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COMPOUNDS & ADVANCED SILICON

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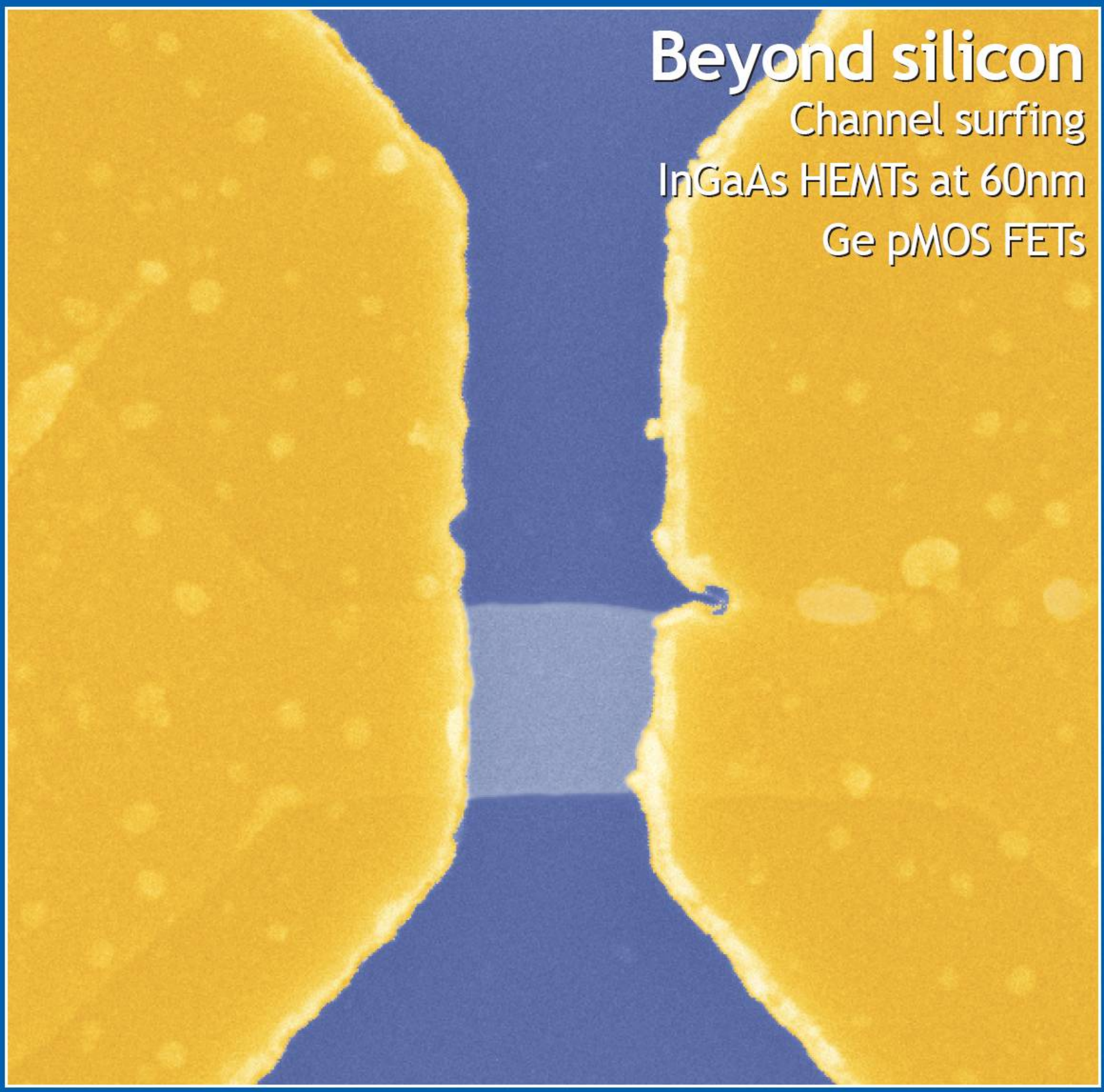

Avanex divests ex-Alcatel fabs • Cermet's non-polar nitrides
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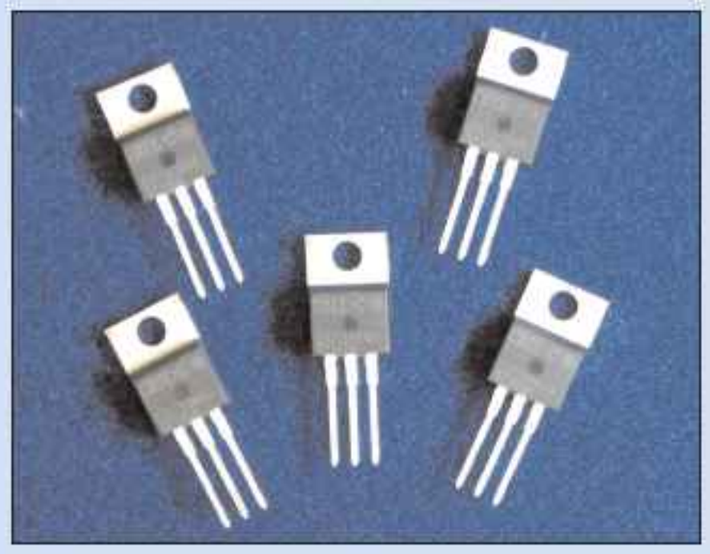
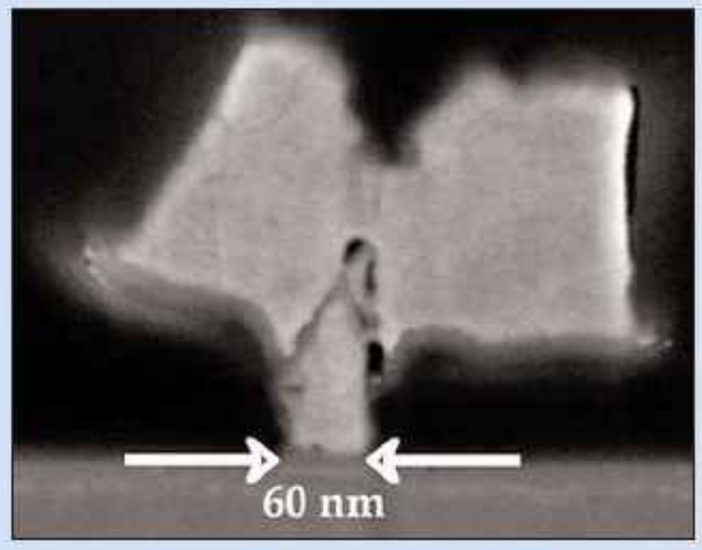
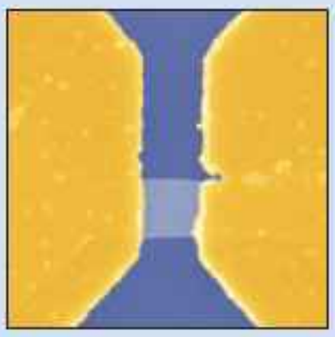
p8 RFMD's new pHEMT-based RF switch products, showcased at January's IEEE Radio and Wireless event.



p16 Cree's new 1200V Zero Recovery SiC Schottky rectifiers, with current rating boosted from 20A to 50A.



p36 Cross-sectional SEM of MIT's InGaAs HEMT with a gate length of 60nm (similar to leading-edge silicon).



Cover: Scanning electron micrograph (in false color) of a transistor made by carving nanoribbons, semi-transparent conduction barriers and quantum dots all in the same atomically thin layer of graphene. Au contacts shown in gold; SiO_2/Si substrate in blue. The width of the graphene wire is 200nm. **p41**

editorial

Getting compounds into the channels

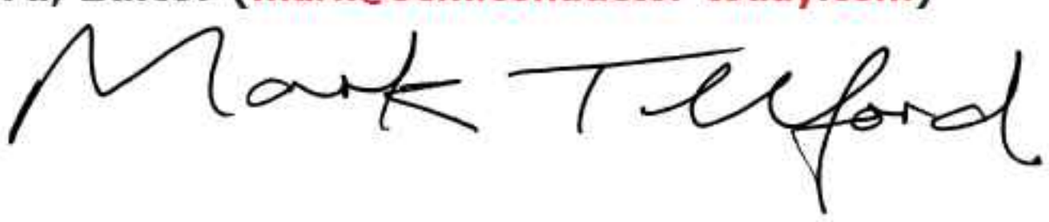
As part of this issue's focus on the topic of 'Beyond silicon', on pages 18–19 we report the latest developments in advanced silicon technology. This includes Axiom entering production of single-chip CMOS power amplifiers for GSM/GPRS cell phones as well as the introduction by both Intel and IBM (working with AMD and its other development partners Sony and Toshiba) of CMOS silicon transistors with both high-k gate dielectrics (hafnium-based material grown by atomic layer deposition) and metal gate electrodes. Page 20 reports plans to use ALD to develop the technology further (at Germany's FZ Jülich and a new ALD Foundry at Cenamps in the UK).

Using different gate dielectric and electrode materials and structures can improve the performance of existing silicon CMOS transistor technology and extend its lifetime to the 45nm and perhaps 32nm gate length scales. However, this does not overcome the limitations of the semiconducting material in the transistor's channel.

While the use of strained silicon, silicon germanium and carbon-doped SiGe is well established, the feature article on pages 37–42 ('Channel surfing') elaborates on these steps and details the various routes being explored to extend CMOS beyond silicon's inherent materials performance limitations. For example, the Non-Classical CMOS Research Center (launched last year by the USA's US Semiconductor Research Corporation is targeting alternative III-V based channel materials for the 22nm technology node in 2016–2019, as outlined in the International Technology Roadmap for Semiconductors (ITRS), and perhaps earlier for the 32nm node in 2012–2014. Freescale has been working on III-V MOSFET technology using InGaAs channels for some time, but most recently this has been in collaboration with Scotland's University of Glasgow, which has just received $7.7m in UK government funding to research the required III-V gate oxide layers (see next issue for details). Meanwhile, at last December's IEEE International Electron Devices Meeting, MIT presented InGaAs HEMT devices with gate lengths shrunk to just 60nm, on a par with current silicon production technology (see page 36).

However, the likes of Intel are likely to demand channel technology that is compatible with integration onto silicon substrates on which the incumbent chip manufacturing infrastructure is based. As well as Intel's work with the UK's Qinetiq on indium antimonide (InSb) quantum wells, at IEDM 2006 the Belgian research institute IMEC reported the fabrication of germanium pMOS FET devices in a silicon-compatible process flow using 200mm-diameter Ge-on-Si wafers (see page 36). The sub-32nm CMOS program within which IMEC's work was conducted has industrial affiliates including mainstream silicon manufacturers Infineon, Intel, Micron, NXP, Panasonic, Samsung, STMicroelectronics, Texas Instruments and TSMC. With silicon already literally straining to fulfill the demands of 32nm for 2012, such interest in alternative channel materials will only accelerate.

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



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

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

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news

Market for 40Gbps components and modules $500m by 2012

Telecoms equipment makers will purchase about $500m of 40Gbps transponders and components by 2012, according to CIR's market report 'The Transition to 40Gbps'.

Having run the gamut from over-hyped 'next big thing' to dead and buried, 40Gbps has again emerged as a topic of conversation in the market, says CIR. But now real deployments are beginning, and technology advances and the availability of 40G transponders have made 40Gbps worth considering. The market is currently at the VSR (2km) level, with deployments mainly limited to core routers. Some carriers (e.g. AT&T, Sprint and SOFTBANK) plan to upgrade backbone networks to 40Gbps, but CIR believes industry-wide 40Gbps roll-outs won't ramp up until 2010. Whether or not 40G achieves the market prominence of 10G technology remains to be seen, but that in any case won't happen until 2015 at the earliest.

Nonetheless, 40G will find sizeable markets much earlier than that. CIR expects the escalation in the 40Gbps market to be driven by new technology enablers and cost improvements as well as bandwidth demands. The most important recent innovation has been the emergence of advanced optical modulation schemes and improved dispersion compensation, both of which make 40Gbps transmission over existing networks much more practical. 40Gbps technology also offers inherent operational advantages, in that most network engineers believe that routers work at a much higher rate of efficiency if bit streams remain intact rather than carried as several lower-rate channels. Also, 40Gbps SONET telecom data transmission provides this capability in a way that Ethernet, for example, cannot match.

So far, many of the large component and module makers such as JDSU, Avanex, Finisar and Bookham have not entered the market. However, CIR expects that this will change as volumes for 40Gbps ports rise into the tens of thousands. Modules and components firms are extremely affordable and it would not take much to acquire some of the smaller firms. CIR concludes that firms like Apogee, CoreOptics, Inphi, Kailight, Picometrix or Teraxion could be absorbed in the next two to three years.

- Apogee has since been acquired by CyOptics (see next issue).

www.cir-inc.com

North America handset shipments to grow 6% to 163 million in 2007

North American handset shipments are expected to grow 6% in 2007 to 163 million units, according to Strategy Analytics.

With aggressive subsidies at the heart of their strategies, operators will focus on driving 3G handsets across their user base. Evolution-data optimized (EV-DO) sales will more than double from 23 million in 2006, while W-CDMA will push toward 10 million units.

The North American handset market continues to be dominated by Motorola, which has a 38% share of shipments and a leading position in all the major US cellular interfaces.

Behind Motorola, rivals LG, Samsung, and Nokia are in a virtual dead-heat race for share, says Strategy Analytics.

Samsung is best positioned to emerge victorious, with positions at all major operators. However, it will struggle to maintain focus on the North American market as it tries to balance global handset development priorities, reckons the market research firm.

However, LG will win the race if it can speed its W-CDMA device launches to extend its 50% W-CDMA share position while balancing entry-tier and high-tier CDMA and GSM growth, concludes Strategy Analytics.

www.strategyanalytics.net

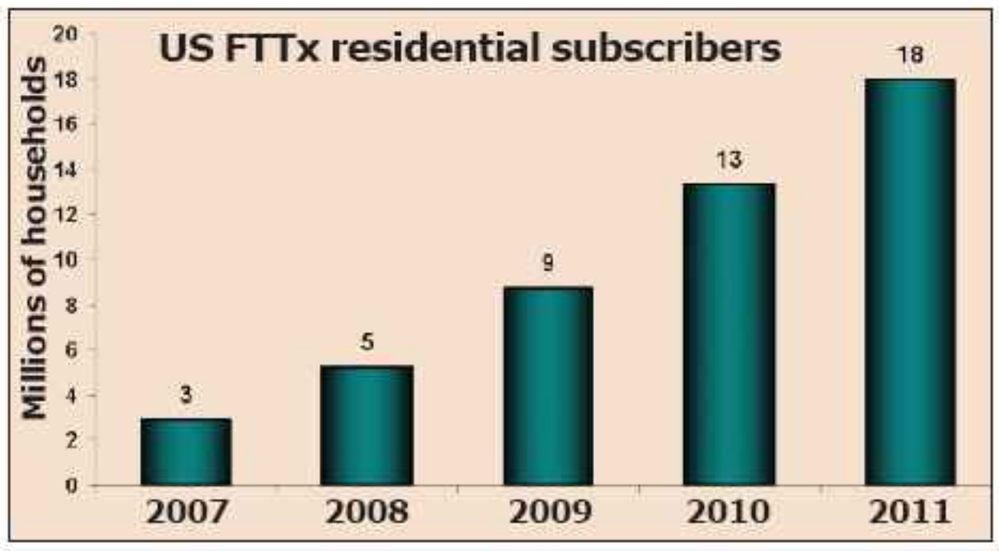
Wi-Fi, WiMAX and 3G to coexist and compete

According to the report '3G, Wi-Fi, WiMAX, and Others Battle for Wireless Supremacy' from In-Stat, for each of the three main technologies for broadcasting wireless data at broadband speeds to consumer devices, ultimate adoption will vary greatly depending upon in which region they are deployed, namely:

- 3G is commonplace in developed countries and is starting to appear in developing regions.
- The more developed the region, the more important it is for WiMAX to be mobile.
- Other technologies, such as 802.20, have the potential to play a role in future, but have a long way to go to achieve that potential.

www.in-stat.com

US fiber subscribers to reach 18m by 2011



The number of US households subscribing to FTTx (fiber-to-the-home, -curb and -premises) will rise from 3m in 2007 to 18m by the end of 2011, says Parks Associates in 'FTTx and BPL [broadband over power lines]: Analysis and Outlook'.

Fiber subscriptions will join DSL and cable as mainstream broadband access methods over the next five years, driven by aggressive deployments by the main telecom companies and increased consumer demand for new data, voice, and video services.

"While fiber is a small percentage of total US broadband household subscriptions today, it will achieve a faster growth rate than DSL and cable did after their inception," says analyst Chris Roden. "Companies like Verizon and AT&T are hoping to match and surpass the broadband offerings from the cable MSOs, and their bold plans to upgrade their existing copper networks will drive fiber growth," he adds.

"Increasing consumer demand for bundled services such as video-on-demand and IPTV will also fuel the increase in fiber subscriptions," Roden concludes.

www.parksassociates.com

Fibre Channel switch sales to pass $2bn in 2008

Fibre Channel switch revenues are expected to exceed $2bn by 2008 and to increase continually through 2011, according to a 5-Year Forecast Report by Dell'Oro Group.

"Enterprises are installing fiber cabling to future-proof their network," says Tam Dell'Oro. "Fibre Channel then becomes a 'no brainer' choice for storage networking over alternatives such as iSCSI and Ethernet," he adds. "On a high-end switch, 1Gbps Ethernet over fiber is selling for about $600 a port — the same price as a 4Gbps Fibre Channel port that provides four times the bandwidth."

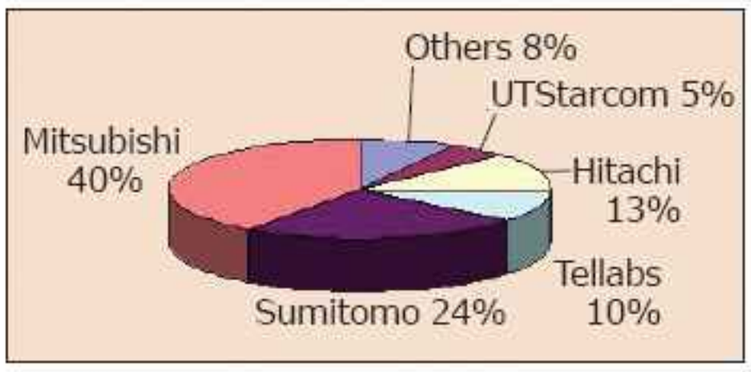
Also, shipments of host bus adapter (HBA) ports will grow significantly over the next five years as blade server makers shift manufacturing of mezzanine HBA cards to HBA vendors, such as Emulex and QLogic.

www.DellOro.com

US, Korea FTTH build-outs in '07 follow 58% growth in '06

After flat growth in the Q2 and Q3, fiber to the home (FTTH) shipments grew 41% in Q4/2006, driving full-year 2006 growth of 58% to a record 4.6m shipments of optical network terminal (ONT) and optical line terminal (OLT) ports, according to the report 'Broadband Shipment Analysis' from market research firm Dittberner. The jump in Q4 was due to the change in mix of detached homes and apartments in the dominant Japanese FTTH market.

The FTTH equipment market is still dominated by domestic Japanese suppliers Mitsubishi, Sumitomo and Hitachi, who supply Gigabit Ethernet passive optical network (GPON) equipment. Japan has 4.8m FTTH subscribers, which is about four times more than the next largest market (the USA). So, even though the USA's largest FTTH supplier (Tellabs) saw its shipments



FTTH equipment market shares in '06.

grow by 27% in 2006 due to US FTTH build-out, it kept pace with neither the Japanese nor the overall market; its market share was just 10%. The top five suppliers increased their market share from 91.6% to 91.9% in 2006.

Dittberner predicts changes in 2007. In the USA, Verizon will add 1m FTTH subscribers in 2007 (mostly with GPON), which should boost Tellabs' shipments as well as those of Alcatel-Lucent (Verizon's chosen GPON supplier). Also, in Q4/2006, Alcatel-Lucent announced a GPON initiative with France Telecom. Meanwhile, Siemens' shipment of a large number of GPON OLTs reflects the start of a large FTTH build-out in Korea.

These new FTTH initiatives, plus the existing Japanese build-out, will drive market growth to 6.8m ports in 2007, Dittberner reckons. The market share of Japanese suppliers will shrink to 55% of FTTH ports shipped (from 82% in 2006). The market share for BPON (broadband) shipments will drop sharply, while GPON will become significant in the coming years as major service providers in Europe and North America launch more GPON FTTH initiatives. Siemens (whose merger with Nokia is pending), Alcatel-Lucent, and Ericsson (which recently acquired Entrisphere) are poised to benefit the most.

www.Dittberner.com

Proliferation of W-EDGE places pressure on smaller component makers

W-EDGE has emerged as the de facto standard for new handsets, as exemplified by the blizzard of new W-EDGE transceivers announced at the 3GSM World Congress 2007 in Barcelona, Spain, according to the Strategy Analytics report "New Transceivers at 3GSM '07 Mark the Ascendance of W-EDGE".

New transceivers for W-EDGE announced by component suppliers ranged from small, highly integrated two-transceiver solutions to completely integrated baseband-transceiver systems on chip (SoCs).

"Transceiver makers have aggressively embraced multi-band W-EDGE, a move that, until recently, they had considered with trepidation given the uncertainties of the market and the technical challenges," says Christopher Taylor, director, RF & Wireless Components for Strategy Analytics. W-EDGE handsets can operate across multiple regions by supporting W-CDMA, EDGE and legacy GSM and GPRS modes.

"The complexity of new radio components for W-EDGE handsets has pushed the leading suppliers into two camps: those that specialize in power amplifiers bundled with transceivers as an optimized solution, and those that offer ultra-compact, multi-band transceivers and matching basebands fabricated with the latest CMOS technology," adds Stephen Entwistle, VP of the Strategy Analytics Strategic Technologies Practice. "Playing in this market has gotten more challenging with W-EDGE, especially for smaller players that lack system expertise."

www.strategyanalytics.com

Compound industry moving into profit

The compound semiconductor industry in general is demonstrating positive results as it moves into profitability, says market research firm Strategy Analytics.

In 'Compound Semiconductor Industry January–February 2007 Review: Microelectronics', Strategy Analytics reports that, in Q4/2006, the GaAs IC industry averaged a profit margin of 6%, with strong performances at market leaders and specialty niche players, and one GaAs IC manufacturer's profit margins approaching 35%.

Outside the slew of product announcements from February's 3GSM World Congress 2007, Hittite and Mimix Broadband announced products targeting high-frequency applications, while M/A-COM announced products based on both GaAs and SiGe.

Also, momentum continues to build in wide-bandgap semiconductors for RF and power, with Raytheon reporting that its GaN MMICs had completed the equivalent of nine years of continuous operation (see February issue, page 8).

In 'Compound Semiconductor Industry January–February 2007 Review: Optoelectronics and Materials', Strategy Analytics also reports that in fourth-quarter 2006, of the companies covered, GaAs substrate maker AXT had the best performance, generating profit margins of 26% (see news page 12). The firm's reputation among end-users has improved considerably over 2006 (see article on page 34), so a significant market share gain is expected. The challenge will be to maintain this momentum in 2007 and beyond.

In the GaN sector, epiwafer foundry Picogiga International announced pre-production availability of silicon-on-polysilicon-carbide (SopSiC) substrates for GaN device production, leveraging the synergy between its III-V MBE capabilities and the silicon-on-insulator technology of parent company SOITEC.

"With the exception of JDSU, companies involved in the telecoms sector were still struggling with profitability, but the market is picking up, so performances should improve in 2007," reckons Asif Anwar, director of Strategy Analytics' GaAs and Compound Semiconductor Technologies (GaAs) service. "Equipment manufacturers continue to find strong demand from the LED sector, which in its own right was still showing positive margins despite lower revenues."

Equipment manufacturers continue to find strong demand from the LED sector

Stephen Entwistle, VP of Strategy Analytics' Strategic Technologies Practice, adds, "2006 was a good year for the industry with strong demand helping to drive revenues. At the same time, companies adopted focused strategies that included divesting operations that did not tie in with their core business, helping them to move towards profitability."

● The latest divestment came at the beginning of March, with optical communications component and module maker Avanex of Fremont, CA, USA agreeing to sell a 90% stake in its ex-Alcatel Optronics subsidiary Avanex France S.A. (which makes laser, terrestrial pump, submarine pump and fiber Bragg grating products at its InP and GaAs fabs in Nozay).

Avanex France is being bought by its current head Didier Sauvage and Global Research Company (see page 30).

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GaAs IC makers' continuing growth drives profitability

Last quarter the major GaAs-based RFIC makers all reported further sales growth and profits.

RFMD's quarterly revenue rises 13.8% to a record $281m

For its fiscal Q3/2007 (to end-December 2006), RF Micro Devices of Greensboro, NC, USA reported record revenue of $281.1m (up 13.8% sequentially and 35.2% year-on-year), reflecting "strength at leading handset makers, market share gains in RF semiconductors, and record demand for its cellular transceivers and transmit modules". Sales of Polaris Total Radio solutions grew for a tenth consecutive quarter.

