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C O M P O U N D S & A D V A N C E D S I L I C O N

Vol. 2 • Issue 7 • September 2007

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Narrow bandgap semiconductors: Narrow gap, wide focus Oval-lens LEDs put the focus on street lighting



RFMD buys Sirenza; TriQuint buys Peak • Raw materials pricing
IQE supplying epi to Anadigics • First HVPE blue & green LEDs

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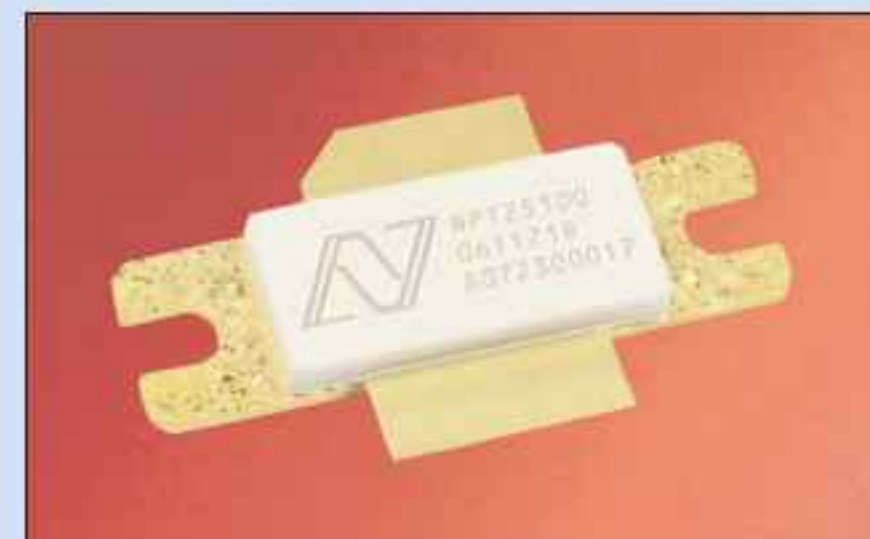
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p16 Nitronex's 28V, 100W-class NPT25100 GaN-on-Si HEMT RF power transistor is now production-qualified.



p27 Photograph of the first epitaxial structures for blue InGaN-based LEDs grown by hydride vapor phase epitaxy (courtesy of TDI).



p35 The new 2495-L3 Series 808nm fiber-coupled diode laser, which doubles the power output of JDSU's previous 808nm products.



Cover: EPS Soltec's solar-powered street-lamps incorporate 12 of Osram Opto Semiconductors' new Golden Dragon Oval LEDs. Specially developed oval

lenses direct the light down at an angle of 80° x 120°, reducing sideways light loss and cutting light pollution compared to normal circular light distribution. **p28**

Urge to diversify speeds consolidation

As previewed briefly in the last issue, following quarter-to-quarter revenue declines in Q1/2007 by both of the top two RFIC makers RF Micro Devices and Skyworks, an even greater slump in their main customer Motorola's mobile phone handset sales in Q2/2007 (from 18.4% to 13.8% market share, falling behind Samsung into third place — see page 4) has caused a second consecutive drop in revenues for both firms (by 17.8% and 2.8%, respectively — see pages 7–8).

In contrast, the revenues of both the third-largest RFIC maker, TriQuint, and the fastest-growing, Anadigics, increased by 3% and 8.7%, respectively. The difference is due to a richer product mix in high-growth sectors (e.g. 97% of wireless revenue being 3G-related versus 3% 2G-related, in the case of Anadigics) and a more diverse split between high-value markets (infrastructure and military) and the high-volume handset market (the latter comprising just 54% of sales for TriQuint, versus 94% for RFMD).

Indeed, in August TriQuint diversified further by agreeing to acquire RF transistor designer Peak Devices for its wide-band technology (which, despite being silicon-based, can be incorporated into TriQuint's GaAs and GaN designs, the firm reckons) — see page 11.

Likewise, aiming to diversify from cellular markets, RFMD has agreed to acquire fabless RF component supplier Sirenza Microdevices, whose wide range of both silicon and GaAs-based products spans multiple markets, including broadband/cable TV, wireless infrastructure, WiMAX and defense. Meanwhile, to extend the applications of its core RF and analog capabilities further, Skyworks has expanded the addressable market for its Linear Products business by gaining certification to automotive standards. In addition, as we closed for press, Anadigics announced the acquisition of the RF Group design center of power device manufacturer Fairchild Semiconductor, as Anadigics aims to accelerate its development of devices for 3G cellular, WiFi and WiMAX markets (see next issue for details).

Such urgency among the main RFIC makers to diversify is thus speeding consolidation in the wireless component sector, as highlighted by market research firm Strategy Analytics. The top three GaAs IC makers, RFMD, Skyworks and TriQuint, grew their market share from 47% in 2005 to 55% in 2006 (see page 6) as mid-tier suppliers are squeezed out while the GaAs IC sector 'bifurcates' into top-tier, high-volume suppliers and small, niche suppliers serving unique strategic needs (see July–August issue, page 40). Indeed, given the dominance of just a few handset makers (led by Nokia, Samsung and Motorola), Strategy Analytics reckons that the supplier base for handset power amplifiers and front-end modules could follow the consolidation seen earlier in the market for cellular base-station power amplifiers (where just two suppliers remain). The market research firm suggest that as few as six suppliers of handset power amplifiers could remain by 2012, so further acquisitions may be ahead.

Mark Telford

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

Regular issues contain:

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

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

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PERFORMANCE

Motorola cedes 2nd place to Samsung

In Q2/2007, cell-phone shipments reached 258m units, up by a modest 4% on Q1's 247m and 11% year-on-year as growth continues to slow this year, according to market research firm Strategy Analytics in its report 'Q2 2007 Global Handset Market Share Update'.

With almost 101m shipments, Nokia grew its market share to a record 39.1% as it remained dominant in emerging markets. "We expect Nokia to surpass [its target of] 40% in the second half," says Strategy Analytics analyst Bonny Joy.

For Motorola (35.5m shipments) its crisis deepened further, allowing Samsung (37.4m) to take second place for the first time due to a combination of aggressive marketing and an attractive 3G device portfolio, says Strategy Analytics' associate director Neil Mawston. "Its 48% annual growth has come partly at the expense of Motorola, whose lackluster product portfolio across all tiers urgently needs refreshing."

Fourth-largest vendor Sony Ericsson took 10% share (its highest since Sony and Ericsson merged in 2001) after 59% annual growth in shipments, as demand for its J, K and W Series phones remains high.

Samsung's 48% annual growth has come partly at the expense of Motorola, whose lackluster product portfolio across all tiers urgently needs refreshing

Fifth-largest vendor LG also grew its market share and profits, achieving its first double-digit operating margin (11%) since 2002).

Apple shipped 0.3m of its new

iPhone, giving it 0.1% share. However, Strategy Analytics forecasts this will rise to 1% by end 2007.

Strategy Analytics forecasts total shipments of 283m units for Q3 and 1125m for full-year 2007.

www.strategyanalytics.net

Backlighting semiconductor market to grow to \$4.5bn in 2012

The market for semiconductors in backlighting applications will grow 50% from \$3bn in 2006 to around \$4.5bn in 2012, forecasts UK-based market analyst firm IMS Research.

Most small displays (e.g. in portable applications such as portable media players, digital cameras and cellular terminals) have used LED backlighting for some years, and this market is still showing growth.

However, as LEDs are becoming brighter and light guides are becoming more efficient, fewer LEDs will be required for a specific backlight application, making LED backlighting more economic for larger displays. So, the market is increasingly being driven by adoption in medium- and large-sized screens for applications such as notebook PCs (shipping since Q4/2006) and LCD TVs (which are now entering the market as the cost of LED backlight units continues to fall).

With increasing acceptance of LEDs in these applications, IMS predicts that the incumbent cold-cathode fluorescent lamp (CCFL) market will stall. However, IMS expects CCFL manufacturers to respond with improved products, keeping price pressure high. IMS also expects the development of collaborative innovations such as hybrid backlighting incorporating both technologies.

Similar growth will be shown by the closely related market for ambient light sensors. This is driven mainly by portable applications, since ambient light sensors can automatically adjust the brightness of a backlight to the surrounding light conditions, helping to maximize battery time. In certain mobile applications such as cellular handsets, the display can consume up to 30% of the battery power, IMS notes.

www.imsresearch.com

Cell-phone shipments (in millions) and market shares.

Shipments	Q1/06	Q2/06	2006	Q1/07	Q2/07
Nokia	75.1	78.4	347.5	91.1	100.8
Samsung	26.7	25.2	113.8	34.8	37.4
Motorola	46.1	51.9	217.4	45.4	35.5
Sony Ericsson	13.3	15.7	74.8	21.8	24.9
LG Electronics	15.6	15.3	64.4	15.8	19.1
Others	45.9	45.8	184.0	38.3	40.1
Total	222.7	232.3	1001.9	247.2	257.8
Share	Q1/06	Q2/06	2006	Q1/07	Q2/07
Nokia	33.7%	33.7%	34.7%	36.9%	39.1%
Samsung	12.0%	10.9%	11.4%	14.1%	14.5%
Motorola	20.7%	22.3%	21.7%	18.4%	13.8%
Sony Ericsson	6.0%	6.8%	7.5%	8.8%	9.7%
LG Electronics	7.0%	6.6%	6.4%	6.4%	7.4%
Others	20.6%	19.7%	18.4%	15.5%	15.6%
Growth (y/y)	27.9%	24.0%	22.6%	11.0%	11.0%

GaN-based LEDs the main consumer of nitride materials

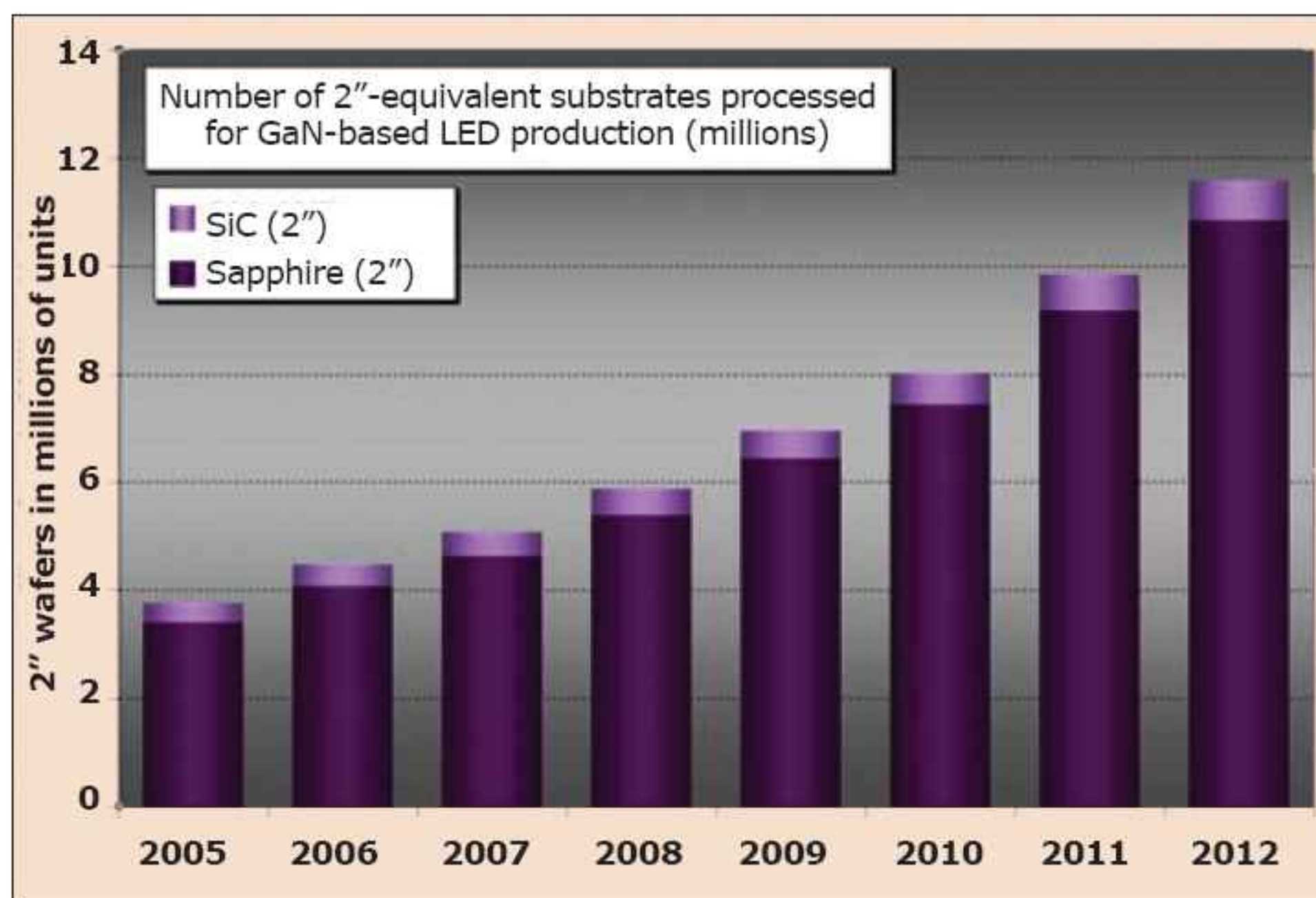
With an annual volume of more than 5 million 2"-equivalent substrates, GaN-based green, blue and white LEDs represent the main consumer of nitride substrates, targeting a \$3.5bn market at the device level, according to the report 'New Perspectives for Nitride Materials and Devices' from Yole Développement. Currently, silicon carbide substrates account for about 10% of total production and sapphire the rest.

In 2006, the sapphire material market just exceeded \$150m, says Yole. The LED market is now tending towards equilibrium: two thirds are manufactured on 2" substrates and one third on 3" substrates (while Japan's Showa Denko earlier this year started production of LEDs on 4" sapphire substrates).

SiC is also entering 4" production at Cree Inc of Durham, NC, USA. However, it cannot be considered a real open market, says Yole (since Cree makes not only SiC substrates but also LEDs based on them).

Yole reckons that the nitride substrate market can be seen as being partially unstable, because of the rapid emergence of new substrates for GaN epitaxy. GaN-on-silicon, GaN-on-ZnO, GaN-on-germanium, GaN-on-glass, GaN-on-AlN and composite substrates like GaN-on-diamond or GaN-on-SopSiC (from Picogiga) are now all pursuing the same goal: the best compromise between GaN quality, large substrate diameter, low bowing, high thermal conductivity, a controlled thermal coefficient of expansion, and low-cost. The main target is a 6" substrate (now available off-the-shelf from select firms). This is opening doors to higher LED productivity for the solid-state lighting (SSL) general illumination market, says Yole.

In the RF market, GaN HEMTs can now challenge Si LDMOS and GaAs pHEMTs for base-stations (3G, 4G, WiMAX, etc). With devices reaching a saturated power output of 174W at 6GHz under 48V polarization, GaN can now be implemented both in the 2m deployed cell-phone



Annual volume of 2"-equivalent substrates for GaN-based LED production.

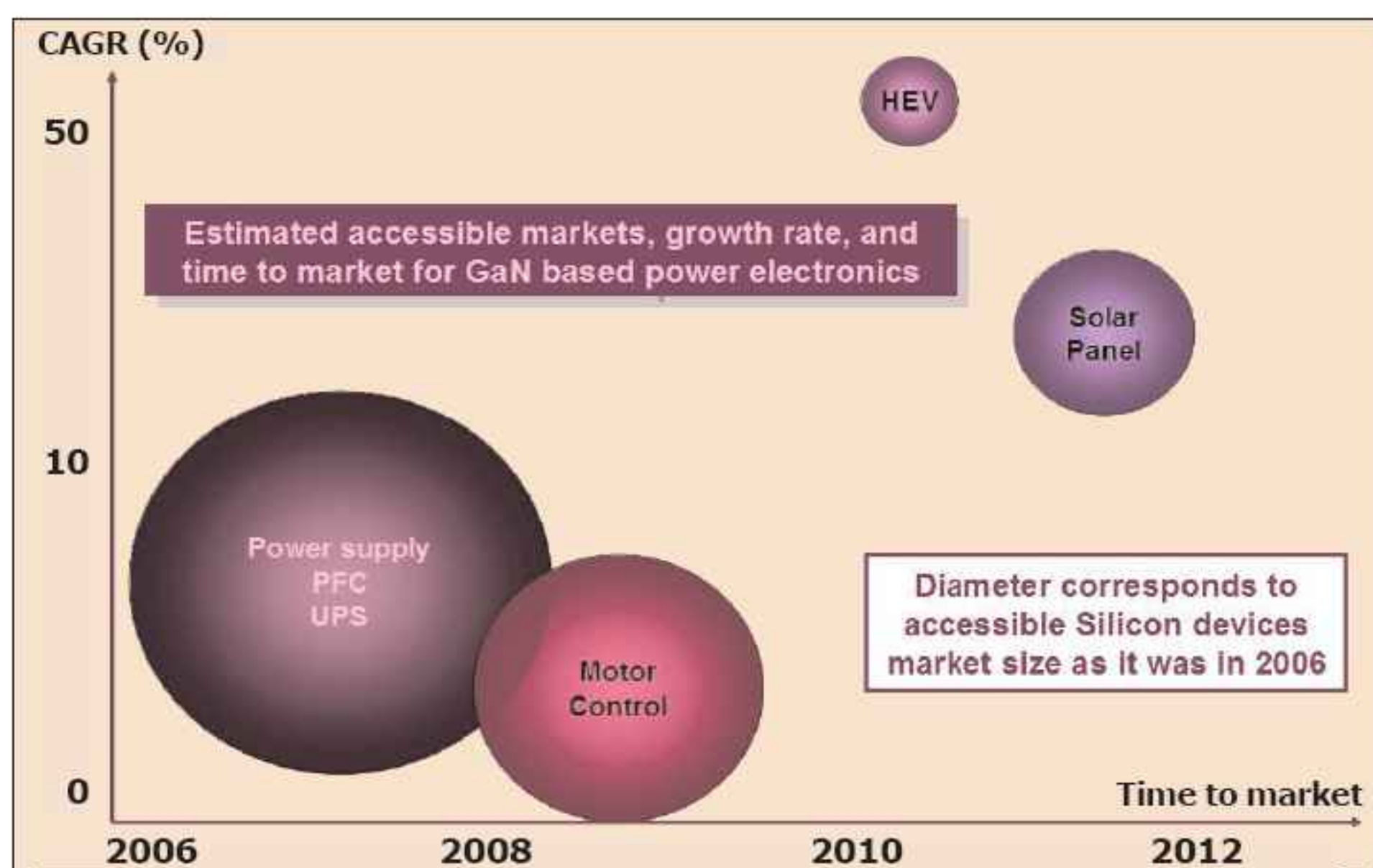
base-stations and in the coming WiMAX network infrastructure. Yole forecasts a market of 10,000 4" epiwafers in the near future.

With GaN (like SiC) being a wide-bandgap material that allows high breakdown voltages, the path to usage in power electronics is wide open, says Yole. However, GaN growth is hetero-epitaxial, often with an AlN nucleation layer, forcing devices to be designed laterally. Lateral devices are limited in breakdown voltage compared to vertical

devices, and can rapidly become bulky for high power densities.

So there is a subtle trade-off between the substrate diameter, power density, chip size and device cost. But, in other terms, GaN power devices on sapphire, silicon or composite substrates can compete with SiC from a cost point of view by using larger (4") substrates to compensate for the bigger chip size needed for a given power density, concludes the report.

www.yole.fr



Accessible markets, growth rates and time to market for GaN power electronics.

RFMD, Skyworks and TriQuint grow GaAs device market share to 55%, at expense of Japanese and European rivals

GaAs device revenues (merchant and captive) grew 10% year-on-year in 2006 to \$3.1bn, says market research firm Strategy Analytics in its annual ranking of the world's top ten GaAs device manufacturers. Nine out of the top ten are based in North America, which continues to cement its dominance of the market.

The market is now split between firms that target high-volume applications and those that have focused on high-value industry applications, reckons Strategy Analytics.

Consequently, market leaders RFMD, Skyworks and TriQuint have consolidated their collective share from 47% in 2005 to 55% in 2006.

Of the top three, TriQuint grew fastest, with its GaAs device revenues rising 37% year-on-year. "TriQuint is the only company out of the top three that has consistently had its feet planted firmly in both the high-volume commercial and high-value infrastructure and specialist camps," the report notes. This allows the firm to balance cyclical high-

volume markets with demand for its products in high-value applications, it continues. "TriQuint has shown that it can cope with a changeable and unusually active marketplace over the past year and compete in key accounts at the top tier of the handset market [now supplying production volume for four of the top five handset makers], while also consolidating its own leadership positions in infrastructure and military markets." TriQuint also remained the world's largest GaAs foundry in 2006.

The fastest growing GaAs device makers in the top ten were Hittite, Anadigics and Avago Technologies, collectively accounting for 15% of the GaAs device market in 2006.

Compared to the North American suppliers, the only Japanese firm in the top ten is Mitsubishi Electric, as Japanese suppliers have continued to lose market share in the mainstream cellular handset market. However, "Switch complexities are increasing, which could potentially provide Japanese companies with an

opportunity to regain lost ground in the cellular handset market," notes Asif Anwar, director of Strategy Analytics' GaAs service. "Japanese market requirements may be particularly demanding, which will play to the strengths of companies like NEC, Sony and Eudyna Devices." Also, Japanese companies NEC, Toshiba and Mitsubishi Electric continued to be the top three suppliers of discrete GaAs devices in 2006.

In Europe, the largest GaAs device suppliers were Filtronic, UMS and OMMIC. "Filtronic was the largest European GaAs device supplier in 2006, but missed out on a top ten place," says Stephen Entwistle, VP of the market research firm's Strategic Technologies Practice. "UMS was close behind, and Filtronic's time as the number one European GaAs device supplier may be short-lived [especially since main customer RF Micro Devices is taking all pHEMT switch production in-house, starting in September]."

www.strategyanalytics.net

Handset advances to drive RF semiconductor market

The report 'World Handset RF Semiconductor Markets' from Frost & Sullivan reckons that the RF transceiver segment generated the most revenue in 2006, totaling \$3.045bn, and should reach \$5.95bn in 2010.

"Handsets have evolved rapidly, from a simple and voice-only device to a sophisticated device that supports voice, high-speed data, and other applications such as GPS and Bluetooth," says research analyst Gokul Ramanujam. "The adoption of 3G technology has also aided handset and RF semiconductor manufacturers, with 3G phones requiring a design with higher complexity."

Handset RF semiconductor markets continue to progress steadily, with most segments showing significant growth, mainly due to high volume shipments of mobile handsets over

the last few years. In particular, the continued rise in penetration in developing countries such as India and China has created many opportunities for handset makers, driving the market for handset RF semiconductors. With 2.75G yet to take off and deployment of 3G in the pipeline, the market in these countries should thrive in the next few years.

Also, with 4G technology and 3G long-term evolution (LTE) in development, the RF semiconductors market will likely grow exponentially in future, Frost & Sullivan reckons.

However, the cell phone's evolution to a multi-dimensional device has exerted enormous pressure on both handset makers and RF semiconductor suppliers to pack in as many functions as possible in the limited front-end space. To stay in line with

board space constraints and consumer demand, a focus on reduced component count, form factor, and bill of materials is a key trend.

"To enable this scenario, the kind of scaling proposed by Moore's Law would be ideal, but is not realistically possible in all cases," says Ramanujam. "A balance of all factors such as reduced component count, combined with cost effectiveness, is likely to assist RF semiconductor manufacturers in revenue generation."

The transition to integration has affected the market for discrete component manufacturers by reducing profits. Companies with a diverse product line and the skill to integrate discrete components into modules will be more likely to succeed, predicts Frost & Sullivan.

www.semiconductors.frost.com

TriQuint's profits slashed despite revenue growth in WLAN, WCDMA/EDGE and transmit modules

For Q2/2007, GaAs-based wireless communications component maker TriQuint Semiconductor Inc of Hillsboro, OR, USA reported revenues of \$113.8m (up 3% on Q1's \$110.6m and up 18% on \$96.3m a year ago).

This was split by application sector as military (11%), networks (35%) and handsets (54%).

Year-on-year growth was 20% in military (led by satellite revenue), 9.6% in networks (including 40% in WLAN due to better-than-expected growth in first-generation MIMO solutions, and 103% growth in ground-station products) and faster-than-market growth of 28% in handsets (driven by WCDMA, EDGE and GSM shipments and increases in foundry business for CDMA).

For the sixth consecutive quarter, Motorola and Samsung each comprised more than 10% of revenues (24% collectively).

Specifically, year-on-year, revenues grew by 152% for WCDMA/EDGE and by 141% for transmit modules (with GSM transmit modules grow-

ing 60% — including Vodaphone handsets made by ZTE for China and India — and CDMA, WCDMA and EDGE modules now ramping into production).

"Strong revenue performance is due to new product success and design wins with both new and existing customers [including a record number of handset design wins]," says president and CEO Ralph Quinsey.

"In Q2 we launched our vision 'Simplifying RF Connectivity' for broadband communications, providing RF engineers around the world unique, highly integrated products, more high-performance packaged devices and simplified channel access," he adds. "With the launch, we released our first product selection guide, an overview of nearly 500 new and existing RF products."

However, gross margin has fallen from 31.1% last quarter to 26.5%. Of this 4.6% drop, 3.6% was due to \$4.1m in excess inventory charges, mainly because of a single device, applicable uniquely to a platform that did not meet expectations at

Motorola. Also, manufacturing cost reduction plans involving changes to process flow (expected to save \$1.5m per quarter) were delayed for engineering evaluation from Q2 to Q3. Hence, Q2 net income was down from an expected \$6m (and \$6.4m last quarter) to just \$1.4m.

Nevertheless, orders in Q2 were \$108m (the firm's second highest ever). For Q3, revenue is expected to rise slightly from Q2 (moderated by inventory adjustments as well as foundry demand dropping back). In particular, growth is expected at all handset customers, Quinsey says, including its two '10%' customers Motorola and Samsung. For Q4, he expects both handset and network revenue growth to accelerate.

For full-year 2007, he expects rises in revenue of 14–18 % and in earnings of 10–20%, compared to 2006's \$401.8m and \$22.4m, respectively. Earlier, in February, TriQuint had forecast growth of 18–20% and 40–50% for revenue and net income, respectively, for full-year 2007.

www.triquint.com

Skyworks grows profit, driven by linear products and 3G

For its fiscal Q3 (to end June), Skyworks Solutions Inc of Woburn, MA, USA, which makes linear products, power amplifiers, front-end modules and radio solutions, has reported revenue of \$175.1m (in line with guidance at the end of fiscal Q2). This is down from \$180.2m in the March quarter and \$196m in the December quarter in the aftermath of problems at handset maker Motorola (which accounted for 23% of Skyworks' revenues in 2006).

Yet, on a pro forma basis, year-on-year Skyworks has more than doubled both net income, from \$8.0m to \$16.8m (largely due to Skyworks terminating its loss-making base-band product operations last October) and diluted earnings per share, from \$0.05 to \$0.11.

"Skyworks' ability to exceed earnings per share expectations despite the dynamics at a large tier-one handset OEM demonstrates the diversity of our portfolio and the strength of the company's new business model," says president and CEO David J. Aldrich.

During the June quarter, Skyworks unveiled new linear products for WiMAX, high-definition TV tuners, remote meter reading and medical imaging applications; launched CDMA and EDGE front-end modules in support of Motorola's recently introduced RAZR 2 series; ramped Intera front-end modules and Helios radios for LG's record-selling Shine phone and Samsung's new SGH-U600 Ultra Series handsets, respectively; and supported Sony

Ericsson's recent debut of their HSDPA-capable handset platforms including the multiband, WEDGE K850 cybershot camera phone.

"Linear products momentum coupled with multiple 3G product ramps spanning both new and existing customers are positioning Skyworks to outpace market growth," says Aldrich. "Crisp operational execution will enable further gross margin expansion and bottom-line improvement."

