008 as existing design wins ramp in multiple markets.

Beyond core cellular markets, RFMD expects high-margin, diversified revenue growth in fiscal 2008, driven by sales of the firm's GaN devices, wireless LAN front ends, GPS solutions and multi-market products. In the March quarter RFMD grew sales of wireless LAN front ends and expects sequential growth in the June quarter.

The firm also experienced greater GPS-related design activity with leading mobile device makers. RFMD also started to ship GaN devices to a top-tier military supplier, and expects additional shipments and customer orders in the June quarter. "RFMD is aggressively investing in opportunities for diversified growth and evaluating strategic options to bolster revenue and earnings contribution," says Bruggeworth.

RFMD's balance sheet was boosted by its recent \$375m convertible note offering, which will help it to both streamline the supply chain in its cellular business and jumpstart its diversification efforts, reckons CFO Dean Priddy.

www.rfmd.com

RFMD expands Shanghai facility to include R&D

RFMD has added an R&D center in its facility in Shanghai's Zhanjiang High-Tech Park.

The new center will expand RFMD's product development capacity to support original design manufacturers (ODMs), original equipment manufacturers (OEMs) and local and international handset makers throughout the Far East. Increasing RFMD's internal design capacity of front-end solutions and transceivers will allow improved

design cycle times and reduced manufacturing and shipping costs to customers, the firm says.

"RFMD's continued expansion into the Greater China market demonstrates our focus on supporting the local manufacturers in this territory," says Greg Thompson, VP of worldwide sales and applications engineering. "This new location will expand our R&D efforts, while strengthening RFMD's operations across Greater China as a complete

source for design, manufacturing, supply chain, sales and field applications engineering support."

RFMD investment in Greater China already includes a sales and customer support center in Shenzhen, a module assembly facility as well as test and tape & reel facility in Beijing, a customer support center in Shanghai, and a sales and customer support center in Taipei, Taiwan. RFMD employs more than 1000 people in the region.

Skyworks hit by Motorola slump, but income triples year-on-year after baseband disposal

For fiscal Q2/2007 (to end March) Skyworks Solutions Inc of Woburn, MA reported revenue of \$180.2m, up 5% on core revenue of \$172.3m a year ago (though down 2.7% from \$185.2m including baseband products, discontinued in October). However, revenue is down 8% sequentially on \$196m in the quarter to end December, as Skyworks has also been hit by falling orders from Motorola (which accounts for 20–25% of Skyworks' revenue).

Nevertheless, due to exiting the loss-making baseband business, on a pro forma basis (excluding exit charges), Skyworks has seen a rise in operating income from \$6.7m a year ago to \$17.6m, and in net income from \$4.6m to \$16.7m

"Skyworks' second fiscal quarter results demonstrate the strength of our new business model and reflects our efforts since exiting the baseband product area two quarters ago," says president and CEO David J. Aldrich. "We have since focused exclusively on our core analog and RF businesses and have improved profitability more than three-fold year over year," he adds. "Our earnings leverage will become even more evident as we ramp several key, high-profile programs over the next several months."

During the quarter, Skyworks received production orders for a front-end solution in support of a 'forthcoming multimedia, music platform' [possibly Apple's iPhone]; powered several popular models with Helios (including LG's GPRS Chocolate series and Samsung's ultra-slim EDGE Trace); and unveiled the Helios WEDGE transceiver (the industry's first single-chip all-CMOS radio solution that eliminates the need for interstage filters). Skyworks also expanded its Linear Products portfolio with 15 new products, including CMOS switches, high-performance gain blocks and personal area networking solutions targeting broadband, infrastructure, medical, and auto-

motive applications.

Consequently, Skyworks' June-quarter guidance is less affected by weakness at Motorola than expected. "Following the short-term digestion of Motorola's inventory, new wins with Motorola, Samsung, LG, and Ericsson are expected to drive both revenue and earnings growth in the coming quarters," the firm says. For its fiscal Q3, Skyworks expects that several of its new product ramps will largely offset the weakness at Motorola.

● During the quarter, Skyworks raised \$200m via a convertible debt offering, redeemed \$130m of short-term debt, and repurchased 4.3m shares of common stock.

www.skyworksinc.com

TriQuint boosted by new top-five handset customer

For Q1/2007, TriQuint Semiconductor Inc of Hillsboro, OR, USA has reported better-than-seasonal revenues of \$110.6m, roughly level with the prior quarter's \$114.3m but up 26% on \$87.9m a year ago (and slightly above the firm's \$106–110m guidance).

Revenues by application comprised handsets (53%), networks (35%) and military (12%).

As a proportion of handset revenue, by primary product, power amplifiers and PA modules have risen from 52% in Q3/2006 to 67% in Q4 and now 74% while RF filters and front-end modules have fallen from 25% to 19% and now 16%.

According to president and CEO Ralph Quinsey, the favorable product mix and improved yields on high-volume handset products has led to gross margin rising from 29.9% in Q4/2006 to 31.6%, and earnings rising from \$2.2m in Q4/2006 to \$6.4m (above the midpoint of the firm's guidance).

During Q1/2007, TriQuint began shipments of power amplifier modules to a new top-five handset customer, and reported a record number of new handset design wins. The firm also booked \$7.4m in R&D, supported by military and other contracts, mostly from year three of its DARPA GaN develop-

ment project "We recorded strong design win activity for handset products in the quarter, increased revenue in the space market and continued strong quote activity in the military market," summarizes Quinsey.

For Q2/2007, TriQuint expects revenue to be flat to slightly up on Q1.

www.triquint.com

Anadigics maintains 40% growth and cuts losses after shedding fiber-optic subsidiary

Anadigics Inc of Warren, NJ, USA has reported Q1/2007 net sales of \$49.6m, up 2.3% on the prior quarter and up 43% on \$34.7m a year ago.

Excluding a loss of \$965,000 from the discontinued fiber-optic subsidiary Telcom Devices Inc (which was sold in April), the loss from continuing operations was \$196,000 (reduced from \$4.3m a year ago). Pro forma income from continuing operations (excluding non-cash stock compensation expense) was \$3.7m (compared to a loss of \$2.9m a year ago).

At the end of the quarter, cash reserves were \$179.2m, up from \$83.5m at the end of December, mainly due to the proceeds of a public offering of common stock completed in mid-March.

"We are positioned for growth in the attractive broadband wireless and wireline markets, and have announced our plans [in early April] to jointly build, with Kunshan New and Hi-Tech Industrial Development Zone, the first world-class GaAs wafer fab in China [to be operational in first-half 2009]," says Dr Bami Bastani, president and CEO.

"Our continued improving financial results highlight a richer product mix," says chief financial officer Tom Shields. "The focus on core products balanced with continued strong market demand is expected to further strengthen our financial leverage," he adds.

Sales for Q2/2007 are expected to grow 5–7% sequentially (and up 33–35% year-on-year for continuing operations).

www.anadigics.com

Anadigics appoints broadband cable expert to board...

Anadigics Inc of Warren, NJ, USA has elected David Fellows to its board. Since January, Fellows has been executive VP and executive fellow with Comcast Cable (a US provider of cable, entertainment and communications products and services), advising on technology matters (after being CTO from 2003 to 2006). From December 2001 until its acquisition by Comcast in 2003 he was CTO at ATT Broadband.

Fellows has been instrumental in defining future cable networks, including implementing a nationwide IP platform that enables a converged network for voice, video and data, says CEO Bami Bastani. "I'm sure he will provide valuable insight to Anadigics broadband strategy."

...and launches RF amp for CATV

Anadigics has launched the ABA3130 single-chip, low-noise, high-linearity RF amplifier with integrated gain control, the latest addition to its portfolio of RF products for cable TV front-ends. Designed to replace discrete solutions, the fully integrated ABA3130 can improve receiver performance in cable TV digital set-top boxes and analog and digital TVs, the firm claims.

To ensure compatibility with tuners being developed for the upgrade to 1GHz cable systems being rolled out globally, the ABA3130 features wideband operation of 50MHz to 1.1GHz. Anadigics says it is already shipping the part to a leading cable box manufacturer.

"According to In-Stat market research, sales of cable set-top boxes increased nearly 80% between 2005 and 2006, to 27.5m units worldwide," says Ron Michels, Anadigics' senior VP and general manager of Broadband Products. "As integrated tuners continue to penetrate this market, we anticipate an increase in the need for companion products."

www.anadigics.com

Kopin expects HBT recovery in H2/2007

For Q1/2007, Kopin Corp of Taunton, MA, USA has reported revenue of \$18.1m, down from \$18.7m a year ago but up slightly from \$17.9m last quarter.

Counteracting CyberDisplay revenues rising from \$5.9m a year ago to \$9.0m, III-V revenues (GaAs-based HBT epiwafers) of \$9.1m are down on \$12.8m a year ago. "While sales of our III-V prod-

ucts were affected by industry softness in the first quarter, we expect our HBT product revenue to trend positively over the course of 2007,

Sales of our III-V products were affected by industry softness... customers continued their migration to InGaP transistors

particularly in the second half of the year," says chairman and CEO Dr John C.C. Fan. "Our integrated circuit customers continued their migration to InGaP transistors, the new generation of HBT structures for advanced wireless handsets... the transition to InGaP transistors is accelerating," Fan adds. "To meet the anticipated demand, we have been increasing capacity both in Taunton and at our Taiwanese OEM. Two new large-capacity machines are already beginning initial production, and we remain on track to increase capacity by 50% in the second half of this year."

Kopin remains on track to achieve its 2007 revenue guidance of \$80-90m (up 12-27% on 2006), with most coming in second-half 2007, says Fan.

www.kopin.com

Kopin granted stay of delisting by Nasdaq while it restates results

Like its results for Q4/2006 and full-year 2006, Kopin's Q1/2007 results are preliminary. The firm has been unable to file the corresponding form 10-K and 10-Q financial reports with the Securities and Exchange Commission on time. This is due to the firm's voluntary review of its past stock option granting practices by an independent special investigative committee appointed by the board of directors (assisted by legal and accounting experts).

On 3 May, the committee issued its preliminary findings that some of the 34 grant dates between 1995 and 2006 were dated incorrectly (mostly due to administrative delay between approval and allocation of options, but in certain cases due to the selection of earlier

grant dates). However, the committee uncovered no information indicating that anyone acted with conscious recognition that the backward selection of grant prices would violate any plan provision or would require the firm to incur compensation expense as a result. Nevertheless, Kopin will need to restate certain financial statements for fiscal years 1995 through 2006 and the related interim periods.

Subsequently, on 15 May, the Nasdaq Listing and Hearing Review Council stayed the delisting of Kopin's common stock on The Nasdaq Stock Market until the firm's situation can be further reviewed. Kopin has been given until 1 June to provide more information to support its request for a stay of its delisting.

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IN BRIEF

Northrop awards Gold Subcontractor Status to IQE-RF

US defense contractor Northrop Grumman's Space Technology Group (NGST) of Redondo Beach, CA, USA has awarded Gold Subcontractor Status to IQE-RF of Somerset, NJ, USA (formerly the electronic materials division of Emcore but now a wholly owned subsidiary of epiwafer foundry IQE plc of Cardiff, UK).

The award from NGST is in recognition of the service level provided by IQE-RF in terms of timely deliveries, reporting quality, and the overall customer relationship.

IQE-RF uses MOCVD to manufacture products including gallium nitride high-electron-mobility transistors (HEMTs) on both silicon carbide and silicon substrates, InGaP heterojunction bipolar transistors (HBTs), and GaAs-based BiFETs (bipolar field-effect transistors), complementing IQE's products manufactured elsewhere, such as pseudomorphic HEMTs (pHEMTs), optoelectronic materials and photovoltaics.

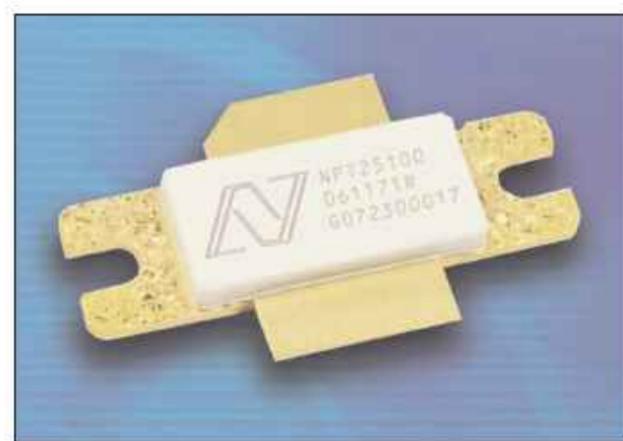
In March 2005 Northrop Grumman was awarded a three-year, \$16.5m contract from the US Defense Advanced Research Projects Agency (DARPA) to develop millimeter-wave GaN HEMTs on SiC substrates as part of the initiative 'Wide Band Gap Semiconductors for Radio Frequency Applications' (military space communication and radar systems). "IQE's technical findings, coupled with our research, continues to push the program towards its ultimate goal [to produce a Q-band (>40GHz) amplifier module with a continuous-wave power output of 20W]," says Northrop Grumman.

www.iqep.com

Nitronex launches 100W GaN-on-Si HEMT power transistor for WiMAX

Nitronex of Durham, NC, USA, which manufactures RF power transistors for commercial wireless infrastructure, broadband and military markets based on GaN-on-silicon, has developed a 28V, 100W GaN HEMT (exhibited at the IEEE MTT-S event, in Honolulu, Hawaii, 3-7 June).

Designed using Nitronex's SIGANTIC NRF1 process, the NPT25100 power transistor is targeted at 2.3-2.7GHz WiMAX applications. Typical performance is rated using a mobile WiMAX waveform digital modulation scheme defined as a single-carrier OFDM (orthogonal frequency-division multiplexing) signal 64-QAM 3/4, 8-burst, 3.5MHz channel bandwidth, and 10.3dB PAR (peak-to-average ratio) at 0.01% probability on CCDF (complementary cumulative distribution function). Under these test conditions, the NPT25100 will deliver 14.5dB of gain (typical), 21% efficiency, and less than 2.5% EVM (error vector magnitude) — all at greater than 10W of power.



Nitronex's 100W GaN-on-silicon NPT25100 power transistor.

"The market for 2.5GHz WiMAX solutions is accelerating and the NPT25100 HEMT device will deliver the kind of price and performance our customers need," says VP of sales & marketing Chris Rauh.

The NPT25100 is packaged in a thermally enhanced copper moly copper package that will be offered in both bolt-down and pill versions. Samples and application boards will be available from June and full production qualification is expected in July. The 1000-piece suggested price is \$90.

www.nitronex.com

Anadigics' CEO joins Nitronex board

Nitronex has added Bami Bastani (president and CEO of GaAs-based RFIC maker Anadigics Inc of Warren, NJ, USA since 1998) to its board of directors.

"Nitronex's recent expansion of its GaN-on-Si R&D and manufacturing operations has solidified it as the leader in GaN-on-Si power device technology," says Bastani. "Nitronex is well positioned to continue its new product development and ramp-up of volume production of its GaN-on-Si power transistors that meet the demand of cellular, broadband and WiMAX markets."

Bastani is a member of the board of directors for Glowpoint Inc, and is on the advisory boards for Electrical Engineering at Ohio State University, and the College of



Engineering at the University of Arkansas. In the past, Bastani has served on the board of directors for GlobespanVirata (GSPN) of Red Bank, NJ (a provider of

DSL & Wi-Fi Chipset solutions, until its merger with Conexant).

Bastani was previously executive VP for the System LSI Group at Fujitsu Microelectronics and (at National Semiconductors) VP and general manager for the Embedded Technologies Division and the Memory Products Division, as well as VP of Technology Development.



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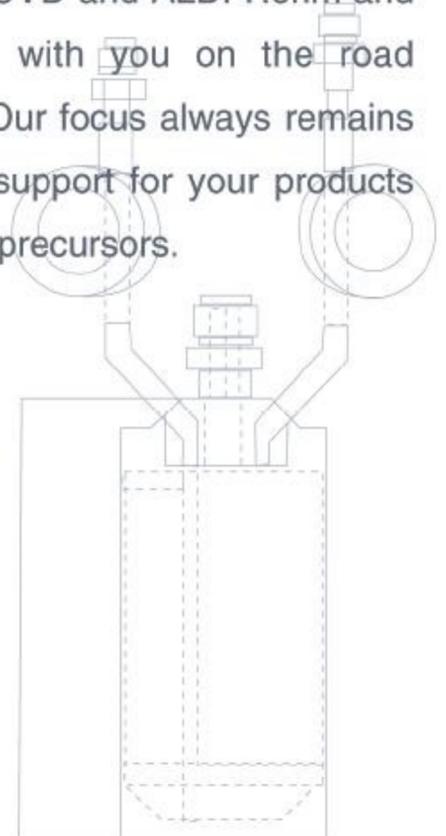
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SOITEC enters pause in growth

For its fiscal Q4/2006–2007 (to end March), SOITEC of Bernin, France, which makes engineered substrates such as silicon-on-insulator and strained SOI (sSOI), reported revenue of €97.1m, up 25.6% year-on-year (following growth of 67.1%, 41.5% then 40.4% in Q1, Q2 and Q3, respectively). However, this is down slightly on the Q3's €99.6m due to the US dollar weakening against the Euro.

SOITEC's epiwafer foundry subsidiary Picogiga recorded modest sequential sales growth, to €1.7m.

For full-year fiscal 2006–2007, SOITEC's sales were a record €372.0m, up 41.5% on the prior year's €262.8m (despite the dollar weakening by 4.6% against the Euro during the year), due to the adoption of SOI in consumer markets. Wafer sales rose by 42.7% to €358.9m, driven mainly by 72.9% growth in 300mm SOI wafers (to 69% of total wafer sales). Sales of other diameters (mainly 200mm) grew 13.5%. Picogiga contributed €8.7m.

Compared to the previous year, gross profit rose by more 50% to €108.1m, due to the greater sales volumes, controlled selling prices, and continued improvements in manufacturing efficiency. Net income more than doubled to €46.2m.

As the supply chain continues to absorb excess inventories at main customers, amid short-term uncertainty over demand SOITEC remains cautious, particularly for Q1 (to end June), and anticipates a flat first-half fiscal 2007–2008. So, SOITEC is focusing on improving its profitability by adapting its cost structure to current demand (without impacting construction of its new Singapore plant, which remains on schedule).