RFMD believes it is benefiting from market share consolidation at its largest customers and robust overall unit demand for cellular handsets. For the nine months to end-December, revenue was $766m (up 41% on the previous year). RFMD is on target to exceed $1bn in annual revenue for the first time.

Excluding the discontinuation of WLAN chipset development and a gain of $36.3m on December's sale of Bluetooth assets to Qualcomm, for fiscal Q3/2007 net income was $34.3m (up from $23.7m the prior quarter and $16.4m a year previously), boosted by increased internal GaAs pHEMT production, increased internal assembly, and revenue growth in excess of expense growth.

For the March 2007 quarter, RFMD expects revenue of $250–260m, and to grow market share in cellular products (driven by growth in sales of Polaris cellular transceivers, as well as cellular power amplifier modules and transmit modules). "We expect our growth to be led by our industry-leading power amplifiers as well as our Polaris family of Total Radio transceiver solutions," says RF Micro Devices' president and chief executive officer Bob Bruggeworth.

Current customer forecasts indicate a less-than-seasonal decline in the company's core cellular business. Legacy 802.11b radio and Bluetooth components are expected to decline sequentially at a greater-than-seasonal rate, as a result of divestitures.

"Initial production ramps of our [high-voltage] GaN-based products and our software-based GPS solutions will commence in 2007, which we expect will contribute positively to growth, diversification and profitability," adds Bruggeworth.

"We are advancing toward our long-term operating model of 15% operating income," said Dean Priddy, who is both chief financial officer and VP, finance and administration. "With our expanded manufacturing capacity, we believe that RFMD is capable of continued revenue growth and reduced manufacturing costs."

www.rfmd.com

RFMD debuts its first GaAs pHEMT RF switch products

After investing heavily in GaAs pHEMT chip making capacity last year, at January's IEEE Radio and Wireless conference in Long Beach, CA, USA, RFMD showcased its first RF switch products (in production for initial customers).

The high-power RF1200 and RF1450 leverage the switch technology developed for use in RFMD's own transmit modules (leading to improved profit margins) and enable front-end applications in market segments including multi-mode GSM/WCDMA cellular handsets, antenna tuners, 802.11a/b/g WLAN and cellular infrastructure.

Entering the RF switch market expands RFMD's total addressable market while complementing its growing product portfolio of cellular transmit modules. The first two RF switch products enable complex front-end applications of feature-rich multi-mode handsets, improve overall RF system performance and help enable new architectures, says president and CEO Bob Bruggeworth.

RFMD's new pHEMT products.

The RF1200 is a single-pole double-throw (SPDT) switch (fabricated with a 0.5µm GaAs pHEMT process and packaged in a 2mm x 2mm, 6-pin, leadless QFN package) that meets the linearity requirements for WCDMA and features low insertion loss (0.35dB at 1GHz), low control voltage (2.6–5V), high isolation (25dB at 1GHz), and good harmonic characteristics (–80dBc at 1GHz), RFMD claims.

The RF1450 is a single-pole four-throw (SP4T) switch (packaged in a 3mm x 3mm x 0.6mm, 16-pin, leadless QFN package) designed to provide superior linearity performance for multimode WCDMA applications. Insertion loss is 0.60dB (maximum), isolation is 15dB at 2.2GHz and harmonics are –75dBc at 1GHz. Integrated decoding logic allows switch control with just two control lines.

Skyworks doubles profit

For fiscal Q1/2007 (to end-December), GaAs RFIC maker Skyworks Solutions Inc of Woburn, MA, USA reported revenue of $196m, down slightly on $198m a year ago but up 8% on the $181m for continuing operations (excluding base-band products, which Skyworks terminated in October to focus on its core analog and RF business).

On a pro forma basis, operating income was $22.9m, up 97% on the prior quarter and 65% year-on-year. Net income was a record $21.4m, up 105% sequentially. The results demonstrate the financial leverage of the new operating model, says president and CEO David J. Aldrich. "With an intensified focus on our differentiated product portfolio and increasing profitability, we plan to build on this foundation as we set the stage for several program ramps in 2007," he adds.

During the quarter, Skyworks increased EDGE and WCDMA front-end module shipments (more than doubling year-on-year), it powered Sony Ericsson's GSM/GPRS, EDGE and WCDMA Walkman series with front-end solutions, it shipped nearly 12m complete radios (up more than 30% year-on-year), it received initial Helios production orders for LG's newest GPRS Chocolate phone, it ramped Helios to support Samsung's next-generation EDGE models (including the ultra-slim Trace, the thinnest bar phone in the USA), and it secured design wins with quad-band Helios EDGE radios. The firm also supported MediaTek Inc (a supplier of complete reference designs within China) with Helios solutions, it delivered record Linear Products revenue (a fourth successive quarter of growth), it started production of direct conversion transceivers for a tier-one infrastructure customer deploying WiMAX, and it launched a mixer for GSM and EDGE base-stations in support of Ericsson.

For its fiscal Q2/2007, Skyworks expects revenue to fall to $180m, with typical handset market seasonality offset by new products.

www.skyworksinc.com

TriQuint's seventh quarter of growth driven by handset focus

For Q4/2006, TriQuint Semiconductor Inc of Hillsboro, OR, USA reported its seventh consecutive quarter of revenue growth: $114.3m, up 11% on Q3/2006's $103.3m and up 35% on $84.7m a year previously for continuing operations (and above the forecast $108–112m). Compared to Q3, handset revenue rose 24% and military revenue 26%. Net income of $6.4m was down slightly on Q3's $8.1m but more than double $2.9m a year previously.

For full-year 2006, revenues were $401.8m (up 36% from 2005's $294.8m). This was driven by handset revenue up 64% (with broadband revenue up 32% and military revenue up 11%).

TriQuint adds that it increased penetration of tier-one handset suppliers. Shipments of transmit modules were 43m (up from just 5m in 2005). Power amplifier revenue grew 2.5 times as TriQuint extended its success in GSM to EDGE/WEDGE and began sampling WCDMA base-station PAs. Revenue for optical polarization mode dispersion (PMD) modules grew 85%.

"Our strategy of being a focused supplier of RF power, filtering and switching technology in highly integrated solutions is gaining traction with both customers and chipset partners alike," reckons president and CEO Ralph Quinsey. TriQuint's design wins in 2006 placed it in about 97 new phone models. The firm estimates that its share in the handset market has now grown to 8–9%.

After equity compensation expense of $9.1m, net income was $22.4m. This is up from 2005's $4m (which included $8.2m from discontinued optoelectronic operations, mainly from their sale).

Revenue is expected to be down slightly in Q1/2007 to $106–110m. However, for full-year 2007 compared to 2006, TriQuint expects revenue up 18–20% as well as net income up 40–50%.

www.triquint.com

Anadigics eliminates losses after seventh quarter of growth

Anadigics Inc of Warren, NJ, USA, which makes RFICs and front-end solutions for wireless handsets and broadband communications, has reported full-year 2006 sales of $169.9m, up 57% on 2005's $108.3m. Net loss was cut from $31.2m to $8.9m, and pro forma loss was cut from $28.6m to just $0.5m.

For Q4/2006, sales were $49.1m (up a higher-than-forecast 10% on the prior quarter and 48% on $33.3m year-on-year) — its seventh consecutive quarter of growth. Net loss has been cut from $3.9m a year ago and $1.3m last quarter to just $0.1m. But pro forma income (excluding non-cash stock compensation expense) was $2.8m, compared to a loss of $3.3m a year ago.

Cash and short- and long-term marketable securities fell from $130.5m at the end of Q3/2006 to $83.5m, due to repayment of the firm's $46.7m in convertible notes (which matured in November).

"The company is positioned to capitalize on the rapidly growing voice, data and video segments of the wireless and broadband communications markets, where we offer 3G/3.5G products that use the W-CDMA, the HSDPA, HSUPA and EDGE standards, 4G products for WiMAX and WiBRO systems, WiFi products that use the 802.11 a/b/g and 802.11n (draft-n, MIMO) standards [for WLAN], CATV set-top box and infrastructure and FTTP products," says Dr Bami Bastani, president and CEO. In January Anadigics began production shipments of WLAN 802.11n PAs, as well as shipments of PAs for Samsung's Blackjack Windows mobile UMTS and HSDPA smartphone, following shipments of PAs supporting Qualcomm's HSPA solutions in December.

Anadigics expects Q1/2007 sales to be equal to up 3% sequentially (up 38–42% year-on-year), despite industry seasonality.

www.anadigics.com

IN BRIEF

WJ appoints Japan distributor

WJ Communications has begun a strategic partnership with Altima Corp of Shin-Yokohama (a Japanese distributor and solution provider of electronics products and design services) for the distribution of WJ's entire product portfolio (RF products and solutions for the wireless infrastructure and RFID reader markets).

"We see Japan as a significant market for growth," said Haresh Patel, WJ's senior VP sales & marketing. "Altima's strong presence and experienced professionals in Japan will give WJ's RF semiconductor and RFID line of products significant exposure in Japan," he adds. "Altima's strong sales & support team will help WJ better meet the unique market needs in Japan."

WJ says its sales partnership program is focused on strengthening its direct sales and distribution channels worldwide.

www.altimanet.com

Anadigics raises $98.8m for capital expenditure

GaAs-based IC manufacturer Anadigics Inc of Warren, NJ, USA has completed its underwritten public offering of 8.625 million shares of its common stock (including 1.125 million shares after the underwriters exercised their overallotment option in full).

The net proceeds of $98.8m will be used for general corporate purposes, including capital expenditure at its 6-inch GaAs fabrication plant, where it manufactures power amplifiers, tuner ICs, active splitters and line amplifiers for the broadband wireless and wireline communications markets.

www.anadigics.com

WJ grew 54% in 2006, tempered by Q4 wireless infrastructure slowdown

WJ Communications Inc of San Jose, CA, USA (which supplies wireless infrastructure RFICs and multi-chip modules as well as RFID reader modules) reported five-year record high revenue of $48.6m for 2006 (up 54% on 2005's $31.6m). Gross margin rose from 46% of revenue in 2005 to 51%. Operating loss was halved from 2005's $22m to $11m.

"We achieved significant year-on-year revenue growth while managing transitions in our business, including the pending closure of our wafer fabrication facility [in Milpitas, CA]," said CEO Bruce Diamond. This should yield quarterly cost savings of $1.0–1.25m upon completion, as WJ transitions to a fabless business model (outsourcing GaAs and InGaP HBT wafer production to foundry partner Global Communication Semiconductors Inc of Torrance, CA).

But for Q4/2006 revenue was $11.1m (down on Q3's $12.7m and $11.7m a year ago). Gross margin fell to 44.3% (from 55.7% in Q3 and 49.5% a year ago) due to lower revenue, a less profitable mix, a charge of $400,000 associated with the fab closure, and a rise in inventory reserve charges. Operating loss rose from Q3's $2.3m to $3.3m.

"In late 2006, the wireless infrastructure industry experienced widespread weakness in demand, and we believe this slowdown will continue into the first quarter," says Diamond.

"However, based on customer feedback and traction for our newly introduced products, we expect 2007 to be another year of growth," he reckons. During 2006, WJ introduced 21 new products (five times as many as in 2005) and secured the first major design win for its 28V InGaP HBT power amplifier products (introduced in November).

"We continue to gain traction and increase our growth opportunities across all of our target markets, with particular emphasis in wireless power, WiMax and RFID," he continued. "We believe that our aggressive product introductions in these markets will further our penetration and drive growth in 2007 and beyond. The pending closure of our wafer facility, and the associated cost savings, will provide additional improvement," he adds. WJ aims to introduce 15 new products in first-half 2007, believing the accelerated rate of product introductions will help drive future revenue growth.

www.wj.com

Hittite grew revenues 60% in 2006

Hittite Microwave Corp of Chelmsford, MA, USA, a fabless designer of ICs, modules and subsystems for RF, microwave and millimeter-wave applications, reported full-year 2006 revenue of $130.3m, up a huge 61.5% on 2005's $80.7m. This includes a slightly higher-than-forecast $35.4m in Q4 (up 2.2% on Q3 and 55.8% on $22.7m a year ago).

Net income rose 112% from $20.1m in 2005 to $42.7m in 2006. In Q4, income was $12.1m (more than the forecast $10.4–10.8m), up from $7.1m a year ago and $11.6m in Q3. Cash reserves rose $16.9m in Q4 to $122.6m at the end of 2006.

"We strengthened our business during the year in many ways, adding three new product lines, introducing 91 new standard products, and opening one new design center [in Ottawa, Canada] and two new sales offices," says chairman and CEO Stephen Daly. "For 2007, we will remain focused on growing our revenue by expanding our product lines and sales channels, and continuing to invest in our R&D team and new product pipeline," he adds.

For Q1/2007, Hittite expects revenue of $35–36m (level with Q4) and income of $11.2–11.8m.

www.hittite.com

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(NASDAQ: AXTI)

Kopin HBT sales fell again in Q4 but strong rebound expected

For Q4/2006, Kopin Corp of Taunton, MA, USA reported III-V epiwafer revenue was $9m, down 33% on $13.5m a year ago and 10% on Q3's $10m, due to an inventory correction in the market, says president and CEO Dr John C.C. Fan.

For full-year 2006, revenues for III-V products were $43.9m (up 3% from $42.7m).

Although Kopin saw some lingering effects of the III-V inventory correction in January, the company begins the new year with "a strong tailwind of demand" as wireless circuit partners shift to Kopin's newest-generation of InGaP HBTs for advanced wireless handsets, the firm says.

"We are beginning 2007 with solid momentum and our outlook for the year is favorable," says Fan. For full-year 2007, Kopin expects revenue of $80-90m (up 12-27% on 2006), with the growth rate accelerating in the second half of the year. "We have established a number of milestones for the coming months, including the expansion of our III-V production capacity," he adds.

"We are on schedule to increase HBT capacity by 50% over 2006 levels by qualifying our Taiwanese OEM and installing additional production tools at one of our Taunton, Massachusetts facilities," Fan says. "Some of our Taiwanese OEM's systems already have been qualified. In Taunton, we have taken delivery of three new Aixtron 'Integrated Concept Platform' tools.

* Kopin's results are preliminary (until the firm files its Form 10-K for 2006), since they do not take into account adjustments that may be required in connection with completion of the independent review of its past stock option grant practices (by a special committee appointed by the board of directors, assisted by independent legal and accounting experts).

Due to the review, Kopin was also unable to file its Form 10-Q report for the quarter to end-September 2006. Kopin consequently received notification that its common stock would be delisted from The Nasdaq Stock Market. On 21 November the firm requested a hearing before the Nasdaq Listing Qualifications Panel, which was held on 18 January. Subsequently, the panel has determined to stay the delisting, subject to the conditions that Kopin:

- by 11 April provides the Nasdaq Hearings Department with the special committee's final investigatory report, which must answer a series of questions about its investigation (in lieu of the final report, the company must provide the Hearings Department with specific written responses to such questions); and
- by 14 May becomes current in its delinquent periodic reports, and files any required restatements.

Otherwise, the panel will suspend trading of the stock, unless the Nasdaq Listing Council elects to review the case and stay delisting.

www.kopin.com

AXT's last quarter yielded return to profit in 2006

AXT Inc of Fremont, CA, USA has reported revenue for Q4/2006 of $13.1m (up 4.2% on Q3's $12.5m and 70% on $7.7m a year ago). This comprised substrate revenue for GaAs of $11.1m (up 4.7% from Q3's $10.6m), for InP of $456,000 (up from $340,000), and for Ge of $318,000 (down from $387,000), plus raw materials revenues of $1.2m (compared with $1.3m).

"We were able to achieve tremendous yield improvements and cost reductions in nearly all areas of our manufacturing process, including longer [GaAs] ingot growth and shorter cycle times in crystal growing, and less material losses during slicing," says CEO Phil Yin. "These yield improvements and cost reduction programs helped to drive our gross margins to 38.2% in the fourth quarter [from 27.7% in Q3] and allowed us to achieve profitability sooner than we had expected."

Operating expenses were $3.8m (down from Q3's $4.5m, which included a $1.4m impairment charge to write down the firm's US property). Compared with operating losses of $3.4m a year ago and $971,000 in Q3/2006, Q4 yielded an income of $1.2m. Net income rose from just $639,000 in Q3 to $3.4m (including a gain of $1.3m from selling the firm's remaining shares in Finisar Corp).

For full-year 2006, revenue was $44.4m (up 67.5% from 2005's $26.5m), driven by "strong market conditions, positive customer reception for our products and solid company-wide execution of our plans", says Yin. Gross margin rose from just 8.3% to 28.7%. Net income was $944,000, compared with a loss of $12.2m in 2005. The last time the company achieved profitability was in the year 2000.

For Q1/2007, AXT expects revenue to rise slightly to $13.1–13.6m.

- In December, AXT raised $28.1m in a public offering of shares. Together with $16m already in hand, the $44m available will be used for 'general corporate purposes', including capacity expansions for substrates and raw materials, and the acquisition of 'complementary technology'.

www.axt.com

RFMD's military orders to boost GaN foundry strategy

In its report 'RF Micro Devices Adds GaN Foundry Strategy to Maintain Leadership in Compound Semiconductor Industry' market research firm Strategy Analytics concludes that RFMD has developed a coherent strategy to pursue developing markets for GaN.

Although RFMD has traditionally focused on high-volume consumer markets for its products (with its compound semiconductor revenues exceeding $700m in 2006, reckons Strategy Analytics), involvement from the US Department of Defense has helped it speed development of GaN, culminating in orders in January from a military system maker, validating its GaN product line with the commercial RF infrastructure sector and other markets.

Strategy Analytics says that this will help RFMD's strategy of becoming a low-cost GaN foundry that can serve a broad range of markets looking for GaN expertise, giving it an additional revenue line with strong growth potential.

Strategy Analytics forecasts that the GaN microelectronic device market will grow at a compound annual growth rate (CAGR) of 151% through to 2010, with military applications accounting for 50% of demand. It also believes that SiC will remain the dominant substrate through 2010.

"RFMD has taken advantage of existing process lines and equipment while choosing to focus on 3-inch production only for its GaN operations using SiC bulk substrates exclusively as the starting material," notes Asif Anwar, director of Strategy Analytics' GaAs and Compound Semiconductor Technologies. "This has allowed RFMD to minimize capital expenditure and ramp-up quickly to commercial production levels."

"The military sector offers a high-value revenue stream that can offset the cyclical nature of RFMD's other business units," adds Stephen Entwistle, VP of the Strategic Technologies Practice. "Receiving orders from the military sector will further validate the maturity and reliability of RFMD's GaN process with the commercial RF infrastructure industry, while the foundry strategy will allow the company to target areas outside of the RF infrastructure market."

www.strategyanalytics.net

Fujitsu develops GaN HEMT amplifier for mobile WiMAX

After starting joint development in May 2006, telecoms company KDDI Corp and Fujitsu Ltd (both of Tokyo) have produced a practical, prototype high-efficiency transmitter amplifier (based on GaN HEMT technology developed by Fujitsu Laboratories Ltd) for the IEEE 802.16e-2005 mobile WiMAX wireless broadband communications protocol.

To reduce both infrastructure and operating costs required for mobile WiMAX systems, KDDI has been exploring ways to make base-stations smaller and more energy-efficient. Fujitsu has optimized the design of the amplifier circuits for higher efficiency and improved its 3G-proven digital pre-distortion technology (distortion-compensation technology in which a signal that can offset the distortion generated by an amplifier is added in advance to the amplifier's input signal).

The resultant prototype transmitter amplifier achieves a power output of 25W operating in the 2.5GHz frequency band at a power efficiency of about 30% for orthogonal frequency division multiplexing (OFDM) 16QAM signals (double the efficiency of conventional amplifiers used with currently available 3G systems, it is claimed).

Since amplifiers can dictate base-station performance, high efficiency can enable equipment benefits such as downsizing, lighter weight, greater power efficiency, less noise, and reduced maintenance. Deployment is expected to roughly half the size and power requirements of outdoor base-stations compared to conventional amplifiers, enabling a significant reduction in equipment space requirements. Improved efficiency also enables downsizing of collateral infrastructure such as air-conditioning equipment and power sources (e.g. back-up batteries), further reducing the costs of mobile WiMAX base-stations. The development paves the way for practical use of GaN HEMT-based high-efficiency amplifiers, says Fujitsu.

Fujitsu aims to enable practical use of the amplifier for mobile communication base-stations, including mobile WiMAX. From this year, in addition to embedding it into systems, Fujitsu plans to initiate a standalone business focused on power amplifiers for broadband wireless networks.

www.fujitsu.com

www.kddi.com

GaN-on-Si HEMT project funded

The Deshpande Center for Technological Innovation (part of the Massachusetts Institute of Technology's School of Engineering) is awarding $628,000 in spring 2007 grants to seven MIT research teams.

Recipients include a $50,000 'Ignition' grant for Tomás Palacios (assistant professor in the Department of Electrical Engineering and Computer Science and the Microsystems Technology Lab) for the project 'Gallium Nitride High Electron Mobility Transistors'. This will investigate GaN fabrication technology using silicon substrates to reduce the cost and improve the performance of electronic products.

"Our goal is to assist in bringing MIT research projects out of the labs," said Leon Sandler, executive director of the Deshpande Center.

http://web.mit.edu/deshpandecenter

Kopin's GaN HEMTs qualified for production for wireless base-stations

GaAs-based HBT epiwafer supplier Kopin Corp of Taunton, MA, USA says it has developed GaN HEMTs for use in next-generation military, public mobile radio, WiMAX and WCDMA base-station products. The total addressable market for such GaN infrastructure products is estimated to be as high as $1bn annually, providing strong future revenue growth potential, the firm reckons.

"As the world's largest supplier of epitaxial wafers grown by metal organic chemical vapor deposition, Kopin is committed to providing our customers with high-performance, high-quality GaN HEMT products by utilizing our infrastructure," says president and CEO Dr John C. C. Fan. "Since 2004, we have been working with several US companies on the development of our GaN HEMT products, and we are delighted that a leader in GaN-enabled base-station products has recently qualified these wafers for production."

"The superior electrical properties of GaN enable transistors with unparalleled levels of high power densities over wide frequency ranges," says chief technology officer Dr Hong Choi. "GaN HEMTs can provide higher-efficiency, more compact solutions than competing technologies for a variety of commercial and military systems, including wireless base-stations, X-band radar, millimeter-wave military communication links, and electronic warfare," he adds.

Kopin has focused on using silicon carbide substrates, but efforts have also been extended to other starting materials, including sapphire.

www.kopin.com

Nitronex and Rockwell Collins to co-develop GaN-on-Si power transistor manufacturing for military applications

Nitronex Corp, which manufactures GaN-on-Si RF power transistors for the commercial wireless infrastructure and broadband markets, is to further develop manufacturing infrastructure for military applications after teaming with Rockwell Collins, which develops and deploys communication and aviation electronics solutions for both commercial and government applications. Specifically, Rockwell Collins' Government Systems provides defense electronics products and systems (including communication, navigation and integrated systems for airborne, ground and shipboard applications) to the US Department of Defense and foreign militaries.

Funded by the US Air Force Research Lab (AFRL), the manufacturing technology program began in Q4/2006 and is expected to continue through 2009. "The approval of funding from the US military validates that GaN-on-Si is a significant technology platform for the development of future communication systems," says Kevin Linthicum, Nitronex's chief technology officer & VP Engineering.

The agreement between Nitronex and Rockwell Collins is expected to accelerate the development of the manufacturing technology process for GaN-on-silicon infrastructure.

www.nitronex.com
www.rockwellcollins.com

New MMIC product development manager

Nitronex has appointed Bernard D. Geller (an IEEE senior member) as MMIC product development manager.

"His experience [wireless communication design and development] will help us continue to push the boundaries of GaN-on-Si technology and explore new approaches to RF product design," said Chris Rauh, VP of sales & marketing.

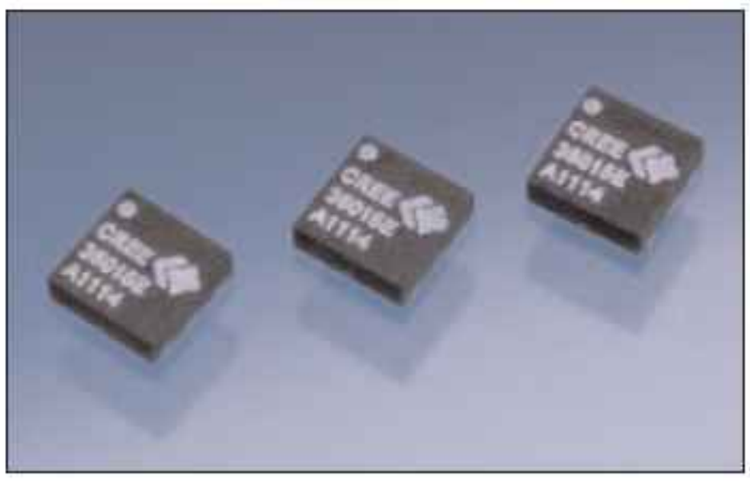
Nitronex recently relocated from Raleigh, NC to Durham, NC where, coincidentally, Geller was manager of RF Design at Mitsubishi Electric Design Engineering Center-East (also in Durham), where he developed GaAs MMIC power amplifiers and switches for satellite communication applications. Prior to that, he was manager of Integrated Components at Sarnoff Corp (developing integrated RF subsystems using multilayer ceramics) and manager of the Microwave Circuits Department at COMSAT Laboratories (developing high-efficiency and high-linearity power amplifiers for satellite communication systems).