For its fiscal Q4, Skyworks expects sequential revenue growth of 6–10% (fueled by new, multimode product launches and the transition of several design wins into high-volume production) and targets pro forma earnings per share of \$0.12–0.14.

www.skyworksinc.com

RFMD ships 100 millionth WCDMA cellular front end

RFMD claims it is the wireless industry's first company to ship 100 million WCDMA cellular front ends for 3G handsets. RFMD attributes this to continued strong sales of 3G multimode handsets.

"Demand for cellular front ends in 3G multimode handsets is growing significantly faster than the handset market, as 3G handsets proliferate and as new 3G bands are added," says Eric Creviston, corporate VP of the cellular products group.

In the June quarter, RFMD's WCDMA front end revenue significantly outpaced the rate of growth of the handset market, and the firm is booked for sequential growth in WCDMA front end revenue in the September quarter of greater than 50%.

RFMD forecasts that the 3G multimode market will exceed 580m handsets by 2011, reflecting a five-year compound annual growth rate of about 51%. Also, RFMD estimates that the average 3G multimode handset will support about 2.7 UMTS frequency bands by 2011.

Dollar content for RFMD is being driven by 3G multimode devices (which include a GPRS/EDGE path and at least one UMTS path, both of which require PA-based front end solutions and associated complementary RF components). As 3G multimode devices proliferate and as the number of bands increases to support multiple regions, the market for cellular front ends and complementary components in 3G multimode handsets is expected to significantly outpace the rate of growth of cellular handsets. In addition, an increasing proportion of 3G multimode handsets also include WiFi capability (RFMD also supplies wireless LAN front ends for WiFi-enabled handsets).

RFMD's sales fall 11% in June quarter, but 9–16% bounceback expected in Q3

For its fiscal Q1/2008 (to end-June) RF Micro Devices Inc of Greensboro, NC, USA has reported revenue of \$211.6m (down a second successive quarter, by 11.2% from \$238.3m a year ago and 17.8% from last quarter's \$257.3m). Net income has fallen from \$30.1m to \$25.3m.

Results are consistent with April's guidance, reflecting weakness at "a large handset customer" (Motorola, RFMD's second-largest customer, which accounted for a third of sales in 2006), offset partly by strength at other large handset makers such as Nokia and Samsung.

In the Cellular sector, WCDMA revenue grew 30% sequentially (and is booked for more than 50% growth in the September quarter, boosted by the first customer shipments of its Polaris 3 RF solution, the launch of which has led to a strategic supply agreement with Nokia).

In the Wireless Connectivity sector, wireless LAN front-end revenue grew more than 50% sequentially (and is booked for more than 50% growth in the September quarter). RFMD started shipping WLAN front ends to a new customer in cellular handsets, and won a new 802.11n WLAN design at a "leading manufacturer of wireless broadband routers". Also, RFMD's GPS architecture has been selected by a 'leading handset manufacturer'.

In the Infrastructure sector, at June's IEEE MTT-S International Microwave Symposium in Hawaii, RFMD launched the RF386x family of GaAs pHEMT multi-market low-noise amplifiers (with shipments starting to multiple base-station OEMs), as well as announcing the first shipments of its high-power, wide-bandwidth RF3822 GaN PowerIC to a "top-tier military supplier", and a GaN design win for a high-power S-band military radar application (for which RFMD expects to start shipments in 2008). The firm expects further customer orders for its GaN technology related to mili-

tary communications, general-purpose amplifiers, radar and military jammers in the September quarter.

For the September quarter, driven by handsets and multi-market products, RFMD forecasts revenue to grow by 9–16% sequentially to \$230–245m (not including revenue growth from Motorola, with which RFMD has considerable design activity, the firm says).

"In our primary market of cellular handsets, RFMD expects to increase [market] share and grow dollar content [per handset] as mobile devices increase in complexity and require additional high-performance RF content [via cellular front ends]," says president and CEO Bob Bruggeworth. RFMD expects over 60% of its cellular revenue to come from WCDMA and EDGE products. It also expects to grow market share and increase dollar content per handset through sales of complementary cellular components and complete RF solutions, including its Polaris 2 and new Polaris 3 RF solutions (which start shipping in Q3, and will expand RFMD's Polaris customer base to include an additional top-tier handset maker).

"Beyond handsets, we anticipate high-margin, diversified revenue growth, driven by sales of GaN devices, wireless LAN front ends and a broadening portfolio of multi-market products," Bruggeworth adds. These products expand the firm's addressable market and should increase its average gross margin. RFMD is experiencing 'favorable design activity' related to its GPS products, and expects its first high-volume shipments to a leading handset OEM in calendar year 2009.

"We are capitalizing on our strong balance sheet to streamline our supply chain [bringing pHEMT switch manufacturing fully in-house by September] and accelerate our diversification efforts," concludes chief financial officer Dean Priddy.

www.rfmd.com

Anadigics reports ninth quarter of growth, up 8.7%, driven by 3G

For Q2/2007, RFIC maker Anadigics Inc of Warren, NJ, USA has reported record sales of \$53.9m, representing its ninth consecutive quarter of growth (up 37% on \$39.3m a year ago and up 8.7% on Q1's \$49.6m, compared to the expected 5-7%).

Net income was \$1.9m, compared with \$1.2m in Q1 and \$2.8m a year ago. Pro forma income (excluding non-cash stock compensation expense) rose \$2.0m sequentially to \$5.7m.

Of total revenues, 48% came from broadband wireless products (2.5G, 2.75G and 3G multimedia handsets), 22% from broadband mobility (WLAN 802.11a,b,g,n MIMO and WiMAX, smartphones and datacards), and 28% from broadband wireline (CATV set-top boxes and CATV infrastructure, which grew 40% and 69% year-on-year, respectively). In particular, for WLAN, the 802.11a,b and g standards accounted for 70% of unit sales and 802.11n for 30% (up from just 10% in Q1/2007). However, by revenue, this split was 55%:45%, showing the higher value of 802.11n products.

In terms of growth, broadband product group revenues were up 6.3% sequentially, driven by strong set-top box demand. Revenue for first-half 2007 was up 54% year-on-year, driven by very strong demand for wireless LAN and CATV.

Wireless product group revenues were up 11% sequentially and 24% year-on-year for the quarter, led by very strong 3G revenue. Revenues for first-half 2007 were up 27% year-on-year.

In particular, the record overall revenue was driven by Anadigics' 3G portfolio, for which revenue grew 38% sequentially and 83% year-on-year, says president and CEO Bami Bastani. While wireless comprised 52% of overall revenue, this includes 3G products comprising

as much as 49% of overall revenue (i.e. 97% of wireless revenues, with growth in 3G more than offsetting GSM revenues dropping from 12% of wireless revenues in Q1/2007 to just 3% in Q2).

"Anadigics is well positioned strategically in the three growth markets of 3G, WLAN and CATV to capitalize on our strong market position," says Bastani. Anadigics' top customers in Q2/2007 were Cisco, Intel, LG Electronics, Huawei, and Samsung. Bastani

adds that recent shifts in handset market share (away from Motorola) have favored Anadigics' customers Samsung and LG, which have gained market share, boosted by 'better 3G portfolios' (as well as rating

as the top two phone brands in the USA for advanced entertainment features such as mobile TV, games and music, with 22% and 20% market share for such phones, respectively, compared to just 6% for the nearest competitor).

During Q2/2007, Anadigics shipped power amplifiers to LG Electronics for its VX8700 Shine 3G mobile phone and its TV-capable VX9400 phone, to Samsung for its SGH-F500 MPEG4 video 3G phone, its SPH-m610 3G EVDO handset, its SCH-u540 Neon 3G handset, and its SGH-I520 smartphone (which is using Anadigics' AWT6223 UMTS/EDGE 3G penta-band power amplifier), and to Huawei for its music-optimized U120 3G mobile phone.

Recent shifts in handset market share (away from Motorola) have favored Anadigics' customers Samsung and LG, which have gained market share

In addition, in mid-May Anadigics entered the EDGE market by launching the AWT6172 quad-band Linear EDGE power amplifier module. This new product has gained significant market traction, says Bastani, and should contribute to growth in Q3/2007. Anadigics also launched its ARA2017 programmable gain upstream amplifier and AIT1061 integrated wideband data tuner (the industry's first complete RF front-end chip-set for cable modems designed to meet the new DOCSIS 3.0 specification, it is claimed), which are expected to ramp in mid-2008.

Demand for new products is continuing to accelerate rapidly, says chief financial officer Tom Shields, fuelling strong growth prospects for second-half 2007 and 2008. For Q3/2007, Anadigics expects revenue to rise by about 10% sequentially and 35% year-on-year, driven by wireless revenues.

Correspondingly, Anadigics increased its R&D spending over the planned amount for Q2/2007 (contributing to increased operating expenditure), he adds. In future, R&D expenses will be maintained at about \$0.5m per quarter.

In addition, Anadigics invested \$8m in capital expenditure during Q2. The existing GaAs wafer fab in Warren, NJ now supports quarterly revenue run-rates of \$85-90m. Capex in 2008 is expected to be \$15-20m, adds Shields. Bastani confirms that the new wafer fab in Kunshan New and Hi-Tech Industrial Development Zone, China (which broke ground on 9 July) will take about nine months to complete construction and should start operation by Q1/2009. After being ramped up in stages, once fully equipped it should double Anadigics' GaAs fab capacity.

www.anadigics.com

Sirenza reports record revenue

RF component maker Sirenza Microdevices Inc of Broomfield, CO, USA has reported record quarterly revenue of \$46.7m for Q2/2007 (to end June), up by about 20% on the \$39.1m in Q1.

Excluding charges, Q2 saw rises in gross margin from 45% in Q1 to 49% and in net income from \$6.2m in Q1 to \$8.7m in Q2.

Sirenza has now reported 15 consecutive quarters of positive cash flow from operations.

"In what has historically been a seasonally slower half of the year for Sirenza, we exceeded the upper end of our revenue and pro forma earnings guidance as we continued our drive to diversify our business," says president and CEO Robert Van Buskirk. "We currently see ongoing strength in our major end markets, including CATV transmission applications, mobile wireless infrastructure applications and emerging wireless access applications such as WiMAX," he adds. "In the second quarter, we continued production of our high-performance, high-power RF modules for HDTV light source applications and we made excellent progress in our China manufacturing transition activities."

● Sirenza shipped 1 million CATV modules in first-half 2007. "This milestone demonstrates the current strength in the CATV amplifier module market," said Greg Baker, VP and general manager of the broadband and consumer division. Production volume is being driven mainly by the firm's 1GHz power amplifier module line-up.

"We intend to continue to expand our customer base, expand our volume production and better utilize our increased manufacturing and test capacity in our highly automated manufacturing facility, here in Nuernberg, Germany," added Guenter Leicht, general manager of Sirenza's subsidiary Premier Devices Germany.

RFMD diversifies by acquiring Sirenza

The world's biggest GaAs RFIC maker, RF Micro Devices Inc of Greensboro, NC, USA, has agreed to acquire RF component supplier Sirenza Microdevices of Broomfield, CO, USA for about \$900m (\$300m in cash plus the rest in stock).

The transaction has been approved by the two boards of directors, and should be completed in Q4/2007, subject to approval by stockholders as well as regulatory approval. Current RFMD and Sirenza stockholders will then own about 67% and 33% of the combined firm, respectively. The board is expected to consist of nine members from RFMD and two from Sirenza.

RFMD designs and manufactures radio systems and solutions including power amplifiers, transmit modules, cellular transceivers and system-on-chip (SoC) solutions, mainly for cell-phone handsets, cellular base-stations, wireless local area networks (WLANs) and global positioning systems (GPS).

Sirenza and its subsidiary Premier Devices Inc of San Jose, CA, USA, which has manufacturing facilities in Shanghai, China and Nuremberg, Germany, design and develop silicon and GaAs-based ICs, multi-chip modules (MCM) and passive RF components for commercial communications, consumer, and aerospace, defense and homeland security equipment markets.

RFMD says that the acquisition will accelerate its penetration of the multi-application high-growth end markets that Sirenza addresses, and extends its IC design and integration expertise into those markets. Sirenza's more diversified portfolio and customer base should increase RFMD's total addressable market by about 67% to more than \$20bn.

The management teams will be combined to address the resulting expanded opportunities. RFMD's

Bob Bruggeworth will continue as president and CEO, but Sirenza's president and CEO Bob Van Buskirk will relocate to North Carolina and lead RFMD's new Multi-Market Products Group.

"This strategic acquisition brings together two companies with leadership positions and considerable expertise in RF systems and solutions," says Bruggeworth. "It creates the world's largest, most diversified and best positioned RF company, with a broad set of customers and a diversified product portfolio of high-performance components and systems-level solutions." The takeover will allow RFMD to apply its cellular-focused RF integration and system-level design expertise across Sirenza's multiple high-growth RF markets, including broadband/CATV, wireless infrastructure, WiMAX and aerospace and defense.

The takeover will also allow Sirenza to expand its revenue stream beyond component-level solutions and drive supply chain and procurement efficiencies, due to RFMD's high-volume manufacturing capabilities, adds Bruggeworth. "Our two businesses are highly complementary in terms of customers, markets, products and manufacturing expertise".

"We have great potential to accelerate revenue growth and expand margins by leveraging the technology base, supply chain and leadership position RFMD has achieved [in the cellular market]," says Van Buskirk. "There is a tremendous opportunity to apply the highly integrated, systems-level design expertise demanded by RFMD's cellular handset customers to the markets that Sirenza currently serves," he adds. "Our very complementary companies can deliver more highly integrated solutions."

www.rfmd.com

www.sirenza.com

TriQuint acquiring Peak for wide-band amplifier design

RF communications chip and module maker TriQuint Semiconductor Inc of Hillsboro, OR, USA has agreed to acquire fabless RF transistor supplier Peak Devices Inc of Boulder, CO, USA in a \$15m transaction that is expected to close within Q3/2007.

Founded in 2000, Peak designs and manufactures silicon-based bipolar, MOSFET and LDMOS low-power and high-power RF discrete transistors for applications in wireless communications, HF/VHF/UHF, two-way communications, FM and TV broadcast, avionics, radar and military.

"Peak has developed proprietary semiconductor technology that has broad application across multiple markets," says TriQuint's CEO Ralph Quinsey. "With this technology, a single wide-bandwidth amplifier may replace complex high-power multiplexer-combined-amplifiers," he adds. "To replace multiple

amplifiers, optimized for various frequency bands and modulation schemes, with a single device has long been a goal of our industry. This is a technology that can truly enable the software-definable radio."

Peak aims to launch a device that can cover multiple octaves of bandwidth (e.g. 700–2800MHz for most wireless networks). The wide-band technology can be incorporated into TriQuint's GaAs and GaN designs.

"The combination of Peak Devices and TriQuint Semiconductor brings together extremely complementary capabilities," says Peak Devices' CEO Bill McCalpin, who retains his responsibilities while reporting to TriQuint's senior management.

"I see numerous opportunities for Peak's technologies to enhance TriQuint's existing product lines, as well as building new high-power RF product segments," he adds.

TriQuint's strategy has been to diversify beyond mobile handsets. The firm's revenues for mobile handset and multi-market RF products are almost equal in size. The acquisition of Peak Devices will bolster TriQuint's focus on the multi-market general RF power segment, and further position it in applications such as military communications, base-station products and broadband solutions, says Quinsey.

As well as its wide-band technology, Peak offers a complete portfolio of traditional RF power devices. Peak provides an alternative to costly redesign by developing drop-in replacements for LDMOS and bipolar RF power applications, extending product life, says the firm's marketing manager, Mike Lincoln.

www.peakdevices.com

www.triquint.com/rf

Skyworks receives certification for automotive quality standard

Skyworks Solutions Inc of Woburn, MA, USA has received ISO/TS 16949 certification, allowing it to supply to the automotive market (estimated by Lehman Brothers to represent a total available market of \$16bn).

ISO/TS 16949 was developed by the International Organization for Standardization in conjunction with the International Automotive Task Force (IATF), comprising vehicle makers including BMW, DaimlerChrysler, Fiat, Ford, GM, Peugeot-Citroen, Renault and Volkswagen.

Skyworks makes power amplifiers, front-end modules and direct conversion radios (for multimedia handsets), but launched its linear products business to leverage its core RF and analog product portfolio and modeling capabilities, along with its catalog sales channels and specialized rep and distributor net-

works, in non-handset applications. So far, Skyworks has secured design wins in cellular infrastructure, broadband, medical and industrial markets.

The automotive sector offers a range of semiconductor growth opportunities, says Skyworks, as cars use wireless technology for keyless entry, Bluetooth, GPS, satellite radios, climate control, sensors etc.

"Automotive represents a core end-market for analog and mixed-signal semiconductor companies and suppliers of discrete semiconductor components, among others," adds Lehman Brothers.

Given that ISO/TS 16949 is a differentiating standard across a wide range of industries, certification also creates opportunities in markets such as broadband, consumer electronics, meter reading, and RFID, Skyworks reckons.

The audit process covered design, manufacturing, design validation, final test, packing and shipping. Skyworks' facilities accredited under ISO/TS16949 include: its plant in Woburn, MA for the fabrication of 4" GaAs pHEMT and MESFET wafers as well as silicon wafers for switches, control devices and amplifiers, and discrete RF diodes; its plant in Mexicali, Mexico for final test and tape & reel for modules, RF chip-scale and fine-pitch ball grid array (FPBGA) packages, as well as RF, analog and systems test; and its failure analysis (FA)/reliability lab in Newbury Park, CA, USA. The stringent certification gives Skyworks the opportunity to significantly expand its Linear Products business, says Nien-Tsu Shen, VP of quality.

www.skyworksinc.com

Kopin receives \$3m state grant; expands Taunton plant

During a ceremony to mark the receipt of a new \$3m state development grant, Kopin Corp announced plans for an expansion of its production facility in Taunton, MA, USA (for completion later this year) to support the growing demand for its microdisplay and GaAs-based heterojunction bipolar transistor (HBT) products.

"The grant represents a partnership between Kopin and the Commonwealth of Massachusetts to create jobs," said Dr John C.C. Fan, president & CEO. "This grant is a continuation of our strategy which includes federal, state and Kopin resources and revenues to develop leading-edge display products for use in consumer and military applications."

The state grant will be used for the construction of clean room facilities, infrastructure improvements and a job training program. Kopin expects to increase its workforce over the next five years and beyond. Currently, there are about 140 people working at the Taunton facility.

www.kopin.com

Kopin expects stronger III-V revenues in second-half 2007

Kopin has reported limited results for Q2/2007 (preliminary until it files its quarterly report on Form 10-Q).

Total revenue from sales of HBTs and its liquid-crystal CyberDisplays was \$21.8m, up more than 15% on \$18.1m in Q1 and \$18.9m a year ago.

Revenue from HBTs was \$11.1m, down on \$12.1m a year ago but up 20% on the \$9.1m in Q1/2007. First-half 2007 HBT revenues were \$20.2m, down on the \$24.9m for first-half 2006.

"We expect stronger HBT revenues in the second half of this year," said president & CEO, Dr John C.C. Fan. "We are on track with the installation and qualification of three of

the world's most advanced and largest [MOCVD] HBT production systems in our Taunton facility. By the end of this year, our capacity should be about 50% higher than our 2005 capacity levels," Fan added. "In addition, these advanced systems should enhance our operational efficiencies and improve the uniformity and process control of our 6" wafer products."

For fiscal 2007, Kopin has raised its forecast from \$80-90m to \$90-95m. "We anticipate continued growth in III-V, driven by demand for advanced wireless handsets and WiFi systems equipped with our transistors," said Fan.

● Kopin has received a Nasdaq Staff Determination letter after failing to file its Q2/2007 results (in addition to its Q3/2006, full-year 2006 and Q1/2007 results). The delays are due to Kopin's special investigative committee investigating its past stock option granting practices.

On 2 August, the Nasdaq Listing and Hearing Review Council gave Kopin until 25 September to file the reports and any restatements with the US Securities and Exchange Commission. Kopin has requested continued listing on the Nasdaq Global Market beyond that date to allow it to complete its investigation and file audited financial statements.

RRFC gets National Security Agency accreditation

Raytheon Company's semiconductor foundry, Raytheon Radio Frequency Components (RRFC) of Andover, MA, USA, has been accredited as a Department of Defense Category 1 Trusted Foundry by the US National Security Agency's Trusted Access Program Office.

RRFC designs, develops and manufactures gallium arsenide and gallium nitride monolithic microwave integrated circuits (MMICs) and modules for Raytheon's radar, electronic warfare, communications and weapon systems.

The agency's Category 1 designation, the highest awarded by the Department of Defense, recognizes Raytheon's support of defense systems that are vital to mission effectiveness or operational readiness of deployed or contingency forces, and indicates that the loss or degradation of these systems results in immediate and sustained loss of effectiveness.

"This accreditation reflects our capability to provide the stringent protection measures required by the National Security Administration for

gallium arsenide and gallium nitride foundries," says Mark Russell, VP of Engineering for Raytheon Integrated Defense Systems.

The Integrated Defense Systems business is Raytheon's leader in Joint Battlespace Integration, providing affordable, integrated solutions to a broad international and domestic customer base, including the US Missile Defense Agency, the Armed Forces, and the Department of Homeland Security.

www.raytheon.com

www.nsa.gov/business/tapo.cfm

IQE wins multi-year contract as Anadigics' preferred epi supplier

Substrate and epiwafer supplier IQE plc of Cardiff, UK says that its RF Business Unit has been selected by RFIC maker Anadigics Inc of Warren, NJ, USA to be its preferred supplier of GaAs epiwafers.

As part of a multi-year contract valued at about \$50m over the first two years, IQE will provide a range of wafer products to be used to manufacture wireless chips for 3G handsets and base-stations, latest-generation (802.11n) Wi-Fi systems for infrastructure and Wi-Fi-enabled laptop computers, WiMAX, broadband fibre-optic systems, and

satellite set-top-box applications.

"We have been working very closely with Anadigics over the last two years to support their rapid growth plans," says CEO, Dr Drew Nelson. In July, Anadigics broke ground on building a 6" GaAs fab in Kunshan, China. "This major contract award recognizes the unique advantages that IQE can offer as a pure-play wafer supplier, including multi-site, multi-platform manufacturing, a complete product range for the wireless communications industry, significant additional wafer capacity to support the rapidly growing

demands of this and other customers, and advanced engineering support for current and future product development," Nelson adds.

"We have chosen IQE as our preferred epi supplier on the basis of their diligent support of our rapidly growing business over the last two years, and in recognition of their wafer production strategy, which gives us confidence that they can fully support our aggressive growth plans over the next few years," says Anadigics' president and CEO, Dr Bami Bastani.

www.iqep.com

Growth in wireless drives IQE to operational profit

For first-half 2007, IQE's revenues were £23.7m, up 62% on £14.6m a year ago and slightly above the market forecasts of £22.5m. This was despite the impact of a slow start in January and February and the exchange rate worsening from \$1.78/£ to \$1.97/£. At a constant exchange rate, revenue would be up 80% to £26.2m.

Apart from optoelectronics (about 20% of revenues) and electronics (6%), over 70% comes from wireless (up from 60% a year ago).

"Continued strong growth in the global wireless marketplace, combined with a shift towards high-end, fully featured handsets, high-speed Wi-Fi and satellite communications systems, all of which use increasing amounts of our products, have driven revenues ahead of expectations during the first half of the year," says CEO Drew Nelson.

"Our position in the wireless market was substantially bolstered by the two major acquisitions made during 2006 [epiwafer foundries MBE Technology Pte Ltd of Singapore and IQE RF of Somerset, NJ, USA (formerly Emcore's Electronic Mat-

erials & Device division)]." By gaining exposure to the wireless power amplifier and Asia-Pacific markets, IQE's product and customer reach has been substantially enhanced, it is claimed. The higher profile has also generated interest with potential new customers. The acquisitions have been integrated smoothly and have performed ahead of management expectations, the firm adds. Indeed, IQE has negotiated a 'very attractive opportunity' to relocate the Singapore plant to a much larger clean-room facility 'at minimal capital cost', involving significant government assistance, including the offer of tax-free status over the next 10 years. The relocation will enable 'significant future capacity expansion' to support the rapidly growing business in the Asia-Pacific region, particularly in China (where Anadigics is expanding).

In first-half 2007, gross profit tripled year-on-year to £3.9m. Earnings before interest, taxes, depreciation and amortization (EBITDA) were £1.3m, compared to a loss of £0.8m. Due to the

increased revenues and strong operational gearing, IQE has also moved from an operating loss of £1.5m to operating profit of £0.1m. Net loss is cut from £1.6m to £0.5m.

Nelson reckons that the move into operating profit is a key milestone in IQE's continuing progress, and shows the strength of the firm's business model. "As more customers become cross-qualified at our various manufacturing locations worldwide, we will be able to leverage our additional manufacturing capacity, which we expect will result in continued strong growth."

Also during first-half 2007, IQE was awarded R&D contracts worth about \$4m. One, as part of a UK consortium, is to develop high-efficiency GaN-based LEDs for solid-state lighting. Others include developing strontium titanium oxide on silicon epiwafers (STO/Si) using MBE, and advanced material structures for increased processing speed in future silicon-based memory and logic ICs. IQE also says that it is progressing its terrestrial solar cell activities through customer-funded programmes.

NSF grant for integration of compound devices on silicon

AmberWave Systems Corp of Salem, NH, USA and Rochester Institute of Technology (RIT) have been awarded a three-year grant from the US National Science Foundation (NSF) to research the integration of compound semiconductor devices on silicon using an AmberWave development called aspect ratio trapping (ART).

ART could open the door to faster, more powerful chips in applications from silicon-based photonics to improved photovoltaic cells, says the firm. In silicon photonics, ART could allow manufacturers to combine different materials onto a silicon base.

"This award plays on the value of industry and university collaboration and the demonstrated strengths of AmberWave in the area of epitaxial thin-film electronic materials, and of RIT's Microelectronics researchers in the area of integrating novel materials into mainstream silicon microelectronics devices to enhance performance," says Dr Donald Boyd, VP for research at RIT.

ART would allow manufacturers to capitalize on their investments in current manufacturing technologies, reducing costs considerably, and allowing the devices to be included in a wide range of products at consumer friendly prices, AmberWave claims.

"This research holds the potential for seamlessly integrating III-V and silicon microelectronics to retain the best properties of each, opening up the possibility for truly massive speed improvements in memory and processor chips, integrated silicon-photonics devices for ultra-high bandwidth fiber-optic communications, and novel radio frequency chips for wireless communications," Boyd adds.

The principal investigators for the collaboration are Dr Santosh Kurinec and Dr Sean Rommel of RIT's Department of Microelectronic Engineering.

www.amberwave.com
www.rit.edu

Intel reports high-performance compound on silicon

In August, Intel reported the fabrication of what is claimed to be the first high-performance compound devices on silicon (IEEE Electron Device Letters, Vol. 28 (8), p685). Using either of two material types (InSb and InGaAs), in each case the performance is as good as their counterparts on GaAs wafers. Plots of the maximum frequency of depletion-mode devices against power dissipation for two InGaAs devices (one on InP and one on silicon) show that the two curves overlap each other, as well as showing significantly better performance (both higher cut-off frequency and lower DC power dissipation) than equivalently sized silicon devices.

Also, at December's IEDM 2007 conference, Intel intends to report newer results for much thinner buffer layers, as well as data on enhancement-mode devices.

<http://blogs.intel.com/research/2007/08/enforcingmoorelaw.html>

ACCO raises \$10m first-round funding for RF CMOS PAs

Analog and RF IC design firm ACCO S.A. of Saint Germain en Laye, France has raised \$10m in first-round funding. UK-based Pond Venture Partners (Europe's largest early-stage technology venture capital fund) and Partech International (which invests exclusively in information technology) join Siparex Ventures, a seed-level investor since October 2005. Pond partner Jamie Urquhart (a former chief operating officer at ARM) is interim CEO, tasked with helping to find a permanent CEO.