However, new product launches by major customers should drive growth over the year as a whole.

www.soitec.com

Cree demos 100mm ZMP SiC substrates

Cree Inc of Durham, NC, USA says it has demonstrated zero-micropipe (ZMP), n-type silicon carbide substrates with a diameter of 100mm (4-inch). The firm already sells 76.2mm (3-inch) ZMP n-type 4H-SiC substrates (specified as having zero micropipes per cm^2) as well as (since September 2005) 100mm n-type 4H-SiC substrates specified as ultra-low micropipe (<5 per cm^2), low micropipe (<15 per cm^2) and select micropipe (16–30 per cm^2).

Micropipe crystalline defects in SiC can not only decrease the number of usable electronic devices produced per wafer but also affect the performance parameters of each device produced (power-switching devices, LEDs and RF power transistors for wireless communications). These defects have previously been present in nearly all SiC wafers manufactured and sold by commercial substrate vendors, Cree claims.

However, the first commercially available, zero-micropipe SiC substrates (with diameters of 2- and 3-

inches) were developed by Intrinsic Semiconductor Corp of Dulles, VA, USA. Cree subsequently acquired Intrinsic in June 2006 and integrated the firm's ZMP technology into its product line. Together with previous research and development efforts at Cree — partially funded by the US Army and the US Defense Advanced Research Projects Agency (DARPA) — the micropipe density in 100mm SiC substrates has been dramatically reduced. Cree's latest announcement demonstrates that it is possible to eliminate these defects in large-area wafers too, the firm says.

"We expect that ZMP technology can significantly improve device yields, expand the range of products that can be designed and produced, and enable manufacturing at higher-volume levels than had been possible before," says Dr Cengiz Balkas, Cree's VP and general manager for materials (and former president and CEO of Intrinsic).

www.cree.com

Indium Corp hires Guckes to develop gallium and germanium business

Indium Corp of Clinton, NY, USA, which supplies both commercial-grade and high-purity indium, has hired Terry Guckes as business development director for the Metals & Chemicals Business Unit. He assumes the responsibility for extending existing relationships and creating new customer opportunities for the firm's gallium and germanium products.

Guckes has extensive industry experience in specialty chemicals, batteries, solar, and gallium, as well as in production and reclaim and refinement of raw materials.

Guckes was formerly corporate officer and VP of Electronic Chemicals for GEO Specialty Chemicals Inc of Cleveland, OH, USA, which was



once the main supplier of gallium and gallium chemical derivatives.

Another major focus for the firm is indium for the burgeoning CIGS (copper indium gallium diselenide) photovoltaic manufacturing sector.

www.indium.com



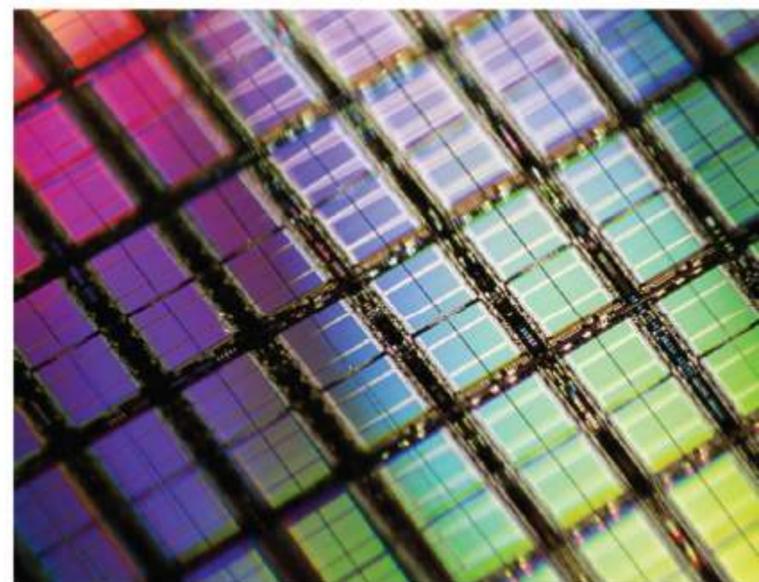
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AXT's 6" GaAs sales dip in Q1, but rebound expected in Q2

AXT Inc of Fremont, CA, USA has reported Q1/2007 revenue of \$12.5m. Though up 47% from \$8.5m a year ago (as AXT continues to recover), this is down 5% from Q4/2006's \$13.1m (and below February's guidance of \$13.1-13.6m).

Despite growing 29% from \$6.8m a year ago, GaAs substrate revenue is \$8.8m, down 20% on Q4/2006's \$11.1m. Specifically, 6" diameter wafer sales fell from \$4.9m to \$3.3m, due mainly to delays in BiFET qualifications of certain customers and smaller-than-expected orders from a few handset market customers.

However, InP substrate revenue has grown from \$296,000 a year ago and \$456,000 in Q4/2006 to \$518,000 in Q1/2007. In addition, germanium substrate revenue (for solar cells and LEDs) continues to

rise rapidly, from just \$36,000 a year ago and \$318,000 in Q4/2006 to as much as \$541,000 in Q1/2007.

Sales of raw materials (mainly 99.99%-pure gallium) have more than doubled from \$1.2m in Q4/2006 to \$2.6m in Q1/2007, boosted by three new Japanese customers (although these additional sales are not expected to be repeated in such magnitude in Q2/2007).

Despite the drop in total revenue, gross margin is still rising, from 17.8% of revenue a year ago and 38.2% in Q4/2006 to 43.2% in Q1/2007. As well as continued benefit from manufacturing yield improvements, this was due to "significant engineering and operating achievements in our cost reduction efforts, coupled with positive product mix," says CEO Phil Yin.

Net income was \$1.3m, down from \$3.4m in Q4/2006 but still a big improvement from a net loss of \$2.2m a year ago. Also, compared with a \$2.3m operating loss a year ago, operating income in Q1/2007 still equalled Q4/2006's \$1.2m.

For Q2/2007, AXT expects revenue to rebound to \$13.1-13.5m.

"Qualification activity across all of our product lines has been robust and early feedback from our existing customers and potential customers leads us to believe that 2007 will be a strong year for AXT," says Yin. "AXT continues to execute well at all levels and our accomplishments, coupled with our growing market and significant competitive advantages, position us well for continued growth in 2007."

www.axt.com

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(NASDAQ: AXTI)

Aixtron delivers 1000th compound semi epitaxy reactor

Aixtron AG of Aachen, Germany has delivered its 1000th compound semiconductor epitaxy reactor.

The Close Coupled Showerhead (CCS) MOCVD system, in 30x2" wafer configuration, was installed at the fab in Lungtan Industrial Park in Taoyuan, Taiwan of Formosa Epitaxy Corp (Forepi), which claims to be the only LED wafer and chip manufacturer in Taiwan that offers the full optical spectrum ranging over high-power InGaN blue, green and near-UV LEDs.

Founded in 1999, Forepi is one of Aixtron's oldest long-term customers, says Aixtron's executive VP and COO, Dr Bernd Schulte. "This tool is one of our latest high-capacity GaN reactors, which offer the largest wafer capacity in the world," Schulte claims.

The system complements Forepi's substantial installed base of Aixtron MOCVD systems (including several high-throughput AIX 2400/2600G3 HT MOCVD Planetary Reactors). "The new CCS MOCVD tool will give us a high-yield process matching our needs for new-generation high-power blue-green LED wafers," says Forepi's president, Dr Fen-Ren Chien, and should give it the capacity ramp up it needs for the booming LED marketplace, he adds.

"Over two thirds of our reactors have been shipped to South East Asia, reflecting the significant surge in demand from Asia for high-brightness red, yellow, orange, blue-green and white LEDs," says Schulte. "The total installed base of the Aixtron group systems, including our semiconductor equipment, is now more than 1600," he adds.

www.aixtron.com

Veeco's boom in MOCVD orders driven by GaN HB-LED market

Veeco Instruments Inc of Woodbury, NY, USA has reported Q1/2007 sales of \$99.2m (59% process equipment; 41% metrology). This is up 6% on \$93.9m a year ago but down 19% sequentially on Q4/2006's \$123.1m. However, shipments were \$110m, due to increased activity for new MOCVD products (with revenue recognition in subsequent quarters).

Of the total revenue: 36% were for data storage, 10% for semiconductors, 21% for high-brightness LEDs/wireless [MOCVD and MBE epitaxial deposition equipment], and 33% for scientific research. Geographically, 35% came from North America, 15% from Europe, 20% from Japan, and 30% from the Asia-Pacific.

Although down 16% on a year ago, bookings were \$105.9m (with processing equipment rising to 65% and metrology falling to 35%). Of the total orders, 28% were for data storage (down 58% year-on-year), 11% for semiconductors (up 16%), 37% for HB-LEDs/wireless (up 60%) and 24% for research (up 18%); 32% came from North America, 18% from Europe, 12% from Japan, and 38% from the Asia-Pacific (i.e. a shift from Japan to Asia-Pacific).

Comparing the orders to revenues reflects "significant growth in the HB-LED/wireless sector," says chairman Edward H. Braun, as it overtakes data storage as Veeco's biggest market sector. Veeco's HB-LED/wireless revenues were up 39% and orders were up 60%

year-on-year (and up 37% sequentially). "We continue to experience positive customer acceptance for our new K-Series MOCVD systems," says Braun. In Q1/2007, Veeco received multi-system orders worth almost \$11m from HB-LED makers in Europe and Asia. LED market expansion for outdoor signage and lighting, small LCD panel backlighting and automotive applications have led to a positive bookings trend over the last nine quarters, with the large-area LCD market still to come (6-12 months away). New solar cell applications are also adding to MOCVD growth.

Veeco's total Q1/2007 gross margin was 44%, higher than forecast due to improved margins in MOCVD systems. On a generally accepted accounting principles (GAAP) basis, operating income has risen slightly from \$1.6m a year ago to \$1.7m and net income from \$0.2m to \$0.3m.

For Q2/2007, Veeco expects growth in revenues to \$100-105m and bookings to \$110m±5%. For full-year 2007, it expects revenues to grow 5% to \$450-465m, driven by HB-LED/wireless sales growth of 30% to \$115m (followed by growth of 30% again in 2008 to \$150m, then 15% in 2009 to \$175m).

● In Q1/2007, Veeco also reduced long-term debt by \$56m and exchanged a substantial portion of its convertible notes (worth \$118.7m), "significantly improving the firm's capital structure," says Braun.

www.veeco.com

Veeco appoints Peeler as CEO

After seeking a new CEO last November, Veeco has appointed John R. Peeler (president of JDSU's Communications Test and Measurement business) as CEO, succeeding Edward H. Braun, who remains chairman. Peeler will be appointed to the board within 30 days of starting in early July.

Previously, Peeler was CEO of Acterna Inc (acquired by JDSU in 2005).

Peeler has a proven track record of leadership, managing complex technology in high-growth markets, says Braun. "His experience will be vital in leading Veeco to new levels of growth and profitability."

Asian LED makers drive doubling of Aixtron revenues, but slowing orders flag weak second-half 2007

For Q1/2007, deposition equipment maker Aixtron of Aachen, Germany has reported its second consecutive quarter of record revenue: €63.8m (double Q1/2006's €32.0m, and up slightly on Q4/2006's €63.1m). The firm says that the growth is due to the large order backlog, combined with high demand in recent quarters for deposition equipment for LEDs, especially from Asia.

Revenues from Asia have grown 114% from €26.6m a year ago to €56.9m (rising from 83% of revenues to 90%). Europe fell from €2.4m to €1.5m (from 8% of revenues to just 2%). The USA grew from €3m to €5.4m (maintaining 8–9% of revenues).

Of equipment revenue of €57.4m, 76% was for compounds (€43.5m, almost triple €14.7m a year ago) and 24% for silicon (all for DRAM and NAND flash memory products: €13.9m, up 30% from €10.7m a year ago). The rise in demand for AlInGaP systems over the last few quarters has been fuelled by increased demand for red, yellow and orange LEDs, says Aixtron.

Due to economies of scale and efficiency improvements, operating costs have been cut from 47% of revenue a year ago to just 25%. Gross profit doubled from €12m to €24.2m. Net income was €7.6m (compared to a net loss of €3.1m in Q1/2006).

Cash and cash equivalents at the end of March were up from €35.5m a year ago to €43.7m.

"We have continued to benefit from the increased revenue volumes and internal efficiency gains, despite a weakening US dollar," says CEO Paul Hyland.

Q1/2007 also saw the fourth consecutive quarter of equipment order intake above €40m, at €40.5m. This is up 28% on €31.7m in Q1/2006, but down 9% on Q4/2006's €44.5m. Order backlog is €70m (down from €85.1m at the end of December).

Growth is due to high demand in recent quarters for deposition equipment for LEDs, especially from Asia.

Despite the slowing order intake, Aixtron says it remains confident of the medium to long-term health of its targeted markets. In particular, customers will require some time to integrate and qualify the large-capacity GaN systems purchased in 2006. Also, in the telecom/datacom end market area, existing customer capacity means that sustainable revenue growth is unlikely to return before late 2007 at the earliest.

Nevertheless, Aixtron has reiterated its full-year 2007 guidance (given in March) of revenue of €190–200m (up 11–16% on 2006's €171.7m), with second-half 2007 weaker than the first half. "The order intake and market development are very much in line with our expectations, giving us increased confidence in our year-end guidance and beginning to point towards an encouraging outlook for 2008," says Hyland. Aixtron expects that order intake will increase towards the end of 2007, and that trends for 2008–2010 remain encouraging.

www.aixtron.com

Korea's Epiplus & EpiValley expand for LED production

Epiplus Co Ltd of Eyon-hansan Industrial Park in Gyeonggi-Do, South Korea has ordered an AIX 2600G3 Planetary Reactor from Aixtron, to mass produce AlGaInP ultrahigh-brightness (UHB) red LEDs.

In 49x2" wafer configuration, the MOCVD system comes in Aixtron's new IC (Integrated Concept) layout, facilitating the use of digital mass flow controllers and the new AIXACT control system design.

Epiplus previously prepared a AIX2600G3 system for UHB-LED mass production at KOPTI Institute in Kwangju, leading to its decision to scale up production.

CEO Hae-Sung Park said it had ordered the reactor to advance its strategic business expansion,

focusing on red LEDs for display back-lighting units (BLUs). Epiplus claims to be the only Korean mass supplier of red LEDs. The new reactor will allow it to keep pace with demands regarding device quality and cost control, says Park.

Also, Korean LED maker EpiValley says that it has qualified and begun using its Thomas Swan CRIUS Close Coupled Showerhead CCS 30x2" MOCVD reactor in its production facilities in Kwangju City, which was commissioned only recently from Aixtron.

EpiValley is the first firm to produce blue HB-LED epiwafers on this system, which is claimed to be the world's most productive MOCVD system for production of GaN-

based LEDs. To date, the largest reactors for GaN-based LEDs mass production were qualified with a capacity of between 18x2" and 24x2".

EpiValley's plan is to manufacture LEDs for side-view application in mobile phones. "Using this system we have a big advantage with respect to quality and productivity, which allows EpiValley to compete within the huge LED BLU (back-light unit) and lighting market," says DJ Park, EpiValley's president and CEO. With 12 MOCVD Systems already in operation, EpiValley claims to have the largest manufacturing capacity in Korea.

www.epiplus.com

www.epivalley.com

IN BRIEF

Braunschweig orders CV profiler

Germany's Institute of Semiconductor Technology (part of the University of Braunschweig) has ordered a CVP21 electrochemical CV wafer profiler from WEP (Wolff für Elektronik- und Programmentwicklungen) of Furtwangen im Schwarzwald, Germany.

The Institute of Semiconductor Technology researches materials including silicon, germanium, silicon carbide, arsenides, phosphides, antimonides, nitrides, and zinc oxide. Recently, it also installed a Thomas Swan 3x2" Close Coupled Showerhead (CCS) MOCVD epitaxy reactor from Aixtron to research GaN and ZnO material properties and optoelectronic devices (see March issue, p24).

www.wepcontrol.com

Riber grows sales 19% year-on-year

For Q1/2007, MBE equipment maker Riber of Bezons, France has reported sales of €1.3m (up 19% on €1.1m a year ago), including accessories, components and revenues from the rental over one quarter of the machine installed for the Riber/IMEC partnership.

During Q1, installation was completed of the machine for the Riber/IMEC partnership, which is being used to develop micro-processors based on III-V and high-k dielectric oxide materials. First results are expected by July.

Also, Riber and the CNRS-CRHEA research institute in Valbonne, France started the development of monolithic white LEDs based on gallium nitride (GaN), after ANR (Agence National de la Recherche)

approved funding for the program in February. The advantage compared to existing LEDs should be the ability to choose the 'warmth' of the white color and to allow simple and cost-effective manufacturing by avoiding the use of phosphors.

Order backlog at the end of March was €8.1m. Riber has since received three orders for research machines (including two for new customers) for a total of €2.2m, raising the backlog to €10.3m (in line with company's forecasts).

Riber maintains its previous sales forecast for 2007 of €16-18m (although this is lower than the forecast of €16-20m given at the end of March, and down from 2006's revenue of €20m).

www.riber.com

Aviza reports second consecutive profitable quarter

For its fiscal Q2/2007 (to end-March) etch and deposition system maker Aviza Technology Inc of Scotts Valley, CA, USA has reported a second consecutive quarter of net profitability (\$1.4m, compared to last quarter's \$1.1m and a loss of \$5.3m a year ago). Revenues of \$61.6m were up 70% on \$36.2m a year ago, although this is down slightly on last quarter's \$62m.

During the quarter, Aviza received an order for its Advanced Vertical Processor (AVP) 200mm thermal processing system from a Chinese foundry (marking a new customer win) as well as an order for its Sigma fxP physical vapor deposition (PVD) system from Cension Semiconductor Manufacturing Corp of Chengdu, China (a foundry managed by Chinese chip maker SMIC). Aviza also announced a follow-on shipment of an Sigma fxP system to a 'US-based supplier of devices for the communications market'.