Geller holds 22 US patents, and has been chair of the MTT Technical Committee on Wireless Communications and chair of the International Microwave Symposium's Technical Program Subcommittee on Wireless Communications.

Cree samples high-efficiency GaN HEMTs for WiMAX PAs

Cree Inc of Durham, NC, USA is shipping sample quantities of three new GaN HEMTs. Optimized for high efficiency, high gain and wide bandwidth, the devices provide exceptional linear power and efficiency for WiMAX and broadband wireless access applications operating at 2.3–3.9GHz, the firm claims.

The CGH27015S operates over the 2.3–2.9GHz frequency range, with typically 2.5W of average output power and 28% drain efficiency (up to a 40% improvement over traditional technologies such as silicon LDMOS or GaAs under 802.16-2004 WiMAX signals and requirements). Small-signal gain is 15dB and error vector magnitude (EVM) is 2.0% under orthogonal frequency-division multiplexing (OFDM) modulation when operated at 28V.



Cree's CGH35015S GaN HEMT.

The CGH35015S (also in an over-mold QFN package) operates over the 3.3–3.9GHz range, with typically more than 2.5W of average output power and 28% drain efficiency (up to a 50% improvement). Typical small-signal gain is 13dB.

The CGH35030F operates over 3.3–3.9GHz with 4W of average output power and 23% efficiency. Small-signal gain exceeds 11dB and EVM is 2% under OFDM modulation.

When used in an efficiency-enhancement circuit, a pair of these transistors produced more than 10W of average power with over 42% efficiency in the 3.5GHz WiMAX band.

The small 3mm x 3mm plastic over-mold QFN packages of the CGH27015S and CGH35015S allow the use of low-cost, high-speed assembly methods, while preserving outstanding RF performance with a RoHS-compliant device, says Jim Milligan, business area manager for RF products. "The CGH35030F provides further flexibility for RF designers needing additional power at high efficiency to enable new system architectures such as distributed wireless base stations employing remote radio heads," he adds.

www.cree.com/wireless

TranSiC, KTH and Acreo share €1.3m in Swedish government funding to develop SiC power modules

Sweden's government is providing €1.3m in funding for a three-year collaborative project between Royal Institute of Technology (KTH) in Kista, TranSiC AB, which makes SiC-based power bipolar junction transistors (BJTs), and research institute Acreo (also of Kista). The aim is to develop new SiC power modules.

Support comes from VINNOVA (the government agency for innovation systems) and Energimyndigheten (the Swedish Energy Agency), which gave initial support to TranSiC when it was spun off from KTH in 2005.

"Our support for SiC components is a logical step from our earlier financial contributions in the area of manufacturing of silicon carbide material," says Svante Söderholm, project manager at the Swedish Energy Agency which, together with VINNOVA, previously provided €6m in Swedish government funding over three years to Norstel AB of Norrköping, Sweden (which was spun off from Finnish silicon wafer maker Okmetic Oyj in 2005).

Via development and device fabrication performed in the Electrum Laboratory in Kista (where a 4" wafer line suited to SiC device technology is available), TranSiC was the first company to offer SiC power transistors on the market, it is claimed. The firm says that its BitSiC (bipolar power transistor in SiC) components have very low switching losses, high breakdown voltages and can handle high currents.

TranSiC made available engineering samples of its first product in Q2/2006 (the BiTSiC 1206 for applications at V_{max} = 1200V, 2A and operating junction temperatures of up to 175°C). The goal is to have a 30A prototype device by the end of 2007, plus a packaged prototype able to handle 225°C.

Applications include compact motor control (exceeding 1kW), e.g. in next-generation hybrid-electric vehicles (HEVs), where high temperatures are normally a great problem for current silicon transistors. The project also has a very strong bond to the Swedish automotive industry, says TranSiC, as well as to the Lund Institute of Technology and Chalmers University of Technology in Göteborg. Last November TranSiC raised €0.44m ($0.6m) in first-round venture funding led by Volvo Technology Transfer Corp. "For the automotive industry, managing power electronics is an increasing challenge. TranSiC's products increase design flexibility and efficiency of hybrid drivelines," said VTT's investment director Johan M Carlsson at the time.

Much of the funding will be spent on developing SiC epitaxy, packaging, discretes and modules, improved structures for higher breakdown voltages, and higher current operation. CEO Bo Hammarlund says the support will make a big difference to TranSiC in promoting its products to customers in Europe, USA and Japan, for whom the development of packaging technology for high-temperature applications is key.

www.transic.com

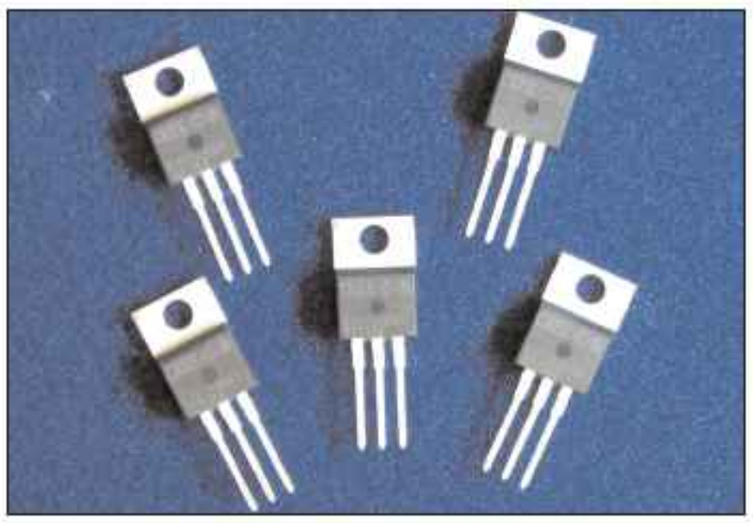
Cree launches high-power, 50A SiC Schottky rectifier

Cree Inc of Durham, NC, USA is shipping production quantities of a new 50A Zero Recovery SiC Schottky rectifier operating at 1200V. Its existing range of 300–1200V rectifiers have current ratings up to 20A.

Cree says the CPW2-1200S050 is a power-handling device that can greatly improve levels of efficiency in power inverters, enabling applications such as solar and wind power converters, industrial motor drives and electric vehicles to increase operating efficiency.

Compared with traditional silicon diodes, Cree says that the SiC-based Zero Recovery rectifiers can:

- simplify power factor correction (PFC) boost design by eliminating snubbers and reducing the component count.



50A Zero Recovery Schottky rectifier.

- reduce power losses, leading to cooler operating temperatures;
- produce significantly less electromagnetic interference (EMI);
- better support new design objectives for efficiency set forth by the US Environmental Protection Agency, California Electric Commission, and other agencies.

Recent Cree advances in material quality has allowed it to expand its product offerings to much higher powers, opening new applications, says John Palmour, executive VP for advanced devices.

Cree claims the CPW2-1200S050 features the industry's largest-area SiC die (8.2mm x 4mm). Fundamental to the advances in chip area and power level are very low defect density substrates, including zero micropipe SiC substrates, enabled by research performed by Intrinsic Semiconductor (acquired in 2006) in combination with research efforts funded by the US Defense Advanced Research Projects Agency (DARPA) and the Army Research Laboratories.

www.cree.com

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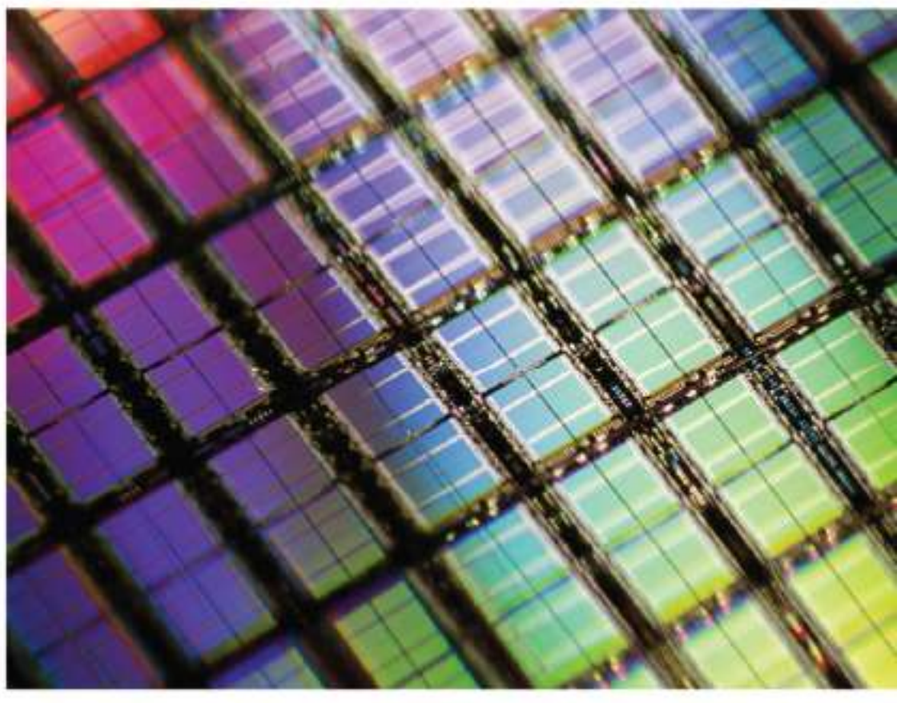

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Axiom ramping production of GSM type-approved CMOS PA

In February, Axiom Microdevices Inc of Irvine, CA, USA raised $25m in a Series C round of funding (led by Tallwood Venture Capital and joined by existing investors US Venture Partners, Anthem Venture Partners, and VentureTech Alliance). The funds are being used to ramp production of the firm's first-generation CMOS power amplifiers (PAs) and to develop its product roadmap.

Founded in 2002 with patented technology developed at the California Institute of Technology, Axiom claims to be the first firm to provide cell-phone PAs fully integrated on a single CMOS silicon die (using commodity 130nm process technology).

"We are providing handset manufacturers with the time-tested advantages of mainstream CMOS through integration," says CEO Brett Butler. "CMOS integration has been instrumental in driving down the cost of cellular handsets over the past 10 years," adds Ron Yara, general partner of Tallwood Venture Capital. "Handset makers must continue to fully utilize mainstream CMOS if they are to satisfy cost and supply continuity needs," he claims.

In late February, Axiom said that its AX502 CMOS PA (designed into a cellular handset) had completed full type approval (FTA) testing for compliance with GSM specifications and performance requirements. Its reliability had already been proven through thousands of hours of life testing at accelerated operating conditions, including load mismatches of 15:1 VSWR (voltage standing wave ratio) and elevated supply voltages.

Axiom's technology allows the use of mainstream 130nm CMOS silicon process technology to integrate full quad-band GSM/GPRS PA functions (all of the functions between transmitter output and transmit/receive switch, including power gain stages, small-signal control circuitry and 50Ω matching) on a single die.

"The cellular handset industry is now starting to enjoy the benefits that accompany moving the last major RF function into mainstream CMOS," said Donald McClymont, VP of marketing. This development will enable "new levels of integration and new cost points," he claims.

www.axiom-micro.com

Axiom appoints VP of operations

Axiom has appointed Gary Cheek as VP of operations, responsible for building and leading its operations team and ramping production of its CMOS power amplifiers.

Cheek has more than 20 years of experience in engineering and manufacturing operations. Before joining Axiom, he was responsible for foundry operations at Analog Devices Inc (ADI) and Conexant Systems Inc. At ADI, his responsibilities included engineering and manufacturing operations, from business relationships to capacity rationalization and yield management. At Conexant, he led its move to a fabless manufacturing model and was responsible for front-end and back-end operations, overseeing all manufacturing, facilities, quality, supply-chain management, manufacturing business operations and procurement. Cheek has also been an executive for several startups as well as an operations management consultant.

Intel and AmberWave settle strained silicon patent infringement lawsuit with 10-year license agreement

Intel of Santa Clara, CA, USA and AmberWave Systems Corp of Salem, NH, USA have settled all patent infringement suits pending between them related to AmberWave's strained silicon patent portfolio.

Under the agreement, Intel has received a license to all AmberWave patents and patent applications either existing today or filed during the agreement's 10-year term.

The firms have also agreed to continuing discussions and evaluation of AmberWave's ongoing technology R&D efforts. Intel will make license payments to AmberWave over the duration of the agreement.

Founded in 1999, AmberWave researches, develops and licenses materials technology, including strained silicon, for high-speed electronic and optoelectronic chips. It says that its strained silicon technology is the result of more than 15 years of research at MIT, AT&T Bell Labs and its own research facility. AmberWave has a 5000ft^2 cleanroom and a portfolio of over 150 issued and pending patents. It also offers manufacturing and technical support services enabling licensees to integrate its technology into manufacturing processes.

Last July AmberWave raised $25m in a Series E round of funding (adding to the $66.7m it raised in its four previous rounds).

www.amberwave.com
www.intel.com

IBM and Intel develop high-k gate dielectric transistors

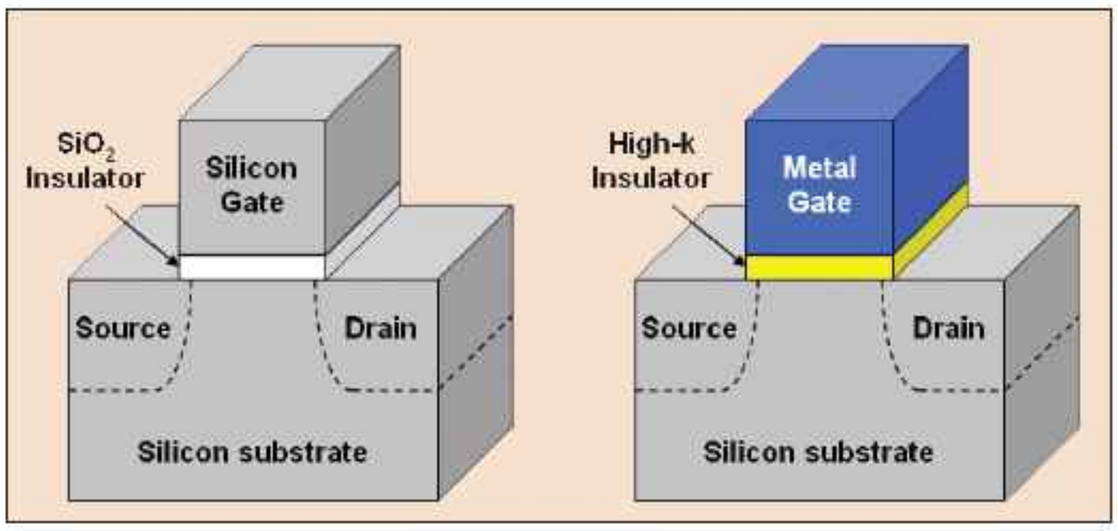
Both IBM and Intel have announced the development of transistors that use a high-dielectric-constant (high-k) gate oxide layer.

For over 40 years, ICs have been based on silicon CMOS transistor technology incorporating a SiO_2 dielectric layer that insulates the transistor's conducting channel from the gate electrode that switches current flow in the channel on and off. Shrinking the transistors' dimensions (including the gate dielectric layer thickness) has sustained Moore's Law (the doubling every 12–18 months of the number of transistors on a chip and hence chip performance and function).

However, using the established materials and transistor design, the thickness of the SiO_2 gate dielectric layer is down to just 1.2nm thick (five atomic layers) in Intel's 65nm process technology. The shrinking leads to increased current leakage through the gate dielectric (causing wastage of electric current and unnecessary heating), recognized as one of the most formidable technical challenges facing Moore's Law.

For its 45nm transistor technology, Intel replaced SiO_2 with a hafnium-based high-k gate dielectric material (deposited using atomic layer deposition). This allows the use of a thicker layer with the same electrical capacitance, reducing current leakage more than 10-fold compared to using silicon dioxide.

But the high-k gate dielectric is incompatible with existing polysilicon gate electrodes, causing two fundamental problems: threshold voltage pinning (Fermi-level pinning) and phonon scattering, which both cause lower transistor performance. So, Intel has also developed a transistor gate electrode that uses a new combination of unspecified metal materials compatible with hafnium (using different combinations for the complementary NMOS and PMOS transistors in CMOS).



Standard (left) and high-k/metal gate (right) transistors.

Intel claims to be first to implement a combination of high-k gate dielectric and metal gates in 45nm process technology. "The implementation of high-k and metal materials marks the biggest change in transistor technology since the introduction of polysilicon gate MOS transistors in the late 1960s," says co-founder Gordon Moore.

Intel claims that the combination of the high-k gate dielectric with the metal gate for its 45nm process technology provides more than a 20% increase in drive current (or higher transistor performance) while conversely reducing source–drain current leakage more than five-fold, improving the energy efficiency of the transistor. "Our implementation of novel high-k and metal gate transistors for our 45nm process technology will help Intel deliver even faster, more energy-efficient multi-core products that build upon our successful Intel Core 2 and Xeon family of processors, and extend Moore's Law well into the next decade," claims senior fellow Mark Bohr.

Intel has five early-version 45nm processors working (targeted at five different market segments), running Windows Vista, Mac OS X, Windows XP and Linux operating systems, as well as various applications. These are the first of 15 planned 45nm processors (codenamed 'Penryn') across desktop, mobile, workstation and enterprise segments. Intel plans to put its new transistors in the next-generation family of Intel Core 2 Duo, Intel Core 2 Quad and Xeon multi-core processors. The firm says it remains on track for 45nm production in second-half 2007.

Meanwhile, working with AMD and its other development partners Sony and Toshiba, IBM has also substituted SiO_2 with "a new, higher-k gate dielectric material" that provides superior electrical properties, enhancing the transistor's function while allowing its size to be shrunk beyond existing limits. This clears a path toward chip circuitry that is smaller, faster and more power-efficient than previously thought possible, the firm adds.

"Until now, the chip industry was facing a major roadblock in terms of how far we could push current technology," says Dr T.C. Chen, IBM Research's VP of Science and Technology. "After more than 10 years of effort, we now have a way forward." The development should ensure the future of CMOS-based logic using silicon-based transistors and Moore's Law well into the next decade, the firm reckons.

IBM adds that the technology can be incorporated into existing chip manufacturing lines with minimal changes to tooling and processes, making it economically viable. The firm has already inserted the technology into its manufacturing line in East Fishkill, NY and will apply it to products with chip circuits as small as 45nm starting in 2008.

www.intel.com
www.research.ibm.com

IN BRIEF

Silicon-based LNAs for UMTS/HSxPA and WLAN

At February's 3GSM World Congress 2007 in Barcelona, Spain, Infineon Technologies of Munich, Germany launched what it claims is the first commercial silicon-based low noise amplifiers (LNAs) that offer better performance-price ratio compared to GaAs alternatives while also helping compliance with 3GPP regulations.

Based on its carbon-doped silicon germanium (SiGe:C) process, the BGA700L16 is a dual-band LNA for wireless LAN (802.11a/b/g/n) systems and the BGA734L16 is a tri-band LNA for UMTS or HSxPA applications. Sample quantities are shipping in 2.3mm x 2.3mm x 0.39mm TSLP-16 packages, suiting low-profile multimedia phones and highly integrated WLAN modules. Volume production was scheduled for April.

The BGA700L16 integrates a single-stage amplifier for the 2.45GHz band and a two-stage amplifier to meet the requirements of the 4.9–5.95GHz band. The chip has a noise figure of just 1.3dB at 5.5GHz and features internally matched inputs and outputs, shut-down mode and temperature stabilization.

Integrating three amplifiers for the 800MHz, 1.9GHz and 2.1GHz cellular bands on one chip, the BGA734L16 has a noise figure of just 1.2dB for the 2.1GHz band. It also has a temperature-stabilizing circuit, 1kV ESD protection and an output matching network (50Ω). It provides gain control for a better dynamic range and system performance in environments with high levels of interference. Also, controlled gain offers the benefit of extending battery life.

www.infineon.com

Cenamps to provide ALD foundry using Oxford Instruments tool

The Centre of Excellence for Nano, Micro and Photonic Systems (Cenamps) in Newcastle, UK (which is funded by the One NorthEast regional development agency) has chosen a FlexAL atomic layer deposition tool from Oxford Instruments Plasma Technology for its new ALD Foundry, which will begin operations in July.

The foundry service is aimed at organizations wanting to explore commercial applications of ALD films, and to research and trial the precisely controlled and conformal coatings that ALD can offer, says Dr David Robbins, Cenamps' chief technology officer. ALD can be applied to not only silicon technology but also micro-mechanical devices, nanotechnology, optoelectronics, and plastic electronics. The FlexAL's versatile design allows Cenamps to offer a wide range of ALD coatings, he adds.

"We see the Cenamps foundry service as key to realising the benefits ALD can bring to these new areas, by enabling organizations to explore ALD at low commercial risk," says Chris Hodson, an applications specialist at Oxford Instruments, which believes that the foundry service will enable product innovation in a range of industries.

Oxford Instruments launched the FlexAL ALD system in 2006, combining remote plasma processes with thermal ALD to enable a wide choice of materials and precursors for ultra-thin film deposition, in addition to low-temperature processes and the ability to handle from small wafer pieces up to full 200mm wafers.

www.cenamps.com

FZ Jülich orders ALD & AVD modules for CMOS gate stacks & Si nanowires

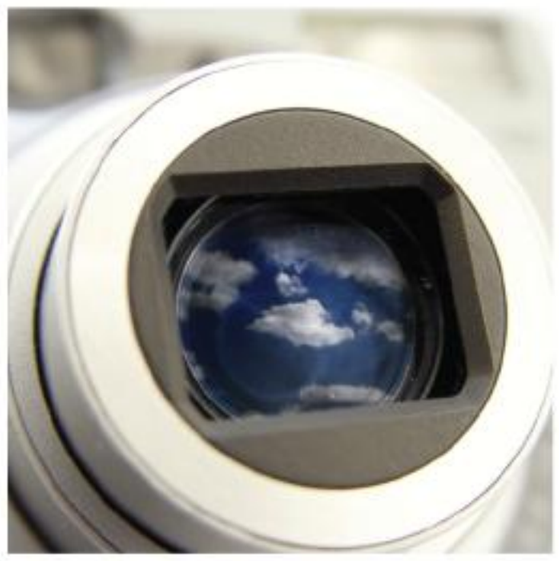
In Q4/2006, within the framework of a project funded by Germany's BMBF (Federal Ministry of Education and Research), Forschungszentrum bought two Tricent deposition modules from Aixtron of Aachen, Germany, for the development of advanced thin-film processes for CMOS transistor gate stacks and silicon nanowire structures. Also, as part of the process and material development work, FZ Jülich and Aixtron have a cooperation and demonstration laboratory agreement.

FZ Jülich will use Aixtron's Tricent atomic layer deposition module to deposit alternative high-k dielectric films, and a Tricent atomic vapor deposition module to deposit metallic/metal nitride electrode films. Both modules will be added to the automated 200/300mm wafer handling platform, which is already equipped with a Tricent CVD module for SiGe processing.

"New advanced materials are key for faster transistors," says professor Siegfried Mantl of FZ Jülich's Institute of Bio- and Nano-Systems (IBN). The BMBF funding for FZ Jülich is aimed at strengthening research on silicon, particularly for innovative silicon-based nano-electronics, he explains. one of the Jülich developments. The integration of the new modules onto the cluster tool allows the synthesis of new materials on the atomic scale. "We will be capable of growing highly uniform high-k dielectric films down to a few atomic layers on large-area structured wafers," Mantl adds. Combined with FZ Jülich's strained silicon on insulator (SSOI) technology and the thin-film deposition of metal nitride electrodes, IBN will implement enabling technology for the development of powerful nano-transistors, he concludes

www.aixtron.com

Focus



on the future...