Founded in 1994 by chief technology officer Denis Masliah, ACCO previously provided high-frequency chip design services to fabless semiconductor companies and system companies. However, it decided earlier this year to raise venture capital funds to support the

transition of its business model to itself being a fabless semiconductor company, based on its demonstration of what it claims is an innovative approach to using RF CMOS silicon for power amplifier (PA) design that can enable lower-cost, more reliable and more highly integrated handheld mobile devices. Some of the first-round funds have already gone into funding the manufacture of proof-of-concept prototypes. ACCO is currently filing patents for the CMOS power amplifier.

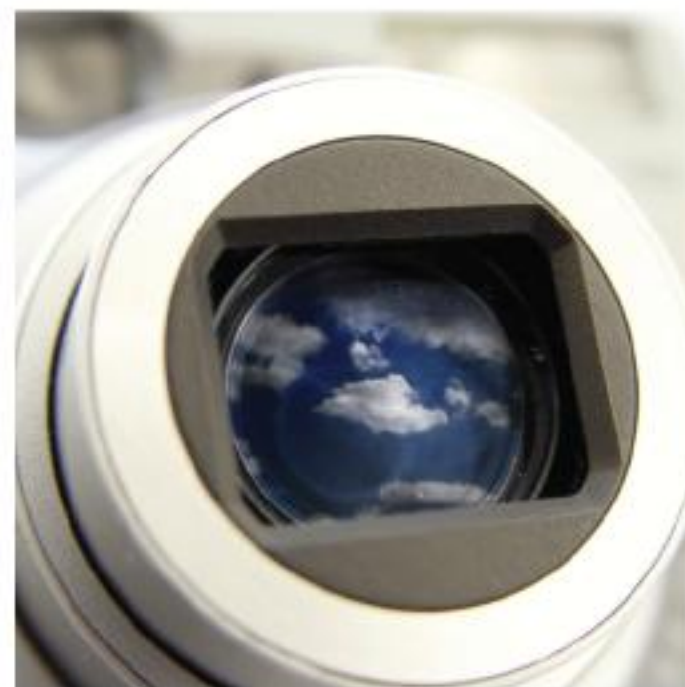
CMOS has previously been used for PAs in GSM cell phones and Bluetooth and wireless LANs, but not for the higher frequencies of 3G cell phones and WiMAX, where GaAs-based PAs predominate. But now Masliah claims that the problem of the low breakdown voltage

in conventional CMOS (especially as device dimensions are scaled down to achieve higher operating frequencies) is overcome in ACCO's MASMOS technology for all current CMOS nodes (from 180nm to 65nm and beyond to 45nm), enabling it to compete with GaAs on performance for 3G applications.

"The wireless handset market is always looking for innovative solutions to satisfy continuously growing consumer expectations in terms of cost and battery life," says Richard Irving, managing partner at Pond Venture Partners. "We are convinced ACCO will play a significant role in meeting these needs."

ACCO aims to have CMOS PA products in cell-phone handsets in 2009, according to Masliah.

www.acco-ic.com



Advanced CVD and ALD Precursors

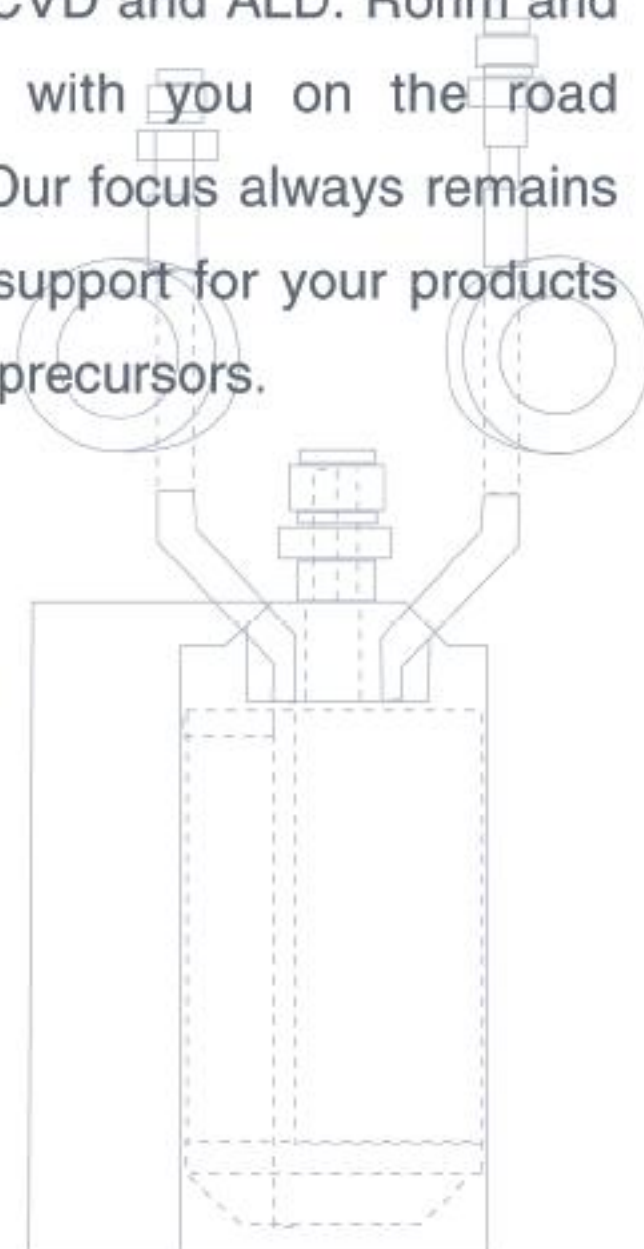
For more than 30 years Rohm and Haas Electronic Materials has delivered industry-leading precursors for CVD used in state-of-the-art compound semiconductor applications around the world. Now silicon semiconductor technology is poised for a leap forward with the promise

of new materials for advanced CVD and ALD. Rohm and Haas Electronic Materials is with you on the road forward, wherever it takes us. Our focus always remains offering unrivaled applications support for your products and providing the best possible precursors.



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www.rohmhaas.com

Nitronex's 100W GaN-on-Si HEMT production qualified

Nitronex of Durham, NC, USA says that, after rigorous testing, its 28V, 100W-class NPT25100 GaN-on-Si HEMT RF power transistors are now qualified for volume production.

Designed using Nitronex's patented SIGANTIC NRF1 process, the NPT25100 is optimized for continuous wave (CW), pulsed, WiMAX, W-CDMA and long-term evolution (LTE) applications operating between 2.1–2.7GHz.

The NPT25100 was launched at the IEEE MTT-S event in Hawaii in early June, targeting 2.3–2.7GHz WiMAX applications. "We have extended the operating frequency and increased the power output of the NPT25100 devices, while reducing the cost per watt for peak power to the lowest in the GaN industry," says director of marketing Ray Crampton.



Nitronex's production-qualified NPT25100 GaN-on-Si HEMT.

Typical performance is rated using a mobile WiMAX waveform, defined as a single-carrier orthogonal frequency-division multiplexing (OFDM) signal 64-QAM 3/4, 8-burst, 3.5MHz channel bandwidth and 10.3dB PAR (peak-to-average ratio) @ 0.01% probability on CCDF (complementary cumulative distribution function). Under these

conditions, the NPT25100 will deliver 16.5dB power gain (up from the 14.5dB announced in June) with a drain efficiency of 26% (increased from 21%) and an error vector magnitude (EVM) of 2.0% (reduced from 2.5%) — all at 10W of power. Typical two-tone peak envelope power (PEP) is 125W and drain efficiency is more than 65%.

The NPT25100 is packaged in a thermally enhanced copper moly copper package in a bolt-down version, with a pill version due to be available in fourth-quarter 2007. Typical pricing is \$90 each in quantities of 1000 (less than 72 cents per Watt for peak power).

A product qualification document is available at:

www.nitronex.com/wimaxgan/wimaxgan.html

BAE wins \$8m US defense contract to develop 160W GaN amplifier

UK-based aerospace and defense contractor BAE Systems says that its Electronics & Integrated Solutions (E&IS) business in Merrimack, NH, USA has been awarded an \$8m contract from the US Army Communications-Electronics Command to develop a 160 Watt gallium nitride power amplifier for communications, electronic warfare, and radar applications. Partnering BAE Systems on the program are materials supplier Rohm and Haas of Blacksburg, VA, USA and the University of Colorado.

The solid-state technology will replace the older traveling-wave vacuum tubes that are currently used to produce high-power radio frequency signals, and are intended to aid warfighters by more effectively disrupting enemy communications and radar signals, while protecting friendly communications.

"DARPA [the US Defense Advanced Research Projects Agency] has identified BAE Systems' GaN technology

as an important material for future military applications in electronic warfare, radar, and air-to-ground, air-to-satellite, and ground-to-ground communications systems," says Dr John Evans, the manager for DARPA's Disruptive Manufacturing Technology program (through which it solicits proposals to reduce cost and time for production of military components). BAE Systems was chosen from among 40 bidders.

"Using this technology, we can develop systems that are significantly less expensive, more reliable, and lower in weight," says Tony Immorlica, program manager of microwave device programs at BAE Systems. The first prototypes could be deployed by the end of the decade.

The DARPA agent for the program is the US Army Communications-Electronics Research, Development, and Engineering Center in Fort Monmouth, NJ, USA.

www.baesystems.com

European GaN alliance enters second phase

Following the launch in September 2006 of an alliance to develop GaN technology for cellular infrastructure between Fraunhofer Institute for Applied Solid-State Physics IAF in Freiburg, Germany and industrial partners NXP Semiconductors (formerly Philips Semiconductors) in Eindhoven, The Netherlands and United Monolithic Semiconductors (the Thales-EADS joint venture with plants in Orsay, France and Ulm, Germany), a second phase was announced in late July.

The aim is, by 2009, to introduce Fraunhofer IAF's GaN technology into volume production of broadband amplifiers at UMS for wireless infrastructure applications, representing Europe's first volume production of GaN-based chips for RF applications.

www.iaf.fraunhofer.de

www.ums-gaas.com

www.nxp.com



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IN BRIEF

Cree's silicon carbide MESFETs used in MILMEGA's UHF power amplifiers

Cree Inc of Durham, NC, USA says that its silicon carbide MESFET devices are being used by MILMEGA Ltd of Ryde, Isle of Wight, UK to provide RF power in a new range of robust UHF power amplifiers, which are designed for the electro-magnetic-compatibility (EMC) and test-instrumentation markets. The inherent benefits of SiC MESFETs provide high reliability and power density, ease of power upgrade, and portability, it is claimed.

Founded in 1987, MILMEGA designs and manufactures solid-state, high-power broadband amplifiers ranging in frequency from 200MHz to 14GHz, with power levels from 1W to above 1kW.

"We selected Cree SiC MESFET devices based on their power density and efficiency advantages," says the firm's managing director Pat Moore. "They enable amplifier products that are up to three times smaller and lighter than those using conventional transistor technology. This provides MILMEGA with a unique advantage in terms of performance and cost versus existing competitive products," Moore claims.

"We are encouraged by our customers' extremely positive feedback on these products from our product launch at the recent IEEE EMC Symposium [in Hawaii in July]," Moore adds. "Further, we continue to favor Cree's products within their SiC MESFET and GaN HEMT families and have a number of innovative new products using these devices planned for release in the near future."

www.cree.com

www.MILMEGA.co.uk

C9 to build fabrication plant based on SiC-on-silicon technology

Following the award of a \$1.75m grant from the state of New York, C9 Corp of Kingston, NY, USA has announced plans to build an SiC wafer fab and offices at the Saratoga Technology + Energy Plant (STEP) in Malta, NY (to be operational late next year). The firm aims to create 35 jobs there by 2010.

C9 is a privately funded firm founded in 2005 by executives at three New York-based companies:

- chief technology officer Dr C.G. Wang (president and CEO of device R&D firm Nanodynamics-88, which grows silicon-on-insulator wafers and is supported mainly by defense contracts and awards);

- president and CEO Kevin Donegan (CEO of Amtrade, which brings military R&D technologies to the commercial market); and

- chief operating officer and senior VP Frank Falatyn (president and CEO of manufacturing services firm FALA Technologies).

Currently co-located at FALA's plant in Kingston, C9's focus is to bring to market the semiconductor technologies of Nanodynamics-88, which is developing large, high-voltage devices such as SiC Schottky diodes for the power conversion market.

The firm's primary technologies include: SiC-based devices that are claimed to be defect-free (with epitaxial quality products 'equivalent to those currently found in standard semiconductor wafer processing'); SiC/silicon-on-insulator (SOI) wafers; specialty thermal materials; and harsh-environment products.

C9 is consequently manufacturing SiC-based superlattice wafers, grown on 100-150mm silicon substrate, for high-power electric switching devices and high-temperature, high-speed chips. Secondly, C9 is also developing a program to produce light-weight isotopes (silicon 28, silicon 30 and carbon 13), which have the enhanced thermal characteristics needed for improving both silicon and SiC-based wafer products.



C9's CEO Kevin Donegan, reflecting on the firm's SiC-on-silicon wafers.

Wang created three of the nine known methods of isotope enrichment as well as the firm's current approach to SiC fabrication (the firm's core patented products). Thirdly, C9 plans to make silicon and SiC wafers using its silicon-on-insulator (SOI) technology (for high-speed and harsh-environment microprocessors and control chips).

CEO Donegan, who previously led a team from SAIC, Northrop Grumman, United Defense and Satcon for the DARPA CHPS (Combat Hybrid Power System) program that started in 1997, says that the firm will develop technology for use by the US Department of Defense. C9 has invested \$11m in research and development of SiC wafers for the military's hybrid electric armored vehicle program. The military is expected to also use the technology in solar-related projects.

C9 says that it has several ongoing contracts with defense contractors and military agencies, as well as commercial agreements underway to provide materials and devices (Amtrade has previously designed and issued proposals for converter platforms up to the megawatt class for corporate clients.) The firm adds that it is currently in discussions with prospective business partners.

www.c9corp.com

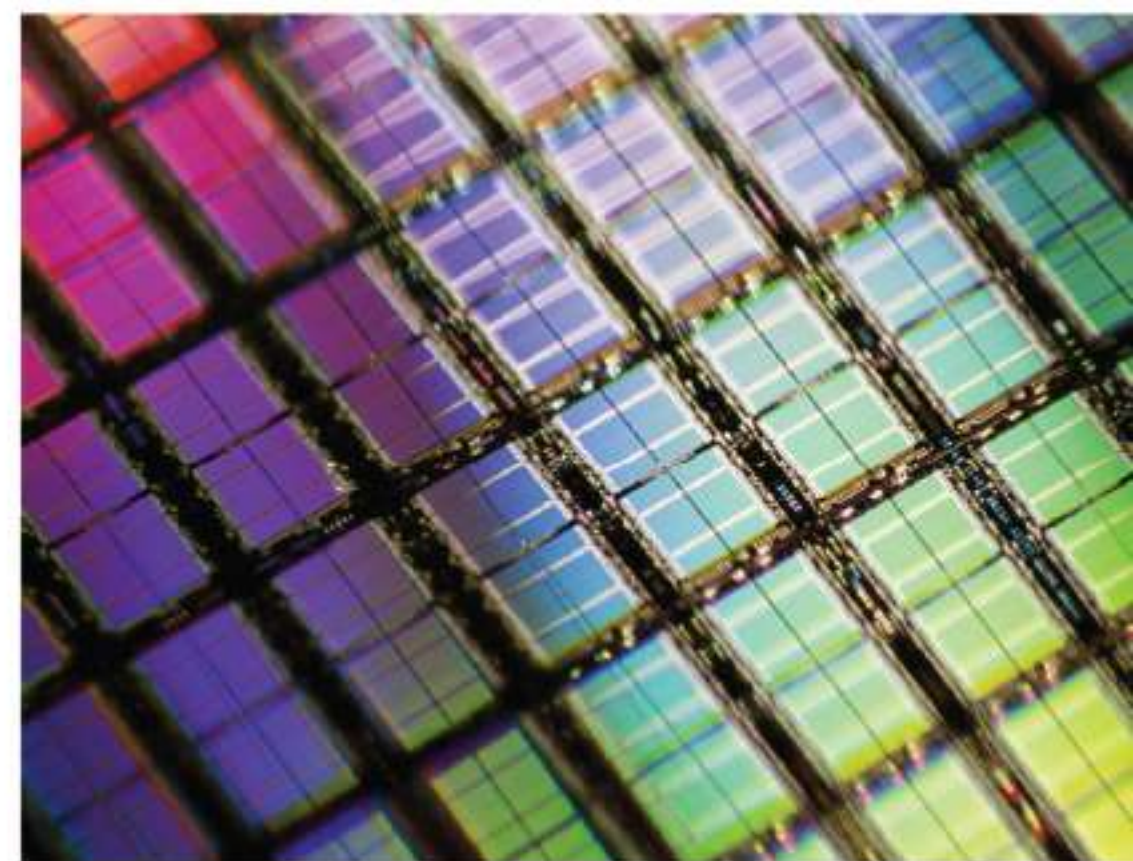


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SURFACE TECHNOLOGY SYSTEMS

Microsemi enters SiC epi supply agreement with SemiSouth

Microsemi Corp of Irvine, CA, USA and SemiSouth Laboratories Inc of Starkville, MS, USA have agreed to cooperate on SiC epiwafer supply as well as certain technical exchanges.

SemiSouth, which was spun out of Mississippi State University (MSU) in 2000, specializes in SiC epitaxy and microelectronic device fabrication. Microsemi designs and manufactures analog mixed-signal ICs and high-reliability semiconductors which manage and control or regulate power, protect against transient voltage spikes, and transmit, receive, and amplify signals. Products include individual components as well as IC solutions that enhance designs by improving performance and reliability, optimizing battery performance, reducing size or protecting circuits. The main markets include defense, commercial air, satellite, medical, notebook computers, LCD TVs, mobile, and connectivity applications.



SemiSouth's SiC manufacturing plant in Starkville, MS.

"We are pleased to enter into a closer working relationship with SemiSouth," says Russell Crecraft, Microsemi's Power Products Group VP and general manager. "Microsemi's requirements for SiC wafers will grow in the future and we expect that this agreement will help SemiSouth's talented team of engineers to continue their progress toward highly

This agreement represents a great step forward for the SiC power electronics market

manufacturable silicon carbide epitaxy."

"At SemiSouth, our long-term goals have always been to enable the SiC power device market through high-quality SiC epitaxy wafers and devices," says the firm's president Jeff Casady. In August 2006 it opened its high-volume SiC epiwafer and power semiconductor fab, raised \$5m in venture capital, and won a five-year Small Business Technology Transfer (STTR) Phase III contract (worth \$3.95m initially) from the Air Force Research Laboratory to extend the design, fabrication, and reliability testing of SiC power devices toward military qualification and reproducible manufacturability. "Microsemi has a great track record of supplying high-performance power device products, and this agreement represents a great step forward for the SiC power electronics market," Casady adds.

www.semisouth.com
www.microsemi.com

Caracal receives US patent for epitaxial growth of silicon carbide using chlorinated chemistry

Caracal Inc of Ford City, near Pittsburgh, PA, USA has been awarded US patent no. 7247513, related to epitaxial growth of SiC using chlorinated chemistry. Patents are also pending in several other countries.

Epitaxial SiC growth rates for conventional chemistry are typically 5–10µm/h. Caracal's approach increases this to more than 100µm/h, while maintaining quality and doping, the firm says. This enables the realization of very high-voltage power devices.

Caracal is a development-stage company founded in 2003 to research, manufacture, and market semiconductor-grade SiC sub-

strates for the power, RF, and electro-optic markets, for applications where the demands of higher voltage, frequency, or temperature make traditional silicon (or alternative) substrates inadequate.

Caracal was co-founded by VP Olle Kordina from the SiC MS center at Linköping University in Sweden (who was at Sterling Semiconductor in 2001) and entrepreneur Rajiv Enand as president/CEO.

Caracal uses source materials based on gases rather than powders to produce substrates, claiming that it can cut the cost of making SiC wafers by almost 90%. Caracal is making use of crystals using chlori-

nated halo-hydrocarbons to get their high quality and high yields.

Seed capital was provided in the form of a \$33,000 startup grant and a \$164,000 research grant from The Pittsburgh Digital Greenhouse (now known as the Technology Collaborative) and three investments totaling \$600,000, plus business assistance, provided by Innovation Works (both organizations are state-sponsored by the commonwealth of Pennsylvania). The technology has been developed over the past few years with funding from the Office of Naval Research (for its next-generation warships).

www.caracalsemi.com

GaAs substrate demand and gallium shortages boost AXT

For Q2/2007, AXT Inc of Fremont, CA, USA has reported revenue of \$13.6m (up 9% on Q1's \$12.5m and 20% on \$10.4m a year ago).

GaAs substrate revenue has grown from \$8.1m a year ago and \$8.8m in Q1 to \$9.3m. However, 6" wafer sales are down from \$3.0m a year ago and \$3.3m in Q1 to \$2.8m, mainly due to delays in BiFET qualifications at certain customers.

However, 70–80% of these have now been completed. Also, in late June, AXT won some large orders for 6" wafers, for delivery in Q3.

InP substrate revenue was \$660,000 (up on Q1's \$518,000 and \$613,000 a year ago), mainly due to a one-off sale of scrap wafers.

Germanium substrate revenue was \$402,000, down on Q1's \$541,000 due to slightly lower demand from a major Chinese customer, but up greatly on \$169,000 a year ago.

Sales of raw materials (mainly 99.99% pure gallium) were \$3.3m, up from \$2.6m in Q1 and \$1.4m a

year ago, mainly due to rising prices (particularly for raw gallium) and sales to two new European customers (one of which is also a competitor to AXT's substrate business).

The Asia-Pacific region has grown over the last few quarters to 61% of revenue, with Europe 20% and North America 19% (although the latter should grow due to rising sales to photovoltaics manufacturers).

Operating expenses have been cut from \$4.4m a year ago and \$4.2m in Q1 to \$3.6m (included a bad debt expense of \$574,000 due to slow-paying customers, mainly in Asia). Also in Q2, AXT agreed the \$5.35m sale of its plant in Fremont (where it maintains sales, administration and customer service functions).

Net income was \$1.2m, versus a loss of \$876,000 a year ago.

"After an industry-wide pause to complete BiFET qualifications and digest some excess inventory, we are poised for renewed growth in our 6" products. Demand is return-

ing across all areas of our core GaAs business and we are completing several strategically important qualifications that will begin to generate revenue in the second half of the fiscal year," says CEO Phil Yin.

"Shortages in gallium raw material and increasing interest in emerging applications such as photovoltaics are illuminating the unique competitive positioning that AXT is likely to benefit from over the next several years," adds Yin. "Our strategy to vertically integrate our raw material needs has not only proven to be very effective in regards to raw materials pricing and volume, it has clearly become a major differentiator in our industry."

AXT aims to increase ownership in its raw materials joint ventures, particularly those producing arsenic and germanium. It is also investigating SiC, GaN, and diamond materials, for possible future production.

For Q3/2007, AXT expects revenue to rise slightly to \$14.0–14.6m.

www.axt.com (and see article on p45)

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IN BRIEF

Nanometrics appoints CEO

Metrology equipment maker Nanometrics Inc of Milpitas, CA, USA has appointed Timothy J. Stultz as president, CEO and board member. He succeeds Bruce C. Rhine, who becomes chairman, while founder Vincent J. Coates becomes vice chairman.

Stultz joins from Imago Scientific Instruments, where he was president and CEO since 2003. Formerly, he was president and CEO of diagnostic system developer ThauMDx. From 1994 to 1999, he was VP and general manager with Veeco Instruments, heading its metrology business.

Stultz brings experience in building up companies in the capital equipment industry, especially in the metrology sector, says Rhine.

www.nanometrics.com

Bruker launches D2 Cryso for GaAs, SiC

At the Denver X-ray Conference, analytical x-ray systems maker Bruker AXS of Karlsruhe, Germany launched its D2 Cryso system, a bench-top crystal orientation analyzer which uses a patented method of energy-dispersive x-ray diffraction (ED-XRD).

Bruker says that the new system is suited to determining the lattice orientations of medium and large single crystals, including GaAs, SiC, silicon and germanium.

The ED-XRD method eliminates multiple rotation axes or costly area detectors, making the system robust and virtually maintenance free. Also, Bruker's new 30mm XFlash silicone-drift detector (SDD) has high energy resolution and speed and needs no cooling water.

As well as fully automatic crystal orientation analysis in QC, there's also an expert mode for crystal growth R&D.

www.bruker-axs.de

EVG to distribute SemiProbe's wafer-level probing systems

Wafer-bonding and lithography equipment supplier EV Group (EVG) of St Florian, Austria has signed a global agreement to distribute the manual, semi-automatic and fully automatic wafer probing systems of SemiProbe LLC of Colchester, VT, USA in combination with EVG's process equipment.

EVG's policy is to offer complementary partner products, providing a single source for wafer processing needs (in March, it signed a global agreement to distribute the ZIII-NIR Wafer Inspection System of McBain Instruments of Chatsworth, CA, USA).

SemiProbe's probing family allows EVG to have a test tool to probe all bonded wafers either post-bond (SemiProbe standalone prober) or pre- and post-bond (integrated in EVG systems). "This approach allows 24/7 production with minimum intervention," says EVG product manager Thomas Wagenleitner.

SemiProbe's systems suit uses from the lab to high-volume production.

Users can buy either a standalone probe system or a turn-key, application-specific probing/testing solution. Several new solutions range from engineering probe systems to 'known good die' systems to small-footprint and high-throughput production systems. SemiProbe also offers the world's first 'Probe System For Life' (PSL) family of probers (which provide users a continuous upgrade path from manual to automatic, giving capital equipment savings by allowing purchase of what is needed and affordable now while allowing field upgrade later as needs change).

"Partnering with EVG is an opportunity to expand SemiProbe into new global markets that involve integrated process and test solutions," says SemiProbe's CEO Denis Place. The firm's probe systems are supplementary to EVG bonding and alignment process systems, he adds.

www.EVGroup.com

www.semiprobe.com

Ultra-thin wafer handling solution with high-temperature and high-vacuum capabilities

As a result of a multiyear collaborative partnership, at July's SEMICON West 2007 trade show EVG and Brewer Science Inc of Rolla, MO, USA introduced a system with temporary wafer bonding technology that provides new capabilities and yield performance for processing ultra-thin wafers (e.g. in 3D packaging applications), it is claimed.

The solution consists of Brewer Science's new WaferBOND HT temporary wafer bond series of materials and EVG's proven EVG850TB/DB bonding and debonding equipment platforms, and the development of a method for safely and reliably processing sub-100 micron thinned wafers.

The technology performs temporary bonding of original thickness

device wafers onto rigid carrier wafers. Application of the WaferBOND HT materials via a spin-coating, baking and subsequent bonding process is performed on an EVG850TB system. The resultant wafer-stack maintains optimum yield and manufacturing performance through thinning and subsequent backside processing steps.

The new WaferBOND HT materials enable use of the EVG850TB/DB system with previously unattainable high-temperature processing steps as well as high-vacuum compatibility, it is claimed.

The two firms say that they have also extended their collaboration to increase the process latitude for future material sets.

www.brewerscience.com

IN BRIEF

Chinese start-up HC SemiTek gears up for GaN HB-LEDs

Start-up Huacan SemiTek Co Ltd (HC SemiTek) of Wuhan University Science Park, China has received and commissioned its first Thomas Swan Close Coupled Showerhead (CCS) MOCVD reactor from Aixtron, supplied in a 19x2" wafer configuration.

"It is our strategic plan to quickly gain the ability to develop and manufacture GaN-based high-brightness LEDs," says founder Dr Chen Changqing. HC SemiTek's technical team already has expertise with the performance and operation of the Thomas Swan CCS MOCVD reactor from previous staff positions at local institutes.