Income from operations was the same as last quarter (\$2.7m) and compares with a loss of \$3.9m a year ago. Gross margin has improved from 25.4% a year ago to 30.7%. Net income was \$1.4m (compared to \$1.1m last quarter and a net loss of \$5.3m a year ago), mainly due to an improvement in product mix and a reduction in interest expense.

In February, Aviza completed an underwritten public offering of 4 million shares of its common stock at a price of \$6.50 per share, followed in April by the underwriter exercising its over-allotment option and purchasing an extra 600,000 shares, raising net proceeds to about \$28m. Aviza has since (in April) also completed a new \$55m credit facility.

"The company remained focused on our business strategy of diversifying our product offerings to penetrate our markets with our

single-wafer ALD, PVD and etch products, expanding our markets and increasing our presence in Asia," says president and CEO Jerry Cutini.

For its fiscal Q3/2007, Aviza expects revenues of \$55-60m, and operating income of about \$500,000.

For fiscal 2007, following the forecast it gave on last November, Aviza continues to expect revenues of \$220-240m (a rebound of 37-49% on fiscal 2006's \$160.9m, which was down 6% on fiscal 2005). However, it has now reduced its forecast for net income from about 2% of revenues (\$4.4-4.8m) to less than \$500,000 (though still better than the net loss of \$14.7m in fiscal 2006). The downward revision is partly due to expected increases in operating expenses in the UK (as a result of to the impact of the strength of the British pound versus the US dollar).

www.avizatechnology.com

LED market drives Rubicon to expand sapphire capacity

Driven by growing demand from LED makers, Rubicon Technology of Franklin Park, IL, USA, which manufactures sapphire substrates and components, is adding a new 30,000ft² production facility in the Chicago area, complementing the firm's existing 80,000ft² operation.

The expansion aims to increase capacity by 25% as soon as Q1/2008 and by 40% by the end of 2008, enabling the firm to address growing demand for both small- and large-diameter sapphire wafers.

Rubicon expects sapphire wafer usage to grow significantly as LEDs are adopted in emerging applications such as backlighting units for computer and video displays, as well as automotive lighting. Industry analyst group Strategies Unlimited

reports that the overall market for high-brightness LED applications has already reached \$4.2bn, and that the LED lighting market alone should grow 38% annually to \$1bn by 2011. Single-crystal sapphire substrates are key as the general illumination market begins to turn to LEDs, adds Rubicon.

As the LED market drives volume demand for sapphire wafers, new applications and processes call for larger-diameter sapphire substrates, claims Rubicon. The firm uses proprietary crystal growing technologies and manufacturing platforms to produce 4"-8" sapphire wafers, which are increasingly being used for high-performance LEDs. Large-diameter sapphire is also used as wafer carriers for

other substrates and as optical windows in the aerospace, medical device and sensor markets.

In early April, Hercules Technology Growth Capital Inc of Palo Alto, CA provided \$16m of growth capital and equipment financing. "Hercules' debt leasing financing program provides the springboard Rubicon needs to increase the capacity and sophistication of our manufacturing capabilities in order to continue to bring evolving solutions and support rapid growth for our customers," says CEO Raja M. Parvez.

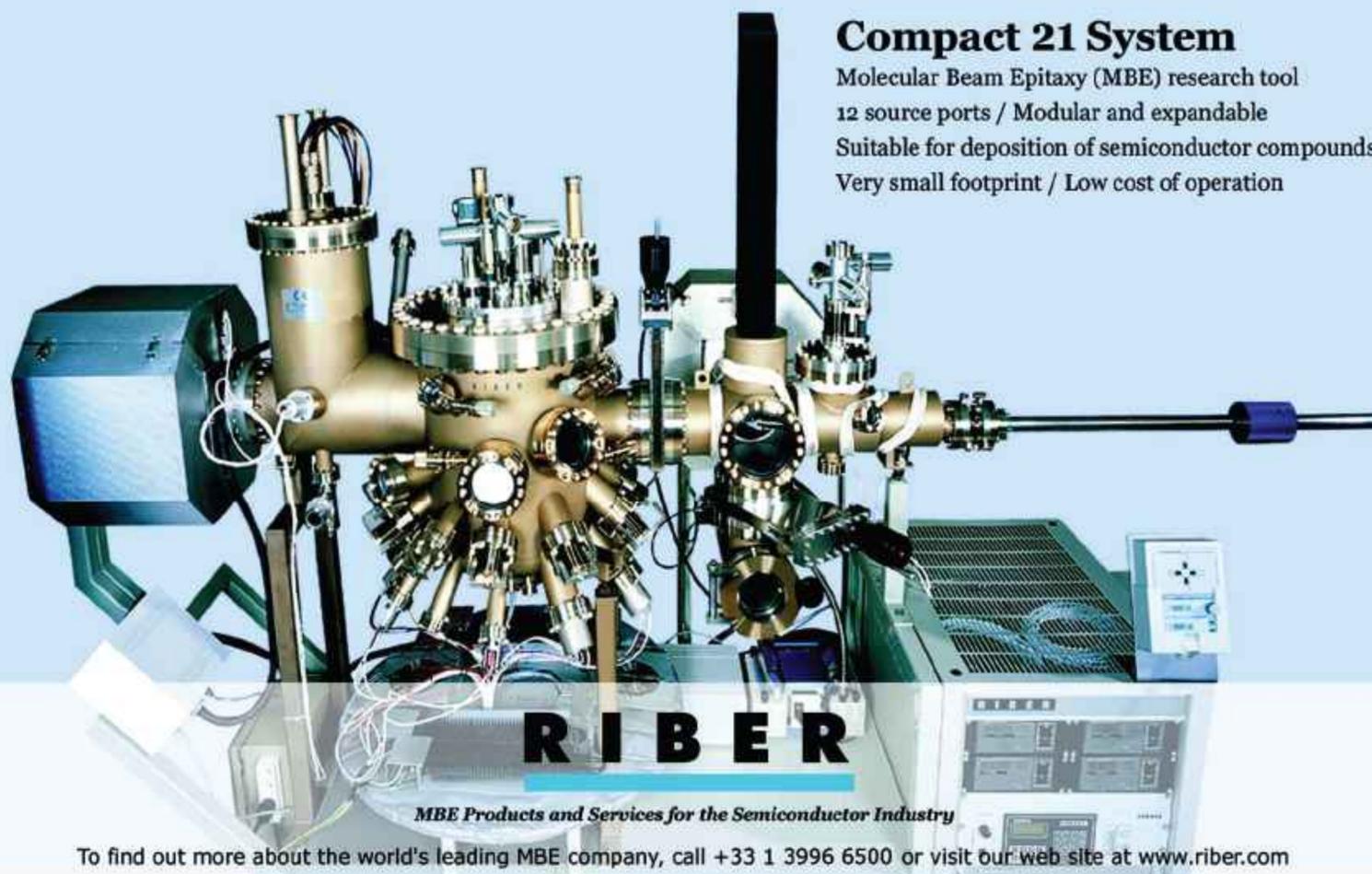
Rubicon is already backed by investors including AH Ventures, Cross Atlantic Partners, Gazelle TechVentures, K.B. Partners, and River Cities Capital Funds.

www.rubicon-es2.com

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New Wave fights Laser Solutions over sapphire scribing

After alleging infringement of its Taiwan patent no. 194157 'Scribing Sapphire Substrates With a Solid State UV Laser' on its AccuScribe family of blue LED wafer-scribing systems, New Wave Research Inc of Fremont, CA, USA has been issued a preliminary injunction order by the Taipei District Court prohibiting the RPYULAS MP-T1 030 and MPT-2030 systems of rival Laser Solutions Co Ltd of Kyoto, Japan (and distributor Leopard International Co Ltd) from being manufactured, sold, offered for sale, used or imported into Taiwan.

New Wave Research has filed over 14 patents since launching the technology five years ago, and been awarded patents in the USA, Taiwan and China.

Laser Solutions has since been able to remove the restriction by

posting a bond to secure against potential loss of business by New Wave (in the event that the injunction is upheld) and in the meantime is free to trade as normal.

Laser Solutions claims that the court issued the preliminary injunction order without reviewing the merit of the case, and that such orders are often used by patentees as a competition tactic before the legal battle is concluded. Laser Solutions also claims that New Wave's allegation of infringement violates the Republic of China Fair Trade Act.

Previously, in August 2006, a Taiwanese court issued New Wave a provisional attachment ruling regarding alleged infringement by rival DPSS UV laser equipment maker Uni-Via Technology Inc of Taipei Hsien, Taiwan.

● The People's Republic of China's Patent Office has awarded New Wave patent number ZL 03 1 42382.5 'Scribing Sapphire Substrates with a Solid State UV Laser' covering processes and technology associated with AccuScribe for blue LEDs.

"This new patent attests to New Wave Research's seriousness in defending its intellectual property on an international level," says CEO Pei Hsien Fang. "Our global IP portfolio provides rock-solid protection of all core AccuScribe technology... we have prevailed in all litigation cases involving copycat technology — spanning multiple countries and continents," he adds. "We welcome dialog from companies interested in exploring licensing agreements of AccuScribe technology and other New Wave Research innovations."

www.new-wave.com

IN BRIEF

SAS starts shipping sapphire substrates

Small/medium-diameter silicon wafer maker Sino-American Silicon Products Inc (SAS) of Hsinchu, Taiwan has started sampling sapphire substrates to Taiwanese LED makers, including Epistar, Huga Optotech and Tekcore, according to Digitimes. Products were expected to begin shipping in May, with amounts predicted to hit 30,000 wafers.

SAS had previously said that it would start producing sapphire substrates in second-half 2007.

● In April, SAS named its new chairman and CEO as MK Lu, chairman of Actron Technology Corp (in which LED maker Lite-On Technology has a stake) and former general manager at Lite-On Semiconductor. Lite-On Technology is also a major shareholder in LED epiwafer and chip maker Epistar (also based in Hsinchu).

www.saswafer.com

JPSA expands to new plant & 100mm sapphire wafer dicing for LEDs

In response to increased demand from LED makers migrating to 100mm sapphire wafers, J. P. Sercel Associates is now offering an expanded, 100mm sapphire wafer dicing capability for its IX-200 Chromadice diode-pumped solid-state (DPSS) UV laser wafer singulation system, enabled by new high-accuracy integrated Z-theta capable motorized air-bearing stages with non-contact operation (compared to worm and wheel rotary designs). The IX-200 can cut larger wafers without impinging on the 20µm streets, it is claimed.

The Chromadice can process four 100mm wafers per hour, compared to ten 2" wafers per hour previously. Since each 100mm wafer has four times as many die as a 2" wafer, this equates to cutting 16 2" wafers per hour, allowing higher LED manufacturing throughput as well as yield.

The UV DPSS laser system delivers high-speed wafer dicing and cutting with yields greater than 99% at

less than \$2 per wafer, JPSA claims.

The process is tolerant of wafer warp and bow and is suitable for all wafer types (including GaAs and silicon). The new Z-theta stage provides 360° rotational capability, and its Z-axis capability can accommodate wafers of varying thicknesses and diameters, allowing a wide range of applications.

The IX-200 is also suitable for wafer trimming and scribing. An excimer laser version is also available for via drilling, micromachining, thin-film patterning and packaging applications including LED liftoff.

● JPSA has completed moving its headquarters from Hollis, NH, USA to a larger, 35,000ft² manufacturing and administrative facility (once part of the University of New Hampshire) in the Hackett Hill Research Park in Manchester, NH.

A future Phase II construction will expand space to 110,000ft² for projected growth over the next five years.

www.jpsalaser.com

BluGlass awards first equipment manufacturing contract

BluGlass Ltd of Sydney, Australia (which was spun off from Macquarie University in mid-2005) has signed its first design and manufacture agreement with Ireland-based EMF Semiconductor Systems Ltd. When paired with BluGlass's remote plasma CVD (RPCVD) for low-temperature deposition of GaN onto glass substrates (rather than conventional MOCVD on sapphire), the componentry supplied by EMF will form the backbone of the firm's first commercial-scale prototype system for low-cost manufacturing GaN-based LEDs.

"The new equipment will allow us to demonstrate to the world's leading LED manufacturers that our cost-saving technology works on a commercial scale," says CEO David Jordan. "We will be able for the first time to make commercial quantities of GaN wafers for high-brightness white LEDs in our new facility in Sydney. This will be a critical step

to engaging the major global LED lighting companies in our technology," he adds. "The new equipment will be installed in our Sydney plant in the coming months, transforming our operations to a commercial-scale system and pushing us closer towards earning our first revenues."

The EMF contract was signed after BluGlass executives visited leading LED companies in Asia, the US and

Europe to discuss progress on the development of their technology.

After its commercial-scale machinery has been fully commissioned, BluGlass aims to license such equipment to LED lighting companies. BluGlass also aims to earn revenues through royalties for the use of the technology.

www.bluglass.com.au
www.emf.co.uk

Access Macquarie's MD made a director

BluGlass has also strengthened its board by appointing Dr Peter Dodd as a non-executive director.

Dodd has more than 20 years experience in investment banking and is currently managing director of Access Macquarie Ltd, the commercial arm of Macquarie University, which is a major shareholder in BluGlass due to developing the technology now owned by the firm. Dodd is also chairman of Transgrid,

the New South Wales government corporation that owns and operates the State's electricity grid.

"His formidable industry, banking and academic experience will add strong commercial and investment knowledge to our team," says Dr Mike Taverner, chairman. "He will immediately become an important part in directing the development and commercialization of our technology."

Production solutions for HB LEDs

Systems and processes with industry-leading batch capability

Oxford Instruments' process tools offer industry-leading production solutions for HB LEDs; high throughput and high yield with excellent in-wafer, wafer-to-wafer and run-to-run uniformity.

Substrate preparation

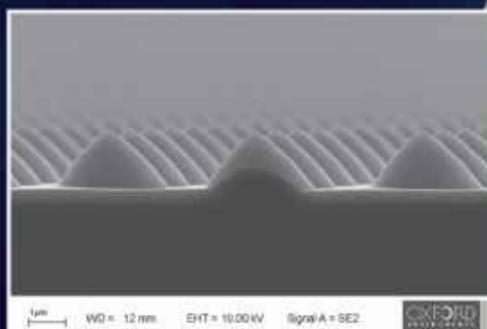
Sapphire, SiC, GaN etching
20 x 2" up to 4 x 4"

GaN, AlGaIn, AlGaInP and related materials etching

20 x 2" up to 4 x 4" (GaN, AlGaIn)
10 x 2" up to 3 X 4" (AlGaInP)

Hard mask and passivation

SiO₂ and SiN_x deposition and etch
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Osram sampling 1000lm OSTAR LED for general lighting

At the Lightfair International 2007 event in New York, Osram Opto said that it is now producing samples of the most powerful version of its OSTAR LED product (for market launch this summer). The new cool-white LED produces a luminous flux of more than 1000 lumen, making it brighter than a 50W halogen lamp, suiting a wide range of applications in general lighting applications.

In mid-February Osram announced that it had developed the 1000lm OSTAR cold-white LED as part of the German government's BMBF NanoLux program.



Osram's 1000lm OSTAR LED.

Basing the new LED on the well-established OSTAR product (which has a luminous efficacy of 75lm/W at an operating current of 350mA) enabled rapid transfer of the latest performance levels from the development stage to the production stage, says Osram. The high luminous flux of the new version is due to optimizing the overall chip, package and epitaxial process, it adds.

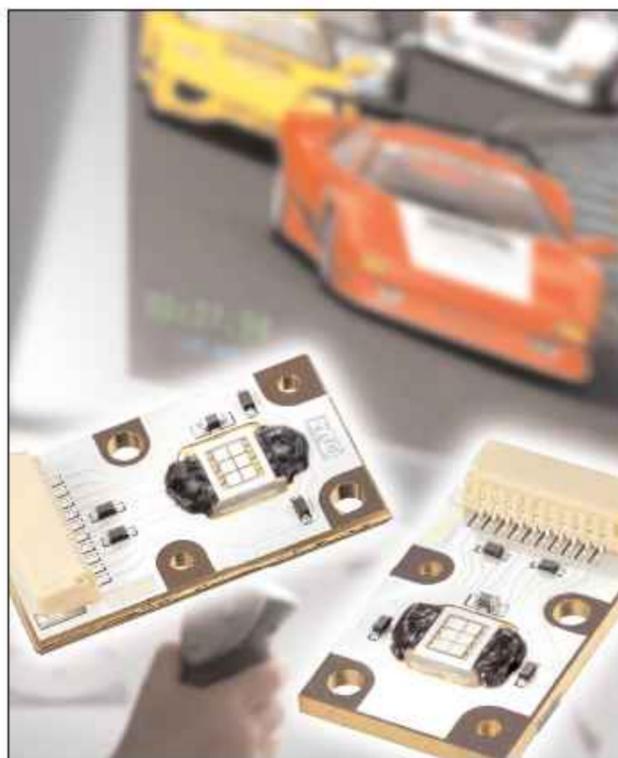
The new 1000lm OSTAR includes six closely packed 1mm² high-power ThinGaN chips, yielding high brightness (a single OSTAR with a 38° reflector can illuminate a desk with over 500 lux from a height of 2m).

Six-chip OSTAR Projection light source introduced

Osram Opto has launched a version of its OSTAR Projection LED light source that incorporates six 1mm² chips, offering stronger monochromatic light with a system brightness of 120 lumens in pocket projectors (and up to 140 lumens by optimizing the system).

Such mini-projectors can therefore be made brighter, more colorful and more flexible, says the firm. Screen content such as computer games no longer has to be viewed only on a small display but can be projected onto walls in large format.

OSTAR Projection is available in red (617nm), green (517nm) and blue (655nm), so more colors and



Six-chip OSTAR Projection LEDs.

tones in the color triangle can be displayed than prescribed by the National Television Systems Committee (NTSC) standard.

Two package versions with different alignments of the chip surface offer flexibility in the mechanical design of the lighting system.

The new OSTAR Projection source has a lifespan of up to 50,000 hours, corresponding to 5.7 years of continuous operation (far exceeding the lifespan of conventional projection lighting systems, the firm claims). Alternatively, the source can operate with higher current and greater brightness but with reduced lifespan, says Osram.

Opel shows concept car with all-LED exterior lighting

At March's Geneva Motor Show, Opel (General Motors' brand in Europe) unveiled its Gran Turismo Coupé (GTC) sports concept car, which uses high-power LEDs from Osram Opto Semiconductors of Regensburg, Germany for all the interior and exterior lighting.