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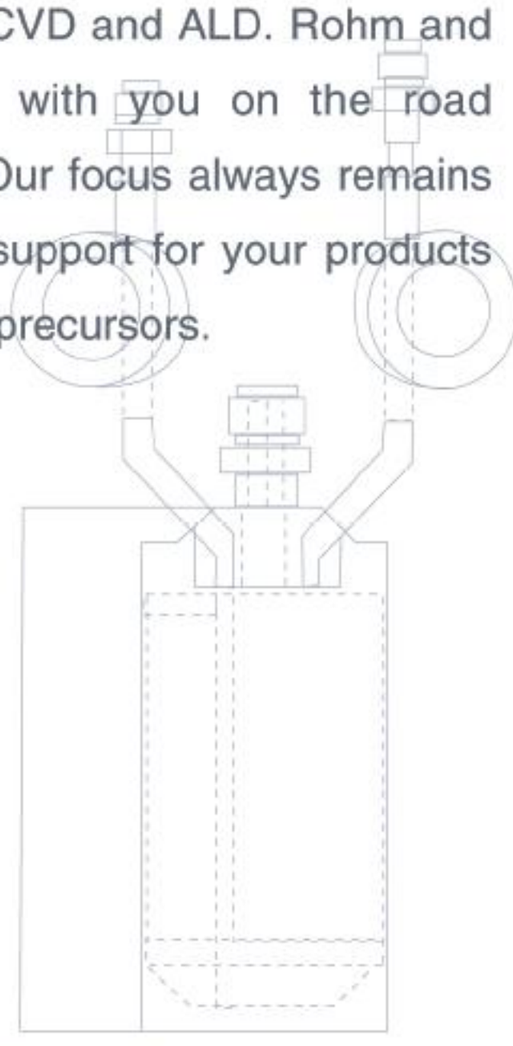

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Sigma-Aldrich buys Epichem

Epichem Group Ltd of Bromborough, UK, which supplies high-purity gases and chemicals (including metalorganic precursors), has been acquired for $60m in cash by Sigma-Aldrich Corp, which is based in St Louis, MO, USA. Sigma-Aldrich aims to expand the Hitech segment of its SAFC business (which is one of the world's 10 largest fine chemical businesses, with annual sales of nearly $437m in 2005).

Sigma-Aldrich reckons that Epichem's $40m in annual revenues will help it to achieve its growth goals in key high-technology markets over the next several years, as well as will being neutral to mildly accretive to earnings in 2007, with no significant initial charges.

Barry Leese, Epichem's co-founder, managing director and majority equity holder, has been appointed president of SAFC Hitech. Epichem's management and employees will remain in place.

"Epichem's strong product portfolio and solid relationships with key end-users and equipment suppliers brings important new global customer relationships to SAFC Hitech," says SAFC's president Frank Wicks. "Their experienced team, capabilities and contacts combined with SAFC's industry-leading development, manufacturing, global footprint and financial strength will allow us to provide the electronics industry with even better specialized, high-quality materials," he claims. Sigma-Aldrich employs 7300 staff across 35 countries.

"This venture pairs solid development and commercial manufacturing capabilities with a robust product portfolio and customer-centric collaborative R&D process, strongly positioning us to become a leading supplier and developer of new materials," says Leese.

"The semiconductor industry continuously demands fresh materials and architectures to improve power, performance and density to deliver next-generation advanced technology products," adds Arvind Sodhani, president of Intel Capital (the sole investor in financing Epichem in October 2005). "Epichem is an innovator in semiconductor materials and the combination with Sigma-Aldrich brings together complementary strengths."

www.sigma-aldrich.com

Synova to license Laser MicroJet technology

Synova of Lausanne, Switzerland has unveiled a strategic business model allowing select partners to license its Laser MicroJet technology (patented water jet-guided laser technology for use in the volume production of semiconductors, flat-panel displays, solar cells, medical instrumentation and automotive devices).

Founded in 1997 and with more than 60 fully operational systems at customer sites worldwide, Synova will continue to develop, sell and service its own Laser MicroJet-based products. But it will also offer non-exclusive licenses of its Laser MicroJet module (comprising a coupling unit, laser-source and water pump) for integration into both end-user and equipment manufacturer systems.

In end-user licensing agreements, the module is available for purchase royalty free. Modules are also available to equipment manufacturers under a prefixed, royalty-based licensing agreement. To encourage long-term collaboration, agreements will also encompass technology and knowledge transfer. Synova says its representatives will work closely with licensees to ensure effective integration of the Laser MicroJet to help maintain optimal process flexibility for end-users.

"This move to expand our infrastructure through strategic licensing agreements is a critical part of our growth strategy to serve Laser MicroJet users on a global scale," says CEO Bernold Richerzhagen.

By creating a network of strategic channel partners, Synova says the licensing model will facilitate a new revenue stream, and position its technology in additional global markets and applications as well as enabling an increase in production, service and distribution capacity. It will also allow the firm to focus on customers in its core industries: semiconductors, flat-panel displays, solar energy, medical instruments, and automotive. Primary target applications include dicing and edge grinding of wafers.

While continuing to target such core markets, Synova is also moving into fields such as photovoltaics/solar cells. In addition, the firm is opening its technology to R&D institutions and universities to foster development of advanced applications. Last year, Synova opened micromachining centers (MMCs) for demonstration, test and development of new applications in Fremont, CA (Silicon Valley); Boston, MA; Kyoto, Japan; and Seoul, Korea.

Synova is currently in negotiation over licensing partnerships, which it plans to unveil throughout the year and beyond.

●Synova has appointed Notker Kling as general manager of North American operations, chartered with overseeing its two US MMCs (due to become fully operational by end-Q1/2007) and continuing to leverage them to better serve the company's customers in the region. His responsibilities are aligned with Synova's aim to build worldwide adoption of Laser MicroJet technology in its key markets.

www.synova.ch

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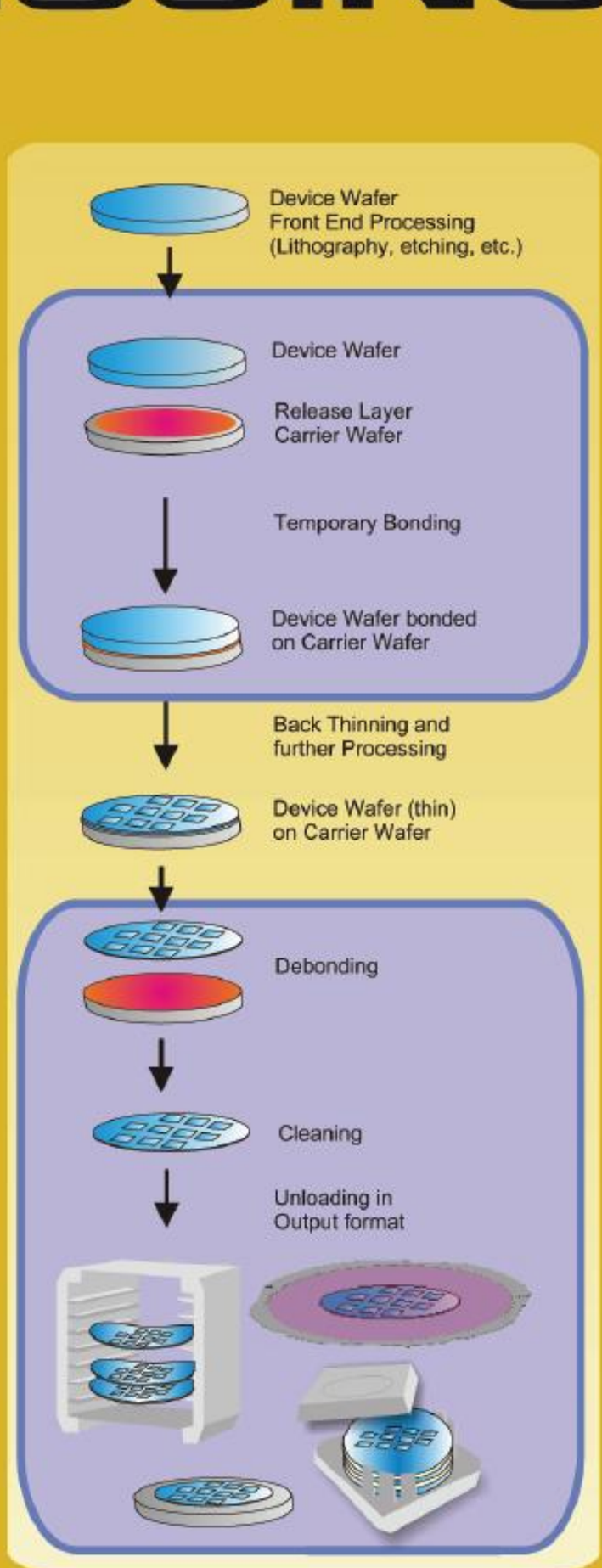

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Aixtron's 23% growth in 2006 drives return to profitability

Deposition equipment maker Aixtron AG of Aachen, Germany has reported revenues of €171.7m for 2006, up 23% on 2005's €139.4m. This was boosted by fourth-quarter revenue of €63.1m, up a massive 54% on Q3's €40.9m.

The firm says the rise is due to a more positive market environment for semiconductor equipment, the expanded range (following the integration of atomic layer deposition and chemical vapor deposition equipment maker Genus Inc, acquired in March 2005), and improving demand for newly launched MOCVD products.

By region, total revenues were:

- 79% from Asia (up from 74% in 2005);
- 13% from Europe (down from 16%);
- just 8% from the USA (down from 10%).

By applications, revenues were:

- 44% from LEDs (especially in Asia);
- 32% from silicon;
- 5% for consumer/optoelecronics;
- 19% from displays and other applications.

President and CEO Paul Hyland recalls that Aixtron's aim at the beginning of 2006 was to reduce its dependence on revenues from compound semiconductor applications. From 82% of revenues in 2004 and 58% in 2005, the proportion was 56% in 2006 (based on 19% growth in revenue to €97m for compounds). This trend has developed as silicon-related revenues have grown from just 1% of total revenues in 2004 to 23% in 2005 (boosted by the Genus acquisition) and now 27% in 2006 (to €46.1m).

The increased revenues, plus the review of costs and operating practices, yielded net income of €5.9m in 2006, compared to its target of break-even for 2006 and a net loss of €53.5m in 2005.

Total equipment order intake was €178m (up 57% on €113.6m in 2005). Equipment order intake for compound semiconductors was €136.8m (up 79%, from 67% of total orders in 2005 to 77% in 2006), reflecting a significant mid-year rise in demand from LED end-application markets, as well as current confidence in the sector and customers' positive response to new products launched at the end of 2005 (which comprised a third of all orders). Equipment orders for silicon were €41.2m (up 11%, though down from 33% of orders in 2005 to 23% in 2006). This growth was based on robust demand for CVD equipment for memory applications. Although demand for silicon systems has historically been more volatile than demand for compounds, demand for traditional CVD technology has been relatively stable for five quarters now, says Hyland.

While order intake for compounds will be more muted in early 2007, says Hyland, Aixtron believes that 2007 revenues will remain at a healthy level for both compound semiconductor and silicon applications. Equipment order backlog at the end of 2006 was €85.1m (up 75% on €48.6m at the end of 2005). This was split 87%/13% between compounds and silicon (compared to 76%/24% at the end of 2005). So, for fiscal 2007, Hyland expects revenues of €190–200m and a profit of €15–16m.

www.aixtron.com

Veeco's HB-LED/wireless revenues grew 42% in 2006

Veeco Instruments Inc of Woodbury, NY, USA has reported Q4/2006 revenue of $123.1m (up 9% on $112.8m a year ago). Of total sales, 63% was process equipment (including MOCVD and MBE systems) and 37% was metrology equipment. Net income was $7.6m (up from $2.7m a year ago), which was significantly above Veeco's guidance.

Bookings were $109.1m (up 6% on a year ago), at the low end of Veeco's guidance ($115±5%). This was due to a pause in data storage capital equipment purchases (20% of total orders, compared to 37% of sales), partially offset by strength in high-brightness LED/wireless and scientific research (28% and 34%, respectively, compared to 22% and 26% of sales). "We continue to benefit from a diverse market strategy," says CEO Edward H. Braun.

Full-year 2006 revenue was $441m (up 8% on 2005's $410.2m): 61% process equipment and 39% metrology equipment. By region, total revenues were:

- 33% from North America;
- 16% from Europe;
- 13% from Japan; and
- 38% from Asia-Pacific.

Net income was $14.9m, compared to a loss of $0.9m in 2005.

In 2006, revenue grew 10% in data storage and 42% in HB-LED/wireless. "Veeco has a rich pipeline of new products tied to our customers' technology roadmaps in data storage, HB-LED/wireless, semiconductor and scientific research, which we currently expect will lead to 2007 revenue growth," says Braun.

However, for Q1/2007, Veeco expects revenues of $95–105m (down on Q4/2006) and bookings of $110m±5% (flat on Q4).

www.veeco.com

China gears up with epitaxial reactors

In Q1/2007 Aixtron of Aachen, Germany secured multiple repeat orders for multi-wafer MOCVD systems worth more than €7.5m ($9.85m) from existing customers in China, for the production of blue, green and red LEDs as well as novel, innovative GaN LEDs. The systems will be fully installed and booked in second-half 2007. Such business confirms China's long-term high-tech development and underlines its claim to play a major role in compound semiconductor device manufacturing, says Aixtron.

The orders include the largest capacity, production-proven GaN systems, the 30x2″-capacity CRIUS closed-coupled-showerhead reactor and 42x2″-capacity AIX 2800G4 HT Planetary Reactor, which were launched last year and represent Aixtron's latest MOCVD developments, qualified for the mass production of GaN LEDs.

"Following the fast qualification of both our large-capacity reactors at various customer sites, we have gained recognition of our new technologies," says Dr Bernd Schulte, chief operating officer.

In February, MBE reactor maker Riber of Bezons, France received an order from a Chinese research institute for a single-wafer Compact21T research machine. This is Riber's 49th order in total for the Compact21T (which is the world's most prevalent MBE research machine, the firm claims).

In December, Riber received an order for a Compact21HM system (a variant of the Compact21) from an unnamed research institute in China. Riber said then that it had 14 research machines installed with 10 clients in China.

Riber views China as an important market due to its considerable investment in R&D.

Also, Riber says that it views China as an important market due to its considerable investment in R&D. The firm expects to benefit further in future from China's investment in compound semiconductor R&D equipment.

www.aixtron.com
www.riber.com

Aviza public offering to raise $24m

Etch and deposition equipment maker Aviza Technology Inc of Scotts Valley, CA, USA has announced the pricing at $6.50 per share of its underwritten public offering on the Nasdaq Global Market of 4 million shares of its common stock.

Aviza estimates that the net proceeds should be about $23.9m, or $27.6m if the sole underwriter, Needham & Company LLC, exercises its option (up to 8 April) to purchase up to 600,000 additional shares to cover over-allotments.

Aviza intends to use the proceeds for working capital, R&D, and other general corporate purposes, which may include repaying borrowings under its mortgage and revolving lines of credit.

For its fiscal Q1/2007 (to end-December), Aviza reported revenues of $62.2m (up 19.6% sequentially and 114.9% year-on-year) and net income of $1.1m (up from $779,000 last quarter and a loss of $4.6m a year ago, mainly due to an improvement in product mix).

www.avizatechnology.com

IN BRIEF

Novalux expanding with another reactor

Novalux Inc of Sunnyvale, CA, USA has ordered a second 2600G3 multiwafer Planetary MOCVD reactor from Aixtron to expand manufacturing of its NECSEL (Novalux Extended Cavity Surface Emitting Laser) devices.

The new 2600G3 IC (Integrated Concept) system (in 8x4″ wafer configuration) will be used alongside an earlier Aixtron 2600G3 MOCVD reactor to mass produce Novalux's proprietary lasers for projection displays.

A specialist in solid-state lighting for projection displays, Novalux's portfolio includes high-power red, green and blue NECSEL surface-emitting laser devices.

www.aixtron.com

Riber completes Yokogawa MBE reactor installation

In early February, Riber said that it had completed the installation and conditioning of an MBE 49 multi-4″ wafer production reactor ordered in April 2006 by Japan's Yokogawa Electric Corp, which makes optical communications components as well as industrial automation and control systems, digital sensors, and test and measurement equipment.

The tool is being used to make HBTs for optical communication networks, after Yokogawa last year spent $230m building a large chip fabrication plant in Sagamihara near Tokyo.

In March 2006, Yokogawa agreed to supply high-speed III-V components to network system maker Fujitsu for deployment in optical networks operating at 40Gb/s and above.

www.riber.com

Halma acquires Labsphere

UK-based safety, health and sensor technology group Halma plc has acquired Labsphere Inc of North Sutton, NH, USA (which makes light measurement products, including LED testing equipment) from X-Rite Inc for about $15m.

Founded in 1979, Labsphere's products include LED, laser and traditional light-source light measurement systems; uniform light sources for imaging device calibration; spectroscopy accessories; and high-diffuse-reflectance materials and coatings for applications in backlit panel displays, computed radiography, and system calibration. The technologies have resulted in multiple patents in areas such as testing LEDs on-wafer. For 2006 Labsphere had revenues of $12.5m and an operating profit of $2.4m.

Labsphere joins Ocean Optics and Mikropack GmbH in the photonics sector of Halma's health & analysis business group. The acquisition will create opportunities for technical and marketing collaborations as Halma grows the sector, the firm says.

www.halmapr.com

Ocean Optics has made Ling Sun director of Asia Operations, heading its new Ocean Optics Asia (China) office in Shanghai. Sun will provide a regional approach to the sales and service of optical sensing, display optics, and biophotonics technologies in the Asian market.

Sun will lead a team of application, sales and software engineers, supporting distributors and customers in the Pacific Rim, responsible for bringing fiber-optic spectrometers, optical sensors, sampling accessories, light sources, fibers, probes, thin films and optics to new applications and markets.

Previously, Sun spent two years as lead engineer for Ocean Optics products at distributor BAS Japan.

"With a regional team in place, we will be better positioned to bring Ocean Optics technologies to customers throughout Asia," says Sun.

www.oceanopticschina.cn

Nextreme appoints CTO and senior technical fellow

Nextreme Thermal Solutions of Research Triangle Park, NC, USA, which makes thin-film thermoelectric components for thermal management, has appointed Dr Seri Lee (former senior thermal scientist for Intel's Silicon and Platform Solutions Group) as chief technology officer.

Lee has also held positions at Amkor Technology as manager of Thermal Characterization and Aavid Thermal Technologies as director of Advanced Thermal Engineering.

As a member of the ASME Heat Transfer Division K-16 Committee on Heat Transfer in Electronic Equipment and the IEEE/SemiTherm Executive Committee, Lee has a wide range of thermal management experience, which is "part of our plan to build a world-class technology team focusing on electronic and optoelectronic packaging and thermal management," says CEO Jesko von Windheim. "Lee's addition positions the company to address many of the most demanding issues in thermal management for advanced technology products," he adds. "Lee will bring a new focus to the company's efforts in the area of thermoelectric power generation."

CTO Seri Lee.

Nextreme has also appointed Dr Phil Deane (ex-director of packaging for JDSU's Advanced Optoelectronic Components Group) as senior technology fellow, to address thermal management and thermoelectric packaging issues. He will define product and packaging strategies for the insertion of thermoelectric coolers into customer's products.

Deane started as an engineer at AT&T Bell Labs working in electronic component packaging, and was then director of the Advanced Packaging Group at Research Triangle Park-based MCNC, and then a principal at Optical Process Technologies (acquired by JDSU in 2000).

"He will be instrumental in developing new packaging solutions to solve our customers' most challenging thermal problems," says von Windheim. "Nextreme's thin-film thermoelectric technology represents a radically new way to achieve in-package cooling," says Deane.

Demand for compact electronic devices with increased capabilities and functionality is a driving force. The evolutionary path is the same for consumer, military, aerospace, medical, communications or automotive markets: smaller and faster with more functionality. This is supported by improvements in process technology, but an emerging gate to evolution is heat management. So, there is a compelling need for new packaging strategies that can deal with ever-increasing thermal problems, says the firm. Thin-film thermoelectric coolers can actively cool devices at the source, within the constraints of smaller, low-profile components, it is claimed.

www.nextremethermal.com

Tegal's sales dip further; signs up Korean distributor

For its fiscal Q3/2007 (to end-December 2006), plasma etch and deposition system maker Tegal Corp of San Jose, CA, USA reported revenues of $4.4m (down 14% on the prior quarter and 30% year-on-year).

"Revenues were lower this quarter because of the timing of shipments of advanced tools," says chairman, president and CEO Thomas Mika.

Net loss has risen from $1.9m a year ago and $3.3m last quarter to $6.1m. Factors affecting profitability included a low-margin shipment, a significant inventory write-off and unusually high service expenses, which will not reoccur, Mika says. Also, Tegal recorded litigation costs of $1.2m, which will be cut drastically in future quarters, he adds. In November, Tegal's PVD subsidiary Sputtered Films Inc (SFI) agreed to terms settling its trade secrets case against Sergey Mishin, Advanced Modular Sputtering (AMS), Agilent Technologies Inc, the Avago Entities and other defendants. A final confidential settlement agreement was executed on 21 December.

"Now that we have been able to put behind us the costs and distraction associated with three years of litigation, we are focused on new initiatives to improve our business," Mika says. "We are in the process of integrating the AMS deposition tool into our operations and beginning to provide field support to former AMS customers... This addition to our product portfolio will help Tegal consolidate a dominant position in the RF MEMS arena... We also continue to make progress toward introducing several new products, including our Compact platform and Nano Layer Deposition (NLD) system," (to be in beta sites within the next few months).

Order backlog is $5m. "Next quarter will be more representative of our overall trend toward an improved business model and improved profitability," concludes Mika.

● Tegal has signed an exclusive agreement (for an initial three-year period) for Korea's Westpac Associates to handle its sales and field service support operations in Korea.

The agreement is "an additional step in our overall strategy to enhance our distribution and support services globally, especially in Asia," says Mika. Westpac was most recently the AMS representative in Korea and was previously the representative for Tegal's PVD subsidiary Sputtered Films Inc. "There are some very good signs of renewed demand for our specialized systems in Korea," claims Mika.

www.westpac.com
www.tegal.com

Cermet launches non-polar nitrides

Cermet Inc of Atlanta, GA, USA, which was spun off from the Georgia Institute of Technology in 1991, has announced the availability of its first nitride substrates with non-polar orientations.

Cermet develops and manufactures substrates and devices based on gallium nitride, zinc oxide and related wide-bandgap semiconductors for use in blue, green and white LEDs (including for solid-state lighting), blue lasers for next-generation optical storage applications, high-frequency RF devices for wireless communications systems, and next-generation optical telecommunications systems.

Growth of nitride LED and laser diode structures using non-polar orientations has attracted much attention, due to the potential enhancements in device characteristics and performance. Cermet's non-polar substrates provide a pathway for the production of these non-polar nitride emitter structures, the firm says.

Last October rival Kyma was awarded Phase I funding under the US Army's Small Business Technology Transfer program to develop its non-polar GaN substrates (which were announced in March 2006).

● In January a University of California, Santa Barbara research team led by Shuji Nakamura, Steven DenBaars and James Speck demonstrated what it claimed was the first laser fabricated on non-polar GaN. The lasers emitted in pulsed mode at the wavelength of 405nm used in high-definition optical data storage such as HD-DVD and Blu-ray.

www.cermetinc.com

Fujimi scales up to 4" sapphire

Wafer polishing materials maker Fujimi Inc of Nagoya, Japan is planning to scale up its production of sapphire wafers for GaN-based LEDs, focusing on 3" and 4" wafers in a market that is currently mainly 2".

In January 2006 Fujimi acquired an 84% stake in Interoptec Co Ltd, which was founded in Tokyo in 2003 and has proprietary technology for fabricating sapphire wafers (shipping samples to GaN epi houses in 2004).

Fujimi has invested ¥500–600m ($5m) in a fab in Ohta, Gunma Prefecture, which last July started full-scale production of 2–4" wafers (available commercially in small volumes). Over the next fiscal year, the firm plans to spend a further ¥400m to boost production capabilities, focusing on larger diameters such as 4" toward the end of 2007. The goal is to reach ¥1bn in sales during the next fiscal year and to double sales over several years.

www.fujimico.com

Aonex and Kyma collaborate to develop GaN growth on sapphire-on-AlN substrates to cut blue laser & LED costs

Aonex Technologies Inc of Pasadena, CA, USA has entered into a collaborative agreement with Kyma Technologies Inc of Raleigh, NC, USA to develop materials to reduce the cost of manufacturing GaN-based devices such as blue laser diodes and LEDs (driven by demand for HD-DVD/Blu-Ray DVD player and solid-state lighting applications, respectively).

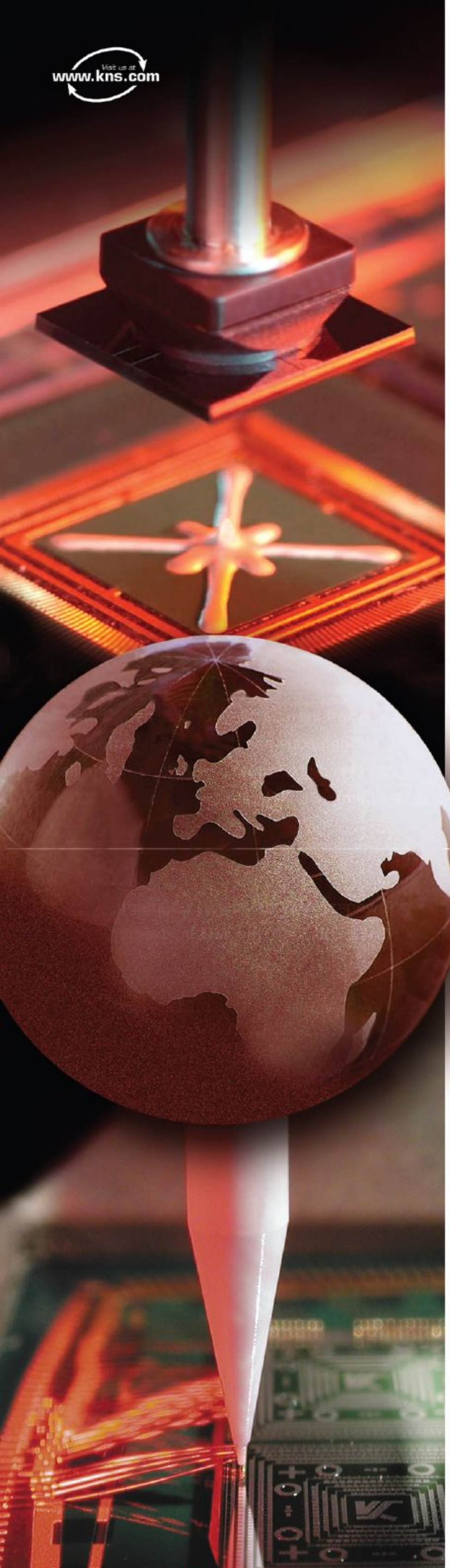
Aonex (which is a majority-owned subsidiary of Arrowhead Research Corp) will provide access to its proprietary A-Sapph wafer technology to Kyma (which was spun out of North Carolina State University in 1998 to develop GaN substrate materials for nitride devices).