In early July, the firm bought a GPT-20 bulk hydrogen purifier from the Johnson Matthey Gas Purification Technology (GPT) group of West Chester, PA, USA (see July/August issue, page 20).

www.wusp.com.cn

China's SCNU installs TS R&D MOCVD system

Aixtron has installed a Thomas Swan 3x2" Close Coupled Showerhead (CCS) FT MOCVD system at the LED R&D center of the South China Normal University (SCNU) in Guangzhou (the first organization in China to use the system) for developing material structures for GaN high-brightness LEDs.

The new 3x2" FT platform is the first in Aixtron's 'Flip Top' range, and includes a compact footprint and all-new digital control of mass flow and pressure controllers.

SCNU's MOCVD lab director, professor Fan Guang-Han, has been conducting MOCVD research in China for 24 years.

www.scnu.edu.cn/eweb

Asian LED makers driving growth

For first-half 2007, deposition tool maker Aixtron of Aachen, Germany has reported revenues of €109.0m (up 61% year-on-year). However, Q2's €45.2m was down on Q1's record €63.8m, due to lower order intake in previous quarters and customer delivery requirements.

Of total H1/2007 sales, 86% were to Asia, 4% to Europe and 10% to the USA (compared to 83%, 8% and 9%, respectively, in H1/2006).

Compound Semiconductor equipment sales rose 131% to €71.8m (66% of total revenues) from just €31.1m (46%) in H1/2006, driven by demand from Asian LED makers.

Qualification of next-generation LED devices (e.g. for automotive applications, backlighting etc) is progressing, with early end-products appearing on the market. Over 30% of revenues and nearly 70% of orders for compound systems were for Aixtron's high-capacity/common-platform systems (launched in late 2005) for GaN LED production, which have now been qualified by key customers (as evidenced by the receipt of repeat and multiple orders).

H1/2007 also saw demand from Asia for systems for the production of blue and red lasers, as well as

small-scale demand for systems for telecom/datacom applications.

Continued qualification and repeat orders for high capacity/platform systems, as well as the favorable product mix, boosted gross margin from 37% a year ago to 39% despite negative currency exchange effects. Net profit was €11.5m in (versus a loss of €4.3m a year ago).

Equipment order intake in H1/2007 was €90.8m (up 12% on €81.2m a year ago). Specifically, after two quarters of decline, in Q2 order intake was €50.3m, up 24% from Q1's €40.5m (driving backlog up 15% from €70.0m to €80.3m).

The pick-up was fuelled by 'healthy' ongoing demand for compound semiconductor equipment (rising to 75% of orders in H1/2007) for the production of LEDs, as well as 'stable' demand for silicon systems for the production of memory products, says CEO Paul Hyland.

Aixtron expects a weaker H2/2007, but "Current positive market development gives us the confidence to confirm the upper end of our prior [full-year] guidance; namely €200m revenues and €16m EBIT [earnings before interest and taxes]," he adds.

www.aixtron.com

EpiValley ramps production for BLU side-view LEDs with three more CRIUS systems

In second-quarter 2007, Aixtron received a further repeat order from long-term customer EpiValley Co Ltd of Kwangju City, South Korea for three Thomas Swan Close Coupled Showerhead (CCS) CRIUS production MOCVD epitaxy reactors.

EpiValley makes chips and epi-wafers for blue, green and UV LEDs and already has at least 12 MOCVD systems in operation. The new systems (with a capacity of 30x2" wafers each) will be dedicated to manufacturing high-brightness GaN-based epiwafers for the production of side-view LEDs.

The firm was previously the first

to commission a CRIUS system (one of the world's most productive MOCVD systems for GaN-based LEDs, Aixtron claims) and, in a very short time, in May became one of the first companies to produce high-brightness blue LED epiwafers on a CRIUS.

Now that customers are ramping up production of side-view LEDs, EpiValley needs to quickly increase wafer throughput, says its president and CEO, Dr D.J. Park. "With all four CRIUS systems in place we will be able to satisfy the twin requirements of performance and price for the vast LED back-light unit (BLU) and solid-state lighting market."

Aixtron becomes first foreign guest member of CSA

Aixtron has become the first foreign guest member of the China Solid State Lighting Alliance (CSA). Its director, Wu Ling, says that Aixtron gained the accolade not only for its MOCVD technology but also for long-term cooperation with the Chinese LED industry, after being active in the CSA for many years.

"Aixtron is closely linked with the Chinese academic community, being active in co-organizing conferences and other scientific forums," says the firm's VP of R&D, professor Michael Heuken. "Our ongoing local research, development and educational effort have been a vital part of our business success story in China." Being a CSA member will further strengthen Aixtron's position, he reckons.

The CSA was founded in 2004 to develop and support China's solid-state lighting industry. Membership now numbers over 40 Chinese SSL companies and research institutes. Its main aim is to promote the technical advancement and industrialization of SSL through resource networking, technology innovation, practical operation, and collaborative development. The alliance also aims to establish an information technology database and a technology service platform for the industry, as well as encouraging the 'win-win' approach that will come from mutual and regional cooperation between upstream and downstream manufacturers in the supply chain. It is also working to establish an international cooperation network for integrating resources.

In addition, the CSA intends to provide a strategic analysis of the SSL market with reference to China's governmental industrial policies, as well as support the industry's responsibility to meet international business standards together with members' individual development (improving China's international competitiveness in the SSL industry).

Veeco's booming HB-LED equipment sales compensate for data storage

For Q2/2007, Veeco Instruments Inc of Woodbury, NY, USA has reported revenue of \$98.8m (61% process equipment; 39% metrology). This is flat sequentially and down 12% on \$111.6m a year ago.

By market sector, 32% came from data storage, 11% semiconductors, 26% high-brightness LED/wireless (MOCVD/MBE deposition equipment) and 31% scientific research (versus 36%, 10%, 21% and 33%, respectively, for Q1/2007). Year-on-year, data storage has fallen 41% while HB-LED/wireless has risen 40%.

"Veeco's revenue was below our guidance [of \$100-105m] due primarily to the field acceptance delay of a new data storage PVD system and end-of-quarter data storage customer factory shut-downs," says chairman Edward H. Braun. Weakness in the semiconductor sector also impacted revenue and profitability. Net loss was \$2.6m, compared to net income of \$3.0m a year ago.

Orders were \$112.5m (down 21% year-on-year, but up 6% sequentially). This included \$77.7m for process equipment (rising to 69% of orders) and \$34.8m for metrology (falling to 31%). By market sector, data storage rebounded by 41% versus Q1. However, year-on-year, data storage is still down 42% and semiconductor is down 58%, while scientific research is up 16% and HB-LED/wireless is up 26%. At

the end of June, order backlog was \$161m (the highest in three years).

"Veeco is currently experiencing a challenging overall data storage market, primarily due to customer consolidation and a slower-than-expected recovery in capital spending, as well as a depressed semiconductor environment," says John R. Peeler (who replaced Braun as CEO at the start of July). "While we have an exciting pipeline of new products across all of our markets, many of these are in the early stages of shipments and therefore carry risks associated with customer acceptance and revenue recognition."

For Q3, Veeco expects revenue to fall slightly to \$92-97m, orders of \$100-115m, and a decline in profitability (due to low metrology sales as well as new data storage products selling at introductory pricing). However, an upturn in Q4 should boost second-half 2007 revenue to \$200-220m (up from \$197.9m in the first half), yielding \$400-420m for the year (down 5-10% on 2006).

"We are disappointed that 2007 will likely not be a growth year, but we are pleased that our strong pipeline of new products will set the stage for an improved 2008," says Peeler. "In the coming months, I will be working with senior management to develop new strategies for improving growth and profitability."

www.veeco.com

Forepi expands blue HB-LED capacity

Veeco says that Formosa Epitaxy Corp (Forepi) bought two TurboDisc K300 GaN MOCVD systems during Q2/2007. The Taiwanese firm, which was founded in 1999 and manufactures InGaN LED epi-wafers and chips, is using the systems to increase its production capacity of blue high-brightness LEDs for outdoor display, lighting, keypad and sideview applications.

Forepi claims to be the only Tai-

wanese LED maker offering the full spectrum of high-power InGaN blue, green and near-UV LEDs.

"The K300's new multi-generational platform will give Forepi a long-term cost of ownership advantage, plus the technology to achieve their future LED brightness roadmap objectives," claims Piero Sferlazzo, Veeco's VP & general manager of MOCVD operations.

www.forepi.com.tw

Kyma launches larger native semi-insulating GaN substrates

Kyma Technologies Inc of Raleigh, NC, USA has announced the availability of 25mm x 25mm native semi-insulating (SI) gallium nitride substrates, adding to its existing range of 10mm x 10mm and 18mm x 18mm SI GaN substrates.

Many customers are developing better and more reliable high-frequency high-power GaN transistors, says Dr Edward Preble, chief operating officer. The 25mm x 25mm product has excellent electrical resistivity properties, as corroborated by mapping measurements made by Tim Bogart, a collaboration partner at the Electro-Optics Center (EOC) of Penn State University, Preble claims. "The larger size and availability are the results of yield

improvements in our native SI GaN boule growth and wafering processes," he adds.

"Our customers can now benefit from the increased device yield expected when developing advanced transistors on a larger, albeit square, substrate," says Dr Drew Hanser, chief technology officer.

Preble adds that Kyma has also produced limited quantities of 30mm x 30mm high-quality native SI GaN substrates, and plans to announce their availability in the coming months.

Kyma's extended SI GaN product line has benefited from financial support from the US Air Force and US Missile Defense Agency (MDA) and from collaborative partnerships in SI GaN related materials and

devices including EOC, the US Air Force Research Laboratory (AFRL), the Naval Research Laboratory (NRL), and the Naval Surface Weapons Center (NSWC). The larger square substrates are natural by-products of Kyma's ongoing efforts, supported by the MDA and AFRL, to develop round three-inch and four-inch native SI GaN substrates, Hanser adds.

● Kyma and AFRL will present a joint paper 'Electrical Properties and Deep Centers in Semi-Insulating Fe-Doped Native GaN Substrates Grown by Hydride Vapor Phase Epitaxy' at the 7th International Conference of Nitride Semiconductors (ICNS-7) in Las Vegas, NV, USA on 24 September.

www.kymatech.com

Crystal IS buys MOCVD reactors to develop AlN-based ultraviolet LEDs

Crystal IS of Green Island, NY, USA has installed two MOCVD reactors (now fully operational) as it aims to supplement its aluminium nitride substrate manufacturing business with full-scale manufacturing of ultraviolet LEDs, according to the web publication timesunion.com. UV LEDs have applications from water purification devices in homes to bio-agent detectors in airports, says the firm.

Until now, to develop its UV LEDs, Crystal IS has had to use MOCVD reactors at Rensselaer Polytechnic Institute in Troy, NY (from which the firm was spun off in 1997) and at the University at Albany (which is part of the State University of New York).

"Before this, we were just focused on being a materials manufacturer. This moves us up the value chain," says Tim Bettles, who is vice presi-

dent of business development, sales and marketing. Crystal IS reckons that UV LEDs could help it increase its annual revenues from a few million dollars to many tens of millions of dollars within the next five years.

Bettles adds that UV LEDs developed by others typically use sapphire substrates, rather than 2" low-defect bulk AlN wafers, as made and used by Crystal IS. A UV LED made of AlN has a higher power output and a longer life-span than those made with sapphire, he claims.

The firm aims to provide samples later this year, and to move into production in 2008.

www.crystal-is.com

<http://timesunion.com/AspStories/story.asp?storyID=607903&category=BUSINESS&BCCode=HOME&newstdate=7/21/2007>

TDI celebrates 10th anniversary

Founded in Gaithersburg, MD, USA in 1997, TDI celebrated its 10th anniversary in August. In 2002, the firm moved to Silver Spring, MD, where it now makes 2", 3" and 4" GaN-on-sapphire, AlN-on-sapphire, AlGaIn-on-sapphire, InN/GaN-on-sapphire, and AlN-on-SiC epiwafers using patented HVPE technology.

President & CEO Vladimir Dmitriev says that a key to success has been the development of high-throughput multi-wafer HVPE equipment and related processing expertise, allowing TDI to provide cost-effective high-quality products. Also, TDI has been awarded more than 30 R&D contracts and grants financed by the US Departments of Defense, Energy, and Commerce.

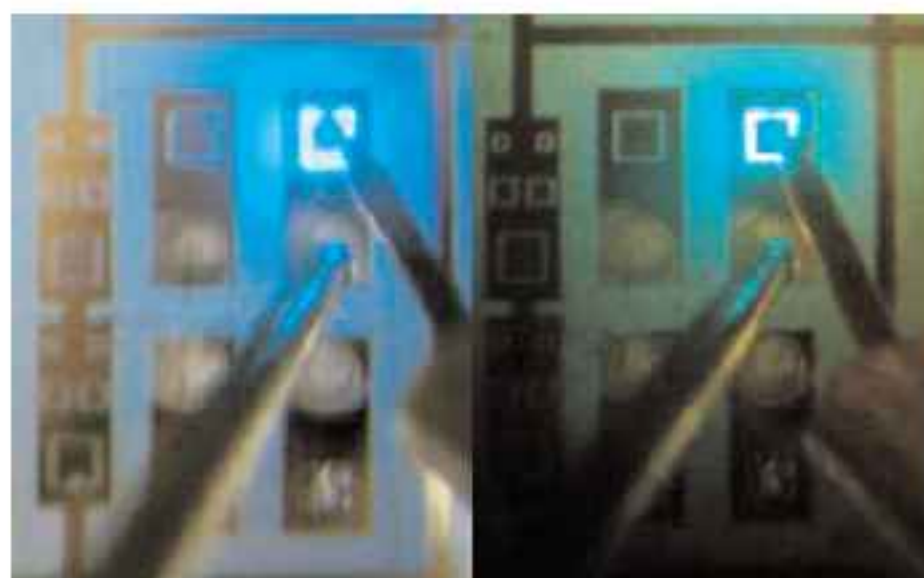
In its fiscal year to end-June 2007, TDI shipped to nearly 100 commercial and academic customers.

www.tdii.com

First HVPE-grown blue & green InGaN LEDs demonstrated

Nitride materials maker Technologies and Devices International Inc (TDI) of Silver Spring, MD, USA says it has fabricated the first epitaxial structures for blue (450–490nm) and green (490–510nm) indium gallium nitride (InGaN)-based LEDs grown entirely by hydride vapor phase epitaxy (HVPE).

"HVPE is known as very cost-effective method to fabricate thick GaN and AlN layers with low defect density. Such materials are typically used as substrates for GaN-based devices," says president and CEO Vladimir Dmitriev. "However, despite fast deposition rates, low defects and strong economics, HVPE has not been considered for the fabrication of device structures with nanometer-thick layers needed to make high efficiency light-emitting devices. Another limitation, he adds, has been the absence of HVPE-grown high-quality InGaN materials used as light-emitting regions of LEDs and LDs (laser diodes). Now, using TDI's HVPE process and equipment, these issues have been



Photos of blue and green LED structures grown by HVPE at TDI.

solved, Dmitriev claims (see below). Demonstrating the devices using HVPE is an important step in the development of low-cost LEDs for solid-state lighting applications, he adds.

"Recently, TDI has completed development of novel HVPE technology to fabricate all major building blocks for light-emitting devices, including epitaxial growth of GaN and InGaN quantum wells and superlattice structures with sharp interfaces, highly efficient n-type and p-type doping for as-grown materials, and InGaN layers for the whole composition range," adds

R&D director Dr Alexander Usikov. "Now, growth rates of AlGaIn, GaN, and InGaIn materials by HVPE can be controlled from very low levels of about 0.5µm/hr needed to make quantum well structures and up to hundred microns per hour to grow thick low-defect layers. There is no other epitaxial method with such a wide range of deposition rates," he claims.

Usikov adds that TDI is working to increase InGaIn content in the LED structures toward the fabrication of yellow and potentially red light-emitting devices.

● The new LEDs, as well as properties of TDI's new InGaIn substrates (see below), are reported at the 4th China International Forum & Exhibition on Solid State Lighting, Shanghai (22–24 August) and the 1st International Conference on White LEDs and Solid State Lighting, Tokyo (26–30 November), and displayed at the 7th International Conference on Nitride Semiconductors, Las Vegas (16–21 September). www.tdii.com

TDI introduces first InGaIn substrate material

TDI has announced the availability of what it says is the world's first InGaIn substrate material.

InGaIn template substrates provide a lattice match for InGaIn-based device epitaxial structures used as the light-emitting regions of GaN-based ultraviolet, blue, green, and white LEDs as well as blue and, potentially, green laser diodes. The match reduces defects in the light-emitting regions, increasing device efficiency and lifetime, says TDI.

"Since the first demonstration of high-quality InGaIn materials grown by HVPE in 2006, we have been receiving continuous requests from our customers regarding these new

products," says president and CEO Vladimir Dmitriev. "We view this effort as one of the key components to enable advanced light emitting devices, particularly for solid state lighting applications."

"No other existing substrates provide such an excellent material match between the substrate and the InGaIn-based light emitting epitaxial structure," adds senior crystal growth specialist Alexander Syrkina. "Composition of the InGaIn can be carefully controlled to produce substrate materials matching customer device structure requests. Crystal lattice and thermal match between the substrate

and the overgrown InGaIn device has been predicted for a long time to reduce defects in the light emitting regions, increase light emitting efficiency and device lifetime."

Fabricated using TDI's proprietary, patented HVPE process, the substrates consist of an InGaIn layer deposited on TDI's existing 2" GaN-on-sapphire wafer products. InN content in the InGaIn layers ranges from 5 to 20 mol.%.

InGaIn substrates are available in limited quantities, but volume production should begin in early 2008.

Product development was supported by the US Department of Energy and Department of Defense.

Osram and LSG co-developing LED fixtures for Raleigh

The Golden Dragon LEDs of Osram Opto Semiconductors GmbH of Regensburg are to be used in low-bay fixtures made by Lighting Science Group Corp (LSG) of Dallas, TX, USA for a lighting project in the City of Raleigh, NC, USA that is expected to be completed by fall 2007.

LSG's Optimized Digital Lighting (ODL) low-bay fixtures, each containing 112 Osram Golden Dragon LEDs, will replace the 12 metal halide lamps that are currently being used to illuminate a pedestrian tunnel running from the Avery C. Upchurch Government Complex to a municipal car-parking garage.

"With Lighting Science's fixtures, we are able to extend the use of Osram's advanced LED technology in its Golden Dragon product into the industrial and commercial lighting markets," says Tom Shottes, president and CEO of Osram Opto Semiconductors Inc.

Raleigh is the first city in the 'LED City' program, which it initiated with LED maker Cree Inc of Durham, NC, USA in February (Toronto joined the program in July). LED lighting projects include garage and parking lot lights, tunnel lighting, streetlights, architectural and accent lighting, portable lighting and pedestrian walkway lighting. LSG has already developed 141 ODL low-bay fixtures incorporating Cree's XLamp LEDs for the Avery C. Upchurch Government Complex's car park (ordered by the City of Raleigh last December).

Previously last year, Osram Opto collaborated on developing LSG's LED-based R-30 and MR-16 lamps (as replacements for the firm's conventional MR-16 metalized reflector halogen lamps).

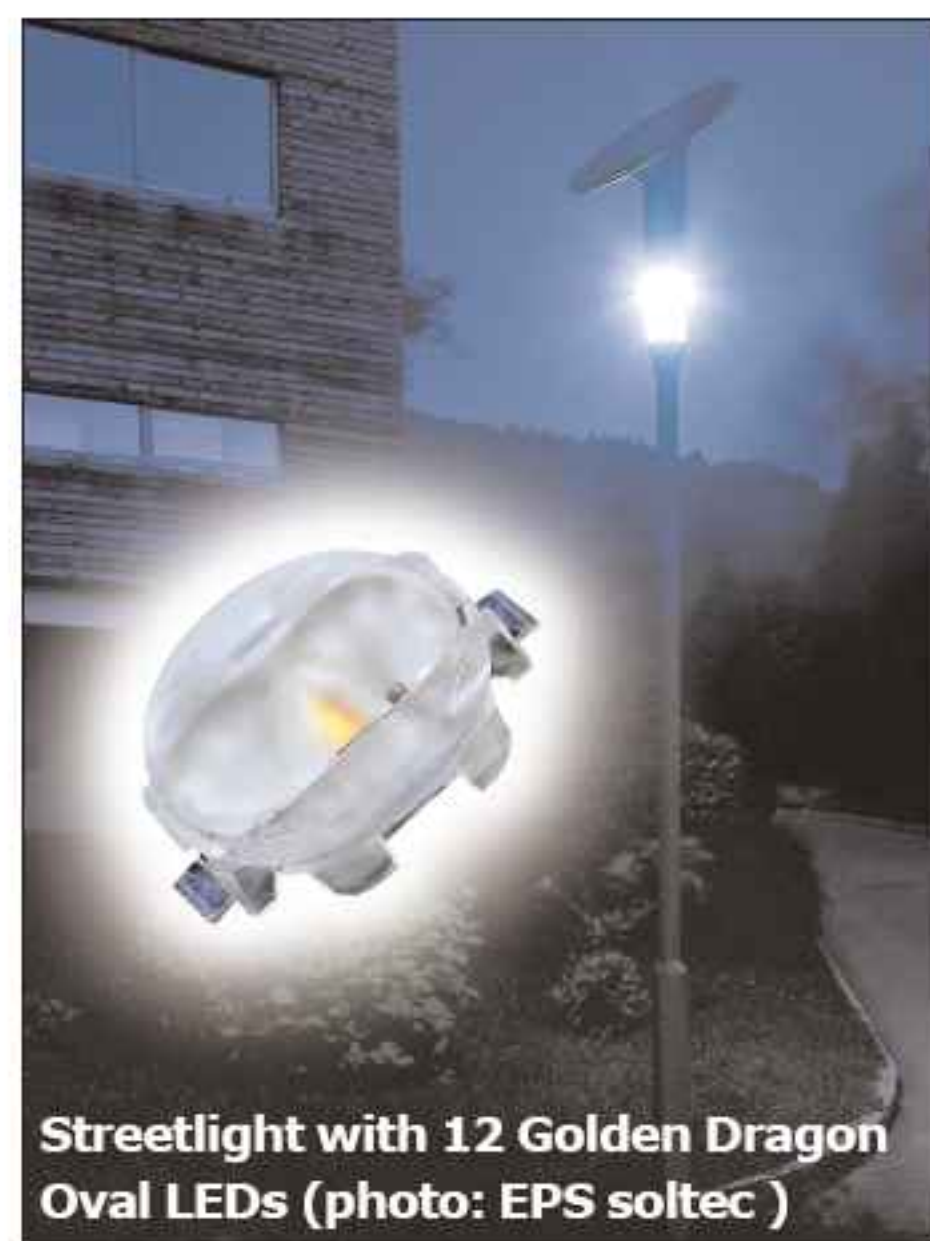
www.lsgc.com

Osram supplying LEDs for streetlights

Osram Opto Semiconductors GmbH of Regensburg, Germany says that its Golden Dragon Oval LEDs have been incorporated into solar-powered streetlights made by EPS Soltec for use in the towns of Diex and Hörbranz in Austria.

For this application, Osram Opto has developed special oval lenses that direct the light down accurately at an angle of $80^\circ \times 120^\circ$ onto the street. So, no light is lost sideways (unlike the normal circular distribution of light from conventional streetlights), cutting light pollution.

In each streetlight, just 12 Golden Dragon Oval LEDs are sufficient to illuminate cycle paths and foot-paths from a height of 3.4m. The LEDs produce 60lm each at 350mA, although for this application they are operated at 130mA and consume 0.35W (compared to 1W in standard applications). Also, they require a voltage of less than 10V rather than a 230V ac power supply, so no inverters are needed for converting the voltage.



Streetlight with 12 Golden Dragon Oval LEDs (photo: EPS soltec)

In addition, the LEDs do not need secondary optics and can be integrated in almost any luminaire design, claims Osram. The lighting can be adapted to ambient light conditions through dimming, and the color temperature can be adapted by combining white and yellow LEDs.

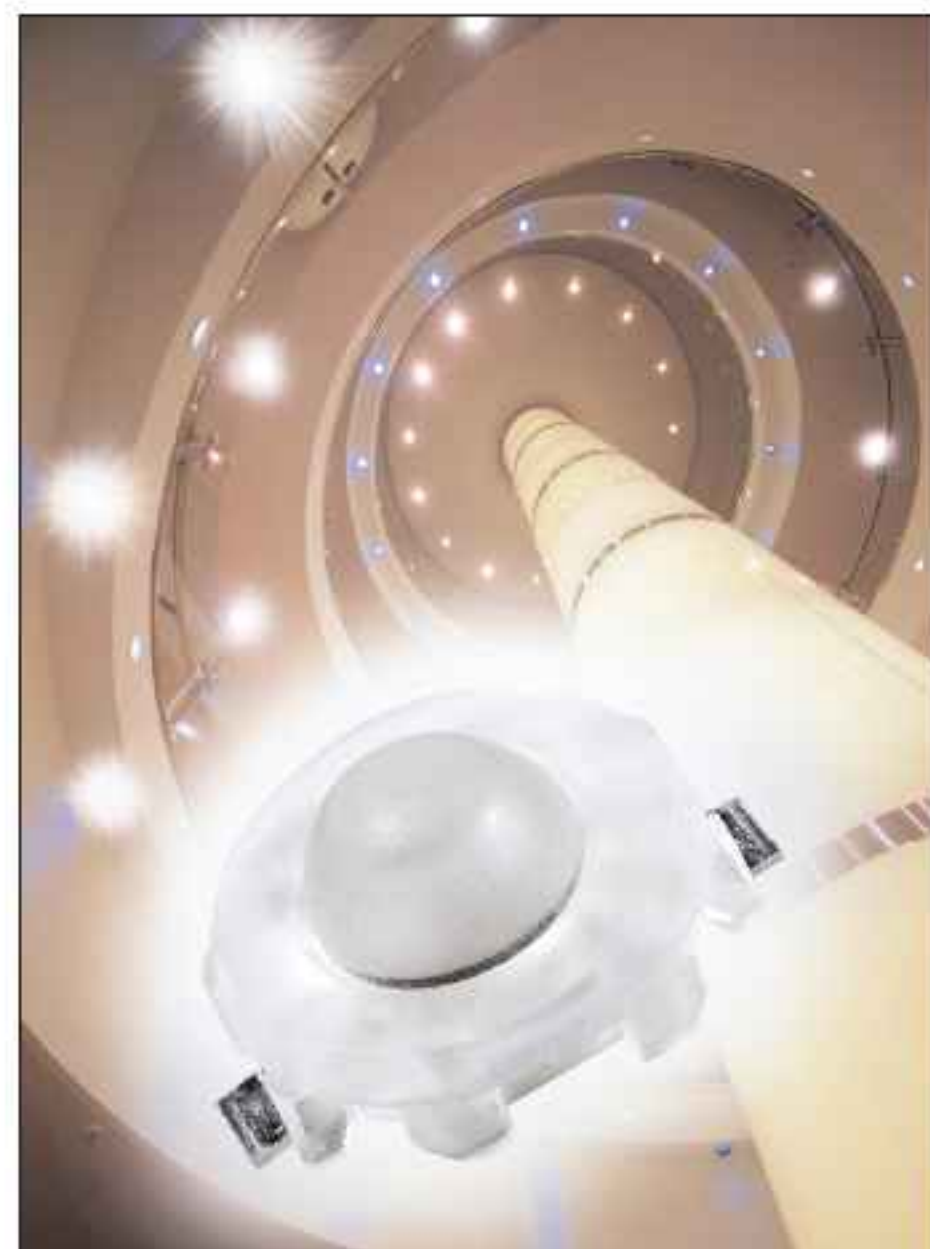
www.osram-os.com

Golden Dragon LEDs unveiled with 20° or 40° lenses for general lighting

Osram Opto Semiconductors has launched new versions of its Golden Dragon LED that have a lens with either a 20° or a 40° beam pattern, giving a strong light source for medium or flood beam characteristics with white or colored light (suited to accent lighting, spotlights, reading lights or desktop lights).