Two OSTAR LEDs are used in each headlight for the dipped beam, with three further OSTAR LEDs in each headlight providing the high beam. Each fog light incorporates one



Opel GTC, showing LED headlamps.

OSTAR. Parking and daylight running lights are provided by

Golden Dragon LEDs. The four dashboard instruments are lit by red TOPLEDs.

● Daytime running lamps based on LEDs have been in production for three years, since first appearing on a high-end Audi model, but in January the Japanese luxury car maker Lexus said that it was introducing the first series production vehicle (the LS 600h L sedan) to feature LED-based headlamps (in the low beam).

Osram expanding with new chip fabs in Malaysia and Germany

Lighting manufacturer Osram of Munich, Germany says that its subsidiary Osram Opto Semiconductors GmbH (the world's second biggest LED maker) will significantly expand production capacity at its assembly plant in Penang, Malaysia by building its second chip fabrication plant (adding to its existing fab at its headquarters in Regensburg, Germany). The new fab will begin operation in 2008, in anticipation of demand for volume lighting and consumer applications. Total investment in the Penang fab will ultimately be "in the high double figures of millions of euros", the firm says.

Osram is also starting to expand the existing LED assembly facilities in Penang. When completed, capacity will be boosted by 50%.

Meanwhile, an existing further construction phase to expand the Regensburg plant (an investment in the "fairly high double figures of millions of euros") will be completed by the end of 2007. Regensburg will continue to manufacture LED wafers for lighting, display and sensor applications. In addition to production, Regensburg also accommodates Osram Opto Semiconductor's central R&D department.

"Opto-semiconductor products are central to our growth strategy," says Osram's CEO Martin Goetzeler. "LEDs are the light sources of the future as they offer so many benefits, including compact dimensions and enormous potential for energy savings. The expansion of our production capacity in Penang and Regensburg is a clear sign that we are on course for sustained growth."

Osram Opto Semiconductors' CEO Ruediger Müller adds: "The expansion of our production sites is our response to increased demand for LEDs throughout the world".

www.osram-os.com

Range of warm white LEDs on show at Lightfair for residential, commercial and decorative lighting

With demand for warm white LEDs for general lighting at an all-time high, says Osram Opto Semiconductors, at this week's Lightfair International 2007 event in New York the firm is exhibiting its portfolio of new warm white colors, ranging from high-flux sources such as the Golden DRAGON and OSTAR products to more subtle devices such as the Power TOPLED and Advanced Power TOPLED. All devices feature increased color stability, long life and low energy consumption.

"No matter which general lighting application, residential, commercial or decorative, Osram Opto Semiconductors offers a full range of LEDs in warm white colors," says Ellen Sizemore, director LED/IR marketing for Osram Opto Semiconductors Inc of San Jose, CA, USA. Due to its broad warm white product portfolio, lighting can be customized to each application for brilliant or subtle effects, she adds.



Osram offers LEDs in different output classes for general lighting applications:

- Osram's most powerful LED product, OSTAR, provides warm white light for downlights (e.g. reading lamps). Consisting of six ThinGaN chips (with the option of a matching lens), its small 20mm x 20mm hex-shaped footprint provides luminous flux of 410lm at 2700K, 460lm at 3000K and 520lm at 4200K color temperatures from an operating current of 700mA with a power input of 15W (a performance similar to halogen lamps).
- Power TOPLED are low-power devices, producing 2.9lm at

2700/3000K, 3.6lm at 3500K and 4.1lm at 4200K, consuming less energy at an operating current of 30mA and costing less. Measuring just 3.4mm x 3.4mm, they fit in the smallest luminaires. This suits decorative lighting (e.g. starlight canopies as well as contour, effect and stair-tread lighting). High efficiency requires less thermal management than more powerful LEDs.

- For emerging general lighting applications (with luminous intensity and size between those of OSTAR and Power TOPLED), the Advanced Power TOPLED is 50% brighter than previous versions. At 140mA, its output of 15lm in white provides efficient lighting in a small package, suiting replacement of designs using early-generation Power LEDs. The Golden DRAGON produces bright white light from a small 350mA emitter with 50lm output. Both products have long lifetimes of up to 50,000 hours due to their heat dissipation capabilities and silicone encapsulation.

ITC extends Lumileds' patent ruling and exclusion order from Epistar's MB LED to OMA and GB LED products

The US International Trade Commission has issued a final determination stating that all of the omni-directional mirror adhesion (OMA), metal-bond (MB), and glue-bond (GB) AlGaInP LED products made by Epistar Corp of Hsinchu Science-based Industrial Park in Taiwan infringe US Patent no. 5,008,718 owned by Philips Lumileds of San Jose, CA, USA.

Lumileds filed its complaint with the ITC in November 2005, alleging that the OMA, GB and MB LEDs of Hsinchu-based United Epitaxy Corp (UEC) infringed its US patent nos 5,376,580, 5,502,316 and 5,008,718. At the end of 2005 the merger between Epistar and UEC was completed, and Epistar became the only respondent.

On 22 February the ITC said that it had adopted portions of the 8 January initial determination by administrative law judge Sidney Harris that:

- Epistar's MB I and MB II products infringe Philips Lumileds' US Patent no. 5,008,718;
- Lumileds' 5,008,718, 5,376,580 and 5,502,316 patents are valid and enforceable;
- Epistar's OMA, MB, and GB products are not licensed under those patents; and
- a limited exclusion order should prevent import of the MB LED chips, packaged lamps, and boards containing them into the USA.

Epistar subsequently filed a petition asking the ITC to reject the initial determination. However, the ITC decided to act on a petition by Philips Lumileds for it to review the initial determination and to consider if the OMA and GB LED products, too, infringe the 5,008,718 patent and if they should also be included in the exclusion order.

The ITC's final determination affirms that none of the OMA, GB and MB products infringe the 5,376,580 and 5,502,316 patents (relating to a 'wafer bonding' LED

manufacturing process). However, the final determination reverses the initial determination regarding the 5,008,718 patent (relating to LEDs with a 'transparent semiconductor window layer' within the chip structures that laterally spreads current away from the metal contact), instead finding infringement not only by the MB products but by the OMA and GB products too.

As a result, the ITC is expanding its limited exclusion order prohibiting the import into the USA of the MB LED chips, packaged lamps containing them, and boards primarily consisting of arrays of such packaged LEDs to the OMA and GB products too.

The limited exclusion order does not become final for 60 days during a period of review of the ITC's decision by the office of the US Trade Representative on behalf of the US President. In the meantime, the ITC has ordered that the bond required to permit temporary importation will be 100% of the value of the LEDs, lamps or boards.

Epistar believes that the USITC has interpreted these patents erroneously to grant exclusive rights to Lumileds to technology that it did not invent and has never used... the USITC's ruling is neither legally nor factually supportable.

Epistar is considering an appeal of the USITC's ruling, and will ask for a stay of enforcement of the limited exclusion order until the appeal is decided

"Philips Lumileds will continue to enforce its intellectual property rights," says the firm's CEO Michael Holt. Philips Lumileds also has a pending action in the US District Court for the Northern District of California in which it asserts its patent rights against Epistar's OMA, MB, and GB products, seeking both damages and an injunction.

"We are obviously disappointed with the decision of the USITC," says Epistar's president Dr Biing-jye Lee. "Epistar believes that the USITC has interpreted these patents erroneously to grant exclusive rights to Lumileds to technology that it did not invent and has never used," he adds. "Epistar believes that the USITC's ruling is neither legally nor factually supportable. For this reason, Epistar is considering an appeal of the USITC's ruling, and will ask for a stay of enforcement of the limited exclusion order until the appeal is decided."

However, Epistar claims that the ITC's exclusion order does not bar the import of completed 'downstream' products (i.e. systems) that may incorporate the LED products.

In addition, Epistar says it expects the impact of the ruling on its customers to be minimal. The firm has developed next-generation MB products (the PE and PN series, already shipping to customers) as well as next-generation OMA and GB products (the Phoenix series, ready for customers' qualification or shipping), neither of which have any infringement issues related to the 5,008,718 patent, the firm claims. Epistar says it will work with its customers to protect their interest and minimize any effect of the exclusion order.

www.philipslumileds.com

www.epistar.com.tw

www.usitc.gov/secretary/fed_reg_notices/337/337-TA-556.Notice.1178736317.pdf

Nichia sues Seoul's Japanese subsidiary over white LEDs

Nichia Corp has filed a complaint in Osaka District Court against Japan Seoul Semiconductor Co Ltd (the Japanese subsidiary of Seoul Semiconductor Co Ltd, the leading LED maker in Korea) and its distributor Kyoei Sangyo Co Ltd alleging that Seoul Semiconductor's 0.5 Watt Z-Power LED P9 series white-LED products infringe its Japanese patents 3511970 and 2778349 relating to GaN blue LED chips.

Nichia seeks damages for past infringement and an injunction against further infringing activity.

In response, Seoul Semiconductor has asked Cree Inc of Durham, NC, USA to verify that it uses Cree's chips, which are covered by a cross-license agreement of 2005 between Cree and Nichia. In May 2006 Cree also signed a five-year supply and patent cross-licensing agreement giving Seoul Semiconductor the right to use Cree's white LED patent (US patent 6,600,175).

Seoul Semiconductor says that a total of 670 LEDs have been provided to Kyoei Sangyo as samples and mass-produced products in six shipments, and that 70 turned out to be from SemiLEDs Corp of Boise, ID, USA.

Seoul Semiconductor says that it has been notified that Cree will relay the above to Nichia, and that Cree believes the situation will be readily resolved.

For the 0.5W P9 LED, SemiLEDs' chips were initially reviewed and used as samples, says Seoul Semiconductor, but currently it provides only Cree chips in products for the Japanese market.

Seoul Semiconductor says it has no intention to dispute the issue

with Nichia, regardless of its patent infringement allegation: "Patents should be respected. But companies should not use patents for their improper sales & marketing purpose in business activities."

Another lawsuit against Seoul Semiconductor and its US subsidiary Seoul Semiconductor Inc was filed by Nichia in the US district court for Northern California in January 2006 is currently pending. Nichia is seeking damages for past infringement as well as an injunction against any further infringing activity, based on Nichia's US design patents for side-view-type white LEDs. However, Seoul Semiconductor claims that Nichia's US design patent is the same as Nichia's Korean design patent that was invalidated by the Korean Intellectual Property Office last December.

www.nichia.com

www.seoulsemicon.com

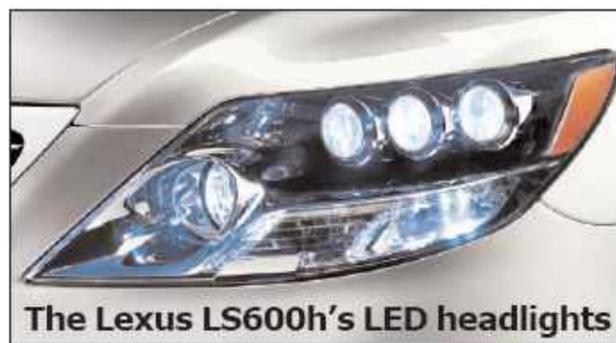
Companies should not use patents for their improper sales & marketing purpose in business activities

Nichia partners with Stanley Electric on white LEDs

Tokyo-based Stanley Electric Co Ltd, one of the world's top LED makers, has become the second licensee of white-LED technology from Japan's Nichia Corp (following Japanese Citizen Electronics Co Ltd in 2002). The agreement will give Stanley access to Nichia's white LED chips and patents, according to EE Times.

The deal should strengthen Nichia's sales of white LEDs into the automotive lighting market, where Stanley is a major supplier.

Stanley expects that the supply of high-power white LED chips from Nichia will enrich its product portfolio and be useful for a wide variety of other applications. In the future, Stanley will consider entering licensed white-LED production as a second step, the firm says.



The Lexus LS600h's LED headlights

Nichia is already collaborating in the development of LED headlights with Koito Manufacturing Co Ltd, a supplier of car-mounted lighting. In late March, Koito said that it had started mass production of the first LED headlights: using Nichia's white LEDs for Toyota's flagship Lexus LS600h model (launched in May).

LEDs have already been used for automotive lamps, e.g. red LEDs for rear combination lamps and white LEDs for license plate lamps.

However, headlights require higher luminance.

Also, Koito has developed an optical control system that uses light from LEDs more effectively. The LS600h's LED headlights produce a light distribution pattern by synthesizing lights obtained from three compact projectors provided in line and lights reflected by a compact reflecting mirror.

To prevent performance degradation caused by temperature rises, highly heat-resistant LEDs and Koito's proprietary cooling structure are used. The product has a long life with little reduction in light output and almost no color change.

www.eetimes.com/news

www.stanley.co.jp

www.nichia.com

QPC quadruples revenue on transition to production

QPC Lasers Inc of Sylmar, CA, USA, which makes high-power lasers for the defense, industrial, and medical markets, has reported Q1/2007 revenue of \$1.1m (up on \$266,000 a year ago). This follows a rise in commercial sales and government contracts due to increased product offerings and expanded sales & marketing efforts, the firm says.

Product revenue was \$653,000 (up on \$548,000 last quarter and \$235,000 a year ago), due mainly to initial production shipments of Generation II fiber-coupled products along with ongoing shipments of the Generation I varicose vein treatment laser. QPC also started shipping its next-generation BrightLase Direct-Diode Laser modules for military and industrial applications (including to US defense contractors for

eye-safe laser engines developed under a US Army project).

Net loss has been cut from \$3.3m a year ago to \$2.4m, due mainly to the product revenue growth as well as a reduction in interest expenses. Gross margin has improved from -5% a year ago to 23%.

Founded in 2000, QPC is a vertically integrated company (from epitaxy through packaging) and performs all critical fabrication processes itself. The company has now begun the transition from the R&D stage to the production stage.

During Q1/2007, QPC won over 30 new orders (many from new customers). "We continued to receive strong orders for our medical lasers, and currently have \$2m in contracts and purchase orders for our Generation II medical module, a significant

milestone as we target the large and growing medical laser sector." The firm also agreed a partnership with Northrop Grumman Space Technology Cutting Edge Optronics for the integration of high-power lasers.

"We are continuing to position the company for strong growth in 2007 and beyond," says CFO and executive vice chairman George Lintz. "In April we closed a \$7.4m financing, which will enhance our ability to focus on growing our product pipeline," he adds. "Our pipeline of product solutions continues on track, and we currently anticipate significant growth throughout the remainder of the year."

For full-year 2007, QPC is targeting revenues of \$6-7.5m (more than double 2006's \$3.1m).

www.QPCLasers.com

Laser 2000 to distribute Intense's lasers in Europe

In an extension of a previous contract via its US subsidiary Intense-HPD, laser manufacturer Intense Ltd of Glasgow, Scotland, UK has agreed to Laser 2000, a European supplier of lasers, optics and fiber-optic equipment, distributing its high-power laser diodes across a number of market segments, including print and imaging, defense, display, and medical devices. Countries covered include the UK, Germany, Austria, Switzerland, Belgium, the Netherlands, Luxembourg, Spain and Italy. "This represents a significant opportunity for Intense to expand its customer base," says the firm's CEO Scott Christie.

"Intense's patented innovations in quantum well intermixing and asymmetric waveguides generate exceptional laser power, brightness, and reliability, providing Laser 2000 with a significant market advantage," says Laser 2000's CEO Manfred Augustin. The new agreement expands Laser 2000's portfolio to include both Intense-HPD's components and modules, as well as

Intense's recently launched high-power arrays, bars, and stacks.

Designed for defense, medical, and display markets, Intense-HPD's high-power laser diodes span from 630nm to 1550nm. Included are the Series 1200 and 1300 visible components; Series 5200 and 5300 visible modules; Series 2100 and 2400 short-pulse components; and Series 1000, 1100 and 3000 infrared components.

Laser 2000 will also distribute Hermes, Intense's high-power 8xx and 9xx nm laser bars and stacks, which are targeted at defense, industrial, and coding and marking markets. Laser 2000 will also carry Intense's INSlam and DLAM individually addressable laser arrays (which are designed for demanding print and imaging applications).

www.intenseco.com

www.laser2000.de

Integrated laser driver system for medical research and display applications

At May's CLEO/QELS 2007 event in Baltimore, MD, USA, Intense launched the HPD7404 Laser Driver System, which is designed for current control and temperature compensation of its high-power free-space or fibered visible laser components and which, unlike traditional laser drivers, is a complete, integrated system. Included are the current driver, temperature-controller, and a choice of high-power red laser diodes: 630, 635

or 655nm up to 700mW, as well as 670 or 690nm up to 1W. The HPD7404 is designed for medical research and display applications, such as photodynamic therapy and red-green-blue (RGB) displays.

The compact, portable system integrates a high-power laser and thermoelectric cooler drivers. The Intense-HPD family of laser driver systems aims to enable use of diode lasers in a wider variety of applications, says the firm.

Nichia to mass produce 250mW blue-violet laser next January

In a seminar at Laser Expo 2007 in Yokohama, Japan in late April, Nichia Corp announced product plans for blue-violet lasers for next-generation DVD drives (Blu-ray Disc and HD DVD), high-power blue lasers for light sources in image display equipment, and a white light source using a blue laser, according to the publication Nikkei Electronics.

Nichia currently mass produces a model of its blue-violet laser with an output power of 130mW operating in pulsed mode for next-generation DVD recorder/players (and, since April, a model capable of 20mW output in continuous-wave mode, focusing on low-cost manufacturing for replay-only equipment). It has also previously sampled a 180mW pulsed-mode model. The firm now says it will start mass producing and shipping a 180mW pulsed-mode model in June, followed by a 250mW model in January 2008. Next-generation DVD equipment can generally record on a dual-layer disc at 4–6x speed using a blue-violet laser emitting about 200mW and 8x



Nichia's existing blue-violet laser.

speed emitting about 240mW, operated in pulsed mode. Nichia also plans to mass produce a 320mW model for 10x speed recording in first-half 2008.