A-Sapph substrates consist of an ultra-thin layer of single-crystal sapphire (less than 500nm thick) bonded to a polycrystalline AlN support substrate. The resulting substrate has a coefficient of thermal expansion (CTE) that is nearly identical to GaN yet offers an industry-standard sapphire growth surface (both c- and r-plane) suitable for MOCVD and HVPE growth. The substrates also offer higher thermal conductivity than bulk sapphire, resulting in improved growth uniformity. Together, these characteristics could enable the scaling of GaN production to larger wafer diameters, which could cut the cost of GaN devices dramatically by enabling an increase in the number of chips per wafer while also improving yields, says Aonex.

Kyma aims to leverage A-Sapph's properties to produce large-area wafers suitable for GaN device making. "The combined attributes of Aonex's A-Sapph substrate technology and Kyma's proprietary high-growth-rate, low-defect-density GaN crystal growth technology have great potential to reduce the costs of a broad range of high-performance nitride semiconductor devices," reckons Kyma's president and CEO, Keith Evans.

Arrowhead says the agreement is part of Aonex's program to sample its substrates to select device and wafer manufacturers. In addition to A-Sapph, Aonex also offers A-GaN substrates, which consist of ultra-thin layers of single-crystal GaN bonded to a polycrystalline AlN support wafer (giving a lower-cost alternative to bulk GaN wafers).

www.kymatech.com
www.arrowheadresearch.com



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Avanex divests majority stake in French ex-Alcatel opto fabs

Optical communications component and module maker Avanex Corp of Fremont, CA, USA has agreed to sell a 90% stake in its subsidiary Avanex France S.A. to France-based Global Research Company (owned by entrepreneur Alexandre Krivine) and to the current head of Avanex France, Didier Sauvage. The subsidiary was acquired from Alcatel Optronics in 2003 and makes laser, terrestrial pump, submarine pump and fiber Bragg grating products at its InP and GaAs fabs in Nozay.

However, Avanex retains a 10% interest and will enter into several commercial and transitional services agreements, "designed to ensure our customers reliable access to the technology, continuity of supply, and provide transition support," said chairman, president and CEO Jo Major. Avanex will maintain a development group of about 20 in France (moved to a separate site), focused on tunable transmission products (10G MSA transponders).

"The divestiture of our fabs and certain product lines simplifies our operating structure, significantly reduces our fixed costs and accelerates our path to profitability," said Major. Avanex expects savings of $12–16m annually, starting from its fiscal Q4/2007.

On completing the sale in Q2/2007, Avanex will pay the purchasers about $17.3m (€13.4m) for anticipated working capital, including accrued liabilities for past restructuring activities. Avanex France S.A. will then be renamed 3S Photonics, with Krivine becoming CEO and Sauvage becoming the firm's first vice president.

"We strongly believe in the potential and opportunity of such industrial activity in Europe and more specifically in France," said Krivine. We believe that, with the new company's technology and expertise, it can play an international role in growing markets such as submarine and terrestrial pumps for telecommunications as well as explore new markets." The firm has 135 staff, and turnover this year is forecast to be €25–30m.

According to the French newspaper Les Echos, the name change accompanies a strategy of diversification into defense, industrial laser and emerging telecom market segments such as fiber-to-the-home (FTTH) as well as medical applications.

● To help finance the deal, Avanex has also entered into a Securities Purchase Agreement with an accredited institutional investor for a private placement of about 10.8m shares of common stock at a price of $1.85 per share ($20m). Avanex will use the proceeds to finance the divestiture, working capital and general corporate purposes.

The investor will be issued warrants exercisable for about 2.7m shares, exercisable at $2.15 per share until expiry in four years time.

www.avanex.com

Avanex appoints new senior vice president and general manager

Avanex has appointed Pat Edsell as senior vice president and general manager, responsible for its product development center in Shanghai and the firm's transmission, components and modules, and advanced modules and subsystems business units.

"Pat Edsell's extensive background in business and the optics industry greatly strengthens our management team," says chairman, president and CEO Jo Major. "Under his direction, our business units will continue to execute strategic elements of our business plan by innovating differentiated products that enable smarter and more flexible networks," Major adds.

Avanex says that Edsell has over 23 years of senior executive experience in the optical and microelectronic industries and a strong track record in improving companies' bottom lines and leading customer-focused teams. Edsell has held several CEO positions. He was previously CEO of NP Photonics, a venture-backed photonics start-up specializing in the sensing, medical and R&D market where he led the development of a new strategic plan for the firm, recruited a management team to execute that plan, and improved the financial performance of the company. Prior to that, he was CEO of Spectra-Physics, where he led its transition from significant losses to solid profitability, and completed a successful IPO and subsequent sale to Thermo Electron. Edsell also held positions at Pharos AB in Stockholm, GP Technologies, Sun Company and GE.

Bookham cutting staffing by 123, mainly at Caswell InP fab

Optical telecom component maker Bookham Inc of San Jose, CA, USA has now completed its review of staff cuts, following February's announcement of further cost-cutting measures (see February issue, page 28).

Bookham's total worldwide staff level of about 2100 will be cut by 123. These include:

- 77 (out of about 200 existing staff) from the 3-inch indium phosphide fabrication plant in Caswell, UK by the end of this year (most by mid-April).
- 10 from the Paignton facility in the UK (now an R&D center focusing on optical subsystems).
- 36 (out of 50) from the chip development facility in Kanata, near Ottawa, Canada.

The latter two facilities were acquired on buying Nortel Networks's optical components business in 2002 for $112m.

The Kanata plant employed 300 staff on its acquisition from Nortel, before losing 200 after the transfer of its InP fab line to Caswell. Now the facility is being closed (remaining staff will work from home). Its existing R&D functions are being redistributed to both Paignton and Bookham's plant in Shenzhen, China.

The Paignton facility employed about 1000 staff on its acquisition from Nortel as a test & assembly plant, before the transfer of these manufacturing lines to Shenzhen (with 600 job losses announced in 2004, followed by 150 in December 2005 and a further 100 or so in 2006), leaving a couple of hundred at the research and development center.

The Caswell plant used to employ over 500 staff as part of Marconi's Optical Components business before Bookham acquired it in 2002 for $24m and subsequently closed its 6-inch GaAs wafer fab line in 2004. Most of the 130 or so remaining will be involved in running the 3-inch InP wafer fab and in administration.

Together with other measures, the cost cutting announced in February is designed to save an extra $6–7m per quarter by this September, with the goal of reaching break-even this year.

www.bookham.com

Infinera files IPO to raise $150m

Infinera Corp of Sunnyvale, CA, USA has filed with the Securities and Exchange Commission for an initial public offering on the Nasdaq Global Market of up to $150m in common stock. It will use the proceeds for working capital and other general corporate purposes, as well as repaying its credit facilities or acquiring other businesses.

Infinera was founded in early 2001 as Zepton Networks Inc and has since raised over $330m in venture capital funding. Investors include Advanced Equities, Kleiner Perkins Caufield & Byers, Mobius Venture Capital, RWI Ventures, Benchmark Capital, Applied Materials Ventures, Cypress Semiconductor, Sprout Group, Venrock Associates, Worldview Technology Partners, Siebel Systems and Sutter Hill Ventures.

The firm claims to have created the only commercially deployed, large-scale photonic integrated circuit. Infinera's PICs incorporate the functionality of over 60 discrete optical components into a pair of InP chips, and are designed for communications, military and sensing applications, including transmitting and receiving at data rates of up to 100Gbit/s in fiber-optic networks.

Infinera uses the PIC technology in its DTN digital optical networking system, which enables optical-to-electrical-to-optical conversion of signals and provides operating simplicity, enhanced revenue generation, faster time-to-service, and capital cost savings, the firm claims.

Infinera's PICs incorporate the functionality of over 60 discrete optical components into a pair of InP chips

Since November 2004, Infinera has been shipping the DTN system to telecoms carriers, cable operators and other service providers as well as distributed enterprises as the key element in long-haul and metro-optical transport networks. It is deployed by 25 customers, including Internet2, Interoute, Level 3 Communications, and Qwest Communications. Infinera claims to have had the largest market share of 10Gbit/s long-haul ports shipped since Q3/2005.

Infinera's revenue has risen from $0.6m in 2004 and $4.1m in 2005 to $58.7m in 2006 (including $44.3m in Q4). Level 3 accounted for 60% of revenue in 2006. However, losses (which were $66.4m in 2004 and $64.6m in 2005) also rose to $89.1m in 2006.

According to analyst firm the Dell'Oro Group, Infinera extended its lead in the global market for shipments of 10Gb/s long-haul DWDM wavelengths in 2006, ranking first with a 34.7% market share (up from 20% in 2005). Dell'Oro says the worldwide long-haul DWDM market grew 26.6% in 2006.

Service providers are increasingly dealing with fast-growing Internet bandwidth, unpredictable demand patterns, and the need for more cost-effective services, says CEO Jagdeep Singh. With 100Gb/s of optical capacity on each line card, Infinera's DTN System (which combines high-capacity transport, fully reconfigurable switching, and GMPLS service intelligence in one platform) is designed to meet the needs of high-bandwidth networks and fast-growing networks.

www.infinera.com

Infinera acquires Little Optics to integrate passive PICs

In February, to add technology to its Digital Optical Networking architecture, Infinera acquired Little Optics Inc of Annapolis Junction, MD, USA, which was founded in 2000 by Brent Little and John Hryniewicz of the University of Maryland's Lab for Physical Sciences and acquired in November 2005 by ICX Nomadics of Stillwater, OK (which creates explosives detection systems for homeland security).

Funded by the Department of Defense, Little Optics has developed integrated optical devices using planar lightwave circuit (PLC) technology and proprietary glass materials to deliver photonic integration that is designed to be superior to traditional PLC technology. The firm's passive integration techniques are in the development stage, and complement Infinera's active large-scale InP-based PICs. Infinera intends to combine its PIC technology with Little Optics' Hydex glass-based substrate and VLSI photonics platform.

"The Infinera DTN system is designed to deliver significant benefits to customers in terms of size, weight, power consumption, and scalability. Integration has enabled Infinera to develop the digital architecture which is designed to be more flexible, simpler, and quicker to deploy," says chief marketing & strategy officer Dave Welch. "When integrated into our product, we believe that Little Optics' technology will bring new capabilities and significant benefits to our photonic integrated circuits and will enable us to enhance the features and capabilities of our Digital Optical Networks."

Little Optics has a 35,000ft^2 facility, including a 4000ft^2 cleanroom for wafer fabrication. Infinera is merging the Little Optics team of 22 staff with its existing engineering team in Annapolis Junction.

GCS and Xponent establish wafer foundry agreement

Epiwafer foundry Global Communication Semiconductors Inc (GCS) and Xponent Photonics Inc (of Torrance and Monrovia, CA, USA, respectively) have established a strategic partnership and wafer foundry agreement to develop high-performance opto devices for fiber-optic communications.

Founded in 1997, GCS offers both RF processes (InP and InGaP HBTs, GaAs pHEMTs, HFETs, integrated passive devices and surface acoustic wave devices) and opto-electronics processes (for products such as GaAs and InGaAs PIN photodiodes and imaging arrays, avalanche photodiodes, quantum well infrared photodetectors, semiconductor optical amplifiers, vertical-cavity surface-emitting lasers, edge-emitting lasers, modulators, and LEDs).

Using its high-volume 4" wafer fab, GCS will manufacture Xponent's optical component product portfolio using its proprietary laser and PIN photodiode processes.

Xponent says that, contrary to the vertically integrated model adopted by most optical device suppliers, its strategy is to become a broad-based horizontal supplier (similar to the dominant IC model, but of merchant optical assemblies and chipsets).

This is enabled by the design-for-manufacturability benefits of Xponent's Surface Mount Photonics (SMP) technology. SMP combines PLC technology with patented active device coupling to allow wafer-scale fabrication, test and burn-in of chips, and assembly using passive alignment on standard low-cost flip-chip die bonders (without any lenses, active laser welding or other active alignment) and environmental sealing with simple encapsulant (rather than hermetic packaging) by existing contract manufacturing infrastructure. All this reduces the cost and complexity of optical devices while improving reach, thermal performance, reliability, power consumption and footprint.

The technology forms the building blocks for a range of optical assemblies. Xponent's initial products target single-mode communications applications, such as triplexers and diplexers for single-fiber applications including PON, point-to-point and bi-directional RF systems and bi-directional assemblies for the rapidly expanding fiber-to-the-premises (FTTP) market sector. However, Xponent says that SMP is suited to a broad range of optical applications that will allow the firm to diversify as it continues to grow. Customers include optical systems vendors, transceiver suppliers and optical subsystem suppliers.

GCS is "right on target with the technology transfer", says Xponent's president and CEO Jeff Rittichier. With the completion of the GCS transfer, Xponent is the world's only completely fabless volume producer of optical components, he claims.

www.gcsincorp.com
www.xponentinc.com

CyOptics to make Syntune's single-chip tunable lasers

To accelerate market introduction of its family of single-chip full-band tunable telecom lasers and transmitters and to ensure a continuous volume supply, Syntune AB of Stockholm, Sweden has announced a co-operative agreement with CyOptics Inc of Breinigsville, PA, USA.

CyOptics uses its automated production platform to provide foundry manufacturing of InP-based optical telecoms wafers and chips at its fab in Lehigh Valley, PA (as well as planar fully automated packaging & test in Matamoros, Mexico). The firm will also use its global sales channels to distribute Syntune's S3500 butterfly package and S3600 Integrated Tunable Laser Assembly (ITLA) C- and L-band products.

Increasing use of wavelength agility and fast traffic provisioning is driving demand for next-generation optical networks. Demand for tunable lasers doubled to 60,000 in 2006, and is expected to continue to grow at a compound annual growth rate of 64% through 2010, says industry analyst Ovum-RHK.

CyOptics has a three-year history of working with Syntune. (Syntune board member John Pilitsis — president of Lucent Optoelectronics from 1993 to 1998 then CEO of Fitel Technologies — retired as CEO of CyOptics in 2005.) "Together we will be well positioned to serve a supply-constrained market," says CyOptics' CEO Ed Coringrato.

Syntune uses a fabless model akin to the silicon industry. Due to robust chip design and standard packaging, it claims it can bring products to market quickly and efficiently. "By partnering with CyOptics, we are able to differentiate our product's performance, cost and delivery." Kevin Green, Syntune's VP of marketing & sales, adds that "CyOptics' strong presence throughout the telecommunications community will give customers easy access to the Syntune product family".

www.syntune.com
www.cyoptics.com

Recovery drives growth

After overcoming quality problems, AXT has returned to profit for the first time since 2000, with customer requalification driving GaAs wafer capacity expansion.

Substrate maker AXT of Fremont, CA, USA was founded as American Crystal Technology in 1986 and was the first company to commercialize the vertical gradient freeze (VGF) technique of growing crystal boules. Compared with the established Horizontal Bridgman and Liquid Encapsulated Czochralski (LEC) methods, VGF substrates have lower stress, greater mechanical strength and scalability, and an orders-of-magnitude lower defect density (specifically, etch pit density). This leads to fewer breakages and higher yields, as well as higher-performance and longer-lifetime devices.

AXT was first to introduce both 6″ GaAs and 2″–4″ InP VGF substrates, and is the only company to use VGF to manufacture germanium substrates. With VGF being broadly adopted by the GaAs industry (and rival suppliers following), AXT gained 70% of the GaAs substrate market, as sales reached a peak of $119.5m in 2001.

Rapid growth yields defects

But, after the telecoms slump, revenues fell to $44.9m in 2002 then $34.7m in 2003, yielding large losses.

To lower operating costs and achieve economies of scale at lower volumes, in Q1/2004 AXT began migrating production to a plant in Tongmei, China, east of Beijing (starting with wafer polishing and cleaning, and ending with moving the last furnace from Fremont in Q2/2006). With 90,000ft^2 of manufacturing area and a further 100,000ft^2 available for expansion, AXT claims it is the world's largest III-V substrate manufacturing plant.

While AXT has strengths in technology development, its weaknesses in manufacturing and quality skill-sets became evident when past production controls proved to be inadequate after transferring the growth process without taking into account variations in temperature, humidity, particulates etc in Tongmei. Starting in Q1/2004, changes in surface quality began to show up as post-epitaxy haze defects during subsequent device processing, resulting in disqualification by many customers. In six consecutive quarters of decline, revenues fell 25% from $35.5m in 2004 to just $26.5m in 2005, as AXT's market share for GaAs substrates fell to below 5%. Operating loss rose to $14.8m in 2004.

Recovery over the last two years

In late March 2005, with the aim of returning to profitability, AXT appointed CEO Phil Yin, a veteran of Monsanto Electronics Materials, IBM Thomas J. Watson Research Center, Crysteco, Mitsubishi Silicon America, ATMI Epitaxial Services, and MOCVD reactor maker Aixtron (its general manager for North America from 2003).

Yin says he perceived a shortage of some critical management skills, particularly the type of production controls prevalent in the silicon industry. To increase cost efficiency and upgrade quality systems and customer service, Yin launched a top-down reorganization, involving recruiting executives with skills in manufacturing technology, sales and marketing.

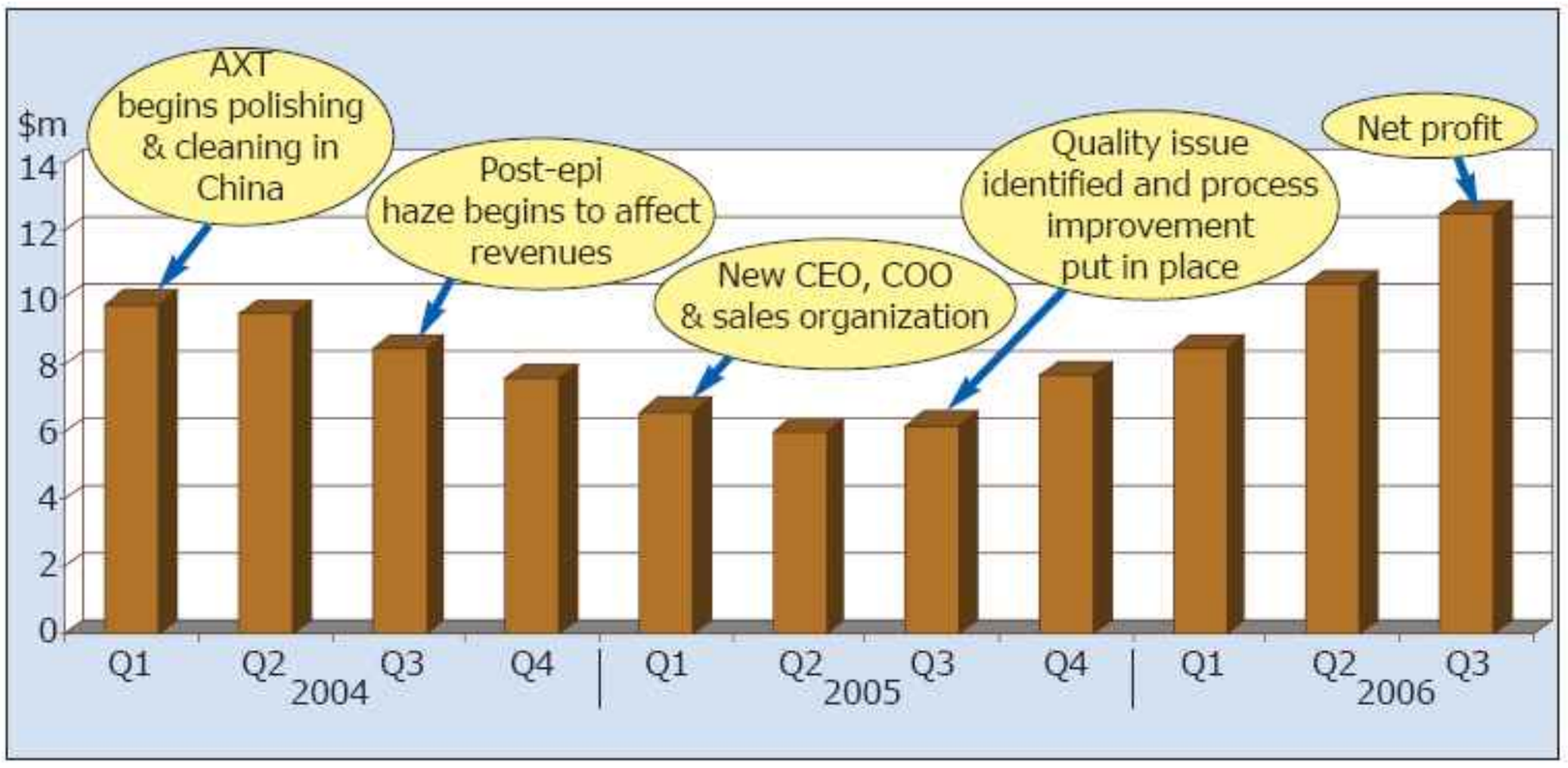
To strengthen the focus on quality, manufacturing efficiency and innovation, Yin created the new post of chief operating officer, which was filled by Minsheng Lin in Tongmei (responsible for all manufacturing, including quality, applications engineering, and production and planning). Lin was recruited in July 2005 from the small-diameter silicon supplier Wafer Works Inc/ Helitek Co Ltd, where (from 1998) he held executive positions in operations and sales & marketing and started up its Taiwan operation. From 1973 Lin held senior operations, quality and engineering positions with Nippon Electric, National Semiconductor (Malaysia), and MEMC Electronic Materials where, from 1994 to 1998, he was director of facilities and quality assurance (starting up its Taiwan operation).

AXT's R&D program has since improved surface quality (via a new polishing and cleaning recipe), enhanced the surface and electrical characteristics and uniformity, reduced haze, increased the ingot length, reduced kerf loss during slicing, and cut the cycle time during crystal growth. All this has led to improved yield and reduced costs.

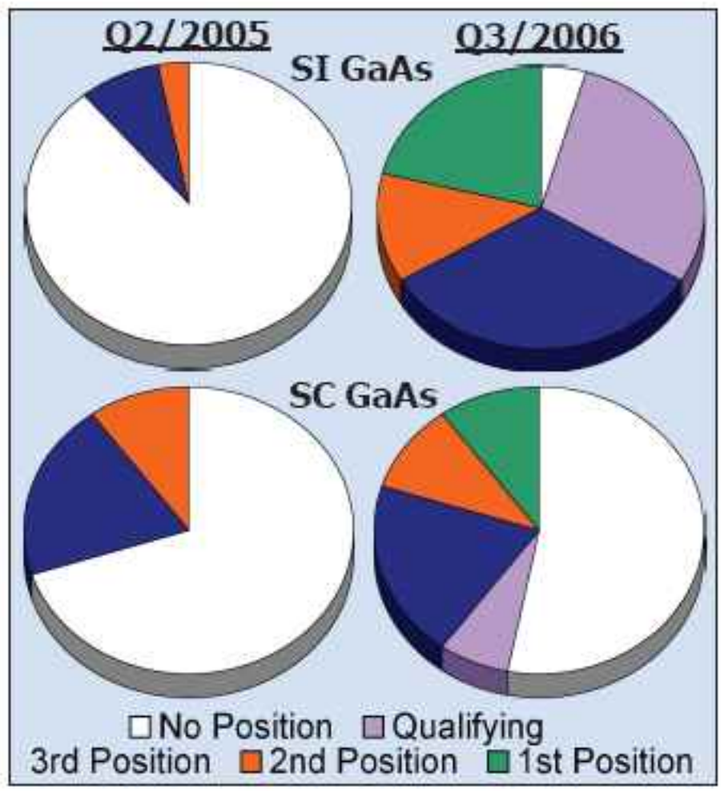
Also, co-founder Davis Zhang (formerly president of AXT-China) was made president of AXT's five raw materials joint ventures in China (formed in 1999–2001) to allow it to better leverage its investments there. Zhang had been senior production manager from 1987, senior VP production from 1994, substrate division president from 1999, and senior VP production again from 2003.