The LED's minimal dimensions (<1cm high, even with integrated lens) make it easier to construct luminaires and hence open up a wider range of design options.

At an operating current of 350mA, typical efficiency is 54lm/W, so power consumption of just 1.12W yields a brightness of 60lm. With a 20° lens, luminance is 155cd and luminance per watt is 139cd/W. With a 40° lens, luminance is 81cd and luminance per watt is 72cd/W.



Golden Dragon LED with $20^\circ/40^\circ$ lens.

www.osram-os.com

BridgeLux raises \$23m in third-round financing to fund expansion of product lines and marketing

BridgeLux Inc of Sunnyvale, CA, USA has completed a \$23m series C funding round led by new investor Chrysalix Energy Venture Capital, and joined by VantagePoint Venture Partners, together with repeat investors DCM (Doll Capital Management), El Dorado Ventures and Harris & Harris Group.

The company was founded in December 2002 with the name eLite Optoelectronics Inc by Dr Heng Liu (who was formerly of North Carolina State University, Emcore, Hewlett Packard, and AXT, but is now CTO of BridgeLux). In April 2006, it raised \$8.5m in series A round funding and changed its name to BridgeLux to reflect its fabless business model (which it claims is unique in the high-brightness LED industry). BridgeLux designs ITO/InGaN-based LED chips for solid-state

lighting, and uses high-volume InGaN LED production capacity in Asia for manufacturing.

The new funding will be used to expand the firm's product lines and marketing, as well as to intensify R&D at the firm's headquarters.

The latest round of financing should also enable an "acceleration of the company into specifically targeted applications that result in true partnerships rather than the more typical commodity-supplier type relationships," says Mark Swoboda, who succeeded Robert Walker as CEO in July. BridgeLux power LED chips have so far been used by LED packagers and integrators as the basis for light sources in backlighting, displays, camera flashes and various niche lighting applications, says the company.

"Chrysalix invests in compelling

technologies and entrepreneurial management teams that are driving fundamental technology changes into the global energy industry," says Chrysalix Energy Venture Capital's managing director Greg Sullivan, who joins BridgeLux's board of directors. "BridgeLux fits right in with that model as a company that can bring any number of key elements into the solution set. We believe BridgeLux's approach is one that will enable solid-state lighting to more quickly reach its full potential for energy savings and sustainability."

"Expect to see BridgeLux demonstrating an accelerated pace of innovation that yields new solutions that truly meet the market at its needs," says Swoboda.

www.bridgelux.com

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Substrate preparation

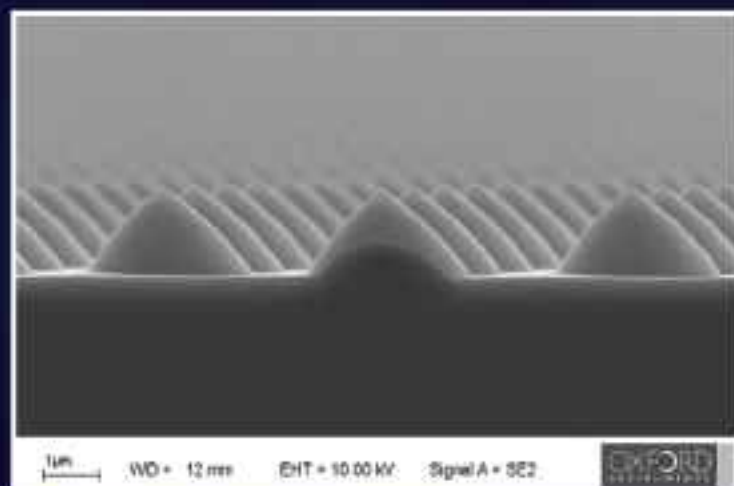
Sapphire, SiC, GaN etching
20 x 2" up to 4 x 4"

GaN, AlGaIn, AlGaInP and related materials etching

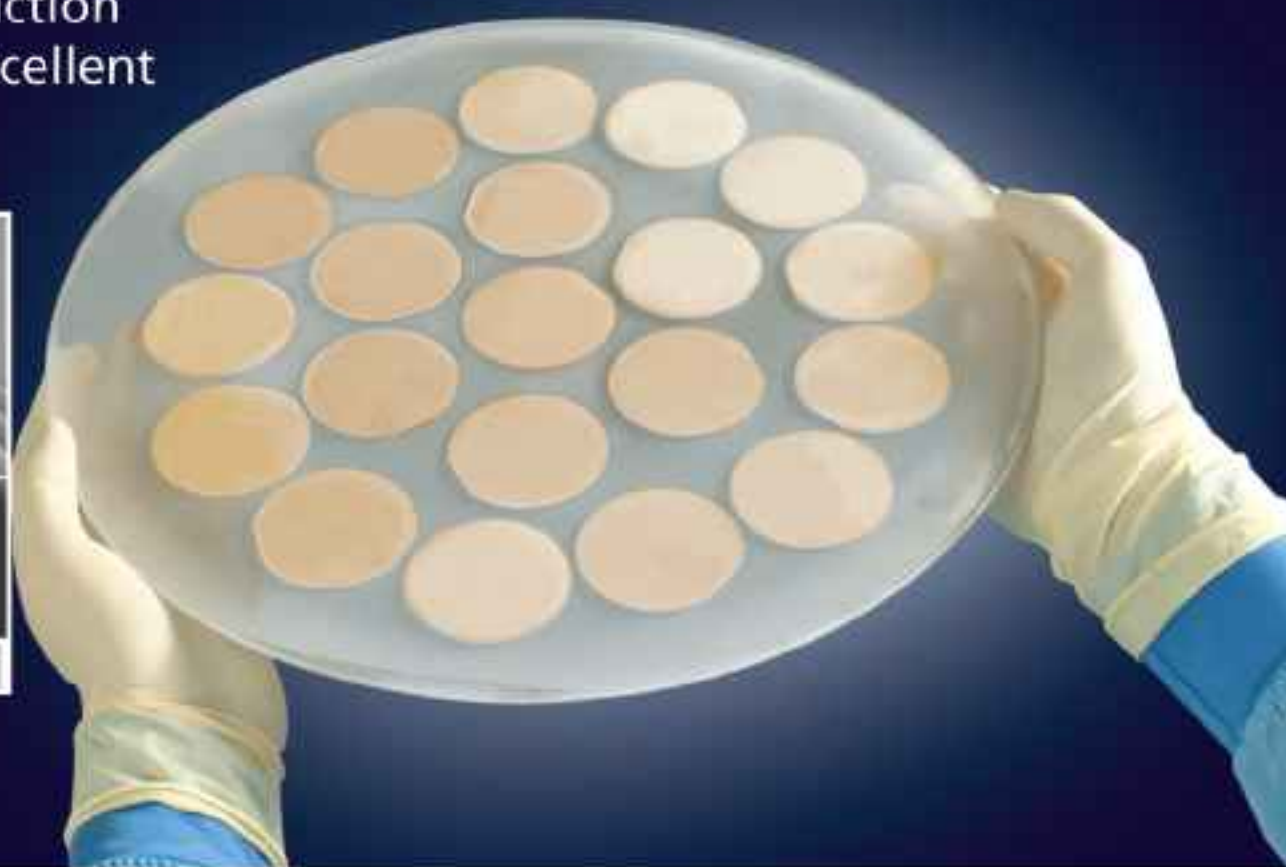
20 x 2" up to 4 x 4" (GaN, AlGaIn)
10 x 2" up to 3 x 4" (AlGaInP)

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IN BRIEF

Nichia settles litigation with UK retailer Argos

Japanese blue and white LED pioneer Nichia Corp has resolved patent infringement proceedings (HC-06C03955) that it launched in the London High Court last November against UK-based retailer Argos Ltd.

According to Nichia, certain white LED Christmas lights marketed by Argos and purchased from third-party Asian manufacturers infringed its European patents (UK) EP 0952 617, EP 0622 858 and EP 0936 682. Nichia was claiming for damages and a permanent injunction from future infringement.

Nichia now says that the issue has been resolved amicably (without any admissions) by Argos and Homebase making a payment to Nichia. The retailers have also agreed to enter into a business arrangement with Nichia.

www.nichia.co.jp

Toshiba doubles white LED brightness

Toshiba has introduced a compact, high-efficiency white LED with double the brightness of its previous-generation devices.

The TLWK1100B LED delivers luminous intensity levels of 1500mcd typically (2000mcd maximum) from a drive current of just 20mA. Maximum power dissipation is 114mW and typical forward voltage (VF) is 3.2V. Operating temperature ranges from -40°C to 100°C.

Available in a standard 3.2mm x 2.9mm x 1.9mm PLCC2 surface-mount package, the robust design suits applications including automotive lighting, LCD backlighting, panel indicators, and the replacement of incandescent bulbs, says the firm.

www.toshiba.com

ITC denies Epistar's motion to stay exclusion order against AlInGaP LEDs

The US International Trade Commission (ITC) has denied Epistar's motion to stay its exclusion order, which came into effect on 12 July, barring importation into the USA of the firm's AlInGaP-based metal-bond (MB), glue-bond (GB) and omnidirectional mirror adhesion (OMA) LED chips (see July/August issue, page 29).

Epistar Corp of Hsinchu, Taiwan filed motions before both the ITC and the US Court of Appeals for the Federal Circuit (CAFC) to stay enforcement after the ITC ruled that the LEDs infringe US Patent no. 5,008,718 belonging to Philips Lumileds Lighting Co of San Jose, CA, USA. On 19 July, the CAFC temporarily stayed the enforcement for up to 30 days.

The ITC has now ruled that "Epis-

tar has not made a showing of likelihood of success on the merits" of its appeal. Lumileds says that the ITC admonished Epistar for relying "on quotes from the ALJ [administrative law judge, who made the initial determination in the investigation on 8 January] that are presented out of order and without context in an attempt to convey a meaning that is in contrast with that actually expressed by the ALJ." Lumileds adds that the ITC also noted Epistar's "tardy arguments made in circumvention of the Commission's rules."

Lumileds reckons that the ruling should clear the way for the CAFC to deny Epistar's other motion to stay the exclusion order, leading to its enforcement.

www.philipslumileds.com

Lumileds delivers 100 millionth Luxeon Flash LED chip

Philips Lumileds Lighting Company of San Jose, CA, USA says it has delivered more than 100 million units of its Luxeon Flash power LEDs to camera phone manufacturers. The functional flash market for camera phones was established less than three years ago when the firm released its first-generation Luxeon Flash, which became one of the most quickly adopted and dominant products in firm's history. Lumileds claims that its Luxeon Flash LEDs are uniquely capable of providing the quality illumination for camera flash applications in 2 megapixel and higher camera phones, as well as for video and flashlight applications that are currently being built into mobile handsets.

"Prior to the introduction of Luxeon Flash, there were no solutions available that provided the illumination necessary to produce quality images in low light

environments, and users were limited to taking daytime pictures," says Richard Weiss, VP Digital Imaging Business. "Only Luxeon Flash power LEDs provide the light output for video and still imaging without sacrificing battery life. Xenon can't provide the sustained light output and requires significantly more space and high-voltage. And, low power LEDs can't deliver the illumination needed for digital imaging."

Technology innovation has allowed Luxeon Flash to more than triple its light output and efficacy in less than three years. Cell phones have rapidly become a primary digital imaging platform, providing still-image and video capability and, as imaging systems improve, more light is required to deliver the resolution and quality that drive increased usage, transmission and customer satisfaction.

www.philipslumileds.com

AOT loses Taiwan patent invalidation action against Seoul Semiconductor

The Taiwan Intellectual Property Office has dismissed a patent invalidation action filed by the country's Advanced Optoelectronic Technology Inc (AOT) of Hsinchu Science-based Industrial Park relating to the white LED patent in Taiwan of rival Seoul Semiconductor Co Ltd (SSC), which is not only the largest LED manufacturer in Korea but also one of the ten largest worldwide.

According to SSC, AOT has been infringing on SSC's patent on a white LED manufacturing method in Korea since 2002. In August 2005 a judge in the Seoul Central District Court ruled that AOT had infringed SSC's white LED patent technology. In November 2006, the

Intellectual Property Tribunal in Korea turned down AOT's claim to invalidate SSC's Korean patent registration.

SSC says that it has also won cases pertaining to its white LED patent against both Itswell and Mediana Electronics in Korea.

SSC says that its white LED patent technology can be applied to high-efficiency LEDs for flash, general lighting, automotive and mobile-handset keypads. The company adds that it has already completed the registration process for its patents in countries including Japan, Taiwan, China and the USA.

www.seoulsemicon.com

www.aot.com.tw

Seoul's new flash LED to replace xenon lamps in digital cameras

Korea's Seoul Semiconductor Co Ltd has launched the FCW211Z series of super-bright and ultra-mini flash LEDs as a replacement for xenon lamps (which are in general use as a flash light source for digital cameras or 5 megapixel camera phones). The new LEDs are being applied to the flashes of a 'global digital camera manufacturer', the firm claims.

The FCW211Z flash LED can operate at a high current of 2A, and emits with a luminous intensity of up to 100 candelas (indicating a brightness more than twice that of conventional LEDs for flash). Furthermore, the light energy (light power times flash exposure time) of 26.49 lux-secs is comparable to that of a high-capacity xenon lamp, the firm claims, and is expected to exceed the level of xenon in the near future.

The flash LED's small size supports the miniaturization of devices, suiting ultra-small products such as mobile phones, digital cameras and video cameras. The width, length and height of 3.5mm

x 3.0mm x 0.75mm, respectively, compare with 10.1mm x 4.6mm x 3.5mm for a xenon lamp for a mobile phone.

Seoul Semiconductor claims that the FCW211Z series enables the display of moving images and continuous shooting without the need for charging, whereas conventional xenon lamps are not available for these functions. Also, the series offers a lifespan more than twice as long as a conventional xenon lamp, the firm adds.

Up to now, the performance of conventional LEDs has not been the best for flash due to poor brightness, despite their availability in moving image, ultra-mini size, and long lifespan, says Byung Hack Lee, head of the firm's chip and module business division. However, the FCW211Z series now enables both the advantages of LEDs and superior image quality with brightness that is comparable to a xenon lamp, Seoul Semiconductor claims.

www.acriche.com

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UK support for NoveLELS solid-state lighting project

The UK Government's Department for Business, Enterprise and Regulatory Reform (formerly part of Department of Trade and Industry) is granting £3.3m (including £1.7m from the UK Government and Technology Strategy Board) for the research project NoveLELS (Novel LEDs for Efficient Lighting Solutions).

NoveLELS started in March and focuses on developing and commercializing high-efficiency, high-brightness GaN LED-based solid-state light sources (to be trialled for use in aircraft cockpits and exterior lighting and consumer LCD devices).

The project was started through the formation of a vertically integrated consortium of nine partners consisting of:

- three large aerospace firms: Airbus UK Ltd (which makes external lighting systems as well as wings), Anglo-Italian helicopter maker AgustaWestland (a Finmeccanica company), and GE Aviation's UK-based Systems division (formerly Smiths Aerospace), which makes flight display products;
- two universities (the University of Bath and Brunel University, which are leading the project's research on novel LED chips and phosphor technology); and

- four small-to-medium enterprises (SMEs: epiwafer foundry IQE plc of Cardiff, Wales, Exxelis Ltd of Glasgow, Scotland, and University of Southampton spin-off Mesophotonics Ltd, as well as Enfis Ltd of Swansea, Wales, which floated on the London Stock Exchange's Alternative Investment Market in March, as project leader).

A major project goal is to stimulate the commercialization of GaN epitaxy and LED chip manufacturing in conjunction with advanced phosphors and thermally efficient packaging to create novel LED arrays and light engines for solid-state lighting applications. The use of photonic crystal technology pioneered by Mesophotonics along with epitaxial processes pioneered at University of Bath (by the GaN Technology Group of professor W.N. Wang) and phosphor technology developed at Brunel University will result in high luminous efficacy and tailored spatial profile aims to provide key benefits in terms of energy efficiency and optical coupling efficiency.

A significant spin-off will be the trial of a new method of GaN-based LED chip production that is expected to dramatically reduce the cost per lumen of solid-state light

sources by allowing scale-up to larger epiwafer sizes without significant loss of yield via Bath's new GaN epitaxial processes.

End-users in the aerospace and LCD backlighting markets will evaluate use of the LED technology within their applications. Adoption of the technology by the partners into these markets will be a measurable output of the project. Also, the expected improvement in light quality and energy efficiency should allow the LED arrays and light engines to be used in other markets such as architectural, commercial office, entertainment and retail lighting, as well as eventually being used in the home.

"By supporting this large collaborative project, the UK Government is stimulating both essential research and IP generation which will promote the UK to the forefront of leading research on a global level, along with enabling a commercialization route for epitaxy, chip fabrication and LED array manufacture within the UK," says NoveLELS' project manager Dr Gareth Jones, chief technology officer of Enfis Ltd's parent company Enfis Group plc.

www.enfis.com

Group IV wins funding for Si-based solid-state lighting

Group IV Semiconductor Inc of Ottawa, Canada has received 'substantial' new investment in a funding round led by Montreal-based Garage Technology Ventures Canada together with Applied Ventures LLC (a subsidiary of process equipment maker Applied Materials Inc of Santa Clara, CA, USA), plus existing investors Khosla Ventures of Menlo Park, CA, USA and Canada-based BDC Venture Capital. The funding will further expand Group IV's program to develop its silicon-based nanofilm light-emitting technology, which use a single-chip, AC-powered process intended to cut the cost of solid-state lighting.

"Group IV fits our model of identifying true innovation that has the clear potential to materially impact or redefine existing or emerging markets," says Tom Sweeney, managing director and general partner of Garage Technology Ventures Canada.

"Our vision is to create silicon-based light engines — many times more efficient than conventional bulbs and much more economical than today's LED alternatives," says CEO Stephen Naor.

Group IV will also collaborate with Applied Materials to develop a low-cost manufacturing process that should enable it to accelerate its technology towards product com-

mercialization and production. Production cost is considered to be the last remaining hurdle for mass adoption of solid-state lighting, so Group IV projects that its materials system will provide an advantage in creating high-efficiency, long-life lighting products that outperform incandescent, compact fluorescent and fluorescent lighting.

"Group IV has significant technology that complements Applied Materials' work in developing cost-effective nanomanufacturing technology solutions," says J. Christopher Moran, VP and general manager of Applied Ventures.

www.groupivsemi.com

Cotco expansion to triple Cree's white XLamp LED capacity

Cree Inc of Durham, NC, USA has unveiled plans to significantly increase white XLamp LED manufacturing capacity at the plant in HuiZhou, Guangdong, China of its Hong Kong-based subsidiary COTCO, tripling Cree's existing capacity for packaging lighting-class LEDs.

Speaking at the 4th China International Forum & Exhibition on Solid State Lighting in Shanghai, Chris James, vice president of marketing & business development, characterized the planned expansion as part of Cree's multifaceted efforts both to accelerate the adoption of LED lighting in China and to build momentum for the LED lighting revolution worldwide.

"China is a critical growth market for LEDs in general illumination applications and represents an unmatched opportunity due to the early-stage development [in China] of a national lighting infrastructure, explosive economic growth, the need for energy-efficient technologies and a growing concern over air and ground pollution," said James. "The acquisition of COTCO Luminant Device Ltd [for \$204m, completed last quarter] was the first step and gave Cree significant local manufacturing and sales capability in China," he added. "This expansion of white LED capacity is the next step, and we continue to develop plans to extend our capabilities and drive the LED lighting market."

● COTCO International Ltd, a subsidiary of COTCO Luminant Device Ltd, has been honored by Hong Kong and Shanghai Banking Corp with the HSBC Living Business Award Certificate of Excellence in recognition of its contributions to the environment and to the local community.

"COTCO is committed to environmental protection, community service and overall management quality and effectiveness," says Scott Schwab, managing director of Cree Asia Pacific.

● COTCO and its strategic partners have won their bid to provide the landscape lighting at the Water Cube, the National Aquatics Center (and competition venue for the 2008 Olympic games), for which Cree's XLamp LEDs will be adopted.

Cree's annual revenue down 7%, but recovery gains pace

For its fiscal 2007 (ended 24 June), Cree Inc of Durham, NC, USA, which manufactures LEDs as well as SiC substrates and SiC- and GaN-based RF components, reported revenue of \$394.1m, down 7% on fiscal 2006's \$423.0m. Net income was \$57.3m, down from \$76.7m.

"Fiscal 2007 was a challenging but successful year for Cree as we made great strides in our transformation from an LED chip and SiC materials technology company into a components company positioned to lead the LED lighting revolution," says chairman and CEO Chuck Swoboda.

However, in Q4/2007 revenue was \$111.2m, up 23% on Q3 and 4% on \$106.7m a year ago. In particular, LED revenue was \$92m, up 8% on \$85.1m a year ago and up 37% on Q3's \$67m (recovering strongly after sequential changes in revenue of -3% then -21% then 3% in the last three quarters).

Materials revenue (SiC substrates) was \$8.8m (down for a second consecutive quarter: by 12% sequentially on Q3, which was itself down 6% on Q2). High-power product revenue (SiC- and GaN-based RF components) was \$2.6m (down 49% on Q3, which was also down 6% on Q2).

Net income was \$6.4m (down on the \$13.2m a year ago), including an expense of \$1.0m (partly related to the \$204m acquisition of China-based COTCO, a supplier of high-brightness packaged LEDs,

Growing XLamp LED sales, our new high-brightness packaged LED product line and a more stable LED chip business has put Cree in a strong position for growth in fiscal 2008

which was completed during the quarter). Gross margin was 29%.

"In the fourth quarter, we again delivered financial results that were in line with our previously announced targets, and the COTCO integration is off to a good start," says Swoboda.

During Q4, Cree announced the commercial availability of XLamp LEDs with a minimum luminous flux of 100lm at 350mA (up almost 70% over the last year) — the first LEDs to be available in volume with this level of performance, it is claimed.

"We believe the combination of growing XLamp LED sales, our new high-brightness packaged LED product line and a more stable LED chip business has put Cree in a strong position for growth in fiscal 2008."

For Q1/2008, Cree expects revenue of \$110-115m.

www.cree.com

Advanced Photonix's telecom, medical and industrial revenue growth offsets military order delays

For its fiscal Q1/2008 (to end-June), Advanced Photonix Inc of Ann Arbor, MI, USA reported sales of \$6.1m, flat on last quarter's \$6.2m but up 8% on \$5.7m a year ago.

Products of the vertically integrated optoelectronics manufacturer include patented silicon-, InP- and GaAs-based APD, PIN, and FILTRODE photodetectors; high-speed optical receivers (HSORs); and the T-Ray 2000 and QA1000 THz terahertz instrumentation platforms.

Year-on-year, telecom revenues grew 69% to \$1.3m, driven by high-performance 10 and 40Gb/s markets. Medical revenue grew 74% to \$1.1m. The firm expects this market to stay strong for the rest of the year, leading to significant year-on-year growth. Industrial Sensing/NDT (non-destructive testing) revenues grew 21% to \$2.9m. Military/aerospace revenue fell 53% to \$0.87m, mainly due to delays in military orders. The firm expects military sales to be flat to slightly down year-on-year. Homeland Security revenues were down by \$11,000, and are expected to remain uneven quarter to quarter, but increase for fiscal 2008.

Due mainly to the product mix of lower military sales and higher industrial sensing sales, gross margin has fallen from 43.5% to 40.2%. Meanwhile, operating expenses grew to \$3.5m, due mainly to a rise of \$310,000 in non-recurring expenses from consolidating wafer fabrication into one facility. Net loss has risen from \$1.2m to \$1.9m.

The firm anticipates continuing to expand its sales and marketing for the growing telecom market, and for business development of the terahertz product platform targeted at the industrial/NDT and homeland security markets.

Advanced Photonix's HSOR product platform continues to show strong year-on-year growth, which would have been higher without delays in production releases on new design wins at several customers, says chairman and CEO Richard Kurtz. "Our Optosolutions product platform provided strong revenue from the medical and industrial markets that helped to offset the decline in our military revenues," he adds. "With the release of our new T-Ray 4000 product, we have been

actively engaged in various markets and application development work... We believe this continuing application development will begin to pay off in fiscal 2008."

Advanced Photonix maintains its previous guidance of 15-25% revenue growth for fiscal 2008.

● Advanced Photonix has announced a new design win to supply 10Gb/s HSORs to a 'leading telecom system OEM'. The initial purchase commitment is for \$700,000, for volume shipments in the coming months.

The PT-15SFA industry-standard small-form-factor (SFF) 17-pin packaged PIN receiver is targeted at applications that require greater bandwidth in order to provide the overhead for forward error correction (FEC) algorithms necessary for long-distance transmission. The firm's 10Gb/s high-speed optical receivers are packaged in industry-standard and custom packages and are available in either PIN or avalanche photodiode configuration.

"We look forward to a long and mutually beneficial partnership with this OEM," says Kurtz.

www.advancedphotonix.com

QPC's revenues triple, driven by medical and defense

For Q2/2007, QPC Lasers Inc of the Los Angeles suburb of Sylmar, CA, USA, a vertically integrated manufacturer of high-power semiconductor lasers for industrial, defense, and medical markets, has reported total revenue of \$1.8m (up 216% on \$577,000 a year ago, due to increases in both product and government revenue). Product revenue was \$850,000 (up 30% on \$653,000 in Q1 and 274% on \$227,000 a year ago).

"The company [which was founded in 2000] continued to make progress in transitioning to a manufacturing and production mode focused on growing our product sales," says Dr Jeffrey Ungar, chairman and CEO.

"We were particularly encouraged by orders [numbering more than 10] that we continue to receive for our medical lasers. To better capitalize on this growth market, we strengthened our management team with the hiring of industry veteran Dr Tom Steele [as director of market development], who will spearhead our efforts to grow our footprint in the medical industry." Also, military and defense business picked up during the quarter, including \$1m in contracts from the US Navy for QPC's generation III technology for directed energy weapons applications. "We look to make continued progress throughout the remainder of the fiscal year," Ungar adds.

Total operating expenses have been cut from \$3.6m a year ago to \$2.5m and gross margin has risen from 14% to 47%. Net loss has been cut from \$4.4m a year ago to \$1.3m, due mainly to the growth in product revenues.

Cash reserves have strengthened from \$1.4m at the end of December to \$10.7m at the end of June.