Regarding high-power blue lasers for use as a light source in image display devices (including rear projectors), in the seminar Nichia detailed a blue laser model that outputs 500mW in continuous-wave mode at an emission wavelength of 445nm. The drive current and voltage are 480mA and 4.8V, respectively, and the life-time exceeds 30,000 hours. In general, a life-time of 10,000 hours is required for display light sources, says Nichia. The firm says it has

achieved a threshold current density of 1.8kA/cm² by improving the laser structure and optimizing the growth conditions. Nichia aims to increase the emission wavelength to 460nm. It also aims to realize light output of over 1W by developing a dedicated package with higher heat dissipation. (For blue-violet lasers for next-generation DVD, Nichia currently uses a multi-purpose can package in an attempt to lower costs.)

Also at the seminar, Nichia presented a light source that uses a phosphor coated on the end surface of an optical fiber to convert the wavelength of the light transmitted by the fiber from a blue laser to obtain pseudo white light. Key target applications are light sources for displays and headlamps.

In third-quarter 2007 Nichia plans to start sample shipments of a model that achieves a luminance of 85cd/mm² with a beam flux of 96lm at a drive current of 500mA.

www.nichia.com

http://techon.nikkeibp.co.jp/english/NEWS_EN/20070507/132034

AOI raises \$28m in funding

Applied Optoelectronics Inc (AOI) of Sugar Land, TX, USA, which makes laser diodes, photodetectors, and optical modules for fiber-optic communications, has raised \$28m in capital through a private-placement Series E funding round. This brings the total raised to \$68.9m since the firm was founded in 1997 at the University of Houston Space Vacuum Epitaxy Center (a NASA Commercial Space Center). The latest funds will be used to expand production capacity and product development, with the aim

Lin joins board

AOI has appointed Chewei Lin to its board of directors. Lin is president of the Desktop Platform Business Unit of VIA Technologies Inc, responsible for VIA's chipset and product roadmap planning. This increases the number of directors to seven.



of expanding its presence in the fiber-optic market.

AOI combines design, wafer growth, processing, packaging, and module design in vertically integrated production of components and modules.

"As the telecommunications industry continues to grow, this investment will better position us to serve the needs of our customers and strengthen our market-leading position," says Dr Thompson Lin, founder, president and CEO. AOI has over 200 clients in 24 countries.

www.ao-inc.com

Product ramp to stem Bookham losses in second-half 2007

For its fiscal Q3/2007 (to end-March), Bookham Inc of San Jose, CA, USA, which designs and manufactures optical telecoms components, modules and subsystems, has reported revenue of \$45m, down 16% from \$53.4m a year ago and down 20% on \$56.3m last quarter. After the end of its long-term supply deal in December, revenue from Nortel was just \$3.1m. Revenue from other customers was \$41.9m, up about 43% on a year ago but essentially flat on the prior quarter as main customers like Cisco Systems reduce their component inventories.

Under generally accepted accounting principles (GAAP), gross margin has fallen from 15% last quarter to 10%, while net loss has risen from \$21.3m last quarter to \$24.3m.

Cash reserves have risen from \$51.5m at the end of the last quarter to \$61.7m, but \$26.9m of this was due to net proceeds from a private placement of stock completed in March.

"For the fourth quarter [to end June], we forecast our revenue will be essentially flat [\$43-47m] due mainly to ongoing inventory reduction programs with some of our top customers," says Dr Peter Bordui, chairman and interim president and CEO. "Nevertheless, we expect sequential improvements in our gross margin [to 12-16%] due to additional savings from our ongoing cost reduction actions" (closing its development facility in Ottawa, Canada and the production line at the Paignton, UK site, and job cuts at the InP fab in Caswell, UK).

"Cost reduction plans remain on track to achieve additional quarterly savings of \$9-10m from December 2006 levels by the end of the September 2007 quarter," adds CFO Steve Abely. "We expect these savings, along with expected improvement in our revenue during the second half of 2007 [from several launched products, which continue to ramp], to translate into improving financial results throughout the remainder of the calendar year."

● At March's OFC 2007 event in Anaheim, CA, Bookham launched its latest LC96 pump module, which it claims to be the world's most powerful 980nm pump laser (with 'kink-free' output of 750mW).

Made at Bookham's GaAs fab in Zurich, Switzerland, the new pump module incorporates the firm's 'generation eight' laser chip (G08). Its performance and reliability also suits uncooled operation.

Previously, in February Bookham's 980nm OceanBright pump laser was selected by Tyco for deployment in undersea fiber-optic cable systems.

● In March, Bookham said that its LambdaFLEX iTLA integrable Tunable Laser Assembly — which has already been deployed in systems supporting 10Gb/s and below — had been selected by equipment vendors for use in 40Gb/s transmission systems, including the MI 40000XS next-generation subsystem of Mintera for DWDM optical transport in metro, regional and ultra-long-haul telecom networks.

www.bookham.com

Technical sales manager for HPLD business in Europe

Optical component, module and subsystem manufacturer Bookham Inc has appointed Dr Pierre Champert as technical sales manager of its high-power laser diode business unit in Zurich, Switzerland.

Originally developed for use in telecoms networks, Bookham says it has directed much effort into adapting and diversifying its high-power laser diodes to markets and applications including industrial, medical, display, analytical, printing, aerospace and defense. The aim of the appointment is now to advance business growth across Europe (with a particular focus on

France) and to further strengthen support and service to customers in the region.

"Europe is particularly important to us as a diverse and advanced industrial market, with a wealth of industries, from automotive to biomedical, using state-of-the-art photonics to maintain their leading



Pierre Champert.

edge," says Gunnar Stolze, who is the European sales director of Industrial Products.

With over 10 years' experience in solid-state and fiber-laser technologies, Champert's appointment is "a sign of the continued investment we are making in commercial, manufacturing and engineering functions."

Before joining Bookham, Champert contributed to business development in Europe at fiber laser and amplifier manufacturer Keopsys SA of Lannion, France. He holds a physics degree from the University of Paris-Orsay and a PhD from Imperial College London.

Optical comms consolidation and inventory correction drive JDSU to cut 400 jobs

For its fiscal Q3/2007 (to end-March), JDSU of Milpitas, CA, USA reported revenue of \$361.7m (54% from the Americas; 27% from Europe; 19% from Asia-Pacific). This is down slightly from Q2's \$366.3m though up 15% on \$314.9m a year ago. "The third quarter was stronger than expected, with a much smaller-than-anticipated seasonal decline," says CEO Kevin Kennedy.

However, Optical Communications segment revenue was \$128.7m (36% of total revenue), up only 1% on a year ago and down 3% from last quarter. Although metro optical and agile product sales have risen (driven by metro-area network build-out), long-haul DWDM sales fell. Also, many customers remain in the midst of operational adjustments or pauses related to either (i) having built larger than expected inventories during 2006 and now executing inventory adjustment initiatives and lean manufacturing initiatives or (ii) five of JDSU's most significant cus-

tomers being involved in consolidation activity. In particular, DWDM long-haul fell for the first time in many quarters.

The overall net loss was \$14.2m, compared with net income of \$3.7m for a year ago.

For fiscal Q4/2007 (to end-June), JDSU expects revenue of \$325-345m (down 4.6-10% on fiscal Q3). In particular, a book-to-bill ratio for the Optical Communications segment "substantially less than 1" has led to "limited visibility" for second-half calendar 2007, says Kennedy.

So, despite fiscal Q3 achieving positive free cash flow for the first time since September 2001

Many customers remain in the midst of operational adjustments or pauses related either to industry consolidations or to lean manufacturing and inventory initiatives

(boosting reserves to \$1.22bn at the end of March), JDSU "remains committed to focused execution of profitability improvement programs," says Kennedy.

JDSU has hence announced new initiatives in its Optical Communications segment that, by the end of calendar 2007, will shed about 400 staff (out of a total 6834 at the end of March), mainly from North America and China. Combined with the \$1m in cost savings already targeted for fiscal Q4, JDSU now expect cost savings of \$4m.

Savings will ramp through fiscal Q1/2008, and it expects to exit calendar 2007 at a run-rate of \$8m in cost savings compared to fiscal Q3.

In addition, to "improve on manufacturing variances", JDSU has united the Optical Communications segment under a single leader for the first time (see the panel below) and "re-sculpted" operations so that the optical communications manufacturing function has a dedicated team.

www.jdsu.com

JDSU's Optical Communications Group gets president

JDSU has appointed David Gudmundson as president of Optical Communications, responsible for sales, operations and product development (completing the integration of these functions under a single Optical Communications business leader). "Our focus will be on driving innovation, customer satisfaction, quality and improved profitability," says Gudmundson.

Gudmundson joined JDSU in December 2003. As senior vice president of Corporate Develop-

ment and Marketing, he played an integral role in strategic transactions (including the acquisitions of Lightwave Electronics, Acterna, and Agility Communications), diversifying JDSU's portfolio and expanding its opportunity in the growing and profitable markets for test and



David Gudmundson

measurement equipment, tunable transponders and solid-state lasers.

Prior to joining JDSU, Gudmundson held various hardware and software development and systems engineering positions at Argo Systems Inc (now part of The Boeing Company) and ESL Incorporated (now part of TRW), then senior leadership roles at Cisco, culminating in vice president and general manager of its security server, DSL, and edge routing business units.

Emcore's dip in fiber revenues compensated by CATV and PVs

Emcore Corp of Albuquerque, NM, USA, which makes components, modules and subsystems for the broadband, fiber-optic, and solar power markets, has reported preliminary results for its fiscal Q2/2007 (to end-March) along with results for fiscal Q1/2007 (to end-December) — delayed due to Emcore's voluntary review of its past stock option grant procedures.

Fiscal Q1 revenue was \$38.5m (slightly higher than guidance), up 8% on \$35.7m from continuing operations a year previously and up 9% from \$35.4m the prior quarter. Fiber Optics revenue was \$25.3m, down 10% from \$28m the prior quarter due to customer inventory management issues (which continued into Q2). However, demand for CATV products saw a significant rise (due to last throughout fiscal 2007). Photovoltaics revenue was \$13.2m (up 23% from \$10.7m a year ago, and up 79% from \$7.3m the prior quarter, following the receipt of export licenses that had delayed shipment previously).

Total revenue for fiscal Q2 was about \$40m (up 10% year-on-year and 3% sequentially).

For fiscal Q1, most of Emcore's 70% year-on-year increase in operating expenses (to \$18.7m) was due to costs incurred via prior-year acquisitions (a \$2.2m non-cash impairment charge for the write-down of intangible assets of Corona Optical Systems), the review of past stock option grants (\$1.9m), and the new terrestrial solar power division (about \$2m). Excluding these charges, net loss has been cut from \$9.7m in the prior quarter to just \$6.5m. However, R&D expenses are expected to increase in Q2 as Emcore completes the second generation of its solar power concentrator system and prepares to transfer system development to production in the September quarter.

In the December quarter, cash reserves fell \$36.7m to about \$88m, partly due to November's \$13.5m investment in a 27% stake in solar energy systems company WorldWater and Power Corp.

Last August's sales of the firm's stake in GELcore as well as its Electronics Materials and Device division have provided capital to invest in the firm's terrestrial photovoltaic strategy and to expand its fiber-

optics business, says president and CEO Reuben F. Richards Jr.

"Our strategic investment in WorldWater and Power and expansion into China are just two examples of these initiatives," he adds. "We have obtained a significant number of new satellite and terrestrial orders in our Photovoltaic division that we believe will help improve operational performance in fiscal 2007." Emcore is the exclusive supplier of multi-junction solar cells, assemblies and concentrator subsystems to WorldWater and Power, with a contract valued at \$100m over the next three years. In April, Emcore said that it is committing to two more investments in WorldWater totaling \$7m.

Emcore expects a much stronger second half, also due to increased strength in CATV and broadband product lines. In mid-April, Emcore purchased Opticomm Corp of San Diego, CA, including its fiber-optic video, audio and data networking business, technologies, and intellectual property. Management expects the transaction to provide about \$7m of revenue in 2007.

www.emcore.com

NASDAQ deadline for filing March-quarter results

Emcore received a NASDAQ Staff Determination letter on 14 May that its common stock is subject to delisting from the NASDAQ Stock Market.

This is due to Emcore's failure to file its report on Form 10-Q for the fiscal quarter to end March with the Securities and Exchange Commission by the deadline of 10 May because of its ongoing review of past stock option grant procedures by a special committee.

The review has concluded that previously filed financial state-

ments need to be restated to reflect additional non-cash stock-based compensation expense and related tax expense. This requires substantial work by independent public accountants and senior management that not only involves restating prior year audited financial statements but also impacts the preparation of audited financial statements for fiscal 2006 (to end-September).

On 10 May, the NASDAQ Listing Qualifications Panel granted Emcore continued listing subject to

certain conditions, including filing its Form 10-K for the fiscal year to end-September 2006, and its Form 10-Q for the quarter to end-December 2006 and all required restatements with the SEC by no later than 18 June.

Emcore plans to file the forms 'as soon as reasonably practicable'. However, if it is unable to do so by the 18 June NASDAQ deadline, then the firm intends to seek an extension to maintain its listing and to provide for a stay of any suspension of trading.

Finisar cuts revenue forecast

Finisar Corp of Sunnyvale, CA, USA has cut its guidance for its fiscal fourth-quarter revenue 2007 (to end-April) from \$104–110m to about \$97m (\$88m from optical subsystems and \$9m from network testing and monitoring products). This is 10% down on the prior quarter's \$107.5m and 5% down on \$102.4m a year ago.

The revision is due partly to:

- the impact of a transition by two customers to 'lean inventory' arrangements (whereby demand for Finisar's products is reduced in conjunction with implementing lower levels of inventory at these customer locations); and
- continued utilization by certain customers of excess inventories of products designed for LAN/SAN

(local-area and storage-area network) applications, which adversely affected demand.

These factors combined to reduce revenues from the sale of optical subsystems by about \$6m more than previously forecast.

However, revenues from optical subsystems for 10–40Gb/s applications in particular should total \$14–15m (in line with its original forecast of \$14–\$17m).

Revenue for the full fiscal 2007 should now be about \$419m, up 15% on fiscal 2006's \$364.3m.

Finisar has also cut the revenues guidance that it gave in early March for its fiscal first-quarter 2008 (to end-July 2007) from \$108–115m to \$105–112m. Nevertheless, this still represents a revenue rebound from

fiscal Q4/2007 due to:

- little or no continuing impact from its customers' lean manufacturing arrangements;
 - anticipated increases in sales of products for 10Gb/s applications;
 - a full quarter of results associated with the acquisitions in March of photonic component and subsystem manufacturer AZNA LLC of Wilmington, MA and transponder manufacturer Kodeos Communications Inc of South Plainfield, NJ.
- * Finisar says it is not providing preliminary bottom-line financial guidance for fiscal Q4/2007 in light of the voluntary review of its historical stock option granting practices and associated accounting impact, which is ongoing.

www.finisar.com

Avanex's revenues enter dip, but targets break-even

For its fiscal Q3/2007 (to end-March) optical communications component and module maker Avanex Corp of Fremont, CA, USA reported net revenue of \$55.1m (including \$3.2m from the product lines of Avanex France S.A., which was divested in mid-April and is now 3S Photonics). This is down slightly from \$55.6m the prior quarter but still up 37% on \$40.1m a year ago.

"Following an exceptionally strong growth quarter [to end-December], we maintained our revenue level, although it was impacted by annual pricing negotiations," says chairman, president and CEO Jo Major.

However, "the continued focus on improving our cost structure generated further net loss improvements [from \$10.2m a year ago and \$8.6m last quarter to \$6.7m]," adds Major. Gross margin was 19% (the same as last quarter), which is up from just 4% a year ago.

"In the third quarter, we continued to improve the fundamentals of our cost structure and flexibility of our operating model," says Marla

Sanchez, senior VP and chief financial officer. "The improvements from the margin expansion programs we launched three quarters ago offset annual pricing adjustments, allowing us to sequentially maintain our gross margin, reduce our operating expenses and improve our net loss."

"Divesting our semiconductor fabs in France marks the final step in our major restructuring efforts," adds Major. "We have succeeded in evolving our operating structure into a low-cost, flexible model that has the ability to react quickly to market demand and provide us with a solid foundation for growth".

"We remain confident in the long-term strength and growth of our markets. The demand for video services and broadband access are the underlying trends fueling market growth," he continues. "The factors indicating the strength of our markets include the announcements of multiple large capital spending programs at the carrier level, increasing installation trends for fiber, and

solid booking trends announced by our customers. We are laying the groundwork for our next wave of growth by developing innovative technologies and strengthening our market presence in key growth segments within the overall telecommunications market."

"In the near-term our sales will be impacted by cyclical deployment patterns of large capacity expansion projects, but we anticipate that we will return to growth in the latter part of the calendar year," concludes Major. For its fiscal Q4/2007 (to end-June), Avanex expects revenue to fall slightly to \$47–52m, but gross margin to rise to 20–25%.

Major says that the firm's top priority remains achieving non-GAAP EBITDA break-even (earnings before interest, taxes, depreciation and amortization) no later than the September 2007 quarter (excluding the effect of non-recurring events, including costs associated with the Avanex France divestiture).

www.avanex.com

Opnext's 42% growth driven by 10Gb/s sales up 70%

Optical communications component and module maker Opnext Inc of Eatontown, NJ, USA has reported preliminary revenues for its fiscal Q4/2007 (to end-March) of \$65.4m (up 5.9% on last quarter's \$61.7m and 41.5% on \$46.2m a year ago). This was driven by: 69.8% growth in 10Gb/s and above products to \$53.3m (mainly from strong demand for Xenpak, XFP, X2, 300-pin tunable, 300-pin fixed wavelength and 40Gb/s product lines), 22.3% growth in sub-10Gb/s products to \$7.5m, and 7.9% growth in industrial and commercial products, partially offset by a \$4.3m drop in sales of DVD products.

Cisco and Alcatel-Lucent represented 38.6% and 21.0% of sales, respectively, and the USA, Europe, Japan and Asia Pacific 59.6%, 26.0%, 10.3%, and 4.1%.

Compared with a net loss of \$2.8m a year ago, net income has risen from \$3.2m last quarter to \$5.0m (excluding \$3.5m of stock-based compensation expense), mainly due to strength in 10Gb/s and above products, the launch of new products, and cost reductions that more than offset price erosion.