Yin has also focused on restoring and growing AXT's customer base via a revamped sales organization:

- John Cerilli was recruited as VP of global sales & marketing from being the head of sales & marketing for the Semiconductor Equipment unit of Aixtron AG in Aachen, Germany. He previously held management and executive positions in wafer fab operations, sales and marketing with Motorola, Intel, and CMP tool maker Speedfam-IPEC.



AXT's quarterly revenues (in millions of dollars) from the start of substrate polishing and cleaning at Tongmei in Q1/2004, through the appearance of post-epi haze defects, reorganization, yield improvement, and net profit.



AXT's market share gains from Q2'05 (left) to Q3'06 (right) for SI (top) and SC (bottom) GaAs.

● Bob Ochrym was recruited as senior director of international sales and joint venture operations (from heading Aixtron's North American sales & marketing). Previously, Ochrym held positions in sales & marketing, business development and product management at Uniroyal Optoelectronics, Northrop Grumman and Rhone-Poulenc. Ochrym is also on SEMI's standards committee for Electronic Materials (GaAs).

Last July, Ochrym was promoted to the newly formed position of VP of business development, focusing on enhancing global sales and joint venture operations (while continuing to maintain certain high-level substrate customers in North America and Europe, reporting to Cerilli, Yin and Zhang).

Consequently, from Q2/2005 to Q3/2006 quarterly revenues have doubled, as market shares have recovered from 5% to 12% for semi-insulating (SI) GaAs, and from 6% to 10% for semiconducting (SC) GaAs. Also, from Q2 to Q3/2006 AXT's Ge substrate revenues more than doubled (boosted by growth in terrestrial photovoltaic cells), although InP wafer sales fell 45% (Yin does not expect much growth in this market). Annual revenue grew 67.5% from 2005's $26.5m to $44.4m in 2006, capped by a return to operating profit in Q4/2006 and the first annual net profit since 2000 as gross margin grew from just 8.3% in 2005 to 28.7% in 2006.

Most recently, sample wafers have been requalified by major GaAs IC manufacturing customers, including for BiFETs (which combine heterojunction bipolar transistors and field-effect transistors on the same chip).

AXT raises $28.1m for expansion

Late last year AXT raised a net $28.1m in a public offering of shares. Together with $16m already in hand, the $44m available will be used for 'general corporate purposes', including expansion. "There are several areas that can yield considerable growth opportunities," says Yin:

1. Substrate growth capacity expansion

As well as focusing on quality and customer service, Yin says that AXT's core business can grow substantially through capacity expansion in areas such as 6" inch semi-insulating GaAs substrates (where the industry is severely constrained) as well as through continued development of its customer base. "We have not seen any information on any competitors increasing capacity for 6" inch semi-insulating GaAs," Yin says.

A capacity increase of 50% for SI GaAs was therefore added in second-half 2006. However, this is already fully utilized. So, with AXT still struggling to meet demand, says Yin, Q1/2007 sees a further 40% expansion, filling its current 90,000ft^2 of manufacturing space. In scaling up the number of furnaces (which now amount to "hundreds" in total), AXT's ability to build its own furnaces enables it to avoid the high cost (about €0.5m) of commercial 6"-wafer VGF furnaces and cut the time to capacity from over 18 months to 2 months.

2. Expanding raw materials

Since AXT has had the output of its Chinese raw materials manufacturing joint ventures to itself, it has not had to buy much raw materials on the open market and is therefore not susceptible to the current constraints on the supply of raw materials in the industry. However, AXT aims to increase the capacities of the joint ventures so that they can sell more. "Our raw materials business is increasingly becoming a key strategic differentiator and thus we will expand raw materials sales efforts and explore new investment opportunities," adds Yin.

3. Acquisition of complementary technology

Yin says that funds will be used to acquire technology. Correspondingly, Bob Ochrym is exploring opportunities for acquiring businesses that complement AXT's existing core product line of raw materials and substrates. Specifically, this could include additional substrate materials with wider energy bandgaps.

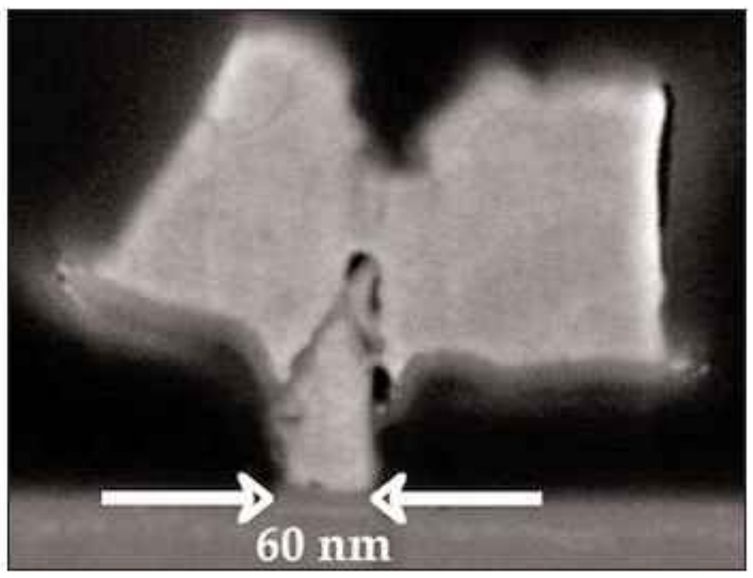
www.axt.com

InGaAs HEMTs challenge Si

At December's IEEE International Electron Devices Meeting (IEDM), the Massachusetts Institute of Technology reported InGaAs-based high-electron mobility transistors with thin InAlAs barrier layers that could replace silicon in logic chips, it is claimed.

The increase in performance of CMOS-based ICs with shrinking of the constituent MOSFET transistors is expected to reach a limit for silicon within the next 10–15 years. "Unless we do something very radical pretty soon, the microelectronics revolution that has enriched our lives in so many different ways might come to a screeching halt," says professor Jesus del Alamo.

Although InGaAs has much higher electron mobility than silicon, HEMTs have been limited to gate lengths of about 100nm. Now, using the capabilities of MIT's Microsystems Technology Laboratories, the Scanning-Electron-Beam Lithography Facility and the Nanostructures



InGaAs HEMT cross section. Critical dimension is 60nm, similar to leading-edge silicon. (Photo: Jesus del Alamo)

Laboratory, del Alamo's group made $In_{0.7}Ga_{0.3}As$ quantum-well HEMTs on InP substrates using a thinner InAlAs barrier layer than before, allowing a gate length of just 60nm (similar to the most advanced 65nm silicon technology available). The devices can carry 2.5 times more current than state-of-the-art silicon devices and provide high performance at supply voltages as low as 0.5V. Del Alamo says that one reason for the performance of the transistors is the high quality of the epitaxial material, grown by epiwafer foundry MBE Technology of Singapore.

The results were described as 'a very important research milestone' by Robert Chau, senior fellow and director of transistor research and nanotechnology at Intel (a sponsor of the research, along with Microelectronics Advanced Research Corp).

But InGaAs transistor technology is still in its infancy, says del Alamo. Challenges include high-volume manufacturing. However, he expects prototype InGaAs devices at the required dimensions to be developed over the next two years and the technology to take off in a decade or so. "With more work, this semiconductor technology could greatly surpass silicon," Del Alamo concludes.

http://web.mit.edu

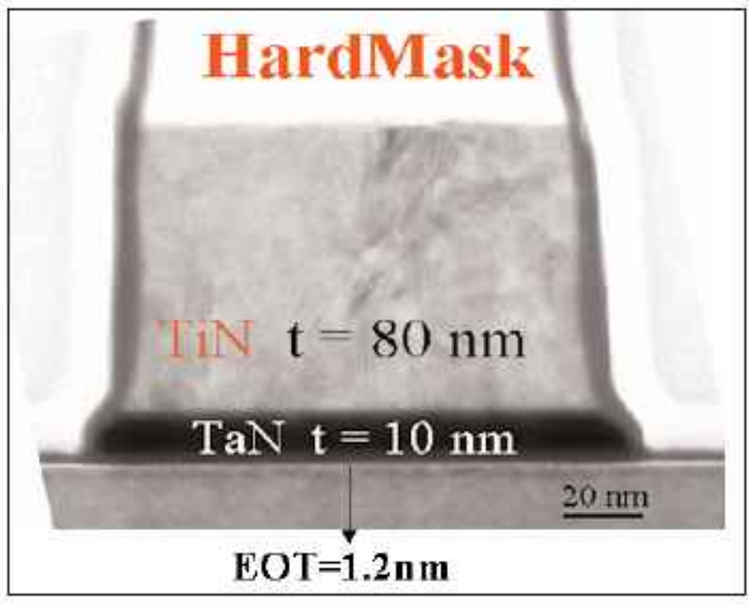
Record Ge pMOS FETs using Si-compatible processing

Also at IEDM 2006, IMEC of Leuven, Belgium reported high-performance germanium pMOS devices using a silicon-compatible process flow.

Ge is being investigated as a promising high-mobility channel material for future nanoscale pMOS devices, showing higher potential than strained silicon. But until now Ge results have been limited to either long-channel or ring-shaped devices. Now, without using enhancement techniques such as strain, IMEC has reported both hole mobility for long-channel devices up to 2.7 times higher than the universal hole mobility for silicon as well as high drive currents for short-channel devices with the shortest gate length reported (125nm), claims IMEC.

A peak mobility of $315cm^2/Vs$ was achieved for a typical 10μm x 10μm device. The effective oxide thickness (EOT) is about 1.2nm, with gate leakage of less than $0.01A/cm^2$. Record Ge pMOS drain current of 670μA/μm was obtained for a gate length of 190nm and V_d of –1.5V.

The pMOS devices were fabricated in a Si-compatible process flow using 200mm Ge-on-Si wafers from ASM. The Ge top layer of the wafers was grown epitaxially directly on silicon. The gate deposition sequence started with Ge surface passivation, consisting of an ultra-thin (~0.6nm) epitaxial Si layer which was partially oxidized after growth. To avoid further oxidation, the Si passivation layer was immediately capped by a 4nm atomic-layer deposited HfO_2 gate dielectric from an ASM Pulsar 2000 reactor followed by 10nm TaN and 80nm TiN deposited using physical vapor deposition.



TEM image of a Ge pMOS with a physical gate length of 125nm and an extremely smooth gate dielectric.

Future research aims to further improve the devices by implementing strain, optimizing the ion implantation conditions, and scaling the gate length further.

The results were obtained within IMEC's core program on (sub)32nm CMOS, which joins forces from nine IC manufacturers and foundries (Infineon, Intel, Micron, NXP, Panasonic, Samsung, STMicroelectronics, Texas Instruments and TSMC).

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Channel surfing

Nanoelectronics developers are aiming to boost channel properties in metal-oxide-semiconductor field-effect transistors (MOSFETs) as used in mainstream complementary MOSFET (CMOS = nMOS +pMOS) silicon technology. Dr Mike Cooke reports.

For many years CMOS gave both high performance and low cost via a single line of development, but the CMOS of today is not the CMOS of the 1960–80s (Figure 1). Pre-1990, modifications were mainly small variations on a well-established theme, making for much smoother development than has been seen in recent years. However, as development has become increasingly difficult, there has been a tendency to split out particular applications and optimize them.

The first major variation for higher-performance chips came in the 1990s, with aluminum being replaced by lower-resistance copper for the on-chip wiring (metal interconnects). A more extended and ongoing development has been lowering the dielectric constant (k) of inter-metal insulation to speed on-chip signal transmission. In the past couple of months, the companies Intel and IBM and research consortia such as Sematech have announced that the gate structure is ready for change to a high-k insulation and metal electrode, replacing the traditional polysilicon electrode and silicon dioxide insulator (which already has some nitrogen mixed in to increase the k value). And these are only the main lines of development.

Logic transistors can be optimized for high speed, low operating power or low standby power. The last two have come to the fore with the rise of battery-powered applications such as mobile phones. Memory producers have opted to focus on developing high density, often going beyond planar structures to three-dimensions, while continuing to use aluminum wiring rather than copper.

The implementation of new technologies is often delayed from the original speculation. The major reconstruction work needed results in workarounds and unexpected difficulties combining to push back the need or ability to use new structures and materials effectively. Further, a new technology needs a long-term future to justify implementation or even significant research funding.

Low-k dielectric materials is an example where far higher k values are being used compared with the predictions of 1999. The prediction of the 1999 International Technology Roadmap for Semiconductors (ITRS) for 2008 was for inter-metal k values of the order of 1.5. The 2006 ITRS update now expects effective k values in 2008 to lie in the range 2.7–3.0. There just aren't any materials that can be used to give a manufacturable k of 1.5 with reasonable yields at low cost. The traditional silicon dioxide inter-metal dielectric has a k value of 3.9.

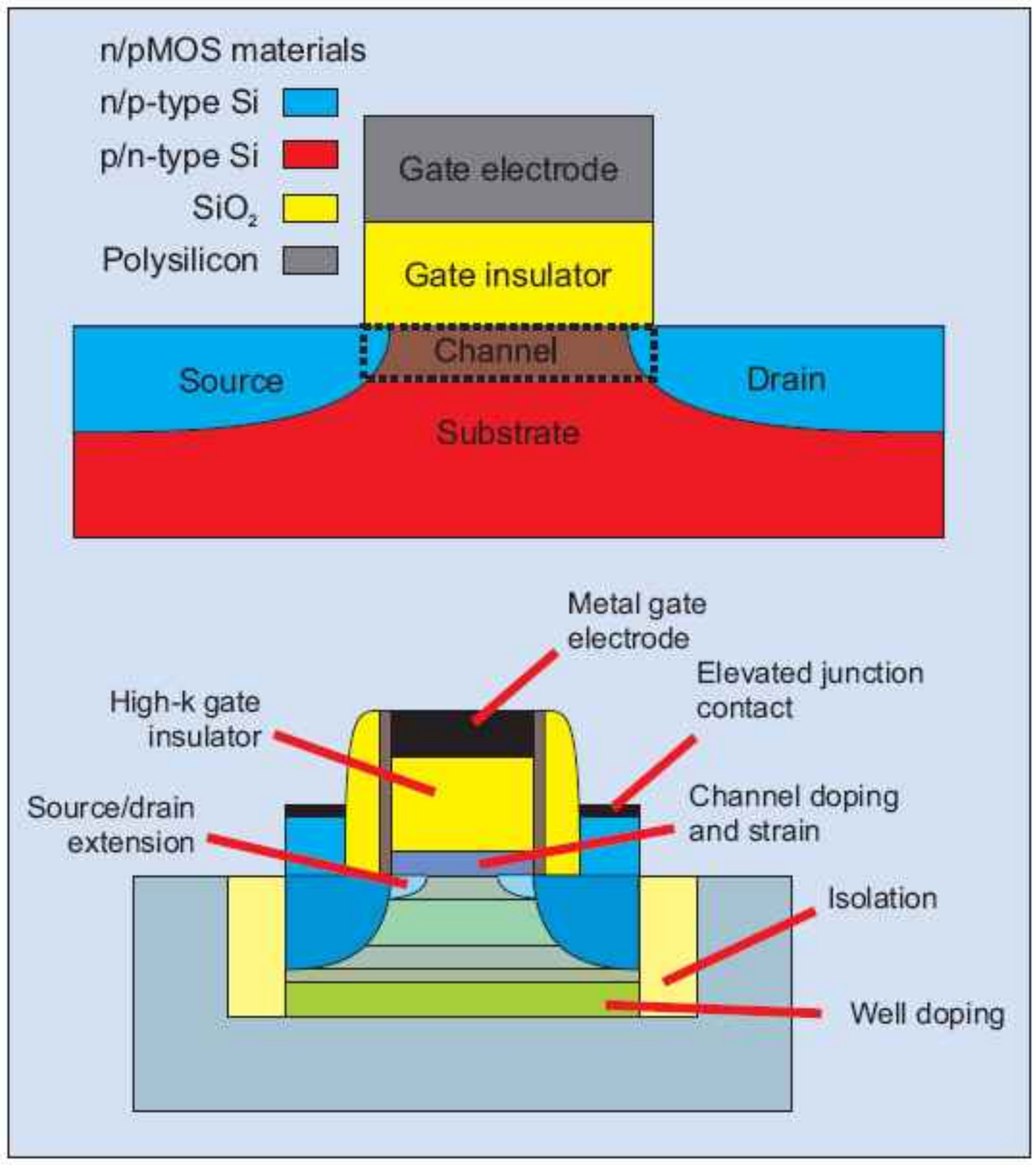


Figure 1. The CMOS of today is not the CMOS of the 1960–80s: traditional structure (top) and some of the new modifications (bottom).

A more recent example of delay has been the implementation of high-k dielectric with metal gate stacks.

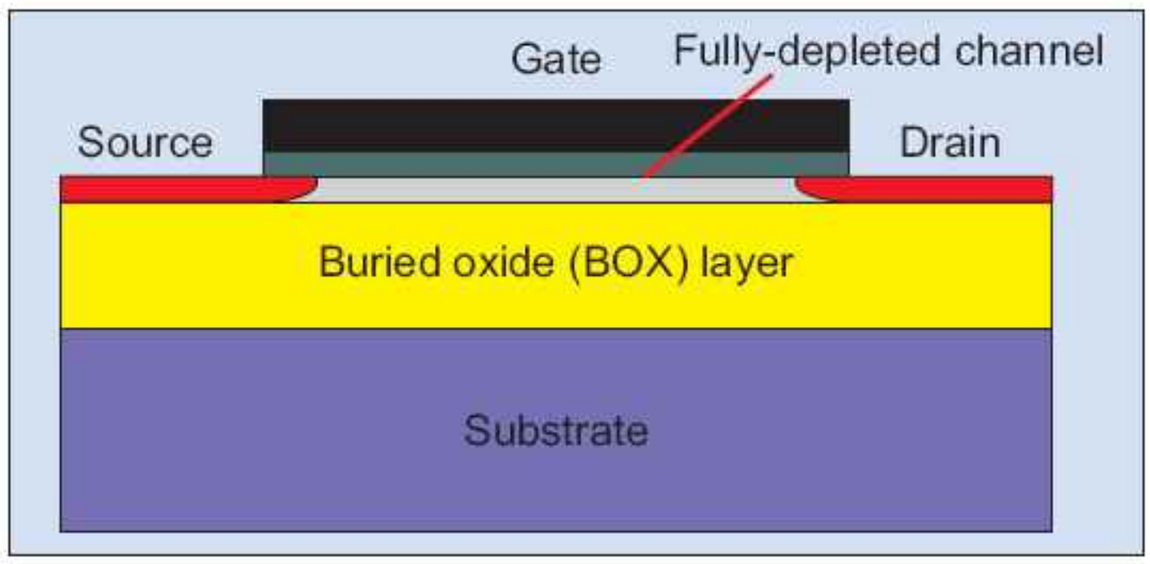


Figure 2. Ultra-thin body fully-depleted (UTB-FD) channel MOSFET.

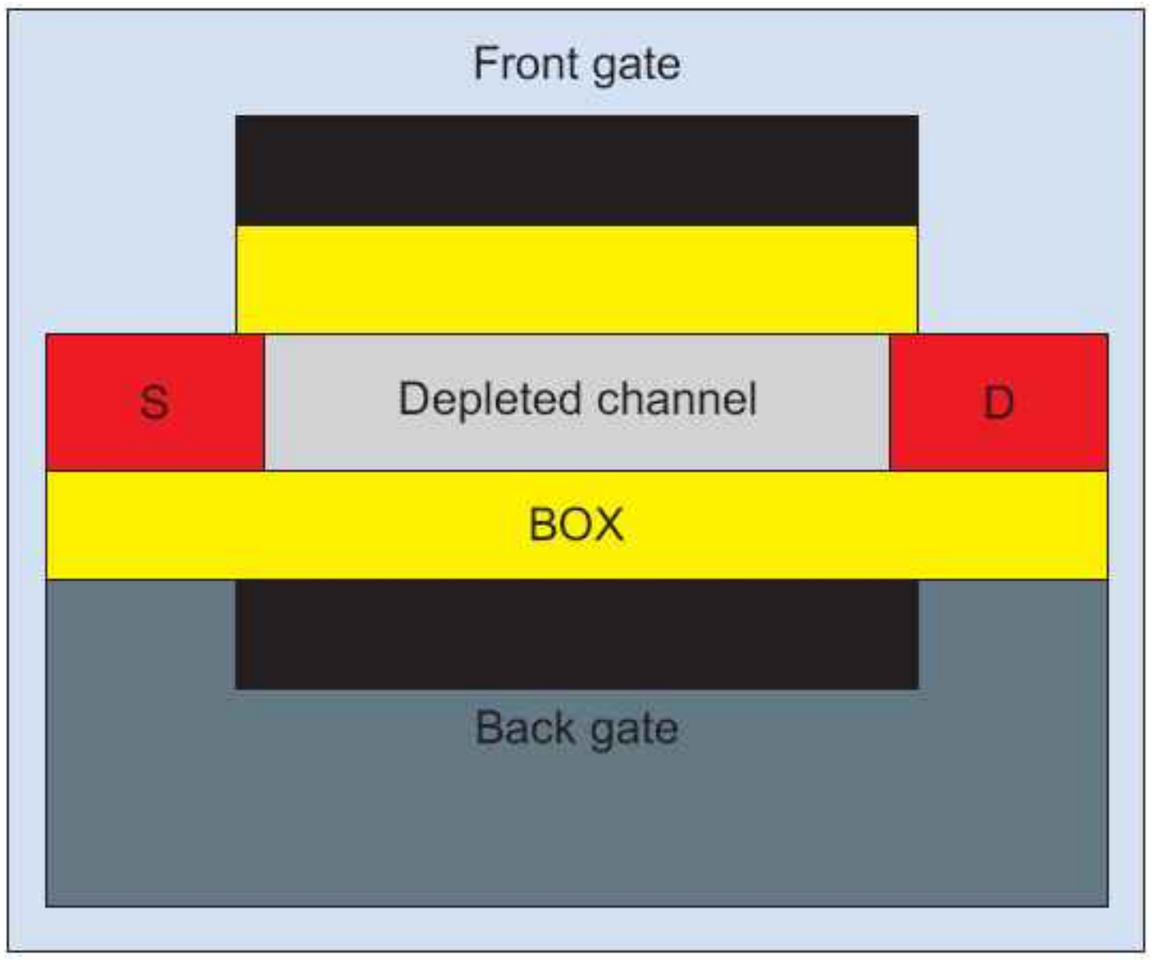


Figure 3. One dual-gate MOSFET structure.

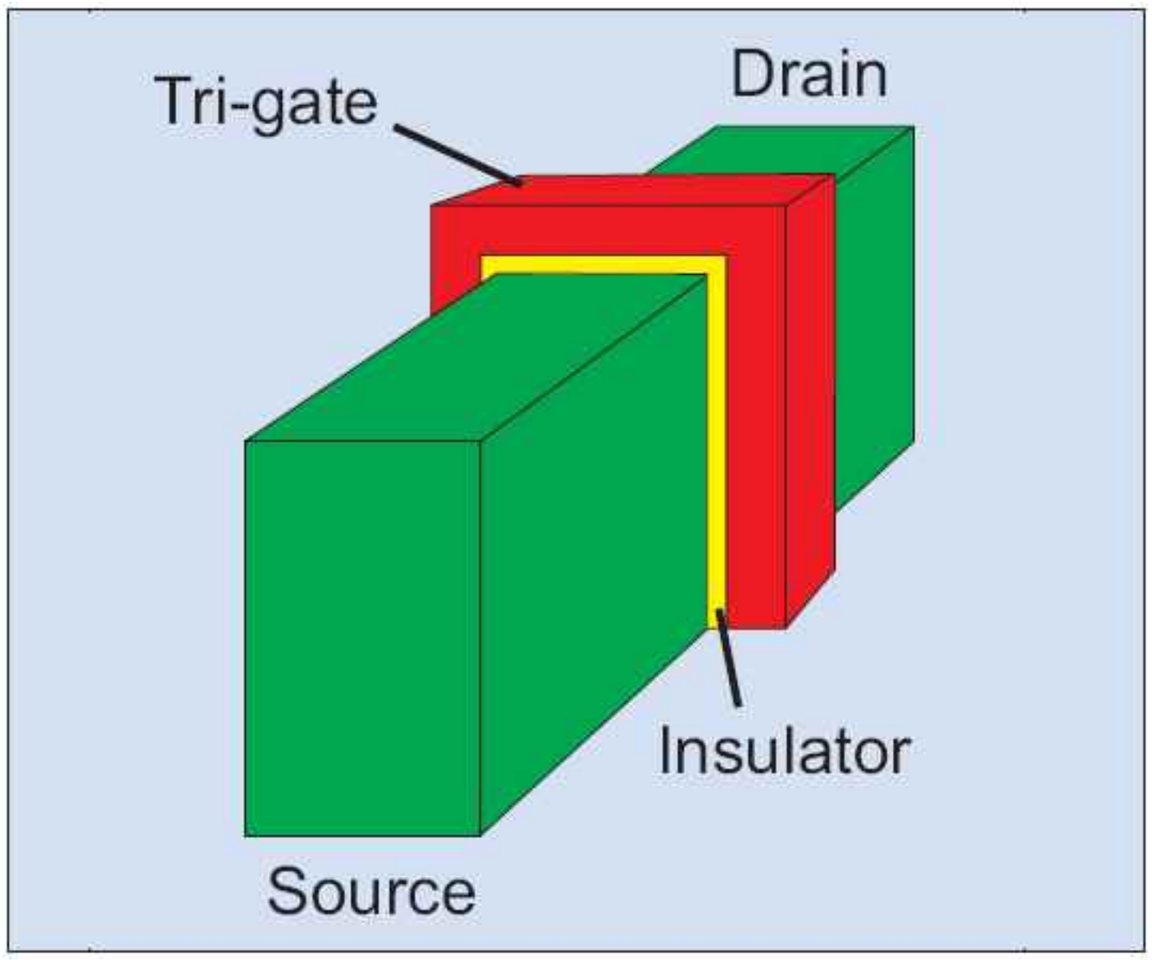


Figure 4. Tri-gate MOSFET as proposed by Intel, among others. In addition, tension (nMOS) or compression (pMOS) can be applied to the channel within the gate structure to increase mobility, along with metal/high-k gate materials.