During Q2/2007, QPC also closed a \$16.9m financing round, which will enhance QPC's ability to launch its generation III product line, says Ungar. QPC is targeting full-year 2007 revenue of \$6-7.5m (up from \$3.1m for 2006).

www.qpclasers.com

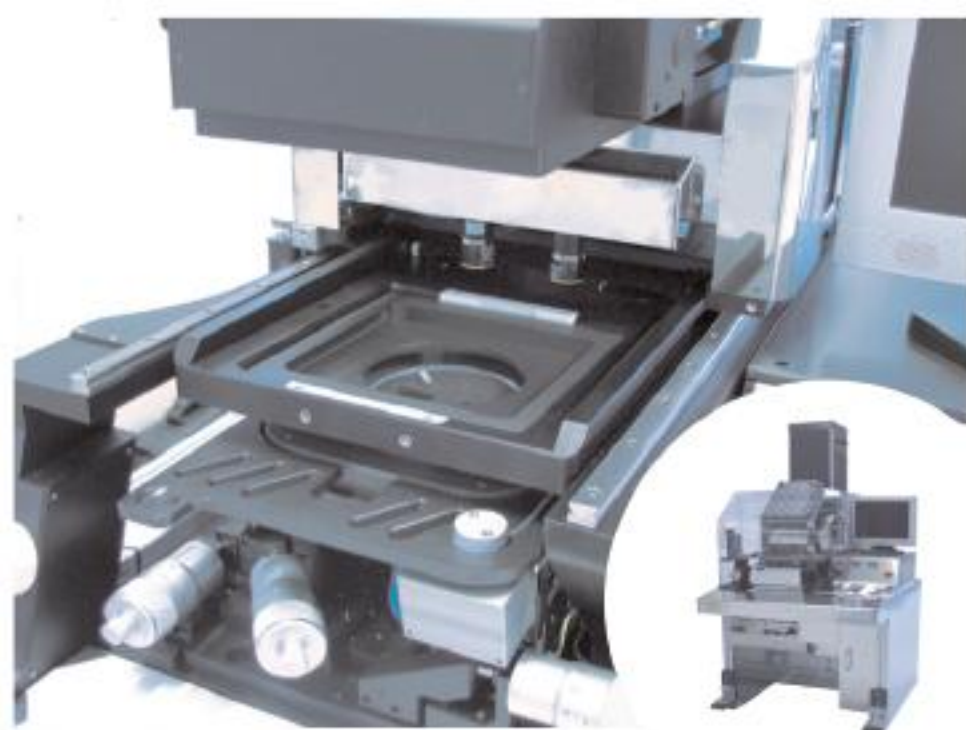
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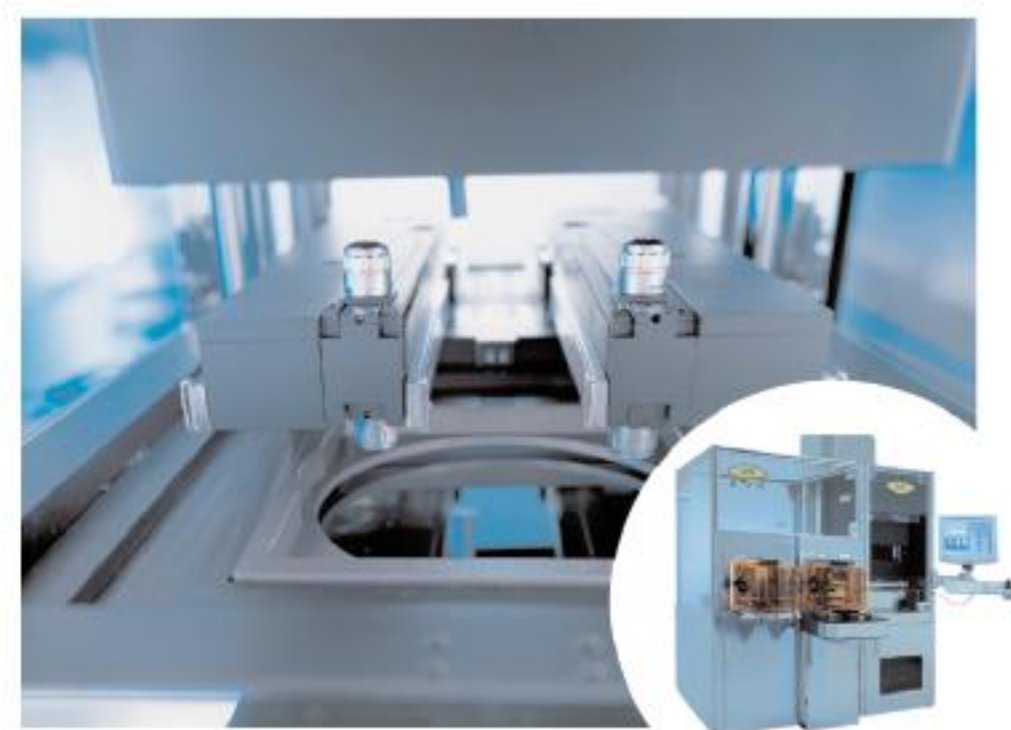
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Intense wins European Space Agency PULSAR contract to develop 1.2kW 808nm high-power laser diode arrays

Intense Ltd of Glasgow, UK has announced a new R&D contract called PULSAR (PUmp Laser Stacks with Aerospace Reliability) with the European Space Agency, which is based in Noordwijk, The Netherlands, for the development of reliable, high-efficiency, high-power laser diode arrays for solid-state laser pumping applications in space.

The focus of the program, which will run for two and a half years, is to improve both the reliability and efficiency of laser diode stacks emitting at a wavelength of 808nm. The arrays will target a power of 1.2kW under pulsed operation with an electro-optical conversion efficiency of 65% (unachievable at 808nm with existing technology).

The increased efficiency should enable considerable power savings aboard space vehicles and reduce heat removal requirements, says Intense, because a smaller fraction of the input energy will be converted into heat. The pumping efficiency can be increased further if

the array's emission spectrum is narrowed and stabilized using volume Bragg gratings. Their integration with the laser diode arrays will be assessed in cooperation with a US manufacturer, adds Intense.

The high-efficiency laser arrays will be manufactured to a demanding lifetime specification of 12 billion shots in a space environment. Intense's patented quantum well intermixing (QWI) technology, which allows passive waveguides to be created near the laser diode's mirrors, should ensure that the device is more robust against radiation damage.

"QWI technology is particularly suited to space-borne applications, as it produces laser diodes with increased radiation hardness," says professor John Marsh, chief technology officer. "We are optimistic we can achieve these ambitious targets, based on the success of the DARPA-funded SHEDS initiative in the USA, where laser efficiency was improved by over 20% at

longer wavelengths," he adds. "Once developed, the PULSAR opportunity will enable further advances in Intense's capabilities at 808nm, benefiting the entire HERMES high-power laser products family."

"The European Space Research and Technology Centre (ESTEC), a division of the European Space Agency, is anxious to improve the efficiency and reliability of laser array pumps in future satellite missions," says Dr Michael Jost, ESTEC's Technical Officer in charge of the contract. "There is a steady increase in the number of payloads incorporating powerful laser sources for applications such as atmospheric sensing, altimetry or optical communication — to name just a few," he adds. "Enhancing the reliability and efficiency of pump laser diodes will enable a reduction in the implementation of redundancy and allow for an extended operational lifetime of the payload."

www.intenseco.com

Intense launches high-power, single-mode 830nm diode lasers for defense, medical, print and imaging

Intense has launched the HPD6020 single-emitter laser diode, a member of its HPD Series 6000 high-power, single-mode laser diode product family that emits at a wavelength of 830nm±5nm with high beam quality and up to 200mW of output power.

"The HPD6020 is the first in a series of new, high-power products resulting from the recent merger [in February] of Intense Ltd and High Power Devices (now Intense-HPD)," says CEO Scott Christie. "Combining the strengths of Intense's patented QWI technology and Intense-HPD's lean, high-volume manufacturing processes enables us to deliver innovative laser products with unrivalled levels of power, brightness, and reliability."

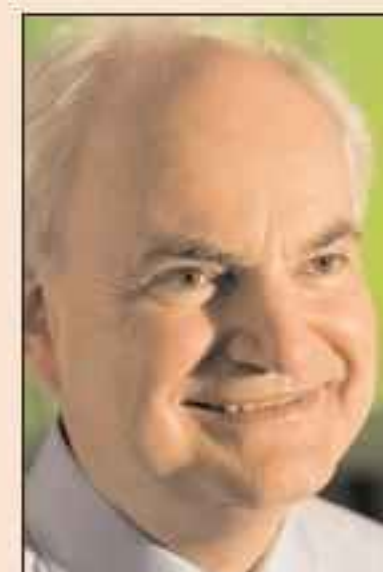
The HPD6020 provides the greater power, efficiency and optical quality needed for demanding new defense, medical, and print & imaging applications (including targeting, sighting, medical imaging and computer-to-plate), the firm claims.

The lasers are available in standard packages including 5.6mm, 9mm and C-mount. Monitor photodiodes are optionally available on the 5.6mm and 9mm packages.

Custom wavelengths are available for OEM applications.

CTO John Marsh elected Fellow of RAE

Professor John Marsh, chief technology officer and board member of Intense Ltd of Glasgow, UK (which provides single- and multimode monolithic laser array products and high-power laser diodes) has been elected a Fellow of the UK Royal Academy of Engineering in honor of his advancement of engineering.

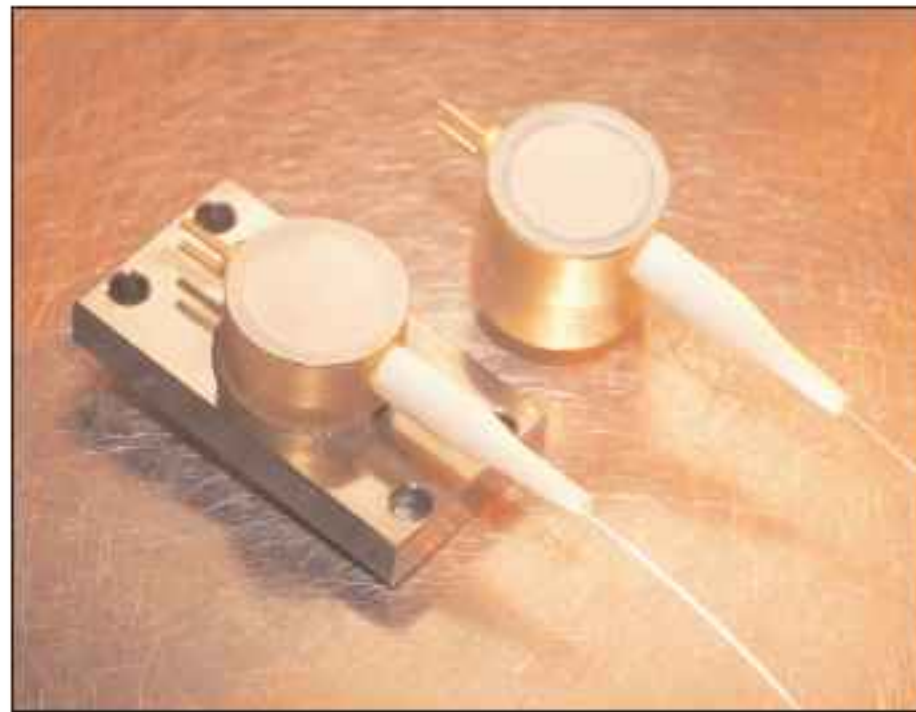


"Our new Fellows demonstrate the importance of engineering in the modern world," says the Royal Academy's president, Lord Browne of Madingley.

JDSU doubles power of its 808nm fiber-coupled lasers for non-telecom industrial, dental & medical applications

JDSU of Milpitas, CA, USA has launched its 2495-L3 Series 808nm fiber-coupled diode laser for industrial, dental and medical applications. New chip technology generates 4W in power output (double that of the firm's previous 808nm offerings), providing the highest brightness among single-emitter 808nm fiber-coupled diode lasers on the market, it is claimed.

"As the diode laser industry has matured, JDSU has leveraged its expertise in the telecom space and applied it to the industrial sector, bringing higher performance and lower cost diode laser solutions to the market," says Alex Schoenfelder, VP and general manager of the firm's Integrated Photonics business unit. "The 2495-L3 Series not only provides a more elegant offering for high-precision laser applications, it also opens the door for JDSU to participate in new markets."



JDSU's new 2495-L3 Series 808nm fiber-coupled diode laser.

For industrial applications, the 2495-L3 can optically pump Nd-doped material to generate a 1064nm beam that can be either used directly or converted to green and UV laser light through harmonic conversion (for material processing applications such as scribing or cutting semiconductor materials). The 2495-L3 provides a brighter, more reliable optical pumping alternative to conven-

tional multi-emitter (bar) diode lasers, the firm claims. In a typical configuration, several devices with 4W fiber output can be bundled together to provide power equal to a conventional bar, providing much higher power per single fiber. The distributed architecture also prevents a single point of failure compared to bar solutions.

There is also growing demand for 808nm diode lasers in the dental and medical fields (Japan has certified this wavelength as the approved frequency for specific procedures).

For soft-tissue dental processes, the 2495-L3 can allow more accurate treatment of diseased gum tissue without disturbing surrounding healthy tissue. In the therapeutic medical area of bio-stimulation, the device can provide localized heat to stimulate damaged muscle tissue to relieve pain and discomfort.

www.jdsu.com

JDSU grows 16% year-on-year, despite transitions at optical communications customers hitting last quarter

For its fiscal 2007 (to end June), fiber-optic module and laser maker JDSU of Milpitas, CA, USA has reported revenue of \$1.4bn, up 16% on fiscal 2006's \$1.2bn, with growth in each operating business segment: 9% in optical communications; 25% in communications test and measurement; 4% in advanced optical technologies; and 19% in commercial lasers etc.

Net loss was cut from \$151.2m to just \$26.3m. Adjusted EBITDA (earnings before interest, taxes, depreciation and amortization) grew from \$17.2m to \$72.9m.

However, for its fiscal fourth-quarter, revenue of \$350.7m fell 3% from \$361.7m the previous quarter (despite being up 10% on \$318.2m a year ago).

Of total revenues:

- 32% came from Optical Communications, down 12% to \$112.7m (despite including VCSEL maker Picolight Inc of Louisville, CO, USA, acquired at the end of May — the lower demand was due to customer initiatives including product platform transitions, changes in supply chain, lean manufacturing, and demand pauses due to consolidation activity);
- 49% came from Communications Test & Measurement (up 5% to \$171.3m, including the firm Innocor, acquired during the quarter);
- 13% came from Advanced Optical Technologies (\$44.7m, down slightly from \$45.6m); and
- 6% came from Commercial Lasers (\$22.1m, down 10%).

Nevertheless, on a non-GAAP basis net income grew from \$12.3m the prior quarter to \$15m in fiscal Q4.

"For the first time in more than five years, JDSU was non-GAAP EPS [earnings per share] positive for all four quarters of the year," says CEO Kevin Kennedy.

"Moving into 2008, we will continue to focus on execution across the company, gross margins, and advancing our business model." In particular, JDSU is particularly optimistic about growth prospects for VCSEL from Picolight, as well as long-term growth for commercial lasers, enabling JDSU to diversify its laser technology from its traditional core application of telecoms.

So, despite fiscal Q4/2007's dip in optical communications sales, for fiscal Q1/2008 (to end September) JDSU expects overall revenue to hold steady at \$345–360m.

End of inventory reductions drives Bookham rebound

For its fiscal Q4/2007 (to end June), Bookham Inc of San Jose, CA, USA, which designs and manufactures InP-based optical components, modules and subsystems for telecoms, datacoms, aerospace, industrial and military markets, has reported revenue of \$45.1m (with Nortel and Huawei each comprising more than 10%). This is up slightly on \$45.0m the prior quarter but down 18% on \$55m a year ago.

Nevertheless, revenue has grown in several legacy products (particularly fixed-wavelength 10Gb/s transmitters and receivers) as well as tunable laser products (up 60% on the prior quarter, and continuing to increase).

For full-year fiscal 2007, revenue was \$202.8m, down 12% on fiscal 2006's \$231.6m. However, net loss has been cut from \$87.5m in fiscal 2006 to \$82.2m.

"We made progress in lowering our overall cost structure [including

restructuring and staff cuts at the InP wafer fab in Caswell, UK], and as a result we have shown improvement in both our gross margin and adjusted EBITDA

[earnings before interest, taxes, depreciation and amortization]," says chairman and interim president & CEO Peter Bordui.

For fiscal Q4/2007, gross margin has risen from 10% last quarter to 16%. Net loss has been cut from \$24.3m to \$13.6m. Adjusted EBITDA has improved from minus \$13.4m a year ago and minus \$14.1m last quarter to just minus \$6.0m.

We are moving beyond the inventory reduction programs at several of our key customers that hurt our revenue in the first half of this calendar year

"We are moving beyond the inventory reduction programs at several of our key customers that hurt our revenue in the first half of this calendar year," says Bordui.

"In product development, we made progress in getting our small-form-factor tunable transponder and 980nm submarine pump laser ready for market. We expect both products will positively impact revenue in the second half of the calendar year," Bordui adds. "Through sales of both new and legacy products, we're currently expecting increased revenue from our three largest customers along with continued penetration into several other tier-one accounts."

For fiscal Q1/2008, Bookham expects revenue to rebound to \$50–54m. The firm also expects improvements in gross margin to 18–22% and in adjusted EBITDA to minus \$3–7m.

www.bookham.com

Infinera's growth drives move into underlying profit

For Q2/2007 (its first quarter as a publicly listed company), Infinera Corp of Sunnyvale, CA, USA, which provides InP-based photonic integrated circuits and digital optical communications systems, has reported revenues of \$58.4m, up 19% from \$49.2m in Q1 (which itself showed growth of 12% from Q4/2006). Infinera's revenues have previously grown from just \$0.6m in 2004 and \$4.1m in 2005 to \$58.7m in 2006.

Compared to Q1/2007, net loss has risen from \$19.8m to \$26.1m. However, exclusion of non-cash stock-based compensation and warrant revaluation expenses reveals an underlying improvement from a loss of \$5.4m in Q1 to a net income of \$2.7m.

The second quarter reflected "continued success in establishing ourselves as a leading systems company in the optical networking industry," claims Infinera's CEO Jagdeep Singh. "As service providers build out their networks to accommodate growing internet traffic, they continue to embrace Infinera's highly differentiated and highly flexible digital optical network architecture as a compelling solution for long-haul and metro optical networks," he adds. During Q2, Infinera added five new customers, bringing the total to 31, and introduced the 40G Tributary Adapter Module (which, it claims, is the industry's most flexible and economical means of deploying 40G services in optical networks).

● Cox Communications (the third-largest cable company in the USA) has selected an Infinera digital optical network for its national transport network, which extends 12,000 miles from coast-to-coast to provide services including voice, video, data, and wireless to residential and business customers.

Earlier, in Q2/2007, Infinera won two new customers: San Francisco-based 'business-grade' IP service provider Telekenex and The State of New Mexico's General Services Department, Communications Division.

Analysts project that, if the high revenue growth rate continues, then Infinera should become profitable in about 2009.

www.infinera.com

Arasor acquires Alfalight and AOFR to bring critical laser and coupler components in-house

Integrated optical chip maker Arasor International Ltd of Mountain View, CA, USA is acquiring Alfalight Inc of Madison, WI, USA, which designs and manufactures high-power diode lasers, and AOFR Pty Ltd of Canberra, Australia (a subsidiary of fiber manufacturer Verrillon Inc of North Grafton, MA, USA), which designs fused fiber components such as optical couplers (manufactured and packaged in Asia). The collective purchase price is US\$63m.

Arasor was founded in 2000 and manufactures integrated optoelectronic chips, with operations in Guangzhou, Beijing and Shanghai in China, Sydney in Australia, Bangalore in India, and Yokohama in Japan. The firm is aiming to establish itself as a solutions company serving system makers in optical network transport, wireless communications ('radio over fiber' wireless access systems) and emerging consumer optoelectronics applications (such as laser-based TV displays).

"With these acquisitions, Arasor has brought the critical laser element in-house, enabling improved profitability and control of future laser developments in Arasor's emerging markets," says chairman and CEO Dr Simon Cao. "We now control the three key elements common to all our products (optical chip, laser chip and coupler elements), and bring significant revenue opportunities to bear in addition to their existing US\$20m per annum revenue streams [customers include Telstra, Avanex and Siemens]," he adds. Cao highlights the prospect of expanding Arasor's product portfolio to include laser components for the telecom market.

Originally founded in 1998, Alfalight has received over USD\$57m of venture funding, and substantial US government funding for R&D. Assets include an InGaAs laser chip fabrication plant. Alfalight's Alu-

minum-Free Active region (ALFA) high-power diode lasers include integrated narrow-spectrum wavelength-stabilization technology (WST). Product lines include chip-on-carrier, Telcordia-qualified fiber-coupled single emitters, and integrated pump modules.

"The management team of Alfalight includes seasoned industry veterans from Motorola and Intel who bring semiconductor manufacturing management experience to our team," says Cao. Alfalight's CEO Mohan Warrior, continues to run the firm in Madison as a subsidiary of

Arasor US Corp (after the transaction closes on or about 1 November). Prior to leading Alfalight over the last four years, he held senior positions at Motorola Semiconductors (now Freescale). Warrior says that acquisition by Arasor brings growth prospects, particularly in the emerging Asian markets of China and India (where telecoms infrastructure is increasingly moving directly from copper to wireless). "Arasor's

unique optical chip technology will dramatically enhance our proprietary laser capabilities to create a diverse range of differentiated telecom & consumer optical products," he adds.

Arasor has brought the critical laser element in-house, enabling improved profitability and control of future laser developments in Arasor's emerging markets

We now control the three key elements common to all our products (optical chip, laser chip and coupler elements)

"This deal expands our customer base & product offering as we leverage our products into Alfalight's existing sales channels in the US, and their products through our current customers & channels in China & India," says Cao.

AOFR was established in 1984 to manufacture optical couplers for fiber lasers and, from 1988, wavelength division multiplexing (WDM) optical communications.

AOFR's technology gives Arasor control over the critical light-delivery element common to all its products, coupling the light between its transmitters (wirelines and wireless) and from a laser TV's source to its display. The firm's products and customers complement Arasor's.

"With this acquisition from Verrillon Inc, we take control of the second critical element of light-delivery technology common to all our products, and broaden our customer base to include most of the tier-one telecom players in the US," says Cao. "Likewise, we expect to leverage our China and India relationships to broaden AOFR's customer base into those hyper-growth markets," he adds. "AOFR also created a critical element of fiber lasers, which will become a critical piece of the access network where we operate our unique optically driven wireless systems," he reckons.

"AOFR has been profitable for an extended period and supplies to the world's top optical, defense and wireless companies," adds Cao. "There is a natural synergy in this deal for both companies which should immediately result in an enhanced financial outcome."

Regarding consolidation of the acquired operations, AOFR production and Alfalight packaging is being moved to Arasor's facility at Nansha, China, while a Taiwanese foundry will be used for the fabrication of Alfalight's lasers.

www.arasor.net

Oplink grows more than 80% annually

For its fiscal Q4/2007 (to end-June), Oplink Communications Inc of Fremont, CA, USA, which designs photonic components, modules and subsystems (manufactured at its facilities in Zhuhai and Shanghai in China), has reported revenue of \$37.2m, up 35% on \$27.6m last quarter and 120% on \$16.9m a year ago.

Of this, \$6.6m has been accrued since 5 June's acquisition, from The Furukawa Electric Co Ltd, of its 58% stake in Optical Communication Products Inc of Woodland Hills, CA, USA (net of the outstanding 42% minority interest which, on 19 June, Oplink agreed to acquire — subject to approval by at least two-thirds of the corresponding shareholders at a meeting early in the December quarter).

Discounting OCP, the \$30.6m in Oplink revenue is up 11% on last quarter and 81% on a year ago.

Excluding about \$1.5m in stock-based compensation expense, \$1.5m in expenses from acquiring OCP and \$216,000 in transitional costs for contract manufacturing (net of an \$807,000 adjustment to reflect the 42% minority interest), consolidated net income was \$5.4m. This is slightly up on \$5.3m the prior quarter and double the \$2.7m a year ago.

Fiscal 2007 revenue was \$107.5m (up 96% on \$54.8m in fiscal 2006). This includes \$100.9m from

Oplink's business (up 84%). Excluding expenses, consolidated net income was \$19.0m.

"We closed the acquisition of our majority interest in OCP, taking the first steps to substantially broaden our portfolio of offerings," says president and CEO Joe Liu. Combined with Oplink's passive devices and subsystems, Liu expects OCP's active components and subsystems for metro applications to increase its market share and competitive position in the industry.

"We intend to continue to improve the efficiency of our operations with the acquisition of the majority interest in OCP and thus realize substantial cost savings over time," Liu adds. "There are many opportunities ahead of us as a combined company, and we expect to further enhance our product portfolio, cost efficiency, quality and competitive market position."

For the quarter to end-September, Oplink expects revenue to rise to \$46–50m.

● After five years as controller (responsible for reporting and managing financial operations, then being named VP finance and acting chief financial officer on 21 June following the resignation of Bruce D. Horn), Shirley Yin has been promoted to Oplink's chief financial officer.

www.oplink.com

OCP reverses decline as it shifts manufacturing from US to China

For its fiscal Q3/2007 (to end June), Optical Communication Products Inc of Woodland Hills, CA, USA has reported revenue of \$17.2m (up 4.6% on \$16.4m the prior quarter and up 15% on \$14.9m a year ago), reversing the declines of previous quarters.

Also during the June quarter, order backlog rose from \$7.7m to \$11.0m.

Operating expenses have been cut from \$18.0m the prior quarter to \$10.9m. This is despite the costs of transitioning manufacturing to Hong Kong-based contract manufacturer SAE Magnetics (H.K.) Ltd (a subsidiary of Japanese firm TDK) rising from \$851,000 to \$1.1m. Some product lines entered manufacturing in July; more will be transferred in September, with initial customer shipments beginning in October. The rise in transitional costs is due mainly to the accrual of severance benefits and costs from the initial production of inventory approaching the planned workforce reduction this quarter. In addition, net loss has been halved, from \$17.1m last quarter to \$8.6m.

Also during the quarter, OCP's board of directors approved a resolution to sell the firm's land and building in Woodland Hills, CA (valued at \$19.7m). It expects to sell the property within 12 months.

www.OCP-inc.com

OCP elects Oplink CEO as non-executive chairman

OCP's board of directors has elected Oplink's president and CEO Joseph Y. Liu as non-executive chairman (succeeding Dr Muoi V. Tran, who resigned in June).

Previously, on agreeing on 19 June to its takeover by Oplink, OCP also agreed to the expansion of its

board to nine members, with the appointment of Oplink board members Liu, Leonard J. Leblanc, Chieh Chang and Jesse W. Jack, as well as Oplink officer Dr Robert Shih. The other board members are OCP's president and CEO Philip F. Otto, and independent directors

Hobart Birmingham, Dr Stewart D. Personick and David Warnes.

Oplink and OCP intend this board composition to remain in effect until completion of the acquisition (expected in September). OCP will then become a privately held company and a subsidiary of Oplink.

Opnext's 10–40Gbps sales rise 88% year-on-year

For its fiscal Q1/2008 (to end June) optical module and component maker Opnext Inc of Eatontown, NJ, USA has reported its fourth consecutive quarter of sales growth and profitability. Revenue of \$67.8m is up 3.7% on \$65.4m last quarter and 67.8% on \$40.4m a year ago.

This growth was due mainly to sales of products for transmission rates of 10Gbps and above rising to \$55.8m, up 4.7% sequentially due to strong demand for 40Gbps and 10Gbps datacom products, and up 88.4% year-on-year due to continuing strong demand for 300-pin tunable, X2, XENPAK, XFP and 40Gbps products.

Sales of products for data rates of less than 10Gbps were \$7.3m, while industrial and commercial product sales were \$4.7m. Sales to Cisco and Alcatel-Lucent were 35% and 23% of total sales, respectively.

Gross margin has grown from 32.8% a year ago and 34.9% last

quarter to 36.0%, mainly due to 10Gbps and above product sales, cost reductions, and a reduction in stock-based compensation expense from last quarter, which collectively more than offset price declines.

Operating results have improved from a loss of \$3.1m a year ago and \$0.5m last quarter to an income of \$4.7m (6.9% of sales). Net income was \$6.7m, an improvement on the net loss of \$3.5m a year ago and net income of \$1.5m last quarter.

"We are encouraged by the overall acceleration of broadband applications globally and the demand it is creating for high-speed optical networks, which has translated into solid demand from our core customer base," says president and CEO Harry Bosco.

During the quarter, Opnext completed the expansion of its 40Gbps manufacturing capacity to meet growing demand. "We also expanded our 10GbE [10 Gigabit

Ethernet] product family to include LX4, LRM and ER X2 modules as well as SR and LRM SFP+ products," says Bosco. "Our 10Gbps telecommunication product line has been expanded to include 80km XFP modules and tunable duobinary transponders for long-haul transmission," he adds. "During the second half of this fiscal year, we expect to further expand our SFP+ and 40Gbps product offerings."

For its fiscal Q2 (to end September) Opnext expects revenue of \$72–75m (up 6.2–10.6% quarter-to-quarter and 30.2–35.6% year-on-year, consistent with the firm's aim to grow at least as fast as the market).