Cash reserves rose by \$123.5m to \$199.8m, largely due to \$171m of net proceeds from February's initial public offering (offset by repaying \$50.9m of short-term loans).

For fiscal 2007, sales were \$222.9m (up 46.9% from \$151.7m the prior year), including: 68.3% growth in 10Gb/s and above products to \$177.1m and 38.7% growth in sub-10Gb/s products to \$26.3m (as strong demand for telecom and datacom SFP products offset falling sales of 2.5Gbps legacy products).

Gross margin has risen from 21.1% to 34.2%, mainly due to the growth in 10Gbps and above products from 69.4% of sales to 79.5%, the introduction of new products, and cost reductions more than offsetting price erosion.

Excluding the \$3.5m stock-based compensation expense, net income improved to \$6m (compared to a net loss of \$30.5m) in fiscal 2006.

President and CEO Harry Bosco says that Opnext has been encouraged by the vibrancy of the optical industry fundamentals and the continued strength of demand for its 10Gb/s portfolio of products and the better-than-expected ramp

in 40Gb/s sales across a broad customer spectrum. "The industry dynamics are healthy and levels of competition and pricing pressure are as expected within our markets," he says. "We are on track with our technology roadmap to enhance our 10Gb/s product line and to broaden our 40Gb/s product line for smaller transceiver module sizes and extended distance applications," Bosco adds. "Our sub-10Gb/s business is improving with the continued shift from legacy to SFP form factors and the introduction of gigabit Ethernet SFP for data application."

"As we enhance our product line, continue to expand our share within existing customers and penetrate new customers, we expect continued growth," Bosco reckons. "We expect our margins to continue to expand as our mix of 10Gb/s and 40Gb/s products grows as a percentage of our total revenue."

For its fiscal Q1 (to end-June), Opnext expects revenue up 3-9% sequentially to \$67.5-71.5m. Longer term, it expect gross margin to approach 40%.

www.opnext.com

OCP losses worsen as it gears for China manufacturing

For its Q2/2007 (to end March), fiber-optic component maker Optical Communication Products Inc of Woodland Hills, CA, USA has reported revenue of \$16.4m, down 3.7% on \$17.0m last quarter and 10.6% on \$18.3m a year ago.

Gross margin has fallen from 34.7% a year ago to 18.8% last quarter and now -3.5%. This reflects lower average selling prices, lower-margin products, and a non-cash inventory reserve charge of \$3.2m to adjust current inventories on hand to market value.

Operating expenses have risen from \$5.6m a year ago then \$9.0m last quarter to \$18.0m (including \$851,000 in transition costs associated with the planned move of

manufacturing to China and a non-cash goodwill impairment charge of \$8.5m). The transition charges were due mainly to the accrual of severance benefits as the firm approaches its planned workforce reduction during fiscal Q4/2007.

Net loss was \$17.1m, compared with \$4.2m last quarter and a net income of \$2.1m a year ago.

"OCP is in the midst of a turnaround that began last year and will continue into fiscal 2008," says CEO Philip F. Otto. "Transitions of this magnitude take time, and we are confident that the decisions we have made are the right ones to position OCP for a return to growth," he adds. "We expected margin volatility and significant transition-

related charges throughout fiscal 2007. Our second-quarter results, however, also reflected industry-wide price erosion and softening of the fiber-to-the-home (FTTH) market in Japan."

OCP has reduced its fiscal 2007 targets for revenue to \$65-70m (from \$80-90m) and for gross margin to 10-12%. The firm says that its long-term goal is to restore sustainable gross margin to levels greater than 30% through strategic initiatives including internally sourced laser integration, reducing the workforce in conjunction with moving manufacturing to China, and transitioning to a higher-margin product mix over time.

www.ocp-inc.com

Oplink challenges OCP's 'poison pill'

Component and module maker Optical Communication Products Inc of Woodland Hills, CA, USA says that, on 3 May, a special committee of its board of directors approved a limited, 30-day shareholder rights plan entitling the owner of each existing share to receive another preferred share of approximately equal value. This is as a precautionary measure to safeguard the interests of its minority shareholders while it evaluates the unsolicited offer made on 23 April by photonic component, module and subsystem maker Oplink Communications Inc of Fremont, CA, USA to acquire OCP's minority shares.

In late April Japanese fiber-maker Furukawa Electric Co Ltd agreed to sell its 58.2% majority ownership stake in OCP to Oplink, which proposed to also purchase OCP's remaining outstanding common stock not owned by Furukawa (also at about \$1.50 per share, a 9% premium to OCP's 30-day average closing price prior to announcing the agreement with Furukawa).

"The special committee has not reached any conclusions, but we will continue to work diligently and announce the results of our evaluation in due course," says special committee chairman Hobart Birmingham (OCP's chairman).

Under the plan, the special committee declared a dividend distribution of one right for each outstanding share of OCP common stock to shareholders of record as of 14 May. These rights (due to expire on 2 June) become exercisable only under three specific conditions: the closing of Oplink's purchase of Furukawa's 58.2% ownership stake in OCP; the acquisition of more than 15% of OCP's outstanding common stock by a third party; or the acquisition of any additional shares by Furukawa or Oplink.

Subsequently, on 7 May, Oplink filed a lawsuit against OCP in the Delaware Court of Chancery seeking: a declaration that the 'poison pill' shareholder rights plan is invalid, as it attempts to prevent the sale of Furukawa's OCP shares to Oplink; an injunction preventing OCP or the special committee from taking further actions to implement the poison pill (including the distribution of rights to OCP shareholders); a declaration affirming the right of Oplink and Furukawa to proceed with their transaction; and other relief, including money damages.

"We remain interested in discussing our proposal to purchase all remaining shares of OCP with the special committee," says Oplink's president and CEO Joe Liu.

"However, we believe that the actions taken by the special committee in adopting the poison pill are inappropriate. While the special committee's stated reason for its actions is to protect the interests of OCP's minority shareholders, the interests of the minority shareholders are not threatened by the transfer of Furukawa's OCP stake to Oplink," he adds.

● On 25 May, Furukawa informed OCP that its directors intend to amend its recently adopted shareholder rights plan for the purposes of consummating the sale of its stake to Oplink.

Based on it having sufficient voting power under both OCP's bylaws and Delaware law, Furukawa says that, on either 4 July or 20 days following the mailing of an information statement to shareholders from OCP (whichever is earliest), it will unilaterally amend OCP's bylaws to expand its board of directors to 12, by appointing four new Furukawa directors. This would raise the total to seven (constituting a majority of the expanded OCP board).

Oplink grows revenues 20%

For its fiscal Q3/2007 (to 1 April), Oplink Communications Inc of Fremont, CA, USA reported revenues of \$27.6m, up 20% on fiscal Q2 and 89% on a year ago.

Calculated in accordance with accounting principles generally accepted in the US (GAAP), net income has risen from \$1.0m a year ago then \$3.1m in fiscal Q2 to \$4.3m.

Via the design facilities at its headquarters in Fremont and low-cost manufacturing at its facilities in Zhuhai and Shanghai, China, Oplink produces photonic components, modules, and subsystems for optical networking applications, including laser chips from GigaComm Corp in Hsinchu, Taiwan (acquired last August) for applications such as fiber-to-the-home (FTTH) components.

"We had good activity with Tellabs, Huawei, and Ericsson in the quarter and increased our revenue contribution from Nortel," says president and CEO Joe Liu. "We continue to experience demand for our ROADM [reconfigurable optical add/drop multiplexing] solutions as well as strong interest in metro, core and edge products for global projects. We have also focused on expanding our revenue sources to broader systems-level solutions."

Oplink forecasts that fiscal Q4 revenue will rise 10% sequentially.

"We are committed to further enhancing our product portfolio, quality, efficiency and competitive position in order to better serve our customers and shareholders," says Liu. "Although we see only modest spending increases in the coming quarter, we remain optimistic about our business outlook and are poised to benefit from next wave of major carrier spending," Liu concludes.

www.oplink.com

Svedice gains new investor

InP opto foundry Svedice AB of Järfälla, Sweden has signed an investment agreement with SFO Technologies (a NeST Group company with products and services in diverse fields, including RF and wireless, power supplies, fiber optics and optronics). SFO becomes a co-investor in Svedice's Swedish investor consortium, which includes contract R&D organization Acreo, STING (Stockholm Innovation and Growth) and VINNOVA (the Swedish Governmental Agency for Innovation Systems). This latest funding follows June 2006's closure of a second round of equity funding.

Svedice was founded in December 2005 after a management buyout of the chip manufacturing operation of Northlight Optronics (formerly the optoelectronics business of Ericsson Microelectronics).

The firm provides customized 2" InP-based optoelectronic chip design and processing foundry services (using Aixtron 2400 multi-wafer MOCVD reactors in its 800m² Class 1000 cleanroom), including 1310nm and 1550nm lasers (including tunables) as well

as PIN and APD (avalanche photodiode) receivers for 2.5 and 10Gb/s applications. For device and process design, computer simulation tools are available, combined with 20 years of design experience in the team. For wafer and chip-on-carrier processing, Svedice offers services such as III-V epitaxial growth, materials characterization, electron-beam writing, lithography, etching, metallization, and testing.

"On the operational side, we have already a well-established, close bi-lateral partnership," says Dr Dirk Sinerius, CEO. "SFO [is] our customer for laser and receiver products and our outsourcing partner for volume manufacturing of chip-on-carriers," he adds. "Supported by the SFO Technologies' sales force, we'll be able [to] expand our customer base and grow our business significantly at a much higher pace."

"I want Svedice to become the center of our optical business unit within SFO Technologies"

SFO is "very focused on the optical communications industry," says NeST group chairman Javad (Jay) Hassan. "I want Svedice to become the center of our optical business unit within SFO Technologies."

● In March 2006, Svedice formed a strategic partnership that involves DMG Technologies of Monterey Park, CA, USA incorporating Svedice-designed products into its own lines of optical subassemblies, as well as distributing Svedice's products in North America.

DMG manufactures optical subassemblies including laser/PIN diodes and APDs for products such as bi-directional devices, connectorized lasers and PIN detectors, and laser combiners used in telecom, datacom, CATV, and instrumentation systems.

The cooperation strengthens Svedice's position in the US market, says Sinerius. "We are going to supply laser and receiver products (chip-on-carrier) for use in standard butterfly packages and transmitter and receiver modules, as well as additional chip-design and wafer-manufacturing services."

www.svedice.com

Infinera prices IPO to raise \$139m

After finally filing with the US Securities and Exchange Commission at the end of February for its long-awaited initial public offering on the NASDAQ Global Market, Infinera Corp of Sunnyvale, CA, USA, a vertically integrated manufacturer of InP-based photonic integrated circuits (through to optical networking communications equipment), has now priced the 14 million shares to be offered at \$10-12.00 each (to raise \$139m). Underwriters have the option to buy an extra 2.1 million shares. The firm plans to use the proceeds to develop new products, finance its growth, and make acquisitions to expand.

Infinera was founded in early 2001 as Zepton Networks Inc and has since raised over \$330m in venture capital funding, including \$78.8m in 2006 (from investors including Advanced Equities, KPCB Holdings, Mobius VI, RWI Ventures, Benchmark Capital Partners, and Worldview Technology Partners).

For 2006, Infinera reported a loss of \$89.1m. However, revenue has risen from just \$0.6m in 2004 and \$4.1m in 2005 to \$58.7m in 2006 (including \$44.3m in Q4).

For the quarter to end-March 2007, Infinera's revenues grew 12% sequentially to \$49m.

www.infinera.com

Albis starts shipping GaAs PD arrays

Enablence Technologies Inc of Ottawa, Canada, which develops FTTH transceivers for optical modems, says that its European subsidiary, Albis Optoelectronics AG of Rüslikon, Switzerland, has made its first customer shipments of GaAs photodiode arrays for use in QSFP transceivers.

This is the first product introduced by Albis since becoming a subsidiary of Enablence [in mid-March]. "The Albis photodiode design library has now grown to more than 30 standard devices," says Enablence's CEO Arvind Chhatbar.

www.albisopto.com

Photodigm launches high-power, single-frequency diode laser platform

At the Conference on Lasers and Electro-Optics (CLEO 2007) in Baltimore, MD, USA, Photodigm Inc of Richardson, TX, USA launched its proprietary diode laser technology platform which, the firm claims, delivers efficiency and diffraction-limited beam quality advantages over conventional laser solutions. Evaluation units of the GaAs-based PH9/10xxSF high-power, single-frequency DBR edge-emitting laser are available in specific wavelengths of 920–1100nm.

Until now, it has been impossible to combine the attributes of high power, diffraction-limited beam quality, low astigmatism, and single-frequency operation in one device, the firm claims. Photodigm says it has applied its design and process technology to create the world's first product that combines all of these characteristics in a laser that provides a single lateral and longitudinal mode beam at power levels which, until now, could only be achieved with a diode-pumped solid-state (DPSS) laser, such as an Nd:YAG laser.

The new laser platform is based on a proprietary distributed Bragg reflector (DBR) ridge waveguide process. The quantum-well epitaxial design of the active layer

enables output power in excess of 500mW, with wall-plug efficiencies of up to 50%, while maintaining single-frequency operation. The laser provides the optical performance of a DPSS laser without the efficiency penalty of its quantum defect, Photodigm says. Furthermore, unlike a DPSS laser, the DBR laser can be produced at wavelengths throughout the semiconductor material's spectral range.

"Our technology represents a significant improvement over conventional broad-area and DPSS solutions," says CEO John E. Spencer. "The immediate availability of our devices, coupled with our long-term roadmap to higher powers and additional wavelengths [1250–1600nm, using InP], means that we can provide our customers with a strategic advantage as they design their next-generation products."

The firm believes that the device will enable new, lower-cost, higher-efficiency products in segments such as free-space communications, digital imaging, defense, and medical devices, including stabilized diode lasers for fiber Bragg grating (FBG) replacement, low-power DPSS replacement, and spectroscopy.

www.photodigm.com

Photodigm awarded \$749,862 by the Texas Emerging Technology Fund

Photodigm has been awarded \$749,862 by the Texas Emerging Technology Fund (TETF) of the North Texas Regional Center for Innovation and Commercialization (NTXRCIC) of Dallas, TX, USA. The NTXRCIC is a not-for-profit corporation that helps to identify, evaluate and develop new technologies by assisting entrepreneurs in starting and growing new ventures.

The award is intended for further development of Photodigm's laser technology. Initial applications are

in progress in an anti-submarine warfare sensor and commercial 'inkless printing' systems.

"The funds provided by the TETF are timely and crucial to the implementation of our product roadmap", says CEO Spencer.

The firm has an intellectual property portfolio of 25 patents and is collaborating on further research with professors at Southern Methodist University (where co-founder, VP and CTO Gary Evans is professor of electrical engineering).

IN BRIEF

Optium completes its acquisition of Kailight

Optium Corp of Horsham, PA, USA, which designs and manufactures optical subsystems supporting core to the edge applications for the telecom and cable TV networks, has completed its acquisition of Kailight Photonics Inc (announced at the end of March) for about \$35m in cash plus a further sum of up to \$5m, depending on the acquired business' performance.

Founded in 2001 and with offices in Dallas, TX and Nes Ziona, Israel, Kailight develops 300-pin 40Gb/s transceivers addressing both line-side and client-side applications. The firm says that its proprietary 40Gb/s technology enables both high performance and next-generation functionality, such as integrated PMD (polarization mode dispersion) compensation and multiple modulation formats not currently available on any existing 300-pin 40Gb/s transceivers on the market.

The acquisition will build on Optium's suite of optical transport solutions (fixed or wavelength-agile 10Gb/s and 40Gb/s transceivers and subsystems, 10Gb/s pluggable transceivers, CATV trunking and distribution subsystems and next-generation WSS ROADMs) and will enable Optium to provide either 40Gb/s modules or full line-card solutions for emerging 40Gb/s applications.

Kailight will operate as a subsidiary from its Nes Ziona facility and will be renamed Optium Israel. Former president and CEO Sagie Tsadka has been named vice president and general manager, and will continue to lead its 40Gb/s initiatives.

www.optium.com

www.kailight.com

Charting routes to zinc oxide applications

A wide bandgap and piezoelectric properties make zinc oxide an interesting material for research into producing and detecting light (up to ultraviolet) and for electromechanical systems. Dr Mike Cooke looks at progress in producing p-type doping, allowing light emission from p-n junctions, and new ideas for mechanical coupling and photodetection from nanowires.

Research into semiconductor materials that are not in the mainstream often comes in spurts. The beginning of a spurt is marked by an old problem overcome or a new idea. Zinc oxide has recently seen something of a renaissance [1], with some progress on the long-term problem of finding techniques to create p-type doping [2]. Also, further new ideas have arisen in application areas in terms of using the piezoelectric properties of the material. Device opportunities include optoelectronics (particularly UV), high power, transparent thin-film transistors and even spintronics. ZnO is often in the frame when nanowires need to be constructed.

Zinc oxide is already used as an electronic material for producing varistors (voltage dependent resistors). Such devices use zinc oxide grains in a metal (e.g. cobalt, bismuth, manganese) oxide matrix. Diode junctions are formed between the grains such that only small currents flow for moderate voltages, but avalanche breakdown at high voltage produces a large current. Such devices are used to divert surges away from delicate circuits.

Polycrystalline ZnO is also used in phosphors, piezoelectric transducers, optical waveguides, acousto-optic media, conductive gas sensors and transparent electrodes (e.g. in photovoltaics). Properties such as piezoelectricity could be further developed to produce surface acoustic wave (SAW) filters for RF devices, such as in mobile wireless electronics.

The material could also be useful for applications needing radiation hardness (e.g. space, defense). Indeed, it is even better than gallium nitride in this respect. For thin-film transistors, it can be deposited in amorphous or crystalline forms on flexible substrates, with the resulting (transparent) material having higher mobility than organic semiconductors. Doping with manganese (Mn) or other 3d transition metals produces spintronic opportunities.