The high-k with metal gate transistor is only now coming into production mainly for low-standby-power (LSTP) devices, while low-operating-power and high-performance implementations are now not due until 2010.

These delays have also knocked back other proposed changes, such as ultra-thin body fully depleted (UTB-FD) channel transistors (Figure 2). The 2006 update of the ITRS delayed the implementation of UTB-FD for high-performance logic from a 2008 schedule (given in ITRS 2005) to 2010. The low-power versions are due a couple of years later.

UTB-FD devices have a non-doped channel to reduce the number of ionized scattering centers. Not only does this give better mobility but, in short channels, it gives a quasi-ballistic enhancement, where some of the carriers travel from the source to the drain without any scattering events. The silicon layer is so thin that the channel is fully depleted of carriers until a gate potential is applied. However, the technology is limited in terms of how thin the silicon layer can be.

Beyond UTB-FD, dual-gate (DG) and more complicated structures are due to be used to shield and better isolate the source and drain regions. One DG structure consists of the usual (front) gate and a buried (back) gate to which a potential can also be applied (Figure 3). Other arrangements have vertical gates (side electrodes) or even gates that wrap around the channel — variously denoted tri-gate (Figure 4), FINFET or omega gate. The dual-gate channel is not doped, as with the UTB-FD structure, so DG structures are expected to benefit from ballistic enhancement too. DG MOSFETs are scheduled to scale out to 2020 and shorter channels (14nm node, physical gate length = 6nm), where the final ballistic enhancement factor is 2.11, while the expected mobility enhancement is only 1.03.

Another approach to dealing with short-channel effects (SCE), which lower the effective mobility of the channel due to high doping or electric field (saturation velocity) levels, is to change the channel composition to higher-mobility materials such as SiGe or a III-V compound semiconductor material (Table 1). Introducing strain can also massage mobilities upwards.

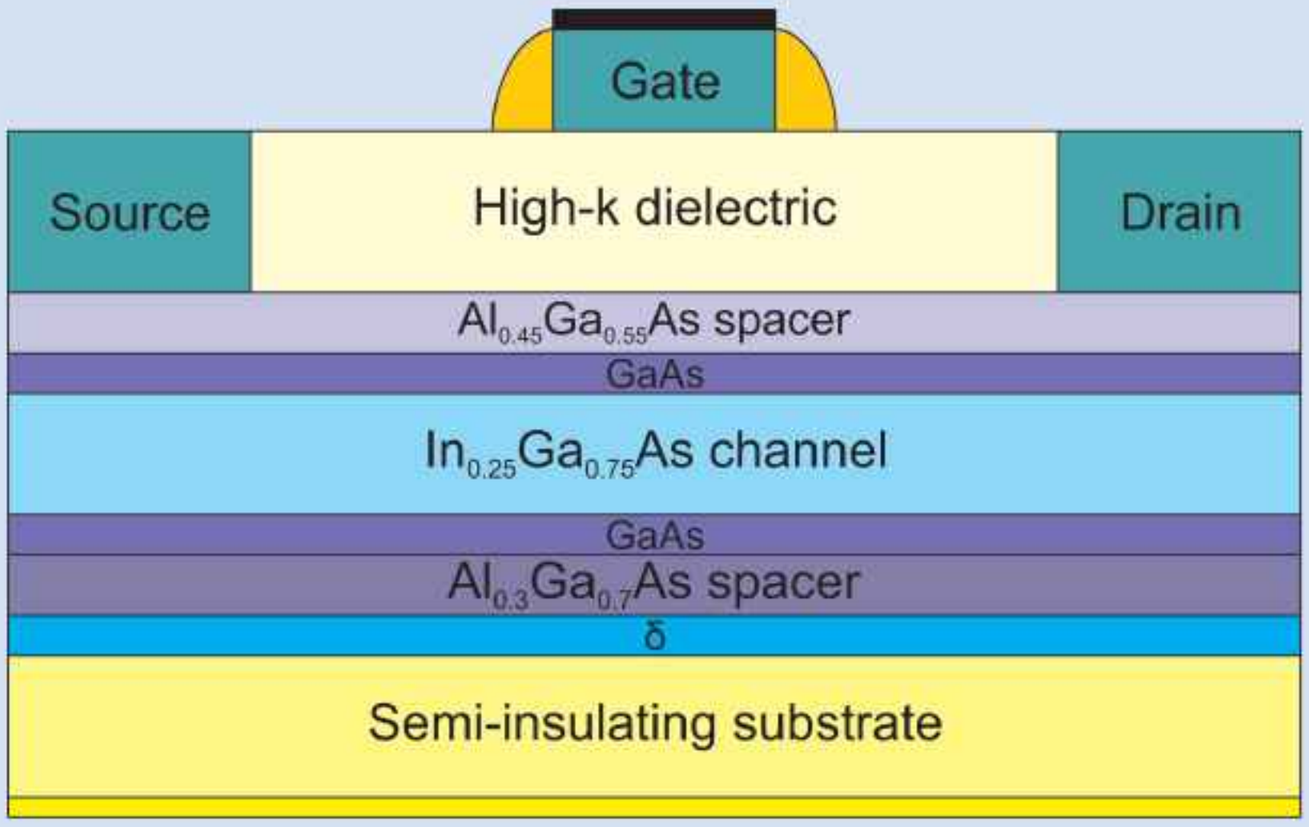
Along with implementations, there are also scheduled discontinuations of technology development: 'extended bulk planar' technology drops off the ITRS map in 2013 and UTB FD channel transistors in 2016. The DG transistor is seen as the 'ultimate MOSFET device', starting around 2011, with scaling projected out to 2020.

Table 1. Mobility and peak velocity comparisons for the conduction band [1].

Material	Mobility ($10^3 cm^2/Vs$)	High-field velocity ($10^7 cm/s$)
Silicon	1	~1
Ge	2	~1
GaAs	5	1–2
$In_{0.53}Ga_{0.47}As$	10	~3.5
InAs	25	5 (?)
InP	3	3.5
GaSb	3	~1
InSb	77	4–5

Upward mobility

Traditional scaling rules for CMOS increases doping concentrations as device dimensions shrink. However, these rules are based on the simplistic view that



	Gate length		
	100.0	70.0	50.0
High-k dielectric	18.0	13.0	9.0
AlGaAs spacer	3.0	1.5	1.0
GaAs spacer	2.0	1.5	1.0
InGaAs channel	10.0	7.0	5.0
AlGaAs spacer	2.0	1.5	1.0
AlGaAs spacer	3.4	2.4	1.7
δ-doping	2.65	3.50	3.25

Figure 5. Implant-free III-V MOSFET simulated by Kalna et al [3]. The table shows layer thicknesses (in nm) and the δ-doping concentration (in $10^{12}cm^{-2}$) for various gate lengths (in nm).

increased doping leads to increased conductivity because mobility is approximately constant, i.e. that the conductivity is proportional to the number of free carriers released by ionized impurities. Unfortunately, among the effects of high doping concentration is the increase in scattering from ionized impurities, reducing mobility severely. Between impurity concentrations of $10^{16}cm^{-3}$ and $10^{20}cm^{-3}$, mobility in silicon falls by almost three orders of magnitude. Another problem with increased doping is that the impurities begin to clump together, creating non-uniformities. Further the electric field in short channels more easily enters the saturation region, where increased fields do not lead to increased carrier velocities. Although the scaling rules look to reduce operating voltages so that the electric field remains below saturation, this is often not possible in short-channel structures, where two-dimensional corrections to one-dimensional models become important (e.g. the field increases near sharp structures).

Mobility enhancement using strained structures of silicon and silicon germanium have already been implemented, first for high-performance transistors around 2004, where higher fields are used to boost performance, and hence carrier velocities may enter the region where they cannot go any higher (i.e. they saturate). To increase electron mobility, a thin layer of silicon is deposited on SiGe, which has a larger lattice constant due to the larger germanium atoms, and hence is in tension. For hole mobility enhancement, a strained layer of SiGe on bulk silicon can be used to provide compression.

However, as scaling continues, the modest improvements in channel mobility provided by strain will not be sufficient and it is expected that new materials such as germanium or III-V compound semiconductors — and, beyond that, 'nanowires' or even carbon nanotubes — will be needed.

Last year, the US Semiconductor Research Corporation (SRC) — an industry-funded university-research consortium for semiconductors and related technologies — launched a Non-Classical CMOS Research Center in order to research III-V materials to extend CMOS capabilities. A team of five universities is to collaborate for three years with more than $7m of funding. Depending on the results, two further years of funding may be agreed.

The aim is to enhance CMOS gate speeds with lower power dissipation and to beat the ITRS schedule for alternative channel materials, with significant impacts on chip manufacturing expected as early as 2012–2014 (32nm). The ITRS plan is for alternative materials to be available for semiconductor production at the 22nm level (2016–2019).

The Non-Classical CMOS Research Center is being led by University of California, Santa Barbara. The four other institutions are Stanford University, University of California, San Diego, the University of Massachusetts-Amherst, and the University of Minnesota.

Applications that should benefit could include communications, computing, gaming, automotive and consumer electronics. The research is partly inspired by the technology and footprint improvements provided by compound semiconductors in communication devices such as satellite dishes, where indium gallium arsenide-based preamps have shrunk dish diameters from 1.5m to 0.5m in less than 10 years, while doubling reception quality.

Unfortunately, CMOS devices are delicately structured — change the channel material and there are implications for the gate stack and other features. For example, the silicon dioxide, or even the new hafnium dioxide (HfO_2) high-k dielectric gate insulators now on silicon CMOS pilot lines, would probably have

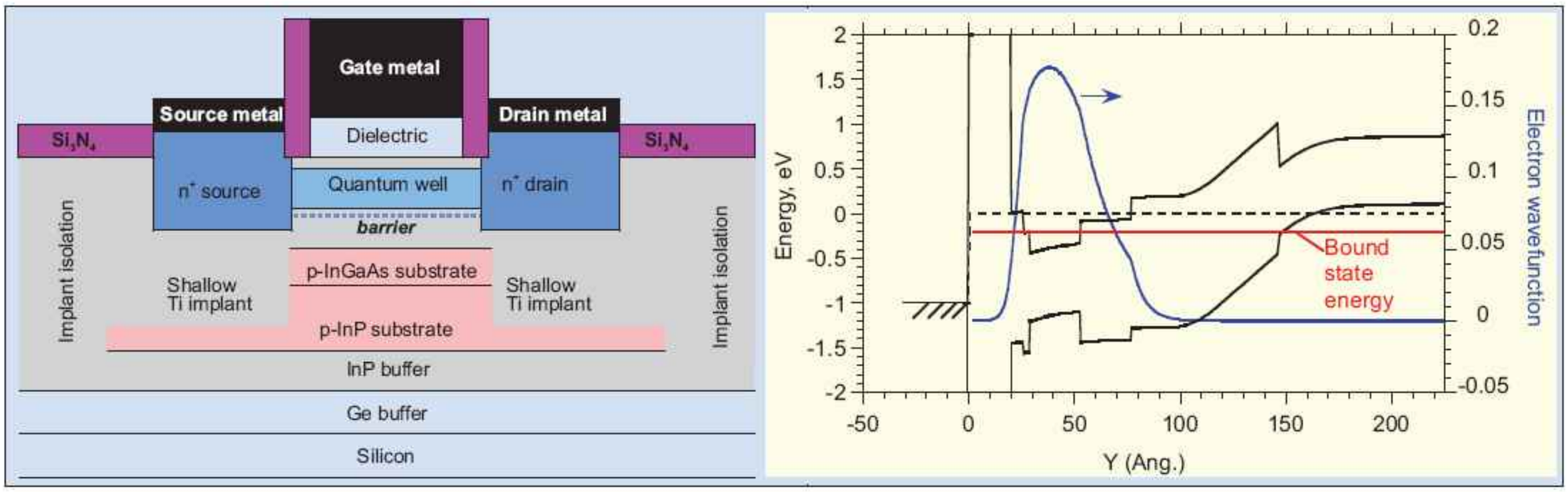


Figure 6. Lattice mismatches between III-V materials and Si create the need for buffer layers: (left) a possible III-V nMOSFET on silicon [4]; (right) graph of quantum well confinement scheme in the vertical direction.

to be changed, since surface states easily arise at the dielectric/channel interface. Indeed, the rise of silicon CMOS was due in no small part to the ease with which the Si/SiO_2 interface could be made to avoid or mitigate these problems. III-V FETs usually contact a metal gate directly to the semiconductor (metal–semiconductor FET, or MESFET).

Although this lack of a native oxide for III-V materials has been a barrier to the successful development of III-V MOSFETs for 30 years, Freescale Semiconductor's Matthias Passlack recently reported progress in assessing $Gd_xGa_{0.4-x}O_{0.6}/Ga_2O_3$ dielectric stacks on GaAs [2]. The relative dielectric constant is 20.8±1 and the breakdown field exceeds 4MV/cm. At an electric field of 1MV/cm, the leakage current density ~$2x10^{-8}A/cm^2$. The interface state density (D_{it}) has a broad, u-shaped minimum of less than $2x10^{11}cm^{-2}eV^{-1}$ on n-type GaAs.

Last year, Passlack joined with Kalna and Asenov of the University of Glasgow in the UK to create a Monte Carlo simulation of an implant-free InGaAs MOSFET (Figure 5). The reason for developing an implant-free MOSFET is that earlier simulations of structures with implants showed that, while 80nm $In_{0.2}Ga_{0.8}As$ MOSFETs would easily outperform Si and strained Si devices, the marginal improvement at 35nm drops dramatically. The implant-free $In_{0.25}Ga_{0.75}As$ MOSFET promises better behavior with vertical and lateral scaling. Moving from a 100nm to a 70nm device delivers a 60% drain current increase and a maximum transconductance of 2080mS/mm. Moving to 50nm, the drain current is 90–100% better than the 100nm version, with a maximum transconductance of 3190mS/mm.

For processing, the standard silicon CMOS infrastructure does not yet exist in an equivalent III-V form tailored to ultrahigh-volume manufacturing rather than niche applications. In addition, semiconductor manufacturers like Intel are fairly insistent that any channel change has to integrate onto a silicon substrate, which is not an easy problem, given the large lattice mismatch in general (Figure 6). Intel has worked with Qinetiq in the UK on indium antimonide (InSb)

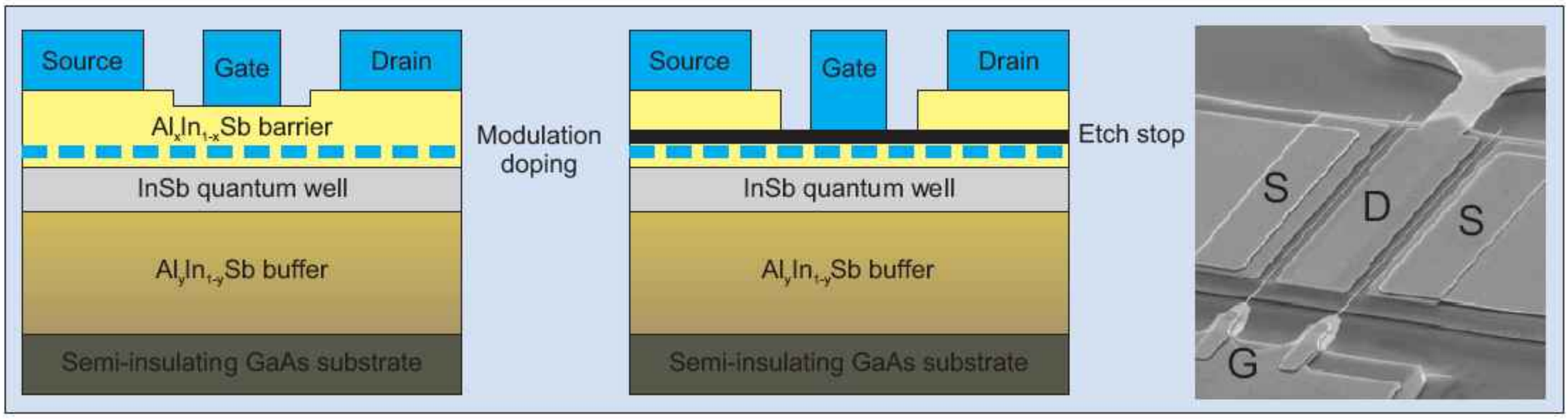


Figure 7. InSb quantum well transistor developed by Intel and Qinetiq [5]. For the 85nm gate length device reported in 2005, the layers were a 3µm AlInSb buffer, a 20nm InSb quantum well, a 5nm thick $Al_{0.2}In_{0.8}Sb$ spacer, δ-doping, and a 45nm $Al_{0.2}In_{0.8}Sb$ barrier with an optional etch stop. The figure shows devices that are (left) depletion-mode (normally-on) and (middle) enhancement-mode (normally-off). The δ-doping consists of a Te donor layer (density 1–$1.8x10^{12}cm^{-2}$). The researchers were able to achieve unity gain cut-offs (f_T) of 305GHz (enhancement) and 256GHz (depletion) with V_{DS} = 0.5V. This is a 50% boost over equivalent silicon nMOS devices while consuming 10x less active power.

quantum well transistors (Figure 7). However, it has not yet reported the realization of its dream of putting such structures onto silicon.

Other drawbacks from the physics of III-V materials include densities of states that are lower than for silicon, with adverse implications for drive current and parasitic capacitances. Lower carrier effective masses in III-Vs can also lead to poor confinement for sub-22nm devices, band–band tunneling, and off-state leakage effects.

Beyond the beyond

III-V or even II-VI materials (such as zinc oxide, ZnO) are still likely to be in the frame for smaller dimensions when nanowire channels are developed. However, it is by no means certain that this is the way the industry will go. Another possibility is carbon nanotubes, where the chicken-wire structure of graphite (due to sp^2 bonding, instead of diamond sp^3 bonding) is rolled into tubes. However, so far, due to the difficulty of working with such small objects, R&D nanotube devices have depended on chance alignments with electrode structures.

III-V or even II-VI materials (such as zinc oxide, ZnO) are still likely to be in the frame for smaller dimensions when nanowire channels are developed.

In the past few years, atomically thin layers of graphitic film, or graphene, have been grown on SiO_2/Si and other substrates, with researchers at the University of Manchester in the UK in the vanguard of this research. Two of the researchers, professor Andre Geim and Dr Kostya Novoselov, give details of a graphene transistor in a review article on progress in graphene studies [6]. The transistor structure is only one atom thick and less than 50 atoms wide. The scientists believe that this could allow the rapid miniaturization of electronics to continue when CMOS technology runs out of steam.

Graphene structures have been grown on top of non-crystalline structures, in liquid suspension, or as suspended membranes. Epitaxial growth on silicon carbide (SiC) produces high-mobility charge carriers, which is important for electronics applications.

Geim does not expect that graphene-based circuits will come of age before 2025. Until then, silicon technology should remain dominant. But he believes graphene is probably the only viable approach after the silicon era comes to an end: "This material combines many enticing features from other technologies that have been considered as alternatives to the silicon-based technology. Graphene combines the most exciting features from carbon-nanotube, single-electron and molecular electronics, all in one."

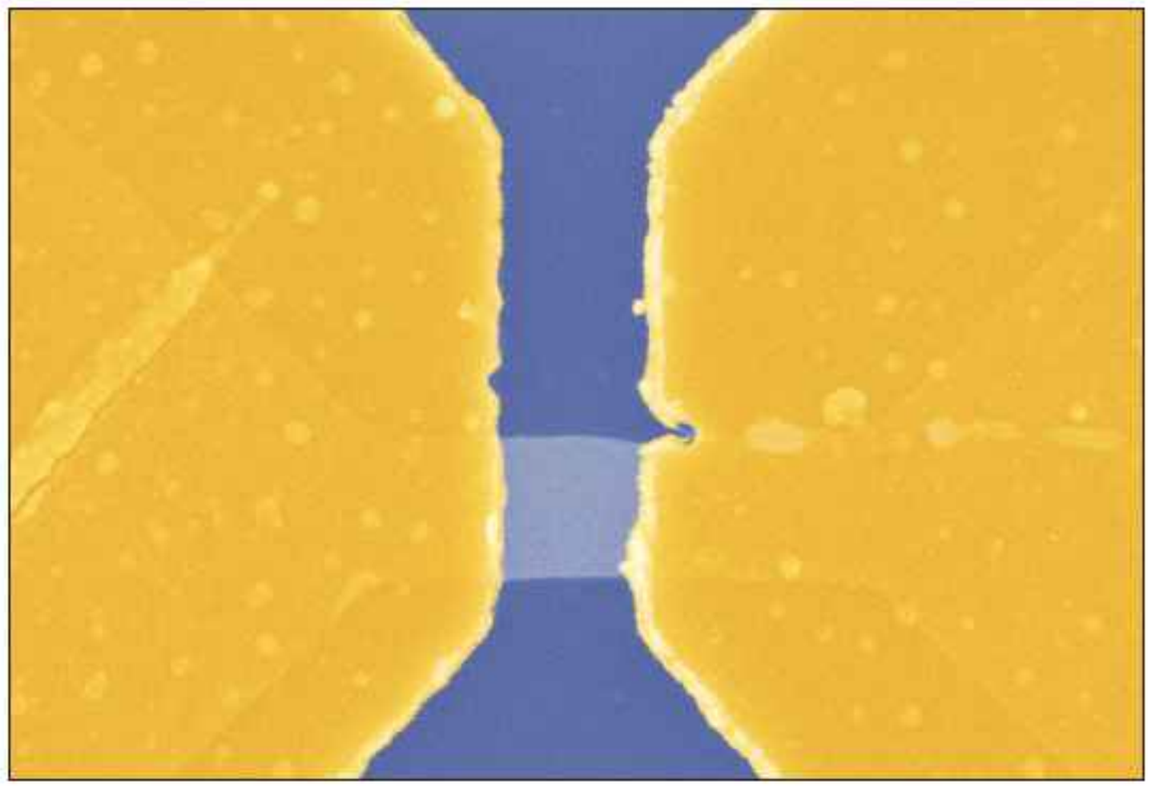


Figure 8. Scanning electron micrograph (in false color) of a transistor made on single-layer graphene. Au contacts shown in gold; SiO_2/Si substrate in blue. The width of the graphene wire is 200nm.

The transistors are made by carving nanoribbons, semi-transparent conduction barriers and quantum dots all in the same graphene layer (Figure 8). The conductance can be controlled by gates (back or side electrodes, also constructed from graphene).