"Longer term, we continue to expect our gross margin to approach 40% and our operating margin to approach 15%, both excluding the impact of stock-based compensation expense," concludes Bosco.

www.opnext.com

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Emcore receives record concentrator solar cell order

After an initial 5MW order earlier this year, Emcore Corp of Albuquerque, NM, USA has been awarded a \$24m follow-on production order for 3 million solar cells (generating 105MW in total), the industry's largest concentrator solar cell order to date.

The cells will be used in the SunCube terrestrial concentrator photovoltaic (CPV) system of Green and Gold Energy (GGE) of Glynde, Australia, which has been designed to produce power at a lower cost than traditional photovoltaic technologies, it is claimed.

GGE's SunCube 1100x CPV system will concentrate light 1100-fold onto a custom-designed and optimized version of Emcore's GaInP/GaAs/Ge Concentrator Triple-Junction (CTJ) solar cell. All cells will be shipped by the end of 2008.

The SunCube system features a high-efficiency (>30%) solar energy concentrator, smart dawn-to-dusk 'Max kWh' internal two-axis sun tracker, as well as a 'Cool PV' low operational PV cell temperature. Extensive testing is being undertaken to ensure high reliability and a lifetime of 20+ years.

With support from the Australian government, the plan is to deploy solar power farms featuring the SunCube low-cost CPV system worldwide. GGE is hence forming a joint venture with another Australian firm to build a SunCube manufacturing facility in Xiamen, China with an ultimate production capacity of 3 million SunCubes (1GW) per year. However, if desired, final SunCube assembly can still be performed locally, the firm adds.

GGE also says that it is entering into distribution agreements with several partners, representing a potential for more than 500MW of annual demand.

"Emcore's solar cell serves as the key enabling technology in our SunCube CPV system," says GGE's CEO Greg Watson. "The patent-pending SunCube, together with its supporting technologies and the Emcore cell, are receiving worldwide recognition as the CPV system capable of delivering truly fossil-fuel-competitive energy," he claims.

"Emcore's CPV solar cells are optimized for our customers' systems to yield state-of-the-art performance with the lowest cost

per kW-hr," says David Danzilio, who is VP and general manager of Emcore's Photovoltaics Division. Emcore has demonstrated record conversion efficiency of 39% under these high concentration conditions (see June issue, page 36), and this performance should enable the most cost-effective CPV system on the market, claims Emcore. The 39%-efficient CPV cells are currently in volume production for multiple customers in a variety of cell sizes.

"Emcore is committed to continually investing in our concentrator cell technology and further expansion of our manufacturing capacity to meet the growing requirements," Danzilio adds. As a part of its planned high-volume product roadmap, Emcore's continuing investment in technology should enable the introduction of CPV solar cell products with conversion efficiencies of greater than 40% under highly concentrated illumination operating conditions required for next-generation, cost-competitive CPV systems, the firm reckons.

www.emcore.com

www.greenandgoldenergy.com.au

Emcore receives fourth Nasdaq notice for not filing quarterly report

On 13 August, Emcore Corp of Albuquerque, NM, USA, which manufactures components and subsystems for the broadband, fiber-optic, and solar markets, received a Nasdaq Staff Determination letter saying that it is not in compliance with Rule 4310(c)(14) due to its failure to file its Form 10-Q report for the fiscal quarter to end June with the Securities and Exchange Commission (SEC) by the required deadline, and that its stock is subject to delisting from the Nasdaq Stock Market.

Emcore had previously received letters for not filing its Form 10-K report for the fiscal year to end September 2006 and its Form 10-Q reports for the quarters to end December 2006 and end March 2007.

The delays are due to the review of past stock option grant practices by a special committee of Emcore's board. On 15 June, the Listing and Hearing Review Council stayed the Nasdaq Listing Qualifications Panel's delisting decision of 10 May, pending submission by Emcore of further information by 10 August.

However, on 10 August, Emcore requested that the council exercise its discretionary authority to grant it an additional extension to regain compliance with Nasdaq's filing requirement. Emcore has since determined appropriate measurement dates for all misdated stock option grants, and is making corresponding accounting adjustments to its financial statements.

The firm is now working to complete the remaining steps necessary to file audited reports with the SEC, hopefully this month.

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Efficiency record reaches 42.8%

Using a novel technology that adds multiple innovations to a very high-performance crystalline silicon solar cell platform, at the end of July the Very High Efficiency Solar Cell (VHESC) consortium raised the world record for combined solar cell efficiency to 42.8% from sunlight at standard terrestrial conditions (versus 15% for conventional solar cells).

The previous record of 40.7% was achieved last December by Boeing subsidiary Spectrolab Inc of Sylmar, CA, USA with a high-concentration device that requires complex tracking optics with a table-size lens more than 30cm thick.

VHESC involves hybrid packages with optical waveguides that split sunlight into constituent wavelength bands, focusing each onto a different die consisting of single-crystal silicon, GaAs, InGaAs and InGaN, optimized for each band.

The system delivers variable concentrations to the different solar cell elements. The concentrator is stationary with a wide acceptance angle optical system that captures large amounts of light and eliminates the need for complicated tracking devices.

Due to portability requirements, the concentrator uses only 20x magnification. So, to optimize absorption and conversion of the solar spectrum, the module uses a novel lateral optical concentrating system that splits sunlight into three different energy bins (high, medium and low) and directs them onto the die of three types of cells of differing spectral sensitivity: one made by Emcore, one by the National Renewable Energy Laboratory, and one by the University of Delaware. The method provides affordability as well as flexibility in the choice of materials and the integration of new technologies as they are developed. The devices are also potentially far thinner (less than 1cm).

The wide acceptance angle optical system of the concentrator captures

large amounts of light, allowing it to be stationary (eliminating complex, expensive sun-tracking devices).

The low profile and lack of moving parts translates into portability, which means these devices could easily go on a laptop computer or a rooftop, says Barnett.

The arrays should be 30 times smaller than currently, enabling mounting on the tops of back-packs (for mobile recharging) or on rooftops (for stationary installations).

The efficiency of 42.8% was achieved less than 21 months after the US Defense Advanced Research Projects Agency

(DARPA) in November 2005 awarded the VHESC consortium about \$13m in funding for the initial phases of the three-phase program to develop affordable portable solar cell battery chargers for the US military. DARPA

aims to reduce the almost 100 pound weight of a US soldier's back-pack by dropping the 20 pound, three-day supply of batteries for powering radios, GPS navigation systems, night-vision goggles etc.

Industrial partners include BP Solar, Blue Square Energy, Energy Focus, Emcore and SAIC. Research partners include the University of Delaware, the National Renewable Energy Laboratory, Georgia Institute of Technology, Purdue University, University of Rochester, Massachusetts Institute of Technology, University of California Santa Barbara, Optical Research Associates and the Australian National University.

The research was led by professor Allen Barnett (former president of AstroPower, now part of GE) and

associate professor Christiana Honsberg, who are, respectively, principal and co-principal investigators of the VHESC program. The two direct the Department of Electrical and Computer Engineering's High Performance Solar Power Program.

"What we've done is create a virtual lab. This has given us access to a broad range of capabilities in terms of expertise and equipment," says Barnett.

During its first 21 months, the VHESC program focused on developing the technology basics. Due to the rapid technical progress, DARPA has now initiated the next phase by funding the newly formed DuPont-University of Delaware VHESC Consortium (with DuPont as principle industrial partner) to transition the lab-scale work to developing a manufacturing prototype and applications testing.

The next two phases (lasting 18 months each, and funded by up to \$100m including industry cost-share) will concentrate on optimizing the approach, to achieve DARPA's three-year goal of 50% efficiency (doubling the efficiency of terrestrial solar cells based on a silicon platform within 50 months), while reducing the cost to \$1000 per m² (the cost of standard solar cells).

"Today, we have five different layers, using different semiconductor materials, and the final design calls for adding a sixth layer in order to achieve our goal of 50% efficiencies," said Barnett.

"The new consortium will provide the strong industry-led and product-focused leadership required to ultimately bring the VHESC product to commercialization," Barnett said. "We now are very confident that we can meet the goals set by DARPA."

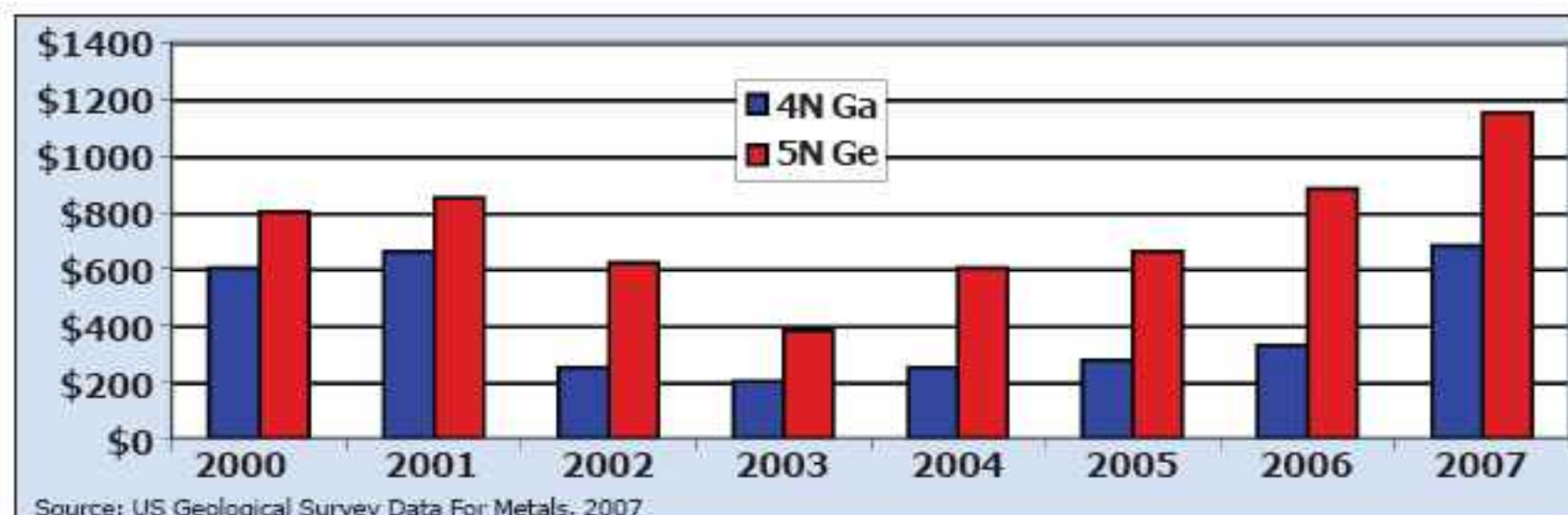
DuPont will rely on the University of Delaware to provide guidance in engineering a low-cost version of the current design (expected to be in commercial production by 2010).

www.darpa.mil/sto/smallunitops/vhesc.htm

DARPA aims to reduce the almost 100 pound weight of a US soldier's back-pack by dropping the 20 pound, three-day supply of batteries

Substrates challenged by raw material prices

To date, AXT remains one of few suppliers that have been able to hold its current price levels for its line of GaAs and germanium substrates despite some very dramatic shifts in supply, demand and price rises for raw materials.



Trend in prices for 4N gallium and 5N germanium, 2000–2007.

In the past 12 months, the cost of 4N gallium metal has risen from about \$350 per kg to \$680 per kg. Currently, 6N and 7N gallium materials, which are used mainly for compound semiconductor crystal growth, are selling for \$750–800 per kg, with projections that costs could reach \$1000 per kg. Also, 5N germanium metal prices have risen substantially from \$630 per kg a year ago to the current price of \$1000–1200 per kg. In second-half 2006, 7N arsenic also exhibited a significant rise, before settling at about \$175 per kg this year.

One of the largest compound semiconductor substrate manufacturing facilities in the world is AXT Inc's, 15 miles southeast of Beijing, China, in the Tongzhou district. However, AXT is also the only substrate maker to have significant in-house capacity to supply its own internal requirements for arsenic, gallium and germanium and, in addition, to offer such raw materials as products to the merchant market.

Established between 1999 and 2001, AXT's five joint venture operations—all located in the vicinity of Beijing and Nanjing (with the exception of its germanium operation, in the northeast region of Inner Mongolia, China)—supply all of the critical materials required for AXT's substrate manufacturing. These include: gallium metal, (4N, 6N, 7N and MBE grade), arsenic (6N, 7N), germanium metal (5N), pyrolytic boron nitride (pBN) crucibles and related parts, and boric oxide (B_2O_3). Also, via its joint venture Beijing Jiya, AXT reworks GaAs scrap for its gallium metal value using a reclaim process developed by Nanjing Jinmei Gallium Co Ltd (which also upgrades the 4N gallium from Beijing Jiya to 6N, 7N and MBE-grade 7N-plus gallium). Although the joint ventures also market and sell raw materials globally, AXT consumes most of its current capacity.

"It takes about 1.3kg of 2N germanium dioxide to convert to 1kg of 5N germanium metal for crystal growth," notes Bob Ochrym, AXT's VP of Business Development

and Raw Materials. "As a result of raw material price increases, current substrate pricing is also predicted to rise, and it is very unlikely that the major substrate suppliers of the world will be lowering their prices in the near future."

In the case of AXT, this increase in raw material pricing underscores the strategic importance of its five China joint venture operations (in three of which AXT has majority ownership). "Having these joint ventures in place is a competitive, sustainable advantage for AXT and our customers," says John J. Cerilli, VP of Global Sales & Marketing. "With the current gallium metal market on allocation, we can continue to provide price and volume stability and guarantees versus our competition, who have to purchase raw materials on the open market."

Over the last year or so, AXT has invested and expanded its capacity in all its joint ventures. In late 2005, the firm took the initiative to double the raw materials capacity of its 4N gallium metal from 12 metric tons (mt) to 24mt, arsenic from 8mt to 18mt, and germanium dioxide from 6mt to 20mt. Such investments are now paying off. The capacity increases were completed in first-half 2007, just before supply in the marketplace began to tighten.

So, although 2007 is proving to be a very interesting year regarding substrate and raw materials supply and demand, AXT reckons that it is well equipped and positioned for such a changeable and dynamic market.

"We are working hard to minimize the impact to our current customers worldwide in terms of continuing to supply their substrates needs and controlling costs," states AXT's CEO Phil Yin. "However, if prices for gallium metal continue to escalate, we will have to review our pricing strategy, as I would think all of our competitors will also do," he adds.

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AXT Inc, Fremont, CA, USA

Narrow focus, wide scope

Both basic research and applications ranging from gas sensing to tomorrow's high-speed computer chips use and characterize semiconductor materials with narrow energy bandgaps. Dr Mike Cooke reports on such opportunities, as described at the Narrow Gap Semiconductor conference.

Manipulating long-wavelength infrared radiation and producing materials with high-mobility electrons are both attractions of narrow-bandgap semiconducting materials. Infrared radiation has many applications, including optical communications over optical fibers and waveguides as well as thermal and passive imaging. The Narrow Gap Semiconductor conference (NGS-13), held at the University of Surrey, UK on 8–12 July, covered a wide range of topics, from the materials studies needed to improve knowledge and technology through to attempts to produce new photonic and electronic devices.

Of particular interest was indium antimonide (InSb), no doubt inspired in part by Intel's interest in using the material in the channel of future field-effect transistors, based on the material's high mobility and saturation velocity: almost 40% of the paper titles mentioned antimony and even some of the remaining 60% dealt with materials containing antimony. Both InSb material properties and devices were under discussion.

Another theme was magnetism, both in terms of using magnetic fields to probe material properties and in manipulating elusive spin properties of electrons and holes (spintronics). In many talks, these two strands came together, based in large part on the exceptionally high magnetic coupling (g-factor) to electrons in InSb.

Another aspect was 'simple versus complex' — many of the structures described consisted of up to 3000 interfaces between semiconductor layers. However, other researchers saw merit in architectural simplicity.

A final theme concerned the properties of carbon-based crystal structures: nanotubes, particularly the ability to now access their optical properties, and the more recently isolated, practically flat 'graphene' carbon layers. These materials are often narrow, zero or negative (semi-metal) bandgap materials.

In this article, we will highlight progress towards both electronic and photonic device applications that were described in some of the presentations at the Narrow Gap Semiconductor conference.

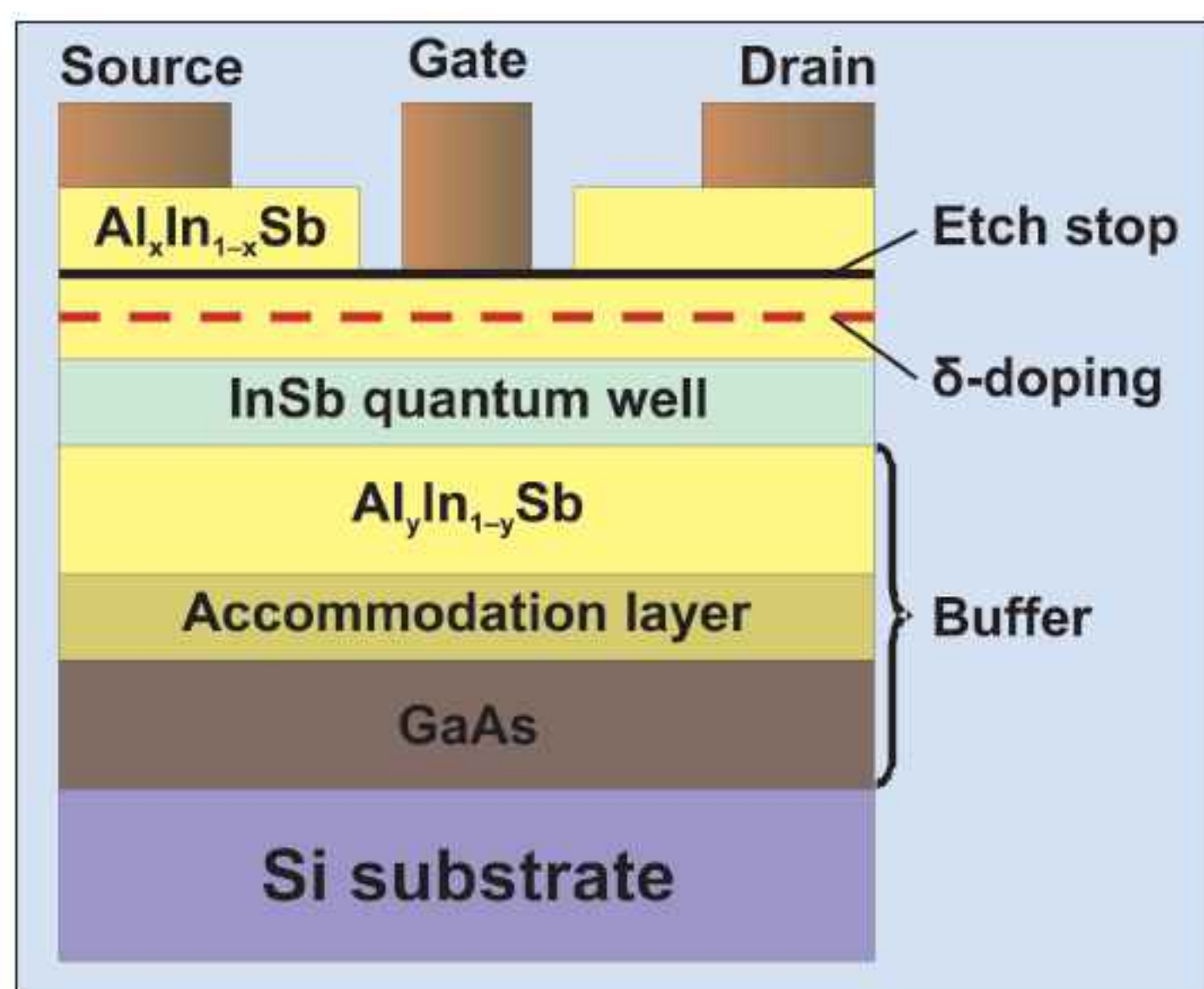


Figure 1. Sketch of Qinetiq/Intel InSb FET on silicon substrate, after Ashley et al, Electronics Letters (5 July 2007). Buffer layer is designed to compensate for the 19% lattice mismatch between silicon and InSb.

Antimony electronics

In some ways Qinetiq, the UK defense research firm, has led the way in developing InSb-based devices. Tim Ashley of Qinetiq gave an overview of the achievements and possibilities for InSb-based devices. One of the most recent achievements has been producing InSb-based field-effect transistors on silicon (Figure 1) rather than on III-V substrates, as insisted on by Intel (Qinetiq's partner in much of this work). Silicon integration is needed not only for integration into the existing CMOS production infrastructure but also because low-cost devices need to be produced on the largest possible substrate for high-volume production — and that means producing on silicon with the largest diameter currently (300mm) and, in future (2012?), possibly reaching 450mm. III-V substrates have not yet reached 200mm in diameter in volume production.

Impressive results have previously been achieved in producing n-channel FETs on semi-insulating GaAs with fast switching speeds and low power drain compared with silicon-based devices in both depletion mode and enhancement mode. The enhancement-mode devices (normally-off, as employed in CMOS) use a recessed gate structure (an uncooled 85nm device shows a 10-fold reduction in active power dissipation and a 1.5-fold increase in speed compared with silicon MOSFETs).

One aspect that needs further work is producing p-channel FETs to complement the n-channel FETs in completing the CMOS equation. Michael Santos, describing joint work between his university, Oklahoma,

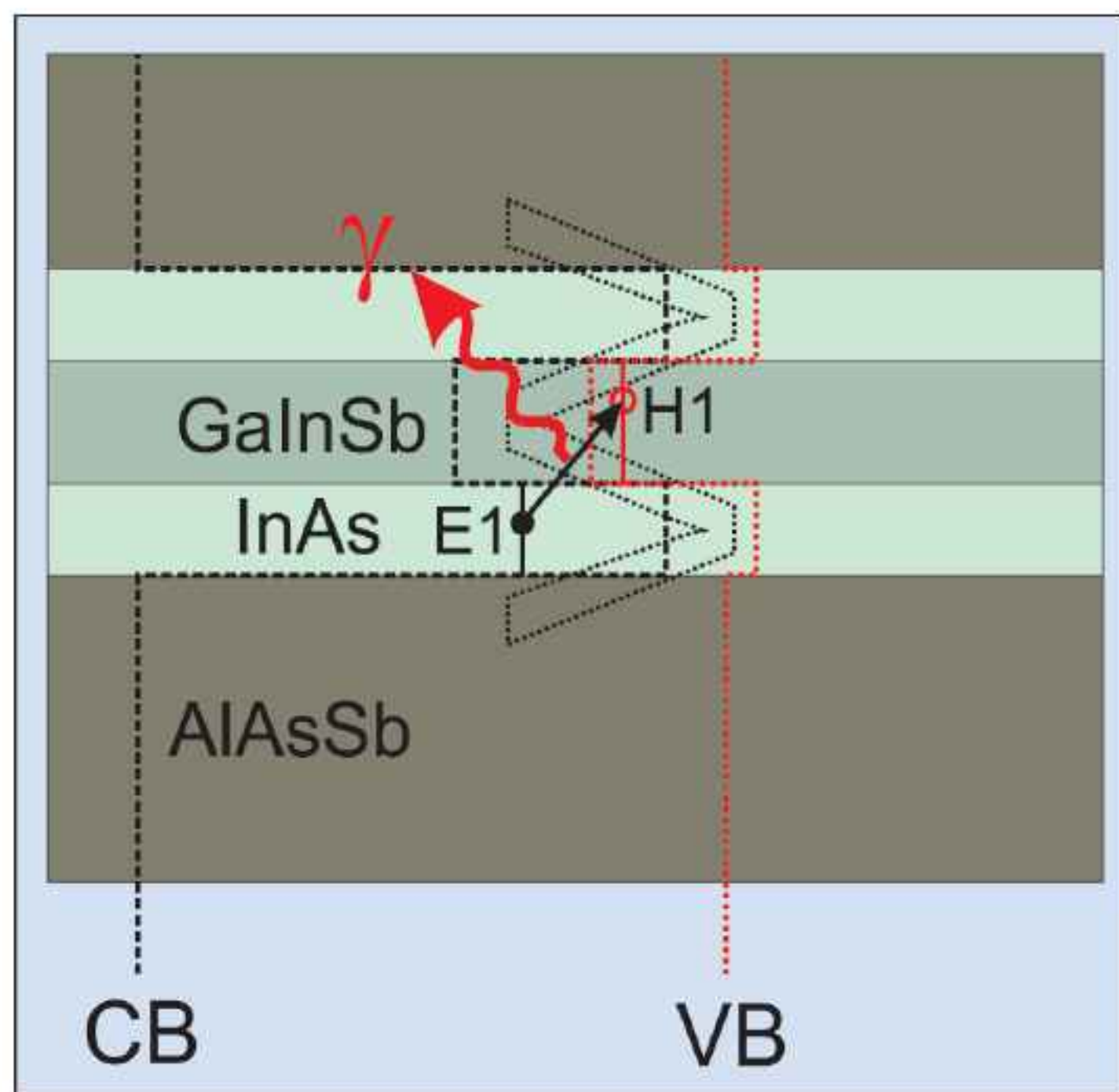


Figure 2. 'W' diode structure creates an electron level E1 in the InAs layers, and a hole level H1 in the GaInSb layer. A transition can create an infrared photon.

and theoreticians at Florida, stated that their motivations included looking for p-channel devices. The researchers performed magneto-optic investigations to determine the valence band structure (from which hole behavior derives) for InSb quantum wells with various strains and levels of confinement. It is found that the effective mass for holes is around four times that of electrons, suggesting a mobility coefficient that is only a quarter of that for electrons. Oklahoma and Florida are also looking to apply the information derived from their work to spintronic structures.

Other possible InSb electronics applications include very high-frequency analogue functions such as low-noise amplification at frequencies well above 100GHz, space-based radar, millimeter-wave and terahertz imaging, direct digital synthesis of radio signals in excess of 5GHz (i.e. without heterodyning to lower the effective frequency), and cryogenic amplifiers.

Another Qinetiq interest is in producing two-dimensional 'focal plane arrays' in standard formats (e.g. 1024x768) of infrared photodetectors for thermal-imaging camera applications. LEDs and sensors for wavelengths of about 5 μ m have also been produced that could have important gas-sensing applications.

Future applications that beckon include quantum secure communications: quantum computers using the large g-factor (at least -33 in a quantum well structure can be achieved) for spin-qubit (quantum bit) manipulation.

For more detail on the characteristics and device opportunities for antimonide semiconductors, see the feature article in the next issue (September).