More recently, ZnO substrates have been produced with a view to providing substrates for nitride-based

optoelectronic devices. For example, Cermet of Atlanta, GA, USA produces ZnO (n-type) bulk substrates up to 50mm in diameter. The wurtzite crystal structure matches much more closely that of GaN and related AlInGaN compound semiconductors compared with traditional sapphire (Al_2O_3) substrates. Indeed, a perfect match is achieved between ZnO and $\text{In}_{0.22}\text{Ga}_{0.78}\text{N}$, and the ZnO-GaN mismatch is of the order of 2% rather than the about 16% for sapphire. This situation is also used in reverse, where a ZnO thin film is grown on a GaN buffer layer on sapphire. However, a general problem arising from the strongly increased ionic character of II-VI bonds in ZnO compared with GaN is that stacking defects can easily occur within a short distance of a perfect interface between the slightly mismatched materials.

Another alloy system that can be used with ZnO is MgCdZnO. Non-equilibrium techniques enable the inclusion of magnesium beyond its normal solubility limit of 10% up to 50%, allowing the band gap to be varied over the range 3.0–4.5eV. Using Cd enables one to slightly lower the bandgap range to 2.8eV. By comparison, the band gap of pure ZnO is about 3.4eV.

Another interesting property of ZnO is its high exciton binding energy of 60meV (bound states of electrons and holes) compared with 21–25meV for GaN and the 26meV $k_B T$ equivalent of room temperature (300K). Superlattice structures of $\text{ZnO}/\text{Mg}_x\text{Zn}_{1-x}\text{O}$ have enabled exciton binding energies to reach 115meV. Excitons are seen as a route to lasers with low threshold currents [3].

The p-type problem

Since unintentionally doped ZnO tends to have n-type properties, p-type doping is difficult to achieve. Such an asymmetric doping limitation is common in wide-bandgap materials. The n-type property in ZnO can be enhanced using doping with Group III elements such as Al or Ga. One factor creating the n-type bias is a shallow donor level that is thought to be associated with hydrogen. In addition to the desire to create

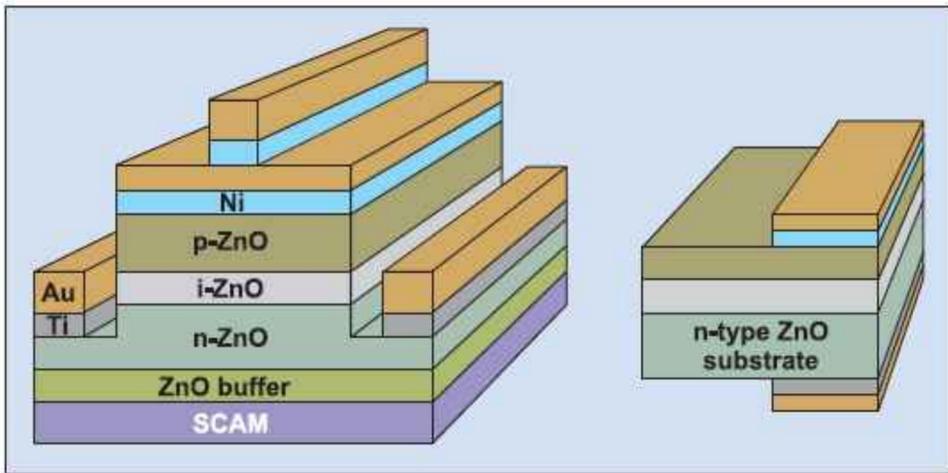


Figure 1. ZnO LED structures on ScAlMgO₄ substrate (left, from [5]) and on pure ZnO substrate (right, as developed by Cermet [6]).

p-n junctions, p-type doping is also seen as being important for creating dilute magnetic semiconductor devices with Curie transitions above room temperature, since theoretical predictions indicate that p-type (but not n-type) Mn-doped ZnO has a ferromagnetic transition [4].

For p-type properties, one looks for acceptor levels, and here Group I or Group III elements are in the frame. Nitrogen is a likely candidate, substituting for oxygen, but the presence of hydrogen either in the transport gas or in the doping precursor (e.g. NH₃) makes it difficult to avoid n-type compensation. Also, the acceptor level is relatively deep, resulting in low hole concentrations ($\sim 10^{17}\text{cm}^{-3}$) and hence high resistivity. Compounding this, hole mobilities are an order of magnitude smaller than for electrons — about $10\text{cm}^2/\text{V}\cdot\text{s}$ rather than $100\text{--}200\text{cm}^2/\text{V}\cdot\text{s}$. Other acceptor doping materials that have been tried include phosphorus, arsenic and antimony.

Part of the problem is that n-type conduction is too easy; even getting intrinsic carrier levels is hard — the electron concentration in ZnO grown on sapphire is typically $10^{17}\text{--}10^{18}/\text{cm}^3$. The electron concentration can be reduced to $10^{16}/\text{cm}^3$ when ZnO is deposited on ScAlMgO₄. Nitrogen is seen as the best option for acceptor doping, because its small ion size reduces compensation effects. However, high-quality ZnO films require growth at more than 800°C , while high concentrations of N are only possible to achieve at temperatures below 500°C .

One method — alternating low- and high-temperature growth ('reverse temperature modulation' growth) — has achieved a hole concentration of $10^{16}/\text{cm}^3$ with a carrier mobility of $8\text{cm}^2/\text{V}\cdot\text{s}$. The low-temperature phase grows 15nm of N-doped ZnO, while the high-temperature phase leaves 1nm of high-quality N-doped material. The process is repeated to achieve the required thickness. Some blue light-emitting diodes have been produced using this technique [5]. ScAlMgO₄ is insulating, so a mesa structure is used, with both contacts made through the top surface (Figure 1, left).

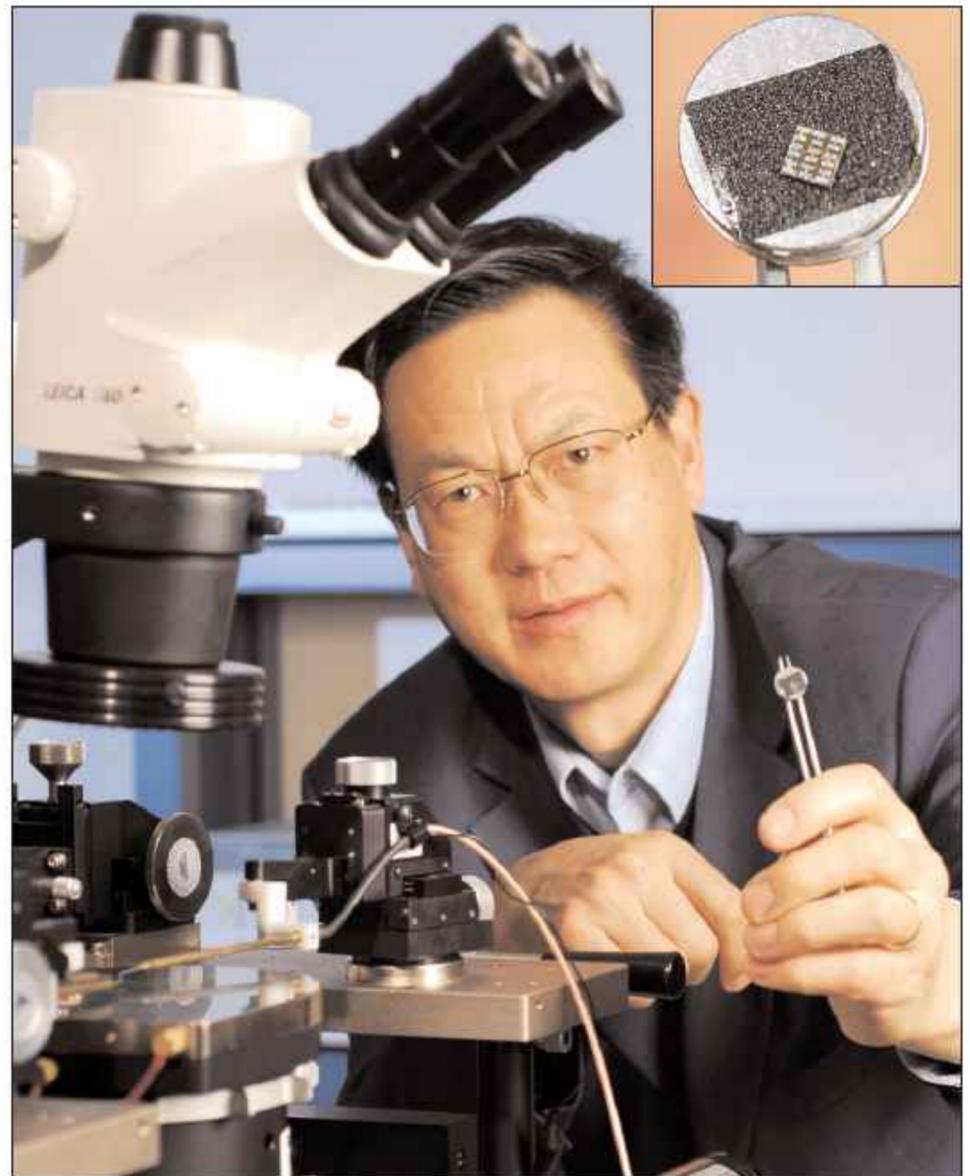


Figure 2. Zhong Lin Wang, Regents professor at the School of Materials Science and Engineering at Georgia Tech, holds a prototype DC nanogenerator fabricated using an array of zinc oxide nanowires. Inset: close-up image. (photos: Gary Meek)

Another attraction of ZnO would arise if high-quality bulk ZnO crystal substrates could be used, since then both top and bottom contacts could be made to the devices (Figure 1, right), as with bulk GaN laser diodes and more traditional GaAs and InP based light-emitting devices.

Cermet, being based in Georgia, has worked with Georgia Institute of Technology on many ZnO projects. Most recently, the company announced an exclusive license agreement for ZnO/nitride semiconductor white LED technology that has been developed with the Georgia Institute of Technology (see February's issue 1, page 16). The devices use nitride emitter structures in combination with ZnO semiconductors to produce white light-emitting diodes. Another project with Georgia Tech and the US Air Force involves developing light emission on ZnO covering the infrared to UV in a single device. The US Army Research Office is also working with the company to develop ZnO p-n junctions for UV/blue emission. It is hoped that homoepitaxial growth of ZnO will result in devices with far fewer of the defects that seriously degrade performance of GaN devices. Also, Cermet believes that such devices will eventually cost less to produce than GaN-based technology. ▶

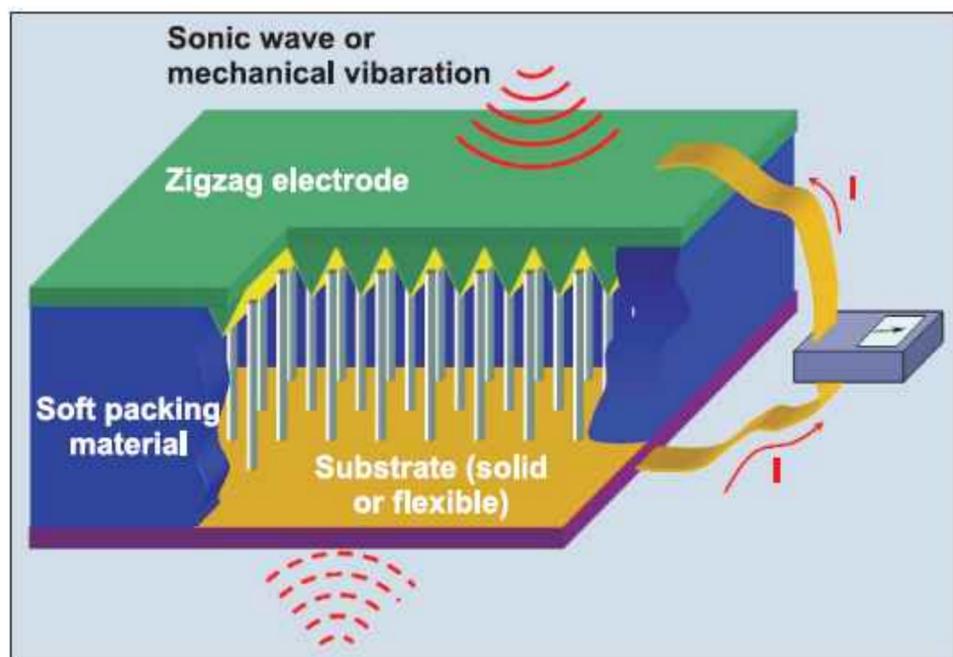


Figure 3. Schematic showing direct current nanogenerator built using aligned ZnO nanowire arrays with a zigzag top electrode. The nanogenerator is driven by an external ultrasonic wave or mechanical vibration and the output current is continuous.

Cermet also reports progress in producing the elusive p-type ZnO layers using metal-organic chemical vapor deposition (MOCVD) on its n-type substrates. While copper and phosphorus doping have been achieved, the company's efforts have focused on nitrogen doping using NH_3 and N_2O sources. Light-emitting diodes made from the resulting p-n junction were driven at 140mA to produce light with a peak wavelength of 384nm [6]. The published paper comments: "This, to our knowledge, is the first clear EL [electroluminescence] peak measured from a ZnO p-n junction LED."

This light is attributed to recombination between shallow donors and nitrogen luminescent centers on the p-side of the junction. Nitrogen-doped ZnO has a photoluminescence peak at around 380nm. Secondary-ion mass spectrometry (SIMS) of the p-type layer suggests a nitrogen concentration of $10^{20}/\text{cm}^3$. Hall measurements give a hole concentration of $9 \times 10^{17}/\text{cm}^3$, but with a low mobility of $1.5 \text{cm}^2/\text{V}\cdot\text{s}$.

Cermet's president Jeff Nause believes ZnO will compete for high-end optoelectronic devices (power LEDs and laser diodes in the visible part of the spectrum) as a substrate for nitride emitters. "For UV devices, ZnO devices may compete if the community arrives at a long-lifetime p-doped ZnO," he adds.

Nano-piezotronics

At Georgia Institute of Technology, new electronic devices are being constructed from zinc oxide nanowires. The Georgia Tech researchers use both the electronic and piezoelectric properties of ZnO to create what have been trademarked as 'nanopiezotronics' [7]. Piezoelectricity describes the change of a material's charge distribution under mechanical strain.

Along with the usual suspects of diodes [8], field-effect transistors and sensors, the researchers have also constructed 'nanogenerators' (Figures 2 and 3) that produce currents operated by bending nanobelts and nanowires of ZnO [9]. Such devices could convert mechanical energy from body movement, muscle stretching, fluid flow or other sources into electricity. By producing current from the bending and releasing of zinc oxide nanowires, these devices could eliminate the need for batteries or other bulky sources for powering nanometer-scale systems.

In piezotronic transistors, current flow is controlled by changing the conductance by bending the nanostructure between the source and drain electrodes (Figure 4). The bending produces a 'gate' potential across the nanowire and the resulting conductance is related to the degree of bending applied.

"The effect is to reduce the width of the channel carrying the current, so you can have a ten-fold difference in the conductivity before and after the bending," explains Zhong Lin Wang (pictured in Figure 2), who is Regents professor in the School of Materials Science and Engineering at the Georgia Institute of Technology.

The change in transistor performance due to bending

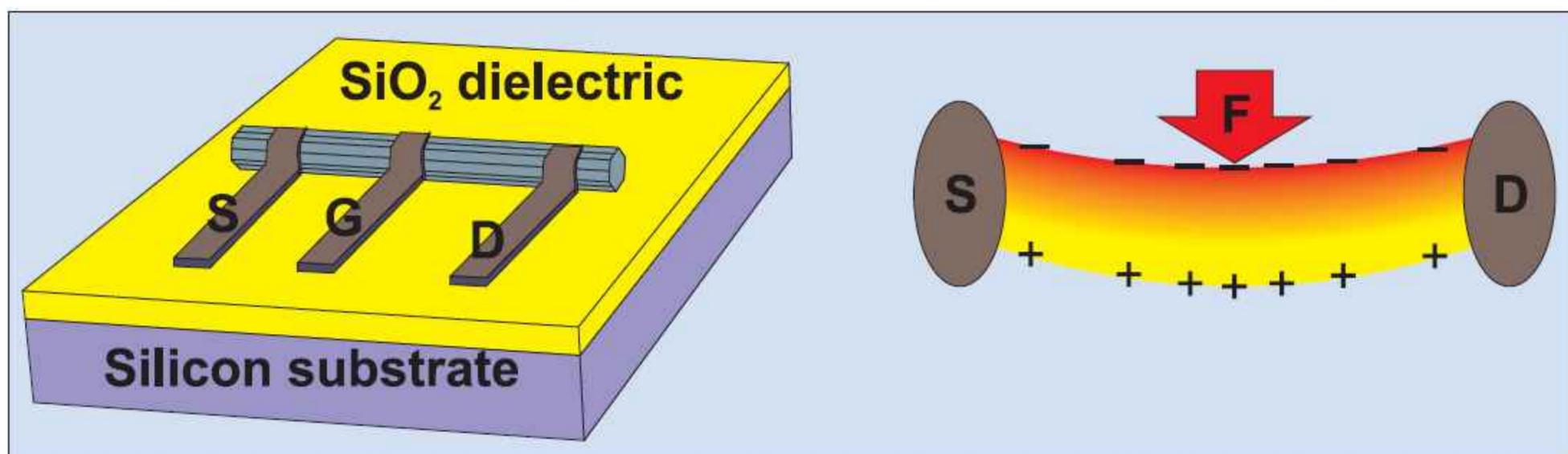


Figure 4. Diagram compares a nanowire/nanobelt based field effect transistor (FET) with a piezoelectric FET. The traditional FET has a gate electrode, either deposited (left) or using the substrate as a 'back gate'. In the 'piezotronic' device (right), the gate electrode is replaced by the piezoelectric field produced across the nanowire/nanobelt by an external force.