"We have made ribbons only a few nanometers wide and cannot rule out the possibility of confining graphene even further — down to maybe a single ring

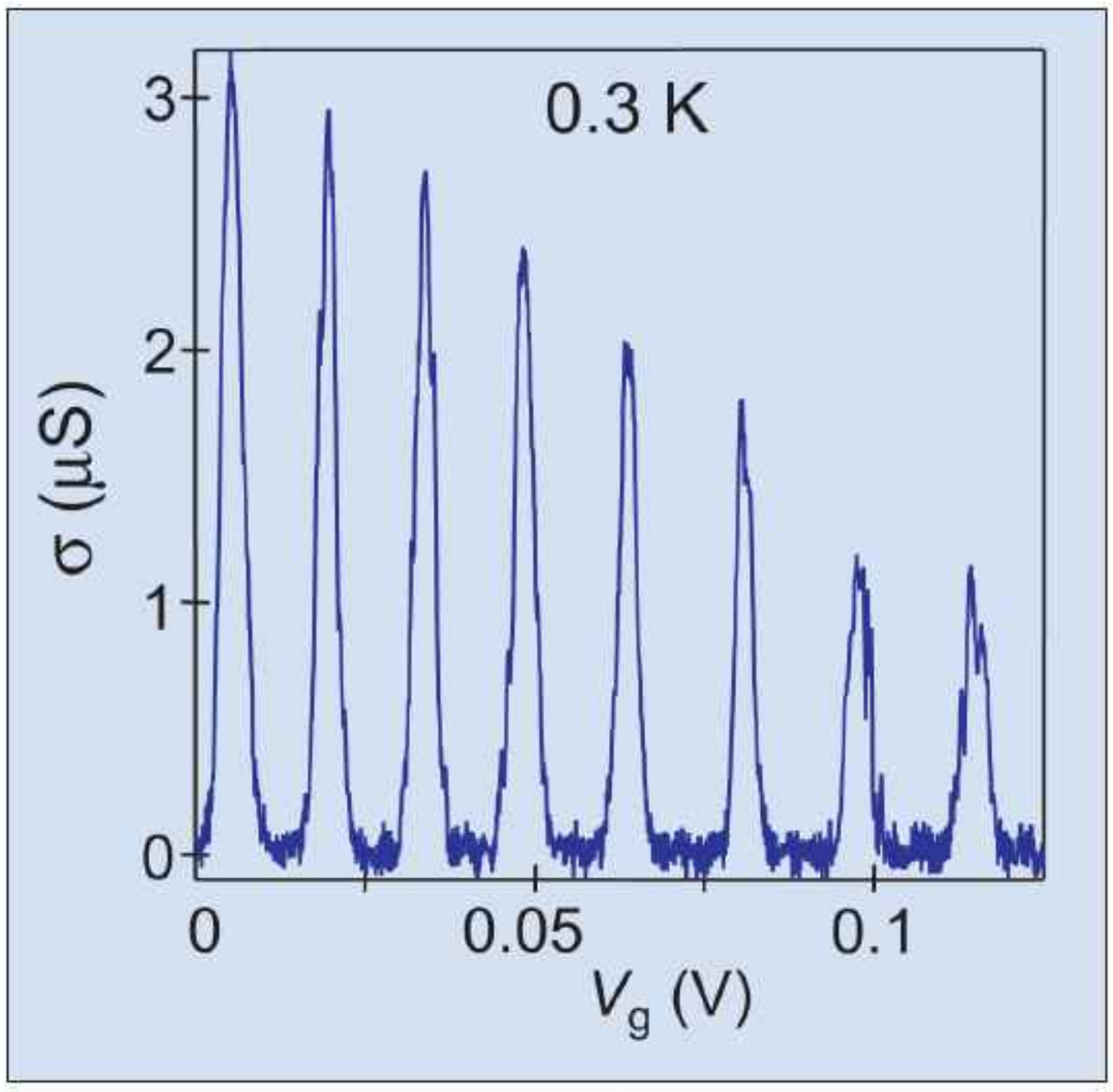


Figure 9. Coulomb blockade of conductance at low temperature (0.3K).

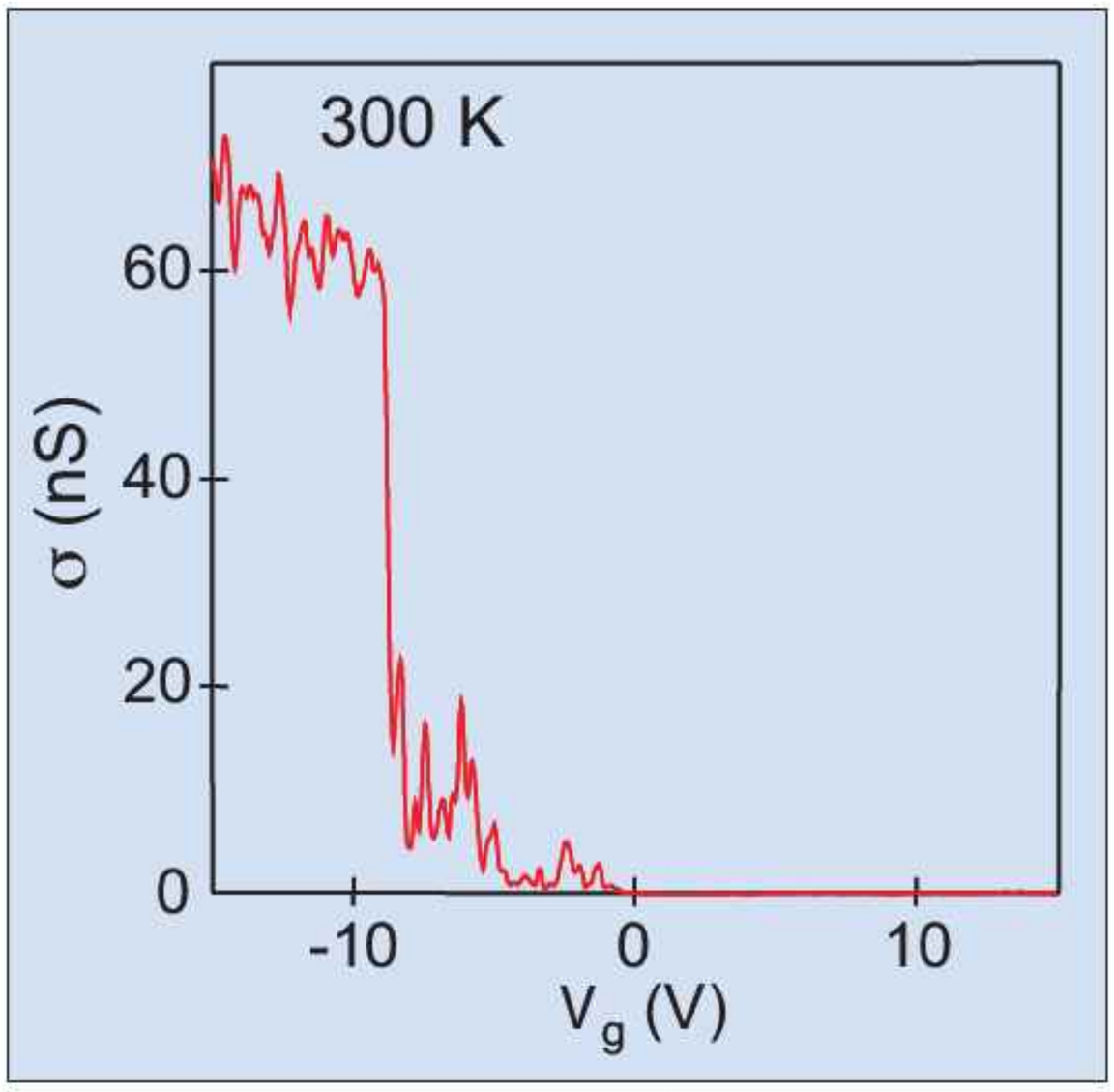


Figure 10. Conductance pinch-off at room temperature.

of carbon atoms," says Geim.

Two graphs of the transistor action for two structures are presented in their article published in the journal Nature Materials. One shows coulomb blockade effects (demonstrating the effects of single charge carriers) in a relatively large quantum dot (0.25μm in diameter) at low temperature (Figure 9). Another graph shows the operation of a device consisting of 10nm-scale structures at room temperature, showing complete pinch-off of the current (Figure 10). The caption for the figure promises that a more detailed presentation is currently "in preparation".

"At the present time, no technology can cut individual elements with nanometer precision. We have to rely on chance by narrowing our ribbons to a few nanometers in width," says Dr Leonid Ponomarenko, who is leading this research at Manchester. "Some of them were too wide and did not work properly, whereas others were over-cut and broken."

But Ponomarenko is optimistic that this proof-of-concept technique can be scaled up: "To make transistors at the true nanometer scale is exactly the same challenge that modern silicon-based technology is facing now. The technology has managed to progress steadily from millimeter-sized transistors to current microprocessors with individual elements down to tens of nanometers in size. The next logical step is true nanometer-sized circuits, and this is where graphene can come into play because it remains stable — unlike silicon or other materials — even at these dimensions."

Geim and his colleagues discovered graphene about two years ago. The Manchester group discovered graphene by using a non-epitaxial process on a SiO_2/Si substrate.

"Our approach is not scalable but it is good enough for research and proof-of-concept devices," says Geim. Other groups use an epitaxial process on silicon carbide that could lead the way to large-scale industrial application, although the present quality of the resulting graphene layers is not good enough for this.

The first graphene-based transistor was reported by the Manchester team at the same time as the discovery of graphene [7], and other groups have reproduced the result (for example, the USA's Georgia Institute of Technlogy has grown the graphene on SiC substrates, [8]). However, these graphene transistors were very 'leaky'.

The new transistors are much less leaky and Geim et al have also shown that graphene remains highly stable and conductive, even when it is cut into strips only a few nanometers wide. All other known materials — including silicon — oxidize, decompose and become unstable at sizes tens times larger. The poor stability of these other materials has been a fundamental barrier to their use in future electronic devices, limiting microelectronics development. ■

References

[1] From Ioffe Institute web-site, www.ioffe.rssi.ru/SVA/NSM/Semicond/
[2] Passlack, J. Vac. Sci. Tech., vol. B23, p. 1773, 2005.
[3] Kalna et al, J. Phys.: Conf. Series vol. 38, p. 200, 2006.
[4] From presentation at UCSB Engineering Insights Meeting, October 2006, by Professor Mark Rodwell.
[5] Datta et al, International Electron Devices Meeting (IEDM) 2005, session 32.1.
[6] Geim and Novoselov, Nature Materials, p.183, March 2007.
[7] Novoselov et al, Science, vol. 306, p. 666, 22 October 2004.
[8] Berger et al, J. Phys. Chem. B, vol. 108, p. 19912, 2004.

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Place Marcel Rebuffat, Parc de Villejust, 91971 Courtabouef,
France
Tel: +33 (0)1 69 31 61 30
Fax: +33 (0)1 69 31 61 79
www.picogiga.com

SemiSouth Laboratories Inc
201 Research Boulevard,
Starkville, MS 39759,
USA
Tel: +1 662 324 7607
Fax: +1 662 324 7997
www.semisouth.com

5 Deposition materials

EMF Ltd
(see section 4 for full contact details)

Epichem Group
Power Road, Bromborough, Wirral,
Merseyside CH62 3QF, UK
Tel: +44 151 334 2774
Fax: +44 151 334 6422
www.epichem.com

Praxair Electronics
542 Route 303, Orangeburg,
NY 10962,
USA
Tel: +1 845 398 8242
Fax: +1 845 398 8304
www.praxair.com/electronics

Rohm and Haas Electronic Materials
60 Willow Street,
North Andover, MA 01845,
USA
Tel: +1 978 557 1700
Fax: +1 978 557 1701
www.metalorganics.com
ELECTRONIC MATERIALS
Leading manufacturer of high-purity MOCVD precursors, including for Ga, In, Al, As, and several dopants. Ge precursors for SiGe films have now been added. Sales professionals have direct experience of epi-growth and device fabrication, giving superior technical service value.

6 Deposition equipment

AIXTRON AG
Kackertstrasse 15-17, Aachen 52072,
Germany
Tel: +49 241 89 09 0
Fax: +49 241 89 09 40
www.aixtron.com
AIXTRON
AIXTRON is a leading provider of deposition equipment to the semiconductor industry. AIXTRON's technology solutions (MOCVD, ALD, AVD®, CVD, OVPD) are used by a diverse range of customers worldwide to build advanced components for electronic and optoelectronic applications based on compound, silicon, or organic semiconductors. Several system configurations of AIXTRON, Epigress, Genus or Thomas Swan are available.

EMF Ltd
(see section 4 for full contact details)

Oxford Instruments Plasma Technology
North End, Yatton,
Bristol, Avon BS49 4AP, UK
Tel: +44 1934 837 000
Fax: +44 1934 837 001
www.oxford-instruments.co.uk
We provide flexible tools and processes for precise materials deposition, etching and controlled nanostructure growth. Core technologies include plasma and ion-beam deposition and etch, ALD and MBE.

Riber
31 rue Casimir Périer, BP 70083,
95873 Bezons Cedex, France
Tel: +33 (0) 1 39 96 65 00
Fax: +33 (0) 1 39 47 45 62
www.riber.com
Riber is a leading supplier of MBE products and related services for the compound semiconductor industry.

Veeco Instruments Inc
100 Sunnyside Blvd.,
Woodbury, NY 11797, USA
Tel: +1 516 677 0200
Fax: +1 516 714 1231
www.veeco.com

Veeco is a world-leading supplier of compound semiconductor equipment, and the only company offering both MOCVD and MBE solutions. With complementary AFM technology and the industry's most advanced Process Integration Center, Veeco tools help grow and measure nanoscale devices in worldwide LED/wireless, data storage, semiconductor and scientific research markets—offering important choices, delivering ideal solutions.

7 Wafer processing materials

Air Products and Chemicals Inc
7201 Hamilton Blvd.,
Allentown, PA 18195, USA
Tel: +1 610 481 4911
www.airproducts.com/compound

MicroChem Corp
1254 Chestnut St. Newton,
MA 02464, USA
Tel: +1 617 965 5511
Fax: +1 617 965 5818
E-mail: sales@microchem.com
www.microchem.com

MicroChem Corp (MCC) is an ISO 9001:2000 certified company. Founded in 1992, it employs 45 people in a 30,000ft^2 facility. MCC develops manufactures and markets specialty materials for niche & emerging microelectronic and MEMS markets.

Praxair Electronics
(see section 5 for full contact details)

8 Wafer processing equipment

EV Group
DI Erich Thallner Strasse 1,
St. Florian/Inn, 4782,
Austria
Tel: +43 7712 5311 0
Fax: +43 7712 5311 4600
www.EVGroup.com

Logitech Ltd
Erskine Ferry Road,
Old Kilpatrick,
near Glasgow G60 5EU,
Scotland,
UK
Tel: +44 (0) 1389 875 444
Fax: +44 (0) 1389 879 042
www.logitech.uk.com
Logitech Ltd is a leading designer and manufacturer of precision bonding, cutting, lapping, polishing and CMP equipment.

Oxford Instruments Plasma Technology
(see section 6 for full contact details)

Surface Technology Systems plc
Imperial Park,
Newport,
Wales NP10 8UJ,
UK
Tel: +44 (0)1633 652400
Fax: +44 (0)1633 652405
www.stsystems.com
A leading manufacturer of plasma etch and deposition equipment, including DRIE, ICP, RIE & PECVD technologies used in the fabrication and packaging of semiconductor devices.

Synova SA
Ch. de la Dent d'Oche,
1024 Ecublens,
Switzerland
Tel: +41 21 694 35 00
Fax: +41 21 694 35 01
www.synova.ch
Inventor of Laser MicroJet® technology, Synova is an experienced supplier of water jet-guided laser solutions for dicing and micro-machining applications.

Tegal Corp
2201 S McDowell Boulevard,
Petaluma, CA 94954,
USA
Tel: +1 707 763 5600
www.tegal.com

Oerlikon Wafer Processing
10050 16th Street North, Suite 100,
St. Petersburg, FL 33716, USA
Tel: +1 727 577 4999
Fax: +1 727 577 3923
www.oerlikonoc.com

Veeco Instruments Inc
(see section 6 for full contact details)

9 Gas and liquid handling equipment

Air Products and Chemicals Inc
(see section 7 for full contact details)

CS CLEAN SYSTEMS AG
Fraunhoferstrasse 4,
Ismaning, 85737, Germany
Tel: +49 89 96 24 00 0
Fax: +49 89 96 24 00 122
www.cscleansystems.com

SAES Pure Gas Inc
4175 Santa Fe Road,
San Luis Obispo, CA 93401,
USA
Tel: +1 805 541 9299
Fax: +1 805 541 9399
www.saesgetters.com

10 Process monitoring and control

k-Space Associates Inc
3626 W. Liberty Rd.,
Ann Arbor, MI 48103,
USA
Tel: +1 734 668 4644
Fax: +1 734 668 4663
www.k-space.com

LayTec GmbH
Helmholtzstr. 13-14, Berlin, 10587
Germany
Tel: +49 30 39 800 80 0
Fax: +49 30 3180 8237
www.laytec.de

11 Inspection equipment

Bruker AXS GmbH
Oestliche Rheinbrueckenstrasse 49,
Karlsruhe, 76187, Germany
Tel: +49 (0)721 595 2888
Fax: +49 (0)721 595 4587
www.bruker-axs.de

KLA-Tencor
160 Rio Robles, Suite 103D,
San Jose, CA 94538-7306,
USA
Tel: +1 408 875 3000
Fax: +1 510 456 2498
www.kla-tencor.com

12 Characterization equipment

J.A. Woollam Co. Inc.
645 M Street Suite 102,
Lincoln, NE 68508
USA
Tel: +1 402 477 7501
Fax: +1 402 477 8214
www.jawoollam.com

Lake Shore Cryotronics Inc
575 McCorkle Boulevard,
Westerville, OH 43082,
USA
Tel: +1 614 891 2244
Fax: +1 614 818 1600
www.lakeshore.com

13 Chip test equipment

Keithley Instruments Inc
28775 Aurora Road,
Cleveland, OH 44139,
USA
Tel: +1 440.248.0400
Fax: +1 440.248.6168
www.keithley.com

SUSS MicroTec Test Systems
228 Suss Drive,
Waterbury Center, VT 05677,
USA
Tel: +1 800 685 7877
Fax: +1 802 244 7853
www.suss.com

14 Assembly/packaging materials

ePAK International Inc
4926 Spicewood Springs Road,
Austin, TX 78759,
USA
Tel: +1 512 231 8083
Fax: +1 512 231 8183
www.epak.com

Gel-Pak
31398 Huntwood Avenue,
Hayward, CA 94544,
USA
Tel: +1 510 576 2220
Fax: +1 510 576 2282
www.gelpak.com

15 Assembly/packaging equipment

Ismeca Europe Semiconductor SA
Helvetie 283,
La Chaux-de-Fonds, 2301,
Switzerland
Tel: +41 329257111
Fax: +41 329257115
www.ismeca.com

J P Sercel Associates Inc
220 Hackett Hill Road,
Manchester, NH 03102, USA
Tel: +1 603 518 3200
Fax: +1 603 518 3298
www.jpsalaser.com

16 Assembly/packaging foundry

Quik-Pak
10987 Via Frontera,
San Diego, CA 92127,
USA
Tel: +1 858 674 4676
Fax: +1 8586 74 4681
www.quikicpak.com

17 Chip foundry

Compound Semiconductor Technologies Ltd
Block 7, Kelvin Campus,
West of Scotland, Glasgow,
Scotland G20 0TH, UK
Tel: +44 141 579 3000
Fax: +44 141 579 3040
www.compoundsemi.co.uk

United Monolithic Semiconductors
Route departementale 128,
BP46, Orsay, 91401,
France
Tel: +33 1 69 33 04 72
Fax: +33 169 33 02 92
www.ums-gaas.com

18 Facility equipment

MEI, LLC
3474 18th Avenue SE,
Albany, OR 97322-7014, USA
Tel: +1 541 917 3626
Fax: +1 541 917 3623
www.marlerenterprises.net

19 Facility consumables

W.L. Gore & Associates
401 Airport Rd,
Elkton, MD 21921-4236,
USA
Tel: +1 410 392 4440
Fax: +1 410 506 8749
www.gore.com

20 Computer hardware & software

Ansoft Corp
4 Station Square, Suite 200,
Pittsburgh, PA 15219,
USA
Tel: +1 412 261 3200
Fax: +1 412 471 9427
www.ansoft.com

21 Services

Henry Butcher International
Brownlow House,
50-51 High Holborn,
London WC1V 6EG, UK
Tel: +44 (0)20 7405 8411
Fax: +44 (0)20 7405 9772
www.henrybutcher.com

M+W Zander Holding AG
Lotterbergstrasse 30,
Stuttgart, Germany
Tel: +49 711 8804 1141
Fax: +49 711 8804 1950
www.mw-zander.com

22 Resources

SEMI Global Headquarters
3081 Zanker Road,
San Jose, CA 95134, USA
Tel: +1 408 943 6900
Fax: +1 408 428 9600
www.semi.org

event calendar

To get an event listed here, e-mail the details to mark@semiconductor-today.com
N.B. For full listings, click www.semiconductor-today.com/event_calendar.htm

12–17 April 2007
Physics of Light-Matter Coupling in Nano-Structures: 7th International Conference (PLMCN7)
Havana, Cuba
E-mail: plmcn7@sheffield.ac.uk
www.shef.ac.uk/physics/plmcn7

15–20 April 2007
LDSD 2007 (Sixth international Conference on Low Dimensional Structures and Devices)
Archipelago of San Andrés, Colombia
E-mail: Jasmine.Technology@ntlworld.com
www.fis.cinvestav.mx/ldsd2007

17–19 April 2007
Blue 2007/Solid State Lighting Suppliers Forum
Hsinchu, Taiwan
E-mail: Blue2007@SolidStateLighting.net
www.Blue-2007.com

14–16 May 2007
8th International Conference on Mid-Infrared Optoelectronics: Materials and Devices (MIOMD-VIII)
Bad Ischl, Austria
E-mail: miomd8@jku.at
www.hlphys.jku.at/miomd8

14–17 May 2007
CS MANTECH (2007 International Conference on Compound Semiconductor Manufacturing Technology)
Hilton Austin, TX, USA
E-mail: csmantech@csmantech.org
www.gaasmantech.org

14–18 May 2007
19th International Conference on Indium Phosphide and Related Materials (IPRM '07)
Matsue, Japan
E-mail: iprm07@ech.co.jp
www.iprm.jp

15–20 May 2007
14th Semiconducting and Insulating Materials Conference (SIMC-XIV)
Fayetteville, AR, USA
E-mail: simc@ibiblio.org
www.ibiblio.org/simc

20–23 May 2007
WOCSDICE 2007 (Workshop on Compound Semiconductor Devices and Integrated Circuits), including WOGATE (Workshop on the GaN Advancement Technology in Europe)
Venice, Italy
E-mail: wocsdice2007@woscdice2007.org
www.wocsdice2007.org

20–24 May 2007
5th International Conference on Solid State Crystals & 8th Polish Conference on Crystal Growth (ICSSC-5 & PCCG-8)
Zakopane, Poland
http://science24.com/event/icssc2007

29 May – 1 June 2007
LED & Solid State Lighting Expo 2007
KINTEX, Seoul, South Korea
E-mail: info@ledexpo.com
www.ledexpo.com

3–6 June 2007
12th European Workshop on Metalorganic Vapour Phase Epitaxy (EW-MOVPE)
Bratislava, Slovakia
E-mail: ew-movpe@savba.sk
http://elu.sav.sk/EW-MOVPE/index.html

5–7 June 2007
euroLED 2007
Birmingham, UK
E-mail: ninab@photonicscluster-uk.org
www.euroled.org

13–16 June 2007
Photonics Festival 2007 (OPTO Taiwan 2007 and LED Lighting Taiwan 2007)
Taipei World Trade Center, Taiwan
E-mail: pamela@mail.pida.org.tw
www.optotaiwan.com

28–29 June 2007
Hetero-SiC'07 Workshop (International Workshop on 3C-SiC Hetero-Epitaxy)
Grenoble, France
E-mail: Didier.Chaussende@inpg.fr
www.lmgp.inpg.fr/Hetero-SiC

9–13 July 2007
OECC/IOOC 2007:
12th OptoElectronics and Communications Conference
16th International Conference on Integrated Optics and Optical Fiber Communication
Yokohama, Japan
E-mail: oecc_iooc2007@ics-inc.co.jp
www.ics-inc.co.jp/OECC_IOOC2007

16–20 July 2007
SEMICON West 2007
San Francisco, CA, USA
E-mail: ktorres@semi.org
www.semi.org

22–27 July 2007
Defects in Semiconductors :
24th International Conference (ICDS-24)
Albuquerque, NM, USA
E-mail: icds24@sandia.gov
www.icds24.org

12–17 August 2007
15th International Conference on Crystal Growth
13th Conference on Vapor Growth and Epitaxy
US Biennial Workshop on Organometallic Vapor Phase Epitaxy
Salt Lake City, UT, USA
E-mail: aacg@att.net
www.crystalgrowth.us/iccg15/index.php

19–24 August 2007
Formation of Semiconductor Interfaces:
11th International Conference (ICFSI-11)
Manaus, Amazonas, Brazil
E-mail: secretary@icfsi2007.com
www.icfsi2007.com

26–30 August 2007
Optics & Photonics (including 7th International Conference on Solid State Lighting)
San Diego, CA, USA
E-mail: jeannea@spie.org
www.spie.org/app/conferences

3–7 September 2007
22nd European Photovoltaic Solar Energy Conference and Exhibition
Milan, Italy
E-mail: pv.conference@wip-munich.de
http://p12611.typo3server.info/7.0.html

16–21 September 2007
7th International Conference on Nitride Semiconductors (ICNS-7)
Las Vegas, NV, USA
E-mail: raabe@tms.org
www.tms.org/Meetings/specialty/icns7/Home.html

17–19 September 2007
Applications of High Power Semiconductor Lasers (AHPSL) 2007
San Diego, CA, USA
E-mail: amueller@intertechusa.com
www.intertechusa.com/conferences

23–26 September 2007
North American Molecular Beam Epitaxy (NAMBE) 2007
Albuquerque, NM, USA
E-mail: motero@chtm.unm.edu
http://nambe07.chtm.unm.edu

24–27 September 2007
Solar Power 2007
Long Beach Convention Center, CA, USA
E-mail: tyager@seia.org
www.solarpowerconference.com/18/

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