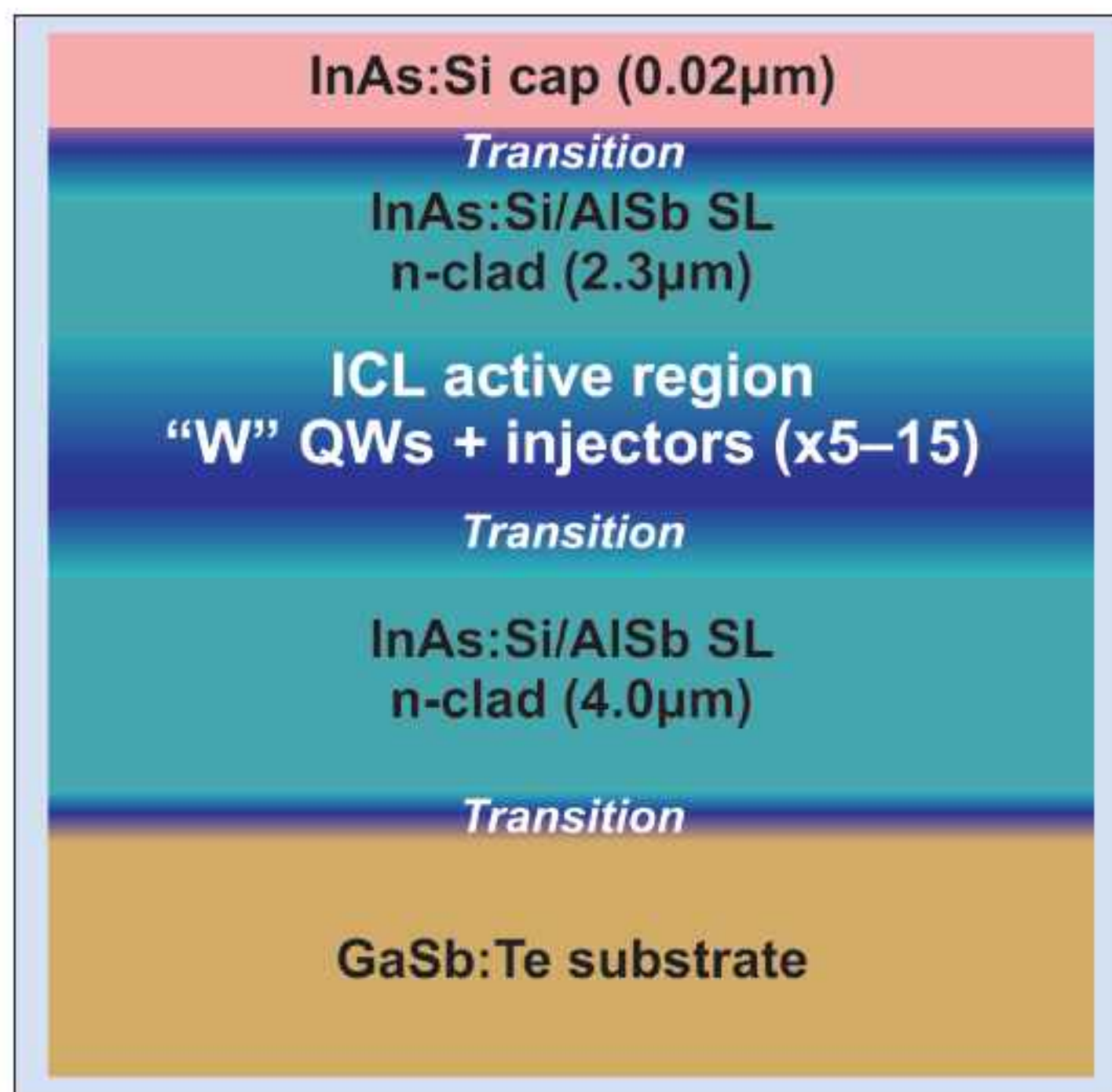


Figure 3. Interband cascade laser structure based on 5-15 strain-compensated 'W' quantum wells and InAs/AlSb injectors in the active layer.

Long-wavelength lasers

As opposed to wide-bandgap materials, where the leading application is production and the detection of short-wavelength visible and ultraviolet light, a narrow bandgap is what is needed to access infrared and even 'terahertz' far-infrared electromagnetic radiation. Chemical sensing (e.g. of atmospheric water and many other gases) is among the applications of long wavelength lasers. Other potential uses are seen in imaging, laser surgery, defense and free-space communications.

In terms of producing light, the main focus of reports at the conference was on producing coherent laser devices, both edge-emitting and surface-emitting. Cascade lasers, where the active region consists of a series of steps, in each of which an electron transition spits out a coherent photon, were also under discussion.

The first cascade laser (developed at Bell Labs in the early 1990s) depended on quantum well structures to create small energy transition 'sub-bands', resulting in 'quantum cascade lasers' (QCLs) of low frequency and long wavelength. However, since then, US military laboratories and others have developed cascade lasers which are dependent on narrow interband transitions. Jerry Meyer described how his team at the US Naval Research Laboratory (NRL) has developed a type-II 'W' diode laser structure (Figure 2) into an interband cascade laser (ICL). This combines previous work on non-cascade diode lasers and ICLs as developed by the US Army Research Lab (and the ARL's spin-out company, Maxion) and NASA's Jet Propulsion Laboratory.

The NRL structure uses up to 15 strain-compensated active stages of W quantum wells and injectors (see

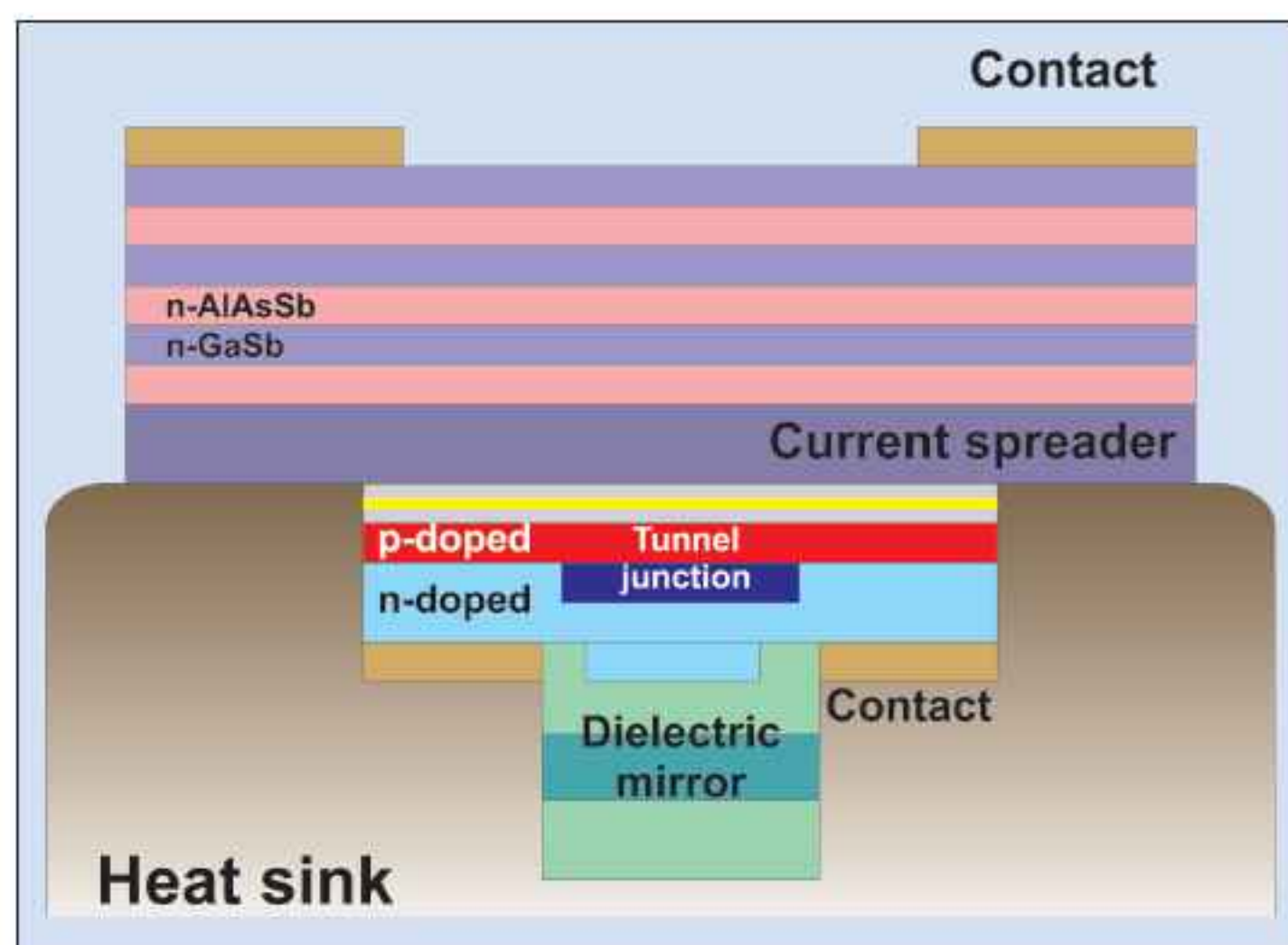


Figure 4. Walter Schottky Institute (WSI) vertical cavity surface emitting laser (VCSEL) concept.

Figure 3). For a 10-stage structure, the epilayer thickness is 7–8 μm , consisting of some 3000 interfaces grown on a Te-doped gallium antimonide (GaSb) substrate. The ICLs generally have lower threshold current for lasing (i.e. it begins lasing sooner) at a given temperature compared with the best W-diode structures. Since these experiments were conducted, NRL has made some of the usual variations for the electro-magnetic waveguide/cavity structures, such as constructing wide (150 μm) gain-guided stripes for high power output (continuous-wave intensity > 1W at 78K), narrow gold-plated ridges producing continuous-wave (CW) lasing up to 269K (power > 250mW, $\lambda \sim 4.05\mu\text{m}$), distributed feedback (DFB) and photonic crystal DFB to provide better beam control and quality. Recently, CW lasing at room temperature has been reported in QCLs. NRL expects similar results from its WICL structure some time this year.

France's Université Montpellier targets high-temperature, short-wavelength (<5 μm) QCL devices using InAs. The choice of InAs-related materials was made because AlAs/GaAs systems are not suitable for these wavelengths. In particular, Montpellier is attracted to the high conduction-band offset (2.1eV) offered by AlSb/InAs structures on GaSb substrates. The researchers achieved peak power near room-temperature operation, even for wavelengths less than 3 μm . Although one expects threshold currents to be inversely proportional to the cavity length of the QCL, there are significant deviations in the Montpellier device. The researchers believe this is due to 'backfilling', where thermal effects cause electrons to be in states that should be empty for lasing operation. Montpellier is working to reduce this and to improve the waveguide structure to enable better laser operation at 400K.

Work towards narrow-bandgap vertical-cavity surface-emitting lasers (VCSEL) and vertical external cavity surface emitting lasers (VECSEL) was mostly optically

pumped, although one group at the Walter Schottky Institute (WSI) in Munich has presented first results on devices designed to be electrically pumped GaSb-based VCSELs (Figure 4). Oliver Dier, speaking on behalf of WSI, reported that several new processing techniques had to be developed (e.g. substrate removal, metal-semiconductor contacts, tunnel junctions) due to the immaturity of antimonide based material technology compared with GaAs or InP. The final device structure consisted of 1200 interfaces. So far, due to the optical thickness of the cavity not being accurate enough, the lasers have only shown resonant electroluminescence below their threshold for lasing. The emission wavelength was 2238nm (2.2 μm) at room temperature.

Photon detection

Tokyo University's Takeji Ueda described work in developing long-wavelength infrared single-photon detectors. Such devices have applications in investigating molecular states, lattice vibrations, superconducting gaps, cyclotron motion and confinement in quantum wells. Competing technologies include photomultiplier tubes, avalanche diodes, superconducting hot-electron bolometers and quantum-dot detectors. Tokyo's interest is in developing technologies for passive microscopy, which depends on the spontaneous emission of objects as opposed to active techniques that use reflected or transmitted radiation from a source. At room temperature, the peak of the passive electromagnetic radiation spectrum falls in the terahertz/LWIR region. Passive techniques enable probing of dynamic and other phenomena of the object under investigation. A drawback is that the signal from such studies can be very weak. Other areas of interest include remote thermometry of biological structures down to cellular or even molecular levels. The requirements are for detectors at the attoWatt or picoWatt level.

Tokyo's suggestion is for a "charge sensitive infrared phototransistor" (CSIP). The photoexcitation and separation of an electron-hole pair creates a positively charged gate that modifies the current flow conductivity in the channel of the device (Figure 5). To gain an appreciable signal, one needs the lifetime of the charged gate to be long while the transit time across the channel must be short. Tokyo's device uses an inter-subband transition in a double quantum well structure to create and separate the electron and hole charges. A field-effect transistor structure is then used to detect the charge. To achieve an appreciable signal/noise capability, the device is cooled in liquid helium. The CSIP detects photons with wavelengths of about 14.5 μm . As the photon flux rises, the device current tends to saturate. Adding a reset switch to the structure enables detection from aW to pW levels. In future work, the researchers plan to increase quantum efficiencies from the present 2%, to extend the range of detectable wavelengths from

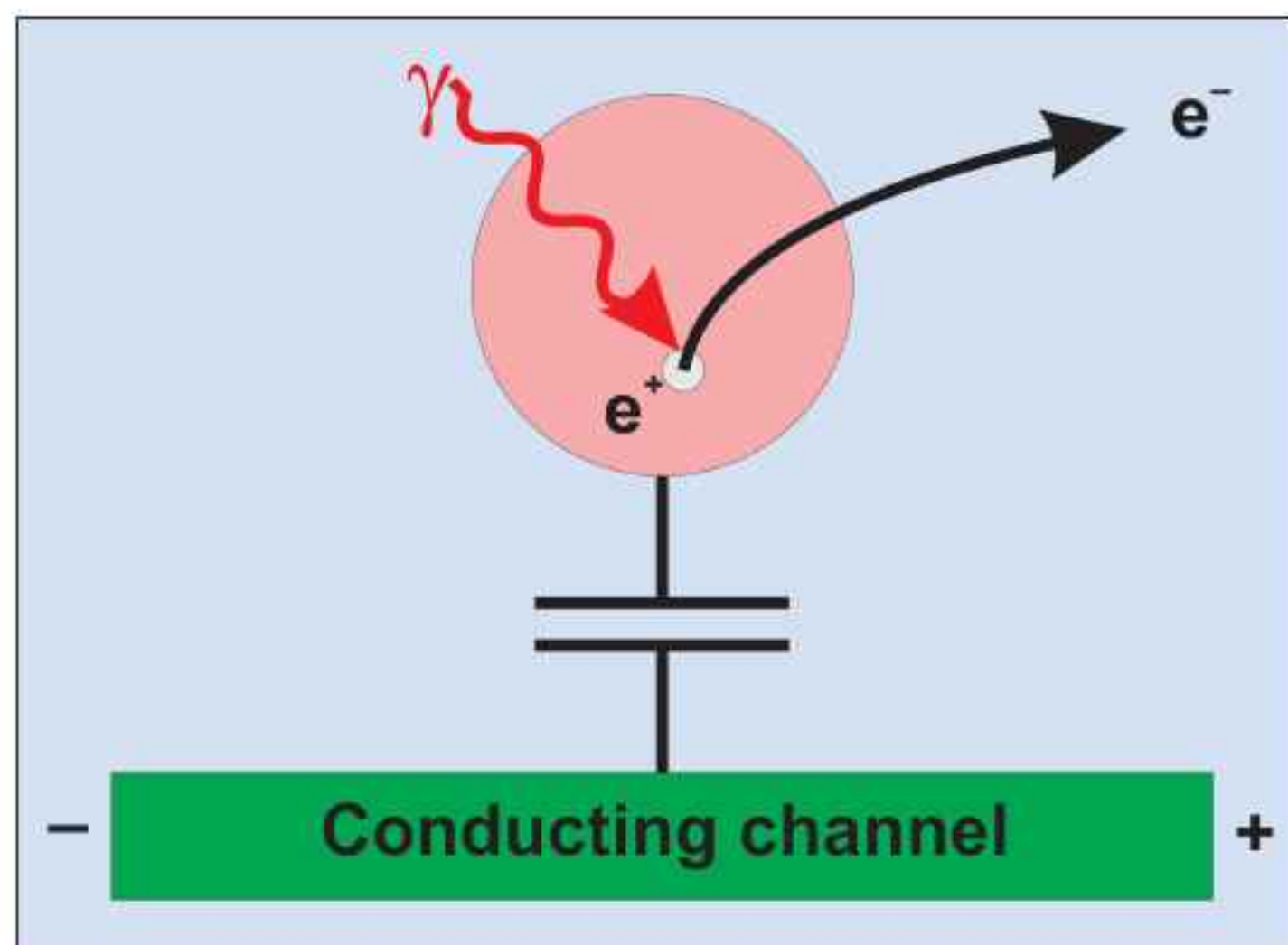


Figure 5. Tokyo University's idea for a 'charge-sensitive infrared phototransistor' (CSIP). Photoexcitation and separation of electron-hole pair creates a positively charged gate that modifies current flow conductivity in channel.

the current $1\mu\text{m}$, to create detector arrays for passive microscopy, and to increase the operating temperature.

Researchers at Austria's Linz University and Graz Technical University target production of low-cost photodetectors using inkjet-printed mercury telluride (HgTe) nanocrystal structures. The devices achieved room-temperature detection of wavelengths up to $3\mu\text{m}$, the longest-wavelength detection from devices built using solution processing (i.e. inkjet-printing). Sensitivity to $1.4\mu\text{m}$ illumination reaches 600mA/W at 70V bias and 4.4A/W for pW illumination at 10V bias. Increasing the nanocrystal size shifts the cut-off wavelength upwards.

Stephan Winnerl of the Forschungszentrum Dresden-Rossendorf described work on photoconduction antennas for THz detection. The aim is to dispense with problems of focusing excitation laser beam spots on micron-size structures, as is usual in THz emitters. Instead, the researchers work on interlaced comb electrodes (Figure 6). As is, such a structure would not emit THz, since photoconduction would occur in both directions, but by adding a shadow mask to one half of the combs a unidirectional photocurrent and hence THz radiation can be produced and detected. The scientists experimented with various types of GaAs substrate, including low-temperature MBE-deposited GaAs substrate (grown at 200°C ; annealed at 600°C for 10 minutes), where nitrogen or arsenic ion implantation offered the best signal/noise ratios (~ 2000). Poorer S/N was achieved for annealed N-implanted and semi-insulating GaAs substrates. Short carrier lifetimes are desired. The researchers also demonstrated emitter-detector pairs built on the same principles for both focused and extended THz beams.

Also looking to the THz frequency range was a collaboration between the French and US national magnetic field facilities (LNCMP, Toulouse and NHFML, Florida),

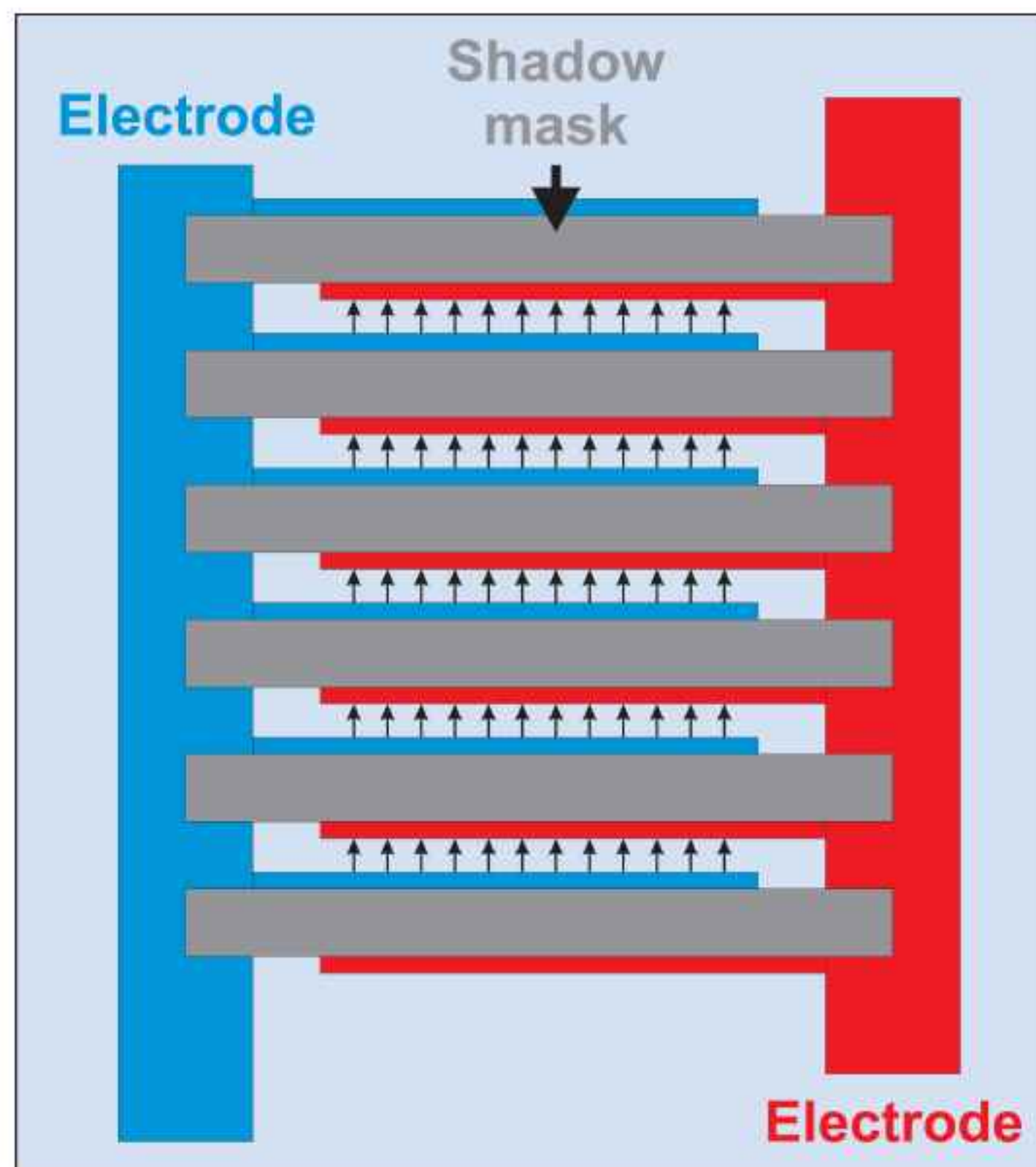


Figure 6. Forschungszentrum Dresden-Rossendorf's design for photoconductive antenna to allow easier excitation and detection of terahertz radiation.

Humboldt University in Berlin, and Kurchatov Institute in Moscow. LNCMP's Michel Goiran says that AlP/GaP quantum wells could lead to electron subband transition devices operating in the wavelength range $30\text{--}60\mu\text{m}$ ($5\text{--}10\text{THz}$) that are inaccessible to other semiconductor nanostructures because of absorption effects. The researchers have worked to clarify the electronic structure of AlP using magnetic measurements and says the system offers opportunities for QW detectors and QCLs.

Chalcogenides

Although less prominent at the conference, tellurium and selenium (chalcogenide) compounds with lead, germanium and silver form another important class of narrow-gap materials. Jeff Urban of Harvard University described work on developing chalcogenides to produce nanostructured thermoelectric materials. Researchers from Ghent University and Université Libre de Bruxelles also see PbSe quantum dots as being useful in their work towards photonic applications on silicon substrates. PbSe exhibits tunable bandgap absorption and nonlinear refraction effects in the range $3000\text{--}1000\text{nm}$. Optical communication applications at 1550nm may be accessed through this work. The researchers are working on producing a ring resonator on silicon-on-insulator wafers. Linz University researchers are looking to introduce strain into PbSeTe and PbTeSe dots on PbTe and PbSe, respectively, with the aim of manipulating band gaps and alignments for mid-IR optoelectronics. ■

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5 Deposition materials

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EMF Ltd
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Fax: +44 151 334 6422
www.epichem.com

Mining & Chemical Products Ltd
(see section 1 for full contact details)

Power + Energy Inc
(see section 8 for full contact details)

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Fax: +1 845 398 8304
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15 Assembly/packaging materials

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The 2007 Compound Semiconductor IC Symposium

We cordially invite you to the 2007 Compound Semiconductor IC Symposium being held October 14 – 17 in beautiful Portland, Oregon. The high-performance wireless and high-speed digital communications markets are thriving due to impressive strides in new materials and devices, greater integration levels, novel circuit implementations, and ever-changing systems partitions. Over the last 29 years the Compound Semiconductor IC Symposium (CSICS — formerly named the GaAs IC Symposium) has been and continues to be the preeminent international forum in which advances in semiconductor circuit and device technology are presented, debated, and discussed. The scope of the Symposium encompasses devices and circuits in GaAs, SiGe, InP, GaN, and InSb as well as targeting the fields of RF/mm-wave CMOS and high-speed digital CMOS to provide a truly comprehensive conference. This is the ideal forum for presentation of the latest results in high-speed digital, analog, microwave/millimeter-wave, mixed-mode, and optoelectronic integrated circuits.

This year's 2007 CSIC Symposium consists of a full 3-day technical program, 2 short courses, a primer course, and a technology exhibition. The technical program consists of approximately 60 high-quality state-of-the-art technical papers, 4 panel sessions, 2 Short Courses on 'Compound Semiconductor Devices and Integrated Circuits for Millimeter Wave Imaging' and 'Compound Semiconductor Power Amplifiers' and an Industry Exhibit. The Symposium will also be offering the popular annual introductory level Primer Course on 'Basics of Compound Semiconductor ICs'. This year the Symposium will feature approximately 15 invited papers on a wide range of important topics encompassing device engineering to circuit application using advanced compound and other related semiconductor technologies. In addition, the Symposium will continue the tradition of including important 'late breaking news' papers.

The technology exhibition will be held on Monday and Tuesday. The exhibition will feature informative and interesting displays with corporate representatives on hand. The list of exhibitors can be found in the CSICS advance program which will be published and distributed in late June.

To complement the Symposium, there are several social events which include the Sunday Evening CSICS Opening Reception, the Monday CSICS Exhibition Opening Reception, the CSICS Tuesday evening Theme Party to be held at McMenamins Pub and Breweries Crystal Ballroom, and the CSICS Exhibition Luncheon on Tuesday. The Theme Party will include entertainment and a tasting of locally produced Oregon wine and beer. A breakfast will also be served on Monday, Tuesday, and Wednesday.

The 2007 IEEE CSICS will be held in Portland, Oregon in the Hilton Portland and Executive Tower located in downtown Portland. Proclaimed as North America's 'Best Big City', according to Money magazine, Portland exhibits unmatched natural beauty as well as a wealth of opportunities for leisure, sports, shopping, and outdoor activities. The conference downtown location is within easy access to the vibrant Pearl District with destination restaurants, art galleries, and shopping. While you're in Portland, be sure to enjoy the scenic beauty of the Columbia River Gorge, enjoy the hike to Multnomah Falls and the drive the Historic Columbia River Highway. Other local attractions include Mt Hood, the Willamette River, the rose gardens, the Japanese garden, the Oregon Coast, and the wine country. Portland has an excellent light rail system which can be used as transportation from the Airport to the Hilton and for getting around town.

For registration and further information, please visit the CSICS website at <http://www.csics.org>. Further questions may be addressed to the Symposium Technical Program Chair: William Peatman, Ph: +1-908-668-5000 ext. 5842, E-mail: wpeatman@anadigics.com

We hope you can attend,
IEEE CSICS Organizing Committee

event calendar

If you would like your event listed in *Semiconductor Today's* Event Calendar, then please e-mail all details to the Editor at mark@semiconductor-today.com

16–20 September 2007

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E-mail: vde-conferences@vde.com

www.vde.com/Conferences_en/ECOC+2007

16–21 September 2007

ICNS-7 (7th International Conference on Nitride Semiconductors)

Las Vegas, NV, USA

E-mail: raabe@tms.org

www.tms.org/Meetings/specialty/icns

17–19 September 2007

AHPSL 2007 (Applications of High Power Semiconductor Lasers)

San Diego, CA, USA

E-mail: amueller@intertechusa.com

www.intertechusa.com/conferences

23–26 September 2007

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http://nambe07.chtm.unm.edu

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www.solarpowerconference.com/18/

24–28 September 2007

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5th International Workshop on Bulk Nitride Semiconductors

Itaparica, Salvador, Bahia, Brazil

E-mail: jaime.freitas@nrl.navy.mil

http://coe-nano.sakura.ne.jp/iwbns-5

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7th International Conference on Numerical Simulation of Optoelectronic Devices

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www.nusod.org

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www.fz-juelich.de/conference/MBE2007

8–12 October 2007

European Microwave Week 2007

Munich, Germany

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9–11 October 2007

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11-12 October 2007

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www.iop.org/Conferences

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www.csics.org

14-19 October 2007

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www.GADEST2007.org

15-18 October 2007

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Compound Semiconductors (ISCS 2007)**

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E-mail: secretary@iscs2007.org

www.iscs2007.org

21-25 October 2007

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Society Annual Meeting**

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www.i-leos.org

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21-23 January 2008

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