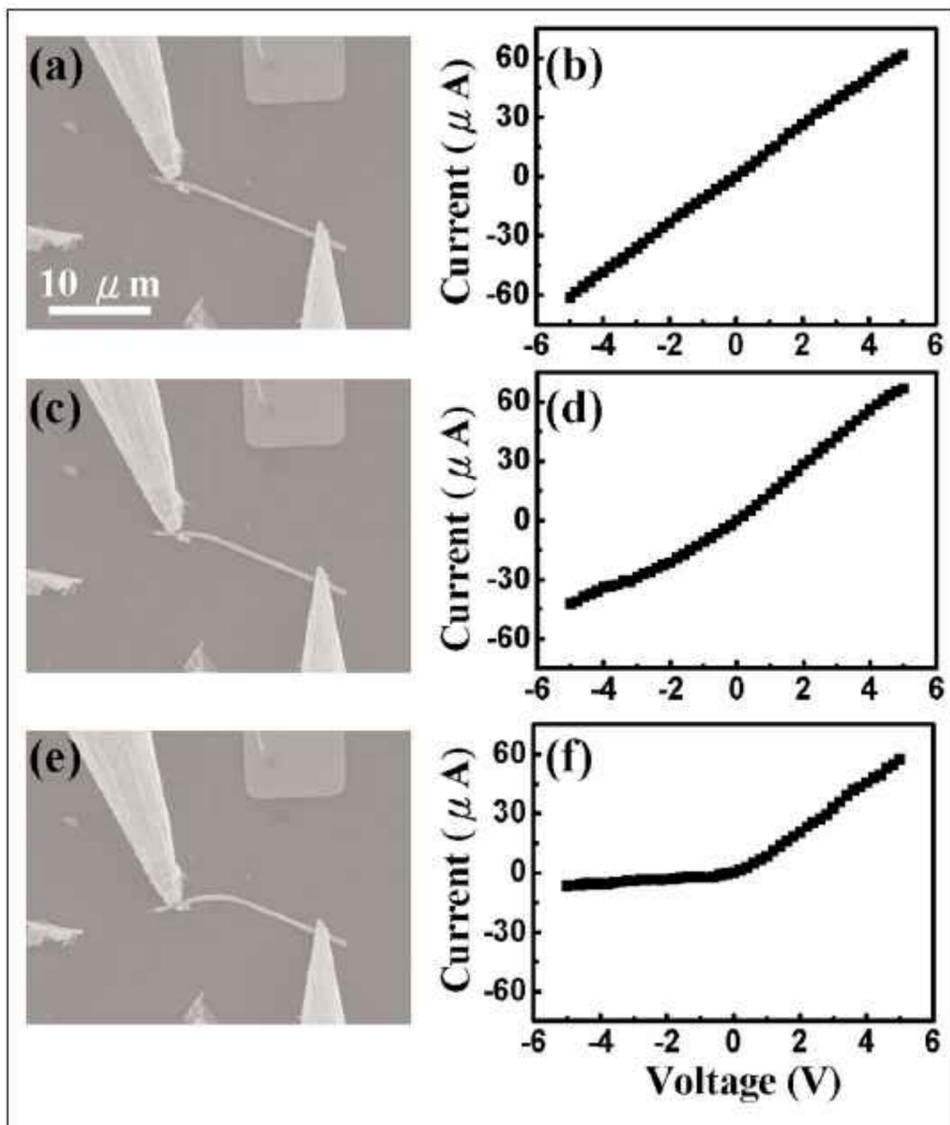


Figure 5. A piezotronic diode is shown (a, c and e) in a sequence of scanning electron microscope images of bending a single zinc oxide nanowire between two probes. The graphs (b, d and f) show the corresponding current flow through the nanowire.

could be used to create sensors for nano- or even pico-Newton forces, the researchers maintain. Another piezotronic sensor configuration could determine blood pressure by measuring the current flow, since ZnO materials are biocompatible, allowing their use in the body without toxic effects.

The diodes created through nano-piezotronic mechanisms take advantage of a potential barrier created at the interface between the electrode and the tensile (stretched) side of the nanowire by mechanical bending (Figure 5). The potential barrier created by the piezoelectric effect limits the flow of current to one direction.

Other ZnO-based nanosensors can detect very low levels of specific compounds by measuring the current change that is created when molecules of the target are adsorbed on to the nanostructure's surface. "Utilizing this kind of device, you could potentially sense a single molecule, because the surface area-to-volume ratio is so high," comments Wang.

Nanowire photodetectors

The University of California San Diego (UCSD) has also been studying ZnO nanowires with a view to producing single-photon detectors [10]. These researchers believe that the relatively large surface area of

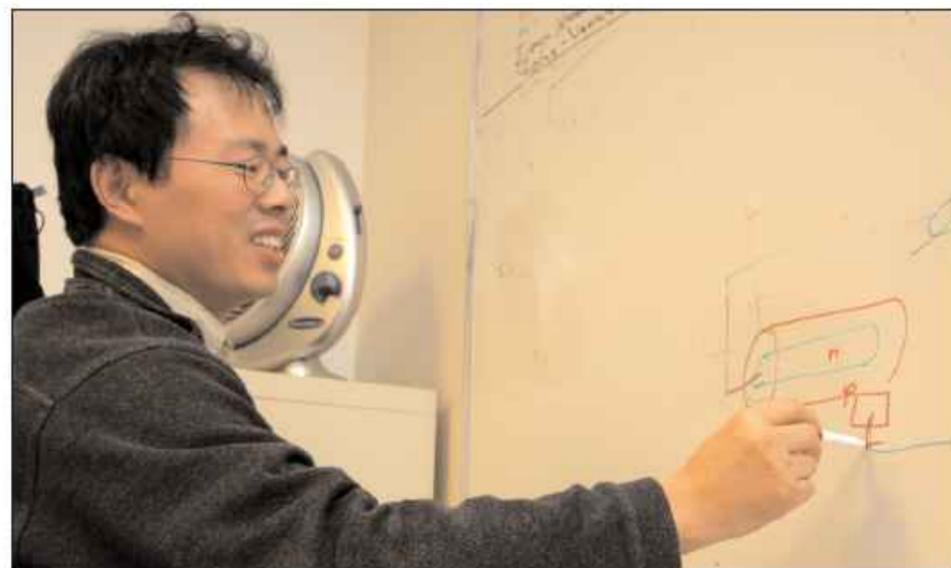


Figure 6. UCSD professor Deli Wang sketches a design for an LED made with a single ZnO nanowire.

nanowires compared with their length and volume makes them extremely sensitive to light. In particular, surface states grab the holes from photogenerated electron-hole pairs, allowing the free electrons to transport charge under an electric field. ZnO nanowire UV photodetector arrays built at UCSD had an internal photoconductive gain as high as 10^8 .

"The surface trap states that help to make nanowires such sensitive light detectors are the very same surface features that engineers desperately avoid when manufacturing semiconductors for computer transistors, where they hamper performance," comments UCSD professor Deli Wang (pictured in Figure 6).

The diameters of the nanowires were of the order of 150–300nm, and the lengths were about 15μm. The nanowires were transferred to thermally oxidized silicon substrates (600nm SiO₂) after growth. Titanium/gold (Ti/Au) electrodes (20nm/160nm) were deposited and patterned (at a spacing of 2μm) on top of the nanowires (see Figure 7).

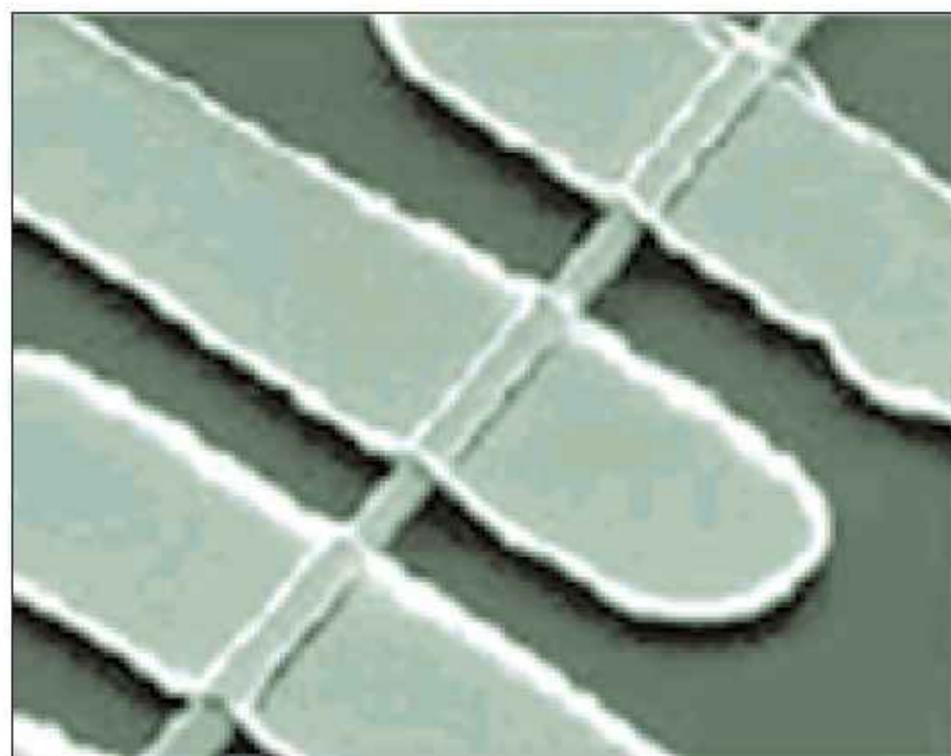


Figure 7. A single zinc oxide (ZnO) nanowire held down by metal contacts. Nanowire segments between the contacts can serve as photodetectors.

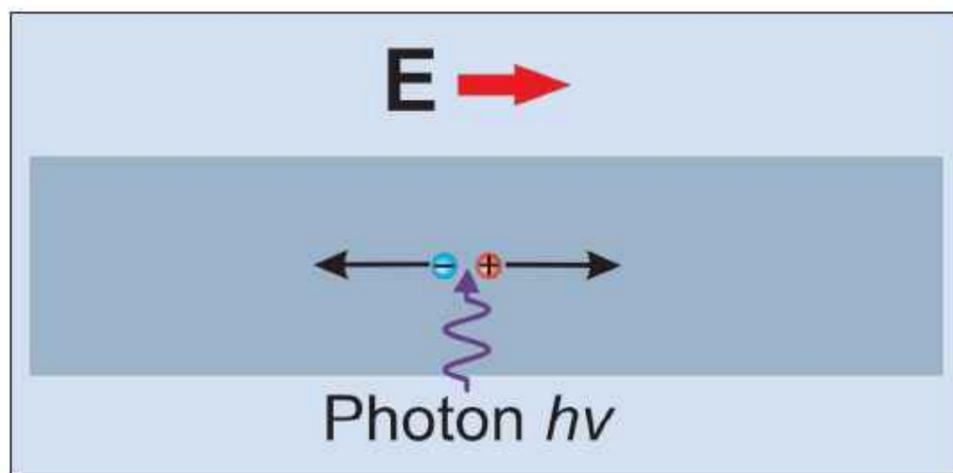


Figure 8. Photogeneration of electron-hole pairs in a section of a nanowire photodetector. The charge carriers run along the wire and increase the wire's current, and light is detected. However, if there are both electrons and holes present, they can recombine, reducing the current.

The photoconduction mechanism was studied using photon pulses of length 10^{-9} – 10^2 seconds. This study showed two main relaxation processes with widely different timescales (20 nanoseconds and 10 seconds). Oxygen-related hole traps form at the nanowire surface, delaying recombination. When holes are trapped (Figures 8 and 9), the oxygen is desorbed to

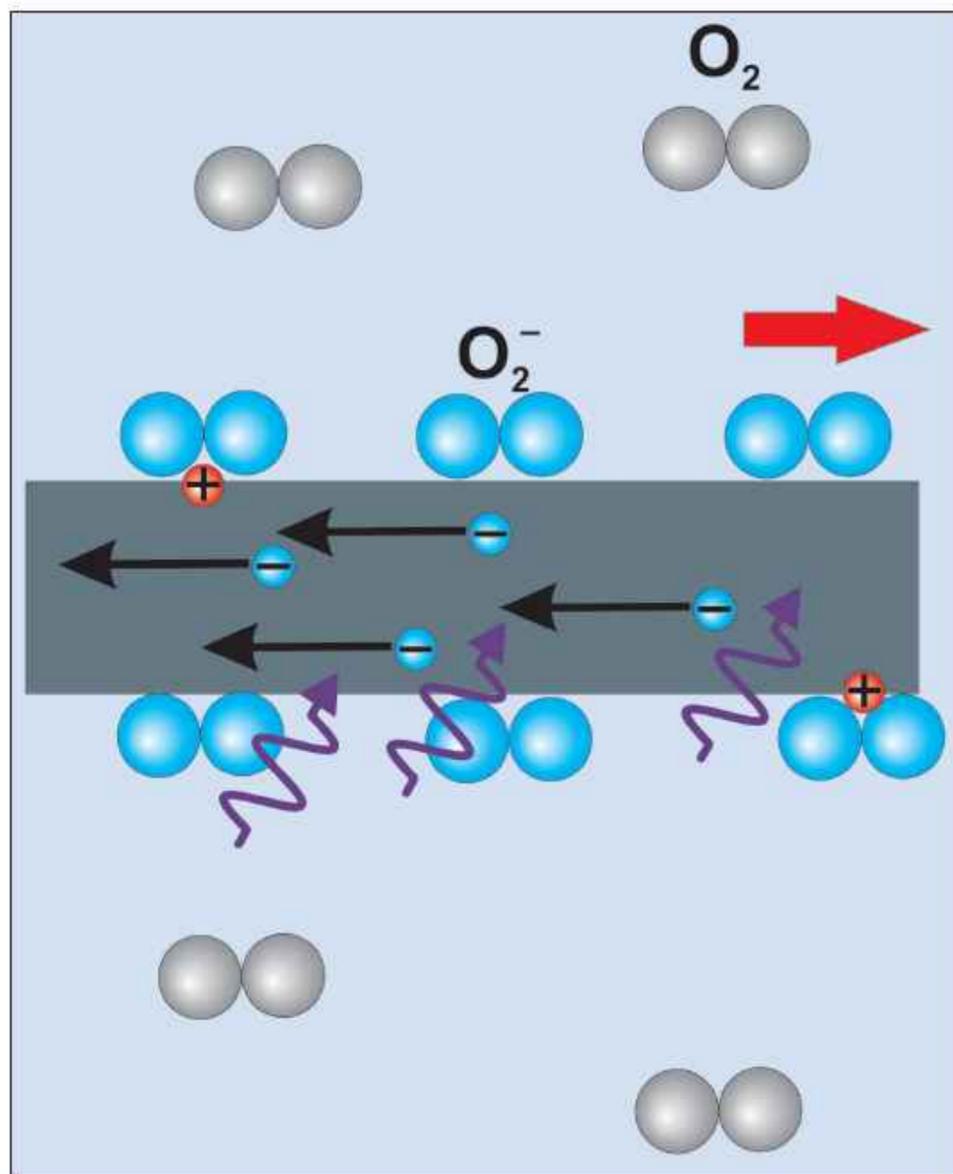


Figure 9. Schematic of proposed hole-trapping and photoconduction mechanisms in ZnO. In ZnO nanowires, the lifetime of the now unpaired electrons is increased by oxygen molecule desorption from the surface, taking away the holes that neutralize the oxygen ions.

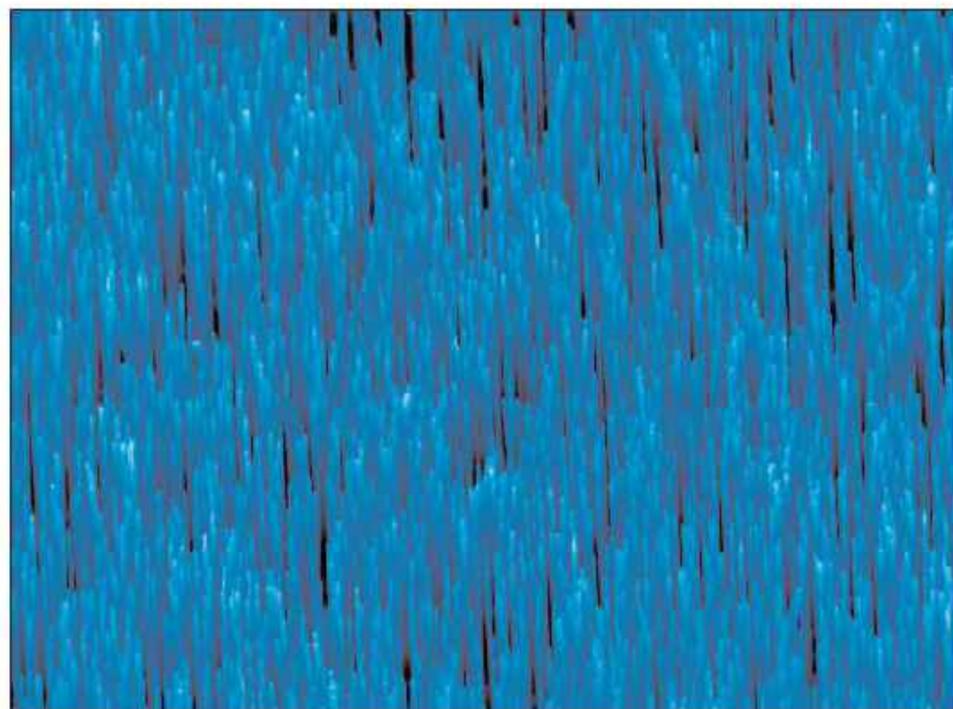


Figure 10. SEM image of p-type ZnO nanowires.

gas, leading to saturation of the photoresponse at high intensity (since there is a limit to the amount of oxygen that can be desorbed) and increased photocurrent at low pressure (since oxygen cannot be reabsorbed, releasing holes).

Despite the long recombination time, the gain-bandwidth product is about 10GHz. Hence, UCSD engineers believe that the high gain and low power consumption of the arrays could lead to new phototransistors and sensing, imaging and intrachip optical interconnect applications. Other nanowire-based devices include field-effect transistors, optically pumped lasers and chemical/biological sensors.

UCSD scientists have also previously made progress in p-type doping of ZnO nanowires (Figure 10), using phosphorus pentoxide as the dopant source [11]. The p-type doping was confirmed by using photoluminescence and electrical measurements on single-nanowire field-effect transistors. Vertical arrays of p-doped ZnO nanowires were grown on A-plane sapphire. Phosphorus-doped nanowire FETs show a transition from n-type to p-type behavior on high-temperature annealing. ■

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 - HEMT
 - RTT, RTD
- Opto-electronics
 - PIN (GaAs, InP)
 - Laser (Short to long wave, power, & VCSEL)
 - QWIP
- SiC
 - GaN HEMT

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